







## IDENTIFICATION OF FACTORS THAT ALTER AXILLARY TEMPERATURE RELIABILITY IN RELATION TO PULMONARY ARTERY CATHETER TEMPERATURE

IDENTIFICAÇÃO DE FATORES QUE ALTERAM A CONFIABILIDADE DA TEMPERATURA AXILAR EM RELAÇÃO À TEMPERATURA DE CATETER DE ARTÉRIA PULMONAR

IDENTIFICACIÓN DE FACTORES QUE ALTERAN LA CONFIABILIDAD DE LA TEMPERATURA AXILAR EN RELACIÓN A LA TEMPERATURA DEL CATÉTER DE LA ARTERIA PULMONAR

 Rafael Lima Rodrigues Carvalho <sup>1</sup>  
 Mariana Avendanha Victoriano <sup>1</sup>  
 Camila Cláudia Campos <sup>1</sup>  
 Selme Silqueira Matos <sup>2</sup>  
 Vania Regina Goveia <sup>2</sup>  
 Flavia Falci Ercole <sup>2</sup>

<sup>1</sup> Universidade Federal de Minas Gerais – UFMG, Escola de Enfermagem, Programa de Pós-Graduação em Enfermagem. Belo Horizonte, MG – Brazil.

<sup>2</sup> UFMG, Escola de Enfermagem, Departamento de Enfermagem Básica. Belo Horizonte, MG – Brazil.

**Corresponding author:** Rafael Lima Rodrigues Carvalho  
E-mail: rafaeljsdr@hotmail.com

### Author's Contributions:

**Conceptualization:** Rafael L. R. Carvalho, Flavia F. Ercole;  
**Data Collection:** Rafael L. R. Carvalho, Mariana A. Victoriano, Camila C. Campos; **Investigation:** Rafael L. R. Carvalho; **Methodology:** Rafael L. R. Carvalho, Flavia F. Ercole; **Project Management:** Rafael L. R. Carvalho, Selme S. Matos, Flavia F. Ercole; **Software:** Rafael L. R. Carvalho; **Statistical Analysis:** Rafael L. R. Carvalho; **Supervision:** Flavia F. Ercole; **Validation:** Rafael L. R. Carvalho; **Writing - Original Draft Preparation:** Rafael L. R. Carvalho, Mariana A. Victoriano, Camila C. Campos; **Writing - Review and Editing:** Rafael L. R. Carvalho, Camila C. Campos, Selme S. Matos, Vania R. Goveia, Flavia F. Ercole.

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### ABSTRACT

**Objectives:** to identify factors that alter the reliability of axillary temperature in relation to pulmonary artery catheter temperature. **Methods:** studying repeated measures using 67 axillary temperature measurements collected from 24 patients admitted to intensive care centers of two hospitals in the metropolitan region of Belo Horizonte between 2017 and 2018. Descriptive analysis and linear regression of the data were performed. **Results:** accuracy of 0.48 and precision of 0.47 were found for axillary temperature measured with a digital thermometer compared with pulmonary artery catheter temperature. Factors that change the reliability of axillary temperature were body mass index and dobutamine dose. **Conclusion:** the found factors were unprecedented in relation to the change in axillary temperature reliability and may help nurses in their decision making by choosing a more accurate method to estimate the actual body temperature. Studies with larger sampling are still necessary to evaluate the intervening factors of the reliability of noninvasive temperature techniques, such as axillary temperature.

**Keywords:** Axilla; Thermometers; Pulmonary Artery; Body Temperature.

### RESUMO

**Objetivos:** identificar fatores que alteram a confiabilidade da temperatura axilar em relação à temperatura de cateter artéria pulmonar. **Métodos:** estudo de medidas repetidas utilizando 67 aferições de temperatura axilar coletadas de 24 pacientes internados em centros de terapia intensiva de dois hospitais da região metropolitana de Belo Horizonte entre 2017 e 2018. Realizada análise descritiva e regressão linear dos dados. **Resultados:** foram encontradas acurácia de 0,48 e precisão de 0,47 referentes à temperatura axilar aferida com termômetro digital comparada com a temperatura de cateter de artéria pulmonar. Os fatores que alteram a confiabilidade da temperatura axilar foram o índice de massa corporal e a dose de dobutamina. **Conclusão:** os fatores encontrados foram inéditos em relação à alteração da confiabilidade da temperatura axilar e poderão auxiliar enfermeiros na tomada de decisão ao escolherem um método mais preciso para estimativa da temperatura real do corpo. Ainda é necessária a realização de estudos com amostragem maior para avaliação dos fatores intervenientes da confiabilidade de técnicas de temperatura não invasivas, como a temperatura axilar.

