Effect of Fluid Resuscitation Educational Intervention on Nurse's Knowledge, Practice and Fluid Creep Related Manifestations for Patients with Burn

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Abstract:
In the first twenty-four hours after a severe burn, it is difficult for burn care experts to resuscitate a patient with a large acute burn. Any possible post-burn alterations should be communicated to the nurse caring for a patient with burn injuries. **The aim**: Determine the effect of fluid resuscitation educational intervention on nurse's knowledge, practice and fluid creep related manifestations for patients with burn. **Design:** a quasi-experimental research design. **Setting:** Burn unit at Tanta University hospital. **Subjects:** a purposive sample of 27 nurses and 40 patients (control & study). **Tools:** Four tools were used; Nurses; knowledge questionnaire, Nurses' practice observational checklist, Burned patient's assessment and Fluid creep related manifestations assessment. **Results:** Significant improvement of mean scores of nurses' knowledge and practice immediately post intervention (p = < 0.001). There was a high significant difference between the study and control group in relation to the overall fluid creep manifestations (p = < 0.001), also there was a negative significant correlation between the nurses' overall knowledge, practice and patients' overall fluid creep related manifestations with p equal < 0.05. **Conclusion:** Nurses' knowledge and practice mean scores had increased significantly post implementation of fluid resuscitation educational intervention for patients with burn compared to pre- implementation of the educational intervention. This improvement had a significant positive effect to decrease fluid creep related manifestations among patients with burn. **Recommendation** the study addressed the importance of continuous assessment of the nurses' educational needs to design and implement periodic educational intervention and workshops accordingly.

Keywords: Educational intervention, Fluid Creep, Fluid resuscitation, Knowledge & practice.

Introduction

Resuscitation of acute, severe burns is a challenge for burn care clinicians, particularly in the first twenty-four hours after the burn occurred. It is one of the key factors of burn victims' survival **(Ete et al. 2019)**. Appropriate fluid resuscitation after moderate to severe burns, is the single most important therapeutic intervention which reduces the early mortality following acute burns **(Faskaj & Belba, 2021)**. Initial resuscitation of burn victims demands considerable volumes in order to restore the right perfusion pressure and prevent organ failure **(Boehm, Menke, 2021)**. Fluid resuscitation requires careful, hourly titration of the infusion rate to meet individual patient needs **(Causbie et al.2021)**. Extensive burns often require large amounts of intravenous fluid due to capillary fluid leakage and tissue swelling **(Schaefer, Nunez Lopez, 2022)**.

Several burn fluid resuscitation formulations have been developed to facilitate fluid delivery during resuscitation. Historical formulas are based on the estimated fluid volume requirements in the first twenty-four hours after a burn, which vary from 2 ml/kg/Total body surface area (TBSA) **(Rizzo et.al, 2021)**. Ete et al. noted that crystalloid or colloid-based resuscitation fluids make it difficult to establish the proper parameters for early fluid resuscitation, since fluid volume is dependent on the size and depth of burns. Rizzo et al. noted that most current recommendations reinforce these criteria by providing methods based on hourly titration of resuscitative fluid to maintain adequate urine output (UO), so limiting over-resuscitation and its associated problems. In certain instances, formula-based fluid resuscitation led to hypervolemia, which was associated with adverse outcomes and an increase in mortality. Inadequate fluid administration may lead to severe renal damage, burn shock, or multi-organ failure.

Fluid creep is a term recently applied to describe patients who receive fluid well in excess of the volumes predicted by traditional formulas for

resuscitation such as the Parkland or Brooke formulas. It is a well-recognised term used for excessive fluid resuscitation in the first 24 h after a burn injury. It increases the risk of developing many of the complications **(Saffle, 2016).** Fluid creep result an increase in intravascular pressure and vascular permeability which lead to fluid leakage, tissue edema, hypoxic index, increased intra-abdominal pressure and increased mortality. The most severe fluid creep complication is the abdominal hypertension that, when uncontrolled, may lead to abdominal compartment syndrome vesical pressure higher than 25 mmHg, associated to pulmonary compliance reduction or oliguria and renal failure **(Dittrich etal. 2019).**

Recognition of fluid creep has driven a large amount of the scientific investigation in the area of acute fluid resuscitation for patients with burn **(Cartotto & Cancio 2017).** The risks of fluid creep and other complications from over resuscitation must be considered and managed. Therefore; efforts should be made to resuscitate patients with burn with the least amount of fluid for adequate organ perfusion to reduce fluid creep manifestations. A nurse caring for a patient with a burn injury must be knowledgeable about the differences that occur after a burn, as well as intelligent and comprehensive in their assessment abilities, in order to detect even the slightest deviations in the patient's condition and successfully manage patients **(Mohammed et al. 2021)**. Therefore, this research evaluated the fluid resuscitation educational intervention effect on nurse's knowledge, practice and fluid creep related manifestations for patients with burn.

Significance of the study:

Burns are a worldwide public health concern, with a lower mortality rate in nations with better wealth. In contrast, non-fetal burns are the major cause of morbidity, hospitalisation for an extended period of time, and impairment. Fluid resuscitation is a distinguishing element of burn care, and the capacity to resuscitate patients effectively is essential for patient survival and prognosis. A nurse caring for a patient with a burn injury must be knowledgeable with the differences that occur after a burn, exhibit cognitive and comprehensive assessment abilities, be able to recognise even minor alterations in the patient's state, and provide appropriate treatment **(Mohammed etal. 2021).**

Aim of the study
To determine the effect of fluid resuscitation educational intervention on nurse's knowledge, practice and fluid creep related manifestations for patients with burn

Research hypothesis:
1. Nurses' knowledge and practice mean scores may exhibit improvement post implementation of the educational intervention regarding fluid resuscitation.
2. Patients with burn will not exhibited manifestations of fluid creep post implementation of the educational intervention regarding fluid resuscitation.

Materials and Method
Study design: A Quasi experimental study.
Setting: Burn Unit, Tanta Emergency Hospital, Tanta University Hospitals,
 Egypt. The hospital has one Burn Unit which consists of 4 wards; each ward contains 4 beds (The capacity of the unit includes16 beds).
Subjects: The sample of the study was consisted of:
Nurses: All available nurses who are working in burn unit (27) were included in this study regardless of their age, sex, years of experience, level of education and residence.
Patients: Purposive sample of 40 adult patients with burn were divided into two equal groups:
Control group: comprises 20 patients who were assessed pre implementation of the educational intervention. **Study group:** comprises 20 patients who were assessed pre and post implementation of the educational intervention.The sample size estimated by Power analysis of independent t tests [One tail, Effect size = 0.55; The significance level (α) at 0.05; Power (1-β) = 0.85].

