Journal of Biosciences and Medicines, 2026, 14(8), 179-185
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Definition of Altitude-Adjusted Anaemia Thresholds in the Democratic Republic of Congo: According to WHO 2024 Recommendations

Antoine Lufimbo Katawandja[1,2*], Jimmy Yuma Ilemba[1,2], Antoine Sadiki Kishabongo[3,4], Philippe Katchunga Bianga[5,6]

[1]Department of Basic Sciences, Faculty of Medicine, University of Kindu, Kindu, Democratic Republic of Congo
[2]Department of Laboratory Medicine, Lumbulumbu Hospital Center, Kindu, Democratic Republic of Congo
[3]Department of Pharmacy, Faculty of Health Sciences, Official University of Bukavu, Bukavu, Democratic Republic of Congo
[4]Department of Laboratory Medicine, General Referral Provincial Hospital of Bukavu, Faculty of Medicine, Catholic University of Bukavu, Bukavu, Democratic Republic of Congo
[5]Department of Internal Medicine, Faculty of Medicine, Official University of Bukavu, Bukavu, Democratic Republic of Congo
[6]Center of Multisectoral Health Research, Faculty of Medicine, Official University of Bukavu, Bukavu, Democratic Republic of Congo
Email: *dralkalufimb@gmail.com

How to cite this paper: Katawandja, A.L., Ilemba, J.Y., Kishabongo, A.S. and Bianga, P.K. (2026) Definition of Altitude-Adjusted Anaemia Thresholds in the Democratic Republic of Congo: According to WHO 2024 Recommendations. *Journal of Biosciences and Medicines*, **14**, 179-185.
https://doi.org/10.4236/jbm.2026.148016

Received: June 15, 2026
Accepted: August 10, 2026
Published: August 13, 2026

Abstract

Problem: In 2025, the World Health Organisation (WHO) revised the haemoglobin thresholds defining anaemia by incorporating more representative global data and contextual adjustments based on age, gender, pregnancy, altitude, smoking, infections and genetics. The objective of this study is to define the thresholds for anemia based on altitude in the major cities of the Democratic Republic of Congo (DRC) using these latest WHO recommendations. **Method:** We grouped the 26 provinces of the DRC into four regions according to altitude: Region A between 1 and 499 meters, Region B between 500 and 999 meters, Region C between 1000 and 1499 meters, and Region D between 1500 and 1999 meters. Then, considering the new WHO recommendations, we established haemoglobin thresholds for each region to define anaemia, considering age, sex, pregnancy status and altitude. **Results:** The results show that Region A comprised 9 provinces (34.6%) and did not require any adjustment to the haemoglobin threshold. Region B comprised 12 provinces (46.1%) and required a +0.4 g/dl adjustment to the haemoglobin threshold. Region C comprised 2 provinces (7.6%) and required an adjustment of +0.8 g/dl to the haemoglobin threshold. Finally, Region D comprised 3 provinces (11.5%) and re-

quired an adjustment of +1.1 g/dl to the haemoglobin threshold. **Conclusion:** This study shows that adjusting the haemoglobin threshold defining anaemia according to altitude improves the accuracy of anaemia diagnosis and avoids errors associated with the uniform application of thresholds. Therefore, rigorous implementation of these adjustments is essential for the effective management of populations at risk of anaemia, particularly in very high-altitude regions of the DRC.

Keywords

Haemoglobin Thresholds, Altitude, Anaemia, DRC

1. Introduction

Anaemia is a global public health problem affecting 30% (571 million) of women aged 15 to 49, 37% (32 million) of pregnant women and 40% (269 million) of children aged 6 to 59 months [1]. The WHO regions of Africa and South-East Asia are the most affected. The WHO haemoglobin thresholds for diagnosing anaemia were initially defined in 1968. These thresholds have remained largely unchanged for more than 50 years, despite criticism of their relevance in various demographic and geographical contexts [2].

In fact, the 1968 thresholds were defined based on studies conducted on small samples in a limited number of countries. There was also a lack of clarity regarding the criteria for selecting reference populations, leading to selection bias. Furthermore, the data used did not truly reflect the geographical, ethnic and physiological disparities among the world's populations. The thresholds were applied uniformly without taking into account certain confounding factors, such as smoking, altitude or inflammation. The failure to adjust the haemoglobin thresholds defined by the WHO in 1968 has resulted in the overdiagnosis of anaemia at high altitude and underdiagnosis among smokers. The universal application of these thresholds may have distorted estimates of anaemia prevalence in some regions [3].

