A STUDY OF TEMPERATURES TAKEN WITH AN ELECTRONIC THERMOMETER AND THE GLASS CLINICAL THERMOMETER

by

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CHAPTER I

INTRODUCTION

Statement of the Problem

The body temperature is an important vital sign used to aid in determining the state of health or illness. Changes in the functioning of the body usually are accompanied by changes in the body temperature. Such changes are often clues to the nature of illness or to alterations in the patient's condition.

Body temperature is defined as the balance maintained between heat produced and heat lost. (9) The measurement of temperature by means of a self-registering glass clinical thermometer has been routine in nursing care, usually on a two times a day basis, but oftener for patients who are febrile. The most expedient method is that of taking the temperature by mouth. (18) The exceptions to oral temperature measurement are not discussed in this study.

Discrepancies have been found in temperatures measured by glass clinical thermometers. (26) Some of the variation in accuracy

could be due to the instrument, some to the reading. Studies have shown that considerable nursing service time is expended on routine activities such as temperature taking. The length of time necessary for a thermometer to reach the highest reading is reported in the literature in varying amounts from one to nine minutes. (5, 22, 26)

It may be questioned whether there is a quicker and more accurate means of obtaining a measurement of body heat. The electronic thermometer has been available in recent years. The manufacturers claim, when properly used, the instrument provides accuracy, economy and safety. The Temspar Electronic Thermometer is battery operated and is transistorized. Some of the outstanding features include 1) single push button operation, 2) automatic reset, 3) red light to indicate when computed temperature is obtained, 4) self-contained, rechargeable battery pack, and 5) color-coded sensors. The temperature is numerically displayed in less than 20 seconds. The disposable plastic probe covers eliminate handling and sterilizing of the sensor (probe). (17)

Studies comparing the use of the electronic thermometer and the glass clinical thermometer are logical, preceding a decision to accept the equipment. Questions arise such as:

1. How much variation exists between the temperature registered by the fast mode and the extended mode of the electronic thermometer?

2. How much variation exists between temperatures registered by glass clinical thermometers when the thermometer is left in the mouth for three minutes, five minutes, and nine minutes?

3. How much variation, if any, exists between the process in question one and that of question two?

4. How much variation, if any, exists when the processes are repeated by three different persons, namely a registered nurse, licensed practical nurse, nurses' aide, all of whom have been taught to use the equipment.

These four questions serve as the framework within which this study was designed.

Purpose of the Study

The purposes of this study were to find answers to the above stated questions, accordingly it is proposed: There is no significant difference between the electronic thermometer readings from the fast and extended modes, and the glass clinical thermometer at the three, five and nine minute readings, as taken and recorded by three different people.

The alternate hypothesis: There is a significant difference between the electronic thermometer readings from the fast and extended modes, and the glass clinical thermometer at the three, five and nine minute readings, as taken and recorded by three different people.

Limitations

This study was limited to data obtained by use of the electronic thermometer and the glass clinical thermometer at three, five and nine minute readings as taken, read, and recorded by three different nurses on 50 patients, 28 in one 280 bed hospital and 22 in one 45 bed nursing home. The data were collected in May 1971.

Explanation of Terms

For the purpose of this study the following terms are used:

Placement time - the length of time the glass thermometer is left in the mouth.

Optimum temperature - the temperature within 0.2 of a degree of the maximum or highest temperature reached in seven to nine minute placement time of the glass thermometer.

Electronic thermometer - a battery operated, transistorized instrument.

Fast mode - the reading from the electronic thermometer when the red dot appears, taking up to 20 seconds.

Extended mode - is incorporated into the electronic thermometer for "conventional temperature taking". (17) When the probe tip is warmer than 90 degrees F. the machine automatically goes into this mode. When the fast mode takes longer than 20 seconds the temperature should be taken by the extended mode. (17)

Steps of the Study

The literature was reviewed to develop a frame of reference regarding the glass clinical thermometer, the electronic clinical thermometer, their accuracies and uses.

The problem was defined by a discussion of the importance and purpose of measuring body heat. From this arose four questions which serve as framework for the study.

It was then proposed to test the null hypothesis; there is no significant difference between the electronic temperature readings from the fast and extended modes, and the glass clinical thermometer at three, five and nine minutes readings, as taken and recorded by three different people.

The study was limited to data obtained by three nurses who used an electronic clinical thermometer, and a glass clinical thermometer, to take oral temperatures of 50 hospital and nursing home patients.

Explanation was made of terms used in the study: 1) placement time, 2) optimum temperature, 3) electronic thermometer, 4) fast mode and 5) extended mode.

A small pilot study was done to test the equipment and process, and to teach the licensed practical nurse and nurses' aide the use of equipment.

Data were then collected at one 280 bed hospital and one 45 bed

nursing home.

The Temspar electronic thermometer was furnished by Parke-Davis Company. Fifty new glass linical thermometers, all from the same box, were obtained from the 280 bed hospital.

Permission for data collection was obtained from the Director of Nursing Service in the hospital and Manager of the nursing home.

The process for collecting the data was explained to each patient and consent was obtained before the data collecting began. Criteria for patient selection were 1) not critically ill, 2) willing to participate, and 3) capable of giving consent.

Three persons, a registered nurse, a licensed practical nurse, and a nurses' aide visited every patient in sequence. Temperatures were taken first with the electronic thermometer, fast and extended modes, and then with the glass clinical thermometer read at three, five and nine minutes. Each temperature was immediately recorded on the form provided. (Appendix A.)

The data were analyzed by analysis of variance first on the glass clinical thermometer for three, five and nine minute readings. Analysis of variance was done for the electronic thermometer fast and extended modes and the glass clinical thermometer, three, five, and nine minute readings.

The study was summarized, conclusions drawn, and recommendations made for further study.

Overview of the Study

This study is presented in four chapters. Chapter I has presented a statement of the problem, purposes of the study, hypothesis, explanation of terms and steps in the development of the study. Chapter II presents a review of literature and related studies. Chapter III reports on the study, describes data collection, analysis and interpretation of the findings. Chapter IV consists of a summary, conclusions and recommendations for further study.

CHAPTER II

REVIEW OF LITERATURE

A search of the literature was made for research reports regarding factors which determine 1) the accuracy of the equipment used to measure oral temperatures, 2) the different equipment which has been used, and 3) the procedures used for determining oral body temperature.

Factors which affect the so-called "normal" temperature, the time, and the methods used for taking body temperatures were identified. Most of the literature reviewed was not documented with research findings, and not all of the research described the analysis by which the conclusion was reached.

It is important to obtain accurate body temperature readings and recordings. All patient charts include a temperature record which should be useful data in determining the patient's health status. Any "inaccuracy which may exist should be within known and acceptable limits." (9) In most hospitals, body temperatures are routinely taken at least twice a day by the nurses or nurses' aides. Measurement of body temperature is considered to be a reliable indication of

the presence or absence of a disease and the severity of the illness. (24)

For some time there has been evidence that the arbitrary "normal" of 98.6 degrees F. is misleading. Normal body temperatures may range from below 98.6 degrees F. to 99.5 degrees F. (22) "Any temperature assessment is based on determining the core temperature of the internal body. About two-thirds of the body mass is at this core temperature while one-third is at the shell or mean skin temperature." (24) Whatever the individual's normal temperature, the fact remains that the body temperature is relied upon as an indication of the health status of that individual. (15) From the primitive era of medicine, body temperature has been used as an important indicator of the systemic reaction to disease. (8) Since there are no other exact measures available for nurses' assessment of body temperature, it is important to improve those being used. (21)

It is assumed that the physicians are familiar with the importance of this sensitive indicator of dynamic body processes; however, measurement of body temperature is frequently omitted in routine office and hospital out-patient and in-patient care. (8) It may be due to the time involved for accurate readings, or to the inconvenience and care of the equipment. There may also be other factors involved, but the real question is what can be done to enable clinicians to obtain reliable measurement of body temperature in the assessment of

patients' condition.

