ISSN 2475-529X

Research Article

Journal of Nursing & Healthcare

Design of Portable New Intelligence Thermometer for Newborn Household

Yan qiuyi[1]*, Yan qiaoyuan[2], Yu hong[3] and Hong huifang[4]

[1]*lecturer, Undergraduate Nursing Education, and Teaching Management, Guilin Medical University, Nursing of college, China*

[2]*PhD, Director of Nursing, Tongji Medical College, Union Hospital, Huazhong University of Science and Technology, Wuhan, China*

[3]*Nurse, The University of Hong Kong-Shenzhen Hospital , Clinical Cancer Center, China*

[4]*Nurse, Xinhua Hospital Affiliated to Shanghai Jiaotong University School of Medicine, Pediatric Emergency Care, China*

***Corresponding author**

Yan qiuyi, lecturer, Undergraduate Nursing Education, and Teaching Management, Guilin Medical University, Nursing of college, China

Submitted: 18 Jan 2020; **Accepted**: 27 Jan 2020; **Published**: 11 Feb 2020

Abstract

Objective: *Design of a portable new intelligent thermometer for newborns using thermo sensitive materials, to compare three different thermometers, in terms of safety, accuracy and effectiveness.*

Methods: *Three thermometers for home use (New Thermometer, Electronic Thermometers and Mercury thermometers) were applied to 20 neonatal patients during 24 h, and the measured values of the three sites of the newborn baby.*

Results: *Pearson correlation all revealed moderate correlation, between the Mercury thermometers and the New Thermometer (cervical r¼0.759, pulmonary arterial catheter body surface projection area r¼0.502, left axillary area r¼0.781), between the Mercury thermometers and the electronic thermometers (cervical r¼0.694, pulmonary arterial catheter body surface projection area r¼0.580, left axillary area r¼0.760) systems, Two thermometers measured in different parts than mercury thermometers R value (0.502 to 0.781). The difference is not statistically significant in the temperature values measured by the new thermometer at the neck and under the left armpit (P≥0.05), the difference between digital thermometers and mercury thermometers is no statistically significant (P≥0.05).*

Conclusion: *The new thermometer is easy to use, safe and stable, and can measure the core body temperature noninvasively. The accuracy of the new thermometer in the projection area of pulmonary artery surface needs further study.*

Keywords: Portable New Intelligent Thermometer, Newborn, Core Body Temperature

Background

The history of body temperature measurement dates back to the 16th century when Santorio invented the world's the first thermometer to measure oral temperature using the principle of thermal expansion of air. At the beginning of the 20th century, the policy of thermal expansion of mercury was used to make it, which ensured the accuracy of body temperature measurement, so it has been widely used in the clinic so far [13]. With the development of science and technology, the electronic thermometer began used in the aerospace industry, and it developed rapidly during SARS.

The thermistor thermometer measures body temperature and displays it directly in the digital form. The reading is intuitive, accurate, sensitive, and quick [13]. Mercury thermometer has long temperature measurement time, fragile and accompanied by mercury poisoning safety hazards and other shortcomings [2], so after the signing of the Water Minamata Convention, the World Health Organization and harmless medical organizations, and strive to use electronic thermometers instead of mercury thermometers by 2020. Because people are aware of the irreversible harm caused by mercury thermometer to human beings and the environment. As early as 1992, Sweden banned the sale of all silver-containing medical equipment.

Since 2000, mercury thermometers have also been banned and sold in the United States, the United Kingdom, France, Denmark, and the Netherlands [15-16]. In 2013, the WHO launched the Global Medical Mercury Elimination Program, which aims to reduce global demand for mercury thermometers and Mercury-filled glass thermometer by 70 percent in 2017 [15-16]. The Chinese Government has also listed the mercury-filled glass thermometer project as a restricted item. However, due to the long tradition of using mercury thermometers, medical institutions still prefer mercury thermometers.

