Manuscript received June 01, 2024; revised June 3, 2024; accepted June 21, 2024; date of publication June 23, 2024
Digital Object Identifier (DOI):

The Impact of Utilizing Various Brands of Cuffs on the Outcomes of Aneroid Sphygmomanometer Measurements

Delsy Anwar[1], Agus Komarudin[2], and Vita Nurdinawati[3]
[1,2,3]Electromedical Engineering Department, Poltekkes Kemenkes Jakarta II, Jakarta, Indonesia

Corresponding author: Vita Nurdinawati (e-mail: vita.nurdinawati@poltekkesjkt2.ac.id).

ABSTRACT An aneroid sphygmomanometer is a medical instrument used to monitor blood pressure in humans. It consists of a cuff, a pump balloon, and a meter with a needle pointer. The objective of this study is to ascertain the impact of utilizing various brands of cuffs on measurement outcomes. The basic framework of this study was the assessment of blood pressure using five distinct brands of sphygmomanometers as the standard measuring tools, along with six cuffs from various brands. This study utilizes primary data collected by employing mandrel size as a surrogate for the dimensions of the human arm. Each sphygmomanometer was used to measure blood pressure, and this process was performed three times for each preset value. The data analysis method employed is descriptive quantitative, utilizing the two-way ANOVA test analysis tool. The fundamental principle behind the two-way ANOVA test analysis approach is to determine whether the different criteria being evaluated have an impact on the desired outcomes. It also allows for the comparison of several averages across numerous categories or groups for a single treatment variable. It was determined that there was a discernible distinction in the outcomes of aneroid sphygmomanometer measures when using various brands of cuffs, however this difference was not statistically significant. The mean value of all measurement settings at 50 mmHg, 100 mmHg, 150 mmHg, 200 mmHg, and 250 mmHg remain within the defined tolerance level of ± 3 mmHg.

INDEX TERMS aneroid sphygmomanometer, cuff brand; digital pressure meters, mandrel size, two-way ANOVA test.

I. INTRODUCTION

Blood pressure is one of the vital signs that can provide insights into an individual's bodily functioning. Vital signs encompass the measurements of blood pressure, body temperature, heart rate, and respiration rate [1]. Blood pressure refers to the force applied to the arterial walls as the heart propels blood throughout the body. According to the World Health Organization (WHO), 32% of the world's mortality in 2021 is due to cardiovascular disease, and there is a direct association between elevated blood pressure levels and cardiovascular disease [2] [3].

Blood pressure parameters are measured in millimeters of mercury (mmHg) and reported as two separate values: systolic and diastolic blood pressure [4]. Systolic blood pressure occurs when the ventricles contract and release blood into the arteries, whereas diastolic blood pressure occurs when the ventricles relax and fill with atrial blood.

Accuracy in measuring blood pressure is an important factor since blood pressure characteristics significantly influence disease diagnosis accuracy. Many diseases can be identified or suggested by an elevation or reduction in an individual's blood pressure. Normatively, it is expected that the brand of the sphygmomanometer should match the brand of the cuff, but in hospitals, it is common to see situations where a different brand of sphygmomanometer is used with a cuff that does not match its brand, or a branded cuff is used without any restrictions.

There are multiple brands of sphygmomanometers being used in health service facilities (Fasilitas Pelayanan Kesehatan, Fasyankes), each with its own set of pros and cons. Frequent and intense usage of the sphygmomanometer often leads to damage to the cuff attachments.

Initially, in order to provide assistance, a type of sphygmomanometer cuff that is not compatible with the specific brand of sphygmomanometer may be utilized. This is due to the unavailability of spare parts or the acquisition of the items from a local retailer specializing in medical equipment accessories.

Users frequently remark when comparing the brand of sphygmomanometer and the brand of cuff used that the measurement results are too dissimilar [5]. This raises the question of whether using a different brand of cuff can impact the measurement findings or not, so to find out the level of accuracy of the tool. The activity that follows is known as calibrating [6]. The sphygmomanometer accuracy value is limited to ≤ 3 mmHg, as per the allowable deviation level (tolerance) [2]. If the deviation (tolerance) value exceeds the limit, it can be determined that the tool does not match the requirements and is unfit for usage [3].

