

# Investigation on the Application Value of Infrared Forehead Temperature Gun in Body Temperature Screening of New Crown Epidemic

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## ABSTRACT

The outbreak of the novel coronavirus pneumonia has had a great impact on the life safety of our people and social production activities. Therefore, it is very important and meaningful to analyze the application value of infrared forehead thermometers in body temperature screening under the new crown pneumonia epidemic and propose improved measures for body temperature detection. This paper summarizes the questionnaire on the application value of infrared forehead thermometer in body temperature screening and the results of staff interviews, and analyzes the principle of infrared forehead thermometer temperature measurement to explain the factors that affect the accuracy of temperature measurement results. Finally, it is concluded that the reflected radiation of the environment and the temperature measurement distance affect the accuracy of the temperature measurement results of the infrared forehead gun.

## 1. Introduction

The outbreak of the novel coronavirus pneumonia virus has had a great impact on the life safety and social activities of our people. In the prevention and control of the epidemic, body temperature monitoring is a vital part. Based on the body temperature observation of a large number of people, the overall prevention and control effect of the epidemic can be monitored. Therefore, evaluating the effectiveness of prevention and control measures based on the temperature measurement of a large number of people is of great significance for epidemic research and response to future emergencies. In summary, accurate and efficient screening of the body temperature of a large number of floating populations is very necessary.

At present, infrared forehead thermometers are com-

monly used for body temperature screening<sup>[1]</sup>. Therefore, it is very important to study the accuracy of infrared forehead thermometer measurement and how to make infrared forehead thermometer overcome external factors to perform body temperature monitoring more effectively.

## 2. Research and Analysis

### 2.1 Research Objects

Select community residents and staff in Lianyungang City, Jiangsu Province and Handan City, Hebei Province to conduct a questionnaire survey; the primary health workers from related units in Lianyungang City, Jiangsu Province and Handan City, Hebei Province were selected for interviews and exchanges.

Inclusion criteria: Skilled in using the questionnaire

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platform; Consciousness, no diagnosis of mental illness; Age 15~75 years old.

## 2.2 Research Method

### (1) Questionnaire survey method

This questionnaire activity uses online electronic questionnaires, in which a total of 315 questionnaires are collected, of which 298 are valid questionnaires, with an effective rate of 94.61%. Obtain more authentic and reliable data to ensure the truthfulness and validity of the survey results.

### (2) On-site interview method

Obtain the actual situation in the operation process by communicating with the staff on duty and the staff, and make preparations for the subsequent optimization of the strategy in the operation specification.

## 2.3 Survey Results

### (1) Questionnaire survey results

According to the distributed questionnaire survey, most of the temperature measuring instruments during the epidemic period were infrared thermometers, and other temperature measuring instruments were used less frequently. And found that most people are willing to accept the temperature detection of infrared forehead guns. The positive attitude of the people not only facilitates their own health monitoring, but also facilitates the operation and service of the entire society. In addition, nearly half of the respondents believe that infrared body temperature measurement is fast and low in cost, which are the advantages and characteristics of infrared forehead thermometers; some respondents pointed out problems such as large errors in the measurement results. Nearly 4/5 of the interviewees hope that the temperature measurement tool can be equipped with some temperature measurement APP to perform auxiliary monitoring of body temperature. Nearly half of the interviewees believed that they would undergo temperature checks about twice a day. Most of the interviewees said that the number of times they received the forehead temperature gun temperature measurement was irregular, which was related to the travel trajectory. It can be seen that under the background that the epidemic situation in my country has stabilized, temperature testing is still being carried out in an orderly manner.

### (2) Interview results

Coordination of residents: Most residents actively cooperate and support the temperature screening work, and the residents understand and support the temperature screening work.

