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Effectiveness of Hae-Band in Measuring Hb Levels in Postpartum Hemorrhage Risk Monitoring

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Abstract
Postpartum hemorrhage is the main cause of high morbidity in the world (75%). Until now, efforts to early detect the risk of postpartum hemorrhage have still not been maximized. Sensor-based smartband can be the development of non-invasive methods in an effort to early detection of declining Hb levels in monitoring the risk of bleeding with practical, fast, precise, accurate, and practical. This research aims to determine the effectiveness of developing and analyzing the effectiveness of the "Hae-band" smartband in monitoring the risk of postpartum hemorrhage. The research method used is Research and Development (R&D), a quasi-experimental one-group pretest-posttest design using a nonequivalent dependent variable. The sampling technique in this research uses non-probability sampling with purposive sampling type. Respondents were selected by purposive sampling with a sample of 35 respondents maternity up to 6 hours postpartum to measure Hb levels and analyze the average levels of Hb and declining levels of HB Hae-band, HB meter POCT and visual estimation of blood loss volume compared with HB meter POCT (gold standard). Data analysis using the descriptive test, validation test, Paired T-Test, Independent T-Test, and multiple linear regression. The research results show that the Hae-band has been developed and is feasible as a measure of Hb levels which has a sensitivity of truth tool as much as 70.0% and can detect a decrease in Hb levels as much as 63.9% (p=0.000) more partially effective than visual estimation (0.24%) Smartband can detect Hb levels with good results compared to the gold standard of blood tests with a difference of 0.324 g/dL (p.0.113) with an average Hb levels at 6 hours PP at 11.19 g/dL compared to the average POCT 11.34 g/dL. This research concludes that Hae-band is more effective in detecting postpartum hemorrhage risk than visual estimation. It is hoped that further research can develop a more modern design where the sensor is more comfortable to use for long periods and has an alternative way of reading the sensor other than on the wrist. Improving accuracy, sensitivity, and higher battery power by improving the type of design, sensor, and wave type to be more suitable for measuring Hb levels can also be developed considering the efficiency of maternal monitoring and recording in the era of digitalization in early detection of bleeding risk.

Keywords: Hae-band, Hb level, Visual Estimation, Postpartum Hemorrhage Risk.

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1. INTRODUCTION

The maternal mortality rate in developing countries is 430 per 100,000 live births compared to 12 per 100,000 live births in developed countries. 94% of maternal deaths in developing countries are caused by bleeding, including bleeding originating from inside the uterus (80-90%), lacerations (10-20%) and coagulopathy (<1%) with as many as 27% of maternal deaths caused by postpartum hemorrhage (James et al., 2022).

Post-partum hemorrhage is the main cause of high maternal morbidity and mortality in most countries in the world. (WHO, 2022) Approximately 14 million women experience bleeding every year, resulting in 70,000 maternal deaths worldwide. Postpartum hemorrhage is the main cause of maternal mortality in developed and developing countries. (James et al., 2022) The number of maternal deaths in Indonesia has increased from 4,627 in 2020 to 7,389 in 2021 with hemorrhage contributing 1,330 cases of the total number of cases (Kementerian Kesehatan Republik Indonesia, 2022).

The maternal mortality rate in East Java is around 184 deaths per 100,000 live births in the 2020 LF SP results. Jember Regency is the district with the highest number of death cases in East Java with 115 cases and 61 cases of postpartum maternal deaths with 9.62% caused by bleeding (Dinas Kesehatan Jawa Timur, 2021). Maternal deaths in Jember Regency in 2022 amounted to 28 pregnant women due to pre-eclampsia - eclampsia (31%), bleeding (25%), infection (12%) and prolonged labor (6%) (Dinas Kesehatan Kabupaten Jember, 2022).

Death due to bleeding can be avoided with the correct diagnosis time, right resources, and right management. The reduction in the death rate due to bleeding is proof that the treatment and prevention of bleeding has been carried out well (Adisasmita, 2017). However, the impact of postpartum hemorrhage is not only the threat of death, morbidity resulting from postpartum hemorrhage such as anemia, fatigue, depression, and the risk of blood transfusions also endanger the mother's condition (Simanjuntak, 2020).