Inclusion criteria include:
- Adult Patients from both sexes.
- Patients admitted to the burn unit within the 24 hours post burn injuries.
- Total body surface area from 20-35 % of moderate burn injury.

Exclusion criteria include:
- Patients who had chronic heart, respiratory and/or kidney diseases.
- Patients who had electrical burn, chemical burn and inhalation injury
- Patient with circumferential burn

Tools of data collection:
For collecting the data in the current study, four tools were utilized
Tool I: Nurses' demographic and knowledge questionnaire: It was developed after reviewing relevant and related literature (Shah etal. 2020).
It consisted of two parts:
Part (1): Nurses demographic Characteristics: to assess nurses; age, sex, education level, marital status, experience years in the previously mentioned settings,

previous attendance of the educational intervention about acute fluid resuscitations.

Part (2): Nurses' knowledge regarding fluid creep: to assess nurse's knowledge regarding burn, nursing care of patients with burn, fluid resuscitation and fluid creep related manifestations that contains 21 questions. Scored as follow; (1) for the correct answer and (0) for wrong answer. To better present knowledge, scores were presented as; low (<60), moderate (<60-<80%) and high (>80%).

Tools (II): Nurses' practice Observational Checklist : It was developed according to (Shah etal. 2020), to assess nursing practice during acute fluid resuscitations among patients with burn. A scoring system was created, allocating 2 point for each correctly and completely done step; while 1 point was given to incomplete done steps and zero score was given to wrong or not done steps. A total score was given to each nurse, the total scores then converted into total percent score. The level of practice was categorized as satisfactory if the total score of nurses practice ≥ 80% and unsatisfactory if the total score of practice < 80.

Tool (III): Burned patient's assessment:
It was developed according to related literature (Van Regenmortel et.al. 2021) to assess patients with burn hemodynamic parameters and presence of fluid creep manifestations; it includes four parts:

Part (1): Patient's demographic characteristics, which includes patient's code, age, sex, marital status, occupation and educational level.

Part (2): Patients' Clinical data: This includes; date of admission, type of burn, total body surface area , past medical history, type of formula and type of fluid used during the resuscitation.

Part (3): Patient's clinical parameters of fluid volume status: it includes patients' weight, urine output and vital signs.

Tool IV: Fluid creep related manifestations assessment:
It was developed according **to (Van Regenmortel, et.al. 2021**) to evaluate the presence of fluid creep manifestations among the studied groups of patients with burn, it includes altered level of consciousness, progressive edema in unburned area, increased blood pressure, dyspnea on lying position, distended external jugular veins, increased body weight, increased abdominal girth, tense distended abdomen, GIT manifestations, absence of distal pulses and abnormal respiration.

Fluid creep related manifestations were categorized as follow:
Absence of signs or symptoms 0, 1 sign or symptom, 2 signs or symptoms, 3 or more signs or symptoms, total score was ranged from 0-3.

Method
- An approval from the ethical committee was taken from the director of the Emergency Hospital, Tanta University Hospitals through official letters from the faculty of nursing.
- Following a review of the relevant literature, the researchers created the study tools.
- A panel of five professionals in the area of critical care nursing specialists, one member of the medical staff, and one expert in medical biostatistics evaluated the validity of the tools.
- The Cronbach alpha test, based on standardised questions, was used to evaluate the reliability of the suggested tools, and the results were 0.761, 0.837, and 0.824, respectively, for tools II, III, and IV.

Ethical consideration:
- An informed consent was obtained from every nurse and patient post explaining the aim of the study.
- The nurses and patients were assured that the study will not cause any harm and they have the right to withdraw from the study at any time without any penalty.
- Data confidentiality, nurses' and patients' privacy were assured through the coding of all data.

A pilot study was performed on 10% of the study samples to test the clarity, and applicability of the different items of the developed tools; the needed modifications were done before the main study.

Data collection:
- Data collection was conducted within the period from October 2021 to March 2022.
- The study was carried out in four phases: Assessment, planning, implementation, and evaluation phases.

Phase 1: Assessment phase
- It was carried out by the researchers to collect data using tools I part 1 & 2 and II to assess nurses' knowledge and practice. The nurses were given the knowledge questionnaire individually (pretest) and they were observed 3 times in 3 different shifts.
- During this phase, the researchers filled the patient assessment using tools III part 1, 2 &3 and tool IV for the control group; first, second and third day of admission.

Phase 2: Planning phase
The educational intervention was planned according to nurses' assessment of knowledge and practice and extensive literature review which included the following:
Aim: to enhance the nurses' knowledge and practice related to fluid resuscitation in addition to decrease fluid creep related manifestations of patient with burn injuries.
Expected outcomes:

- Nurses' knowledge and practice improved post implementation of the educational intervention related to fluid resuscitation.

- Absence of fluid creep related manifestations of patient with burn injuries.

- Preparation of the content to meet the objectives of the educational intervention.

- The educational intervention was translated into Arabic.

- Different educational methods and materials were prepared which included; lectures, group discussion, power point presentation, demonstration and video-based learning.

- The researchers produced an illustrated Arabic pamphlet with both academic and practical sections.

Phase (3): Implementation phase
For Nurses:

- The Educational intervention was implemented by the researchers for nurses using interactive lectures, video presentations, and booklet. Nurses were divided into 5 subgroups of 5 to 6 nurses in each group according to their day shifts distribution. The time for each session ranged from 30 – 45 minutes.

- The researchers implemented the educational intervention for all the nurses in the study group as the following:

For theoretical part:
two sessions were used for two consecutive days;

First session: knowledge about burn causes, types, degrees, depth of burn, burn severity, method of TBSA calculation, phases of burn and nursing care, fluid resuscitation, fluid balance, types of fluids, and formulas used for fluid resuscitation, and nursing care.

Second session: Knowledge about complications of fluid resuscitation, fluid creep definition, causes, risk groups, clinical manifestations, complications and nursing care.

For practical part: two sessions were used for two consecutive days;

First session: This session focused on proper steps of patient assessment pre fluid resuscitation as method of estimation of total body surface area, calculation of total fluid and flow rate per hour and proper steps of care during resuscitation as monitoring intake and output, fluid therapy for burned patient each hour, and assessment of patient's weight.

Second session: This session focused on proper steps of patient monitoring post fluid resuscitation and

accurate monitoring of fluid creep related manifestations.

For patients:

- The control group was assessed for fluid creep related manifestations once only pre implementation of the educational intervention related to fluid resuscitation of patients with burn injuries.

- The study group was assessed for fluid creep related manifestations twice pre and post implementation of the educational intervention related to fluid resuscitation of patients with burn injuries.

- Both control and study groups were assessed 3 times, 1st, 2nd, and 3rd day of admission.

Phase (4) Evaluation phase:

- Practice and knowledge of nurses were evaluated by the researcher 3 times; pre , immediately and one-week post implementation of the educational intervention using tool I part 2 and tool II.

