

Nursing Efficiency in Maintaining Fluid and Electrolyte Balance at Pediatric Intensive Care Units

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Abstract: Background: Fluid and electrolyte balance are critical for the maintenance of life and homeostasis. Therefore, the aim of this study was to evaluate nurses' knowledge and practice in maintaining fluid and electrolyte balance. Methods: Quasi-experimental design [pre, post, and follow-up tests] was utilized to fulfill the purpose of the study. Settings: This study was conducted at Pediatric Intensive Care Units, Menoufia Governorate, Egypt. Sample: A convenient sample of fifty nurses was represented in this study from January to August 2021. Two tools were used for collecting data. First tool: Fluid balance monitoring questionnaire consisted of two parts to assess nurses' knowledge regarding fluid and electrolyte balance and the second tool: Fluid balance monitoring audit to assess nurses' practice of fluid balance monitoring. Results: The mean age and standard deviations of studied nurses were 28±6.9 and 34% of them were aged between 25 and 30 years old. Half of the study sample [50%] had a bachelor's degree. On the pre-test, there were moderately adequate knowledge and incompetent practices of fluid balance monitoring. In conclusion: The study revealed that implementation of a health education program has a positive outcome on the advance of nurses' knowledge and practices about fluid measurement and maintenance. Recommendation: Ongoing in-service education programs must be implemented at Intensive Care Units in order to boost nurses' knowledge, practice, and outcome.

Keywords: Nursing, Fluid and Electrolyte Balance, Pediatric Intensive Care Unit

1. Introduction

Fluid and electrolyte balance is a dynamic process essential for life, and homeostasis [1]. Body fluids regulate body temperature, transport nutrients, gasses throughout the body, and carry waste products to excretion sites [2, 3]. A variety of factors can lead to fluid and electrolyte imbalances in critically ill patients, such as disease processes or medication errors [4, 5]. These factors interfere with the body's ability to absorb electrolytes and have a detrimental impact on organs and are associated with high morbidity and mortality rates among critically ill patients. Each year, millions of patients suffer disabling injuries or death due to unsafe medical practices and care [6].

The most common electrolyte imbalances are deficiencies and excesses of sodium, potassium, calcium, and magnesium

[7, 8]. These disturbances vary greatly in their causes, severity, treatments, and outcomes based on the electrolyte involved. Signs and symptoms of hypovolemia vary depending on the type and duration of fluid loss [9]. For example, lethargy, confusion, anxiety, dry mucous membranes, and tachycardia can present in the early stages of hypovolemia. Late and more ominous signs of volume depletion include decreased response, tachycardia, hypotension, slow capillary refill, weak peripheral pulses, and renal failure [10]. Early detection and management of fluid & electrolyte imbalance can improve patients' outcomes, diminish the length of intensive care stay, and reduce the cost of health care services [8, 11].

The optimal fluid and electrolyte solution changes depending on age, cause, severity, and coexisting morbidity. Three types of fluids are frequently used for active resuscitation like red blood cells, cellular colloid, and

crystalloid fluids with added electrolytes [12]. Risks and complications of fluid therapy are cerebral edema, acute lung injury, acute respiratory distress syndrome, and abdominal compartment syndrome, and transfusion-related lung injury, large volumes may also dilute clotting factors and increase bleeding [secondary coagulopathy], disrupt thrombus formation, and induce hypothermia [13].

Nurses play a vital role in caring for critically ill children through careful assessment and monitoring of any changes in health conditions and providing prompt management [14]. Also, they should have critical thinking and advanced problem-solving skills based on evidence-based practice to ensure the highest quality of care provided to pediatric patients [15]. Proper and accurate documentation of fluid intake and output is essential to prevent the complications of fluid imbalance in critically ill children [16, 17]. Nursing standard is a useful tool to promote nurses' performance and offers a base for measuring the quality of care, developing procedures, and rules that promote health care services [18, 19].

1.1. Operational Definitions

Nursing is the protection, promotion, and optimization of health, prevention of illness, and care of disabled people of all ages.

Fluid and electrolyte balance is a dynamic process that protects cellular function, tissue perfusion, and acid-base balance.

Pediatric Intensive Care Unit [PICU] is a specialist hospital ward that provides treatment for children who have life-threatening conditions.

1.2. Aim of the Study

The study aims to evaluate nurses' knowledge, and practice of maintaining fluid and electrolyte balance at Intensive Care Units, Egypt.

