Abstract. The measurement of response time of pulse oximeter lacks standardized method and proper thresholds and alternative measurement methods are needed to minimize error and improve efficiency in calibration method of pulse oximeter due to the increasing number of pulse oximeter variations distributed due to the covid 19 pandemic. This study aims to measure the Response Time (RT) of a finger pulse oximeter with 6 different types of conditioning to determine the RT mean and standard deviation in order to classify the pulse oximeter based on their types. We evaluated the response time of 50 finger pulse oximeters (20 patient monitor type, 8 handheld type, and 22 fingertip type) using 6 saturation and desaturation conditioning methods with a SpO2 Simulator. Quantitative analysis used to determine the initial threshold value. From 50 pulse oximeters found the fastest response pulse oximeter are fingertip type with mean time are 9.71 seconds and the most stable of each conditioning pulse oximeter are patient monitor type with the average RT 3.47 seconds, and Handheld type are put in the middle. With the conclusion that Patient monitor type are classified in monitoring class, Handheld type are classified both in monitoring and diagnostic class and Fingertip both classified in diagnostic and preventive class.

Keywords: Response time; Calibration; Quantitative Analysis; Patient Monitor; Handheld; Fingertip

1 Introduction

Blood oxygen saturation measured by a pulse oximeter is the interpretation of oxygen bound by hemoglobin in arterial blood vessels. Reduced vascular oxygen saturation occurs due to cardiovascular and respiratory disruptions, leading to insufficient oxygen supply to organs and potential malfunction. Brain malfunction poses a high risk since it regulates overall body functions, potentially resulting in organ failure and death [1].

Pulse oximeters play a vital role in assessing patients' physical condition and have seen increased use due to the COVID-19 pandemic [2]. Originally used in critical care settings, such as operating rooms and intensive care units, they are now commonly used in the community for diagnosis and preventive measures [2]. Despite their widespread use, medical personnel often lack knowledge about the limitations and principles behind their function, In addition, providers do not know the basic principles behind the mechanism of its function, that it has limitations, which can lead to errors in oxygen saturation readings. Understanding these limitations and ensuring proper testing and calibration is crucial [4].

Testing is the process of physically examining, measuring, and assessing the function of a medical device by comparing it to a standard device to determine any measurement errors. On the other hand, calibration is performed to verify the accuracy of a device's indicator value. This procedure is carried out by the Health Facility Inspection Centre (Balai Pengamanan Fasilitas Kesehatan / BPFK) and private calibration agencies in accordance with the work methods issued by the Directorate General of the Ministry of Health of the Republic of Indonesia [6]. In the case of pulse oximeter devices, testing involves conducting physical, functional, and electrical safety checks. Calibration is performed by measuring heart rate and oxygen saturation parameters at specific measuring points [7]. One of the ways to check the device's function is by examining the response time.

The response time of a pulse oximeter refers to the delay between the appearance of arterial hypoxemia (low oxygen levels in the blood) and its detection by the pulse oximeter. Several factors influence the response time, including blood perfusion, skin and nail color, hemoglobin levels, body movement, sensor placement, sensor type, and the quality of device components and connections [8] [4]. This delay in response can lead to errors in oxygen saturation readings, particularly in situations where rapid changes in oxygen saturation are
expected, such as during cardiopulmonary resuscitation, when handling patients with compromised airways, in pediatric patients, delivery mothers with congenital heart or lung disease, or for the early detection of happy hypoxia in COVID-19 patients [8] [9] [10]. Therefore, it is necessary to have a shorter response time for detecting hypoxemia with pulse oximeters [8].

The response time of different pulse oximeters can vary. Some devices have an average response time of 8-15 seconds in default mode, 130 seconds under normal conditions, and 215 seconds when the patient has mild hypothermia [10]. The response time is closely related to the circulation time of blood. Pulse oximeters placed in large blood vessels near the heart, such as the head, earlobes, and trachea, have a faster response time compared to peripheral parts like fingers and toes [11], [12]. To summarize, response time in pulse oximeters refers to the delay in detecting arterial hypoxemia. Factors such as blood perfusion, skin and nail color, hemoglobin levels, body movement, sensor placement, sensor type, and device quality can influence the response time. A shorter response time is necessary for accurate detection of hypoxemia in various clinical situations. Different pulse oximeters have varying response times, with faster detection in devices placed closer to the heart.

