PAPER NAME

Jenie et al.2019Review on wavelength fo r non-invasive blood hemoglobin level m easurement optical dev

WORD COUNT

2593 Words

CHARACTER COUNT

14461 Characters

PAGE COUNT

7 Pages

FILE SIZE

589.4KB

SUBMISSION DATE

Apr 25, 2022 8:13 PM GMT+7

REPORT DATE

Apr 25, 2022 8:14 PM GMT+7

2% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

- 2% Internet database
- 0% Publications database
- Crossref database
- Crossref Posted Content database

Excluded from Similarity Report

- Submitted Works database
- Bibliographic material
- Small Matches (Less then 40 words)
- Manually excluded sources

Review on wavelength for non-invasive blood hemoglobin level measurement optical device

Cite as: AIP Conference Proceedings **2194**, 020046 (2019); https://doi.org/10.1063/1.5139778
Published Online: 18 December 2019

Renan Prasta Jenie, Umu Nasiba, Ika Rahayu, Naufal Muharram Nurdin, Irzaman Husein, and Husin Alatas

Review on Wavelength for Non-Invasive Blood Hemoglobin Level Measurement Optical Device

Renan Prasta Jenie[1, a)], Umu Nasiba[1], Ika Rahayu[2], Naufal Muharram Nurdin[3], Irzaman Husein[4], and Husin Alatas[4, b)]

[1]*Researcher in Department of Physics, Bogor Agricultural University, West Java, Indonesia*
[2]*Lecturer in Department of Biochemistry, Universitas Krida Wacana, Jakarta, Indonesia*
[3]*Lecturer in Department of Community Nutrition, Bogor Agricultural University, West Java, Indonesia*
[4]*Lecturer in Department of Physics, Bogor Agricultural University, West Java, Indonesia*

[a)]*Corresponding author: qwerty.user1983@gmail.com*
[b)]*alatas@apps.ipb.ac.id*

Abstract. Current invasive phlebotomy based blood-hemoglobin-level (BHL) measurement methods have a relatively high level of risk for daily personal use. Phlebotomy is a traumatic procedure with a relatively high risk of diseases, failure, and cost. Researchers globally have agreed that the spectrophotometric method has great potential for mitigating the risk, but researchers have yet to agree on using which wavelength for non-invasive blood hemoglobin level measurement optical device (NI-BHL-MOD). The objective is to survey the wavelength for NI-BHL-MOD and compared it to self-observation. The research team have obtained research articles in the last 25 years from journals and proceedings indexing services such as Scopus, Medline, and Google Scholar. The light wavelength is categorized based on its wavelength value**.** The research team have listed the 22 different wavelengths that other researchers have used for blood hemoglobin level measurement. The research team have described several example research that other researchers have done. The research team also have incorporated human skin optical properties considerations that may interfere with NI-BHL-MOD. The research team also have incorporated self-observation on blood hemoglobin level control (Lypocheck Assayed Biochemistry) using Ultraviolet to Visible Spectrophotometer to understand the wavelength response further. Each wavelength has its potential to be used for NI-BHL-MOD, and Research team shall confirm them with in-vitro blood hemoglobin level test in future research.

INTRODUCTION

Current invasive phlebotomy based blood-hemoglobin-level (BHL) measurement methods have a relatively high level of risk for daily personal use [1]. Phlebotomy is a traumatic procedure with a relatively high risk of diseases, failure, and cost [2, 3]. Several examples of possible phlebotomy induced trauma include bruising, redness, swelling, skin calcification, nerve damage, and allergic reaction. Possible non-exhaustive blood-borne infection includes Human Immunodeficiency Virus (HIV), Hepatitis B or C Virus, Severe acute respiratory syndrome (Sars), and Escherichia coli. Blood specimen could also induce infectious response like cellulitis and abscess, worsen the existing medical condition, and increasing lifetime cancer risk. Phlebotomy procedure could induce iatrogenic anemia, heart attack, pneumonia, stroke and resultant brain damage, and could be fatal. The blood specimen is a hazardous biological waste which demands rigorous handling procedure. That is why only a trained health practitioner should be cleared to administer the phlebotomy procedure.

Several known methods include Tallqvist method, copper-sulfate method, Lovibond comparator, Sahli technique, direct Cyanmeth - hemoglobin method, hemoglobin color scale, HemoCue, automated analyzer, NBM-200 [4], and pulse oximetry [5]. Cyanmeth - hemoglobin method using 540 nm wavelength remains as the gold standard in BHL measurement [6, 7], with 546 nm wavelength as an alternative [8]. All of them implement phlebotomy as blood extraction methods.