Several studies have indicated that rectal temperatures are more accurate than oral temperatures. However, as Robertson stated:

> A sensor placed in the mouth of an adult is accepted as an accurate indicator of body temperature, even though the mouth does not maintain a constant temperature. Since it is the easiest and most acceptable method to most patients, it continues to be used regardless of the inaccuracies. (20)

He further stated that:

> When an adult's temperature increases over a short interval of time it normally indicates unusual physiological activity or drug therapy reactions. Usually this increase is large (2 or 3 degrees C) and easily detected by the least accurate sensor. (20)

However, if readings are to be considered in making clinical assessments, especially in cases in which the temperature is of great significance, they should be accurate. (9)

According to Hill, the traditional method of measuring body temperature has been by the use of a "mercury-in-glass" thermometer. (7) Since Galileo's invention of the first thermometer or temperature measuring device 400 years ago, thermometers have undergone many changes based upon scientific testing, until the development of our present clinical thermometer. (15) Palmer says, "There is no instrument of precision that is more valuable in the diagnosis and prognosis of disease than the clinical thermometer." (16)

Knapp found large inaccuracies in a sample of glass thermometers and the errors experienced were quite unpredictable. In any particular thermometer the amount of error varied with the temperature. Therefore, "unless the user exercises critical inspection of new thermometers and sets minimal standards for acceptance, that is 0.25 of a degree F. maximum deviation, the thermometers will give false information." He found that as the temperature increased, the tendency for error became greater. (9)

A preliminary study was done by Purintun and Bishop, to test the accuracy of thermometers by placing them in a water bath with circulating water to avoid temperature gradient. Readings were taken by two persons after two minutes. The bath temperature remained at 98 degrees F. until all thermometers were read. Then the temperature of the bath was raised to 100 degrees F. with the same proceedings. Finally the temperature of the bath was raised to 104.6 degrees F. The readings were compared with a standard control thermometer. Of 48 new thermometers, 11 or nearly 25 per cent were found to be inaccurate by more than 0.20 of a degree F. (19)

It is expected that thermometers will meet certain standards when purchased. A certificate of guarantee accompanies the thermometer and states that the commercial standard has been met, as set by the government, Bureau of Standards U. S. Department of

Commerce. The criteria for commercial standard include, among others, tests for retreating index, separated mercury column, failure to repeat readings, hard shakers, defects in glass and defective inking. (18) There are some inexpensive thermometers available that are not government certified. (19)

In a study done by DeNosaquo et al., 1000 clinical thermometers were collected by the Food and Drug Administration throughout the United States in the spring of 1940. Of these, 800 were found to meet the requirements and tests specified for clinical thermometers in the commercial standard, C-S 1-32 of the U. S. Department of Commerce, Bureau of Standards. By random sampling of the 800, 20 were selected for further testing. There were no defects found. (3)

In some cases thermometers have been found to be inaccurate by as much as three degrees F. (16) There are certain variables that influence the accuracy of a temperature measurement when taken orally. It was found by Nichols et al., that room temperature can influence the placement time of the thermometer in the mouth. (14) Drinking iced fluids can render the oral temperature "as inaccurate as -1.6 degrees F." The rationale, then for not taking the temperature after iced fluids is that this amount of inaccuracy could result in a fever state going undetected. In a study done by Woodman, Parry and Simms, it was found that if the subject kept his mouth closed for 15 minutes prior to having the temperature taken, the optimum

temperature was reached in three minutes and maximum at five minutes. (26) Gum chewing and hot fluids prolong the deviation in body temperature longer than iced drinks and smoking. Brim reported that nurses should consider temperature taking representative of the many everyday nursing problems for which they have the responsibility for effective and accurate action, and about which they must learn to think scientifically. (2)

Although there have been several papers written on the subject of clinical thermometers, no definite basis for the time designation used for oral clinical thermometers was identified.

In the study done by DeNosaquo, the conclusions were that three minutes should be the minimum time interval allotted for oral clinical thermometers to reach equilibrium in the mouths of individuals under ordinary conditions of use. This conclusion is based on the average time for 493 determinations to come within one-tenth of one degree of maximum reading. Since this is an average and as the same study showed a significant difference between sex and subjects, determined by analysis of variance, there is an inclination to question that three minutes is enough time to determine accurately each individual temperature. (3)

Nichols in 1966 extended the research by DeNosaquo, by comparing oral, rectal and axillary temperatures. Subjects required one to 12 minutes to reach their maximum oral temperature. After

three minutes only 11 per cent had reached the maximum, in seven minutes 53 per cent had reached the maximum, in nine minutes 86 per cent had reached the maximum and at ten minutes over 90 per cent had reached their highest temperature. (15) It required one to 11 minutes for the subjects to reach their optimum temperature (0. 2 of a degree F. lower than maximum or highest). It was found that it took seven minutes of optimum placement time for oral thermometers and according to this finding the recommended placement time of three minutes in literature and nursing texts, would not allow the reading to attain the optimum. (15)

Nichols' findings were analyzed by computing percentages to determine the time necessary for 90 per cent of the subjects to attain maximum and optimum readings; the ranges and frequency distributions of temperature readings were also computed. (15) This study showed a greater difference between rectal and oral temperatures when oral placement time was three minutes than when optimum placement time was used. (15)

A study was done by Nichols and Verhonick (1967) in an air-conditioned environment to determine placement times. The analysis was similar to that in the previous study. The researchers found that in three minutes only 13 per cent of the subjects reached their highest temperature, in five minutes 25 per cent, and in 11 minutes 90 per cent had reached the maximum; thus the maximum placement time

was 11 minutes. Optimum temperatures were reached in three minutes by 38 per cent, and five minutes by 73 per cent. The actual optimum placement time was then considered to be seven minutes. Findings from this research shows that the most frequently recommended placement time of three or five minutes is not sufficient for accurate body temperatures obtained by use of the glass clinical thermometer. (13)

Nichols and Verhonick (1968) decided to replicate their study done in 1967, to see if other untested factors might enter into and change the results of the first research. They increased their number of subjects to make the study more valid. The analysis was again done by calculating percentages to determine the maximum and optimum placement times. The range of differences and the mean differences between five minute readings and the optimum readings and also between the three minute readings and optimum readings were calculated. The subjects required one to 12 minutes to reach their highest readings. Two per cent reached their maximum in three minutes, 11 per cent in five minutes and 90 per cent in 11 minutes. Once again 11 minutes was considered the maximum placement time. The optimum readings required one to 11 minutes. In three minutes 15 per cent reached their optimum temperature, five minutes 43 per cent, and in nine minutes 90 per cent. The optimum placement time in this study was nine minutes compared to the seven minutes in the

previous study. It was assumed that 0.2 of a degree F. below the maximum would not affect nursing or medical decisions, so the optimum placement time was established as best for temperature readings. When using five minute placement time the temperature for more than one half of the individuals was from 0.4 of a degree F. to 1.6 degrees F., less than the highest recorded. If three minute placement time was used, 85 per cent would be lower by 0.4 of a degree F. to 1.6 degrees F. It was reported that if a three minute reading was 99 degrees F., the actual (highest or maximum) reading could be 99.4 degrees F. to 101 degrees F. This could have clinical significance. (14)

Robertson said that there is a need for establishing an economical and acceptable method of temperature measurement with sufficient accuracy. Any measuring device utilized should be convenient, harmless, and painless. (20)

The use of electronic equipment is becoming more acceptable in hospitals. This allows the development and use of new devices which provide information that was unobtainable in the past. With the emphasis on electronics today, new instruments such as electronic thermometers and temperature alarms are increasingly being utilized. (20) The use of electronic monitoring has proven to be very advantageous in intensive care units where accuracy is so important and the oral temperature readings are as frequent as every few

seconds. (24)

In the past, electronic thermometers have proven unsatisfactory in the hospitals, mostly because of the aging of the units and rough handling, which causes them to become less accurate. After two years of use, they were in error exceeding two degrees C. (24)

In 1968, in the U. S., there were approximately 30 manufacturers of electronic thermometers varying in price from $50 to $900. (20) The electronic thermometers are being improved and are no longer as bulky or as costly as when first made. With the invention of the plastic sheath, which protects the probe and is completely disposable, there is no need to worry about sterilization. (24)