Measurement of pulse oximeter response time in the pre-calibration function check process is currently carried out qualitatively with subjective considerations from officers in determining whether the device has a fast or slow response, based on comparisons between pulse oximeters. This is due to the absence of guidance on the method of determining the pulse oximeter response time threshold, from the Director General of Healthcare in 2018. In recent years, the use of pulse oximeters in the community has increased, so that new brands appear on the market that are not well controlled for quality, including the quality of the device's response time. This can reduce the validity of the saturation number indicated by the device, which in turn can lead to errors in determining saturation results and taking necessary medical actions. Therefore, in addition to testing and calibration, proper threshold of response time needs to be done. This is to minimize the possibility of oxygen saturation reading errors by calibration officers and medical personnel, due to pulse oximeters that have a slow response time, and improve the efficiency of the testing and calibration process.

Previous research related to pulse oximeter response time, using a pulse oximeter with a brand and a limited number of devices [4], as well as in certain conditions of hypoxemia in human patients that cause a decrease in the accurate response of the pulse oximeter [13], indicate the need for an alternative method to measure response time of pulse oximeters, as the accuracy of oxygen saturation values can be compromised by uncontrolled variables. One proposed solution is to use a simulator or artificial finger instead of human patients, reducing the influence of uncontrolled variables and allowing for multiple measurements without risking patient harm. The classification model derived from this research divides data into three classes: preventive, diagnostic, and monitoring, each tailored to the specific use of the pulse oximeter.

2 Method

2.1 Pulse Oximeter Calibration

![Fig. 1. Two relationships between R-ratio and oxygen saturation of patients](image)

\[
SaO_2 = \frac{c_o}{c_o + c_n} = \frac{a_{r_2} - a_{r_1}}{(a_{r_2} - a_{o_2})R - (a_{r_1} - a_{o_1})}
\] (1)

Pulse oximeters originally employed equation (1) during their early 1980s manufacturing phase to compute arterial SaO2. However, the use of Beer-Lambert's law as the calculation basis inadequately considered the scattering of light by red blood cells. Despite utilizing an alternate technique, oximetry only partially compensates for scattering due to wavelength variations. Equation (1) is an oversimplification. Figure 1 illustrates two relationships: one based on Beer-Lambert's law applying to computed data from empirical data, connecting the R ratio and patient oxygen saturation. Devices following Beer-Lambert's law often inaccurately estimate oxygen saturation, particularly below 85% SaO2 values. Over time, methods have emerged to incorporate scattering into the theory.

Today, many pulse oximeters rely on lookup tables derived from calibration studies involving healthy volunteers with invasively measured oxygen saturation [12].

2.2 SpO2 Simulator

SpO2 Simulator is a device used as a reference for pulse oximeters, with adjustable parameters (oxygen saturation percentage, heart rate, and blood perfusion percentage) that includes an artificial finger part for testing. Annex FF of ISO 80601-2-61 standard clarifies the distinction between "calibrator" and "simulator." A calibrator is a primary standard with higher accuracy than the Unit Under Test (UUT), while a simulator is a transfer standard that serves as a validated reference. As
described in figure 3. Pulse oximeters use two light wavelengths and the ratio of pulsatile and non-pulsatile signals to determine oxygen saturation. The monitor firmware calculates the R value and displays the oxygen saturation percentage and pulse rate with the comparisons between these values as describe in figure 2. Objective performance verification of pulse oximeters has been challenging [13].