The 2nd International Conference on Science, Mathematics, Environment, and Education
AIP Conf. Proc. 2194, 020046-1–020046-6; https://doi.org/10.1063/1.5139778
Published by AIP Publishing. 978-0-7354-1945-2/$30.00

Researchers around the world have agreed that spectrophotometric method has great potential for mitigating the risk of phlebotomy [9, 10], but we have yet to agree on using which wavelength for non-invasive blood hemoglobin level measurement optical device (NI-BHL-MOD). Researchers have considered dozens of wavelengths as a window for blood hemoglobin level measurement. Several wavelength considered are 228 nm, 260 nm, 423 nm, 446 nm, 458 nm, 531 nm, 542 nm, 577 nm [11], 530 nm [12], 542 nm and 578 nm [13], 660 nm [14], and 700 nm to 1000 nm [15]. Our conjectures on why the wavelength discrepancy exist include the advancement of blood observation technology and different approach each study have been using. We have yet to find the study on this wavelength discrepancy.

This observational study objective is to survey the wavelength for NI-BHL-MOD and compared it to self-observation.

METHOD

The research team have obtained research articles for this review in the last 25 years from journals and proceedings indexing services such as Scopus, Medline, and Google Scholar. The light wavelength is categorized based on its wavelength value.

In February 2019, the research team have done a blood hemoglobin level control (Lypocheck Assayed Biochemistry) observation using Ultraviolet to Visible Spectrophotometer in the Faculty of Medicine, Universitas Krida Wacana. The research team have used three hemoglobin control level (6.3 g/dl, 12.2 mg/dl, 15.2 mg/dl) diluted 800 times in Phosphate Buffered Saline. The research team have calculated the standard deviation and the Pearson correlation of each wavelength to the BHL value. The research team have used the R Project and RKward for data analysis [16].

RESULTS

Usual Non-Invasive Blood Hemoglobin Level Measurement Methods

Simple non-invasive spectrophotometric methods for blood hemoglobin level measurement consist of using a pair of LEDs in a different wavelength. Light wavelength penetrate the human tissue and measured using photodiode. The research team calculated the blood hemoglobin level from the measurement ratio [17, 18]. The researcher further enhances the methods to include the effect of oxygen saturation within hemoglobin. This method is known as pulse oximetry [18].

Blood Hemoglobin Level Measurement Wavelength Observation

Researchers have proposed several wavelength windows for blood hemoglobin level measurement. Anand Kumar Keshari proposed several values from 200 nm to 600 nm range, 228 nm, 260 nm, 423 nm, 446 nm, 458 nm, 531 nm, 542 nm, and 577 nm, based on BHL absorption value [11]. Adam Rudzinski proposes the 400 nm to 500 nm range to measure hemoglobin [19]. Rudzinski study result is in agreement with Towsend study at 400 nm to 450 nm range, with 410 nm as oxyhemoglobin and 430 nm for hemoglobin measurement [20]. A separate study by Fernando Basilio Avila-Rencoret has further confirmed both study result [21]. Lew Lim study shows that the wavelengths below 600 nm could be used to measure Hb and HbO_2, but maybe impended by melanin. He further proposed the range between 514 nm and 632 nm to measure BHL [22]. Which confirm the separate study by McEwen and Reynolds [23]. Rajashree Doshi and Anagha Panditrao have proposed 650 nm and 950 nm value for hemoglobin detection based on their absorbance [17]. Edmund FK Hunt uses 660 nm and 940 nm using pulse oximetry methods based on extinction coefficient, although this may be a compromise due to his original study point a value slightly less than 650 nm [18]. This result is in agreement with Latha [24]. Geoffrey W. J. Clarke proposes a pair of wavelength, below700 nm and over 900 nm using pulse oximetry methods [25]. Hampus Mårtensson Jönsson proposes a range of 950 nm - 1000 nm for BHL measurement based on the absorption coefficient [26]. Other values proposed are 530 nm by Romagnoli [12], 532 nm by Cakiroglu [27], 542 nm and 578 nm by Jolivot [13], 660 nm by Thomaz [14], and 700 nm - 1000 nm by Crespi [15] (Figure 1).