Finally, these thresholds have remained in use for more than half a century, limiting their relevance in a world that is constantly changing in epidemiological, nutritional and hematological terms. These shortcomings have significantly affected the prioritization of nutritional interventions and the planning of health programs. In 2024, the WHO published a major update based on evidence from healthy reference populations worldwide. These new references consider not only demographic parameters but also altitude, smoking, infections, race, ethnicity and genetic factors [4].

Therefore, considering these new WHO recommendations, it is inappropriate to generalize the haemoglobin threshold defining anaemia for all regions of the Democratic Republic of Congo (DRC), a country covering 2,344,845 km^2 characterized by considerable geographical and climatic diversity depending on the region.

The aim of this study is to define the thresholds for anaemia according to altitude in the major cities of the DRC, based on the latest WHO recommendations.

2. Methodology

We used the 2024 WHO recommendations, which established haemoglobin thresholds for defining anaemia based on the 5th percentile for haemoglobin concentration thresholds in a healthy population, taking into account age, sex and pregnancy status (Table 1).

Table 1. Haemoglobin thresholds based on the 5th percentile for defining anaemia.

Population	Haemoglobin concentration (g/dL)
Children aged 6 to 23 months	<10.5
Children aged 24 to 59 months	<11.0
Children aged 5 to 11 years	<11.5
Children aged 12 to 14, girls not pregnant	<12.0
Children aged 12 to 14, boys	<12.0
Adults aged 15 to 65, women not pregnant	<12.0
Adults aged 15 to 65, men	<13.0
First trimester of pregnancy	<11.0
Second trimester of pregnancy	<10.5
Third trimester of pregnancy	<11.0

In addition, these recommendations adjusted the thresholds defining anaemia according to altitude (Table 2). Adjustments are made from an altitude of 500 m.

Table 2. Haemoglobin adjustments according to altitude.

Altitude level (metres above sea level)	Adjustments of the concentration of haemoglobin (g/dL)
1 - 499	0
500 - 999	0.4
1000 - 1499	0.8
1500 - 1999	1.1
2000 - 2499	1.4
2500 - 2999	1.8
3000 - 3499	2.1
3500 - 3999	2.5
4000 - 4499	2.9
4500 - 4999	3.3

Finally, we researched the altitude of the provincial capitals as representative of

each province in the DRC and adjusted the haemoglobin levels according to altitude. The altitude data were obtained from the Geographical Institute of Congo (IGC) and supplemented by the World Bank (2018), ensuring consistency and reliability in the classification of provinces [5].

3. Results

Table 3. Adjustment of haemoglobin levels according to the altitude of residence in 26 provinces of the democratic republic of Congo.

Altitudes (m)	Provinces of the DRC	Adjustment (g/dl)
1 to 499	Thsopo, North Ubangi, South Ubangi, Kwilu, Kinshasa, Maindombe, Equateur, Tshuapa, Mongala **(Region A)**	0
500 to 999	Kongo-Central, Kwango, Haut-Uélé, Bas-Uélé, Maniema, Tanganyika, Lomami, Sankuru, Kasai, Kasai-Central, Kasai-Oriental, Haut-Lomami **(Region B)**	+0.4
1000 to 1499	Haut-Katanga, Lualaba **(Region C)**	+0.8
1500 to 1999	Ituri, North Kivu, South Kivu **(Region D)**	+1.1

Table 3 and Table 4 show, respectively, the adjustment of haemoglobin according to the altitude of residence in 26 provinces of the DRC and the haemoglobin threshold defining anaemia for different age groups, sexes and physiological states (pregnancy), divided into four regions according to altitude above sea level. It appears that Region A comprised 9 provinces (34.6%) and did not require any adjustment to the haemoglobin threshold. Region B comprised 12 provinces (46.1%) and required an adjustment of +0.4 g/dL to the haemoglobin threshold. Region C comprised two provinces (7.6%) and required an adjustment of +0.8 g/dL to the haemoglobin threshold. Finally, Region D comprised three provinces (11.5%) and required an adjustment of +1.1 g/dL to the haemoglobin threshold.

Table 4. Altitude adjusted haemoglobin thresholds by population group in DRC.

