Check for updates

Clinical Nursing Research
2023, Vol. 32(2) 313–322
© The Author(s) 2022
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/10547738221090593
journals.sagepub.com/home/cnr
SAGE

The Effects of Active Warming on Core Body Temperature and Thermal Comfort in Patients After Transurethral Resection of the Prostate: A Randomized Clinical Trial

Hülya Yılmaz, RN, Msc, PhD[1] and Leyla Khorshid, RN, PhD[2]

Abstract

Prevention and treatment of hypothermia by active warming in perioperative period care is recommended but scientific evidence of its effectiveness in a clinical setting is scarce. The purpose of this study was to determine the effects of warmed intravenous fluids (WIVF) on the core body temperature and the patients' thermal comfort. Baseline data of 105 male patients undergoing TUR-P surgery and bladder irrigation were analyzed. The experimental group was warmed using active WIVF, and the control group's routine care was conducted using a cotton blanket. Body temperature was higher in patients in the experimental group than those in the control group. Repeated measures Manova revealed significantly different core temperature changes between groups ($F = 34.446$, $p = .001$). The thermal comfort scores were also higher in the experimental group than in the control group ($x^2 = 203.552$, $p = .001$). The findings indicated that WIVF can enhance body temperature and improve the thermal comfort of patients.

Keywords

body temperature, thermal comfort, nursing care, postoperative care

Introduction

The human body maintains a constant core body temperature of about 37°C despite external temperature changes (Bommadevara & Zhu, 2002). Patients undergoing general anesthesia are vulnerable to a perioperative decrease in core temperature leading to inadvertent perioperative hypothermia (IPH) (Roberson et al., 2013), which is determined by a core body temperature of below 36°C (Wagner, 2006). The use of certain anesthetic agents, a cold environment in the operation room, major fluid or blood loss, the exposure of a large body cavity, tissues and organs remaining exposed during surgery, and the infusion of cold IV fluids and irrigation fluids are contributing factors to IPH (Roberson et al., 2013).

The frequency of IPH is 50% to 90% in surgical patients and this is defined by patients as the worst experience in the clinic (Burns et al., 2009; Constantine et al., 2015; Roberson et al., 2013). The same physiological changes occur in perioperative hypothermic patients. These are metabolic changes integrating with peripheral vasoconstriction, altered tissue perfusion, and inhibition of enzymatic reactions of coagulation (Horosz & Malec-Milewska, 2013; Kiekkas et al., 2011). Because of these changes, patients are at high risk of adverse effects (Slotman et al., 1985) such as perioperative hemorrhage (Rajagopalan et al., 2008), myocardial ischemia (Frank et al., 1997), coagulopathy (Schmied et al., 1996), blood loss and transfusion requirements, and surgical site infections (Kurz et al., 1996). Hypothermia can alter drug metabolism (Leslie et al., 1995), prolonged stay in the post-anesthetic care unit (PACU) or the intensive care unit (ICU), and decrease patient thermal comfort and satisfaction (Woolnough et al., 2009).

Maintaining normothermia in patients having surgery is important for providing safe, good quality, and cost-effective care (Burns et al., 2009). Also, it reduces the incidence of complications, the postoperative length of hospital stay and the risk of surgical site infections, and increases patient

[1]Bursa Uludağ University, Görükle, Bursa, Turkey
[2]Ege University, Bornova, İzmir, Turkey

Corresponding Author:
Hülya Yılmaz, Department of Fundamentals of Nursing, Faculty of Health Sciences, Bursa Uludağ University, Görükle, Bursa 16059, Turkey.
Emails: hlyylmz2017@gmail.com; hlyyilmaz@uludag.edu.tr

satisfaction (Lynch et al., 2010), requiring a team to use the best evidence to guide clinical practices (Burns et al., 2009). When hypothermia is prevented, the comfort level experienced by the patients is higher and they experience less postoperative shivering and sensation of feeling cold (Burger & Fitzpatrick, 2009).

Hypothermia increases discomfort in the anesthetized patient and results in shivering. Thermal discomfort is an unpleasant experience for the patient before and after they are anesthetized (Lynch et al., 2010). Thermal comfort is a subjective, individual response to environmental and physiological conditions in humans (Azmoon et al., 2013). Postoperative inadvertent hypothermia (IH) is an important problem affecting the thermal comfort of patients (O'Brien et al., 2010). In addition, deterioration in thermal comfort is a physiological stressor that can cause an increase in plasma catecholamine concentration, postoperative blood pressure, and heart rate (Kurz, 2008).

Researchers have tried to determine whether different warming methods are effective during the perioperative period. However, the results for successful WIVF are conflicting. In Taiwan, researchers compared the time needed to reach a specific temperature in hypothermic patients ($n = 130$) in the PACU after spinal surgery (warm cotton blanket or a radiant warmer) and the tympanic temperature was measured for each patient every 10 minutes until it reached 36°C. The results of this study showed that the radiant warmer was more effective than warm cotton blankets in increasing patients' body temperatures to 36°C (Yang et al., 2012). In another study, it was found that forced-air warming can increase warming efficacy and reduce complications of perioperative hypothermia in patients undergoing laparoscopic surgery (Su & Nieh, 2018). In a randomized controlled study, it was stated that patient-controlled, forced-air warming gowns in patients undergoing total knee arthroplasty can enhance perioperative body temperature and improve patient satisfaction with thermal comfort (Benson et al., 2012). In a literature review, the authors stated that 30 minutes is the mean duration for prewarming, and a minimum of 10 minutes of prewarming was suggested to significantly reduce rates of hypothermia in perioperative patients (Connelly et al., 2017).

Also, there are studies in the international literature relating to the effectiveness of WIVF methods. The results of these studies included conclusions the such as reducing the amount of analgesia needed in the intraoperative period (Lista et al., 2012), preventing hypothermia and shivering (Chung et al., 2012; Jeong et al., 2008), increasing core body temperature (Andrzejowski et al., 2010; Jeong et al., 2008; Kim et al., 2014; Woolnough et al., 2009), keeping patients nearly normothermic (Xu et al., 2010), preventing postanesthetic hypothermia (Zaman et al., 2018), preventing intraoperative hypothermia (Oshvandi et al., 2014), preventing postoperative shivering (Hasankhani et al., 2005), reducing complaints of cold (Woolnough et al., 2009), decreasing patient stay in the recovery room (Lista et al., 2012; Okeke, 2007), increasing comfort (Cassidy et al., 2001; Self et al., 2013), increasing arm comfort with IV intervention (Hausfeld et al., 2015), increasing thermal comfort (Woolnough et al., 2009), and maintaining maternal normothermia during cesarean surgery (Chebbout et al., 2017).