An electromedical technician plays a crucial role in ensuring the smooth management of medical equipment maintenance in hospitals. This includes ensuring that the equipment is in a ready and usable condition, effectively repairing medical equipment, using high-quality spare parts that meet the manufacturer's specifications, minimizing equipment downtime, which can all have an impact on safety, quality, and cost effectiveness. These factors ultimately affect the quality of patient care and the protection of both the management and medical staff [4].

II. MATERIAL AND METHOD

A. Experiment Settings

This study was conducted by collecting primary data utilizing a mandrel size as a surrogate for the human arm. Measurements were taken with five different brands of aneroid sphygmomanometers and six different brands of sphygmomanometer cuffs. Blood pressure measurements were taken with each sphygmomanometer and repeated three times at each preset value.

1. Material and tools

The instruments utilized in this study include aneroid sphygmomanometers, Digital Pressure Meter, sphygmomanometer cuffs.

2. Experiment

The conceptual framework of this study was developed by measuring blood pressure with an aneroid sphygmomanometer and a digital pressure meter. Blood pressure measurements were analyzed using the two-way ANOVA test.

B. BLOCK DIAGRAM

The values of 50 mmHg, 100 mmHg, 150 mmHg, 200 mmHg, and 250 mmHg are fixed variables that will remain constant during the investigation. The independent variables in this study consist of five branded cuffs and one unbranded cuff. These variables can provide measured values based on the specified settings, which in turn affect the findings of the dependent variable, namely the measurement outcomes. After the measurement results are collected, the average value of all pressure measurement results is determined, and a data normality test is performed, followed by a two-way ANOVA test on the received data. The two-way ANOVA test will determine if there are significant differences in values across different brands of cuffs. Figure 1. depicts all steps of the research process.

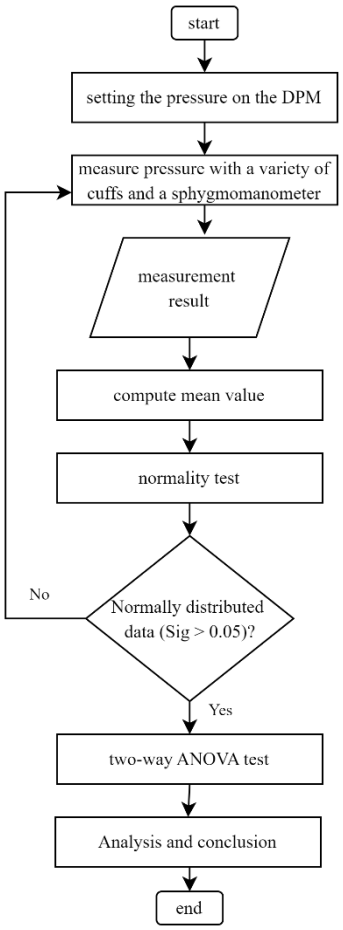

Figure 1. Data collection and analysis flowchart

III. RESULT

Data collection and analysis in this research was carried out using an aneroid sphygmomanometer as standard and a digital pressure meter for data collection. The study involved measuring blood pressure using 5 different brands of aneroid tensimeters. Every object underwent identical procedures, which involved measuring blood pressure using a standardized mandrel size and five various brands of cuffs, as well as one cuff that did not have a brand.

A. DATA RETRIEVAL

First, data is collected for each brand of aneroid sphygmomanometer as follows:

1. Measurement findings obtained with a Gea sphygmomanometer.

Spyghmomanometer brand: Gea	Setting value (mmHg)	Measurement Results		
Cufflinks brand:		I	II	III
Gea	50	49,5	50,9	50,7
	100	99,3	98,8	99,3
	150	149,0	149,7	150,6
	200	200,4	199,6	201,0
	250	249,5	250,8	250,0
General Care	50	50,6	48,1	49,6
	100	99,4	100,4	99,2
	150	149,8	149,3	149,7
	200	199,7	199,2	199,2
	250	248,8	249,6	249,8
OneHealth	50	49,9	48,7	51,0
	100	98,3	98,0	99,0
	150	148,1	149,8	148,2
	200	200,8	198,1	199,0
	250	250,1	247,9	248,0
OneMed	50	49,9	49,4	50,1
	100	98,8	99,0	99,7
	150	149,1	149,4	150,9
	200	200,3	200,2	200,5
	250	250,3	250,4	249,9
Serenity	50	50,6	50,1	48,1
	100	99,4	99,9	100,5
	150	150,6	150,9	150,4
	200	200,1	200,9	201,2
	250	248,7	249,7	249,7
No brand	50	48,8	49,6	49,4
	100	99,6	99,0	98,6
	150	150,5	149,5	148,9
	200	201,3	200,5	200,3
	250	250,6	249,7	249,8

2. Measurement findings obtained with a General Care sphygmomanometer

Spyghmomanometer brand: General Care	Setting value (mmHg)	Measurement Results		
Cufflinks brand:		I	II	III
General Care	50	51,8	49,3	51,0
	100	100,2	99,8	101,2
	150	149,0	150,2	150,9
	200	199,0	199,8	200,8
	250	250,3	249,4	249,6
Gea	50	49,1	49,6	49,2
	100	99,6	99,8	99,6

	150	150,2	149,1	149,9
	200	199,9	199,4	198,7
	250	250,2	249,4	249,2
OneHealth	50	49,8	49,8	49,9
	100	98,5	98,8	99,8
	150	149,0	149,7	149,3
	200	199,0	199,9	198,7
	250	248,3	249,3	249,0
Onemed	50	49,7	50,7	49,0
	100	100,5	99,0	99,1
	150	150,6	151,2	149,2
	200	200,4	200,3	198,6
	250	249,6	249,8	249,4
Serenity	50	49,9	50,3	49,3
	100	99,2	100,4	99,8
	150	148,7	150,5	148,6
	200	199,7	200,1	198,7
	250	249,7	249,5	249,6
No brand	50	50,3	49,8	51,6
	100	100,5	98,8	98,0
	150	149,6	149,4	149,9
	200	198,3	198,5	198,8
	250	248,4	249,9	248,7

3. Measurement findings obtained with a OneHealth sphygmomanometer

Spyghmomanometer brand: OneHealth	Setting value (mmHg)	Measurement Results		
Cufflinks brand:		I	II	III
OneHealth	50	48,7	51,2	49,3
	100	100,6	97,0	99,6
	150	147,2	147,0	147,1
	200	198,8	199,0	199,9
	250	247,8	249,4	247,5
Gea	50	51,0	49,5	48,0
	100	98,6	97,0	98,1
	150	148,4	148,7	147,6
	200	198,8	199,4	198,5
	250	249,0	248,9	247,0
General Care	50	49,5	49,3	49,5
	100	97,6	98,8	97,2
	150	149,3	149,4	149,8
	200	197,9	198,6	197,0
	250	248,8	247,4	247,7
Onemed	50	51,0	49,2	47,2
	100	98,9	97,5	98,3
	150	150,1	147,3	148,9
	200	197,7	197,0	198,8
	250	249,3	247,8	248,2
Serenity	50	49,6	48,7	47,9
	100	98,3	99,7	98,5
	150	147,6	149,0	147,6
	200	199,7	197,7	197,8
	250	248,4	247,0	249,5
No brand	50	49,5	49,7	49,8
	100	99,6	98,3	98,4
	150	147,9	149,5	149,3
	200	201,4	198,0	199,5
	250	249,5	249,9	249,1

4. Measurement findings obtained with a OneMed sphygmomanometer

Spyghmomanometer brand: Onemed	Setting value (mmHg)	Measurement Results		
Cufflinks brand:		I	II	III
Onemed	50	50,7	51,3	51,0
	100	100,2	100,7	101,2
	150	149,9	150,7	150,9
	200	199,5	200,8	200,8
	250	250,7	250,1	249,6