The government in its efforts to reduce the incidence of mortality and morbidity in pregnant, giving birth and postpartum women, especially in reducing the number of postpartum hemorrhages to date, is by innovating a health service system that prioritizes active management of the third stage by ensuring that there are health workers who are trained and expert in the management of the third stage, advocacy for the availability of oxytocin, the existence of protocols for preventing and treating bleeding cases, as well as monitoring to detect bleeding events (Putra et al., 2020).

Monitoring blood loss is one effort that can be done to prevent complications from the risk of bleeding (Diaz et al., 2018).Visual estimation is a common method currently applied throughout the world to measure blood loss after delivery. However, the use of this visual method is considered less accurate in determining the amount of blood loss because blood can be mixed with amniotic fluid or urine, making it difficult for visual assessments to be carried out by health workers (Bell et al., 2020).

Previous research shows that visual estimation has a low rate of objectivity at 9.6% in detecting blood loss. This really depends on the skills and experience of the monitoring health worker. Therefore, an objective and accurate method is needed to monitor the risk of bleeding (Sada et al., 2021).

Measuring Hb levels is an examination method that is felt to have greater value in monitoring the risk of postpartum hemorrhage compared to other invasive and non-invasive methods. Hb levels are the main component in transporting oxygen throughout the body and can indicate anemia and blood deficiency (Ningsi et al., 2023).

The American College of Obstetricians and Gynecologists states that quantitative methods have been proven to be more accurate than visual estimates. This method is Gravimetry. This method is carried out by weighing the item to calculate the difference in weight of the item before and after use with an estimate of the volume of blood lost equivalent to the weight of the blood weighed (I gram = 1 mL) (Katz & Farber, 2021). According to the study, the gravimetric

method considers external blood loss whose conversion is only an estimate. The absence of separation between blood and fluid results in inaccurate measurements (Thurer et al., 2022).

The new prevention that has been developed is the use of technology that supports artificial intelligence which uses cellular technology and digital imaging algorithms using cameras to take images for analysis and measure hemoglobin and blood loss in real time (Obuna et al., 2020).

Appropriate technology in the health sector is currently experiencing rapid development. One technology that is considered capable of monitoring the risk of bleeding practically, quickly, precisely and accurately is the use of an oximeter sensor to monitor hemoglobin levels and oxygen saturation non invasively, continuously, and in real-team during labor. This method can be applied to smarbands (Hasan et al., 2021).

Checking Hb levels using a smartband is considered more practical and effective, including having a more compact form and being easy to carry anywhere without worrying about large storage space, which can be used at any time and does not require a long reading of the results.(Wisana et al., 2022). This research aims to determine the effectiveness of developing and analyzing the effectiveness of the "Hae-band" smartband in monitoring the risk of postpartum hemorrhage.

2.   RESEARCH METHOD

The research method used is Research and Development (R&D), a quasi-experimental one-group pretest-posttest design using a nonequivalent dependent variable. The method to improve active monitoring for postpartum mothers to detect postpartum bleeding. In this developed application there are: sensor feature (oximeter) that can measure hemoglobin levels to monitor the risk of bleeding before delivery and every 2 hours and 6 hours after delivery.

Research procedures in categories R&D consist of five procedures to produce final products so they are ready to be applied in the delivery of health services. The stages used are the adoption of a modified Borg and Gall model (Sugiyono, 2022). This research was carried out in the area of Sumbersari Jember Community Health Center for a period of 1 month, starting in December 2023.

The population in this study were 3rd trimester pregnant women with birth estimate between December 2023 and January 2024 with a total of 35 pregnant women. The sample for this study was women giving birth up to 6 hours postpartum in the working area of the Sumbersari Jember health center. The sampling technique in this research uses non-probability sampling with purposive sampling type. The sample size in this study was calculated using the Lemeshow formula, resulting in a sample size of 35 respondents

The independent variables in this study are Hae-band and Hb Meter PCT. The dependent variables are Hb levels and blood output volume. Data collection techniques use primary data and secondary data. Primary data was obtained from interviews with respondents and the results of checking Hb levels using tools, while secondary data was obtained from world, national, provincial, and regional data from the research location.