- In addition; tool III part 1,2 & 3 and tool IV were used to assess the presence of fluid creep manifestations among the study group of patients with burn: at the first, second and third day of admission.

Statistical analysis of the data
Data were input into the computer and analysed with IBM SPSS version 20.0 software. IBM Corporation (Armonk, New York). Quantitative and percentage descriptors were supplied for qualitative data. The Kolmogorov-Smirnov test was utilised to establish the normality of the distribution. Quantitative data were characterised by range, mean, standard deviation, and median. A two tailed P value < 0.05 was considered statically significant **(Kirkpatrick & Feeney, 2013).**

Results:

Table (1): Mean score of nurses' knowledge throughout the study period

Nurses' Knowledge assessment items	Pre	Immediately	One week	Fr.	p
	Mean ± SD.	Mean ± SD.	Mean ± SD.		
Knowledge related burn injury					
Total Score	1.93 ± 1.04	4.74 ± 0.45	4.30 – 0.82	43.407*	<0.001*
% score	38.52 ± 20.70	94.81 ± 8.93	85.93 ± 16.47		
Knowledge related fluid resuscitation					
Total Score	2.63 ± 1.08	7.41 ± 0.75	6.63 ± 1.36	46.213*	<0.001*
% score	32.87 ± 13.49	92.59 ± 9.34	82.87 ± 17.04		
Knowledge regarding fluid creep					
Total Score	2.07 ± 1.07	3.96 ± 0.19	3.33 ± 0.73		
% score	41.48 ± 21.43	79.26 ± 3.85	66.67 ± 14.68	35.483*	<0.001*
Knowledge regarding care during					
Total Score	0.81 ± 0.56	1.93 ± 0.27	1.74 ± 0.45		
% score	40.74 ± 27.86	96.30 ± 13.34	87.04 ± 22.33		
Overall Knowledge					
Total Score	7.44 ± 1.91	18.04 ± 1.02	16.0 ± 2.20	35.725*	<0.001*
% score	37.22 ± 9.54	90.19 ± 5.09	80.0 ± 11.01		

Fr: Friedman test   **: significant as p ≤ 0.05*

Table (2): Distribution of the studied nurses according to their level of practice throughout the study period

Nurses' Practice assessment steps (n=27)	Pre		Immediately		One week post		Fr.	p
	No.	%	No.	%	No.	%		
Assess pt. pre resuscitation								
Unsatisfactory <80%	27	100.0	3	11.1	6	22.2	42.750*	<0.001*
Satisfactory ≥80	0	0.0	24	88.9	21	77.8		
Monitoring pt. during resuscitation								
Unsatisfactory <80%	25	92.6	4	14.8	9	33.3	31.391*	<0.001*
Satisfactory ≥80	2	7.4	23	85.2	18	66.7		
Signs and symptoms indicating for fluid creep								
Unsatisfactory <80%	27	100.0	7	25.9	13	48.1	28.727*	<0.001*
Satisfactory ≥80	0	0.0	20	74.1	14	51.9		
Overall Practice								
Unsatisfactory <80%	27	100.0	6	22.2	13	48.1	31.182*	<0.001*
Satisfactory ≥80	0	0.0	21	77.8	41	51.9		

Fr: Friedman test   **: significant as p ≤ 0.05*

Table (3): Correlation between nurse's overall knowledge scores and overall practice scores

Overall practice	Overall knowledge	
	r	p
Pre	0.110	0.584
Immediately	-0.010	0.962
One week	0.423*	0.028*

r: Pearson coefficient   **: Statistically significant at p ≤ 0.05*

Table (4): Comparison of the studied patients according to demographic characteristics, Clinical data and Burn resuscitation data

Item	Study (n = 20)		Control (n = 20)		Test of sig.	p
	No.	%	No.	%		
Patient demographic data						
Age (years)						
<30	9	45.0	10	50.0	χ²= 1.271	0.530
30-< 40	4	20.0	6	30.0		
≥40	7	35.0	4	20.0		
Min. – Max.	19.0 – 60.0		19.0 – 54.0		t= 0.929	0.359
Mean ± SD.	34.20 ± 12.78		30.80 ± 10.23			
Median	32.0		29.0			
Sex						
Male	10	50.0	12	60.0	χ²= 0.404	0.525
Female	10	50.0	8	40.0		
Marital status						
Married	14	70.0	10	50.0	χ²= 2.184	MCp= 0.330
Divorced	0	0.0	1	5.0		
Single	6	30.0	9	45.0		
Educational level						
Illiterate	6	30.0	7	35.0	χ²= 1.359	MCp= 1.000
Read and write	1	5.0	2	10.0		
Basic education	2	10.0	1	5.0		
Diploma	9	45.0	9	45.0		
Secondary education	2	10.0	1	5.0		
Occupation						
Manual work	11	55.0	8	40.0	χ²= 4.336	MCp= 0.373
Employee	0	0.0	2	10.0		
Technical work	2	10.0	3	15.0		
Housewife	7	35.0	5	25.0		
Not Working	0	0.0	2	10.0		
Clinical data						
Types of burn						
Wet Thermal	18	90.0	19	95.0	χ²= 0.360	FEp= 1.000
Dry Thermal	2	10.0	1	5.0		
TBSA						
Min. – Max.	15.0 – 36.0		12.0 – 36.0		t= 1.077	0.288
Mean ± SD.	25.0 ± 5.96		22.95 ± 6.08			
Median	25.0		22.50			
Past Medical history						
No	14	70.0	7	35.0	χ²= 5.835	MCp= 0.078
Diabetes Mellitus	2	10.0	2	10.0		
Gastrointestinal Diseases	0	0.0	1	5.0		
Previous Surgeries	4	20.0	10	50.0		
Burn resuscitation data						
Type of formula Modified Brooke Parkland Brooke	13 3 4	65.0 15.0 20.0	18 2 0	90.0 10.0 0.0	4.760	0.110
Type of fluid Crystalloid Colloid Colloid and crystalloid	17 0 3	85.0 0.0 15.0	19 1 0	95.0 5.0 0.0	3.653	0.231

SD: Standard deviation   *t: Student t-test*
χ²: Chi square test   *MC: Monte Carlo*   *FE: Fisher Exact*
: significant as p ≤ 0.05

Table (5): Comparison of the studied patients according to their clinical parameter of fluid volume status