	Hb (g/dl)			
	Region A	Region B	Region C	Regions D
Children, 6 - 23 months	<10.5	<10.9	<11.3	<11.6
Children, 24 - 59 months	<11.0	<11.4	<11.8	<12.1
Children, 5 - 11 years	<11.5	<11.9	<12.3	<12.6
Girls, 12 - 14 years old, not pregnant	<12.0	<12.4	<12.8	<13.1
Boys, 12 - 14 years old	<12.0	<12.4	<12.8	<13.1
Adults women 15 - 65 years old without pregnant	<12.0	<12.4	<12.8	<13.1
Adult males, 15 - 65 years old	<13.0	<13.4	<13.8	<14.1
Pregnancy				
1st trimester	<11.0	<11.4	<11.8	<12.1
2nd trimester	<10.5	<10.9	<11.3	<11.6
3rd trimester	<11.0	<11.4	<11.8	<12.1

This table presents altitude-adjusted haemoglobin thresholds (g/dL) across different population groups. The values vary according to age, sex, pregnancy trimester, and regional altitude, ensuring more accurate diagnosis of anaemia in diverse contexts.

4. Discussions

This study is the first in the DRC to have adjusted haemoglobin thresholds according to altitude for its provinces in accordance with WHO 2025 guidelines. Indeed, recent advances in diagnostic and therapeutic approaches to anaemia highlight the necessity of tailoring haemoglobin thresholds to specific local contexts [6].

Provinces located at low altitudes (1 - 499 m), such as Kinshasa and Équateur, did not require any adjustment, while those between 500 and 999 m, such as Maniema and Kasaï, required a correction of +0.4 g/dl. Higher regions such as Haut-Katanga (1000 - 1499 m) and South Kivu (1500 - 1999 m) benefited from a larger adjustment respectively of +0.8 g/dl and +1.1 g/dl. This study illustrates the importance of contextualizing the diagnosis of anaemia according to the geographical environment. These adjustments help to avoid false diagnoses of anaemia in populations living at high altitudes, where haemoglobin levels are naturally higher due to lower oxygen pressure. Rigorous application of these adjustments improves the accuracy of screening and optimizes nutritional and medical care, particularly for children and pregnant women.

Several authors have evaluated the impact of altitude on haemoglobin thresholds and the relevance of the adjustments proposed by the WHO. Indeed, a study conducted in Cusco, Peru (3400 m), by Gonzales *et al.* showed that the application of altitude-adjusted thresholds overestimated the prevalence of anaemia in adults. However, these authors observed that unadjusted haemoglobin levels were more closely correlated with biomarkers of iron deficiency, suggesting that the adjustment coefficients could be revised, particularly above 3000 m altitude [7].

Studies conducted in La Rinconada (5100 - 5300 m, Peru) have shown that physiological adaptation to altitude can vary considerably across populations, highlighting the need for contextual approaches when defining anaemia thresholds [8].

Another study conducted in Ethiopia among the Amhara and Oromo populations living between 3700 and 4000 metres revealed that the adjusted WHO thresholds artificially increased the prevalence of anaemia, despite the absence of iron deficiency. The researchers highlighted physiological differences between ethnic groups and recommended a population-specific approach to adjusting haemoglobin thresholds [9].

Two other Peruvian studies evaluated the impact of the new WHO 2024 guidelines on altitude-adjusted haemoglobin thresholds, particulary in children and pregnant women living in the Andes. These studies showed that applying the adjusted thresholds significantly increases the apparent prevalence of anaemia, exposing

populations to the risk of overdiagnosis and unjustified treatment. The authors emphasise the need to adapt thresholds to local physiological realities and to strengthen training for healthcare professionals to enable a more nuanced interpretation of biological results [10].

Finally, this study must be interpreted taking into account its limitations. Indeed, this study did not analyze the impact of adjusting the haemoglobin threshold on the prevalence of anaemia, particularly in very high altitude regions of the DRC. Nor did it study the association between certain biological markers, notably iron deficiency or elevated CRP, and the adjusted haemoglobin level.

5. Conclusion

This study shows that adjusting the haemoglobin threshold defining anaemia according to altitude in the DRC leads to an increase in this threshold from low-altitude regions to very high-altitude regions. This adjustment improves the accuracy of anaemia diagnosis and avoids errors associated with the uniform application of thresholds. Rigorous implementation of these adjustments is therefore essential for the effective management of populations at risk of anaemia, particularly in very high altitude regions of the DRC.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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