**Palavras-chave:** Axila; Termômetros; Artéria Pulmonar; Temperatura Corporal.

### RESUMEN

**Objetivos:** identificar los factores que alteran la fiabilidad de la temperatura axilar en relación con la temperatura del catéter de la arteria pulmonar. **Métodos:** estudio de mediciones repetidas utilizando 67 mediciones de temperatura axilar de 24 pacientes ingresados en centros de cuidados intensivos de dos hospitales de la región metropolitana de Belo Horizonte entre 2017 y 2018. Análisis descriptivo y regresión lineal de los datos. **Resultados:** se encontró precisión de 0,48 y precisión de 0,47 para la temperatura axilar medida con termómetro digital en comparación a la temperatura

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*del catéter de la arteria pulmonar. Los factores que alteran la fiabilidad de la temperatura axilar fueron el índice de masa corporal y la dosis de dobutamina. Conclusión: los factores encontrados no tienen precedentes en relación con la alteración en la confiabilidad de la temperatura axilar y pueden ayudar a los enfermeros en la toma de decisiones al elegir un método más preciso para estimar la temperatura corporal real. Son necesarios estudios con muestras más amplias para evaluar los factores que intervienen en la fiabilidad de las técnicas de temperatura no invasivas, como la temperatura axilar.*

*Palabras clave: Axila; Termómetros; Arteria Pulmonar; Temperatura Corporal.*

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## INTRODUCTION

Body Temperature (BT) management is an essential activity in Nursing care, especially in critically ill patients.<sup>1</sup> BT identification is a key part of this management and aids in the diagnosis of diseases<sup>2</sup> as well as in therapeutic activities, such as cooling of individuals after cardiopulmonary arrest.<sup>3</sup> BT changes are common in clinical practice.<sup>4</sup> For this reason, early identification and prevention of thermal changes in critically ill patients is beneficial for reducing morbidity.<sup>5</sup>

Despite being a common event, BT alteration generates the need for interventions in clinical practice, such as the use of antipyretic medications, mechanical cooling methods, or heating with blankets and heaters.<sup>4</sup> This requires the Nursing staff to use accurate and agile temperature measurement methods that adapt to their professional reality.

There are several methods of temperature measurement, which are related to invasive procedures (central venous catheters, urinary catheters, etc.) or non-invasive methods (axillary, oral, among others). Invasive methods, because they are associated with more complex procedures, generate more risks to patient safety. Because they are dependent on central venous catheters or urinary catheters, they are associated with high incidences of primary bloodstream infections or urinary tract infections.

Despite the high risk, the invasive methods are closer to hypothalamic temperature or BT, providing a better parameter for health professionals. An example is the pulmonary artery catheter – which measures the pulmonary artery temperature (PAT), considered the gold standard in BT identification.<sup>6</sup> Although they have better performance in temperature measurement, due to the risk to patient safety, the use of invasive methods is not recommended for everyone, being restricted to surgical and critical patients.

Noninvasive methods are more common in clinical practice and generate little or no risk to the patient. These include axillary temperature (AT), oral temperature and tympanic membrane temperature. However, noninvasive thermometry methods do not have well-established reliability, especially in patients who

require critical care, intubation, and temperature changes.<sup>6</sup> It is also important to highlight the scarcity in the national and international literature of studies that identify factors that may interfere with the reliability of these temperatures.

Among the types of noninvasive thermometry, AT is a popular measurement method in Latin America, Europe and Africa.<sup>4,7</sup> It is measured by a clinical thermometer (mercury or gallium column), digital thermometer or chemical thermometer in the axillary fossa.<sup>8-9</sup> Although widely used in Brazil, AT is considered an unreliable method when compared to invasive thermometer temperatures.<sup>1</sup> In addition, a study conducted by the Emergency Nurses Association (ENA)<sup>5</sup> attests that AT reliability must still be tested in different scenarios, such as critically ill patients.