1.3. Research Hypotheses

The following research hypotheses are formulated to achieve the aim of this study:

Hypotheses 1: Nurses' knowledge will improve post-implementation of the educational nursing strategies regarding fluid and electrolyte balance.

Hypotheses 2: Nurse's practice will improve post-implementation of educational nursing strategies regarding the management of fluid and electrolyte balance.

Hypotheses 3: There will be a positive association between nurses' knowledge and practice post-implementation of educational nursing strategies.

2. Material and Method

2.1. Design

Quasi-experimental research design [pre, post, and follow-up study] was utilized to fulfill the purpose of the study.

2.2. Setting

This study was conducted at Intensive Care Units, Menoufia Governorate, Egypt.

2.3. Sampling

A convenient sample of 50 nurses was included during the period from January to August 2021.

2.3.1. Inclusion Criteria

Nurses' qualifications [e.g. Diploma or Technical Nursing Institute and Bachelor's degree].

All nurses who were on duties at the time of interview at Intensive Care Units.

2.3.2. Exclusion Criteria

Nurses who didn't complete the questionnaire sheet

Tool: Fluid balance monitoring questionnaire, adapted from [20, 21]. It was written in simple clear language consisted of four parts as the following:

Part 1: Nurses' biosocial data contains five questions concerning their age, sex, educational level, years of experience, and attendance of training programs about fluid and electrolyte balance.

Part 2: Nurses' knowledge regarding fluid balance monitoring. This part is used to assess nurses' knowledge, perception, and factors affecting fluid balance monitoring as perceived by nurses. It composed of 3 sections:

Section1: Nurses' knowledge of fluid balance monitoring, it compromised of 8 questions. In the scoring system, each question had two levels of responses as the correct answer was given a score of one and the incorrect answer was given a score of Zero. Correct knowledge equal to $\geq 75\%$ of the total score and $< 75\% - 60\%$ was deemed moderately knowledge while $< 60\%$ of the total score was revealed poor knowledge.

Section 2: Nurses' perception regarding fluid balance monitoring. It compromised ten statements to determine nurses' perception of fluid balance monitoring. It contained 3 subsections:

Subsection 2a: Importance of fluid balance monitoring comprises 5 questions

Subsection 2b: Fluid balance monitoring questionnaire sheet consists of 3 questions

Subsection 2c: Fluid balance calculation involves 2 questions. The scoring system for section 2 depending on 5-point Likert scales ranging from [strongly disagree=1], 2 [disagree=2], [uncertain=3], [agree=4] to [strongly agree=5]. Favorable perception is ≥ 60 percent of the total score, whereas $< 60\%$ is considered unfavorable.

Section 3: Factors affecting fluid balance monitoring as perceived by nurses regarding the inaccurate measurement of equipment, workload, time management, and lack of skills. The scoring system: If the factor influences fluid balance monitoring, the response is yes and no is the response when the factor does not affect fluid balance monitoring.

Tool 2: Fluid balance monitoring audit, this tool was used to assess nurses' practice regarding fluid balance monitoring:

five observational checklists were used to evaluate nurses regarding fluid balance monitoring through five [5] practices: nurse role at patient's admission [items from 1 to 8], intravenous fluid administration [items from 9-20], monitoring fluid intake [items from 21-30], monitoring fluid output [items from 31-39] and assessment I. V fluid imbalance [items from 40-50]. It was collected prior to the implementation of the intervention program and retested after three months. The content of checklists remained equal for the two tests. It consisted of fifty [50] steps. The score for each item ranged from [0 to 2]. The incorrect practice was taken a score of zero [0], correct and incompletely safe practice was taken a score of one [1], the correct and complete safe practice was given a score of two [2]. As a result < 60% was considered incorrect practice, \geq 60-85% was considered a fair safe practice, and more than 85% was considered good safe practice.

2.4. Ethical Considerations

Following an explanation of the study purpose, acceptance letters were obtained from the Vice Dean as well as the responsible authorities at the hospitals. The nurses were assured that participation in the study was voluntary, and informed consent was obtained from those who agreed to participate in the study with confirmation that data would be kept confidential. The data was safely stored in a cabinet, with only the researchers having access to it.

2.5. Tool Development

It was adopted from [20, 21] and modified by the researchers after reviewing the relevant literature, articles, periodicals, books, and magazines on the balance of fluid and electrolyte in children.