Clinical signs of fluid volume status	Study (n = 20)			Control (n = 20)			t (p_1)	t (p_2)	t (p_3)
	1st	2nd	3rd	1st	2nd	3rd			
Patient weight									
Mean ± SD.	84.60 ± 9.92	84.60 ± 9.92	84.60 ± 9.92	70.95 ± 6.67	71.15 ± 6.93	71.17 ± 6.94	5.085^* ($<0.001^*$)	4.972^* ($<0.001^*$)	4.960^* ($<0.001^*$)
F (p_0)	–			3.408 (0.077)					
Total amount of urine									
Mean ± SD.	506.8± 94.48	562.5± 102.3	563.3± 134.7	449.7± 93.81	494 ± 76.1	482.0 ± 84.0	1.915 (0.063)	2.402^* (0.021^*)	2.289^* (0.028^*)
F (p)	$3.685^* (0.034^*)$			$3.586^* (0.037^*)$					
Pulse									
Mean ± SD.	92.55± 18.04	81.40 ± 6.87	80.80 ± 6.83	92.0 ± 22.96	83.80 ± 8.0	81.50 ± 5.98	0.084 (0.933)	1.018 (0.315)	0.345 (0.732)
F (p)	$9.747^* (0.005^*)$			3.695 (0.065)					
Systolic									
Mean ± SD.	101.0± 12.10	114.0 ± 8.83	115.8 ± 8.25	98.25 ± 8.78	109.3 ± 9.63	118.1 ± 9.02	0.823 (0.416)	1.626 (0.112)	0.823 (0.415)
F (p)	$15.147^* (<0.001^*)$			$24.842^* (<0.001^*)$					
Diastolic									
Mean ± SD.	71.05 ± 9.10	76.30 ± 8.96	77.45 ± 9.92	70.95 ± 7.49	75.15 ± 5.17	78.40 ± 6.61	0.038 (0.970)	0.497 (0.622)	0.356 (0.724)
F (p)	$5.426^* (0.016^*)$			$11.240^* (0.001^*)$					
Respiration									
Mean ± SD.	21.70 ± 4.31	21.30 ± 3.13	20.70 ± 2.64	22.80 ± 4.03	22.05 ± 3.53	21.20 ± 3.53	0.834 (0.410)	0.711 (0.482)	0.507 (0.615)
F (p)	1.546 (0.231)			3.537 (0.067)					

SD: Standard deviation   t: Student t-test   F: F test (ANOVA) with repeated measures p_0: p value for comparing between the studied periods
*p_1: p value for comparing between the studied groups in 1st periods p_2: p value for comparing between the studied groups in 2nd periods p_3: p value for comparing between the studied groups in 3rd periods   *: significant as $p \leq 0.05$*

Table (6): Comparison of studied patient according to fluid creep related manifestations

Fluid creep related manifestations	Study (n = 20)				Control (n = 20)				Test of sig.	p
	Present		Absent		Present		Absent			
	No.	%	No.	%	No.	%	No.	%		
Altered LOC	0	0.0	20	100.0	0	0.0	20	100.0	-	-
Progressive edema in unburned areas	3	15.0	17	85.0	5	25.0	15	75.0	χ^2=0.625	MCp= 0.695
Increased BLP	0	0.0	20	100.0	13	65.0	7	35.0	χ^2=19.259*	<0.001*
Dyspnea on lying position	3	15.0	17	85.0	2	10.0	18	90.0	χ^2=0.229	FEp= 1.000
Distended external jugular vein	1	5.0	19	95.0	2	10.0	18	90.0	χ^2=0.360	FEp= 1.000
Increased Body weight	2	10.0	18	90.0	3	15.0	17	85.0	χ^2=0.229	FEp= 1.000
Increased abdominal girth	3	15.0	17	85.0	5	25.0	15	75.0	χ^2=0.625	FEp= 0.695
Tense distended abdomen	3	15.0	17	85.0	5	25.0	15	75.0	χ^2=0.625	FEp= 0.695
GIT manifestations	4	20.0	16	80.0	6	30.0	14	70.0	χ^2=0.533	0.465
Absence of distal pulses	0	0.0	20	100.0	0	0.0	20	100.0	-	-
Abnormal respiration	3	15.0	17	85.0	4	20.0	16	80.0	χ^2=0.173	FEp= 1.000
Overall manifestation										
No	15		75.0		4		20.0		χ^2= 13.587*	<0.001*
1 symptom	1		5.0		9		45.0			
2 symptoms	0		0.0		0		0.0			
3 symptoms or more	4		20.0		7		35.0			
Total Score	1.10 ± 2.25				2.25 ± 2.36				t= 1.579	0.123
% Score	10.0 ± 20.41				20.45 ± 21.45					

LOC.level of consciousness   SD: Standard deviation   t: Student t-test
χ^2*: Chi square test   C: Monte Carlo   FE: Fisher Exact   *: significant as p ≤ 0.05*

Table (7): Correlation of Fluid creep related manifestations with study group demographic data and clinical parameters of fluid volume status

Item	Overall Fluid creep related manifestations	
	r	p
Age (years)	0.579*	0.007*
TBSA	0.295	0.206
Patient weight	0.252	0.283
Total amount of urine		
1st	0.206	0.383
2nd	0.076	0.751
3rd	0.196	0.407
Pulse		
1st	0.048	0.841
2nd	0.001	0.998
3rd	-0.211	0.371
Systolic		
1st	-0.275	0.240
2nd	0.045	0.850
3rd	-0.343	0.139
Diastolic		
1st	0.172	0.467
2nd	0.174	0.464
3rd	0.168	0.479
Respiratory rate		
1st	0.232	0.325
2nd	0.078	0.744
3rd	-0.048	0.841

TBSA.Total Body Surface Area   r: Pearson coefficient   *: significant as p ≤ 0.05

Table (8): Correlation between Overall Fluid creep related manifestations, patient demographic data, clinical data and burn resuscitation data

Patient demographic	Overall Fluid creep related manifestations (n = 20)						χ^2	^{MC}p
	0 (n = 15)		1 (n = 1)		3 symptoms or more (n =4)			
	No.	%	No.	%	No.	%		
Age (years)								
<30	7	46.7	1	100.0	1	25.0		
30-< 40	4	26.7	0	0.0	0	0.0	4.219	0.387
≥40	4	26.7	0	0.0	3	75.0		
Sex								
Male	8	53.3	0	0.0	2	50.0	1.129	1.000
Female	7	46.7	1	100.0	2	50.0		
Marital status								
Married	10	66.7	1	100.0	3	75.0	0.690	1.000
Single	5	33.3	0	0.0	1	25.0		
Educational level								
Illiterate	3	20.0	0	0.0	3	75.0		
Read and write	1	6.7	0	0.0	0	0.0		
Basic education	2	13.3	0	0.0	0	0.0	8.081	0.626
Diplome	7	46.7	1	100.0	1	25.0		
Secondary education	2	13.3	0	0.0	0	0.0		
Occupation								
Manual work	8	53.3	1	100.0	2	50.0		
Technical work	2	13.3	0	0.0	0	0.0	2.370	1.000
Housewife	5	33.3	0	0.0	2	50.0		
Types of burn								
Thermal	13	86.7	1	100.0	4	100.0	1.228	1.000
Chemical	2	13.3	0	0.0	0	0.0		
Past Medical history								
No	11	73.3	0	0.0	3	75.0		
Diabetes Mellitus	2	13.3	0	0.0	0	0.0	4.741	0.354
Surgery	2	13.3	1	100.0	1	25.0		
Type of formula								
Modified Brooke	12	80.0	1	100.0	0	0.0		
Parkland	2	13.3	0	0.0	1	25.0	10.743*	0.009*
Brooke	1	6.7	0	0.0	3	75.0		
Type of fluid								
Crystalloids	15	100.0	1	100.0	1	25.0	10.650*	0.004*
Colloid and crystalloids	0	0.0	0	0.0	3	75.0		