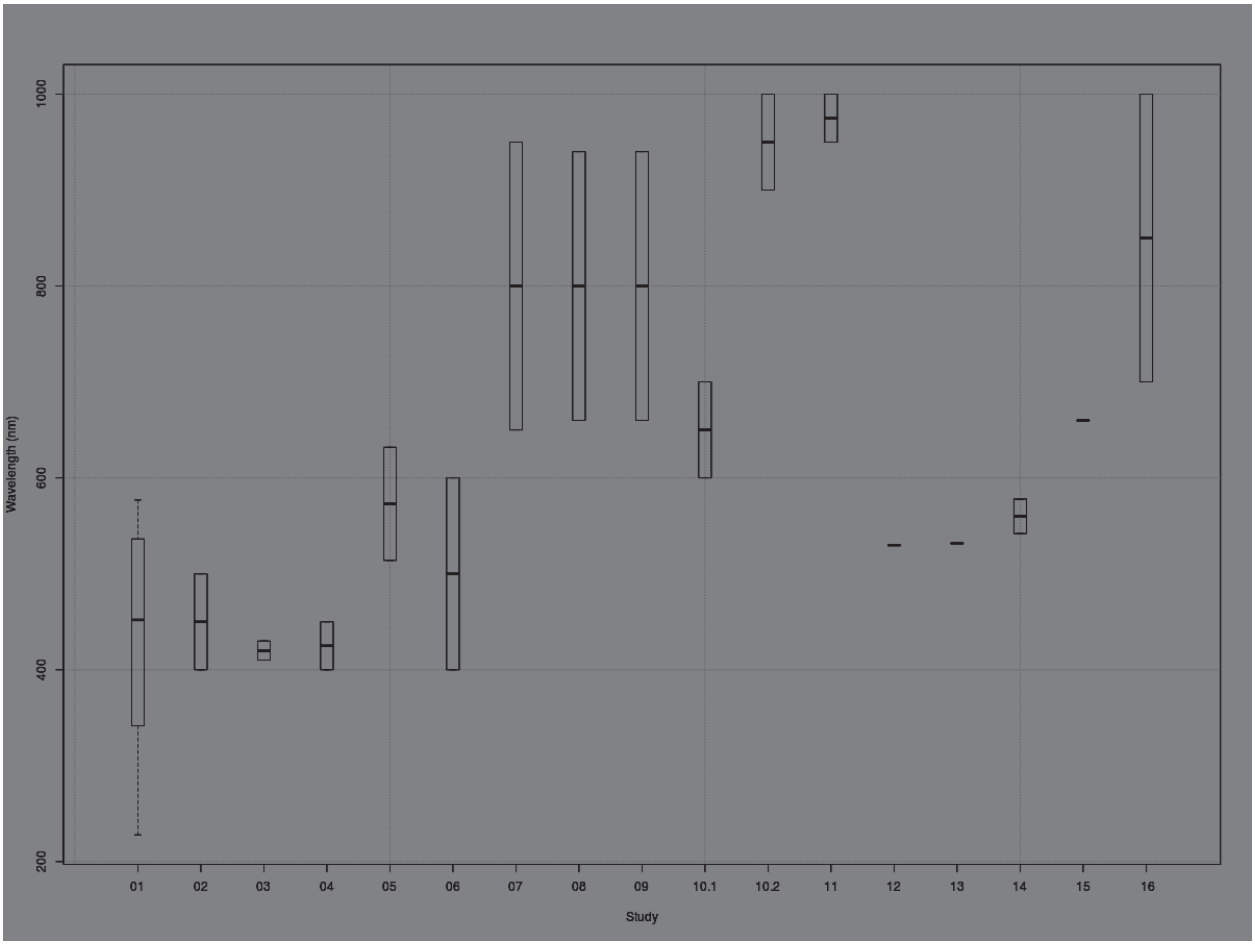

FIGURE 1. Several studies on blood hemoglobin level measurement wavelength. 01. Keshari and Farooqi 2014 [11]. 02. Rudziski et al 2013 [19]. 03. Townsend et al 2014 [20]. 04. Avila Rencoret 2014 [21]. 05. Lim 2015 [22]. 06. McEwen and Reynolds 2014 [23]. 07. Doshi and Panditrao 2013 [17]. 08. Hunt 2013 [18]. 09. Latha et al 2015 [24]. 10.1 and 10.2. Clarke 2015 [25]. 11. Maartensson Jonsson 2015 [26]. 12. Romagnoli et al 2013 [12]. 13. Cakiroglu et al 2013 [27]. 14. Jolivot et al 2013 [13]. 15. Thomaz 2014 [14]. 16. Crespi 2013 [15].