![Fig. 2. R-curve, correlation with O₂ saturation with R value [13]](image)

![Fig. 3. SpO₂ Simulator and how to use it in a pulse oximeter sensor [14]](image)

### 2.3 Materials

The study used 50 finger pulse oximeter with 3 different types of devices consist of 20 patient monitor type (PM), 8 handheld type (HH) and 22 fingertip type (FT) (figure 2). The purpose of selecting these three types of equipment as measuring objects is because they are commonly used in various settings, including hospitals, health centers, and by the general public. Each type of equipment has specific specifications that cater to different consumer needs. For example, patient monitors are frequently found in hospitals, particularly in intensive care units and operating rooms, as they can be used continuously. Fingertip pulse oximeters, on the other hand, have a small and lightweight design and are relatively inexpensive, making them suitable for use by the general public and in health centers. Handheld pulse oximeters have higher specifications than fingertip oximeters and are easier to carry compared to patient monitors, making them ideal for intense usage in emergency departments and intensive care units for measurements at any time.

![Fig. 4. (a) Pulse oximeter fingertip[14]. (b) Pulse oximeter Handheld[15]. (c) Pulse oximeter patient monitor[16]](image)

To ensure the suitability of the pulse oximeter as a measuring object, established reliability standards for the device. The tested device must meet accuracy and precision standards based on the calibration method. This includes the difference between the device's readability and a 1% difference in oxygen saturation within the range of 100-85% oxygen saturation. It is even better if the device possesses a certificate of fitness for use issued by an authorized testing and calibration institution. The tools using in this research are described in the table 1.

<table>
<thead>
<tr>
<th>Tools</th>
<th>Brand / Type</th>
<th>Parameter</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SpO₂ Simulator</td>
<td>Fluke / Spotlite</td>
<td>Oxygen Saturation</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heart Rate</td>
<td>Beat Per Minute</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perfusion Index</td>
<td>%</td>
</tr>
<tr>
<td>Stopwatch</td>
<td>Extech</td>
<td>Time</td>
<td>second</td>
</tr>
<tr>
<td>Thermo hygrometer</td>
<td>Greisinger or Extech</td>
<td>Temperature</td>
<td>°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relative Humidity</td>
<td>%RH</td>
</tr>
</tbody>
</table>

### 2.4 Method

The method of data acquisition involves taking samples by measuring the response time of the 50 finger pulse oximeter in two ways: placing the device on the index finger or thumb, as shown in Figure 5a, and measuring time using a stopwatch; and placing the device on the SpO₂ Simulator and measuring time using a stopwatch, as shown in Figure 5b. Sampling data from the pulse
oximeter response time is performed to measure the accuracy and precision of the measurements at different oxygen saturation conditions. The following conditions are considered:

1) The pulse oximeter is turned on but not yet placed on the finger until a stable result is obtained.
2) The pulse oximeter is turned on but not yet installed on the SpO2 Simulator until stable results are achieved with specific value settings on the simulator such as: 100 %, 99 %, 98 %, 97 %, 95 %, 90 %, 85 %, 80 %, 75 %, and 75 %.
3) The pulse oximeter is turned on and attached to an SpO2 Simulator with high to low oxygen saturation values set (desaturation), measured between points such as: 100-99 %, 98-99 %, 97-95 %, 95-90 %, and 90-85 %.
4) The pulse oximeter is turned on and attached to an SpO2 Simulator with low to high oxygen saturation value settings (re-saturation), measured between points such as: 85-90 %, 90-95 %, 95-97 %, 97-98%, 98-99 %, and 99-100 %.
5) The pulse oximeter is turned on and attached to an SpO2 Simulator with oxygen saturation values set from normal to hypoxemia, with three different oxygen saturation conditions. Such as: 100-95 %, 100-90 %, 100-85 %, 99-95 %, 99-90 %, 99-85 %, 98-95 %, 98-90 %, and 98-85 %.
6) The pulse oximeter is turned on and attached to an SpO2 Simulator with hypoxemia oxygen saturation values set to normal, with three different oxygen saturation conditions. Such as 95-100 %, 95-100 %, 85-100 %, 95-99 %, 90-99 %, 95-98 %, 90-98 %, and 90-85 %.

The data is presented in form of a graph of oxygen saturation values towards response time, with certain saturation setting conditions according to the tables 1-6. And the research location is at calibration laboratory of LPFK Banjarbaru, as well as at hospitals and health facilities that are willing to collect sampling data in kalimantan.

