Monitoring Temperature

Knowledge and skills of outpatients with cancer

Teresa Honaker, RN, OCN®, CMS-RN, Alissa Long, MSN, RN, Debra Lyons, MSN, APRN-BC, RN, Reba McCoy, FNP, MSN, RN-BC, RN, Dana Salters, MBA, RT (R)(M), and Susan K. MacArthur, EdD, MSN, FNP, RN-BC

BACKGROUND: Elevated temperature can be the first sign of infection; obtaining an accurate temperature in patients undergoing chemotherapy is critical.

OBJECTIVES: This study sought to determine outpatients' temperature-monitoring knowledge and skills; whether an educational DVD could increase knowledge; and the level of agreement between a home thermometer and a calibrated hospital thermometer.

METHODS: The intervention was an educational DVD. Patients completed a survey and were observed taking their temperature. Investigators rated whether the correct steps were taken and then obtained the temperature. The bias and precision of the patient's thermometer were determined.

FINDINGS: Knowledge scores averaged 68%. Most participants correctly identified elevated temperatures for fever (91%); less than 50% correctly identified other signs of infection, and less than 25% correctly identified activities that could falsely elevate or depress temperature readings.

KEYWORDS
oral digital thermometer; educational DVD; home thermometer accuracy

DIGITAL OBJECT IDENTIFIER
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THE ROUTINE MEASUREMENT OF BODY TEMPERATURE is an important aspect of monitoring for signs of infection in patients receiving chemotherapy (Reigle & Dienger, 2003). Infections may occur in a variety of body systems, and although the signs and symptoms of each type of infection are different, elevated temperatures occur in many infections and are often the first sign of infection.

Clinicians often assume patients have a thermometer at home that accurately measures temperature, know situations that could falsely alter temperature measurements, and have the skill to use the device properly. A review of patient chemotherapy education studies found that none included content related to proper use of the device itself or situations that affect temperature accuracy (Gao & Yuan, 2011; Prutipinyo, Maikeow, & Sirichotiratana, 2012; Smith et al., 2015). Patient surveys about self-care behaviors reported only one question related to fever ("When is it necessary to contact a physician for a fever?"), with 30% of respondents stating they would not notify a physician if they had a fever (Prutipinyo et al., 2012). No questions were related to the number representing fever, how to measure temperature, frequency of temperature monitoring, or if patients had a thermometer at home.

The knowledge and skills to self-monitor temperature have not yet been studied in patients receiving chemotherapy. However, several studies in the 1990s and 2000s evaluated the knowledge and skills of parents related to temperature monitoring (Banco & Jayashekaramurthy, 1990; Banco & Perry, 1990; Broome, Dokken, Broome, Woodring, & Stegelman, 2003; Fisher, Moore, & Roaman, 1985; Murphy & Liebman, 1995; O'Neill-Murphy, Liebman, & Barnsteiner, 2001; Porter & Wenger, 2000; Walsh & Edwards, 2006). Those studies reported that parents had the following deficits related to obtaining body temperatures of their child:

- 25%–44% of parents did not have a thermometer at home.
- The most common home thermometer used by parents was a glass thermometer (more than 50%).
- Less than half of the parents could accurately read the numbers on a glass thermometer.
- Less than 25% reported the correct ranges for normal and elevated temperatures.

In the one study that evaluated skills (Porter & Wenger, 2000), 61% of parents could not properly use the temperature device.

At the time of these studies, few electronic thermometers were available for home use. Patients now have access, for home use, to a variety of different temperature devices, which range in technological sophistication from the simple (glass or digital electronic oral thermometers) to more complex (electronic temporal artery or tympanic thermometers). Although glass thermometers can be difficult to read because of small numbers and distances between temperature notations (Porter & Wenger, 2000; Smith, 2004), electronic thermometers have an easy-to-read temperature display when temperature equilibration has been reached. The challenge to correctly using electronic thermometers is that the steps for proper temperature device use are more involved and not necessarily easy to remember or perform. This is particularly true of the tympanic thermometer, which is prone to user error related to improper positioning in the ear (Giuliano, Scott, Elliot, & Giuliano, 1999; Hooper & Andrews, 2006; Sessler, 2008). Even the newest electronic thermometer on the market, the temporal artery thermometer, has several essential steps that must be followed to accurately obtain a temperature (Exergen Corporation, 2017). The accuracy of the temporal artery thermometer has been studied in inpatient adult patients with cancer by trained healthcare personnel and deemed an equivalent alternative to oral temperatures in certain patients (Mason et al., 2015). Given these technological challenges when using thermometers, no studies have evaluated patients' ability to properly use these devices.