Newborns, because of their temperature regulation center development, are not perfect, subcutaneous fat thin, poor insulation, heat dissipation, body temperature is easily affected by external factors. Too high or too low body temperature will affect the outcome of children's illness, so accurate temperature measurement plays a vital role in judging and monitoring the changes of children's disease and treatment [1]. Clinical measure temperature to use mercury thermometer more. Still, it is easy to break, slip, and mercury poisoning safety hidden trouble has not advocated for newborns. Electronic thermometers are quick and easy to measure. Still, they cost much more than mercury thermometers, which for years, have been regarded by scientists as the "gold standard" for determining body temperature. However, there have been doubts about electronic thermometer measurements [3-4].

The methods commonly used in hospitals to measure axillary temperature and rectal temperature are easy to irritate, do not cooperate, slip, shift, injury, discomfort, etc., and it isn't straightforward to measure the temperature of children accurately. The capsule contains a disposable sensor and enters the digestive system of the human body to regulate the core body temperature of the human body. In addition to the capsule thermometer, other temperature measurement technology still can not achieve non-invasive body surface measurement of the core temperature. Therefore, it is necessary to choose a new type of thermometer that is accurate, easy to use, safe, and non-invasive, and can measure the core body temperature. We designed a portable new intelligent thermometerand took the temperature of 40 children. We compared the heat of the cervical vertebra, left subaxillary, and Surface projection area of pulmonary arteries, and the results of the analysis are as follows.

Methods

Design, subjects, and setting

The items were hospitalized patients in the Neonatology ward at the Affiliated Hospital of Guilin Medical University, from March to April 2019. The inclusion criteria for 40 included patients were only that the patient signed the informed consent and in a warm box [5]. Adjustment of Warm Box Temperature Management Guidelines. 100 patients were offered participation in the study, and 40 were finally included. Male 24, female 16, gestational age 35~41 weeks, natural delivery 28, cesarean section 12, weight <2 kg, Box temperature 30.6°C ~ 34.4 °C Premature infants 14 cases (35%); full-term offspring 6 cases (15%); aspiration pneumonia 6 cases (15%); jaundice 14 cases (35%).

Methods

Design

Patent project: China national utility model patent certificate (201520240059.8)

A new thermometer is battery-operated reusable electronic devices consisting of a thermistor and a Bluetooth unit.The utility model provides an intelligent thermometer, includes: the clinical thermometer body of various cartoon shapes, locates this internal smart device of clinical thermometer. the intelligence device comprises: a reminder the module for gathering the collection module of human temperature is connected. It carries out the conversion module that changes with the information of its collection with the collection module and is attached. The analysis module analyzes the data of the conversion module, be connected, and expresses the data of its report with an analysis module with the conversion module [14]. The thermometer alerted the newborn's temperature through a smart device — appropriate validation before the use of alternative measurement methods for core temperature in clinical studies. The sensor registers temperature continuously and transmits the information to a mobile device equipped with a specific application. The thermometer has a measurement range of 25~45°C and, according to the manufacturers, and accuracy of ±0.05°C (35~38.5°C) and ±0.1 (<35°C and >38.5°C), respectively. The sensor has a probe that senses the temperature; Bluetooth transmits the data to a mobile device equipped with a particular application. The standard deviation of new thermometers after calibration compared with mercury thermometers 0.1~0.2°C, It's within normal scope.