The gap displayed by the ENA study<sup>5</sup> shows that noninvasive temperatures need further studies to test them. However, such work should not only focus on the verification of reliability against the gold standard, but also on the identification of factors that may modify this reliability. Regarding AT, only two studies address possible factors that change the reliability of this method, indicating that age,<sup>9-10</sup> weight,<sup>9</sup> sedation<sup>10</sup> and vasopressors<sup>9-10</sup> are related to reduced AT accuracy and precision. This raises a question as to whether there are other factors that can modify AT reliability and what is their influence.

The scarcity of scientific evidence on factors that may alter the reliability of this method leaves the Nursing team unsupported to choose whether AT is an appropriate method for the patient who needs their care. Its use in a situation where it is unreliable can lead to less efficient care. Mistakes in BT measurement can lead to underreporting of feverish conditions – delaying initiation of drug treatment<sup>2</sup> – or even disrupt the control of therapeutic hypothermia,<sup>3</sup> leading to more neurological damage to the patient undergoing it.

Several research studies aimed at identifying intrinsic and extrinsic patient factors that alter AT reliability will inform the Nursing staff in choosing a thermometer that best suits each patient's clinical condition. This will provide the professional with the choice of a thermometer best suited to each situation, enabling more accurate, evidence-based care, which will prevent care errors and consequent additional patient morbidity.

Studies that identify factors associated with changes in AT reliability are necessary, especially in gaps in the literature, such as in critically ill patients and in the Brazilian population. This will assist in the execution of a more efficient care based on scientific evidence by the Nursing staff and will contribute to the insertion of Nursing in the conduct of clinical studies, something still incipient in Brazil.

Given the above, the objective of this study is to identify factors that alter the reliability of axillary temperature in relation to pulmonary artery catheter temperature.

## MATERIALS AND METHODS

The data used in this study result in part from a repeated-measures clinical study to assess the reliability of noninvasive thermometry methods compared to pulmonary artery catheter temperature. Repeated measurement studies are those in which the same individual receives multiple interventions.<sup>11</sup> Or, in this case, the axillary and pulmonary artery catheter temperature are measured at the same time.

The sample of this study consisted of patients admitted to the intensive care centers (ICCs) of the participating hospitals and who met the inclusion criteria, as follows: having a pulmonary artery catheter and being 18 years old or older. For the inclusion of the patient, their consent was requested to participate in the research, having signed the Informed Consent Form (ICF).

The inclusion criteria were as it follows ahead: having at least one mechanical impossibility of applying any of the temperature measurement techniques - such as skull base fracture, oral cavity or cephalic surgery; or having removed the pulmonary artery catheter prior to performing any temperature measurements.

For sample calculation, a similar study was performed in the American population<sup>8</sup> based on the GLIMMPSE program, using repeated measures analysis sampling technique. The sample size calculation, considering  $\alpha$  of 5% and  $\beta$  of 90%, was 12 measurements.

Due to the characteristics of the study, it was not possible to perform randomization of interventions performed (temperature collection) or masking. It is worth remembering that in repeated measures research the patient himself is his own control, and it is not necessary to create a control group.

The study was conducted in the ICCs of two hospitals in the metropolitan area of Belo Horizonte.

Hospital 1 is a large teaching public and is a reference for clinical and surgical emergencies in the state of Minas Gerais. It has 547 beds, a surgical center with 16 rooms and four ICUs, which are medical and surgical clinic (MSC), cardiac (CCU), neonatal and pediatric. Data was collected from the MSC ICUs, with 16 beds, receiving clinical and surgical patients treated at the hospital.

The other study institution, Hospital 2, is a private teaching hospital in Belo Horizonte-MG, with 428 beds. It provides health care, with state-of-the-art technologies and equipment for care, especially of high complexity. It has 60 beds in the ICU, the general ICU with 40 beds and the cardiovascular ICU with 10 beds. The assistance is provided by a multi-professional team composed of nurses, Nursing technicians, doctors, psychologists and physiotherapists. Data was collected in the general and cardiac ICU.

The study population consisted of 32 patients who underwent pulmonary catheterization between December

19<sup>th</sup>, 2017 and April 20<sup>th</sup>, 2018 in hospitals 1 and 2. The researchers were able to collect temperature data from 24 patients, making up the final study sample. The other eight patients undergoing pulmonary catheterization met the exclusion criteria, as described in Figure 1.