Pulse Oximetry Blood HemoglobinLevel Measurement Wavelength Observation

Pulse oximetry methods utilize a pair of the sensor to measure each oxy-hemoglobinand deoxy-hemoglobin, and the research team has calculated total BHL from both values. For measurement of deoxy-haemoglobin, Liu Liang Q has proposed the wavelength of 545 nm and 760 nm [28], while Patachia has proposed the wavelength of 780 nm [29]. Herrera Vega has proposed a wavelength of 830 nm [30]. Either Latha and Khandpur have proposed the wavelength between 850 nm and 1000 nm [5, 24], while Clarke proposed the wavelength of 900 nm [25]. Cernat and Vijaya have proposed a wavelength of 940 nm [31, 32].

For measurement of oxy-hemoglobin, Liu Liang Q has proposed the wavelength of 542 nm, 574 nm, and 900 nm [28], while Herrera Vega has proposed the wavelength of 650 nm [30]. Cernat and Vijaya have proposed a wavelength of 660 nm [31, 32]. Latha and Khandpur have proposed the wavelength between 600 nm - 750 nm [5, 24], while Clarke proposed the wavelength of 700 nm [25]. Patachia has proposed a wavelength of 835 nm [29] (Figure 2).

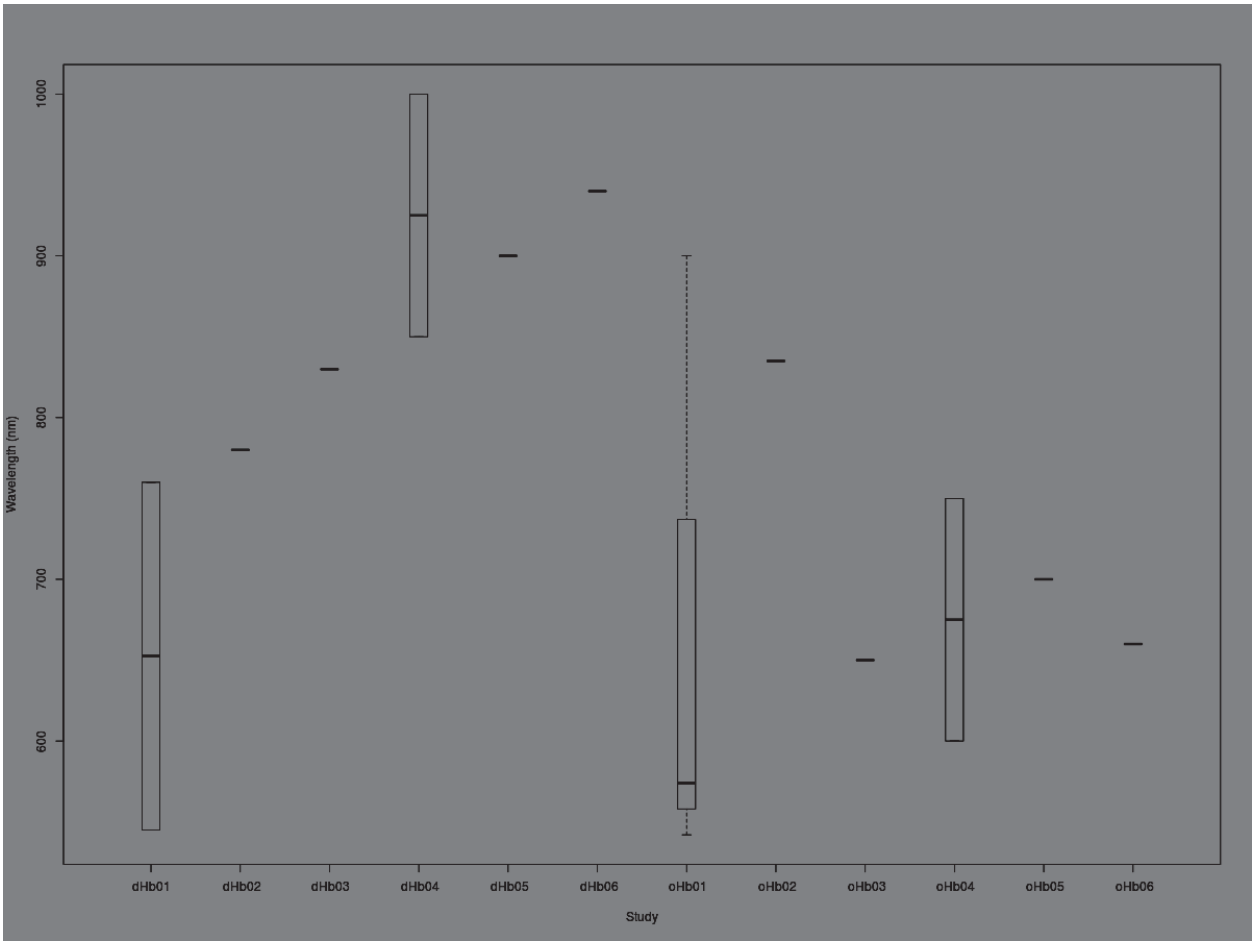

FIGURE 2. Several studies on pulse-oximetry blood-haemoglobin-level measurement wavelength, in which dHb = deoxyhaemoglobin and oHb = oxyhaemoglobin. 01. Liu et al 2015 [28]. 02. Patachia et al 2014 [29]. 03. Herrera-Vega and Orihuela-Espina, 2015 [30]. 04. Latha et al. 2015 and Khandpur 2003 [5, 24]. 05. Clarke 2015 [25]. 06. Cernat et al. 2014 and Vijaya et al. 2013 [31, 32].

Self-Observation of a Blood Hemoglobin Level Control

Observation has shown that using Pearson Correlation; Observer could see a good positive correlation between wavelength absorbance and intended BHL in wavelength 350 nm and above. Furthermore, the standard deviation maximizes at 406 nm, making it an ideal wavelength to measure blood glucose level, while the correlation is just a little lower than above 500 nm. The observation also has shown that wavelength lower than 250 nm has a too low correlation to BHL to be used for a non-invasive measurement device. (Figure 3).