χ^2: *Chi square test*   *MC: Monte Carlo*   *: significant as $p \leq 0.05$*

Table (9): Correlation between patient's fluid creep related manifestations and nurses' knowledge and practice throughout the study period

Item	Overall Fluid creep related manifestations	
	r	p
Overall nurses' knowledge		
Pre	0.359	0.066
Immediately	-0.426*	0.027*
Week 1	-0.611*	0.001*
Overall nurses' practice		
Pre	0.025	0.901
Immediately	-0.457*	0.016*
Week 1	-0.624*	0.001*

r: Pearson coefficient   *: significant as $p \leq 0.05$*

In relation to the distribution of the studied nurses' demographic characteristics; all of them were female, more than third of them and same percent (37%) have bachelor's degree of education and have 1- < 5 experience years and all of them had no previous training about fluid creep.

Table (1): Mean score of nurses' knowledge throughout the study period
There was improvement in all knowledge items immediately post implementation of the intervention and slight decrease in their scores one-week post intervention, same table proved that this improvement was highly statistically significant in all items since p = < 0.001.

Table (2): Distribution of the studied nurses according to their level of practice throughout the study period
This table illustrates distribution of the studied nurses according to their level of practice throughout the study period; it is clear that the nurses' practice improved in all items and in the overall practice score. All nurses (100%) had unsatisfactory level of practice pre intervention in relation to assessment of patient pre- resuscitation, signs and symptoms indicating fluid creep and the overall practice score, which improved to satisfactory practice level by (88.9%), (74.1%) and (77.8%) for the previous mentioned items respectively immediately post the intervention, with some decrease in their practice score one-week post intervention. These improvements in all nurses' practice scores were highly statistically significant with p value < 0.001 for all practice items and overall practice scores.

Table (3): Correlation between nurse's overall knowledge scores and overall practice scores
There is a positive significant correlation between nurses' overall knowledge and overall practice score one-week post intervention (P value =0.028).

Table (4): Comparison of the studied patients according to demographic, Clinical data and Burn resuscitation data
Less than half (45%) and half (50%) of the study and control group respectively were < 30 years of age, more than two thirds (70%) and half (50%) of them were married of the study and control group respectively, less than half and same percent (45%) of both study group and controls had diploma education. In relation to the clinical data, most of the study and control group patients (90%) and (95%) respectively had wet thermal burn, more than two thirds (70%) and more than one third of them (35%) of the study and control group respectively had no past medical history, where one fifth (20%) of the study group and half (50%) of the controls had previous surgeries history. Demographic characteristics and clinical data were insignificant between both groups. In

relation to the studied patients' burn resuscitation data; more than half (65%) and most of the studied patient (90%) receive fluid resuscitation through Modified Brooke formula of the study and control group respectively. Only fifth of the study group and none of the control group received fluid resuscitation through Brooke formula. Most of the study and control group received crystalloids fluid for resuscitation by (85%) and (95%) respectively. None of the study group compared to small percent (5%) of the control group received colloids for fluid resuscitation, where less than fifth (15%) of the study group compared to none of the control group received colloids & crystalloids.

Table (5): Comparison of the studied patients according to their clinical parameters of volume status
There was a high statistically significant difference between study and control in relation to the patient's weight in the 1st 2nd & 3rd day with p value <0.001 each. Total amount of urine in the 2nd & 3rd day was significant between both groups (P value = 0.021 & 0.028 respectively).

Table (6) Comparison of studied patient according to fluid creep related manifestations
This table illustrates the comparison of studied patients according to fluid creep related manifestations; it showed that; less than fifth (15%) of the study group compared to fourth (25%) of the control group and same percent had progressive edema in the unpruned areas, increased abdominal girth and tensed distended abdomen. None of the study group compared to more than half of the control group (65%) had increased blood pressure, with a high significant difference between the studied groups since p value= <0.001. In relation to the overall fluid creep manifestations; majority of the study group (75%) compared to one fifth (20%) of the control group had no symptoms. Minority and small percent (5%) of the study group had only one symptom compared to less than half (45%) of the control group, none of both studied groups had 2 symptoms, in addition; one fifth (20%) and more than third (35%) of the study and control group respectively had 3 symptoms or more.

The overall fluid creep manifestations were significant between both groups (P value <0.001).

Table (7): Correlation of Fluid creep related manifestations with study group demographic data and clinical parameters of fluid volume status
The table displays the correlation between fluid creep related manifestations and clinical parameters of fluid volume status of the study group; it is clear that; only the age is correlated to fluid creep related manifestations with high statistical significance since p value is 0.007.

Table (8): Correlation between overall fluid creep related manifestations, patient demographic data, clinical data and burn resuscitation data

This table illustrates the relation between overall fluid creep related manifestations and patients' demographic data, clinical data and burn resuscitation assessment data of the study group; there were no statistically significant relation between any of the study group demographic or clinical data and the overall fluid creep related manifestations.

Both types of formula and the type of fluid used for fluid resuscitation are significantly correlated to the overall fluid creep related manifestations in the study patients with p value = 0.009 and 0.004 respectively.

Table (9): Correlation between patient's fluid creep related manifestations and nurses' knowledge and practice

There is a negative significant correlation between the nurses' overall knowledge and practice immediately, and one-week post intervention and patients' overall fluid creep related manifestations with p = < 0.05, thus whenever the nurses' knowledge and practice improved, the fluid creep related manifestations decreased.

Discussion:

This study aimed to determine the effect of fluid resuscitation educational intervention on nurse's knowledge, practice and fluid creep related manifestations for patients with burn.

Nurses' knowledge pre and post educational program:

The current study revealed that; there was a noticeable improvement in nurses' knowledge immediately post the intervention in all knowledge items with highly statistically significant difference than the pre intervention which has been slightly decreased one week after. This improvement was expected as the nurses were interested and keen to increase their knowledge; also, this result reflects the effectiveness of the educational intervention to improve nurses' knowledge related to fluid resuscitation for patients with burn while the little decrease on week later indicates the need for continuous reviewing of the educational intervention to refresh their knowledge.