2.6. Validity and Reliability of the Tool

The tool was translated into Arabic and tested for its content validity by a group of five professor experts in Pediatric nursing and Critical Care Nursing. Tool reliability was assessed by using a correlation coefficient [0.8] for nurses' knowledge and $\alpha = 0.92$ for observation checklists.

2.7. Pilot Study

A pilot study was conducted with 5 nurses [10% of the total sample] to test the clarity, and applicability of the tools. In addition to determining the average time, it takes to fill the questionnaire. Because no changes were made to the study tools, 10% of the study sample could be included in the analysis.

2.8. Procedure for Data Collection

Fieldwork: Data collection was conducted from January to August 2021.

2.8.1. The First Phase (Assessment Phase)

At the beginning of the study, the researchers presented

themselves to the nurses and clarified the purpose of the study. Then nurses were requested to complete the interview questionnaire sheet [tool1] which took 15 minutes [Pre-test]. The researchers completed the observational checklist while monitoring fluid and electrolyte balance using Tool 2 [Pre-test]. Nurses weren't informed that they were observed two days per week in the morning shift. The assessment phase lasted three months to complete the desired knowledge and observations. Weaknesses in the knowledge and practice of nursing staff were identified and program goals were set.

2.8.2. The Second Phase (Implementation Phase)

During the implementation phase, the nurses caring for critically ill children received an educational nursing program [Arabic teaching booklet]. The researchers created it after evaluating the current literature and based it on an assessment of nurses' knowledge gained from a structured interviewing questionnaire using tool 1, and to monitor nurses' fluid and electrolyte using tool 2. Edited based on observation from the observational checklist. Groups of nurses were created [each group was interviewed two times per week at morning shift according to their availability]. Each interview extended between 25-30 minutes, and each group involved 3-4 nurses. Each group participated in two educational sessions on the theoretical and practical parts as follows: The first session includes theoretical information about fluid & electrolyte balance, and calculation. The practical session includes fluid and electrolyte monitoring. In these sessions, researchers used lectures, and graphics to convey content in a clear, and simple language. As well as, presented simple training videos for practical skills. The researchers ended the session with a summary of the main points with positive verbal feedback and each nurse received the Arabic teaching booklet for both theoretical & practical parts.

2.8.3. The Third Phase [Evaluation Phase]

The nurse's knowledge and practice of fluid and electrolytes were reviewed immediately post-implementation of an educational program, and it took three months [post-test]. Reassessment of retention was performed after three months [follow-up test].

2.9. Statistical Analysis

Survey data were entered into a statistical package of social sciences [SPSS] version 22 Software. The categorized variables were offered as numbers and percentages. Generally, the level of significance was set at P-value < 0.05 while P-value > 0.05 indicated a non-significant result.

Table 1 illustrates nurses' socio-demographic characteristics, the study revealed that the mean age and standard deviations of the studied sample were 28 ± 6.9 and 34% aged between the 25 to <30 while, 20% of the sample age was more than 35 years. According to their sex, all the study samples were females [100%]. Half of them had bachelor's degrees [50%] while less than one-third of them had nursing diploma [30%]. Furthermore, less than

half of the studied group had six to ten years of experience [40%] and 20% of them had less than five years of experience.

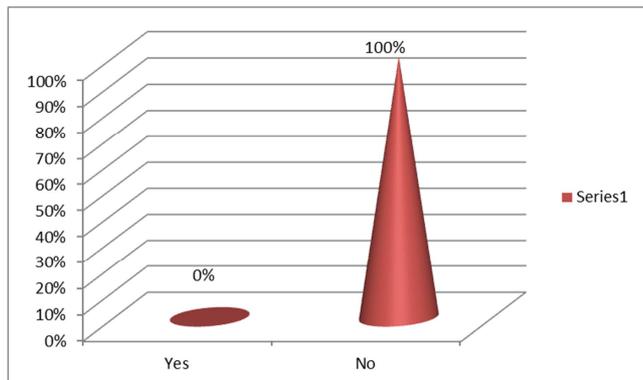


Figure 1. Nurses' previous training in fluid and electrolyte balance.

3. Results

Figure 1 depicted nurses' previous training in fluid and electrolyte balance. It was revealed that none of the nurses had any prior training in fluid and electrolyte balance.

Table 1. Nurses' socio-demographic characteristics [No=50].

