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CONTINUING EDUCATION

2.5 ANCC Contact Hours

Cognitive Workload of Computerized Nursing Process in Intensive Care Units

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The aim of this work was to measure the cognitive workload to complete printed nursing process versus computerized nursing process from International Classification Practice of Nursing in intensive care units. It is a quantitative, before-and-after quasi-experimental design, with a sample of 30 participants. Workload was assessed using National Aeronautics and Space Administration Task-Load Index. Six cognitive categories were measured. The "temporal demand" was the largest contributor to the cognitive workload, and the role of the nursing process in the "performance" category has excelled that of computerized nursing process. It was concluded that computerized nursing process contributes to lower cognitive workload of nurses for being a support system for decision making based on the International Classification Practice of Nursing. The computerized nursing process as a logical structure of the data, information, diagnoses, interventions and results become a reliable option for health improvement of healthcare, because it can enhance nurse safe decision making, with the intent to reduce damage and adverse events to patients in intensive care.

KEY WORDS

Intensive care units • Nursing informatics • Nursing process • Point-of-care systems • Workload

Nursing care, especially in ICUs, brings nurses technological innovation and complex clinical situations that require concentration and constant vigilance. Among the several technologies used and/or developed for healthcare, the nursing process (NP) is considered a guiding healthcare technology that brings to light a sequence of clinical reasoning and judgment, and it is thus a tool to be used by nurses in their professional practice.

The integration between NP and information and communication technologies (ICTs) can support the development and improvement of clinical reasoning and judgment, improve the work of nurses in intensive care, stimulate clinical discussion among peers and the multidisciplinary team, and foster continuous search for information aimed at evidence.[1–7]

Given these considerations, the computerized nursing process (CNP) for ICUs, built on the International Classification for Nursing Practice (ICNP), version 1.0, is a technological tool that can be associated with nursing care. From the early development of this computerized system, developers made sure the CNP was based on a worldwide consolidated classification system and could significantly contribute to patient safety, nursing care based on evidence, and to the electronic clinical record of all NP stages (history, clinical assessment, diagnosis, interventions, and outcomes), without, however, increasing the workload of nurses in the ICU.[1,8,9]

The increasing workload of nurses in patient care, particularly in ICUs, is a factor that can compromise patient safety.[10–14] Another factor that stands out is the excess of available technologies in these environments, which can either increase or decrease workload, as much as it can maximize or minimize the occurrence of damage and/or adverse effects on patients.[2,13,15] In this study, the aim was to measure cognitive workload, that is, the load on working memory during a teaching activity or practice.

An activity such as giving instructions, which includes perception, memory, and language, may aim at the development of abilities to solve problems, think, and rationalize. It has been observed that people learn best when they build on what they already understand, but the vast majority of people have to learn in a short period, and the greatest difficulty is to process information in working memory.[16]

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With the intent to assist nurses to improve patient care safety, free from risks, as well as to contribute to their knowledge, organization, control, and management of care, by using a computerized technology to conduct NP in nursing clinical practice, this study aimed to measure nurse cognitive workload when performing printed NP and CNP from ICNP 1.0 for ICUs.

METHODS

This was a quantitative, before-and-after quasi-experimental design with equivalent group, developed in three ICUs (adult) at three major hospitals of Santa Catarina, Brazil.

The study sample was nonprobabilistic intentional (or purposeful) per trial, composed of 26 nurses working in ICU and four professors. Level of significance $P < .05$ was considered for a confidence interval of 95% with no sample loss, totaling 30 nurses.

The inclusion criteria in the study were (1) nurses: ICU nurses with at least a 6-month working experience; and (2) professors: undergraduate diploma, with proven experience in health/nursing computer aid and/or in intensive care. The only exclusion criterion referred to the participant not completing all of the steps outlined on the protocol.

The survey was conducted in five steps, as follows:

Step 1: Preparation of two simulated clinical cases that included the clinical history and data/nursing information of fictitious patients, based on ICU patient characteristics. The clinical cases were simulated in a way to ensure that nurses and professors had access to the same patients, to avoid bias in the measurement of cognitive workload due to diversity and level of complexity of hospitalized patients in the respective units. In other words, during data collection, cognitive workload measurement of participants in performing printed NP and CNP did not involve, at any time, real patients from ICUs.