These results are supported by many studies which denote the effectiveness of educational intervention to improve the nurses' performance in terms of knowledge and practice. **Kadhim & Hamza, (2020)**, who found that; nurse's knowledge has been improved concerning nursing care for patients with burn among the study group post exposure to educational intervention. **Mohammed etal.,(2021)** proved that; most of nurses had unsatisfactory knowledge about caring of patients with burn in the

pre intervention, stage while the majority of them had satisfactory level of knowledge post implementation of the educational intervention. Also, **Hassan etal., (2022)** revealed that; more than two-thirds of the studied nurses had poor knowledge pre implementation of the educational intervention which significantly improved to a satisfactory level of knowledge post implementation. In addition, **Awad, et al., (2020)** found that; there is a statistical significantly improved in nurses' knowledge related to fluids and electrolytes balance for patients with burn pre implementation of the educational intervention compared to post implementation stage. Moreover, **Mohamed et al., (2018)** proved that there was a highly statistically significant difference in nurses' level of knowledge and practice post implementation of the educational intervention than pre-educational protocol implementation regarding fluid balance monitoring. **Mahran et al., (2019)** illustrated the effectiveness of scenario based learning to improve the nurses' and physicians' knowledge about fluid creep.

Nurses' practice pre and post the educational intervention:

The current study results proved that the nurses' practice has been dramatically improved in all practice items and overall practice score immediately post implementation of the educational intervention with a decrease in their practice level one-week latter. These improvements in the nurses' practice scores were with highly statistically significant. Also, the results of the present study reflect the efficiency of the educational intervention to improve nurses' practice and indicate the importance for periodic training intervention to ensure continuous high quality nursing care related to fluid resuscitation for patients with burn. Thus, the first study hypothesis related to improvement of nurses' knowledge and practice post intervention has been proved.

These study results are consistent with the results of some similar studies done by **Hassan et al., (2022)** proved that; the majority of nurses had satisfactory practice level post implementation of the educational intervention with a statistically significant difference between pre and post- intervention. **Awad et al., (2020)** illustrated that; less than one third of the nurses had satisfactory practices score pre-educational intervention related to monitoring fluid and electrolyte replacement for patients with burn injuries, while increased to the majority of them post intervention application. **Elsayed & Saad (2022)** found that; more than half of the studied nurses had incompetent level of practice related to management of patients with fluid and electrolytes imbalance in critical care units pre an educational intervention, while the majority of them had competent level of

practice at post and follow up phases of educational intervention. Also, **Mohamed et al., (2018),** proved that; the majority of study participant had poor level of practice compared to two thirds of them had satisfactory level of practice post educational protocol implementation related to accurate monitoring fluid balance. In addition, **Sheta & Mahmoud (2018)** documented that nurses' total practices scores were enhanced significantly post implementing of the educational intervention about body fluid balance monitoring for critically ill patients. Moreover, **Abd Elalem & Fouad (2018)** concluded that; about two third of ICU nurses had incompetent and incomplete nursing practice pre-intervention, which improved post intervention after providing a guidelines intervention regarding assessment of fluid balance and measuring fluid input and output. **El-Sayed et al., (2019),** recommended that; providing in-service training on regular basis as needed to update and refresh nursing practice regarding care of patients with burn.

Correlation between nurse's overall knowledge scores and overall practice scores:

The current study demonstrated that; there is a positive significant correlation between nurses' overall knowledge and overall practice score one week after intervention. This finding means whenever nurses' knowledge level increased, their level of practice increased, and this is also evidence for the effectiveness of the program not only improve knowledge, but also when knowledge improve practice level also improve..

This result is supported by **Awad et al., (2020)** who found that; there was highly statistically significant positive correlation between the studied nurses' total knowledge and total practices in relation to monitoring of fluid and electrolyte replacement therapy for patients with burn injury. Also, **Hassan et al., (2022),** indicated that there is a positive correlation between total nurses' knowledge and practice scores pre and after implementation of the educational intervention. In addition, **Elsayed et al., (2022)** illustrated a positive correlation between total level of nurses' knowledge related to management of patients with fluid and electrolytes imbalance in critical care units and their over-all level of practices. In contrast with the study done by **Trikhatri et al., (2019)** who reported that there is a small positive association between nurses' knowledge and practice, although it is not statistically significant. Also, **Mohamed et al., (2018)** revealed no significant correlation between the overall knowledge and practice score at the pre and post educational intervention.

Patients' demographic characteristics, Clinical data and Burn resuscitation data

Regarding the studied patients, the result of the present study demonstrated that there was no statistical difference between study and control group in relation to any of the demographic characteristics and clinical data. This result in the same line with study done by **Luo, et. al (2015)** who reported that there were no significant differences between groups in terms of age, TBSA burned, area of full thickness burns and total amount of fluid infused. Majority of the present study patients received fluid resuscitation using Modified Brooke formula, in contrast with a study done by **Hunter et al., (2016),** they used Parkland formula only, while more than half of their studied patient switched after eight hours to the Muir and Barclay formula as per their study protocol. In addition, **Tang et al., (2014)** in his study used Parkland formula for fluid resuscitation for patients with burn.

Regarding to the type of fluid used for resuscitation; most of the study and control group received crystalloids, with no statistically significant difference between both groups study and control.

Comparison of the studied patients' scores regarding the clinical parameters of volume status

In line with our study, **Tang et al., (2014)** revealed in his study that patients body weight gradually reduced during the study periods after acute fluid resuscitation. Also, **Lindsey et al., (2020)** found that there was a highly statistical significance relation regarding the amount of urine output between the control and study groups who received adjusted ideal body weight index formula. In contrast to **Hunter et al., (2016)** who used urine output as the main parameter to determine the adequacy of fluid resuscitation and found that there was no statistically significant difference between the studied groups. Also, **Luo, et. al (2015)** found that, no significant differences was found between groups in terms of body weight, and total amount of urine output measurement.

Fluid creep related manifestations

The current study results illustrated that; there was a decrease in the fluid creep related manifestations in the study group compared to the controls like progressive edema, increased abdominal girth and tensed distended abdomen, in addition to increased blood pressure. In relation to the overall fluid creep manifestations, it was noted that there was a highly statistically significant improvement in the study group compared to the control group, these results documented that the second study hypothesis has been achieved. These results are supported by **Daniels et al., (2021)** who concluded that; patients who received a significantly higher volume of fluids than the calculated amount edema formation develop, fluid creep which could lead to abdominal

compartment syndrome, cerebral edema, pulmonary edema, and acute respiratory distress syndrome. Also, **Lindsey et al., (2020)** found that there was a significant decrease in acute kidney injury which requiring dialysis as the manifestations of fluid creep among the study group after application of fluid resuscitation protocol for patient with burn compared to the control group.