Demographic characteristic	(No =50)	
	No	%
1- Age:		
20-<	9	18
25-<	17	34
30<	14	28
35-<	10	20
Mean ± SD	28±6.9	
2-Sex		
Male	0	0
Female	50	100
3-Level of education		
Nursing Diploma	15	30
Technical nursing Institute	10	20
Bachelor's degree	25	50
4-Years of experience		
≥ 5	10	20
≥10	20	40
≥-15	15	30
<20	5	10
5-Previous training programs		
Yes	0	0
No	100	100

Table 2. Nurses' knowledge of fluid balance monitoring on pre, post, and follow-up tests [No=50].

Knowledge Items	Pre-test		Post-test		Follow up-test	
	Correct answer		Correct answer		Correct answer	
	No	%	No	%	No	%
1-Average amount of children urine output	36	72	48	96	45	90
2-The required amount of fluid intake for children per day (on average)	23	46	44	88	42	84
3-Type of vital signs is affected by fluid imbalance	40	88	45	90	43	86
4-Clinical signs associated with hypovolemia	42	84	49	98	43	86
5-Nurses care for patients with hypovolemia	28	56	46	92	46	92
6-Nurses care for patients with hypervolemia	37	74	49	98	47	94
7-List types of intravenous solutions for Hypovolemia	38	76	48	96	46	92
8- Normal measurement for CVP in children	36	72	45	90	43	86

Table 2 displays nurses' knowledge of fluid balance monitoring on pre, post, and follow-up tests, the overall accuracy rate of knowledge on pre-test was 64% indicating moderate knowledge. The result depicted that on pre-test there was a discrepancy about the required amount of fluid

intake for children per day and nurses' care for patients with hypovolemia [46%, and 56% respectively]. Meanwhile, the majority of nurses' had correct knowledge on the post and follow-up tests with accurate knowledge [91.25% & 81.81% respectively].

Table 3. Nurses' perception of fluid balance monitoring on pre, post and follow-up tests [No=50].

Items of nurses perception	Pre-test		Post-test		Follow-up	
	NO	%	NO	%	NO	%
1-Recording the intake and output is important as recording patient care activities						
Strongly agree	6	12	49	98	48	96
Agree	36	72	1	2	2	4
Uncertain	8	16	0	0	0	0
Disagree	0	0	0	0	0	0
Strongly disagree	0	0	0	0	0	0
2-Fluid assessment is important to guide nursing care in critically ill patients						
Strongly agree	17	34	50	100	48	96
Agree	11	22	0	0	2	4
Uncertain	22	44	0	0	0	0
Disagree	0	0	0	0	0	0
Strongly disagree	0	0	0	0	0	0
3-Inaccurate fluid calculation is a risk for the critically ill patient						
Strongly agree	16	32	50	100	50	100
Agree	24	48	0	0	0	0

Items of nurses perception	Pre-test		Post-test		Follow-up	
	NO	%	NO	%	NO	%
Uncertain	10	20	0	0	0	0
Disagree	0	0	0	0	0	0
Strongly disagree	0	0	0	0	0	0
4-Fluid balance monitoring is the responsibility of nurses						
Strongly agree	12	24	46	92	49	98
Agree	28	56	4	8	1	2
Uncertain	10	20	0	0	0	0
Disagree	0	0	0	0	0	0
Strongly disagree	0	0	0	0	0	0
5-The nurse is the only person responsible for the fluid calculation						
Strongly agree	0	0	45	90	18	36
Agree	32	64	5	10	32	64
Uncertain	16	32	0	0	0	0
Disagree	0	0	0	0	0	0
Strongly disagree	2	4	0	0	0	0

Table 3 depicts nurses' perception of fluid balance monitoring on pre, post, and follow-up tests, the overall favorable perception on pretest was 77.48% and it was clarified that there were discrepancies in nurses' agreement to record the intake and output as an important patient care activity and fluid balance assessment guides nursing care. On

the post, and follow-up tests, it was clarified that the majority of nurses had a favorable perception of fluid balance monitoring [86.64% and 86.08% respectively]. Also, the entire studied sample agreed that inaccurate fluid calculation is a risk for critically ill patients [100%].

Table 4. Fluid balance monitoring sheet [No=50].