This research begins with the process of acquiring Response Time (RT) data from 50 pulse oximeters. This RT value is obtained by measuring the pause time in the oxygen saturation measurement process on the pulse oximeter attached to the researcher's finger and artificial finger on the simulator, with 6 different conditions according to the explanation in section 3.1. After the RT value of each condition is measured, the measurement data will be analyzed using quantitative analysis in accordance with the explanation in the theoretical basis section 2.4 to obtain the type of distribution of the data set. The results of this analysis will then be compared with references from other medical research journals related to pulse oximeter RT, to see if there is any relevance of the measurement results of the RT measured using the previous research method with the method used by the researcher.

The results of this analysis were also compared with medical journal references related to the time lag threshold of pause hypoxemia detection, especially in medical conditions related to anaesthesia and respiratory abnormalities. This is to assess whether the response time of the current pulse oximeter meets the time lag threshold of hypoxemia detection or not.

The output of this analysis process will result in the grouping of RT values into 3 groups, namely monitoring, diagnosis, and preventive groups. This division is made based on the use of the pulse oximeter in health services, with the fastest response in the monitoring group, and the longest response in the preventive group. In brief, the division of these groups is divided with the following considerations:

1. Monitoring: intended for pulse oximeters that are used continuously and are expected to detect changes in oxygen saturation values in patients quickly and precisely to speed up the treatment process if there are indications of hypoxemia. For example, use in the ICU room, in the operation process in the OK room, and so on.
2. Diagnosis: intended to detect the oxygen saturation value at the beginning of the measurement. As a tool to help doctors diagnose a disease related to oxygen saturation values. It is expected that the pulse oximeter used in this process brings up an accurate value at the beginning of the measurement, thus minimizing the risk of taking pulse oximeter measurements that do not match the actual oxygen saturation value. For example, use in Emergency Units, inpatient units, and so on.
3. Preventive: intended for the screening process or homecare in patients with indications that may experience a decrease in oxygen saturation at any time. It is hoped that the use of this pulse oximeter can help detect early if there is
hypoxemia in the patient. For example, it is used in patients who are undergoing self-isolation due to Covid-19 infection, screening before the Covid-19 antigen or PCR examination process, and in the medical check-up process.

2.5 Data Analysis

Pulse oximeter data were analyzed quantitatively with descriptive and inferential analysis using Microsoft Excel applications.

3 RESULTS

Most of the measured pulse oximeter devices are from Idaman Banjarbaru district hospital from various treatment rooms. Meanwhile, the other data was obtained from devices sent to the laboratory from various healthcare facilities in Kalimantan. The difference in the quantity of these three types of devices is due to the difference in the number of devices available in hospitals and other healthcare facilities. The most commonly used equipment is patient monitors and fingertip oximeters, while the availability of Handhelds tends to be limited in hospitals. This is because fingertip oximeters are easy to use due to their small size, and patient monitors have comprehensive features for examining patients, such as Electrocardiograph (ECG), temperature, Non-invasive blood pressure (NIBP), Respiration rate (RR), oxygen saturation, and other features. On the other hand, Handhelds type only have one feature and are not as compact as fingertip oximeters. This is why Handhelds are not widely used for measuring oxygen saturation in healthcare facilities.

An overview of the distribution of average values and standard deviations obtained from 50 devices, which were used to measure the direct oxygen saturation on the finger. The range of average values spans from 6 to 18 seconds, while the range of standard deviations ranges from 0 to 4 seconds. Device 6, FT exhibited the highest average value and standard deviation. On the other hand, device 36, HH displayed the lowest average value, whereas device 4, FT had the lowest standard deviation. Notably, devices number 5 and 6, both manufactured by the brand Onecare, demonstrated average values and standard deviations that fell outside the overall range of the devices. The overall average of the average values across all devices amounted to 8.64 seconds, with a total standard deviation of 0.95 seconds. The results of analysis of first conditioning data acquisition shows in terms of average, the smallest one is FT at 8.30 seconds and the highest is HH at 12.05 seconds. In terms of standard deviation, the smallest to the highest are PM (1.89 seconds), HH (3.38 seconds), and FT (4.02 seconds). From the clustering graph in figure 6a, based on the average and standard deviation, there are 2 instruments that have results outside the group, namely instrument 6 with an average of 17.92 and a standard deviation of 4.26 seconds, and instrument 13 with an average of 13.32 and a standard deviation of 4.14 seconds.