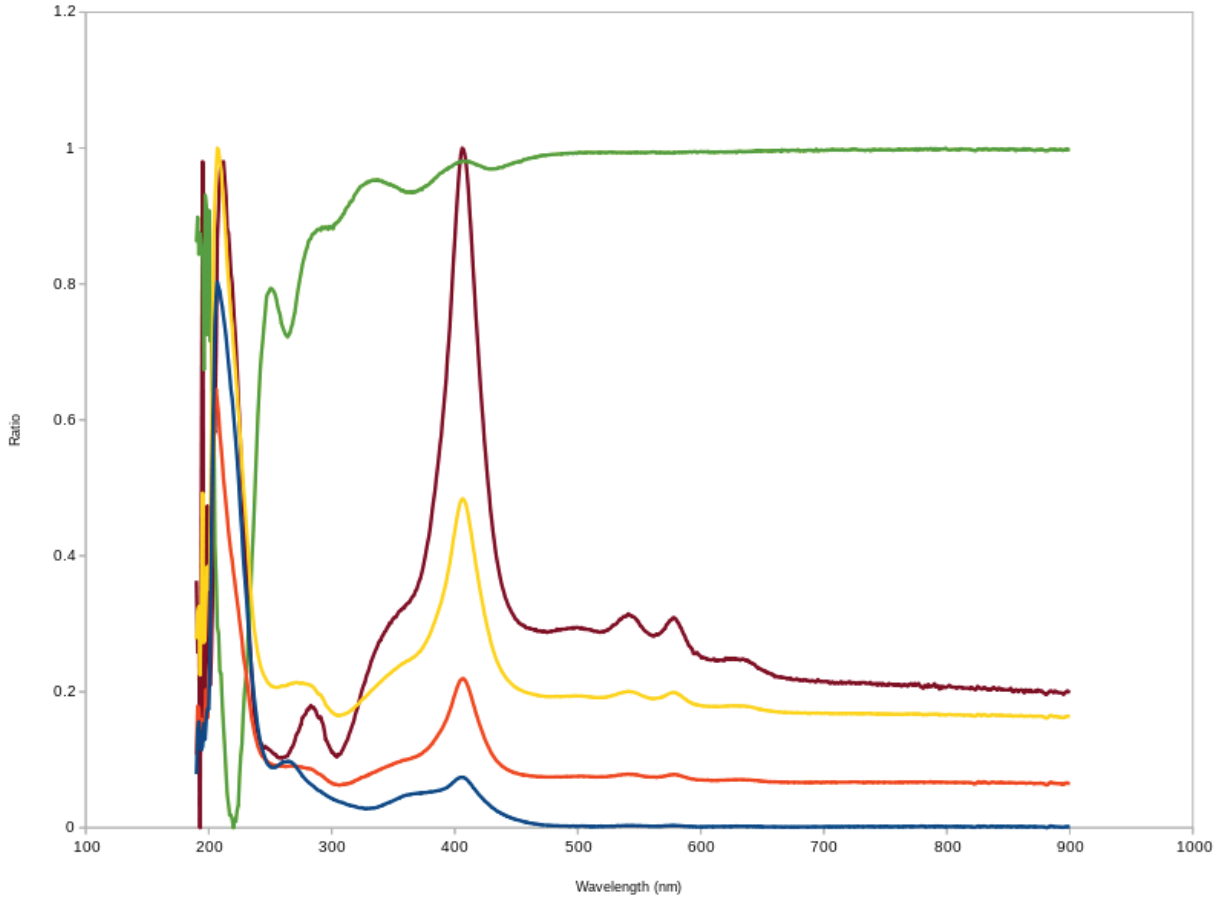

FIGURE 3. Self-observation of a blood hemoglobin level control (Lypocheck Assayed Biochemistry) using Ultraviolet to Visible Spectrophotometer. Blue. Hb 6.3 g/dl. Orange. Hb 12.2 g/dl. Yellow. Hb 15.2 g/dl. Violet. The standard deviation of blood haemoglobin level control. Green. Pearson correlation between wavelength absorbance and blood-hemoglobin-level control values. The research team has projected all values to [0, 1] range.

Non-Invasive Blood Hemoglobin Level Measurement Consideration

Several BHL measurement impediments exist. Bilirubin presence in wavelength window below 500 nm could mask BHL measurement [23, 33]. Melanin could create problems in BHL measurement in under 600 nm wavelength range [22]. Above 1100 nm range, lipid, water, elastin, and collagen within human tissue can impede BHL measurement [26].

General Result Explanation

The study has confirmed the broad wavelength range to measure BHL. In general, based on the comparison between Blood Hemoglobin Level Measurement Wavelength Observation and Pulse Oximetry Blood HemoglobinLevel Measurement Wavelength Observation to Self-Observation of a Blood Hemoglobin Level Control, Our observation has shown that the developer could use all wavelengths between 250 nm to 900 nm as a light source for BHL measurement. Only Keshari proposed wavelength of 228 nm are unconfirmed, as our current spectrophotometer is not able to measure such a low wavelength. The observed 400 nm peak standard deviated is in agreement with the wavelength proposed by Keshari [11], Rudzinski [19], Townsend [20], and Avila-Rencoret [21]. When the research team has combined the Hb data with impediment data, the researcher could derive an HBL measurement window between 600 nm to 1000 nm.

The UV VIS spectrophotometry observation has successfully surveyed all the wavelength between 200 nm to 900 nm. The survey should be confirmed with the wavelength in the near-infrared range, between 1000 nm to 2500 nm range. The physics research team has the survey planned before September 2019. Furthermore, before implementation into non-invasive HBL measurement device, the obtained data should be confirmed using consented human blood. The team shall research before December 2019. The research team has planned for implementation to non-invasive BHL measurement device and In vitro and in vivo test subsequently.

CONCLUSIONS

Each wavelength between 250 nm to 900 nm has its potential to be used for NI-BHL-MOD, based on comparison between Blood Hemoglobin Level Measurement Wavelength Observation and Pulse Oximetry Blood HemoglobinLevel Measurement Wavelength Observation to Self-Observation of a Blood Hemoglobin Level Control, and this research team shall confirm them with in-vitro blood hemoglobin level test in future research.

ACKNOWLEDGMENTS

This observational study are supported by Hibah Penelitian Dasar Unggulan Perguruan Tinggi (PDUPT) Direktorat Jendral Penguatan Riset dan Pengembangan Kemenristekdikti Republik Indonesia under grant 3/E1/KP.PTNBH/2019, 29 March 2019.

The authors declare no competing interests.