Items	Pre-test		Post-test		Follow-up	
	NO	%	NO	%	NO	%
1-Nurses are satisfied with the design of the fluid balance chart sheet						
Strongly agree	10	20	40	80	42	84
Agree	25	50	5	10	3	6
Uncertain	10	20	5	10	5	10
Disagree	5	10	0	0	0	0
Strongly disagree	0	0	0	0	0	0
2-The space to write the fluid numbers on the chart is adequate						
Strongly agree	12	24	2	4	8	16
Agree	12	24	10	20	10	20
Uncertain	23	46	10	20	7	14
Disagree	1	2	13	26	15	30
Strongly disagree	2	4	15	30	10	20
3-Fluid balance information is recorded in too many different places on the patient record						
Strongly agree	10	20	0	0	0	0
Agree	11	22	5	10	3	6
Uncertain	8	16	13	26	10	20
Disagree	14	28	20	40	25	50
Strongly disagree	7	14	12	24	12	24

Table 4 illustrates the fluid balance monitoring sheet, on the pre-test; there was a discrepancy in the fluid balance monitoring sheet. More than two-thirds of nurses [70%] were satisfied with the design of the fluid balance chart sheet while more than half of nurses [52%] disagreed that the space to write the fluid numbers on the chart is adequate and less than half of them disagreed that fluid balance information is recorded in too many different places on patient records [42%]. On post and follow-up tests, the majority of nurses were satisfied with the design of the fluid balance chart sheet. However, the majority of them disagreed with the space to write the fluid numbers on the chart is adequate, and less than two-thirds of them disagreed that fluid balance information is recorded in too many different places on patient records.

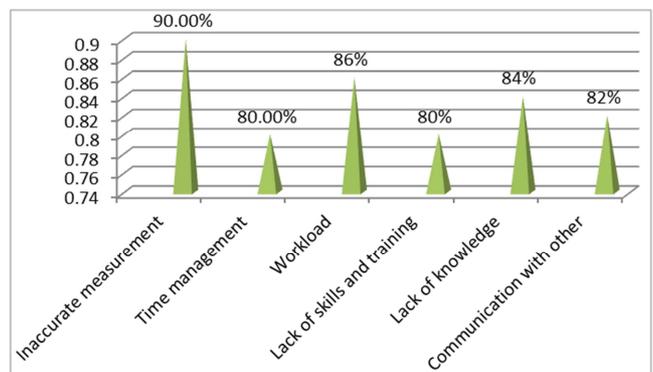


Figure 2. Factors affecting fluid balance monitoring as perceived by nurses.

Table 5. Fluid balance calculation [No=50].

Items	Pre-test		Post-test		Follow-up	
	NO	%	NO	%	NO	%
1-Nurses may be responsible for more than one patient, so it is difficult to monitor all patients regarding the fluid balance.						
Strongly agree	33	66	34	68	35	70
Agree	15	34	16	32	14	28
Uncertain	2	4	0	0	1	2
Disagree	0	0	0	0	0	0
Strongly disagree	0	0	0	0	0	0
2-The 24-hour fluid balance is correctly calculated and documented at the same time every day						
Strongly agree	39	78	40	80	47	94
Agree	8	16	7	14	1	2
Uncertain	1	2	3	6	1	2
Disagree	2	4	0	0	1	2
Strongly disagree	0	0	0	0	0	0

Table 5 shows fluid balance calculation, it was illustrated that more than two-thirds of nurses perception was favorable about being responsible for more than one patient, which makes it difficult to monitor all patients for fluid balance on pre, post, and follow up tests [66%, 68%, and 70% respectively]. The majority of them had favorable perceptions about 24-hour fluid balance is correctly calculated and documented at the same time every day on pre, post, and

follow-up tests [78%, 80%, and 94% respectively].

Figure 2 shows factors affecting fluid balance monitoring as perceived by nurses, it was illustrated that the majority of studied nurses reported that inaccurate measurement of the equipment, time management, workload, lack of skills & training, lack of knowledge, and communication with other healthcare workers [90%, 80%, 86%, 80%, 84%, and 82% respectively] are affecting fluid balance monitoring.

Table 6. Nurses' practice of fluid balance monitoring on pre, post, and follow-up tests [No=50].