Johnson studied the electronic thermometer used in his office. He found that it surpassed the glass thermometer in accuracy and its use was less time consuming. He found it to be plus or minus 0.2 of a degree F. from the highest reading. In two years time, thousands of temperatures were taken with the electonic unit in his office. These reflected a higher reading than the glass clinical thermometers. (8)

Due to the less time involved in taking the temperature with the electronic thermometer, Wilkes found it more convenient to take temperatures routinely. Because of this, unsuspected fevers were often detected. (24)

A study was done by Knapp to determine the degree and type of accuracy or inaccuracy in the glass clinical thermometer and to

compare that thermometer with the electronic clinical thermometer (1966). He used a five gallon bath, well stirred and controlled by an accurate amplifier/heater system, and using an accurate ASTM64C type laboratory thermometer for a reference thermometer. Twelve glass clinical thermometers were selected at random from a community hospital. He placed the bulbs in a cluster around the reference bulb. Then the probes of two electronic thermometers were also placed near the reference bulb. The amplifier/heater was set at different temperatures, from 95 degrees F. to 105 degrees F. The readings of all thermometers, including the reference thermometer, were taken several times at each setting to insure that the system had stabilized and to verify readings. The average error of the glass thermometers was 0.25 of a degree F. at the 98.6 degree setting and maximal errors approaching 0.4 of a degree F. As the temperature increased the average and maximal errors also increased with the maximal approaching 0.7 of a degree F. and averages approaching 0.5 of a degree F. It was noted that the error of the electronic thermometers was less than 0.1 of a degree F. for the greater portion of the range and reached a maximum of 0.15 of a degree F. at the extreme. The electronic thermometers never exceeded an error of 0.15 of a degree F. The error of the electronic thermometer was considered insignificant, over 80 per cent of the range. Knapp concluded:

> The electronic thermometer appears to be far superior to the glass clinical thermometer for temperature determination when the legibility of its scale and its continuous monitoring capability are also taken into consideration. Moreover, until steps are taken to improve the consistency of the quality of glass thermometers, the electronic thermometer presently appears to offer the only solution to the problem of accuracy of temperature determinations. When the accuracy of temperature reading is most important, that is when a patient is febrile, it appears that the glass thermometer is least dependable. When the accuracies of the two thermometers are compared there is no doubt as to the shortcomings of the venerable glass clinical thermometer. (9)

The main motivation of a hospital in purchasing electronic equipment is to save time. However, conservation of time is possible only when instruments are accepted by the staff and used efficiently. Purchasers need to give special consideration to the 1) replacement costs, 2) life expectancy, 3) types of probes required, 4) availability of probes, and 5) repairs that might be needed. Many technical and non technical aspects of clinical temperature measurements must be considered before an item such as the glass clinical thermometer is replaced. After further research, the electronic thermometer may in the future enable the hospital nursing staff to obtain accurate temperature measurements in less time than when using the glass clinical thermometer. (20) It is only a question of time, according to Wilkes, when the convenience, accuracy, time and cost features of the electronic thermometer will be generally recognized and its use widely extended, even perhaps replacing the glass clinical thermometer entirely. (24)

Summary

The literature was reviewed to ascertain factors which affect the accuracies and inaccuracies of the glass clinical thermometer and of the electronic thermometer. The studies of Nichols and Verhonick reported that some of the inaccuracy is in the placement time of the glass clinical thermometer. The studies by Knapp, and Purintun and Bishop showed inaccuracies of the glass clinical thermometer when tested in water baths, and not necessarily the time involved.

Advantages of time saving and greater accuracy of body temperature measurement by use of the electronic thermometer were shown in studies by Knapp, Johnson and Wilkes.

CHAPTER III

REPORT OF THE STUDY

This study was undertaken for the purposes of determining:

1. How much variation exists between the temperature registered by the fast mode and the extended mode of the electronic thermometer.

2. How much variation exists between the temperature registered by glass clinical thermometer when the thermometer is left in the mouth for three minutes, five minutes, and nine minutes.

3. How much variation, if any, exists between the process in one above and that of two.

4. How much variation, if any, exists when the processes are repeated by three different persons, namely a registered nurse, a licensed practical nurse, and a nurses' aide, all of whom have been taught to use the equipment.

The four purposes served as the framework within which this study was designed. It was hypothesized that: There is no significant difference between the electronic thermometer readings from the fast

and extended modes, and the glass clinical thermometer at the three, five and nine minute readings, as taken and recorded by three different people.

The alternate hypothesis was: There is a significant difference between the electronic thermometer readings from the fast and extended modes and the glass clinical thermometer of the three, five, and nine minute readings, as taken and recorded by three different people.

Electronic thermometers had been used on a one week trial basis in two areas of a 280 bed general hospital. Administrative staff were dubious of the accuracy and asked ward staff to conduct a trial test. The temperatures of nine employees were taken four times, a few minutes apart by the same person. Table 1 shows a comparison of the readings.

Table 1. Temperature Readings of An Electronic Thermometer Used on Nine Subjects Four Times a Few Minutes Apart by One Nurse.

Subjects	Readings			
	1	2	3	4
1	98.5	98.5	98.9	99.3
2	96.3	96.8	96.9	97.9
3	97.6	97.7	97.6	98.5
4	98.9	98.9	99.0	98.7
5	98.3	98.1	97.9	98.3
6	98.3	97.7	97.2	98.1
7	97.7	97.9	98.8	97.7
8	98.7	98.9	97.7	98.0
9	98.1	97.9	97.7	98.1

It can be noted that the repeated insertion of a thermometer led to an increase in the final reading for participants one, two, and three, but the final readings for participants five, seven, and nine were identical to those first obtained. There was a decrease for the other three participants. It would take further observation to ascertain the exact reasons for the discrepancies. This small investigation led to the pilot study.

Pilot Study

Preliminary to the development of the study, a pilot study was carried out. A prime purpose of the pilot study was that of ascertaining if further study would be feasible. The pilot study afforded opportunity to assemble a small sample of the data that would be collected in the main study and also teach a nurses' aide and a licensed practical nurse how to use the electronic thermometer and how to record their readings of both types of thermometers. The data from the pilot study were not used in the main study. See Appendix B.

The pilot study was made on seven volunteers, all well people. The process consisted of taking the temperature first with the electronic thermometer, then with the glass clinical thermometer leaving the instrument in place for three, five, and nine minutes. This process was carried out on all seven volunteers by three persons in sequence, namely a registered nurse, a licensed practical nurse,

and a nurses' aide. During the study, it was discovered that the extended mode with the electronic thermometer seemed to compare more closely to the temperature taken with the glass clinical thermometer, than did the fast mode. This led to the decision to use both fast and extended modes with the electronic thermometer for data collection. Table 2 shows the summary table for analysis of variance on the pilot study. The analysis of variance showed no significant differences. The individual differences varied from 0.1 of a degree to 1.6 degrees F. This led to the decision that the study should be done on a greater number of people, for the purpose of finding whether there was a consistant variation of more than 0.5 of a degree F.

Table 2. Summary Table of Analysis of Variance for the Pilot Study Temperatures of Seven Persons Taken by Three Nurses With Electronic Thermometer, Fast and Extended Modes, and Glass Clinical Thermometer Reading at Three, Five and Nine Minutes.

	Sums of Squares	Degrees of Freedom	Mean of Squares	F
A Nurses	1.14	2	0.57	7.808
B Instruments	1.73	4	0.432	5.917
AB	0.20	8	0.025	0.342
Error	6.15	84	0.073	

For raw data see Appendix B.

The Main Study

The information provided and the experience obtained by means of the pilot study resulted in the decision to follow the same processes on a larger number of individuals. The settings for the study consisted of a 280 bed general hospital and a 45 bed nursing home. Administrative clearance for making patient contact and for obtaining data was readily obtained. Conferences were held with the nursing service directors. Consistent cooperation was manifested throughout the data collection period.