Univariate data analysis in the form of the frequency distribution of subject characteristics based on age, parity, history of anemia, and pregnancy interval. Analysis of bivariate data from Hae-band and Hb meter POCT examinations in this study used the paired-t test and independent t-test.

This research has received research ethics permission Number 1336/EA/KEPK/2023.

3.   RESULTS AND DISCUSSION

Table 1. Respondent Characteristics

Characteristics	Frequency (f)	Percentage (%)
Age		
< 20year	3	8.6
20 –35 years old	31	88.6
> 35year	1	2.9
Amount	35	100
Parity		
Nulliparous	9	25.7
Primipara	16	45.7
Multiparous	10	28.6
Amount	35	100
Pregnancy Distance		
First time pregnant	9	25.7
< 2year	1	2.9
2-10year	25	71.4
Amount	35	100

Table 1 shows that the majority of respondents are at the ideal age for giving birth between 20-35 years, namely 31 people (88.6%). The majority of respondents had only given birth to 1 child (Primipara), namely 16 people (45.7%) and the majority had an ideal birth spacing of 2-10 years, 25 people (71.4%).

Table 2. Results of different Hb level tests using Hae-band before giving birth and after 6 hours postpartum

Variable		N	Mean±SD	Correlation	Mean	Sig.
Hb Hae-band	Pretest	35	11.79 ± 0.774	0.891	0.651	0,000
	Posttest	35	11.19 ± 0.945			

Paired sample T-Test

Based on Table 2, it is found that the average difference in Hb levels between before giving birth and 6 hours postpartum is 0.651 g/dL. The results of the significant value from the difference test for Hb levels before and after 6 hours postpartum are <0.05, which indicates that there is a significant difference in the results of Hb levels before giving birth and at 6 hours postpartum.

Table 3. Analysis results of differences in Hb level results between the smartband and POCT Hb meter

Method		n	Q	Mean different	Std.	Sig.
Hb level	Hb meter POCT	35	1,606	0.342	21,350	0.113
	Hae-band	35	1,606			

Based on Table 3, it is known that the significance value of POCT and Hae-band Hb meter levels is 0.113, which is greater than 0.05, with an average of 0.342. So, according to the independent T-Test decision-making, it was found that there was no significant (real) difference between checking Hb levels using POCT and Hae-band Hb meters.

Table 4. Hae-band Partial Effectiveness Test Results and Visual Estimates of Hb Meter POCT

Method	Beta	Coefficient Correlation	SE(%)	R Square	p-value
Hae-band	0.788	0.812	63.9	0.664	0,000
Visual Estimation	-0.079	-0.316	0.24		

Table 4 show that The influence of Hae-band with Hb meter POCT as the gold standard for detecting Hb levels showed a result of 63.9%. Meanwhile, the magnitude of the partial effect of visual estimation in detecting a decrease in Hb levels with the POCT Hb meter shows a figure of 0.24% or in other words, it has an effectiveness of 0.24%. This shows that Hae-band is more effective in detecting a decrease in Hb levels in an effort to detect early postpartum risk compared to visual estimation, although both methods can be used simultaneously to produce better predictions of a decrease in Hb levels.

DISCUSSION
Characteristic Analysis Respondents Based on Age, Parity and Pregnancy Distance as Confounding Variables for Hae-band.

Age
The results of the research analysis showed that the average age of the respondents was obtained is reproductive age, namely 20-35 years (88.6%). Based on Ersalina's report, it was found that age has a relationship with Hb levels, where age ≤ 20 years tends to low Hb level data, this condition will change slowly with increasing age where Hb levels will tend to increase at age > 20 years and will decrease again when entering advanced age (≥ 50 years) (Nidianti et al., 2019).