Assessment of I. V fluid imbalance	Pre-test		Post-test		Follow up-test	
	Done accurately		Done accurately		Done accurately	
	No	%	No	%	No	%
Check patient hemodynamic status periodically.	5	10	50	100	40	80
Observe the patient's mouth and nose and behind the ears.	8	18	34	68	15	30
Assess O2 saturation	45	90	50	100	49	98
Assess skin turgor for elasticity	0	0	40	80	35	70
Assess capillary refill	6	12	48	96	40	80
Check patient investigation lab tests	16	32	47	94	25	50
Measure CVP in an accurate manner periodically.	30	60	45	90	44	88
Assess patients for any signs of fluid deficits	29	58	44	88	45	90
Check any signs for hypervolemia	30	60	40	80	42	84
Auscultate lung sounds	1	2	26	52	33	66
Observe the presence of edema & determine its grades	3	6	27	54	32	64

Table 6 Nurses' practice regarding fluid balance monitoring on pre, post, and follow-up tests, on the pre-test, it was revealed the overall practice score was 31.09% indicating incompetent practices where the minority of studied nurses accurately checked patient hemodynamic status periodically, Auscultate lung sounds and observe the presence of edema & determine its grades [10%, 2%, and 6% respectively]. None of them assessed skin turgor for elasticity. More than half of the studied sample assessed patients for any signs of fluid deficits, and checked any signs for hypervolemia [60%, and 58% respectively]. However, on post-test, the overall practice score was 81.81% representing competent practices. Thus, all nurses checked the patients' hemodynamic status periodically, assessed skin turgor, and assessed the patient for signs of fluid deficits. While, more

than half of the nurses were observed the patient's mouth and nose and behind the ears, auscultate lung sounds [68%, 54%, and 52% respectively]. Furthermore, it was noticed that there was a reduction in total practice scores [76.18%] after three months [follow-up test] than on immediate post-test.

Table 7 showed comparisons between the total mean score of nurses' knowledge, perception, and practice regarding fluid balance monitoring, the study reveals that there was a positive association between nurses' Knowledge and skills post-implementation of an educational program. Also, there were statistically significant differences among the studied nurses in their knowledge, perception, and practices levels between pre, and post-implementation of an educational program.

Table 7. Comparison between the total mean score of nurses' knowledge, perception, and practice regarding fluid balance monitoring [No=50].

Items	Pre-test	Post-test	Follow-up test	P value
	Mean ± SD	Mean ± SD	Mean ± SD	
Knowledge	5.12±2.5	7.3±1.05	7.1±1.37	P1<0.039 * P2<0.107 ^{ns}
Perception	38.74±8.3	43.92±5.6	43.32±3.66	P1=0.000 ** P2<0.000 **
Practice	6.84±5.1	18.0±5.37	16.76±6.21	P1<0.001 ** P2<0.000 **

NB: ** P<.001 ns means not significant * P<.05 P1: between pre and post P2: between pre and follow-up

4. Discussion

The Intensive care unit is a highly specialized unit admitted with patients who had life-threatening diseases that require close supervision and intensive treatments by highly trained nurses to guarantee proper assessment and documentation of patient fluid intake and output chart. The findings of the present study revealed that the mean age and standard deviations of the studied sample were 28±6.9 and 34% aged between 25 to <30 while, 20% of the sample' age was more than 35 years. This result agrees with [18] who stated that the majority of studied nurses were in the age group between 25- 30 and 20% of the sample' age was more than 35 years. This was in accordance with [1] who found that the majority of nurses who work at Zagazig University Hospitals aged below thirty years.

The findings of the present study revealed that all studied nurses were female [100%]. These findings agreed with [3] who stated that all study samples [100%] were females. These results may be explained that nursing is a universal feminine profession in society's culture. According to their educational level, half of the studied sample had a bachelor's degree [50%] and less than one-third of them had a nursing diploma [30%]. This result was contradicted with [21] who found that the most of participants [98.2%] held a bachelor's degree in nursing. Otherwise; this was refuted by [22], who stated that half of the study sample had graduated from a technical institute. Furthermore, less than half of the participants in the study [40%] had six to ten years of experience and 20% of them had less than five years of experience. This data is harmonized with previous research [3] which indicated that 37.02% of nurses had 6-10 years of experience and 36.54% had 1-5 years of experience in critical care units. These findings contradicted those of [23] who showed that [77.5%] of nurses have less than five years of experience while only 22.5% of the studied sample from 5-10 years of experience.

This study depicted that none of the nurses had any prior training in fluid and electrolyte balance. This was in accordance with [24] which found that the majority of nurses had no training program. This finding is contradicted by [25] whose study results revealed that only about a quarter of nurses didn't receive training. These findings agreed with [6] who illustrated that 60% of critical care nurses, had never attended a workshop before. Also, confirmed the findings of [26] who mentioned that the majority of studied nurses [85%]

didn't attend any previous training programs. This shown that in-service training programs for nurses are crucial activities for accurate monitoring of fluid and electrolytes for critically ill patients [3]. Also, this was recommended by [19] who advised conducting organized training programs for novices critical care nurses on fluid measurement and maintenance in order to provide high-quality nursing care for patients. Nurses' fluid balance expertise should also be increased, according to [14], because nurses are the major people in charge of fluid balance monitoring.