The Temspar electronic thermometer was provided by Parke-Davis Company. Previous practice with the electronic thermometer had been sufficient to become adept in its usage. It was known that the metal probe tip on the electronic thermometer must be inserted slowly, having continual contact with the soft tissue in the floor of the mouth, until it reaches the base of the tongue. This takes four to seven seconds. The reason is, the metal tip cools the area it touches and as it is inserted slowly, it warms. When it reaches the base of the tongue it should be warm enough to prevent cooling and a correct temperature can be obtained.

The manufacturer of the electronic thermometer claims that the rechargeable battery permits up to 200 readings between full chargings, or about ten hours of usage. The thermometer is stored

in the recharging stand when not in use to make sure it is charged at all times. (17)

The electronic thermometer used in the study was stored in the recharging stand for two days prior to data collection. After the first five patients, the first two hours of use, the numbers failed to light. An identical thermometer in use in another area of the hospital was loaned for the purpose of finishing that day of data collection. About two hours after the failing thermometer was in the recharging stand, it was again tried and the numbers lighted. There was no more difficulty, and that thermometer was used steadily all day each day thereafter for data collection. The researcher has been unable to obtain an explanation for the mechanical failure.

Fifty glass self-registering clinical thermometers were donated by the hospital. All were obtained from the same box and had not previously been used. It was assumed all were in good condition. No attempt was made to compare to a reference thermometer in a process such as reported by Knapp. (9) Such activity would have enhanced the scientific accuracy of this study but would have been inconsistent with the reality of a hospital or nursing home ward situation.

It had been arbitrarily determined that the use of three persons taking five temperatures on each of fifty patients would result in ample data. The patients were selected according to pre-determined criteria as indicated in Chapter I. There were 28 patients in the hospital and

22 in the nursing home. No attempt was made to stratify the sample according to any variables nor to consider the nature and degree of illness. This may have been a weakness of the study to be considered in any future attempts at replication.

The procedure was explained to each patient and a verbal consent was obtained before the data collection began. Later two persons decided they did not wish to continue, so they were eliminated. Two willing patients were selected to replace those eliminated during the study.

The patients were asked to avoid drinking iced or hot fluids, smoking, or chewing gum for one-half hour before the temperatures were taken. Each of these items has an influence on the recorded temperature. (2)

The data collection took place in a period of four consecutive days between the hours of nine a.m. and three p.m. The temperature of each patient was taken with 1) the electronic thermometer using the fast mode then the extended mode, and 2) the glass clinical thermometer, reading at three minutes, five minutes, and nine minutes. Studies (13, 14, 15) have shown that the optimum temperature is reached at seven to nine minutes. Approximately 30 minutes were required to complete the procedure with each patient. The process was completed by each data collector individually for each patient. Each patient had the temperature taken 15 times. The three nurses

consisted of a registered nurse, a licensed practical nurse, and a nurses' aide, always in that order.

A new glass clinical thermometer was assigned to each patient and used by all three nurses. Each reading was recorded on the data collection sheet as it was taken. See Appendix C.

The multiple variables consisted of two types of instruments, five temperature readings on each of fifty patients repeated by each of three nurses, resulting in fifteen readings per patient.

The multiple variables required an analysis of variance be done, using the F test to determine if there was a significant difference between the readings of the glass clinical thermometer and the electronic thermometer. The analysis of variance was first computed on the readings from the glass clinical thermometer to see if there was a significant difference between the three, five and nine minute readings. Using the 0.01 level of significance, the analysis of variance showed there was no significant difference between the three, five, and nine minute readings with the glass clinical thermometer. Table 3 shows these data.

Table 3. Summary Table of Analysis of Variance for Glass Clinical Thermometer Reading at Three, Five and Nine Minutes on 50 Patients Taken by Three Nurses

Source	Sum of Squares	Degrees of Freedom	Mean of Squares	F
Between subjects		49		
Within subjects		400		
A Nurses	1.522	2	0.761	0.046
B Instruments	7.755	2	3.827	0.234
AB	0.308	4	0.077	0.004
Error	6,400.593	392	16.328	
Total	6,377.615	449	14.204	

The analysis of variance was then computed including all of the readings of the glass clinical thermometer and the fast and extended mode readings of the electronic thermometer. This showed no significant difference between any of the readings from both thermometers at the 0.01 level of significance.

Since there was no significant difference statistically, the null hypothesis must be accepted. The alternate hypothesis was rejected. Table 4 shows the data.

Table 4. Summary Table of Analysis of Variance for Electronic Thermometer Readings of Fast and Extended Modes and Glass Clinical Thermometer Readings at Three, Five and Nine Minutes on 50 Patients Taken by Three Nurses

Source	Sums of Squares	Degrees of Freedom	Mean of Squares	F
Between subjects		49		
Within subjects		700		
A Nurses	1.534	2	0.767	0.066
B Instruments	30.428	4	7.607	0.662
AB	0.672	8	0.084	0.007
Error	7,872.946	686	11.476	
Total	8,324.174	749	11.113	

Interpretation of Findings

Temperatures were taken on 50 adult patients, first with the electronic thermometer, using the fast mode and extended mode, then with the glass clinical thermometer reading it at three, five and nine minutes. The difference between the readings was found to be of no significance statistically by doing an analysis of variance. The null hypothesis was accepted.

It was noticed that the differences, although not statistically significant, were greatest between the two instruments. There was

much less variation between the recordings of the three nurses than between the readings of the instruments.

The statistical finding was based on the entire 50 persons, but patients must be treated individually, so some importance should be placed on the individual readings. The variations ranged from 0.1 of a degree F. to 4.2 degrees F. between the fast mode with the electronic thermometer and the nine minute readings with the glass clinical thermometer. These variations could certainly make a difference in the intervention by a nurse and the decision of a physician in the care of the patient.

Some of the differences in the raw data may be attributed to human error, as there was no way provided to double check the thermometer readings. Each nurse was taught the proper use of the electronic thermometer, however if the probe was inserted too quickly, it could cause some of the differences between the fast mode and the other readings obtained.

There was one problem when involving hospital patients for this type of study. There was difficulty in taking the temperatures one immediately after the other, as patients were taken from the ward to other departments of the hospital for treatments, tests, and other purposes. This delayed or prevented completing the procedure within the approximate one-half hour.

Cross-hatching was done on the raw data to enable the

researcher to compare the temperatures taken on each patient. (Appendices C and D)

The temperatures that were not more than 0.2 of a degree F. from the highest with the electronic thermometer were 1) fast mode 8 per cent, 2) extended mode 37 per cent, and with the glass clinical thermometer 1) three minutes 28 per cent, 2) five minutes 42 per cent, 3) nine minutes 64 per cent.

The temperatures that were not more than 0.5 of a degree F. from the highest with the electronic thermometer were 1) fast mode 48 per cent, 2) extended mode 82 per cent, and with the glass clinical thermometer 1) three minutes 80 per cent, 2) five minutes 92 per cent, 3) nine minutes 99 per cent. These findings are shown on Table 5.

Table 5. Percentage of Each Type of Reading Not More Than 0.2 and 0.5 of a Degree F. From the Highest Reading.

Readings	0.2	0.5
Fast mode	8%	48%
Extended mode	37%	82%
Three minute	28%	80%
Five minute	42%	92%
Nine minute	64%	99%

The fact that three different people took these temperatures may have some influence on the results. It seemed that the nurse

who took the patients' temperature last got a higher reading in most cases.

Studies reported that the optimum placement time for the glass clinical thermometer is seven to nine minutes. Assuming that the highest temperature is the most accurate, this project showed that the nine minute recordings of the glass thermometer were more accurate. On the basis of this, there is need for further consideration of textbook recommendations of placement time for the glass clinical thermometer.

It was found that the readings of the extended mode with the electronic thermometer closely agreed with that of the three minute using the glass clinical thermometer.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

The purpose of the study was to compare the readings of the Temspar electronic thermometer with those of the glass clinical thermometer. The data were collected on 50 hospital and nursing home patients. Three people, a registered nurse, licensed practical nurse, and a nurses' aide took the temperatures first with the electronic thermometer using the fast and extended modes, then with the glass clinical thermometer reading at three, five and nine minutes, in that sequence. Data collection took four consecutive days in May 1971, between the hours of 9 a.m. and 3 p.m.