Clinical Case 1 referred to a 67-year-old male patient, weighing 93 kg, with a history of untreated arterial hypertension and coronary artery disease, who had been a smoker for 47 years, and was admitted to the ICU after being diagnosed with pneumonia. Clinical Case 2 referred to a 35-year-old woman, weighing 70 kg, also a smoker, who had been admitted to the ICU postoperatively for immediate appendectomy and who developed hemodynamic instability, presenting a clinical course compatible with septic shock.

Step 2: Nurses were given a notebook containing Case 1 printed on paper along with the items that comprise the NP from the 1.0 ICNP, specified as history of nursing, clinical assessment, nursing diagnosis, and interventions of respiratory, cardiovascular, neurological, gastrointestinal, and renal systems (five human systems). Participants were instructed to place an "X" in items to complete the NP. After that, nurses received the notebook containing the Clinical Case 2, with the respiratory, cardiovascular, neurological, gastrointestinal, renal, and integumentary systems printed on paper (six human systems). Only the human systems in Clinical Case 1 were printed; that is, the notebook for data collection did not include the musculoskeletal, integumentary, female reproductive, male reproductive, and biopsychosocial systems.

Step 3: After the completion of the evaluation and registration of Clinical Cases 1 and 2, nurses completed the cognitive workload assessment tool to finish all the steps for the NP on paper.

Step 4: On average, 18 to 21 days after the end of Stage 2, nurses assessed the same cases using the computerized system. At this stage, both nurses and professors were registered in the computerized system, with a login and password to access individual records. A demonstration of the CNP was presented to each nurse, including the pages of patient identification, history of nursing, clinical assessment, diagnosis and interventions of every human system, fluid balance, and laboratory tests.

Professors received an electronic message containing the clinical cases, login, password, and detailed guidance on the CNP. At this stage participants performed the assessment and registration of CNP only for the human systems included in the clinical cases, as mentioned in Step 2.

Step 5: After the completion of the assessment and registration of Clinical Cases 1 and 2, nurses and professors completed the cognitive workload assessment tool to finish all the steps for the CNP.

The four university nursing faculty members completed only the CNP because they are specialist teachers in the area, and in this sense, we decided to get additional measures that could strengthen and expand the interpretation and discussion of the results.

Data collection tool was based on the NASA Task Load Index.[17,18] It is a derivative scale of NASA—Bipolar Rating Scale based on the idea that the cognitive workload is a hypothetical construct that must be supported by the person, in order to maintain an acceptable performance level.[18] This tool is free to use in research, but it was in the English version, and it was thus necessary to translate it into Portuguese. Translation was reviewed by three English teachers. The translated tool was tested by two nurses (pretest) who were not part of the sample before it was applied to the participants.

The tool consists of six questions related to the measurement of the following categories: mental demand, physical demand, temporal demand, effort demand, performance and frustration demand, and one category comparison question. Each category was divided into a range of values where participants marked an "X" from "very low" (1) to "very high" (22).

Descriptive statistics (means, SD, maximum and minimum values) were used for data processing and analysis, and inferential statistics (variance and analysis of variance

[ANOVA] and least significant difference [LSD] test) were used to determine the statistical significance of cognitive workload for printed NP and CNP, using Microsoft Excel (Microsoft, Redmond, WA). Significance level $P < .05$ was considered for a confidence interval of 95% for data found.

The study complied with the ethical requirements and provisions of Resolution 196/96 from the National Board of Health, Brazil, and was approved by the three Ethics Committees of Research from the respective institutions by means of protocols 947/10, 036.11, and 069.2011. Also in regard to ethical issues, participants were identified as follows: nurses E1, E2, E3, successively and professors Pr1, Pr2, Pr3, Pr4.

RESULTS

Table 1 presents the results of the categories of nurses regarding mental demand, physical, temporal, effort, performance, and frustration that make up the cognitive load of the NP work on paper.

The categories "mental demand" and "temporal demand" were the categories that best highlight the work of the cognitive load of NP work on paper, because the mean was 16.38 (±3.41 and ±3.76, respectively). The category that had lower cognitive load of the work was "physically demanding."

Table 2 shows results for the assessment of nurses referred to the same six categories that comprise the cognitive workload of CNP.

In CNP, the category with the highest workload of cognitive work, according to a review of nurses, was "performance," obtaining a mean of 15.42 (±3.13). As occurred in the NP work on paper, the category showed the lowest load cognitive work was the "physical demand," with a mean 2.07 (±0.93).