Contrary to current research results, some studies have concluded that changes in the body temperature did not make a significant difference (Baradaranfard et al., 2019), that there was no difference between groups in controlling intraoperative hypothermia (De Mattia et al., 2013), that patients did not report a subjective feeling of thermal comfort in terms of perioperative hypothermia and shivering (Kim et al., 2014), or that there was no significant difference in terms of thermal comfort (Chebbout et al., 2017). It is thought that the controversial results in the literature are due to some limitations being ignored, such as different patient groups, different types and durations of operations, applications of WIVF at different periods before, during and after the operation, different techniques used for WIVF (warming cabinet, blood, and infusion warmer), and different environmental temperatures due to geographical conditions. In patients undergoing TUR-P surgery, there are two factors (anesthesia and bladder irrigation with room temperature fluids) that place the patient at risk of hypothermia. Although one of the internal active warming measures is WIVF, there is no research examining the effectiveness of WIVF systems in the postoperative period in Turkey. This research aimed to examine the effect of intravenous infusion at two different temperatures (a body temperature of 36°C and a room temperature of 20–25°C) on change in core body temperature and thermal comfort level.

Methods

Study Settings

This was a single-center, randomized, trial (ClinicalTrials.gov) to compare a strategy using a medical device with a standard strategy. The CONSORT checklist was followed in reporting this study. The study was conducted in the PACU, ICU and service of a state hospital in the west of a Middle Eastern country.

Sample Size

Power analysis for the sample number used the G*Power (v. 3.1.9.2) program and was based on previous studies. According to Jacob Cohen's effect size coefficients, assuming large effect size in assessments between two independent groups ($d = 0.40$), with $\alpha = .05$ and $1-\beta = .95$ (90% power), each group was required to contain at least 41 people. Patients who were to undergo TUR-P surgery and who agreed to participate in the research were randomly allocated to the experimental group (WIVF, $n = 54$) or the control

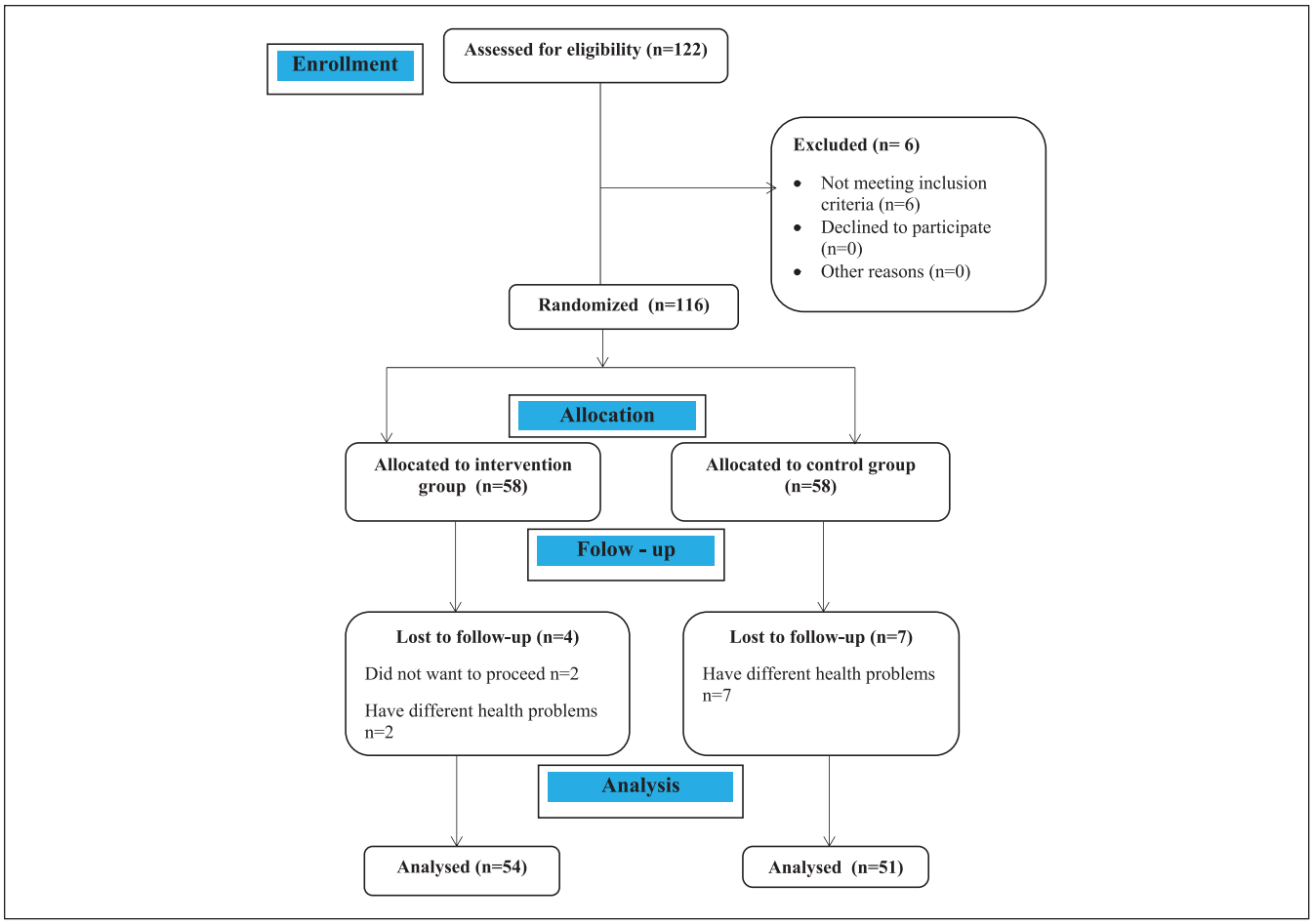


Figure 1. CONSORT diagram showing the flow of participants (study enrollment, randomization, and procedures).

group (room temperature fluids, $n=51$) by the simple randomization technique of drawing lots. A total of 105 participants undergoing TUR-P surgery were recruited from an 1809 bed central hospital.