The purpose of this study is to determine the knowledge and skills of outpatients with cancer related to monitoring their body temperature and to test a brief educational intervention designed to improve temperature-monitoring knowledge. A secondary purpose of the study is to determine the level of agreement between the patient's home thermometer and a hospital calibrated thermometer.

Methods

This study was conducted in an outpatient oncology department of Maury Regional Cancer Center in Columbia, Tennessee. Study approval was obtained from the institution's investigational review board. Data collection was completed from November 2015 to December 2016.

Design

A post-test only randomized clinical trial was used to determine the knowledge and skills of adult outpatients with cancer regarding temperature monitoring and whether a brief educational intervention improved knowledge and skills of temperature measurement. No enrolled patients had experience receiving chemotherapy. The primary outcome variables were patient knowledge of temperature monitoring and correct use of the temperature device. A secondary outcome variable was the level of agreement (bias, precision) between the patient's home thermometer and a calibrated hospital thermometer. Investigators were blinded to treatment group assignment until after consent.

"A brief educational DVD was not effective in improving temperature-monitoring knowledge scores."

Intervention

The educational intervention was a five-minute DVD teaching session focused on temperature monitoring. Content of the educational intervention included the following:

- Purpose of temperature monitoring
- Frequency of temperature monitoring
- When to notify the clinic or physician of temperature elevations
- Factors that can alter temperature accuracy (ingestion of cold or hot fluids, antipyretic medications, improper technique, activities, old or damaged thermometers)
- Signs of infection

The DVD featured the cancer center nurse navigator demonstrating proper temperature-taking methods on a person; these methods included placing the thermometer in the mouth. The instructional DVD was supplemental to printed information the patient received on the importance of temperature taking.

Instruments

Patient knowledge of temperature monitoring was evaluated with an investigator-developed paper-and-pencil test. The test consisted of 10 multiple-choice items focused on the content covered in the educational intervention. Face validity of the test questions was determined by having four oncology clinical experts review the questions for clarity and relevance to temperature monitoring by outpatients with cancer. Time for test completion was about five minutes.

Correct use of a temperature device was evaluated by having participants take their own temperature while an investigator

observed their actions. Correct use of a device was based on the percentage of correctly completed steps for temperature measurement. Items on the observational tool were based on the manufacturers' recommended procedural steps for device use. Participants used the same type of temperature device that they used at home for temperature measurement.

Sample Selection

A convenience sample of adult outpatients with cancer was studied. Inclusion criteria were as follows: being mentally competent, receiving outpatient oncology treatments that require monitoring of body temperature, having no prior experience receiving chemotherapy treatment, having attended at least one prior oncology outpatient clinical visit, and anticipating requiring at least three future visits to the clinic. Patients were excluded if they had severe mucositis that would preclude oral temperature monitoring. A minimum sample size of 60 participants was calculated a priori with power analysis, with a moderate effect size of 0.65, power of 0.8, and alpha of 0.05 (Faul, Erdfelder, Lang, & Buchner, 2007).

Study Procedure

Prior to beginning the study, investigators were trained on how to rate the critical steps in temperature monitoring. Nondisposable thermometers used in the study for comparison to home thermometers were calibrated by biomedical engineering and dedicated to research study use.

During the outpatient oncology visit, consenting patients were asked to identify the type of temperature device used at home and asked to bring that thermometer to the next outpatient visit for accuracy testing. Participants were then randomly assigned to one of two groups (usual care or usual care and a brief educational teaching DVD) using a computer random number sequencer. Participants assigned to view the teaching session DVD viewed it during that outpatient visit. Usual care consisted of verbal instructions to the patient on temperature monitoring, symptoms to monitor for and when to notify the healthcare provider, and a printed handout.

At the following outpatient visit, participants completed a knowledge test. An investigator remained with the participant until the test was completed. Tests then were placed in a sealed envelope by the participant prior to being returned to the investigator.

Following completion of the knowledge test, participants were given a temperature device similar to their home device and asked to take their temperature. The investigator observed the participant during the temperature measurement, noting completion or noncompletion of the critical steps for proper device use. The investigator measured the participant's correct use of the device against a checklist of critical steps. The investigator then measured the participant's temperature with a nondisposable oral electronic thermometer (SureTemp® 68MTX) according to the manufacturer's guidelines.