The work of primary health personnel: The staff are ba-

sically responsible. The prevention and control of the new crown epidemic is a difficult task, and the work pressure of the staff on duty is relatively high. However, the staff insisted on taking up their posts and showed high professionalism. In addition, the staff said that the temperature measurement gun will be inaccurate in temperature measurement, and the outdoor temperature will change from winter to summer. In the face of continuous low temperature or outdoor high temperature measuring gun, the temperature measurement will be inaccurate, which will also affect the normal use of the infrared forehead temperature gun, which will cause a series of problems. The infrared thermometer itself and its irregular operation also bring a series of problems to the measurement of body temperature. In addition, the reserve of professional medical knowledge of grassroots personnel is generally insufficient, and the on-duty personnel report that although non-health personnel have a strong awareness of protection, the actual protection behavior is insufficient.

## 3. Analysis of the Principle of Temperature Measurement

The factors that affect the measurement results of the infrared forehead thermometer mainly include the surrounding environment and the measurement distance. According to the temperature measurement principle of the infrared thermometer, it determines its temperature by receiving the radiation emitted from the surface of the measured object [2]. In actual measurement, the effective radiation received by the infrared thermometer includes three parts: the target's own radiation, environmental reflected radiation and atmospheric radiation.

### 3.1 The Influence of Target's Own Radiation

From the literature [3], it is known that the infrared temperature measuring gun temperature measurement formula is:

$$Q = \tau[\sigma\varepsilon_s(T_s^n - T_r^n) + \sigma\rho_s(T_u^n - T_r^n)] + \sigma\varepsilon_a T_a^n \quad (1)$$

$Q$  indicates the energy density of infrared radiation received by the infrared forehead thermometer;

$T_s^n$ 、 $T_r^n$ 、 $T_u^n$ 、 $T_a^n$  respectively indicate the measured object, temperature sensor, surrounding environment and atmospheric temperature, the unit is K;

$\varepsilon_s$ 、 $\varepsilon_a$  respectively represent the emissivity of the measured object and the emissivity of the atmosphere;

$\tau_a$  represents atmospheric transmittance;  $\rho_s$  represents

the infrared reflectivity of the surface of the measured object.

The infrared radiation of other objects in the surrounding environment will also be accepted by the thermal imager detector. When measuring non-metallic surfaces, it can be considered as  $\rho_s = 1 - \epsilon_s$ .

$\rho$  is a Stefan-Boltzmann constant with a value of  $5.6693 \times 10^{-8} W \cdot m^{-2} \cdot K^{-4}$ .

The temperature of the object itself  $T_s$  can be derived from the above formula [4]:

$$T_s = \sqrt[n]{\frac{Q}{\tau \sigma \epsilon_s} - \frac{\epsilon_u}{\tau \epsilon_s} T_\alpha^n - \frac{\rho_s}{\tau_s} (T_u^n - T_r^n) + T_r^n} \quad (2)$$

It can be seen from the above formula that  $T_s$  is determined by factors such as environmental reflection emissivity, distance coefficient, surrounding environment, atmospheric temperature, environmental reflectivity and perspective rate. This paper focuses on analyzing the influence of the surrounding environment and temperature measurement distance.

### 3.2 The Influence of Reflected Radiation from the Environment

It can be seen from the actual measurement analysis that the ambient temperature has a non-negligible effect on the measured target temperature. According to Kirchhoff's law: In thermal equilibrium, the absorption ratio of any object to blackbody input radiation is equal to the object's emissivity at the same temperature. But the actual human body temperature measurement, input radiation is not black body radiation, and will not be in thermal equilibrium [5].

According to Stephen-Boltzmann's law, the total radiant energy of a black body  $M_o(\lambda, T)$  is proportional to the fourth power of its thermodynamic temperature, namely:

$$M_o(\lambda, T) = \sigma T^4 \quad (3)$$

is the Stephen-Boltzmann constant, and the value is  $5.6693 \times 10^{-8} W \cdot m^{-2} \cdot K^{-4}$ .