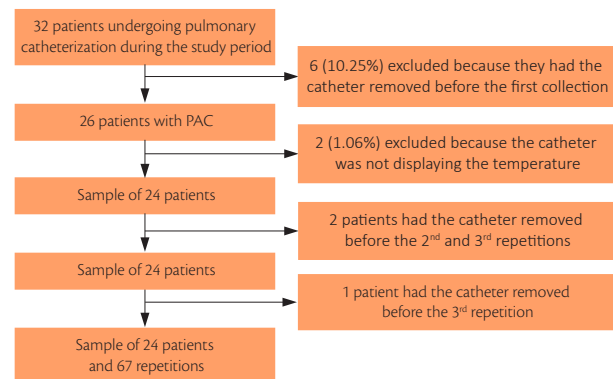


Figure 1 - Flowchart for patient inclusion in the study.

During data collection, each patient had the axillary and pulmonary artery catheter temperature collected at three different times after admission to the intensive care unit, with a two-hour interval between each measurement (while the pulmonary artery catheter was in place). These data resulted in 67 temperature measurements. Each temperature measurement was considered as an entry in the database, and the accuracy and precision of each repetition performed were calculated.

The collected variables addressed sociodemographic data – name of patient, hospital of collection, age (in years old), place of collection (which intensive care unit), skin color and date of hospitalization; data on continued use of medications – noradrenaline dose (mg/hour), vasopressin dose (mg/hour), tridil dose (mg/hour), nipride dose (mg/hour), dobutamine dose (mg/hour), if the patient received any other catecholamine, sedation and its dose (mg/hour); about body temperatures – axillary temperature (in Celsius degrees) and pulmonary artery temperature (Celsius degrees); patient clinical data – use of antipyretics in the last four hours, patient bath in the last hour, use of orotracheal tube (OTT), nasal catheter (L/min), ability to close the mouth during collection, ingestion of last minute foods or liquids, diaphoresis and the gauging side

Data collection at each repetition was performed following these steps:

- collection of sociodemographic data in the patient's bed and on the use of continuous medications;
- temperature collection – the two study outcome temperatures were measured, according to the manufacturer's indication:
  - a. **axillary temperature:** collection of the axillary temperature with the Omron® clinical thermometer

(electronic) – thermometer placed in the right or left axillary fossa, at an angle of 45° in relation to the sagittal line of the body, and the temperature is verified after the sound signal, indicating the temperature balance;

- b. **pulmonary artery temperature:** collected immediately after completion of the axillary temperature. The temperature at issue was shown on the display of the catheter-attached cardiac monitor;
- data collection from the patient’s clinical condition, observed in the Nursing notes;
- record time of end of collection, shift and researchers involved;
- search in the patient’s medical record for the reason for hospitalization and data about weight and height.

Before and after temperature collection, the axillary thermometer used was properly disinfected with a 70% alcohol solution. In addition, before and after the data collection period, the axillary thermometer was calibrated by a clinical engineer to ensure measurement reliability.

All data were collected by the researcher. After data collection, they were entered into Google forms and then exported to an Excel spreadsheet. Finally, they were compiled for the *Stata* 13 program (*Statacorp*, TX) for data analysis.

The main outcome of this study was the reliability of the axillary temperature in Celsius (°C) degrees, a value represented by AT accuracy in relation to PAT (values close to zero represent a more accurate and therefore a reliable method). To obtain AT accuracy, the value identified from PAT was subtracted from the value of the AT in each of the 67 temperatures measures. Subsequently, the mean of the subtraction obtained was calculated, resulting in the accuracy. The secondary outcome was AT accuracy in relation to PAT, which was calculated by obtaining the standard deviation of the calculated values for accuracy.

The collected data were analyzed in two steps. The first was the descriptive statistics with simple and absolute frequency,

measures of variability as standard deviation, variance and quartiles and measures of central tendency as mean and median. Secondly, the reliability of the AT was calculated, calculating the accuracy and standard deviation of this relationship. Subsequently, to achieve the main objective, linear regression analysis was performed to identify factors that could or could not modify the reliability of the AT. To assemble the model, a bivariate analysis was performed using simple linear regression between covariates of interest and the calculated accuracy. For the assembly of the final model, those equations that presented “p” below 0.25 were selected. The final model was assembled based on the *stepwise backward* technique, with the manual removal of each of the variables, observing their interaction both in the “p” value of the equation and in the influence on the F statistics. The variables that maintained a “p” value below 0.05 and had great influence on the value of the F statistic were maintained in the model. After the final model selection, homoscedasticity test and residual normality evaluation were performed to confirm the adequacy of the equation to the linear regression model.