The patients were transferred to the PACU after the surgery, and patients who met the inclusion criteria were assigned to the experimental group or the control group by simple randomization. To randomly allocate the patients to the groups, the name of each group (experimental and control) was written on 150 sheets of paper and these were placed inside identical opaque envelopes. When a participant entered the study, one of the envelopes was opened, and the participant was allocated to that group. The experiment and measurements were carried out by the first researcher, and the patients discovered their groups when the postoperative WIVF was applied to them. Because of the nature of the intervention, blinding could not be performed.

The inclusion criteria were an age of over 18 years, a lack of underlying diseases (hypothyroidism, hyperthyroidism, diabetes, cardiovascular disease, or kidney failure), and the absence of any infection and fever. Patients were included in the study who were undergoing general anesthesia, to whom voluntary hypothermia was not applied during the operation, who had no mental deficiency that could prevent communication, who were hemodynamically stable, who had no visual or hearing impairments, who were not receiving mechanical ventilation support and were not sedated, and who were undergoing bladder irrigation.

The population of the study consisted of 122 volunteers who met the criteria for inclusion in the study. Due to a history of diabetes mellitus in 5 patients and liver transplantation in 1 patient, a total of 116 patients were allocated to the study. In the postoperative period, four patients from the experimental group were excluded from the study because they did not want to continue, or because they requested cold bladder irrigation or a blood transfusion. Unusual conditions such as cold bladder irrigation requests and postoperative complications (increase in blood pressure, arrhythmia, continued nausea, and vomiting) in the control group caused seven patients to be excluded from the study. The research was completed with 54 patients in the experimental group and 51 patients in the control group (Figure 1).

Measurement

Patient description form and thermal comfort scale (TCS). The patient description form was prepared by the researchers following the literature, and consisted of 10 questions. The Thermal Comfort Scale was a Likert-type scale which was developed by Wagner et al. (2006), and the validity and reliability in Turkish were tested by Özsaban (2017) (Wagner et al., 2006). The Cronbach Alpha value of the thermal comfort scale was determined to be .497 by the researchers (Özsaban, 2017). The TCS evaluates the patient's temperature comfort perception subjectively. The scale consists of 13 items in total, and each item is scored between 1 and 6 points. A high score indicates a high temperature comfort level (Wagner et al., 2006). Since Özsaban found the level of reliability to be low in his study, exploratory factor and confirmatory factor analyses were applied to the TCS in the current study, and the Cronbach Alpha value of the thermal comfort scale was determined to be .809.

Blood and IV infusion fluid warmer (BFW-1000). The IV fluid warmer medical devices necessary for conducting the research were purchased from a medical company in the People's Republic of China (Bestman Medical Products). The accuracy and calibration measurement was performed by the relevant company. No medication was given during the WIVF infusion.

Drip setting set (Dosiflow). Thousand milliliter 0.9% isotonic sodium chloride was given at a rate of 250 ml/h per hour to all patients and the infusion was completed in 4 hours in all patients. Equalization of the delivery rate in each patient ensured the reliability of the study.

Tympanic thermometer. Core body temperature was measured using an infrared tympanic thermometer. The infrared tympanic thermometer *(Covidien Products)* is a device that is both accurate and quick for estimating the central body temperature (Chue et al., 2012). Before the data collection phase, the sensitivity of the thermometer was tested and calibration was performed by OMKA Omega Measurement Control Systems Calibration Laboratory Devices Industry and Trade Limited Company.

Interventions

A pilot study was conducted before data collection. Male patients were included to the pilot study who were not in the postoperative period, had no hypothermia or hyperthermia, were compatible with the inclusion criteria of the research and had a physician's order for receiving IV fluid therapy ($n = 3$). A total of 250 ml of 0.9% isotonic sodium chloride which had no added drug was infused IV after heating the solution to 36°C with the medical heating device. No complications developed in the patients during the pilot study, and their body temperature increased by between 0.1°C and 0.3°C from the beginning of infusion to the end. After the pilot study, the data collection phase of the research was started. Patient description information was obtained before the operation from the patients who were undergoing the TUR-P operation. No patients were premedicated. All patients fasted for 8 hours before the TUR-P operation. The operation lasted on average of 60 to 90 minutes for each patient. The patients were covered with a gown and a blanket from their neck to the level of their umbilicus to help protect against heat loss during the operation. The patients were transferred to the PACU unit as soon as they exited the operation, and the first follow-ups were performed in this unit. The patients were awakened from the effect of anesthesia and were able to return to normal spontaneous breathing, and then, after being observed in the PACU unit for 30 to 40 minutes, they were taken to the service or the intensive care unit. The PACU, ICU, and service are located in different rooms within the same department. The three units are the same in terms of ambient temperature and humidity. The independent variable was whether the patient received WIVF or room temperature IV fluids.

The WIVF given to the patients in the experimental group was heated to 36°C using the medical heating device. We monitored the patients during the experiment until the end of the procedure. In the collection of data, the vital signs of the patients in both groups were measured using the same sphygmomanometer and stethoscope. Bedside patient monitoring measurements were used for the PACU and ICU. Body surface temperature was measured by the tympanic body temperature using a digital thermometer via disposable probes. Manual measurements were carried out by the researcher. The vital signs and thermal comfort of the experimental and control group patients were measured. Intervals during warming and patients' thermal comfort perception levels were recorded at two-hourly intervals in the PACU, ICU, and service. The evaluation of thermal comfort was made by the face-to-face interview method for all patients.

In the control group, the warming method consisted of routine care in the PACU, ICU, and service. Routine care was conducted using cotton blankets. Cotton blankets were not warmed with any device. The blanket covered the patient's entire body and all extremities. All other research processes were carried out in the same way as the experimental group. The environment room temperature and humidity in which the research was to be carried out was measured by using a thermo hygrometer. The environment temperature of the room was the same in the PACU, ICU and service on the same day. The environment temperature of the room varied between 20°C and 25°C on the different days on which the research was implemented. The air humidity level was between 32% and 45%. Body temperature was measured as soon as the infusion started and was repeated every 60 minutes using a tympanic thermometer. All the patients in the study had their body temperatures recorded on arrival in

the operating room using a tympanic thermometer. The TCS was applied just before starting the infusion, 120 minutes after starting, and when the infusion was completed. Verbal responses of patients regarding temperature comfort were recorded on the data collection form.