This is not in line with the results of further analysis where this study shows that there is no influence between age and the results of Hb levels using Hae-band (sig. 0.141) where there is only a low relationship between age and the results of Hb levels that can be detected (0.249) (Muhammad, 2012).

Parity
In this study, it was found that 9 people (25.7%) were pregnant for the first time and had never given birth before, namely 16 people gave birth to 1 child (Primipara) (45.7%), and 10 people (28.6%) were multipara. Of the 10 respondents, 3 people had a parity number of 4, and the others < 4. The parity number shows the number of births that resulted in live or dead fetuses. Previous research conducted on Nulliparous respondents (women who have never given birth) using Co-Oximetry (SpHb) which was compared with blood tests in the laboratory, revealed that SpHb results tend to be higher than laboratory test results with an average bias of 1.22–1.36 g/dL (Alfiana et al., 2019).

Pregnancy Spacing
The majority of respondents in the study had ideal pregnancy spacing, namely > 2 years and < 10 years. The distance between pregnancies cannot directly affect the ability to detect Hb levels non-invasively, whether using sensor-based or device monitoring methods such as IoT (Internet of Things), but the distance between pregnancies can influence Hb levels in the blood, which can result in anemia or not (Siregar et al., 2023).

Hae-band can detect Hb levels at various sizes of pregnancy intervals. This is shown by the results of the analysis of this study where the distance between pregnancies has no influence on the results of Hb levels using Hae-band (sig. 0.679). This can be seen from respondents who

were pregnant for the first time and gave birth, finding that the Hb level by the smartband was 11.4 g/dL before giving birth and 11.2 g/dL after 6 hours of giving birth. This result is only 0.2 g/dL lower than measurements using a POCT Hb meter. This difference may occur due to technical factors related to data collection, calibration, and other factors besides gestational spacing (Liu et al., 2020).

Development and Feasibility of The Hae-band as a Tool For Measuring Hb Levels in Mothers Giving Birth Up to 6 Hours Postpartum

The Hae-band design has been successfully developed with the average difference compared to the POCT Hb meter as the gold standard for examination being 0.325 and resulting in a true sensitivity of the Hae-band tool in detecting Hb levels of 70.0% and an error rate of 30% in its ability to measure hemoglobin levels. non-invasively. This technique refers to the work of the *Photoplethysmograph* (PPG) which is a non-invasive method with the main principle of shining two different wavelengths of light through tissue and comparing the way the blood absorbs light below these wavelengths in the blood solution (Jahan et al., 2014). This research does not require any invasive blood samples, so it does not cause pain because the Hae-band uses a MAX30102 oximetry sensor which can process data on hemoglobin levels in the blood by detecting oxyhemoglobin (O2Hb) and deoxyhemoglobin (HHb) in the bloodstream via wavelengths (Kemalasari & Rochmad, 2022).

Comparative Analysis of Measuring Hb Levels Using Hae-band (Non-Invasive) with Hb Meter POCT (Invasive)

This research shows that there are differences in the results of measuring Hb levels before giving birth to 6 hours postpartum using both Hae-band and POCT Hb meters. This can be detected using both invasive and non-invasive Hb-level examination tools. The difference in results between Hae-band and Hb meter POCT can be based on several reasons, namely the use of equipment when collecting data that is less than optimal or other factors from the respondents. Even though there are differences, it is felt that the Hae-band can further improve alert conditions in detecting the risk of postpartum hemorrhage considering that the Hae-band gets a lower average measurement result than the Hb meter POCT which anticipates the lowest measurement of a decreased in Hb levels which can result in the risk of postpartum hemorrhage.

Analysis of the average results of an examination of postpartum maternal Hb levels up to 6 hours of research using Hae-band.

In this study, the average result of postpartum maternal Hb level examination before giving birth or during the first stage of labor using the "Hae-band" Smartband was 11.79 g/dL. Normal Hb levels in pregnant women who are preparing to give birth are > 11 g/dL and it can be said that they are not anemic. Low Hb levels before delivery can cause problems and complications such as: bleeding to death during childbirth, requiring treatment increased consumption of iron-rich intake, and administration of additional pregnancy supplements (Pratama et al., 2020).