In actual human body temperature measurement, the radiant energy of the human body at the same temperature is always less than the radiant energy of the black body. The human body can be regarded as a gray body at this time. The emissivity of the actual object is the ratio of the radiated energy of the actual object to the blackbody under the same temperature state. which is:

$$\epsilon = \frac{M(\lambda, T)}{M_o(\lambda, T)} \quad (4)$$

From (3) (4), the following equations can be derived:

$$M(\lambda, T) = \epsilon \cdot \sigma \cdot T^4 \quad (5)$$

According to Kirchhoff's law, under thermal equilibrium conditions, the ratio of any object's own radiation to its absorption ratio to radiation from a black body is always equal to the radiation force of a black body at the same temperature. Which is:

$$\frac{M(\lambda, T)}{\alpha} = M_o(\lambda, T) \quad (6)$$

You can get:  $\epsilon = \alpha$ .

In the actual situation, the human body can be regarded as a dusty surface. Considering the relationship between the emissivity and absorption ratio of gray body, it must have  $\epsilon = \alpha$  for the human body. That is, for the human body, whether the input radiation comes from a black body or whether it is in a thermal equilibrium condition, the absorption ratio is always equal to the emissivity at the same temperature. In reality, the human body is an opaque object, so the transmittance of the human body can be regarded as zero, and there is only radiation and reflection at this time. In the case of actual human body temperature measurement, there are:  $\rho_s = 1 - \epsilon_s$ .

### 3.3 Influence of Distance Coefficient

As shown in the figure below, the distance coefficient ( $K=S/D$ ) is the ratio of the distance  $S$  from the infrared thermometer to the target and the diameter  $D$  of the temperature measurement target. The distance coefficient has a great influence on the accuracy of infrared temperature measurement. The  $K$  value the larger the value, the higher the resolution [6]. The target object is too far away, the radiant energy received by the infrared temperature measuring gun is reduced, and the measured temperature is lower than the actual temperature of the target object.

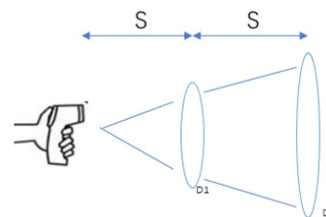


Figure 1. Schematic diagram of measuring distance

## 4. Conclusion

The most important thing in body temperature screening is the accuracy of temperature measurement, but sometimes there are many influencing factors that lead to deviations in the temperature measurement results, which will cause unnecessary misunderstandings and waste of time for epidemic prevention personnel. In more serious cases, suspected patients may be missed, leading to the spread of the virus. So we put forward some suggestions on the use of infrared forehead thermometers.

### 4.1 Ambient Temperature and Measurement Location

In winter, especially in cold areas in the north, it is necessary to measure body temperature outdoors in most cases. Therefore, the temperature measuring gun has certain requirements for the ambient temperature, pay attention to the slow response of the temperature measurement and the error in the measured value. In addition, the forehead measurement error of the infrared forehead thermometer is relatively small.

### 4.2 Equipment Cleaning, Disinfection, Maintenance and Calibration

Dirt and other dirt may block the optical system of the instrument, thereby causing errors in temperature measurement<sup>[7]</sup>. Therefore, it is extremely important to arrange staff to check the infrared forehead thermometer regularly. Clean the infrared forehead thermometer regularly. Cleaning method: First use compressed air to remove large particles and dust, and then wipe with a cotton swab dipped in 95% ethanol. After use, cover the infrared forehead thermometer with the lens cap as soon as possible, and put it in the carrying case for storage. Finally, the relevant factory departments should provide free monitoring and calibration services, and send professionals to regularly calibrate and maintain the instrument to ensure the accuracy of the measurement<sup>[8]</sup>.

### 4.3 Training of Measurement Personnel

Temperature measurement personnel are the most basic level of epidemic prevention personnel, and their sense of responsibility and operation methods can directly affect the measurement results. For example, some operators

have inaccurate measurement due to the distance and irregular operation during temperature measurement. In addition, there will be some surveying personnel who are careless, not pay enough attention to their work, and lack a sense of responsibility to make the survey mere formality. Therefore, the training of temperature measurement personnel is very important and should be paid enough attention.

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