Data Analysis

Data were analyzed using IBM SPSS 24 Statistics version. The data were examined by the Shapiro-Wilk test to determine normal distribution. In the assessment of data methods, mean, SD, and frequency were used as well as Student t-test for both groups for qualitative normal distribution, and the Mann-Whitney U test was used for non-normal distribution. The relationship between categorical variables was analyzed by Chi–square test (χ^2), continuity (Yates), and Fisher exact χ^2 test (for small numbers). In two groups that had continuous variables, variance analysis was used in repeated measures. Data were assessed using a 95% confidence interval, and the level of statistical significance was accepted as $p < .05$

Ethical Considerations

Ethics committee permission was obtained from the XX University Scientific Research and Publication Ethics Committee, institutional permission was obtained from the XX University Faculty of Medicine, and informed consent was obtained from the participating patients. Patients were informed that participation in the study was voluntary and refusing to take part was not associated with any risks. They were provided with information about the aim of the study, data anonymity and confidentiality, and any potential risks to the participants, before their consent was obtained. The data gathered about patients and the study context were carefully stored and protected. The data were saved in a password-protected computer, with hard copies in a locked cabinet in the university office. All procedures followed the General Health Law Regulation on Health Research in force in Turkey, as well as the postulates of the Declaration of Helsinki.

Results

Participants' Characteristics

No significant difference was found between age, profession, education levels, body mass index, or smoking mean scores ($\chi^2 = 0.154$, 0.233, 11.23, 1.458, 0.027, respectively; $p > .05$). There was no statistically significant difference between the groups in the distribution of patients according to systolic and diastolic blood pressure ($t = 0.345$; 0.947, $p > .05$). A statistically significant difference was found between the groups in the distribution of patients according to pulse rate ($t = 3.025$, $p < .05$). Pulse rate was significantly higher at baseline time (0 minute) in the experimental group than in the control group ($p < .05$) (Table 1).

Body Temperature Change Over Time

There was no significant difference between the body temperatures in the patients in the two groups at baseline time (0 minute) ($t = 0.735$, $p > .05$). Body temperature was significantly higher at 60, 120, 180, and 240 minutes in the experimental group than in the control group ($t = 2.151$; 4.343; 7.339; 8.662 respectively, $p < .05$). Since the assumption of sphericity is not provided, measurements over time show significant changes at the 95% confidence level in general ($F = 903.830$; $p < .001$). It also changes according to the mean body temperature of the patients in the groups over time ($F = 34.446$; $p < .001$) (Table 2). In the repeated measurements of core body temperature in both groups, the difference in their interactions is significant.

Thermal Comfort Change Over Time

No significant difference was found between the mean thermal comfort scale score in the patients in the two groups at baseline time (0 minute) ($U = 1275.5$, $p > .05$). A statistically significant difference was found between the mean TCS score in the patients in the two groups at 120 and 240 minutes ($U = 607.0$; 674.5 respectively, $p < .05$) (Table 3). The mean TCS score was significantly higher at 120 and 240 minutes in the experimental group than in the control group.

Discussion

Patients' Core Body Temperature Changes by Time

Researchers have examined the effect of WIVF on body temperature in patients undergoing cesarean section (Chung et al., 2012; Oshvandi et al., 2014; Woolnough et al., 2009), abdominal surgery (Xu et al., 2010; Zaman et al., 2018), coronary artery bypass graft surgery (Jeong et al., 2008), TUR-P surgery (Jaffe et al., 2001; Okeke, 2007), laparoscopic cholecystectomy surgery (Baradaranfard et al., 2019), and short-term surgical operation (Andrzejowski et al., 2010). In the current study, it was found that heated IV fluids increased the body temperature of patients and accelerated the transition to normothermia after the operation.

When the literature was analyzed, it was seen that previous studies on WIVF are in line with our results (Andrzejowski et al., 2010; Chung et al., 2012; Jeong et al., 2008; Kim et al., 2014; Okeke, 2007; Oshvandi et al., 2014; Woolnough et al., 2009; Xu et al., 2010; Zaman et al., 2018). In these studies, WIVF was effective in preventing hypothermia intraoperatively (Jeong et al., 2008; Xu et al., 2010), perioperatively (Andrzejowski et al., 2010; Oshvandi et al., 2014), and during anesthesia (Chung et al., 2012; Kim et al., 2014; Woolnough et al., 2009). In a study by Zaman et al., the effect of WIVF on body temperature after surgery was examined in patients undergoing abdominal surgery. The authors concluded that there was a difference in the mean body

Table 1. Individual Characteristics of Patients.

Variables	EG (n = 54) Mean (SD)		CG (n = 51) Mean (SD)		χ^2	*p*
Age	67.44 (10.50)		67.52 (8.71)			
	N	%	*N*	%		
37–63 ages	15	27.8	17	30.5	0.154	.694
64–90 ages	39	72.2	34	69.5		
Profession						
Active	8	14.8	5	9.8	0.233	.629
Retired	46	85.2	46	90.2		
Education levels						
Primary	22	40.7	17	33.3	11.23	.11
Secondary	6	11.2	6	11.8		
High	18	33.3	7	13.7		
Undergraduate and more	8	14.8	21	41.2		
Body mass index						
Underweight and normal	24	44.4	17	33.3	1.458	.482
Overweight	21	38.9	25	49.1		
Obese and morbidly obese	9	16.7	9	17.6		
Smoking						
Yes	12	22.22	13	25.4	0.027	.870
No	42	77.78	38	74.5		
	IG (*n* = 54) Mean (SD)		CG (*n* = 51) Mean (SD)		*t*	*p*
Systolic blood pressure (mmHg)	128.57 (24.61)		127.05 (19.99)		0.345	.731
Diastolic blood pressure (mmHg)	76.90 (13.56)		74.66 (10.57)		0.947	.346
Pulse rate	75.75 (15.10)		68.47 (8.97)		3.025	.003*

EG = experimental group; CG = control group; SD = standard deviation; χ^2 = chi-squared test results; *t* = independent group T-test.

Table 2. Mean Scores of Core Body Temperature Changes.