An overview of the distribution of average values and standard deviations obtained from 50 devices from second conditioning was found that each device displayed fluctuating averages and standard deviations. The device with the highest average RT was number 17, which had a value of 15.48 seconds and belonged to the PM. On the other hand, device number 36 had the highest standard deviation, measuring 9.46 seconds, and belonged to the Handheld category. Device number 3, also HH, exhibited the lowest averages and standard deviations. The overall average measurement of RT was 8.69 seconds, with a corresponding average standard deviation of 2.24 seconds.

The additional graph 5b indicates that the highest average is possessed by PM, while the other two types have averages below the overall average. The lowest average is found in the FT. Meanwhile, the standard deviation of PM shows the most stable value compared to the other two. In the standard deviation graph of the HH, there is an increase in RT starting from an oxygen saturation of 98% and it experiences a decline when the oxygen saturation approaches 97% and then there is a gradually increase until it reaches its peak at the 85%-point mark within 10 seconds. Afterward, it experiences a decline when the oxygen saturation approaches 70%. Additional figure 2b revealed that three devices, namely 16, 36, and 44, had values that deviated from the average and standard deviation graph. Devices 36 and 44 were FT, while device 16 belonged to the FT type.

From the results of measurement of 3rd conditioning there are a few devices that exhibit fluctuating values compared to the overall average of 11.67 seconds. Therefore, in this measurement, the range of results has a wide range, with the highest average value of 21.44 seconds obtained from device 27 and the lowest average value of 4.90 seconds obtained from device 11. The highest standard deviation is observed in device 16 with a value of 12.70, while the lowest is obtained by device 1 with a value of 0.50. Devices 1 and 27 belong to the PM type, while devices 11 and 16 belong to the FT type.

In graph in additional figure 1c, the average values for each point for the Handheld and patient monitor types exhibit similar characteristics. There is a gradual increase in RT as the oxygen saturation value decreases. However, there is a decrease in RT values at a saturation range of 90-85%. On average, FT has lower values compared to the overall average. Meanwhile, the FS and PM types have average values above the overall
average. The highest average value is attributed to the FS type with a value of 13.36 seconds, while the lowest average belongs to the FT type with a value of 9.52 seconds. The lowest standard deviation is observed in the HH type with a value of 3.45 seconds, whereas the patient monitor type has the highest standard deviation with a value of 5.12 seconds. In terms of standard deviation, the patient monitor type has the highest average value compared to other types, but the graph for each point shows that the patient monitor type has a relatively constant standard deviation. On the other hand, other types exhibit fluctuations and have the highest values at the saturation range of 97-95%.

According to the clustering results shown in Figure 2c, which compare the averages and standard deviations, there are 4 tools that do not fall into any data group: tools 3, 12, 13, and 16. Tool 3 belongs to the FS type, while tools 12, 13, and 16 belong to the FT type. This measurement reveals the existence of 2 distinct groups: one with an average range of 5-15 seconds and a standard deviation below 6 seconds, and another with an average of 20 seconds and a standard deviation below 2 seconds. The group with an average of 20 seconds shares a common characteristic, which is being classified as the PM type and having the same brand, Philips.

The results of measurements of 4th conditioning indicates that the average range of these measurements is 6 to 16 seconds. As for the standard deviation, it falls within the range of 0 to 6 seconds, with some instruments exceeding this range of values. The overall average of the 50 values is 11.07 seconds, with a standard deviation average of 3.12 seconds. The instrument with the highest average is instrument 26, with a value of 17.57 seconds, while the lowest is instrument 6, with a value of 5.53 seconds. The highest standard deviation is found in instrument 12, with a value of 17.57 seconds, and the lowest is in instrument 43, with a value of 0.81 seconds.