Concerning nurses' knowledge of fluid balance monitoring on pre, post, and follow-up tests, the results depicted that the overall accuracy rate of knowledge on pre-test was 64% indicating moderately adequate knowledge. This was consistent with [25] who revealed that 62% of the sample had moderately adequate knowledge. Also, there was a discrepancy about the required amount of fluid intake for children per day and nurses' care for patients with Hypovolemia [46%, and 56% respectively]. These results were attributed to a lack of nurses' education and training of fluid and electrolyte balance, so delivering continuous educational programs is vital to help nurses to diagnose and respond to fluid balance irregularities. This was clarified by [26] who recommended more guidance and education regarding monitoring fluid balance would be helpful. This was exemplified by [27] who stated that critical care nurses should be able to manage fluid balance irregularities. Similarly [28] advocated for the implementation of educational guidelines about fluid prescription into the ICU.

The majority of nurses had correct knowledge on the post and follow-up tests with accurate knowledge [91.25% & 81.81% respectively]. This was corresponded to [18] who stated that nurses were equipped with theoretical and practical knowledge about fluid balance monitoring after implementation of training programs. This highlighted the need for continuing education programs to maintain tissue perfusion while preserving fluid and electrolyte balance. In the same line, [30] have pointed out that fluid balance is critical in nursing care since it ensures homeostasis and adequate tissue perfusion. Therefore, constant nurses' assessment of fluid and electrolyte balance is vital to identify errors and plan for further training to improve their knowledge and care.

On the pre-test, the overall favorable perception of nurses of fluid balance monitoring was 77.48%. Furthermore, there were discrepancies in nurses' agreement to record the intake and output as an important patient care activity, and fluid

balance assessment guides nursing care. This was comparable to [17, 31] who reported a difference between fluids ordered and recorded as provided. An Egyptian study [18] found that more than two-thirds of the nurses documented fluid balance charts accurately. On the post, and follow-up tests, the majority of nurses had a favorable perception of fluid balance monitoring [86.64% and 86.08% respectively]. Correspondingly, the entire studied sample agreed that inaccurate fluid calculation is a risk for critically ill patients [100%]. This clarified the importance of continuous education programs for conserving fluid and electrolyte balance to maintain optimal tissue perfusion and promote patient safety.

As regards the fluid balance monitoring sheet, the results depicted that on the pre-test there was a discrepancy in the fluid balance monitoring sheet. More than two-thirds of nurses [70%] were satisfied with the design of the fluid balance chart sheet while more than half of nurses [52%] disagreed that the space to write the fluid numbers on the chart is adequate and less than half of them disagreed that fluid balance information is recorded in too many different places on patient records [42%]. This may be attributed to the heavy workload. This is consistent with findings from Egyptian studies [20, 32] which found that nurses' intense workload was affected by nurses' intervention. As a result, it was suggested that reducing the nurse-to-patient ratio in ICU to 1:1 might help with the delivery of high-quality nursing care. On the post, and follow-up tests, the majority of nurses were satisfied with the design of the fluid balance chart sheet.

However, the majority of respondents disagreed that there is enough space to write the fluid numbers on the chart, and less than two-thirds of them disagreed that fluid balance information is recorded in too many different places on patient records. This is highlighting the need for an educational program for critical care nurses on preserving fluid, and electrolyte balance to promote patient safety. Furthermore, a study conducted by [17] emphasized the necessity of enhancing nurses' education in order to improve fluid balance monitoring practice. Additionally, [33] found that continual in-service training program for nurses is a vital concern that allows the professional nurse to keep up with the latest developments in nursing science, hence improving nursing practice. Also similar to [34] who reported that fluid balance monitoring is inaccurate across all wards putting patients' safety at risk. This issue can be solved by raising knowledge on the necessity of fluid balance.

Regarding fluid balance calculation, the present study illustrated that more than two-thirds of nurses' perception was favorable about being responsible for more than one patient, which makes it difficult to monitor all patients for fluid balance on pre, post, and follow up tests [66%, 68%, and 70% respectively]. Also, the majority of them had favorable perceptions about 24-hour fluid balance being correctly calculated and documented at the same time every day on pre, post, and follow-up tests [78%, 80%, and 94% respectively]. This clarified the improvement of nurses' perception after conducting the educational program. As a

result, [28] emphasized the importance of continuous training programs about fluid balance calculation, and monitoring skills to promote patients' safety. Also in the same line with [3, 23] stated that empowering education is a paradigm for in-service training for nurses according to educational needs connected to practice nursing skills. This will enable nurses to complete professional activities more competently and correctly.