An analysis of variance showed no statistical difference between the electronic thermometer and the glass clinical thermometer, and also no statistical difference between the three, five and nine minute readings of the glass clinical thermometer or between readings made by three people who took the temperatures. The findings were such that the null hypothesis, there is no significant difference between the temperature readings from the electronic thermometer of the fast and extended modes, and the glass clinical thermometer at the

three, five and nine minute readings, as taken and recorded by three different people, was accepted.

Although the difference was not statistically significant, there were differences varying from 0.1 of a degree F. to 4.2 degrees F. It could be speculated that with acutely ill patients this difference might result in changes in therapy.

Only 48 per cent of the temperatures taken with the electronic thermometer fast mode were within 0.5 of a degree F. of the highest temperature. The extended mode compared closely to the three minute reading with the glass clinical thermometer. If it can be assumed that the highest temperatures are the most accurate, based on the findings of this study the nine minute readings with the glass clinical thermometer were the most accurate.

Conclusions

On the basis of a study done with 50 patients none of whom was acutely ill, no generalizations can be made. Certain weaknesses become apparent; these have led to recommended changes in any replication. The findings do suggest such conclusions as

1. Variations in temperature readings exist according to type of measuring device and length of time instrument is in place.

2. Nursing textbooks do not agree on the placement time for glass clinical thermometers. Those textbooks do not mention the electronic thermometer.

Recommendations

1. Based on the findings of this study a replication is recommended with the following changes:

   a. use an electronic thermometer from another company to see if there is a difference in the performance.

   b. involve a group of willing people who are not hospital patients. This would prevent interruptions and delays encountered with hospital patients.

   c. take the temperatures rectally. The cooling effect of the metal tip of the electronic thermometer on the tissues in the mouth is not present in the rectal area. The rectal area has a complex of blood vessels near the mucus membrane. Because of this difference in structure, the electronic thermometer may be more accurate and useful for rectal temperatures.

   d. rotate personnel taking the temperatures and rotate the instruments to determine if the final readings

are always higher or if this rotating has any effect on the temperatures recorded.

e. arrange for some person to verify readings and recordings.

2. Replicate with changes as suggested above but select participants who are febrile.

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APPENDICES

APPENDIX A

Data Collection Sheet

APPENDIX A

Data Collection Sheet

NURSE I

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.

NURSE II

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.

NURSE III

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.

APPENDIX B

Pilot Study

APPENDIX B

PILOT STUDY

Temperatures of Seven Volunteers, Well Persons, Taken First with the Electronic Thermometer and Then with the Glass Clinical Thermometer, by Three Nurses

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	98.5	98.8	98.8	99.0	99.1	1	98.7	98.5	98.4	98.6	98.8	1	97.5	98.1	98.4	98.6	98.6
2	98.5	98.9	98.6	98.8	99.0	2	98.1	98.2	97.8	97.8	98.0	2	98.6	99.1	98.6	99.0	99.0
3	98.3	98.5	98.4	98.4	98.4	3	98.2	98.6	98.6	98.6	98.6	3	98.8	98.4	98.6	98.6	98.7
4	98.8	99.0	98.6	98.6	98.8	4	98.5	98.8	98.2	98.2	98.6	4	98.4	98.8	98.4	98.6	98.8
5	98.2	98.8	99.0	99.0	99.0	5	98.2	98.6	98.6	98.7	98.7	5	98.5	98.5	98.4	98.6	98.7
6	98.9	98.9	98.8	99.0	99.0	6	98.3	98.6	98.6	98.6	98.8	6	98.8	99.0	99.0	99.2	99.2
7	96.8	97.8	98.0	98.0	98.2	7	97.9	97.9	97.4	97.9	98.0	7	97.7	98.0	97.8	98.0	98.0

APPENDIX C

Cross-hatching of all Temperatures taken on 50 Patients which are within 0.5 of a degree F. of the Highest Temperature of each Patient

APPENDIX C

Cross-hatching of All Temperatures Taken on 50 Patients Which are within 0.5 of a Degree F. of the Highest Temperature of Each Patient

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	97.1	97.1	97.6	97.6	97.8	1	97.7	97.9	98.0	98.0	98.0	1	97.9	98.1	98.0	98.0	98.1
2	97.5	97.9	98.2	98.4	98.6	2	97.9	98.6	98.0	98.0	98.6	2	98.1	98.9	98.6	98.6	98.6
3	96.9	97.3	97.6	97.8	98.6	3	97.6	97.7	98.0	98.2	98.6	3	96.7	97.6	97.6	98.2	98.6
4	98.3	98.7	98.4	98.4	98.6	4	98.6	98.6	98.2	98.2	98.4	4	98.1	98.7	98.2	98.2	98.4
5	98.4	98.7	98.0	98.2	98.6	5	98.6	98.8	98.4	98.6	98.6	5	96.9	97.3	97.6	97.6	98.0
6	97.1	97.6	97.6	97.6	97.8	6	96.3	97.1	97.0	97.6	97.8	6	97.5	98.2	97.8	98.0	98.0
7	97.1	97.5	97.6	97.8	98.0	7	97.0	97.4	97.6	97.6	97.8	7	97.7	98.0	98.0	98.0	98.0
8	99.5	99.8	100.0	100.1	100.2	8	99.9	100.1	100.0	100.1	100.1	8	99.9	100.1	100.0	100.1	100.1
9	98.7	98.7	98.8	98.8	98.8	9	98.0	98.5	98.4	98.6	98.6	9	97.7	98.5	99.0	99.0	99.0
10	97.6	98.0	97.6	98.0	98.0	10	97.9	98.0	98.1	98.1	98.1	10	97.7	98.0	98.1	98.4	98.6
11	97.8	98.1	98.0	98.0	98.2	11	97.0	97.4	97.6	98.0	98.0	11	97.4	97.4	98.1	98.4	98.4
12	99.4	99.1	98.8	99.2	99.4	12	99.0	99.4	98.0	98.4	98.1	12	99.1	99.1	99.3	99.4	99.4
13	98.5	98.6	98.4	98.4	98.6	13	96.9	97.3	98.0	98.1	98.4	13	98.1	98.3	98.4	98.6	98.6
14	97.7	97.9	98.0	98.0	98.2	14	97.9	98.0	98.0	98.0	98.1	14	97.6	97.6	98.0	98.0	98.2
15	97.9	98.7	98.6	98.6	98.8	15	97.9	98.4	98.6	98.7	98.8	15	97.3	97.7	98.6	98.6	98.6
16	97.3	97.7	98.0	98.0	98.2	16	97.3	98.0	97.6	97.9	98.0	16	97.1	98.0	98.0	98.0	98.0
17	97.2	97.5	97.2	97.3	97.4	17	97.3	97.9	97.2	97.4	97.9	17	97.3	97.4	98.4	98.4	98.4

APPENDIX C. (continued)

NURSE I

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
18	95.3	95.7	95.4	96.2	96.8
19	97.2	97.3	96.6	97.2	97.8
20	97.9	99.1	99.2	99.2	99.4
21	99.1	99.3	99.0	99.0	99.0
22	96.1	96.2	97.6	97.7	97.8
23	97.7	97.7	97.6	97.6	97.8
24	96.9	96.8	98.2	98.4	98.6
25	97.9	98.1	98.2	98.4	98.4
26	96.9	97.6	97.6	97.8	98.0
27	97.7	98.0	98.2	98.2	98.4
28	97.7	97.5	98.2	98.2	98.4
29	96.3	96.6	96.4	96.4	96.6
30	97.7	97.9	98.0	98.0	98.2
31	97.7	97.7	97.6	97.9	98.2
32	98.5	98.4	98.4	98.4	98.4
33	97.3	97.3	97.8	97.8	98.0
34	97.5	97.8	97.4	97.4	97.4