Gea	50	51,6	51,3	50,9
	100	99,3	100,7	100,7
	150	150,4	150,3	151,9
	200	199,9	200,5	201,6
	250	250,5	250,9	251,2
General Care	50	50,9	48,9	51,7
	100	99,1	100,3	100,7
	150	150,6	150,4	149,7
	200	198,7	199,8	202,6
	250	250,8	248,4	251,0
OneHealth	50	49,5	49,9	50,7
	100	100,7	100,8	99,1
	150	151,5	151,3	151,4
	200	201,5	200,6	199,4
	250	249,9	250,6	250,6
Serenity	50	50,9	51,0	51,6
	100	99,9	101,7	99,8
	150	150,8	151,9	151,1
	200	200,8	201,8	200,8
	250	250,1	249,5	250,5
No brand	50	50,8	51,3	51,1
	100	100,6	101,9	101,8
	150	151,7	151,3	151,7
	200	201,1	201,7	201,5
	250	251,4	250,8	249,7

5. Measurement findings obtained with a Serenity sphygmomanometer

Spyghmomanometer brand: Serenity	Setting value (mmHg)	Measurement Results		
Cufflinks brand:		I	II	III
Serenity	50	51,8	51,9	49,9
	100	100,4	102,2	99,4
	150	151,9	151,5	150,6
	200	202,1	201,8	200,2
	250	251,0	251,6	249,9
Gea	50	51,8	50,5	49,1
	100	101,7	100,8	98,0
	150	151,1	151,9	149,4
	200	201,9	201,9	199,3
	250	251,4	250,2	250,1
General Care	50	50,5	51,8	52,1
	100	102,2	101,4	102,1
	150	152,0	151,9	152,2
	200	202,1	201,8	202,3
	250	250,7	251,0	251,4
OneHealth	50	51,7	51,5	51,8
	100	101,8	100,9	101,6
	150	151,8	151,3	151,9
	200	201,9	201,8	202,3
	250	251,3	251,2	251,7
Onemed	50	51,8	52,1	52,0
	100	101,2	101,4	101,6
	150	151,7	152,0	152,1
	200	201,7	201,1	202,2
	250	251,6	250,8	251,2
No brand	50	52,1	51,9	51,7
	100	101,2	101,5	102,0
	150	151,8	152,3	151,8
	200	202,9	201,9	202,1
	250	252,3	251,6	251,5

B. DATA NORMALITY TEST RESULT

The Kolmogorov-Smirnov test findings in the Figure 3. indicate that pressure data for setting values is regularly distributed. This is demonstrated by the Sig (2-tailed) values

that are greater than 0.05, namely setting 50 mmHg Sig (2-tailed) value 0.262, setting 100 mmHg Sig (2-tailed) value 0.847, setting 150 mmHg Sig value (2-tailed) 0.777, setting 200 mmHg Sig value (2-tailed) 0.765, and setting 250 mmHg Sig value (2-tailed) 0.477.

Table 1. Data normality of One-Samples Kolmogorov-Smirnov test results

Result	Set 50	Set 100	Set 150	Set 200	Set 250
N	90	90	90	90	90
Normal parameters[a,b] Mean	50.276	99.793	150.087	200.123	249.796
Std. Deviation	1.1463	1.2969	1.3693	1.4015	1.1604
Most Extreme Differences Absolute	1.106	0.065	0.070	0.070	0.089
Positive	1.106	0.065	0.053	0.066	0.042
Negative	-0.085	-0.061	-0.070	-0.070	-0.089
Kolmopgorov-Smirnov Z	1.007	0.613	0.660	0.667	0.843
Asymp. Sig. (2-tailed)	0.262	0.847	0.777	0.765	0.477

a. Test distribution is normal
b. Calculated from data

The two-way ANOVA's estimated marginal means output results table displays the descriptive value of every variable.