	EG		CG			
Variables	*N*	Mean (SD)	*N*	Mean (SD)	*t*	*p*
0 minute	54	35.06 (0.46)	51	34.99 (0.44)	0.735	.464
First follow-up	54	35.57 (0.49)	51	35.37 (0.44)	2.151	.034
Second follow-up	54	36.11 (0.46)	51	35.72 (0.44)	4.343	.000
Third follow-up	54	36.63 (0.41)	51	36.06 (0.38)	7.339	.000
Fourth follow-up	54	37.06 (0.47)	51	36.35 (0.34)	8.662	.000
F, p	Time	*F* = 903.830		*p* = .000		$p < .001$
	Group	*F* = 34.446		*p* = .000		$p < .001$

EG = experimental group; CG = control group; SD = standard deviation; *t* = post hoc Bonferroni independent group T-test; *F* = *repeated* measures Manova test.

temperature after 30 minutes with patients in the experimental group coming to the recovery unit ($p < .05$) (Zaman et al., 2018). Similarly, in the current study, body temperature was found to be higher after 60 minutes in patients in the experimental group (Sessler, 1997).

In studies conducted on WIVF and irrigation fluids to prevent hypothermia, it was found that body temperatures were higher by an average of 0.4°C (medium level of evidence) in the first half-hour after induction and 0.51°C higher in the first hour (medium evidence level) in patients in the administration group compared with the control groups (Campbell et al., 2015). In the present study, administration of room temperature IV fluids contributed to hypothermia; hence, infusion of warm fluids was evaluated as an important method of heat conservation.

Negative consequences related to the effect of WIVF on hypothermia were seen in the literature. In one study, it was shown that the mean body temperature of patients

Table 3. Mean Scores of Thermal Comfort Scale Changes.

	EG ($n=54$)		CG ($n=51$)				
Variables	Min–Max	Mean (SD)	Min–Max	Mean (SD)	*Z*	*U*	*p*
Pre-test	23–65	40.66 (8.25)	18–56	38.80 (9.12)	−0.653	1,275.5	.514
First follow-up	38–78	66.01 (10.07)	35–74	55.98 (9.69)	−4.941	607.0	.000
Second Follow-up	55–78	74.16 (5.52)	48–78	67.78 (8.30)	−4.557	674.5	.000

$x^{2‡} = 203.552$ $p = .000$.
EG = experimental group; CG = control group; SD = standard deviation; $x^{2‡}$ = repeated measures Friedman analysis; ¶*U* = Mann Whitney U Testi post hoc Bonferroni.

undergoing laparoscopic cholecystectomy surgery was not significantly different at different times in any of the groups (Baradaranfard et al., 2019). In the current study, a *Bestman fluid ınfusion warmer* was used to heat IV fluids. This device automatically heats the serum set and fluids passed through a lidded chamber with a temperature sensor to 36°C. Warming was performed synchronously during infusion. In a study by Baradaranfard et al., preheated Ringer solution was applied to the patients immediately after anesthesia induction and after entering the recovery unit. Therefore, the differences between findings may be due to the types of fluids, infusion for different periods, and different forms of heating.

In another study, the researchers examined the effectiveness of WIVF to control intraoperative hypothermia. It was concluded that, in the intraoperative period, WIVF infusion did not prevent hypothermia on its own (De Mattia et al., 2013). Body temperature was measured from the axillary region with a digital thermometer. The measurements closest to the body's internal temperature are obtained by digital measurement from the ear (Campbell et al., 2015). Temperature measurement with an axillary digital thermometer gives lower results compared to infrared temperature measurement from the ear. It was found that patients' temperatures which were measured by the ear were 0.6°C higher than the underarm digital thermometer measurement (Çoban & Dolgun, 2016). Significant variation in research results may be due to the different body temperature measuring sites and measuring instruments.

In the current study, the warm-up time of the patients in the experimental group was determined as 60 minutes faster than the warm-up time of the patients in the control group. In a systematic review, it was stated that patients to whom the active heating method was applied warmed up 90 minutes faster than patients who were warmed with cotton blankets (Warttig et al., 2014). The current research supports the results of the literature, which emphasizes that patients heated by the active heating method warm up in a shorter time than with passive heating (Benson et al., 2012; Warttig et al., 2014).

In a study with adult patients who required general anesthesia for abdominal surgery, fluids were infused at room temperature in the control group ($n=15$), while in the test group ($n=15$), fluids were infused at 37°C. In the control group, core temperature decreased to 35.5 ± 0.3°C during the first 3 hours and then stabilized at the end of anesthesia. In the test group, core temperature decreased during the first 60 minutes but increased to 36.9 ± 0.3°C at the end of anesthesia. Infusion of warm fluid is effective in keeping patients nearly normothermic (Self et al., 2013). The results of the present study support the result of this study.

In a study with patients who had laparoscopic thoracic or abdominal surgery, esophageal core temperature was measured during surgery, and tympanic core temperature was measured every 30 minutes preoperatively and in the postanaesthesia care unit. The authors concluded that forced-air warming can increase warming efficacy and reduce complications of perioperative hypothermia in patients undergoing laparoscopic surgery (Su & Nieh, 2018).

Thermal comfort change of patients according to time

In the current study, it was found that WIVF induced thermal comfort in patients with inadvertent hypothermia during the postoperative period. Our findings are similar to the results in the literature (Cassidy et al., 2001; Hausfeld et al., 2015; Self et al., 2013; Woolnough et al., 2009). Researchers studied the effect of WIVF in a double-blind randomized pilot study in adult patients and measured patients' comfort with a visual analog scale (VAS). They found that the comfort level was higher in patients in the test group than in those in the control group (Self et al., 2013).

Hausfeld et al. (2015) examined the effect of WIVF on patients' arm comfort in pediatric patients ($n=126$), and measured the arm comfort of patients after 15 and 60 minutes of the initiation of the IV fluid bolus. They found that the arm comfort level in the 15th minute in patients in the WIVF group was significantly higher than at the beginning. In the same study, it was reported that the arm comfort level was different between the test and control groups over time ($p < .05$) (Hausfeld et al., 2015). Similarly, in the present study, the thermal comfort level was found to be higher in the second and third measurements in patients in the experimental group.

In this study, no adverse events resulted from the administration of WIVF. Woolnough et al. (2009) examined the

effect of heated IV fluids on temperature comfort in elective cesarean section under spinal-epidural anesthesia. They reported that temperature comfort increased in patients in the heated IV fluid group but did not affect tremors (Woolnough et al., 2009).