NURSE II

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
18	97.6	98.0	97.9	98.0	98.0
19	96.3	96.6	97.4	97.4	97.7
20	98.8	99.2	99.1	99.2	99.6
21	98.6	99.3	99.0	99.0	99.1
22	97.9	98.4	98.6	98.7	98.8
23	97.6	98.0	97.6	97.8	98.2
24	97.7	98.4	97.9	98.0	98.6
25	97.4	98.0	98.1	98.2	98.4
26	97.6	98.0	98.0	98.0	98.4
27	97.9	98.0	98.4	98.5	98.6
28	98.3	99.1	99.0	99.0	99.2
29	96.3	97.0	97.0	97.2	97.3
30	97.9	98.0	97.8	98.0	98.1
31	96.9	97.7	97.9	97.9	98.0
32	97.9	98.3	98.0	98.2	98.4
33	97.3	98.0	98.0	98.0	98.0
34	97.1	97.5	97.0	97.1	97.4

NURSE III

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
18	96.7	97.3	97.0	97.1	97.4
19	97.9	98.0	98.0	98.1	98.1
20	98.3	98.6	95.6	98.4	98.4
21	99.4	99.4	98.7	99.1	99.2
22	97.9	98.3	98.1	98.1	98.1
23	94.0	96.6	96.8	96.8	97.8
24	97.7	98.5	98.4	98.4	98.6
25	97.5	98.1	97.8	97.8	97.8
26	97.9	98.0	98.0	98.1	98.1
27	98.1	97.9	98.0	98.0	98.0
28	98.1	98.9	98.6	98.7	98.8
29	95.9	97.2	96.6	96.6	96.6
30	98.0	97.7	98.0	98.0	98.0
31	97.7	97.9	98.0	98.0	98.0
32	97.9	97.9	97.9	97.9	98.4
33	97.9	98.1	97.9	97.9	98.0
34	96.9	97.4	97.4	97.4	97.6

APPENDIX C. (continued)

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
35	95.0	95.6	97.0	97.4	98.2	35	95.1	96.2	97.0	98.0	98.0	35	96.1	96.2	97.8	98.0	98.0
36	96.5	96.7	97.0	97.4	97.4	36	96.1	96.9	97.0	97.4	97.4	36	96.1	97.1	97.6	97.6	97.8
37	97.9	98.2	98.2	98.4	98.4	37	97.3	97.7	98.0	98.0	98.4	37	97.3	98.4	98.4	98.4	98.4
38	96.9	96.8	97.0	97.0	97.6	38	97.0	97.3	96.9	97.8	98.0	38	96.9	97.8	97.4	97.8	97.8
39	98.6	98.7	98.8	98.8	99.0	39	97.9	98.3	98.6	98.6	98.8	39	98.0	97.9	98.4	98.6	98.6
40	97.7	97.7	98.0	98.2	98.2	40	98.1	98.3	98.2	98.2	98.2	40	97.6	98.0	98.2	98.2	98.2
41	97.3	97.6	95.4	96.4	96.8	41	97.0	97.0	97.0	97.0	97.4	41	97.1	97.1	97.2	97.4	97.4
42	96.9	97.1	97.0	97.2	97.4	42	96.7	97.1	96.8	96.8	97.0	42	96.9	97.0	97.1	97.1	97.4
43	98.1	98.2	98.0	98.2	98.2	43	98.1	98.7	98.2	98.2	98.2	43	98.5	98.3	97.9	98.2	98.2
44	96.7	98.9	98.6	98.6	98.8	44	98.8	99.0	98.6	98.7	99.0	44	98.6	98.8	98.6	98.6	98.6
45	98.3	98.6	98.4	98.4	98.4	45	98.1	98.6	98.0	98.4	98.4	45	98.1	98.1	98.4	98.4	98.4
46	98.1	98.6	98.0	98.0	98.4	46	98.1	98.6	98.0	98.2	98.4	46	98.4	98.5	98.4	98.4	98.4
47	97.6	98.5	98.2	98.2	98.2	47	98.6	98.7	98.2	98.4	98.6	47	97.9	98.5	98.8	98.8	98.8
48	97.6	97.6	97.6	97.8	97.9	48	97.6	97.9	97.6	97.9	97.9	48	97.7	97.9	97.8	98.0	98.0
49	96.3	96.7	96.0	96.2	96.4	49	98.2	98.4	98.0	98.0	98.2	49	96.9	96.8	96.8	96.8	96.9
50	96.9	97.6	97.4	97.4	97.5	50	96.0	96.2	96.0	96.4	96.8	50	97.7	97.8	97.4	97.6	97.9

APPENDIX D

Cross-hatching of all Temperatures Taken on 50 Patients which are within 0.2 of a degree F. of the Highest Temperature of each Patient

APPENDIX D

Cross-hatching of All Temperatures Taken on 50 Patients Which are within 0.2 of a Degree F. of the Highest Temperature of Each Patient

NURSE I

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	97.1	97.1	97.6	97.6	97.8
2	97.5	97.9	98.2	98.4	98.6
3	96.9	97.3	97.6	97.8	~~98.6~~
4	98.3	~~98.7~~	98.4	98.4	~~98.6~~
5	98.4	~~98.7~~	98.0	98.2	~~98.6~~
6	97.1	97.6	97.6	97.6	97.8
7	97.1	97.5	97.6	~~97.8~~	~~98.0~~
8	99.5	99.8	~~100.0~~	~~100.1~~	~~100.2~~
9	98.7	98.7	~~98.8~~	~~98.8~~	~~98.8~~
10	97.6	98.0	97.6	98.0	98.0
11	97.8	98.1	98.0	98.0	~~98.2~~
12	~~99.4~~	99.1	98.8	~~99.2~~	~~99.4~~
13	~~98.5~~	~~98.5~~	~~98.4~~	~~98.4~~	~~98.6~~
14	97.7	97.9	~~98.0~~	~~98.0~~	~~98.2~~
15	97.9	~~98.7~~	~~98.6~~	~~98.6~~	~~98.8~~
16	97.3	97.7	~~98.0~~	~~98.0~~	~~98.2~~
17	97.2	97.5	97.2	97.3	97.4

NURSE II

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	97.7	~~97.9~~	~~98.0~~	~~98.0~~	~~98.0~~
2	97.9	98.6	98.0	98.0	98.6
3	97.6	97.7	98.0	98.2	~~98.6~~
4	~~98.6~~	~~98.6~~	98.2	98.2	98.4
5	~~98.6~~	~~98.8~~	98.4	~~98.6~~	~~98.6~~
6	96.3	97.1	97.0	97.6	97.8
7	97.0	97.4	97.6	97.6	~~97.8~~
8	99.9	~~100.1~~	~~100.0~~	~~100.1~~	~~100.1~~
9	98.0	98.5	98.4	98.6	98.6
10	97.9	98.0	98.1	98.1	98.1
11	97.0	97.4	97.6	98.0	98.0
12	99.0	~~99.4~~	98.0	98.4	99.1
13	96.9	97.3	98.0	98.1	~~98.4~~
14	97.9	~~98.0~~	~~98.0~~	~~98.0~~	~~98.1~~
15	97.9	98.4	~~98.6~~	~~98.7~~	~~98.8~~
16	97.3	~~98.0~~	97.6	97.9	~~98.0~~
17	97.3	97.9	97.2	97.4	97.9

NURSE III

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	97.9	~~98.1~~	~~98.0~~	~~98.0~~	~~98.1~~
2	98.1	~~98.9~~	98.6	98.6	98.6
3	96.7	97.6	97.6	98.2	~~98.6~~
4	98.1	~~98.7~~	98.2	98.2	98.4
5	96.9	97.3	97.6	97.6	98.0
6	97.5	~~98.2~~	97.8	~~98.0~~	~~98.0~~
7	97.7	~~98.0~~	~~98.0~~	~~98.0~~	~~98.0~~
8	99.9	~~100.1~~	100.0	~~100.1~~	~~100.1~~
9	97.7	98.5	~~99.0~~	~~99.0~~	~~99.0~~
10	97.7	98.0	98.1	~~98.4~~	~~98.6~~
11	97.4	97.4	98.1	~~98.4~~	~~98.4~~
12	99.1	99.1	~~99.3~~	~~99.4~~	~~99.4~~
13	98.1	98.3	~~98.4~~	~~98.6~~	~~98.6~~
14	97.6	97.6	~~98.0~~	~~98.0~~	~~98.2~~
15	97.3	97.7	~~98.6~~	~~98.6~~	~~98.6~~
16	97.1	~~98.0~~	~~98.0~~	~~98.0~~	~~98.0~~
17	97.3	97.4	~~98.4~~	~~98.4~~	~~98.4~~