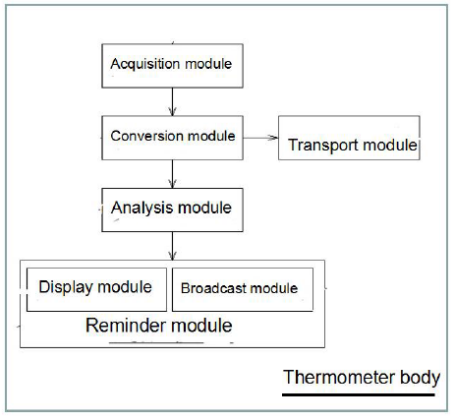

Figure I: Internal Structure

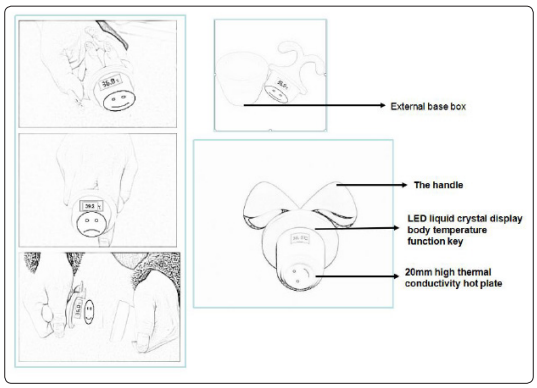

Figure 2: Schematic diagram

Subjects and setting

Assess whether the skin of the newborn is intact and exclude the influence of activities and diet. Measure the temperature at 19:00, the ambient temperature was 24 °C ~ 26 °C, the temperature was 30.6 °C~ 34.4 °C, and the relative humidity was 65% ~70%. Drop the mercury thermometer below 35°C, put it into warm water at 40°C at the same time, and take it out after 3 min. Choose thermometer with reading difference < 0.2 °C and no crack in glass tube [6]. Electronic thermometer YT308 for diving medicine (electronic thermometer), Shanghai conventional glass mercury thermometer (mercury thermometer), New thermometer. The three parts of the neck, the left armpit, and Surface projection area of pulmonary arteries. The same subject was measured simultaneously, follow the standard operation procedure of temperature measurement [7]. One person measures and one person records. Clean the thermometer with a surface disinfectant before and after use.

Statistical analysis

We used SPSS18.0 analysis and meant ± standard deviation (SD) to represent the data. And hypothesis test was performed by ANOVA (F analysis) of randomized block design data. P≤0.05 was considered statistically significant. Temperature registrations from each of the thermometers were compared with concurrent temperature registrations from the mercury thermometer by Pearson's correlation analysis and linear regression analysis. The scatter plot method reflects the changing law and direct correlation of body temperature, as well as the changing trend of different measurement data. The table calculates the mean deviation of each thermometer from the mercury temperature.

Ethical consideration

The study was conducted according to the local institution's ethical requirements and was approved by the Regional Board for Ethical Vetting.

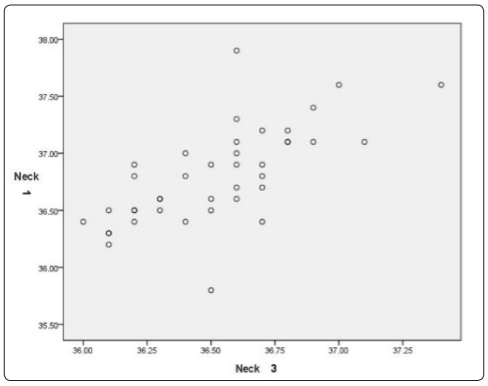

Figure 3: The temperature measurement values of the new thermometer (Neck 1) and mercury thermometer (Neck 3) were positively correlated and robust correlation.

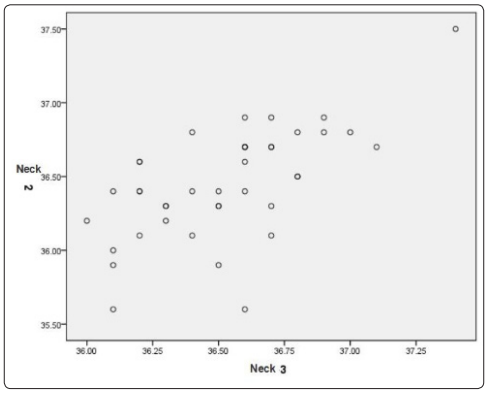

Figure 4: The temperature measurement values of the electronic thermometer (Neck 2) and mercury thermometer (Neck 3) were positively correlated and robust correlation