Cassidy et al. (2001) stated that the WIVF (250 ml) showed a tendency in favor of increased comfort in a study which was aimed at determining whether body temperature and patient comfort were improved in 20 adult patients receiving IV fluids in the pre-hospital emergency medical service. However, they reported that the sample size was too small to reach a precise conclusion (Cassidy et al., 2001). In addition, numerous studies reporting that various intravenous fluids or applied active heating methods improved temperature comfort supported our research findings (Cassidy et al., 2001; Hausfeld et al., 2015; Self et al., 2013). To maintain and raise the temperature comfort level, the internal body temperature should be at an optimal value. In the literature, it is recommended that patients with IH related to surgery should be heated with effective heating methods to increase the temperature comfort level (Benson et al., 2012).

In the literature, it is seen that different results have been obtained related to the effect of WIVF on temperature comfort. Kim et al. (2014) randomly assigned participants to the group of room temperature ($n=26$) or IV fluids preheated at 41°C ($n=27$). They explained that neither group reported a statistically significant subjective sense of thermal comfort (Kim et al., 2014). However, they used a circulating hot water blanket for patients in the two groups, and so the temperature comfort of the patients in the room temperature group may not have been affected. A heating cabinet was preferred as the WIVF method. In this method, the IV fluid removed from the cabinet may have been affected by the temperature of the room during the infusion, and thus the temperature merit may have been reduced.

Chung et al. (2012) reported that a WIVF group did not differ in thermal comfort (Chung et al., 2012). In the present study, a heating cabinet was preferred as the IV fluid heating method and spinal anesthesia was applied. The development of maternal hypothermia is likely to occur rapidly during spinal anesthesia because it is known that thermoregulation deteriorates in both epidural and spinal anesthesia (Saito et al., 1998). The low level of subjective thermal comfort may be due to thermoregulation disorder.

Limitations

Several limitations to the present study should be highlighted. The fact that the study was conducted in one center, the fact that responses to the questions included in the questionnaire were obtained from patients, and the fact that thermal comfort was measured on only one scale were limitations of the study. The results related to thermal comfort level obtained from our study could vary from one individual, culture or society to another. Therefore, they cannot be generalized. The elapsed time on surgery was evaluated; 0 to 30 minutes; 30 to 60 minutes, 60 to 90 minutes; 90 to 120 minutes categorically. Time in the operation room was not except for the 60 to 90 minutes interval. There was no TUR-P operation in our study, except for the 60 to 90 minutes interval. Therefore, the uncertainty of the elapsed time on surgery is another limitation.

All the instruments were measured by the first researcher. Precise determination of bleeding volume is difficult in surgery (Miller et al., 2010), and this issue is even more difficult in TUR-P. It was therefore not possible to measure the amount of intraoperative bleeding. It was not known whether or not the patients were using corticosteroids. In addition, the amount of fluid infused intraoperatively was not known, and so these factors have affected the results of the study.

Conclusion

It was determined that WIVF increased body temperature and temperature comfort levels in postoperative hypothermia. WIVF should be included as nursing care because of high postoperative inadvertent hypothermia rates. Therefore, nurses as patients' advocates should prevent the incidence of patients' complications in the PACU/ICU and service by precisely checking vital signs, especially temperature, and by undertaking other preventive experiments such as infusion of warmed intravenous fluids. "Elapsed time on surgery", "the time in the operating room" should be evaluated in future studies. Further researches should be repeated with a large population.

Relevance to Clinical Practice

For hospitals that are unable to use WIVF with postsurgical hypothermia patients in the PACU, ICU, or service, the blood and infusion warmer is a more efficient device to rewarm patients, especially TUR-P patients. WIVF should be included in nursing care because of high postoperative inadvertent hypothermia rates. WIVF may prevent postoperative hypothermia, and improve patients' thermal comfort in those undergoing TUR-P.

Acknowledgments

We greatly appreciate the kind cooperation of the patients who participated in this study, as well as for their consent to share their thoughts and experiences. We thank all the nurses and health care team members who supported the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Hülya Yılmaz https://orcid.org/0000-0003-4729-1987

References

Andrzejowski, J. C., Turnbull, D., Nandakumar, A., Gowthaman, S., & Eapen, G. (2010). A randomised single blinded study of the administration of pre-warmed fluid vs active fluid warming on the incidence of peri-operative hypothermia in short surgical procedures. *Anaesthesia*, *65*(9), 942–945. https://doi.org/10.1111/j.1365-2044.2010.06473.x

Azmoon, H., Dehghan, H., Akbari, J., & Souri, S. (2013). The relationship between thermal comfort and light intensity with sleep quality and eye tiredness in shift work nurses. *Journal of Environmental and Public Health*, *2013*, 639184–639185. https://doi.org/10.1155/2013/639184

Baradaranfard, F., Jabalameli, M., Ghadami, A., & Aarabi, A. (2019). Evaluation of warming effectiveness on physiological indices of patients undergoing laparoscopic cholecystectomy surgery: A randomized controlled clinical trial. *Journal of PeriAnesthesia Nursing*, *34*, 1016–1024. https://doi.org/10.1016/j.jopan.2018.11.013

Benson, E. E., McMillan, D. E., & Ong, B. (2012). Original research: The effects of active warming on patient temperature and pain after total knee arthroplasty. *The American Journal of Nursing*, *112*(5), 26–33. https://doi.org/10.1097/01.NAJ.0000414315.41460.bf

Bommadevara, M., & Zhu, L. (2002). Temperature difference between the body core and arterial blood supplied to the brain during hyperthermia or hypothermia in humans. *Biomechanics and Modeling in Mechanobiology*, *1*(2), 137–149. https://doi.org/10.1007/s10237-002-0011-2

Burger, L., & Fitzpatrick, J. (2009). Prevention of inadvertent perioperative hypothermia. *British Journal of Nursing*, *18*, 1114–1119. https://doi.org/10.12968/bjon.2009.18.18.44553

Burns, S., Wojnakowski, M., Piotrowski, K., & Caraffa, G. (2009). Unintentional hypothermia: implications for perianesthesia nurses. *Journal of PeriAnesthesia Nursing*, *24*(3), 167–173. https://doi:10.1016/j.jopan.2009.03.003

Campbell, G., Alderson, P., Smith, A. F., & Warttig, S. (2015). Warming of intravenous and irrigation fluids for preventing inadvertent perioperative hypothermia. *Cochrane Database of Systematic Reviews*, (4), CD009891. https://doi.org/10.1002/14651858.CD009891.pub2.