Table 4. The output results represent the estimated marginal means Tensimeter*Manset

Dependent Variable: Set 50

Tensimeter	Manset	Mean	95% Confidence Interval		
			Std. Error	Lower Bound	Upper Bound
Gea	Gea	50.367	0.518	49.330	51.404
	General Care	49.433	0.518	49.396	50.470
	OneHealth	49.867	0.518	49.830	50.904
	OneMed	49.800	0.518	49.763	50.837
	Serenity	49.600	0.518	49.563	50.637
	No brand	49.267	0.518	49.230	50.304
General Care	Gea	49.300	0.518	48.263	50.337
	General Care	50.700	0.518	49.663	51.737
	OneHealth	49.833	0.518	48.796	50.870
	OneMed	49.800	0.518	48.763	50.837
	Serenity	49.833	0.518	48.796	50.870
	No brand	50.567	0.518	48.530	51.604
OneHealth	Gea	49.500	0.518	48.463	50.537
	General Care	49.433	0.518	48.396	50.470
	OneHealth	49.733	0.518	48.696	50.770
	OneMed	48.133	0.518	48.096	50.170
	Serenity	48.733	0.518	48.696	49.770
	No brand	49.667	0.518	48.630	50.704
OneMed	Gea	51.267	0.518	50.230	52.304
	General Care	50.500	0.518	49.463	51.537
	OneHealth	50.033	0.518	48.996	51.070
	OneMed	51.000	0.518	49.963	52.037
	Serenity	51.167	0.518	50.130	52.204
	No brand	51.067	0.518	50.030	52.104
Serenity	Gea	50.467	0.518	49.430	51.504
	General Care	51.467	0.518	50.430	52.504
	OneHealth	51.667	0.518	50.630	52.704
	OneMed	51.967	0.518	50.930	53.004
	Serenity	51.200	0.518	50.163	52.237
	No brand	51.900	0.518	50.863	52.937

Gea cuff mean value 50.367, General Care cuff mean value 49.433, OneHealth cuff mean value 49.867, OneMed cuff mean value 49.800, Serenity cuff mean value 49.600, unbranded cuff mean value 49.267 obtained with a Gea brand sphygmomanometer.

Table 5. Test results for between-subjects' effects

Dependent variable: Set50

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	68.573[a]	29	2.365	2.933	0.000
Intercept	227486.834	1	227486.834	282163.934	0.000
Tensimeter	51.998	4	13.000	16.124	0.000
Manset	1.389	5	0.278	0.345	0.884
Tensimeter*Manset	15.186	20	0.759	0.942	0.540
Error	48.373	60	0.806		
Total	227603.780	90			
Corrected Total	116.946	89			

a.R Squared = 0.586 (Adjusted R Squared = 0.386)

As shown in Table 5. The interpretation of the output results is as follows: - For factor 1 of the sphygmomanometer, since the significance value (Sig) is 0.000, which is less than 0.05, the null hypothesis (Ho) is rejected and the alternative hypothesis (Ha) is accepted. This indicates that there is a statistically significant difference.

For the factor 2 cuff, the null hypothesis (Ho) is accepted because the significance value (Sig) of 0.884 is greater than 0.05. This indicates that there is no significant difference.

For factor 3, the interaction between the sphygmomanometer and cuff is not significant (Sig = 0.540 > 0.05). Therefore, the null hypothesis (Ho) is accepted, indicating that there is no interaction.

Table 6. Homogeneous subsets of sphygmomanometer output result.

Set50

Tukey HSD[a,b]

Tensimeter	N	Subset		
		1	2	3
OneHealth	18	49.367		
Gea	18	49.722		
General Care	18	50.006	50.006	
OneMed	18		50.839	50.839
Serenity	18			51.444
Sig.	18	0.219	0.054	0.268

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 0.806.
a. Uses Harmonic Mean Sample Size = 18.000
b. Alpha = 0.05.

The Tukey HSD result is utilized to assess the similarity of the averages. The following is an interpretation of Figure 6:

Subset 1 contains measurement data for the Sphygmomanometers of the OneHealth, Gea, and General Care brands. Consequently, there is no notable disparity in the average measurements of the three brands of Sphygmomanometer. Put simply, the mean measurements of the three brands of Sphygmomanometer are identical.

Subset 2 contains measurement data for the Sphygmomanometer brands General Care and OneMed. Consequently, the average measurements of the two brands of Sphygmomanometer exhibit no significant disparity. Put simply, the average measurements of the two brands of Sphygmomanometer are identical.