An investigator checked the accuracy of the patient's home device by taking the patient's temperature with the home device, followed immediately by the nondisposable oral electronic thermometer. If temperature differences between the home and oral electronic devices exceeded experts' recommendations, participants were provided with a disposable digital thermometer to use at home for temperature monitoring in the future. Following completion of the study procedures, participants who had not seen the teaching session DVD had an opportunity to do so prior to leaving the outpatient visit.

TABLE 1.
SAMPLE CHARACTERISTICS BY GROUP

CHARACTERISTIC	NO DVD (N = 41) n	DVD (N = 46) n
Gender		
Female	35	33
Male	6	13
Education level[a]		
Less than high school	6	7
High school	21	26
Community college	6	6
College	2	5
Graduate school	4	2
Reason for clinic visit		
Infusion chemotherapy	31	38
Supportive care	4	7
Blood or other infusion	1	1
Other	5	–
Thermometer used at home		
Oral digital electronic	32	33
Oral mercury	3	3
Temporal artery	1	2
Tympanic	1	2
No thermometer at home	4	6

[a]In the no-DVD group, one participant only completed third grade and one participant did not respond.

Data Analysis

Descriptive statistics were used to summarize the data. Scores for temperature knowledge and correct device use for the two groups (DVD education or no education) were compared with an unpaired Student's t-test. The level of significance for all tests was $p < 0.05$. Differences (bias) and level of agreement (precision) between the patient's home thermometer and the calibrated nondisposable oral thermometer were calculated using standard formulas for bias and precision and graphed according to standard methods (Hanneman, 2008). Clinically acceptable levels of bias and precision were determined from expert recommendations and were set at a bias of 0.54°F or less and a precision of 0.9°F or less (Bridges & Thomas, 2009; Lawson et al., 2007).

Results

A total of 87 patients (46 in the DVD group, 41 in the no-DVD group) were studied during a 13-month period. Ages ranged from 25–85 years ($\bar{X}$ = 58.5, SD = 11.8), with the majority of participants being women (see Table 1). Highest educational preparation was varied, with 61 participants having no post–high school education.

Most participants used an oral digital thermometer at home (n = 65). Ten of the 87 participants stated they did not have a thermometer at home. No differences were found between the two groups (DVD education versus no DVD education) on any of the demographic or patient characteristic data ($p > 0.05$).

Scores on the test for knowledge of temperature monitoring ranged from 40%–100% for the 87 participants ($\bar{X}$ = 68%, SD = 15%). Most participants correctly identified the level at which temperatures are considered to be a fever (n = 79). Less than 50% of participants (n = 34) correctly identified other signs of infection, and less than 25% (n = 20) correctly identified activities that could falsely elevate or depress oral temperature readings. Test items incorrectly identified by more than 25% of the respondents are summarized in Table 2. Most participants could not correctly identify the variety of locations for temperature measurement, other symptoms of infection besides fever, and activities that could falsely elevate temperature. No differences were found between the two groups on any of the knowledge test item responses ($p > 0.05$).

Scores on the observational test of how well the participants followed the manufacturers' steps for how to use the device they had at home were as follows:

- 60%–100 % (average of 91%) for the oral digital thermometer (n = 65)
- 80%–100% (average of 93%) for the tympanic thermometer (n = 3)
- 100% for the oral mercury thermometer (n = 1)
- 100% for the temporal artery thermometer (n = 3)

No differences were found between the two groups on correct use of the temperature device used at home ($p > 0.05$).

Temperatures measured with the clinical reference device ranged from 96.8°F–99.8°F ($\bar{X}$ = 98.1°F, SD = 0.5°F). The bias and precision values of the home oral digital thermometer were within the experts' recommended range for clinically acceptable equivalency with the electronic nondisposable oral thermometer. No comparisons were made for the oral mercury, tympanic, and temporal artery thermometers because of the insufficient number of participants using those devices. Bias and precision values were within an acceptable range for use in clinical practice when the investigator measured temperature with the hospital oral electronic thermometer compared to each of the following situations being tested for patients who used a digital oral thermometer at home (n = 65): patient using the hospital oral electronic thermometer, patient using a home thermometer, and the investigator using the patient's home thermometer. Bias and precision values were smallest when only the hospital oral electronic thermometer was used by the patient and investigator, with the largest bias and precision values observed when the investigator measured temperature with the patient's home thermometer.