The study was approved by the UFMG Ethics Committee – CAAE 71553317.7.0000.5149 and of one of the study hospitals – CAAE 71553317.7.3001.5125.

## RESULTS

Data was collected between December 19<sup>th</sup>, 2017 and April 25<sup>th</sup>, 2018 on 24 patients and 67 temperature measurements, with a mean of 2.79 repetitions per patient.

The information was collected from two hospitals, as described in the methodology, and eight patients came from the adult ICC of Hospital 1, and 16 from Hospital 2. Of these, five were admitted to the cardiovascular ICC and 11 to the general ICC.

Reliability between AT and PAT averaged 0.479 °C, with an SD of 0.448 (95% CI: -0.4 – 1.35). The data about the study sample are best described in Table 1.

Table 1 - Sociodemographic and hospitalization data of the patients in the study. *Belo Horizonte, MG, Brazil – 2019*

		n	%	Mean	Median	Standard deviation	Quartiles 1 and 3
Gender	Female	8	33.34	–	–	–	–
	Male	16	66.67	–	–	–	–
Age		–	–	54.87	54.5	12.55	49.5 – 61.5
Body Mass Index				27.68	25.55	0.08	
Hospital	1	8	33.34	–	–	–	–
	2	16	66.67	–	–	–	–
Reason for hospitalization	Hepatic transplant	18	75	–	–	–	–
	Hepatic transplant	3	12.50	–	–	–	–
	Valve change	2	8.33	–	–	–	–
	Duodenum neoplasia resection	1	4.17	–	–	–	–

When analyzing the reliability of the modifying AT-related factors, simple linear regression was initially performed with the patient's covariates; skin color; BMI; weight; sedation use; using antipyretic in the last four hours; bath in time before collection; using OTT at the time of collection; CN at the time of collection; if the patient was in diaphoresis; temperature of the environment: ambient humidity; patient's ability to close the arm; doses of noradrenaline, vasopressin, dobutamine and nitroglycerine; and if the patient was under hypothermia or hyperthermia. During the bivariate analysis, the variables BMI ( $p=0.022$ ), weight ( $p=0.097$ ), noradrenaline dose ( $p = 0.224$ ), dobutamine dose ( $p=0.098$ ), tridil dose ( $p=0.021$ ), miliridone dose ( $p=0.188$ ) were selected for multivariate analysis. After assembling the model, only the variables BMI and dobutamine dose were related to the alteration of accuracy in AT. The relationship is best explained in Table 2.

Table 2 - Result of the final adjustment of the linear regression model of the independent variables surveyed in relation to AT reliability in the study patients. *Belo Horizonte, MG, Brazil – 2019*

Variables	Reliability change	CI 95%	P value
BMI	-0.032	-0.54 – -0.1	0.005
Dobutamine dose	1.24	1.16 – 1.32	< 0.000

$R^2=0.17$ ;  $p=0.003$ ; constant: 1.42.

After analyzing the homoscedasticity of the data, a p value of 0.66 was found, recognizing that the sample is homoscedastic. Regarding normality, the model residues were plotted, which showed no tendency to distribution.

## DISCUSSION

The temperature measured by the axillary thermometer is widely used in Brazilian clinical practice, and is common in Europe and Africa.<sup>4</sup> Although commonly used, studies have shown that it does not have a good prediction of body temperature.<sup>1,6,8-9</sup> In a meta-analysis of studies that evaluated the reliability of temperature measurement methods, a clustered accuracy of 0.33 of PAT,<sup>1</sup> a value close to that found in this study.

Even with some disadvantages, the axillary thermometer is a useful tool and can be used to identify changes in BT in both outbreaks of infectious diseases<sup>12</sup> or even in a home environment.<sup>7</sup> AT is an economical, easy-to-access and easy-to-use measurement method.<sup>9</sup>

Although the axillary thermometer is an affordable method, it should be used with caution. This study identified two factors among the respondents that alter AT reliability. They are BMI and dobutamine.