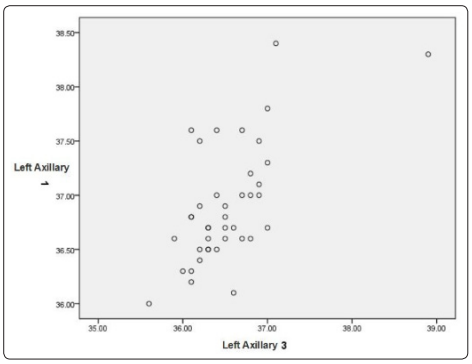

Figure 5: The temperature measurement values of the new thermometer (Left Axillary 1) and mercury thermometer (Left Axillary 3) were positively correlated and robust correlation.

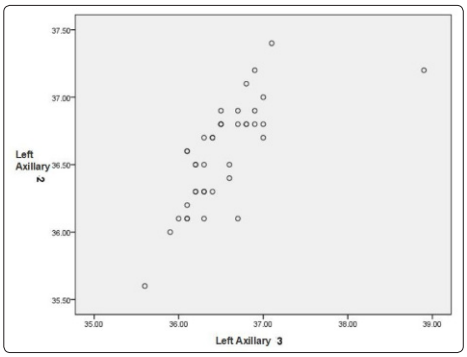

Figure 6: The temperature measurement values of the electronic thermometer (Left Axillary 2) and mercury thermometer (Left Axillary 3) were positively correlated, and the correlation was moderate

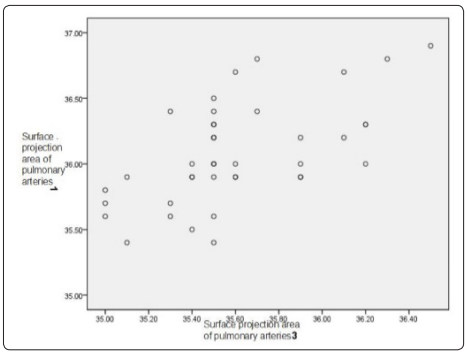

Figure 7: The temperature measurement values of the new thermometer (Surface projection area of pulmonary arteries1) and mercury thermometer (Surface projection area of pulmonary arteries 3) were positively correlated, and the correlation is low

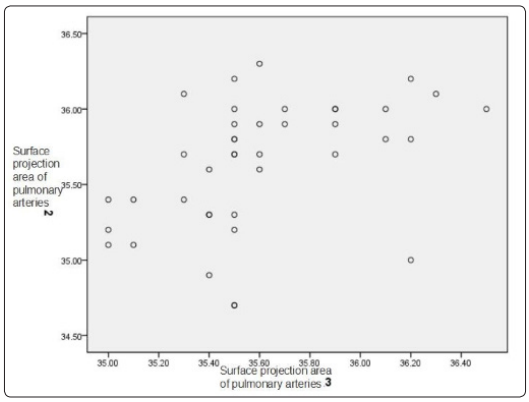

Figure 8: The temperature measurement values of the electronic thermometer (Surface projection area of pulmonary arteries 2) and mercury thermometer (Surface projection area of pulmonary arteries 3) were positively correlated and the correlation is low

Table 1: Comparisons between the two electronic thermometers and mercury thermometer

Type	site	Average deviation from mercury thermometer mean ±SD [°C]	Correlation value r(r^2)	After normalization: Correlation valuer (r^2)	Regression Formula (T=mercury thermometer measurement)
New	neck	0.365±0.289	0.759 (0.576)	0.743 (0.552)	1.144T-4.895
Thermometer	Pulmonary arterial catheter surface area	0.390±0.395	0.502 (0.252)	0.458 (0.210)	0.592T+14.931
	left axillary	0.315±0.404	0.781 (0.610)	0.767 (0.589)	0.613T+14.449
Electronic	neck	-0.010±0.229	0.694 (0.481)	0.672 (0.452)	0.703T+10.828
Thermometer	Pulmonary arterial catheter surface area	0.040±0.352	0.580 (0.336)	0.548 (0.300)	0.651T+12.471
	left axillary	0.045±0.441	0.760 (0.578)	0.744 (0.554)	0.424T+21.076