In graph 5d, it can be observed that the fourth conditioning measurement exhibits an inverted curve compared to the third conditioning. Thus, it can be generally concluded that higher saturation values result in lower response time. The average characteristic of fingertip is lower than the overall average, while the average for PM and HH is higher than the overall average. However, there is a difference in the curve for PM, where there is no increase in response time values at the saturation of 90-95%, unlike FT and FS. The standard deviation generated by FT and HH experiences significant fluctuations at points 90-95% and 97-98%. On the other hand, the curve generated by PM tends to be constant across the point changes and below the average standard deviation value. The highest average response time is for PM type with a value of 13.45 seconds, and the lowest is for FT type with a value of 9.04 seconds. Meanwhile, the highest standard deviation is for FT type with a value of 4.53 seconds, and the lowest is for PM type with a value of 3.42 seconds.

After performing clustering by comparing two values, namely the average and standard deviation shown in figure 6d, the range of results falling within the linear line is from an average range of 5 to 20 seconds and a standard deviation below 6 seconds. There are 4 instruments that have measurements outside of the cluster, namely instruments 12, 16, 36, and 50. Instrument 16 is of type FS, while the rest are of type FT.

From the measurement results of 50 instruments with 5th conditioning, the range of average values obtained is 6 to 20 seconds. There is an instrument, namely instrument 5 (FT-type), that has a relatively high average and standard deviation outside the range of other instruments, with an average value of 27.81 seconds and a standard deviation of 22 seconds. The smallest average value is found in instrument 4 (FT type) with a value of 6.56 seconds, and the smallest standard deviation is in instrument 25 with a value of 0.71 seconds (PM type). The total average value is 14.23 seconds, and the average value of the standard deviation is 2.92 seconds.

In additional figure 1e, the measurement results of the average value for FT-type instruments show lower values compared to other instrument types and the overall average. On the other hand, PM and FS types have values above the overall average. However, for each data point, PM exhibits a tendency of constant values for each given change, while other types show significant variations, especially for FT-type instruments. Similar to the previous graph, the standard deviation for each data point is more stable for PM compared to other instrument types, with different characteristics for each type of instrument. The highest average value is found in FS with a value of 15.70 seconds, while the lowest is in FT instruments with a value of 12.27 seconds. As for the standard deviation, the highest value is observed in FT-type instruments with a value of 7.27 seconds, and the lowest value is in PM-type instruments with a value of 4.29 seconds.

According to the graph shown in figure 6e, there is 1 instrument that has a significantly different value compared to its group, which is instrument 5 of FT type. Additionally, there are 2 instruments whose standard deviation values are outside the range of their respective groups, namely instrument 6 of FT type and instrument 3 of FS type. There are instruments that have an average range above 20 seconds, with a very small standard deviation (approaching 0). These 5 instruments share the same characteristics, as they have the same brand and
The results of measurement of 6th conditioning indicates the range of average values obtained is 6 – 20 seconds. There are 3 devices with values above this range, namely devices 13, 16, and 50 with device type FT. On the other hand, the standard deviation has a range between 0 – 10 seconds, with the two highest values being device 6 with a standard deviation of 10.11 seconds and device 50 with a standard deviation of 8.35 seconds.

According to the information shown in additional figure 1f, the average results for PM exhibit a stable curve and higher values compared to the other 2 types of instruments, surpassing the overall average value. The curve tendency for all types tends to decrease as the normal saturation value setting decreases. The highest average is observed in PM with a value of 14.81 seconds, while the lowest is in FT with a value of 11.57 seconds. The highest standard deviation is found in FT with a value of 5.91 seconds, and the lowest is in FS with a value of 1.22 seconds. Figure 6e shows that the range of average values is from 6 to 20 seconds.

The clustering results shown in the plotting diagram in figure 6f, where the average values are compared with the standard deviation values, indicate measurement results within the range of 5-20 seconds for the average values and 0-6 seconds for the standard deviation. There are 4 devices that have values outside this range, namely devices 6, 13, 16, and 50 with fingertip device type.