APPENDIX D. (continued)

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
18	95.3	95.7	95.4	96.2	96.8	18	97.6	98.0	97.9	98.0	98.0	18	96.7	97.3	97.0	97.1	97.4
19	97.2	97.3	96.6	97.2	97.8	19	96.3	96.6	97.4	97.4	97.7	19	97.9	98.0	98.0	98.1	98.1
20	97.9	99.1	99.2	99.2	99.4	20	98.8	99.2	99.1	99.2	99.6	20	98.3	98.8	95.6	98.4	98.4
21	99.1	99.3	99.0	99.0	99.0	21	98.6	99.3	99.0	99.0	99.1	21	98.4	98.4	98.7	99.1	99.2
22	98.1	98.2	97.6	97.7	97.8	22	97.9	98.4	98.6	98.7	98.8	22	97.9	98.3	98.1	98.1	98.1
23	97.7	97.7	97.6	97.6	97.8	23	97.6	98.0	97.6	97.8	98.2	23	94.0	96.6	96.8	96.8	97.8
24	96.9	98.3	98.2	98.4	98.6	24	97.7	98.4	97.9	98.0	98.6	24	97.7	98.5	98.4	98.4	98.6
25	97.9	98.1	98.2	98.4	98.4	25	97.4	98.0	98.1	98.2	98.4	25	97.5	98.1	97.8	97.8	97.8
26	96.9	97.6	97.6	97.8	98.0	26	97.6	98.0	98.0	98.0	98.4	26	97.9	98.0	98.0	98.1	98.1
27	97.7	98.0	98.2	98.2	98.4	27	97.9	98.0	98.4	98.5	98.6	27	98.1	97.9	98.0	98.0	98.0
28	97.7	97.5	98.2	98.2	98.4	28	98.3	99.1	99.0	99.0	99.2	28	98.1	98.9	98.6	98.7	98.8
29	96.3	96.6	96.4	96.4	96.6	29	96.3	97.0	97.0	97.2	97.3	29	95.9	97.2	96.6	96.6	96.6
30	97.7	97.9	98.0	98.0	98.2	30	97.9	98.0	97.8	98.0	98.1	30	98.0	97.7	98.0	98.0	98.0
31	97.7	97.7	97.6	97.9	98.2	31	96.9	97.7	97.9	97.9	98.0	31	97.7	97.9	98.0	98.0	98.0
32	98.5	98.4	98.4	98.4	98.4	32	97.9	98.4	98.0	98.2	98.4	32	97.9	97.9	97.9	97.9	98.4
33	97.3	97.3	97.8	97.8	98.0	33	97.3	98.0	98.0	98.0	98.0	33	98.9	98.1	97.9	97.9	98.0
34	97.5	97.8	97.4	97.4	97.4	34	97.1	97.5	97.0	97.1	97.4	34	96.9	97.4	97.4	97.4	97.6

APPENDIX D. (continued)

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
35	95.0	95.6	97.0	97.4	98.2	35	95.1	96.2	97.0	98.0	98.0	35	96.1	96.2	97.8	98.0	98.0
36	96.5	96.7	97.0	97.4	97.4	36	96.1	96.9	97.0	97.4	97.4	36	96.1	97.1	97.6	97.6	97.8
37	97.9	98.2	98.2	98.4	98.4	37	97.3	97.7	98.0	98.0	98.4	37	97.3	98.4	98.4	98.4	98.4
38	96.9	96.8	97.0	97.0	97.6	38	97.0	97.3	96.9	97.8	98.0	38	96.9	97.8	97.4	97.8	97.8
39	98.6	98.7	98.8	98.8	99.0	39	97.9	98.3	98.6	98.6	98.8	39	98.0	97.9	98.4	98.6	98.6
40	97.7	97.7	98.0	98.2	98.2	40	98.1	98.3	98.2	98.2	98.2	40	97.6	98.0	98.2	98.2	98.2
41	97.3	97.6	95.4	96.4	96.8	41	97.0	97.0	97.0	97.0	97.4	41	97.1	97.1	97.2	97.4	97.4
42	96.9	97.1	97.0	97.2	97.4	42	96.7	97.1	96.8	96.8	97.0	42	96.9	97.0	97.1	97.1	97.4
43	98.1	98.2	98.0	98.2	98.2	43	98.1	98.7	98.2	98.2	98.2	43	98.5	98.3	97.9	98.2	98.2
44	98.7	98.9	98.6	98.6	98.8	44	98.8	99.0	98.6	98.7	99.0	44	98.6	98.8	98.6	98.6	98.6
45	98.3	98.6	98.4	98.4	98.4	45	98.1	98.6	98.0	98.4	98.4	45	98.1	98.1	98.4	98.4	98.4
46	98.1	98.6	98.0	98.0	98.4	46	98.1	98.6	98.0	98.2	98.4	46	98.4	98.5	98.4	98.4	98.4
47	97.6	98.5	98.2	98.2	98.2	47	98.6	98.7	98.2	98.4	98.6	47	97.9	98.5	98.8	98.8	98.8
48	97.6	97.6	97.6	97.8	97.9	48	97.6	97.9	97.6	97.9	97.9	48	97.7	97.9	97.8	98.0	98.0
49	96.3	96.7	96.0	96.2	96.4	49	98.2	98.4	98.0	98.0	98.2	49	96.9	96.8	96.8	96.8	96.9
50	96.9	97.6	97.4	97.4	97.5	50	96.0	96.2	96.0	96.4	96.8	50	97.7	97.8	97.4	97.6	97.9

APPENDIX E

Raw Data

APPENDIX E

Temperatures of 50 Adult Persons Taken by Three Nurses, First with Electronic Thermometer using Fast and Extended Modes and then Glass Clinical Thermometer Reading at Three, Five and Nine Minutes

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
1	97.1	97.1	97.6	97.6	97.8	1	97.7	97.9	98.0	98.0	98.0	1	97.9	98.1	98.0	98.0	98.1
2	97.5	97.9	98.2	98.4	98.6	2	97.9	98.6	98.0	98.0	98.6	2	98.1	98.9	98.6	98.6	98.6
3	96.9	97.3	97.6	97.8	98.6	3	97.6	97.7	98.0	98.2	98.6	3	96.7	97.6	97.6	98.2	98.6
4	98.3	98.7	98.4	98.4	98.6	4	98.6	98.6	98.2	98.2	98.4	4	98.1	98.7	98.2	98.2	98.4
5	98.4	98.7	98.0	98.2	98.6	5	98.6	98.8	98.4	98.6	98.6	5	96.9	97.3	97.6	97.6	98.0
6	97.1	97.6	97.6	97.6	97.8	6	96.3	97.1	97.0	97.6	97.8	6	97.5	98.2	97.8	98.0	98.0
7	97.1	97.5	97.6	97.8	98.0	7	97.0	97.4	97.6	97.6	97.8	7	97.7	98.0	98.0	98.0	98.0
8	99.5	99.8	100.0	100.1	100.2	8	99.9	100.1	100.0	100.1	100.1	8	99.9	100.1	100.0	100.1	100.1
9	98.7	98.7	98.8	98.8	98.8	9	98.0	98.5	98.4	98.6	98.6	9	97.7	98.5	99.0	99.0	99.0
10	97.6	98.0	97.6	98.0	98.0	10	97.9	98.0	98.1	98.1	98.1	10	97.7	98.0	98.1	98.4	98.6
11	97.8	98.1	98.0	98.0	98.2	11	97.0	97.4	97.6	98.0	98.0	11	97.4	97.4	98.1	98.4	98.4
12	99.4	99.1	98.8	99.2	99.4	12	99.0	99.4	98.0	98.4	99.1	12	99.1	99.1	99.3	99.4	99.4
13	98.5	98.5	98.4	98.4	98.6	13	96.9	97.3	98.0	98.1	98.4	13	98.1	98.3	98.4	98.6	98.6
14	97.7	97.9	98.0	98.0	98.2	14	97.9	98.0	98.0	98.0	98.1	14	97.6	97.6	98.0	98.0	98.2
15	97.9	98.7	98.6	98.6	98.8	15	97.9	98.4	98.6	98.7	98.8	15	97.3	97.7	98.6	98.6	98.6
16	97.3	97.7	98.0	98.0	98.2	16	97.3	98.0	97.6	97.9	98.0	16	97.1	98.0	98.0	98.0	98.0
17	97.2	97.5	97.2	97.3	97.4	17	97.3	97.9	97.2	97.4	97.9	17	97.3	97.4	98.4	98.4	98.4