Concerning the factors affecting fluid balance monitoring, the majority of studied nurses reported that shows factors affecting fluid balance monitoring as perceived by nurses, it was illustrated that the majority of the studied nurses reported that inaccurate measurement of equipment, time management, workload, lack of skills & training, lack of knowledge, and communication with other health-care workers [90%, 80%, 86%, 80%, 84%, and 82% respectively] are affecting fluid balance monitoring. The results of this study are similar to [35-37] who reported that shortage of nursing staff, a deficit in knowledge, and a heavy workload are factors affecting fluid balance monitoring. Therefore, it could be suggested that reducing the nurse-patient ratio in ICU to 1:1 can contribute to accurate measurement and documentation of patients' parameters.

As regards nurses' practice of fluid balance monitoring, it was revealed that on the pre-test, the overall practice score was 31.09% indicating incompetent practices where the minority of studied nurses accurately checked patient hemodynamic status periodically, auscultate lung sounds, and observe the presence of edema & determine its grades [10%, 2%, and 6% respectively]. None of them assessed skin turgor for elasticity. This was similar to [38], who illustrated that 97.2% of nurses had an unsatisfactory level of practice regarding fluid & electrolyte imbalances monitoring and management. This demonstrated that every practicing nurse needs to acquire theoretical and technical information which is necessary to develop her skills in clinical practice. More than half of the studied sample assessed patients for any signs of fluid deficits and checked any signs for hypervolemia [60%, and 58% respectively]. This was agreed with [35], whose results showed that 60% of the studied sample assessed patients for signs of fluid deficits, and checked signs for hypervolemia.

However, on post-test, the overall practice score was 81.81% representing competent practices. Thus, all nurses checked the patient hemodynamic status periodically, assessed skin turgor, and assessed the patient for signs of fluid deficits. This emphasized the importance of continuous educational programs for nurses managing critically ill children for completing the professional tasks competently and correctly. This was confirmed by [25] who stated that implementation of health education program had a positive effect on the improvement of practices regarding body fluid balance assessment post-program implementation. This finding was in line with [39], who showed that there was an enhancement of nurses' practices regarding fluid and electrolyte balance providing an education program about body fluid monitoring.

More than half of the nurses were observed the patient's

mouth and nose and behind the ears, auscultated lung sounds [68%, 54%, and 52% respectively]. This may be rendered to overworked and overscheduled nurses that affect their practice leading to physical and mental exhaustion in addition to job dissatisfaction. Furthermore, it was noticed that there was a reduction in total practice scores [76.18%] after three months [follow-up test] than on immediate post-test. This reduction in knowledge might be due to the elapse of a long period of time after conducting an educational program. This demonstrates the crucial need for continuous education programs to equip nurses with the required knowledge to enable them to provide safe care.

Concerning comparisons between the total mean score of nurses' knowledge, perception, and practice, there was a positive association between nurses' Knowledge and skills post-implementation of an educational program. Also, there were statistically significant differences among the studied nurses in their knowledge, perception, and practices levels between pre, and post-implementation of an educational program. These findings are in agreement with [40, 41] who concluded that there were highly statistically significant differences between pre and post-program implementation in relation to the total mean score of nurses' practices regarding measuring fluid input for critically ill patients for all items of fluid input [$P < 0.001$].

5. Conclusion

The results were concluded that more than one-third of the studied sample was between the age of 25 to <30 (34%) and 20% of the sample' age was more than 35 years. On the pre-test, there was a discrepancy about the required amount of fluid intake for children per day and nurses' care for patients with hypovolemia (46% and 56% respectively). The implementation of a health education program has a positive outcome on the improvement of nurses' knowledge and practices about fluid measurement and maintenance compared to the pre-implementation of the program.

6. Recommendations

Educational interventions should be implemented for all nurses to improve their knowledge about fluid, electrolyte, and acid-base balance.

Updating nurses' performance and newly joined nurses about fluid balance.

Continuing in-service educational programs and emphasizing evidence-based practices regarding fluid balance monitoring.

Similar study can be done with large sample size.

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