Such identified factors are in agreement with the scarce literature on the subject. Research conducted in Spain<sup>9</sup> found that weight gain may be related to AT reliability, however, the other factors found by these authors - gender and age - were not related to changes in reliability in this study.

Medications altering the reliability of noninvasive measurement methods have also been reported by other authors.<sup>8,10</sup> However, only one study conducted in Australia<sup>10</sup> stated that dobutamine is a factor influencing the reliability of noninvasive temperatures, including AT.

Dobutamine is a cardiotoxic inotropic, widely used in critically ill patients with left ventricular dysfunction.<sup>13-15</sup> Because of this, it is administered especially in critical care settings, and in particular for the care of patients who have suffered cardiorespiratory arrest due to ventricular dysfunction.<sup>13</sup> Other indications of this drug also include patients with trauma or severe neurological disorders.<sup>14-15</sup> According to the American Heart Association,<sup>16</sup> one of the recommended precautions for patients after cardiopulmonary arrest (CPA) is the maintenance of body cooling, thus avoiding neurological harms. It is worth noting that, in these patients, the use of dobutamine is common<sup>13</sup> and according to the data herein found, each 1 mg/h increase in dobutamine alters by 1.24 °C the difference between AT in relation to PAT.

Thus, in therapeutically cooled patients whose temperature control is essential to prevent neurological damage and who are taking dobutamine, the axillary thermometer should not be used. Dobutamine alters AT reliability, indicating different temperatures than BT.

The axillary thermometer in a patient receiving dobutamine and undergoing therapeutic cooling may lead to failures in temperature measurement, which may lead to a temperature below the therapeutic goal. Thus, this failure in BT measurement may decrease the effectiveness of therapeutic cooling therapy in neurological protection of patients who have undergone CPA.

In this situation, it is suggested to search for other forms of temperature measurement, preferably more precise methods, such as the delayed bladder catheter thermometer or even the esophageal thermometer.<sup>1</sup>

Another factor that changes the AT, found in this study, is the BMI. This index is calculated based on a simple formula, taking into account the height and weight of the individual.<sup>17</sup> It is a widely used indicator for assessing nutritional status, however it does not distinguish muscle mass from fat mass and is less accurate in certain population groups such as the elderly.<sup>17</sup> Each BMI unit changes AT accuracy compared to BT by - 0.032. This indicates that higher BMI values lead to more thermometer reliability.

BMI, unlike dobutamine, is a factor that is present in the daily lives of all nurses and in various clinical conditions. Obese, malnourished or eutrophic people will be cared for in different settings. And as a vital sign, BT should be measured for the identification of infectious processes or for simple control. BT is measured in the various units where the patient can be found, either in intensive care units, where the number of infections,<sup>18</sup> is increasing, or in primary health care settings.

These findings underscore the importance of conscious use of the axillary thermometer, especially during a temperature in screening, as in yellow fever outbreaks in primary care units,<sup>19</sup> where a patient with low BMI may be misclassified as afebrile.

Despite the factors submitted by this research, the axillary thermometer is recommended, especially for its ease of access. It is valid to reinforce that nurses should use clinical reasoning when using this thermometer, identifying situations in which it may not be indicated and using another method that is available.

It is noteworthy that this study was conducted in a small sample of 24 individuals with 67 repetitions in two hospitals in the city of Belo Horizonte. This indicates that the data found may only be applicable to the profile of the population served at these hospitals.

Moreover, it can be inferred that there are still other factors that may alter AT reliability and were not tested in this study. Thus, the results found should be considered, but need to be better explored by further investigations. Such action may improve the understanding of the relationship of intrinsic and extrinsic factors to the patient in altering AT reliability in relation to pulmonary artery temperature.

## CONCLUSION

In this study, an accuracy of 0.48 and a precision of 0.47 were found for the axillary thermometer, as compared with PAT. The final linear regression model demonstrated that the factors that alter AT reliability were BMI and dobutamine.

Further studies are needed to identify factors that affect the reliability of axillary temperature and other methods, providing nurses with the correct assessment of the patient's temperature and allowing the adoption of more accurate and agile care, aiming at safe and effective assistance.

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