APPENDIX E. (continued)

NURSE I						NURSE II						NURSE III					
Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer			Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.		Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
18	95.3	95.7	95.4	96.2	96.8	18	97.6	98.0	97.9	98.0	98.0	18	96.7	97.3	97.0	97.1	97.4
19	97.2	97.3	96.6	97.2	97.8	19	96.3	96.6	97.4	97.4	97.7	19	97.9	98.0	98.0	98.1	98.1
20	97.9	99.1	99.2	99.2	99.4	20	98.8	99.2	99.1	99.2	99.6	20	98.3	98.8	95.6	98.4	98.4
21	99.1	99.3	99.0	99.0	99.0	21	98.6	99.3	99.0	99.0	99.1	21	99.4	99.4	98.7	99.1	99.2
22	98.1	98.2	97.6	97.7	97.8	22	97.9	98.4	98.6	98.7	98.8	22	97.9	98.3	98.1	98.1	98.1
23	97.7	97.7	97.6	97.6	97.8	23	97.6	98.0	97.6	97.8	98.2	23	94.0	96.6	96.8	96.8	97.8
24	96.9	98.3	98.2	98.4	98.6	24	97.7	98.4	97.9	98.0	98.6	24	97.7	98.5	98.4	98.4	98.6
25	97.9	98.1	98.2	98.4	98.4	25	97.4	98.0	98.1	98.2	98.4	25	97.5	98.1	97.8	97.8	97.8
26	96.9	97.6	97.6	97.8	98.0	26	97.6	98.0	98.0	98.0	98.4	26	97.9	98.0	98.0	98.1	98.1
27	97.7	98.0	98.2	98.2	98.4	27	97.9	98.0	98.4	98.5	98.6	27	98.1	97.9	98.0	98.0	98.0
28	97.7	97.5	98.2	98.2	98.4	28	98.3	99.1	99.0	99.0	99.2	28	98.1	98.9	98.6	98.7	98.8
29	96.3	96.6	96.4	96.4	96.6	29	96.3	97.0	97.0	97.2	97.3	29	95.9	97.2	96.6	96.6	96.6
30	97.7	97.9	98.0	98.0	98.2	30	97.9	98.0	97.8	98.0	98.1	30	98.0	97.7	98.0	98.0	98.0
31	97.7	97.7	97.6	97.9	98.2	31	96.9	97.7	97.9	97.9	98.0	31	97.7	97.9	98.0	98.0	98.0
32	98.5	98.4	98.4	98.4	98.4	32	97.9	98.3	98.0	98.2	98.4	32	97.9	97.9	97.9	97.9	98.4
33	97.3	97.3	97.8	97.8	98.0	33	97.3	98.0	98.0	98.0	98.0	33	97.9	98.1	97.9	97.9	98.0
34	97.5	97.8	97.4	97.4	97.4	34	97.1	97.5	97.0	97.1	97.4	34	96.9	97.4	97.4	97.4	97.6

APPENDIX E. (continued)

NURSE I

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
35	95.0	95.6	97.0	97.4	98.2
36	96.5	96.7	97.0	97.4	97.4
37	97.9	98.2	98.2	98.4	98.4
38	96.9	96.8	97.0	97.0	97.6
39	98.6	98.7	98.8	98.8	99.0
40	97.7	97.7	98.0	98.2	98.2
41	97.3	97.6	95.4	96.4	96.8
42	96.9	97.1	97.0	97.2	97.4
43	98.1	98.2	98.0	98.2	98.2
44	98.7	98.9	98.6	98.6	98.8
45	98.3	98.6	98.4	98.4	98.4
46	98.1	98.6	98.0	98.0	98.4
47	97.6	98.5	98.2	98.2	98.2
48	97.6	97.6	97.6	97.8	97.9
49	96.3	96.7	96.0	96.2	96.4
50	96.9	97.6	97.4	97.4	97.5

NURSE II

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
35	95.1	96.2	97.0	98.0	98.0
36	96.1	96.9	97.0	97.4	97.4
37	97.3	97.7	98.0	98.0	98.4
38	97.0	97.3	96.9	97.8	98.0
39	97.9	98.3	98.6	98.6	98.8
40	98.1	98.3	98.2	98.2	98.2
41	97.0	97.0	97.0	97.0	97.4
42	96.7	97.1	96.8	96.8	97.0
43	98.1	98.7	98.2	98.2	98.2
44	98.8	99.0	98.6	98.7	99.0
45	98.1	98.6	98.0	98.4	98.4
46	98.1	98.6	98.0	98.2	98.4
47	98.6	98.7	98.2	98.4	98.6
48	97.6	97.9	97.6	97.9	97.9
49	98.2	98.4	98.0	98.0	98.2
50	96.0	96.2	96.0	96.4	96.8

NURSE III

Patient Number	Electronic Thermometer		Glass Thermometer		
	Fast Mode	Ext. Mode	3 min.	5 min.	9 min.
35	96.1	96.2	97.8	98.0	98.0
36	96.1	97.1	97.6	97.6	97.8
37	97.3	98.4	98.4	98.4	98.4
38	96.9	97.8	97.4	97.8	97.8
39	98.0	97.9	98.4	98.6	98.6
40	97.6	98.0	98.2	98.2	98.2
41	97.1	97.1	97.2	97.4	97.4
42	96.9	97.0	97.1	97.1	97.4
43	98.5	98.3	97.9	98.2	98.2
44	98.6	98.8	98.6	98.6	98.6
45	98.1	98.1	98.4	98.4	98.4
46	98.4	98.5	98.4	98.4	98.4
47	97.9	98.5	98.8	98.8	98.8
48	97.7	97.9	97.8	98.0	98.0
49	96.9	96.8	96.8	96.8	96.9
50	97.7	97.8	97.4	97.6	97.9

AN ABSTRACT OF THE THESIS OF

Annette Lofftus

For the Master of Science in Nursing Education

Date of Receiving this degree June 9, 1972

Title: A STUDY OF TEMPERATURES TAKEN WITH AN ELECTRONIC THERMOMETER AND GLASS CLINICAL THERMOMETER

Approved: [redacted]
Associate Professor in charge of Thesis

A study was made to compare the readings of the Temspar electronic thermometer with those of the glass clinical thermometer. The data were collected on 50 hospital and nursing home patients. Three people, a registered nurse, licensed practical nurse, and a nurses' aide took the temperatures first with the electronic thermometer using the fast and extended modes, then with the glass clinical thermometer reading at three, five, and nine minutes, in that sequence.

An analysis of variance showed no statistical differences between the electronic thermometer and the glass clinical thermometer,

2. Nursing textbooks do not agree with the placement time for glass clinical thermometers. Those textbooks do not mention the electronic thermometer.

Recommendations

1. Based on the findings of this study a replication is recommended with the following changes, a) use an electronic thermometer from another company, b) involve a group of willing people who are not hospital patients, c) take the temperatures rectally, d) rotate personnel taking temperatures and rotate the instruments and e) arrange for some person to verify readings and recordings.

2. Replicate with changes as suggested above but select participants who are febrile.