Of the test temperatures measured, very few of the temperature differences when the investigator measured with a nondisposable oral electronic thermometer had values greater than 1°F from the test device, and none of the temperatures measured had more than 2°F differences.

TABLE 2.
OUTCOME VARIABLES BY GROUP

	NO DVD (N = 41)		DVD (N = 46)	
ITEM	$\bar{X}$	**SD**	$\bar{X}$	**SD**
Knowledge test score	65.1	15.7	69.6	15
ITEM		**n**		**n**
Items with more than 10 participants with incorrect responses				
Locations where temperature can be taken		24		21
Time to wait after ingesting cold or hot fluids		14		13
Frequency for taking temperature when elevated		20		20
Temperature at which the physician or clinic should be contacted		11		13
Besides high temperature, other symptoms to watch for with fever		28		25
Activities that could falsely elevate temperature		32		35

Note. Scores range from 0–100, with higher scores reflecting greater understanding.

IMPLICATIONS FOR PRACTICE

- Educate patients so they can avoid activities that could adversely affect temperature readings and know how to identify signs of common infections, besides an elevated temperature.
- Consider providing patients with a disposable thermometer to use at home to ensure that they have a proper thermometer to monitor their temperature.
- Validate home medical equipment for accuracy (bias and precision), because patients make treatment decisions based on equipment readings.

Discussion

This study determined that the vast majority of participants used a digital oral thermometer at home. Ten participants did not have a thermometer at home. Most participants properly used the thermometer, but knowledge of temperature monitoring was moderately low. High numbers of participants were unable to correctly identify the various locations for proper placement of a thermometer in the oral cavity, symptoms of infection other than fever, and activities that could falsely elevate temperature. No differences were found in the knowledge or proper use scores of participants who had viewed the educational DVD on monitoring temperature or those who had not seen the DVD ($p > 0.05$). Differences and level of agreement between patients' digital oral thermometers used at home and the calibrated hospital nondisposable oral electronic thermometer were within the acceptable range for clinical use.

This study evaluated the ability of outpatients with cancer to correctly use their home temperature device and their knowledge of how to monitor their bodies for signs and symptoms of fever and infection. Results indicate that skills for correctly obtaining an oral temperature were high, but 10 participants reported a lack of a thermometer device at home, despite prior instruction on the need to perform daily temperature monitoring. This latter finding is concerning because temperature monitoring is essential for early detection of infection in these immunocompromised patients. In addition, most patients' knowledge of how often they should monitor their temperature when fever was present was poor, regardless of whether they had viewed the educational DVD about temperature monitoring.

Sixty-seven participants could not identify common activities that could falsely increase or decrease an oral temperature. Given that 1°F–2°F temperature alterations are possible as long as 15 minutes after ingestion of hot and cold beverages (Quatara et al., 2007), patients who use oral temperature devices should not obtain temperatures after those activities. Another knowledge deficit was about alternate locations for temperature monitoring. Because stomatitis occurs frequently in patients receiving chemotherapy, the axillary route for temperature is preferred. These patients require instruction about taking axillary temperature readings.

In this study, the DVD as a method for instruction did not affect knowledge scores about temperature monitoring. This finding is different from prior educational intervention studies of parental knowledge of temperature monitoring and fever management in children (Broome et al., 2003; Murphy & Liebman, 1995; Walsh & Edwards, 2006). This difference in findings could be related to the brevity of the study's DVD educational program (five minutes versus longer periods in parental studies), the format for the education program (DVD only versus DVD plus written information), timing of when it was seen by the participant (immediately before chemotherapy treatment began versus during well-baby outpatient or emergency department visits), or completion of the knowledge test a week after viewing the educational program. The viewing of the DVD and then starting chemotherapy for a major life-threatening illness also could be a factor inhibiting the patients' attention to the details of temperature taking because patients were psychologically and cognitively integrating a new diagnosis of cancer. The effect in both study groups of "chemobrain" may be responsible for the performance on the knowledge test.