The comparison standard is the mercury thermometer, T=mercury thermometer The new thermometer had the strongest correlation to the mercury thermometer(r=0.781; r2=0.610; p=.000). compared with electronic thermometers (r=0.760; r2=0.578; p=.000). Figure 1 and Table 1, Pearson correlation all revealed moderate relationship, between the Mercury thermometers and the New Thermometer (cervical r¼0.759, Surface projection area of pulmonary arteries r¼0.502, left axillary area r¼0.781) , between the Mercury thermometers and the electronic thermometers (cervical r¼0.694, Surface projection area of pulmonary arteries r¼0.580, left axillary area r¼0.760) systems, Two thermometer measured in different parts than mercury thermometers R-value (0.502 to 0.781). It is consistent with the research of Guo Zhen Hua [12].

Table 2: Three kinds of thermometers were compared in different parts ($\bar{x}$± s)

Type of thermometer	Axillary Temperature	Neck Temperature	Pulmonary Arterial Catheter Surface Area Temperature	F1	P1
New Thermometer	36.855±0.508	36.855±0.439	36.045±0.424	39.119	<0.001
Electronic Thermometer	36.585±0.362	36.450±0.295	35.695±0.403	104.635	<0.001
Mercury Thermometer	36.540±0.648	36.460±0.291	35.655±0.359	47.148	<0.001
F2	6.673	24.899	15.674		
P2	0.003	<0.001	<0.001		

F1, P1:Comparison of measurement sites of three kinds of thermometers
F2, P2:Comparison of three thermometer measurements

Table 3: Pairwise comparison of the P values of the three thermometers in different parts of the analysis of variance (LSD)

Type of thermometer	Axillary Temperature	Neck Temperature	Pulmonary Arterial Catheter Surface Area Temperature
New—Electronic	0.006	<0.001	<0.001
New—Mercury	0.002	<0.001	<0.001
Electronic—Mercury	0.632	0.870	0.605

Table 4: Variance analysis of three different thermometers was used to compare the P values (LSD)

Site	New Temperature	Electronic Temperature	Mercury Temperature
Neck——Pulmonary Arterial Catheter Surface Area	<0.001	<0.001	<0.001
Neck—Axillary	0.774	0.049	0.432
Pulmonary Arterial Catheter Surface Area — Axillary	<0.001	<0.001	<0.001

The difference is not statistically significant in the temperature values measured by the new thermometer at the neck. Under the left armpit (P≥0.05), the difference between digital thermometers and mercury thermometers is no statistically significant (P≥0.05). The difference between the new thermometer and electronic thermometer was statistically significant (P≤0.05). The difference between the new type thermometer and mercury thermometer was statistically substantial (both P≤0.05) (Table 2). The measured values of electronic thermometer and mercury thermometer were the same, with no difference of P≥0.05 and no statistical significance. There were differences between the new thermometer and electronic thermometer, and between the new thermometer and mercury thermometer, P≤0.05, which was statistically significant (Table 3). There was no difference in the temperature values measured by the new thermometer in the two parts of the neck and left armpit. There was no difference in the temperature values measured by the mercury thermometer in the neck and left armpit (P≥0.05), showing no statistical significance. The others (all P≤0.05) were statistically significant (Table 4). The measurement of the electronic thermometer and mercury thermometer is equally accurate and stable, which is consistent with the conclusion confirmed by Ye Chao [3]. Zhang GUI Ying [6] et al. At the same time, it shows that the temperature measurement time of electronic thermometer is significantly shorter than that of a mercury thermometer.

The application of electronic thermometer to measure body temperature can not only improve the safety of newborns but also benefit the operation of nursing staff, save time and improve work efficiency, which is a convenient way to measure newborn body temperature [3].