When comparing only the mean of each category of the NP and CNP, it is evident that the categories "mental demand,"

Table 1

Assessment of Cognitive Workload of Printed NP From ICNP 1.0—Nurses; Florianópolis, Santa Catarina, Brazil; November 2011 to March 2012

Nurses	Mental Demand	Physical Demand	Temporal Demand	Effort Demand	Performance	Frustration Demand
Nurse 1	13	6	16	12	8	11
Nurse 2	14	1	16	11	8	1
Nurse 3	18	8	17	16	11	10
Nurse 4	16	5	22	18	11	21
Nurse 5	20	5	15	20	10	3
Nurse 6	7	1	8	6	8	4
Nurse 7	14	3	14	14	14	3
Nurse 8	22	3	22	22	10	11
Nurse 9	14	3	13	8	11	1
Nurse 10	21	1	15	11	10	8
Nurse 11	19	2	8	16	15	2
Nurse 12	17	2	14	13	17	13
Nurse 13	12	1	16	5	10	1
Nurse 14	17	2	18	14	10	11
Nurse 15	13	1	19	13	10	1
Nurse 16	19	1	16	10	9	1
Nurse 17	19	1	22	19	15	1
Nurse 18	12	3	21	11	13	5
Nurse 19	17	1	16	15	12	1
Nurse 20	19	3	19	18	10	17
Nurse 21	18	4	14	15	6	8
Nurse 22	19	1	19	16	12	9
Nurse 23	16	3	21	19	10	10
Nurse 24	20	3	16	15	10	7
Nurse 25	14	4	17	12	13	13
Nurse 26	16	4	12	5	10	10
Mean	16.38	2.76	16.38	13.61	10.88	7.038
SD	3.41	1.81	3.76	4.50	2.47	5.55
Maximum	22	8	22	22	17	21
Minimum	7	1	8	5	6	1
Variance	11.68	03.30	14.16	20, 32	6.10	30.83

Table 2

Assessment of Cognitive Workload of PEI From ICNP 1.0—Nurses; Florianópolis, Santa Catarina, Brazil; November 2011 to March 2012

Nurses	Mental Demand	Physical Demand	Temporal Demand	Effort Demand	Performance	Frustration Demand
Nurse 1	12	2	8	9	12	6
Nurse 2	12	1	1	6	11	1
Nurse 3	13	3	12	10	15	3
Nurse 4	13	4	13	11	18	9
Nurse 5	6	4	8	8	16	2
Nurse 6	4	1	3	3	10	2
Nurse 7	12	3	12	10	16	1
Nurse 8	17	2	4	4	20	4
Nurse 9	12	3	10	4	15	1
Nurse 10	12	1	10	10	15	2
Nurse 11	14	2	3	12	19	2
Nurse 12	13	2	12	10	21	3
Nurse 13	10	1	6	3	18	1
Nurse 14	13	2	11	11	12	2
Nurse 15	12	1	11	12	12	9
Nurse 16	6	1	6	6	17	2
Nurse 17	9	1	3	8	19	1
Nurse 18	10	2	12	7	15	3
Nurse 19	15	1	13	14	14	1
Nurse 20	16	2	11	10	12	7
Nurse 21	13	3	11	13	10	2
Nurse 22	15	2	14	14	16	5
Nurse 23	12	3	14	13	19	4
Nurse 24	6	2	9	10	17	3
Nurse 25	12	3	12	11	18	3
Nurse 26	13	2	9	13	14	4
Mean	11.61	2.07	9.15	9.30	15.42	3.19
SD	3.18	0.93	3.80	3.33	3.13	2.31
Maximum	17	4	14	14	21	9
Minimum	4	1	1	3	10	1
Variance	10.16	0.87	14.45	11.10	9.85	5.36

"physical demand," "temporal demand," "effort demand," and "demand of frustration" were higher in NP on paper. Only the category "performance" had higher mean in CNP.

Table 3 shows the ANOVA test (two-factor with replication) based on the mean of each category evaluated by nurses, for both printed NP and CNP. All ANOVA results obtained $P < .000$, showing a significant difference for the cognitive workload categories of printed NP and CNP (sample); difference was found for means of workload categories (columns), and at least one category showed a different behavior when changing from printed NP to CNP (interactions).