Correlation of Fluid creep related manifestations with study group demographic data and clinical parameters of volume status

Confirming our results, **Daniels et al., (2021)** in a retrospective study related to fluid resuscitation volume among adults during the first 24 hours after burn injury; they concluded that age had significant influences on complications and mortality rate among patient with burn. Also, **Saffle (2016),** agreed that age is correlated to the development of abdominal compartment syndrome (ACS) as a sign of fluid creep, at the same study there is controversy related to the total burn size, which correlated with the development of ACS, in addition he found that patients who exceeded targeted urine outputs need more amount of fluid for resuscitation, although even patients who resuscitated to appropriate urine outputs showed fluid creep manifestations. Another contrast by **Lindsey et al., (2020),** who found that; patients in the treatment group who received an adjusted ideal body weight indexed formula had a decreased urine output with a corresponding decrease in the incidence of acute kidney injury requiring dialysis as evidenced by decreased fluid creep during burn resuscitation.

Correlation between overall fluid creep related manifestations and burn resuscitation data

The present study illustrated that; concerning the burn resuscitation data; both types of formula and type of fluid used for fluid resuscitation were significantly correlated to the overall fluid creep related manifestations, it was found that the patients who were resuscitated using Modified Brooke and by crystalloids solutions show less manifestations than the patients who were resuscitated using parkland and Brooke formulas and by crystalloids and colloids solutions. This result is consistent with **Ete et al., (2019)** who discovered that employing the Parkland formula for burn resuscitation resulted in aggressive fluid infusion in the first eight hours after the burn, which, if not monitored and titrated in a timely manner, might lead to fluid creep. Also proved that patients received only crystalloid fluid in first day, exhibited less extremity edema than those who received colloids. At the same line, **Tang et al, (2014)** found that; after acute fluid resuscitation with Parkland formula, the patient's body weight often increased by five to fifteen percent of the pre-injury level as a sign of fluid creep.

In contrast **Faskaj et al., (2021)** in their observational prospective cohort study concluded that; colloids by their oncotic properties can better preserve intravascular volume than crystalloids and consequently decrease fluid volume demands. Also, **Cartotto et al., (2016)** in systematic review study concluded that; there is sound experimental evidence that proves colloids' ability to improve intravascular colloid osmotic pressure, expand intravascular volume, decrease resuscitation requirements, and decrease edema in unburned areas following a major burn.

Correlation between patient's fluid creep related manifestations and nurses' knowledge and practice

The present study illustrated that; the nurses' overall knowledge and practice immediately and one-week post intervention are negatively correlated with the presence of patients' fluid creep related manifestations. This means; whenever the nurses' knowledge and practice improved, the fluid creep related manifestations decreased which reflects the positive effect of the intervention on the patient's outcome to decrease fluid creep related manifestations. The result of the current study is supported by **Abd-Elaziz, (2018)** who reported a highly statistically significant difference after educational intervention regarding identifying the high-risk patients for abdominal compartment syndrome and intra-abdominal hypertension as signs of fluid creep.

After extensive review of literature, it was found that although there are many studies that proved the positive effect of nursing educational intervention to improve the patients' outcome, but still there is a lack of recent and updated studies which investigate the effect of such intervention on patients' outcome in relation to the area of fluid creep as a complication of over fluid burn resuscitation.

Conclusion:

There was a significant improvement in nurses' knowledge and practice mean scores post-implementation of educational intervention regarding fluid resuscitation for patient with burn compared to pre-implementation of the educational intervention. In addition, this improvement had a significant positive effect to decrease fluid creep related manifestations among patients with burn.

 Recommendations:

1. Educational needs should be periodically assessed for the nurses in burn units.
2. Designing and implementing educational interventions for the nurses in burn units based on their needs and literature updates to continuously update their knowledge related to management of patients with burn.

3. Periodic provision of in-service nursing training program and workshops regarding care of burned patient with more focus on acute burn resuscitation, in order to ensure consistent high quality nursing care for those patients in such a critical period.
4. Further studied with larger sample size is highly recommended.

References:

▪ **Abd-Elaziz, W.W., (2018):** Effect of Educational Program on Critical Care Nurses' Knowledge and Awareness Regarding Intra-Abdominal Hypertension and Abdominal Compartment Syndrome, IOSR Journal of Nursing and Health Science e-ISSN:.7(6): 12-8. DOI: 10.9790/1959-0706101218.

▪ **Abd Elalem, S, & Fouad, N., (2018):** Effect of an Instruction Intervention about Body Fluid Balance Assessment on Knowledge and Practice among Nurses in Intensive Care Unit International Journal of Novel Research in Healthcare and Nursing; 5 (1): 94-105.

▪ **Awad, M.O., Mohamed, S., & Hamed, S. (2020):** Effect of an Educational Program on Nurse's Performance Regard Monitoring Fluid and Electrolyte Replacement for Burned Patients. Egyptian Journal of Health Care, 11(4): 460-481. doi: 10.21608/ejhc.2020.134886.

▪ **Boehm, D.; & Menke, H. (2021):** A History of Fluid Management—From "One Size Fits All" to an Individualized Fluid Therapy in Burn Resuscitation. Medicina, 57, 187. https://doi.org/10.3390/ medicina57020187.

▪ **Cartotto, R., Greenhalgh, D.G., & Cancio, C., (2017):** Burn State of the Science: Fluid Resuscitation. J Burn Care Res, 38(3):e596-e604. doi: 10.1097/BCR.0000000000000541. Erratum in: J Burn Care Res., 1;38(4):269. PMID: 28328669.

▪ **Cartotto, R., &Greenhalgh, D., (2016):** Colloids in Acute Burn Resuscitation. Crit Care Clin.;32(4):507-23. doi: 10.1016/j.ccc.2016.06.002. PMID: 27600123.

▪ **Causbie, J.M., Sattler, L.A., Basel, A.P., Britton, G.W., & Cancio, L.C. (2021):** State of the Art: An Update on Adult Burn Resuscitation. *European Burn Journal*.

▪ **Daniels, M., Fuchs, P.C., Lefering, R., Grigutsch, D., Seyhan, H., Limper, U., The German Burn Registry, &** Schiefer **J.L., (2021):** Is the Parkland formula still the best method for determining the fluid resuscitation volume in adults for the first 24 hours after injury? - A retrospective analysis of burn patients in Germany. Burns.;47(4):914-21. doi: 10.1016/j.burns.10.001. Epub. PMID: 33143988.

▪ **Dittrich, M. H., & Hosni, N. D., (2019):** Brunow de Carvalho W., Resuscitation in Extensive Burn in Pediatrics and Fluid Creep: an Update, Curr Treat Options Peds 5:448–457 DOI 10.1007/s40746-019-00182-3.