Subset 3 contains measurement data from the OneMed brand Sphygmomanometer and the Serenity brand Sphygmomanometer. Consequently, the average measurements of the two brands of Sphygmomanometer exhibit no significant disparity. Put simply, the average measurements of the two brands of Spyghmomanometer are identical.

Table 7. Output results for homogeneous cuff subsets

Homogeneous subsets

Set50

Tukey HSD[a,b]

Manset	N	Subset
		1
Serenity	15	50.107
Gea	15	50.180

OneHealth	15	50.227
General Care	15	50.307
OneMed	15	50.340
No brand		50.493
Sig.		0.845

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = 0.806.
a. Uses Harmonic Mean Sample Size = 15.000
b. Alpha = 0.05.

The Tukey HSD output is utilized to determine the average similarity. Figure 7 above is interpreted as follows:

Subset 1 contains measurement data for Serenity, Gea, OneHealth, General Care, OneMed, and unbranded cuffs. This indicates that there is no statistically significant variation in the average measurements of the 6 brands of cuffs, implying that the average measurements of all 6 brands are identical.

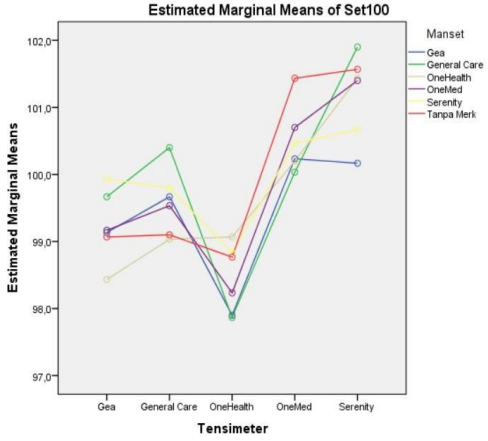

Figure 8. Profile plots the output results.

The profile plot diagram in Figure 8 above aims to assess how far the average value is between the brand of sphygmomanometer and the brand of cuff.

IV. CONCLUSION

Based on the data collecting and data processing that was carried out in this research, it can be inferred that the average total value at the setting point is 50 mmHg: Gea brand cuff 50.180; General Care brand cuff 50.307; OneHealth brand cuff 50.227; OneMed brand cuff 50.340; Serenity brand cufflinks 50.107; and unbranded cufflinks 50.493. There is a variance in measurement results between different brands of cuffs on the Aneroid Sphygmomanometer, although it is not substantial and remains within the tolerance range.

V. REFERENCES

[1] A. Sapra, A. Malik, and P. Bhandari, "Vital Sign Assessment- PMID : 31985994," no. December 2019, 2020.

[2] S. S. Mousavi, M. A. Reyna, G. D. Clifford, and R. Sameni, "A Survey on Blood Pressure Measurement Technologies: Addressing Potential Sources of Bias," *Sensors*, vol. 24, no. 6, pp. 1–33, 2024, doi: 10.3390/s24061730.

[3] A. C. Flint *et al.*, "Effect of Systolic and Diastolic Blood Pressure on Cardiovascular Outcomes," *N. Engl. J. Med.*, vol. 381, no. 3, pp. 243–251, 2019, doi: 10.1056/nejmoa1803180.

[4] S. Magder, "The meaning of blood pressure 11 Medical and Health Sciences 1102 Cardiorespiratory Medicine and Haematology Luigi Forni," *Crit. Care*, vol. 22, no. 1, pp. 1–10, 2018.

[5] Y. Ostchega, T. Nwankwo, G. Zhang, and M. Chiappa, "Blood pressure cuff comparability study," *Blood Press. Monit.*, vol. 21, no. 6, pp. 345–351, 2016, doi: 10.1097/MBP.0000000000000208.

[6] M. J. Turner, C. Speechly, and N. Bignell, "Sphygmomanometer calibration Why, how and how often?," *Aust. Fam. Physician*, vol. 36, no. 10, pp. 834–837, 2007.