To confirm behavioral differences that occurred between printed NP and CNP, ANOVA test (single factor) was performed based on the differences between the means obtained in printed NP and CNP for each category that makes up cognitive workload. $P < .000$ showed that the variation between printed NP and CNP is different for each category when changing from one instrument to

Table 3

ANOVA Test for Printed NP and PEI; Florianópolis, Santa Catarina, Brazil; November 2011 to March 2012

Source of Variation	SS	*df*	MS	*F*	*P*	Critical *F*
Sample	576.2051282	1	576.20513	50.01781	.00000 (1.07629E)	3.87264226
Columns	6075.025641	5	1215.0051	105.4692	.00000 (5.88958E)	2.24408703
Interactions	1106.717949	5	221.34359	19.21385	.00000 (1.37734E)	2.24408703
In	3456	300	11.52			
Total	11213.94872	311				

Abbreviations: *df*, degrees of freedom; MS, mean of squares; SS, sum of squares.

another, pointing out that the categories have different behaviors among themselves.

Then the LSD test, performed after the ANOVA, aimed to check which differences between the means of printed NP and CNP categories were different among themselves. From a difference of 3.10 between the means found for each category, obtained from the Bonferroni correction, it is possible to state that the categories were evaluated by nurses differently both on printed NP and CNP.

The LSD test showed differences between the means of two categories of cognitive workload. In printed NP, "temporal demand" was regarded as the category with significant difference for CNP. That is, according to nurses, pressure and time spent to complete printed NP were considered greater than those spent for CNP. In CNP, differences between means showed that "performance" was the category of cognitive workload with highest gain when going from printed NP to computerized system.

Table 4 shows the results of the evaluation of professors regarding the categories of temporal demand, physical demand, effort demand, performance, and frustration demand that comprise the cognitive workload of CNP.

In the evaluation made by professors, the category with the highest mean, 18.25 (±1.70), was "performance," indicating that they felt they were successful in performing the CNP. The reduced number of professors did not allow for the performance of the ANOVA test.

DISCUSSION

A number of factors that comprise the nursing workload in ICUs have become the focus of interest for researchers/nurses because of the changing profile of critically ill patients, the existence and impact of several available technologies, and the need for skilled professionals.[12,14,19]

In addition to checking the time spent for the completion of nursing activities, such as basic care and ventilatory, cardiovascular, renal, neurological, and metabolic support, along with specific interventions, measuring the cognitive workload of nurses in certain ICU activities can contribute to the learning of these professionals, as well as positively affect patient safety.

The cognitive workload experienced by professionals is considered a complex and personal function, because it involves task-specific characteristics, the effort invested in its completion, and the direct relationship between unique factors and personal motivation,[20–23] which may be intrinsic, germane, and extraneous. The intrinsic load refers to the inherent difficulty in any activity.

The germane load refers to the cognitive load to process, build, and automate schemes/activities, and finally, the extraneous load covers the cognitive load caused by excess of information or activity.[16]

The most used technique to measure the cognitive workload is directly asking people involved in the activity. Such approach supposes that the workload of activity is a subjective event, because it involves directly assigning a task/activity to be completed by someone.[21]

Several scales have been specifically developed to measure cognitive workload of work.[24] The NASA Task Load Index scale considers that the workload is the product of the interaction between the demands of activity, the circumstances in which the task should be performed, and the skills, behaviors, and perceptions of people.[18]

The "mental demand" category, defined as mental and perceptual activity of nurses,[18] indicated that printed NP required increased workload for thinking, deciding, calculating, remembering, looking, and searching when completing the clinical record of the proposed activity.

The measurement of the "physical demand" category, understood as how much physical activity (push, pull, move, control, and activate)[18] was required to complete the NP, showed that the evaluators found that physical demand was "very low." For the printed NP, the physical demand was to pass the pages of notebooks containing the two cases, marking an "X" on data and information at clinical assessment, diagnoses and interventions, and correspondents, and in CNP, all they had to do was click on selected items to complete the electronic registration of nursing care.

"Temporal demand" was the category that most contributed to the cognitive workload, according to the assessment

Table 4

Assessment of Cognitive Workload of CNP From ICNP 1.0—Professors; Florianópolis, Santa Catarina, Brazil; November 2011 to March 2012

Professors	Mental Demand	Physical Demand	Temporal demand	Effort Demand	Performance	Frustration Demand
Prof 1	10	1	7	8	16	2
Prof 2	9	2	5	9	18	1
Prof 3	11	2	6	9	20	1
Prof 4	10	3	7	10	19	2
Mean	10	2	6.25	9	18.25	1.5
DesPad	0.81	0.81	0.95	0.81	1.70	0.57
Maximum	11	3	7	10	20	2
Minimum	9	1	5	8	16	1

of nurses in printed NP; that is, the participants considered the pressure and time spent to perform the proposed tasks close to "very high."