Cassidy, E. S., Adkins, C. R., Rayl, J. H., & Wipfler, Ej 3rd. (2001). Evaluation of warmed intravenous fluids in the prehospital setting. *Air Medical Journal*, *20*(5), 25–26. https://doi.org/10.1016/S1067-991X(01)70055-7

Chebbout, R., Newton, R. S., Walters, M., Wrench, I. J., & Woolnough, M. (2017). Does the addition of active body warming to in-line intravenous fluid warming prevent maternal hypothermia during elective caesarean section? A randomised controlled trial. *International Journal of Obstetric Anesthesia*, *31*, 37–44. https://doi.org/10.1016/j.ijoa.2017.04.008

Chue, A. L., Moore, R. L., Cavey, A., Ashley, E. A., Stepniewska, K., Nosten, F., & McGready, R. (2012). Comparability of tympanic and oral mercury thermometers at high ambient temperatures. *BMC Research Notes*, *5*(1), 1–6. https://doi.org/10.1186/1756-0500-5-356

Chung, S. H., Lee, B. S., Yang, H. J., Kweon, K. S., Kim, H. H., Song, J., & Shin, D. W. (2012). Effect of preoperative warming during cesarean section under spinal anesthesia. *Korean Journal of Anesthesiology*, *62*(5), 454–460. https://doi.org/10.4097/kjae.2012.62.5.454

Çoban, B., & Dolgun, A. (2016). A comparision of axillary with infrared tympanic and non-contact infrared thermometry. *Journal of Pediatric Infection*, *10*(3), 82–85. https://doi:10.5152/ced.2016.2417

Connelly, L., Cramer, E., DeMott, Q., Piperno, J., Coyne, B., Winfield, C., & Swanberg, M. (2017). The optimal time and method for surgical prewarming: A comprehensive review of the literature. *Journal of PeriAnesthesia Nursing*, *32*(3), 199–209. https://doi.org/10.1016/j.jopan.2015.11.010

Constantine, R. S., Kenkel, M., Hein, R. E., Cortez, R., Anigian, K., Davis, K. E., & Kenkel, J. M. (2015). The impact of perioperative hypothermia on plastic surgery outcomes: A multivariate logistic regression of 1062 cases. *Aesthetic Surgery Journal*, *35*(1), 81–88. https://doi.org/10.1093/asj/sju022

De Mattia, A. L., Barbosa, M. H., de Freitas Filho, J. P., Rocha Ade, M., & Pereira, N. H. (2013). Warmed intravenous infusion for controlling intraoperative hypothermia. *Revista Latino-Americana de Enfermagem*, *21*(3), 803–810. https://doi.org/10.1590/S0104-11692013000300021

Frank, S. M., Fleisher, L. A., Breslow, M. J., Higgins, M. S., Olson, K. F., Kelly, S., & Beattie, C. (1997). Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events: A randomized clinical trial. *JAMA*, *277*(14), 1127–1134. https://doi:10.1001/jama.1997.03540380041029.

Hasankhani, H., Mohammadi, E., Moazzami, F., Mokhtari, M., & Naghizadeh, M. M. (2005). The effects of warming intravenous fluids on perioperative haemodynamic situation, postoperative shivering and recovery in orthopaedic surgery. *British Journal of Anaesthetic and Recovery Nursing*, *6*(1), 7–11. https://doi.org/10.1017/s1742645605000045

Hausfeld, K., Baker, R. B., Boettcher-Prior, P., Hancock, D., Helms, C., Jablonski, T., Lin, L., Menne, K., Mittermeier, J., & Morris, M. (2015). Randomized prospective clinical trial comparing room temperature and warmed intravenous fluid boluses on pediatric patients' comfort. *Journal of Pediatric Nursing*, *30*(6), e3–e9. https://doi.org/10.1016/j.pedn.2015.07.006

Horosz, B., & Malec-Milewska, M. (2013). Inadvertent intraoperative hypothermia. *Anaesthesiology Intensive Therapy*, *45*(1), 38–43. https://doi.org/10.5603/AIT.2013.0009

Jaffe, J. S., McCullough, T. C., Harkaway, R. C., & Ginsberg, P. C. (2001). Effects of irrigation fluid temperature on core body temperature during transurethral resection of the prostate. *Urology*, *57*(6), 1078–1081. https://doi.org/10.1016/s0090-4295(01)00993-1

Jeong, S. M., Hahm, K. D., Jeong, Y. B., Yang, H. S., & Choi, I. C. (2008). Warming of intravenous fluids prevents hypothermia during off-pump coronary artery bypass graft surgery. *Journal of Cardiothoracic and Vascular Anesthesia*, *22*(1), 67–70. https://doi.org/10.1053/j.jvca.2007.04.003

Kiekkas, P., Theodorakopoulou, G., Stefanopoulos, N., Tsotas, D., & Baltopoulos, G. I. (2011). Postoperative hypothermia and mortality in critically ill adults: Review and meta-analysis. *Australian Journal of Advanced Nursing*, *28*(4), 60–67.

Kim, G., Kim, M. H., Lee, S. M., Choi, S. J., Shin, Y. H., & Jeong, H. J. (2014). Effect of pre-warmed intravenous fluids on perioperative hypothermia and shivering after ambulatory surgery under monitored anesthesia care. *Journal of Anesthesia*, *28*(6), 880–885. https://doi.org/10.1007/s00540-014-1820-z

Kurz, A. (2008). Thermal care in the perioperative period. *Best Practice & Research Clinical Anaesthesiology*, *22*(1), 39–62. https://doi.org/10.1016/j.bpa.2007.10.004

Kurz, A., Sessler, D. I., & Lenhardt, R. (1996). Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. *New England Journal of Medicine*, *334*, 1209–1216. https://doi.org/10.1056/nejm199605093341901

Leslie, K., Sessler, D. I., Bjorksten, A. R., & Moayeri, A. (1995). Mild hypothermia alters propofol pharmacokinetics and increases the duration of action of atracurium. *Anesthesia & Analgesia*, *80*(5), 1007-1014. https://doi:10.1213/00000539-199505000-00027.