▪ **Elsayed, E., & Saad, N. (2022**): Effect of Hybrid Educational Program on Nurses' Performance regarding Caring of Patients with Fluid and Electrolytes Imbalance in Critical Care Units. International Egyptian Journal of Nursing Sciences and Research, 2(2): 253-68. doi: 10.21608/ejnsr.2022.212457.

▪ **El-Sayed, A.E., EL-Guindi, F.K. , & Omar, H. A. (2019):** Nursing Core Competencies of Staff Nurses Providing Care for Burned Patients. Egyptian Journal of Health Care, 10(4): 1-16. doi: 10.21608/ejhc.2019.62556

▪ **Ete, G., Chaturvedi, G., Barreto, E., & Paul, M. K., (2019):** Effectiveness of Parkland formula in the estimation of resuscitation fluid volume in adult thermal burns, Chinese Journal of Traumatology, 22, 113- 116, PMID: 30962126 PMCID: PMC6488519 DOI: 10.1016/j.cjtee.2019.01.006

▪ **Faskaj, B. & Belba, M. (2021):** Impact of Fluid Resuscitation Regimes in Relative Risk of Mortality in Burned Patients, Albanian Journal of Trauma and Emergency Surgery, 5(2): 849-53. doi: 10.32391/ajtes. v5i2.231.

▪ **Hassan, A., Fathy Attia, A., & Mohamed, N. (2022):** Effect of Educational Program on Pediatric Nurses' Knowledge and Practice Regarding Assessment of Body Fluid Balance for Critically Ill Children. Assiut Scientific Nursing Journal, 10(28): 200-8. doi: 10.21608/asnj.2022.110682.1278

▪ **Hunter, J.E., Drew, P.J., Potokar, T.S., Dickson, W., & Hemington- Gorse, S.J., (2016):** Albumin resuscitation in burns: a hybrid regime to mitigate fluid creep. Scars Burn Heal.22;2:2059513116642083. doi: 10.1177/2059513116642083. PMID: 29799553; PMCID: PMC5965311.

▪ **Kadhim, H. & Hamza, R.A., (2020):** Effectiveness of an Educational Program on Nurses' Knowledge toward Burn **Management**, Medico-legal Update, , 20 (4). DOI: https://doi.org/10.37506/mlu.v20i4.2129.

▪ **Kirkpatrick LA, & Feeney BC., (2013):** A simple guide to IBM SPSS statistics for version 20.0. Student ed. Belmont, Calif.: Wadsworth, Cengage Learning.

▪ **Lindsey, L., Purvis, M.V., Miles, D., Lintner, A., Scott, V., McGinn, K., Bright, A., & Kahn, S.A., (2020):** An Adjusted Ideal Body Weight Index Formula with Fresh Frozen Plasma (FFP) Rescue Decreases Fluid Creep During Burn Resuscitation.

Ann Burns Fire Disasters. 33(3):216-23. PMID: 33304212; PMCID: PMC7680196.

▪ **Luo, Q., Li, W., Zou, X., Dang, Y., Wang, K., Wu, J., & Li, Y., (2015):** Modelling Fluid Resuscitation by Formulating Infusion Rate and Urine Output in Severe Thermal Burn Adult Patients: A Retrospective Cohort Study, BioMed Research International: 508043http://dx.doi.org/10.1155/2015/508043.

▪ **Mahran, G., Mahgoub, A. & Abass, M., (2019):** The effect of scenario based teaching for critical care nurses and physicians on their knowledge of fluid creep, Journal of Nursing Education and Practice, 9 (4): 86-97. DOI: https://doi.org/10.5430/jnep.v9n4p86.

▪ **Mohammed, R., Hassan, M. & Mohammed, I.R., (2021):** Effect of an Educational Nursing Program on Nurses' Performance Regarding Burn Injury Management, International Journal of Novel Research in Healthcare and Nursing, 8(2): 50-63. ISSN 2394-7330.

▪ **Mohamed, M., Mohammed, I., & Taha, S. (2018):** Effect of Educational Protocol Regarding Accurate Monitoring Fluid Balance on Critical Care Nurses' Knowledge and Practice. Minia Scientific Nursing Journal., 004 (1): 76-82. doi: 10.21608/msnj.2018.187767

▪ **Rizzo, J.A., Liu, N.T., Coates, E..C, Serio-Melvin, M.L., Foster, K.N., Shabbir, M., Pham, T.N., & Salinas, J., (2022):** Initial Results of the American Burn Association Observational Multicenter Evaluation on the Effectiveness of the Burn Navigator. J Burn Care Res., 43(3):728-34. doi: 10.1093/jbcr/irab182. PMID: 34652443.

▪ **Saffle, J.R., (2016):** Fluid creep and over-resuscitation. Crit Care Clin ; 32:587-98, doi:http://dx.doi.org/10.1016/j. ccc.2016.06.007.

▪ **Schaefer, T.J., & Nunez Lopez, O., (2022):** Burn Resuscitation and Management. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; PMID: 28613546.

▪ **Shah, A., Pedraza, I., Mitchell, C. & Kramer, G.C., (2020):** Fluid volumes infused during burn resuscitation 1980-2015: A quantitative review. Burns., 46(1):52-7. doi: 10.1016/j.burns.11.013., PMID: 31862276.

▪ **Sheta, H. & Mahmoud, M.(2018):** Effectiveness of Structured Educational Program on Knowledge and Practice among Nurses Regarding Body Fluid Balance Assessment for Critically Ill Patients, IOSR Journal of Nursing and Health Science; (7)5: 74-83, DOI: 10.9790/1959-0705117483.

▪ **Tang, Y., Chen, I., Yen, J., Lu, C., Lai, C., Liu, H., Chang, H., & Chen, Y. (2014):** Fluid restriction for treatment of "fluid creep" after acute burn resuscitation. Hong Kong Journal of Emergency Medicine, 21(4): 222–9. https://search.informit.org/doi/10.3316/informit.436 505801300459.

▪ **Trikhatri ,Ch., . Rana, G. & Angadi, S. (2019):** Knowledge and Practice regarding Fluid and Electrolytes Administration among Nurses Working in a Teaching Hospital, Chitwan, IOSR Journal of Nursing and Health Science, 8 (5), PP 12-19, DOI: 10.9790/1959-0805021219.

▪ **Van Regenmortel, N., Moers, L., Langer. T., Roelant. E., De Weerdt, T., Caironi, P., Malbrain, MLNG., Elbers ,P., Van den Wyngaert, T., & Jorens, PG. , (2021),** Fluid-induced harm in the hospital: look beyond volume and start considering sodium. From physiology towards recommendations for daily practice in hospitalized adults. Ann Intensive Care.11(1):79. doi: 10.1186/s13613-021-00851-3. PMID: 33999276; PMCID: PMC8128950.