The mean Smartband "Haeband" Hb level in respondents 6 hours after delivery was 11.04 g/dL. Normal Hb levels after giving birth for each woman vary depending on the individual's specific conditions, where generally normal Hb levels are in the range of 12-16 g/dL. However, generally mothers in labor experience a significant decrease in Hb levels after 6-48 hours of giving birth. This is in line with other research by Fasiha et al which states that the average decrease in Hb levels in pregnant women with normal delivery is 1.2 g/dL, which is a normal condition. This decrease occurs in normal circumstances after a normal delivery process with blood loss <500 ml (Fasiha et al., 2022).

Analysis of the Effectiveness of Using Hae-band Compared with Visual Estimation Methods in Monitoring The Risk Of Postpartum Hemorrhage.

In this study, it was found that visual estimation was effective with an influence size of 0.24%, while Hae-band development had an effectiveness of 63.9% in predicting the results of invasive reduction in hemoglobin levels on Hb meter using the POCT method with a simultaneous influence size of 66.4% as standard. gold inspection. This shows that the Hae-band is more effective in predicting a decrease in hemoglobin levels in an effort to monitor the risk of postpartum Hemorrhage (Aminuddin, 2021). Several researchers have stated that the visual estimation method is less accurate in detecting postpartum bleeding and requires objective measurement methods (Julieta & Giri, 2021).

This Hae-band series uses the Max30102 oximeter sensor which has been carried out in previous research. The results of measuring the tool using this sensor have an accuracy level of up to 94.91% in measuring Hb levels and 98.99% in measuring oxygen levels in the body as an infrared light emitter and photodetector because this type of sensor has low noise so it is easy to position (Muthmainnah & Tabriawan, 2022).

The working principle of the sensor in detecting Hb levels in this research is to use the PPG method, where when the LED light is turned on it will emit a light signal, when attached to the tissue it will enter the capillary blood vessels and there will be a change in the light intensity captured by the photodetector. These changes will be processed into data on the results of the respondent's Hb levels (Karina & Thohari, 2018).

In this research, there are several limitations related to tools and technical implementation, namely the absence of repeated testing on extreme data during use trials. The time for collecting pretest data on maternal Hb levels tends to be difficult controlled considering that the pretest examination was carried out in the 1st stage of labor. There are women in early 2nd stage labor who are checked because they consider the time or arrival of the patient's complete opening. This can affect the interpretation of Hb level results due to rushed data collection techniques. Reading Hb levels still uses a button by pressing it for approximately 2 seconds, this can result in pressing the button incorrectly and increase the time for collecting examination data to be longer. Use for a long time requires more power because the Haeband smartband uses a 3.7 volt battery which requires frequent but short charging times each time to avoid wear (weakening of function) in the battery which is adapted to the sensor.

4. **CONCLUSION**

The Hae-band has been developed as a tool to measure Hb levels as an additional instrument in an effort to early detect the risk of postpartum hemorrhage. The Hae-band was declared suitable as a tool for measuring Hb levels in mothers giving birth up to 6 hours postpartum with a tool sensitivity of 70.0% There was no significant difference between the results of Hae-band measurements (Non-invasive) and Hb meter blood collection using the POCT method (sig. 0.113) and the average value difference was 0.324 g/dL. The average hemoglobin level before delivery was 11.79 g/dL while the average hemoglobin level 6 hours after delivery was 11.19 g/Dl. The Hae-band was more effective than visual estimation in monitoring the risk of postpartum hemorrhage by 63.9% by showing a very strong correlation level with the Hb meter POCT method as the gold standard for examination (r=0.78).

It is hoped that further research can develop a more modern design where the sensor is more comfortable to use for long periods and has an alternative way of reading the sensor other than on the wrist. Improving accuracy, sensitivity and higher battery power by improving the type of design, sensor and wave type to be more suitable for measuring Hb levels can also be developed considering the efficiency of maternal monitoring and recording in the era of digitalization in early detection of bleeding risk.

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