Lista, F., Doherty, C. D., Backstein, R. M., & Ahmad, J. (2012). The impact of perioperative warming in an outpatient aesthetic surgery setting. *Aesthetic Surgery Journal*, *32*(5), 613–620. https://doi.org/10.1177/1090820x12449342

Lynch, S., Dixon, J., & Leary, D. (2010). Reducing the risk of unplanned perioperative hypothermia. *AORN Journal*, *92*: 553–562. https://doi:10.1016/j.aorn.2010.06.015

Miller, R. D., Eriksson, L. I., Fleisher, L. A., Wiener-Kronish, J. P., & Young, W. L. (2010). *Miller's anesthesia* (7th ed.). Churchill Livingstone.

Okeke, L. I. (2007). Effect of warm intravenous and irrigating fluids on body temperature during transurethral resection of the prostate gland. *BMC Urology*, *7*, 15–17. https://doi.org/10.1186/1471-2490-7-15

Oshvandi, K., Shiri, F. H., Fazel, M. R., Safari, M., & Ravari, A. (2014). The effect of pre-warmed intravenous fluids on prevention of intraoperative hypothermia in cesarean section. *Iranian Journal of Nursing and Midwifery Research*, *19*(1), 64–69.

Özsaban, A. (2017). *The effect of active warming method on postoperative hypothermia on the control of body temperature and thermal comfort sensation* [Doctoral Thesis]. Istanbul University, Institute of Health Sciences, Fundamentals of Nursing Department. İstanbul.

O'Brien, D., Greenfield, M. L., Anderson, J. E., Smith, B. A., & Morris, M. (2010). Comfort, satisfaction, and anxiolysis in surgical patients using a patient-adjustable comfort warming system: A prospective randomized clinical trial. *Journal of PeriAnesthesia Nursing*, *25*(2), 88–93. https://doi.org/10.1016/j.jopan.2010.01.008

Rajagopalan, S., Mascha, E., Na, J., & Sessler, D. I. (2008). The effects of mild perioperative hypothermia on blood loss and transfusion requirement. *The Journal of the American Society of Anesthesiologists*, *108* (1), 71–77. https://doi:10.1097/01.anes.0000296719.73450.52

Roberson, M. C., Dieckmann, L. S., Rodriguez, R. E., & Austin, P. N. (2013). A review of the evidence for active preoperative warming of adults undergoing general anesthesia. *AANA Journal*, *81*(5), 351–356.

Saito, T., Sessler, D. I., Fujita, K., Ooi, Y., & Jeffrey, R. (1998). Thermoregulatory effects of spinal and epidural anesthesia during cesarean delivery. *Regional Anesthesia and Pain Medicine*, *23*(4), 418–423. https://doi:10.1016/S1098-7339(98)90017-7

Schmied, H., Reiter, A., Kurz, A., Sessler, D. I., & Kozek, S. (1996). Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. *Lancet*, *347*, 289–292. https://doi.org/10.1016/s0140-6736(96)90466-3

Self, W. H., White, S. J., McNaughton, C. D., Storrow, A. B., Slovis, C. M., & Collins, S. P. (2013). Warming intravenous fluids for improved patient comfort in the emergency department: A pilot crossover randomized controlled trial. *The Western Journal of Emergency Medicine*, *14*(5), 542–546. https://doi.org/10.5811/westjem.2013.1.13303

Sessler, D. I. (1997). Mild perioperative hypothermia. *New England Journal of Medicine*, *336*(24), 1730–1737.

Slotman, G. J., Jed, E. H., & Burchard, K. W. (1985). Adverse effects of hypothermia in postoperative patients. *American Journal of Surgery*, *149*(4), 495–501. https://doi.org/10.1016/s0002-9610(85)80046-5

Su, S. F., & Nieh, H. C. (2018). Efficacy of forced-air warming for preventing perioperative hypothermia and related complications in patients undergoing laparoscopic surgery: A randomized controlled trial. *International Journal of Nursing Practice*, *24*(5), e12660-10. https://doi.org/10.1111/ijn.12660

Wagner, D., Byrne, M., & Kolcaba, K. (2006). Effects of comfort warming on preoperative patients. *AORN Journal*, *84*(3), 427–448. https://doi.org/10.1016/S0001-2092(06)63920-3

Wagner, V. D. (2006). Unplanned perioperative hypothermia and surgical complications: evidence for prevention. *Perioperative Nursing Clinics*, *1*(3), 267–281. https://doi:10.1016/j.cpen.2006.05.008

Warttig, S., Alderson, P., Campbell, G., & Smith, A. F. (2014). Interventions for treating inadvertent postoperative hypothermia. *Cochrane Database of Systematic Reviews*, *11*, CD009892–NaN51. https://doi.org/10.1002/14651858.CD009892.pub2

Woolnough, M., Allam, J., Hemingway, C., Cox, M., & Yentis, S. M. (2009). Intra-operative fluid warming in elective caesarean section: A blinded randomised controlled trial. *International Journal of Obstetric Anesthesia*, *18*(4), 346–351. https://doi.org/10.1016/j.ijoa.2009.02.009

Xu, H. X., You, Z. J., Zhang, H., & Li, Z. (2010). Prevention of hypothermia by infusion of warm fluid during abdominal surgery. *Journal of PeriAnesthesia Nursing*, *25*(6), 366–370. https://doi.org/10.1016/j.jopan.2010.10.007

Yang, H. L., Lee, H. F., Chu, T. L., Su, Y. Y., Ho, L. H., & Fan, J. Y. (2012). The comparison of two recovery room warming methods for hypothermia patients who had undergone spinal surgery. *Journal of Nursing Scholarship*, *44*(1), 2–10. https://doi.org/10.1111/j.1547-5069.2011.01426.x

Zaman, S. S., Rahmani, F., Majedi, M. A., Roshani, D., & Valiee, S. (2018). A clinical trial of the effect of warm intravenous fluids on core temperature and shivering in patients undergoing abdominal surgery. *Journal of PeriAnesthesia Nursing*, *33*(5), 616–625. https://doi.org/10.1016/j.jopan.2016.12.010

Author Biographies

Hülya Yılmaz, is a Lecturer (RN, Msc, PhD) position at the Bursa Uludağ University Faculty of Health Sciences.

Leyla Khorshid, is a Professor (RN, PhD, Professor) position at the Ege University Faculty of Nursing.