The mean value of the new thermometer is 0.3 °C ~ 0.4 °C higher than that of an electronic thermometer and mercury thermometer. According to the calibration report of the new thermometer, the standard deviation is 0.1°C, which is larger than the actual variation. The result may be related to the sample size chosen in this study, the lack of research, or the more significant influence of environmental temperature.

Questionnaires

Thermometers have failed many times, and the results show that they should be carefully evaluated, This resulted in a positive or negative number, either indicating that the specific measure was above or below the patient's average in the particular measurement method. In contrary to our expectations, correlations between the new thermometer and mercury thermometer were even lower after this normalization, ranging from 0.458 to 0.767 (Table 1).

Discussion

Mercury thermometer is the traditional "gold standard" because of its solid glass structure and stable mercury performance. Therefore, it has the advantages of accurate indication, high stability, low price, and easy to use. But the disadvantage of mercury thermometer is easy to break, and the environmental pollution is more serious, the measurement time is longer, the newborn is not easy to accept, disinfection cumbersome, reading is not intuitive [9].In contrast, the electronic thermometer reading is intuitive, easy to use, high accuracy. However, the accuracy of the indicator is easily affected by electronic components, battery power, and other factors. The stability is lower than that of mercury thermometer [10]. The new thermometer is simple to sterilize, reducing the workload of nursing staff and reducing the possibility of cross-infection. Ergonomics is a science and technology to solve the relationship between "man-machine-environment."Content is a human technology. The 3D engineering design of the human body, the shape of the cartoon handle, the appearance is attractive to the child. The three thermometers projected an area of about 0.8 ~ 1°C on the surface of the pulmonary artery below the measurement of the axilla, which fits the description of the new edition of basic nursing [8]. Body surface temperature is usually unstable and will vary within a specific range, and is generally lower than the body core temperature due to the influence of ambient temperature. Lu [11]also confirmed the impact of measurement sites and environmental temperature on the body temperature of healthy older people.

On the one hand, there are certain limitations in this study, because the sensor does not have enough contact area with the skin during the temperature measurement, the trunk skin loses more heat, and the bone, skin, body fat hinder the internal heat transfer. The difference is not statistically significant in the temperature values measured by the new thermometer at the neck. Under the left armpit (P≥0.05), the difference between digital thermometers and mercury thermometers is no statistically significant (P≥0.05). Since the arteries in the neck and left armpit has an abundant blood supply, and less heat is lost in a relatively closed space, making them better able to wrap around temperature sensors.

Research suggests that a warm environment, the newborn's neck, left axillary temperature of the Surface projection area of pulmonary arteries, a new type of thermometer has reliable stability, safe, convenient. Still, in the surface projection area of pulmonary arteries with the electronic thermometer, mercury thermometer measured values are different; the results show that noninvasive body core temperature measurement remains to be further validation and research.For example, the thermometer thermistor sensor is modified to a flat shape to increase skin contact; Create a virtual enclosed space that is fully covered with sensors to reduce heat dissipation on the skin surface of the temperature measurement area.

With the advent of the era of big data, to unify the standard value of body temperature and facilitate diagnosis, core temperature should be selected as the only standard of body temperature. It is also necessary to develop a thermometer that is accurate, easy to use, safe and non-invasive, and can measure the core body temperature on the body surface. It is also required to study further its accuracy and how to measure the core temperature on the body surface under non-invasive circumstances. Compared with axillary, popliteal, forehead, neck, and other parts of the body, the body surface projection area of the pulmonary artery is closer to the core part of the body. It is also the most sensitive part to sense the fluctuation of the chest and the beating of the heart. It is the best position to measure body temperature, respiration, blood pressure, and pulse.