Based on a literature review, this is the first published study to evaluate the accuracy of the oral digital device used at home by patients. Compared to a hospital calibrated oral electronic thermometer, bias and precision values for the home thermometer were within the ranges considered adequate for use in clinical practice. Bias and precision are an estimate of the accuracy of a device (Hanneman, 2008). The larger the bias, which is the average difference between two devices, the more disparity there is between the two temperature devices. Precision evaluates how consistent or repeatable the individual differences are between the two devices and the sample of measurements. Large precision values indicate that a device has poor repeatability. Bias and precision values were smallest when the same hospital oral electronic thermometer was used by both the patient and the investigator, indicating that the patient's technique for temperature monitoring was similar to the trained investigator. The largest bias and precision values observed occurred when the investigator measured temperature with the patient's home thermometer device and the hospital calibrated device, indicating that the lower level of agreement was related to the accuracy of the home device and not user technique. However, this higher level of bias and precision was still within the acceptable range of a bias of 0.54°F or less and precision of 0.9°F or less (Bridges & Thomas, 2009; Lawson et al., 2007). These data, along with published data on disposable oral digital thermometers (Counts et al., 2014), indicate that these home thermometers are accurate enough for temperature measurement.

Study Limitations

One limitation of this study is the use of one chemotherapy outpatient setting. Different results may be seen in other settings or types of patients. Other limitations are the length of the educational intervention (five minutes) and the method of delivery for the educational content (DVD only). Use of a longer educational program, repetition of the education, or combination of the

DVD education with other methods may be required to achieve higher knowledge scores. The environment in which the DVD was viewed by the patient (in the cancer center at the bedside) may have been a distraction to the patient because the area is not private but rather an open bay with treatment chairs. The knowledge test was not pilot tested prior to use with patients for validity and reliability. The knowledge test may not be the best method to evaluate knowledge. The results of the observation checklist were not tabulated to determine which steps in the procedure were not being done correctly. The focus was on the knowledge test to validate any change seen with the intervention.

Implications for Practice

Healthcare providers can find better ways to educate patients so they can identify fever and signs of infection at home. Patients' knowledge can be reassessed periodically for gaps in understanding and reinforced with education on subsequent visits. A paper-and-pencil knowledge test may not be the best method to evaluate learning. Other evaluation methods can validate comprehension. Patients may not have a working thermometer at home, so clinicians may provide patients with a disposable thermometer to ensure that they have a proper thermometer to monitor their temperature. To ensure the accuracy of home-based thermometers, patients can bring them into clinics so they can be calibrated to a hospital nondisposable oral electronic thermometer. In addition, patients can demonstrate to clinicians how they use their thermometer to show temperature-measurement competency. For patients receiving chemotherapy, patient education addresses the following outcomes:

- Own or obtain a reliable home thermometer.
- Demonstrate proper use of the home thermometer.
- Verbalize understanding of activities that may alter temperature reading.
- Verbalize understanding of all signs and symptoms of infection.
- Verbalize understanding of how and when to contact the healthcare provider.

Conclusion

Although this study found that patients were able to perform the steps of temperature monitoring properly, the vast majority could not identify activities that could falsely elevate or depress temperature readings. Ten participants did not have a thermometer at home. Clinicians can confirm whether patients have appropriate self-monitoring equipment (e.g., thermometer, blood pressure machine) at home or know where to obtain them. A brief educational DVD on temperature monitoring was not effective in improving temperature-monitoring knowledge scores. This study confirmed that patients' home thermometers had acceptable bias and precision values. Additional studies can determine the most reliable, easy-to-use home thermometer (oral, tympanic, temporal artery) and most effective methods to optimize knowledge related to teaching the skill of correct temperature taking and monitoring of all possible signs and symptoms of infection. Additional nursing, interprofessional, and biomedical device studies can determine the value of routine bias and precision testing of home use devices compared to medical-grade equipment.

Teresa Honaker, RN, OCN®, CMS-RN, is a nurse navigator, **Alissa Long, MSN, RN,** is a clinical educator, **Debra Lyons, MSN, APRN-BC, RN,** is a nurse manager in the infusion center, **Reba McCoy, FNP, MSN, RN-BC, RN,** is a family nurse practitioner, **Dana Salters, MBA, RT (R)(M),** is the administrative director of oncology, and **Susan K. MacArthur, EdD, MSN, FNP, RN-BC,** is the director of nursing professional development, all at the Maury Regional Medical Center in Columbia, TN. Honaker can be reached at thonaker@mauryregional.com, with copy to CJONEditor@ons.org.
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- Other than confirming an elevated temperature as a sign of infection, what are other early signs of infection that you teach patients to report to you and their other providers?
- From your experience in practice, do patients have working thermometers at home? If they do not, how do you ensure that patients will monitor their temperature at home?

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