4 DISCUSSION

PM exhibits the highest average value the first conditioning and the longest in the fifth and sixth conditioning. The graph shows a higher RT average value compared to other devices, with a more linear shape in comparison. The fastest standard deviation occurs in the first conditioning, whereas the longest is observed in the third data. However, the RT of the PM is more stable compared to other types. Therefore, PM is suitable for and classified as monitoring pulse oximeter for conditions that require consistent RT for each change in oxygen saturation. Despite not responding as quickly as other devices, PM provides better stability compared to other types, along with the capability to measure other required parameters in the monitoring process, especially in condition necessitating continuous monitoring of vital patients such as surgical rooms and intensive care units.

For FT type, the fastest average value and standard deviation were found in the second data conditioning and the longest in the fifth data conditioning. These showed that for the initial response to the value of each oxygen saturation, the FT type has fastest response to read the oxygen saturation value, but slowest response in desaturation oxygen changes from normal to hypoxemia. Subsequently, FT type is very suitable to be classified and used for preventive and diagnostic pulse oximeter, considering that the speed of response is superior to other pulse oximeter type. In addition, FT physical form is small and compact, making it suitable and handy for high mobility usage such as in emergency rooms, outpatient rooms, screening patients for medical check-up, and etc. this oximeter type also appropriate for home use for the wider community which only takes measurements at a certain time for monitoring their oxygen saturation.

For HH type, the fastest mean value is found in the second data, and the longest mean value is found in data 3 and 5. The most unstable standard deviation is found in data 2, while the most stable standard deviation is found in data 4 and 6. It can be concluded that just like the FT type, Handheld is appropriate for use in the initial examination because it has an initial response to different saturation values that are fast. As for saturation conditions from high to low values, for measurements between points and normal oxygen saturation values to hypoxemia handhelds tend to detect longer when compared to those values measured from low to high oxygen saturation values, but in general this type tends to be stable for measurements with oxygen saturation values that rise and fall between points and from normal to hypoxemia values. This makes it suitable for initial screening as well as for continuous screening. From its use in the hospital. This tool is placed in the NICU, ICU and partly in the emergency room. With the aim of being able to take measurements during non-real-time periodic monitoring carried out by medical personnel to record data on critical patients and emergency departments every hour. Due to the large battery capacity and display of the tool, but the size of this type of tool is not too large when compared to the PM type, allowing the use of this tool with high mobility but with the position of the tool remaining standby around the room where it is used. So this tool is possible if it is included in the monitoring and diagnostic class when viewed from the response and characteristics of this type of tool.
For the total device, the fastest average value was found in data 1, while the longest average value was found in data 5 and 6. The most unstable standard deviation was found in conditions 3 and 4. This is in line with the principle that the higher the distance from the decrease or increase in oxygen saturation, the longer the device response will be. It was also found that the response on the finger was much faster when compared to the pulse oximeter response on the simulator. This is because the simulator uses an artificial finger which produces a smaller and more stable signal when compared to a human finger which produces a larger and fluctuating signal.

5 CONCLUSION

Response time (RT) of the three types of sensors, namely patient monitor, fingertip, and handheld have different characteristics. RT for the type of pulse oximeter on the patient monitor has a longer average response when compared to the other two types, but RT remains stable in all types of measurements both at high and low saturation. In the fingertip type there is a fast RT with an average of 3 seconds, but the lower the measured oxygen saturation value, the RT also slows down. And there are several tools that have RTs that are quite high from the average RT of other tools and RTs that are inconsistent in several measurement parameters. In the practice of data collection, the author found that some of these inconsistent devices were generally pulse oximeters without brands or were brands that had just spread in the communities.

For the overall RT range as shown in table 2, the mean range of the RT 50 pulse oximeter measurements is 4 - 22 seconds, while the standard deviation is 0 - 23 seconds. By continuing to include data that is outside the range of each conditioning, for the average range with the highest value of 22 seconds is still a fairly fast value when compared to the highest RT value of around 27 seconds. While for standard deviation, 23 seconds is a range far enough that it is necessary to add pulse oximeter data to ensure this range is still included in the average or not.

6 ACKNOWLEDGMENTS

Alhamdulillahi rabbil alamin, I thank Allah for all the favors that the author has received and the ease of working on this report, as well as both parents who always encourage and finance my studies. Then I would like to thank the supervisor and Mrs. Rini and Mrs. Arni who have always helped me from the beginning until now.

7 REFERENCES