REFERENCES

1. The State of Queensland Health, **5** (2011).
2. J. Yeaw, W.C. Lee, M. Aagren, and T. Christensen, J Manag Care Pharm **18**, 21 (2012).
3. A.P.F. Turner, Chem. Soc. Rev. **42**, 3184 (2013).
4. T. Srivastava, H. Negandhi, S.B. Neogi, J. Sharma, and R. Saxena, J Hematol Transfus **2**, 1028 (2014).
5. R.S. Khandpur, *Handbook of Biomedical Instrumentation* (Tata McGraw-Hill, New Delhi, 2003).
6. W. Fm and S. Kigondu C, J. Med. Diagn. Methods **5**, (2016).
7. E.I. Obeagu, E.I. Okeke, and C. Anonde Andrew, Int J Curr Res Biol Med **1**, 1 (2016).
8. L. Aksoy, Rev. Méd Vét **164**, 34 (2013).
9. I. Abdulhalim and S. Srivastava, J. Biosens. Bioelectron. **06**, (2015).
10. A. Srivastava, M.K. Chowdhury, S. Sharma, and N. Sharma, Adv. Bioresearch (2014).
11. A.K. Keshari and H. Farooqi, Int. J. Sci. Technoledge **2**, 36 (2014).
12. S. Romagnoli, O. Tujjar, and A.R. De Gaudio, OA Anaesth. **1**, 16 (2013).
13. R. Jolivot, Y. Benezeth, and F. Marzani, Int. J. Biomed. ImagingInternet **978289**, 15 (2013).
14. F. da C.F. Thomaz, (2014).
15. F. Crespi, Curr. Synth. Syst. Biol. **01**, (2013).
16. S. Rödiger, T. Friedrichsmeier, P. Kapat, M. Michalke, and others, J. Stat. Softw. **49**, 1 (2012).
17. R. Doshi and A. Panditrao, Int. J. Eng. Res. Appl. **3**, (2013).
18. E.F. Hunt, (2013).
19. A. Rudziński, M. Bukat, and J. Łazowski, in edited by W.L. Woliński, Z. Jankiewicz, and R.S. Romaniuk (2013), p. 870307.
20. D. Townsend, F. D'Aiuto, and J. Deanfield, J. Med. Biol. Eng. **34**, 172 (2014).
21. F.B. Avila-Rencoret, (2014).
22. L. Lim, (2015).
23. M. McEwen and K.J. Reynolds, 5 (2014).
24. A. Latha, B.R. Murthy, L. Suresh, and others, Publ. Int. J. Innov. Sci. Eng. Technol. **2**, (2015).
25. G.W. Clarke, Signal Quality Analysis in Pulse Oximetry: Modelling and Detection of Motion Artifact, Carleton University Ottawa, 2015.
26. H. M\a artensson Jönsson, (2015).
27. B. Çakiroglu, R. Gözüküçük, and O. Sinanoglu, JPMA **63**, (2013).
28. L.Q. Liu, R. Deegan, and A. Gall, HSOA J. Phys. Med. Rehabil. Disabil. **1**, (2015).
29. M. Patachia, C. Popa, S. Banita, and D. Dumitras, Romanian Rep. Phys. **66**, 1061 (2014).
30. J. Herrera-Vega and F. Orihuela-Espina, *Image Reconstruction in Functional Optical Neuroimaging The Modelling and Separation of the Scalp Blood Flow: A Research Proposal* (Technical Report CCC-15-002, Division of Computational Sciences. National Institute of Astrophysics, Optics and Electronics, INAOE (Mexico), 2015).
31. R.A. Cernat, C. Ungureanu, G.M. Ungureanu, R. Aarts, and J. Arends, in *Proc Eur. Conf. Ambient Intell.* (2014), pp. 1–17.
32. K. Vijaya, R. Selvamani, G. Mariyappan, and K. Gobi, in *Natl. Conf. Syst. Des. Inf. Process.* (2013), p. 235.
33. A. Silapetere, J. Spigulis, and I. Saknite, Latv. J. Phys. Tech. Sci. **51**, (2014).

2% Overall Similarity

Top sources found in the following databases:

- 2% Internet database
- Crossref database
- 0% Publications database
- Crossref Posted Content database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1 **researchgate.net** 2%

Internet

Excluded from Similarity Report

- Submitted Works database
- Small Matches (Less then 40 words)
- Bibliographic material
- Manually excluded sources

EXCLUDED SOURCES

Renan Prasta Jenie, Umu Nasiba, Ika Rahayu, Naufal Muharram Nurdin, Irzam... Crossref	96%
aip.scitation.org Internet	96%