In relation to the time factor, studies show positive effects when integrating ICTs to nursing care, namely, improved direct care, outcomes, and practice environment; satisfaction of patients and family; reduced time for documentation/clinical record and workload; and reduced occurrence of errors and adverse events.[1–7] The reduced time factor for CNP, clinical registration/documentation and storage, and retrieval and access to data and information, enables nurses to increase time for direct patient care at bedside.

In a study that measured time spent by 10 nurses to complete five clinical cases in printed NP and in CNP from ICNP 1.0 in ICUs, results showed a significant difference between the two technologies; that is, nurses spent more time to complete printed NP (mean, 35.6 minutes) compared with CNP (mean, 27.1 minutes).

This research has highlighted the need for nurses to seek new resources that can leverage and improve their time, providing a productive and stimulating work environment and improving the quality of care, without increasing their workload.[25]

The "effort demand" category measured how difficult it was for nurses, both mentally and physically,[18] to perform the printed NP and CNP.

The "performance" category measured how successful the participants felt when conducting the proposed tasks.[18] The "frustration demand" category measured how insecure, discouraged, irritated, stressed, and annoyed[18] nurses and professors felt during the performance of the proposed activities.

When comparing only the means of each category of printed NP and CNP, it was clear that the "mental demand," "physical demand," "temporal demand," "effort demand," and "frustration demand" categories were higher for printed NP. Only "performance" had higher mean for CNP.

The six categories can be placed into three groups that characterize production workload. Group 1 consists of the "mental," "physical," and "time" categories, and it is characterized by the properties associated with the activity. Group 2 is made up by "effort" and "performance," considered to have characteristics of behavior and ability. And for last, Group 3 includes "frustration," which is considered an individual characteristic.[21]

A possible explanation for lower performance and higher effort by health professionals to perform the activity (printed NP) may be related to the complexity and format of the proposed activity. Data recording in static formats, such as paper, is passive in the processes of decision making and has limited interactivity. This means that it is not possible to add to data and information of printed NP interactive models to aid nurses in making safe decisions, such as warning systems, electronic databases, real-time care protocols, and sounds, among others.[26]

On the other hand, it is understood in this study that although the participants were exposed to the ICNP terminology on paper, the removal of terminology in 18 to 21 days was enough because the ICNP is not yet incorporated into clinical practice of nurses in Brazil, and beyond addition, we sought to standardize clinical cases in order to improve the assessment of workload. In this regard, it is believed that the biases were controlled.

Because CNP is also considered a support system for decision making (SSDM) based on the 1.0 version of ICNP, it includes an active knowledge base able to use patient data and information to generate real-time–specific diagnoses, interventions, and outcomes, according to patient needs, contributing thereby to the reduction of cognitive workload.

Several studies indicate that SSDMs available from electronic records, in this study CNP, provide professional expertise and properly screened information presented in real time and improve individual performance in the provision of patient care and public health.[27–30]

Other positive aspects of SSDMs that can be highlighted are greater patient safety and improved quality and efficiency of care. All aspects can be highlighted when integrating this technology into nursing care, because these systems indicate/suggest clinical diagnostics, the most appropriate treatment plan, alert systems, systems for disease management, reduced errors and adverse events related to drugs, request for laboratory tests and/or imaging, faster processing of information, compliance/implementation of best evidence through the availability of guidelines, and access to online databases.[27–30]

CONCLUSIONS

Intensive care units are known as hospital care environments that have the most available data and technologies aimed at continued assistance of patient requiring complex and specialized care. Computerized nursing process is a technology that offers nurses the possibility to record, organize, plan, manage, and measure the healthcare provided in these facilities in an effective manner and in real time.

When measuring the cognitive workload to complete printed NP and CNP, it became clear that CNP contributed to lower nurse and professor cognitive workload. That is, in CNP, "mental demand," "physical demand," "temporal demand," "effort demand," and "frustration demand" had lower means in relation to printed NP.

It is important to note that both nurses and professors considered that the "performance" was better to perform the proposed activities when using CNP. Because CNP is a SSDM, and because it possesses a logical structuring of data and information (patient data and clinical assessment of nursing), diagnostics, interventions and results of each Human systems based on CIPE 1.0, it also organizes information care. In this sense, the CNP can contribute to clinical decision making of nurses at the bedside.

Suitable instruments for the assessment of workload are needed to measure the cognitive workload of nurses. NASA-TLX proved to be effective for measuring the cognitive perceptions of nurses regarding their workload.

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To complete this test and additional continuing education activities related to nursing informatics, go to: http://nursing.ceconnection.com/browse/sources/21.