The reading of the new thermometer is intuitive. Although it is stable, fast, safe, and convenient, the measured data are different from those of the mercury thermometer; It is a reference method for core body temperature. (Neck Temperature 0.365±0.289; Pulmonary Arterial Catheter Surface Area Temperature 0.390±0.395; left Axillary Temperature 0.315±0.404); r(r2) Neck 0.759 (0.576); Pulmonary Arterial Catheter Surface Area 0.502 (0.252); left Axillary Temperature 0.781 (0.610); $P1<0.001$; $P\leq0.05$. The new thermometers have been compared with body surface thermometers but not with contactless infrared measurements.No comparison was made with the gold standard internal core temperature measurements.

To obtain core body temperature data more accurately, we need to further adapt to the changes in market demand and conduct in-depth research on data, electronics, information, and network. It can 24 hours continuous measurement of body temperature of the newborn, can be constant monitoring temperature, can be observed temperature change curve, can export temperature history, able to operate without a button, also will alarm intelligent thermometer, real-time accurate first-hand clinical data collection, express condition analysis, and judgment. Digital, electronic, information, network is undoubted to neonatal clinical research adds a lot of convenient ways.

References

1. Liu shulan, Liu xiaoyan (2018) Application and management of electronic thermometer in pediatric ward [J]. chinese journal of medicine guide 16: 293-294.
2. Lin yin, Fan yanfang (2013) Comparison of three kinds of thermometers for body temperature measurement [J].Strait Journal of Preventive Medicine 19: 86-87.
3. Ye chao, Zhu hong (2008) Explore the feasibility about the Electronic thermometer using the neonate's temperature measurement[J].Journal of Nursing 15: 8-9.
4. Wu xiaochun,Gao cuiling (2017) Analysis on the current situation and countermeasures of mercury thermometer in China [J].Academic Forum 38: 140-145.
5. Rutter N (2005) Temperature control and disorders [J].Elsevier Churchill Living stone 267-279.
6. huang guiying (2012) Clinical study on measuring the temperature of premature infant's back with electronic thermometer [J].Today Nurse154.
7. Long lin (2010) Fundamental Nursing [M].Beijing: People' s Military Medical Publisher 251.
8. Jiang anli,Cao meijuan. (2012) Fundamental Nursing, The 2nd Edition [M].Beijing: People's Military Medical Publisher 401-402.
9. Gou juxiang, Zhou qian (2016) Compared the results of non-contact infrared thermometer and mercury thermometer [J]. West China Medical Journal 31: 961-962.
10. Li rongjing, Li rao (2016) Comparison of clinical application of non-contact infrared thermometer and mercury thermometer [J]. West China Medical Journal 31: 1899-1901.
11. Lu SH, Dai YT, Yen CJ (2009) The effects of measurement site and ambient temperature on body temperature values in healthy older adults: a cross-sectional comparative study [J]. Int J Nurs Stud 46: 1415-1422.
12. Guo zhenhua, Liu ximei (2014) Comparison of temperature measurement of axillary, urinary bladder and pulmonary artery in intensive patients [J].Acad J China PLA Med Sch35: 837-839.
13. Zhao xiaowei.Design and Implementation of Smart Temperature Measurement System Based on Bluetooth 4.0 LE [D],The Degree of Master of Engineering, Nanjing University of Posts and Telecommunications, 2015.
14. Fu dawei. Portable Monitor for Animal Heat [D] The Master Degree Dissertation of Jilin University, 2006.
15. Beijing Zhiyan Kexin Consulting Co., Ltd .China Thermometer Market Deep Survey and Investment Prospect Research Report 2014-2020 [R], 2014.
16. Wu weiguang.Smart Thermometers Market in 2015- Prospect Forecast for Smart Thermometers Market [EB/OL]
17. Hu xuefeng. Overview of Methods for Measuring Body Temperature [J].Port Health Control, 2013, 18 (6):55-57.
18. Chen huiying (2016) Application Analysis of Three Methods of Temperature Measurement in Emergency Pre-examination Triage [J].Medical Innovation of China 13: 112-114.

Copyright: *©2020 Yan qiuyi, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.*