

To the editor:

Altitude above sea level as a variable for definition of anemia

I read with special interest the Perspective article by Drs Beutler and Waalen¹ about the definition of anemia. The authors refer to some variables, such as the sex, age, and race of the individuals, that may influence their levels of hemoglobin in normal conditions. In the final part of their paper, they suggest lower normal levels of hemoglobin for adults, according to their age, sex, and race, based on the Scripps-Kaiser data,¹ so that the definition of anemia can be made with more precision.

In countries where cities are located in different altitudes above sea level, this variable is critical and should always be taken into account when defining anemia.² The data presented by Beutler and Waalen may be correct for individuals living at sea level (San Diego), but they are not correct for healthy individuals living at higher altitudes. Interestingly, the data presented by Beutler and Waalen for white men living at sea level are similar to those that we found and published for Mexican mestizos living at the same altitude, but significantly lower than those for individuals living at higher altitudes, such as Mexico City or Puebla (my home town), both located 2240 m above sea level.³ For example, a hemoglobin level of 137 g/L for adult men is normal at sea level, but it is

definitely low and indicative of anemia if the individual lives in Mexico City.

In summary, the altitude of the residence site of healthy individuals is critical for the definition of anemia and should always be taken into account, along with the other variables addressed by Drs Beutler and Waalen.

Guillermo J. Ruíz-Argüelles

Correspondence: Guillermo J. Ruíz-Argüelles, Director General, Centro de Hematología y Medicina Interna de Puebla, 8B Sur 3710, 72530 Puebla, Mexico; e-mail: gruiz1@clinica.ruiz.com.

References

1. Beutler E, Waalen J. The definition of anemia: what is the lower limit of normal of the blood hemoglobin concentration? *Blood*. 2006;107:1747-1750.
2. Ruíz-Argüelles GJ. Índices y parámetros eritrocíticos en diversas alturas sobre el nivel del mar. In: López-Borrasca A, ed. *Enciclopedia Iberoamericana de Hematología*, Vol. IV. Salamanca, Spain: Editorial Universidad de Salamanca; 1992:605-606.
3. Ruíz-Argüelles GJ, Sánchez-Medal L, Loria A, Piedras J, Córdova MS. Red cell indices in normal adults residing at altitudes from sea level to 2670 meters. *Am J Hematol*. 1989;8:265-271.

Response:

Hemoglobin levels, altitude, and smoking

Dr Ruíz-Argüelles makes a very valid point in calling attention to the effect of altitude on normal hemoglobin levels.

The magnitude of this effect has been documented in a report from the Center for Disease Control (CDC)¹ published in 1989 based on data from the CDC Pediatric Nutrition Surveillance system and from a classical study by Hurtado et al,² and by Dr Ruíz-Argüelles and colleagues in their studies. These results are summarized in Table 1.

In the United States, there are only a few major cities where this adjustment is required. These include Santa Fe, NM, at 6989 ft (2130 m); Denver, CO, at 5260 ft (1603 m); Albuquerque, NM, at 4955 ft (1510 m); Reno, NV, at 4498 ft (1371 m); Salt Lake City,

UT, at 4266 ft (1300 m); El Paso, TX, at 3695 ft (1126 m), and Billings, MT, at 3124 ft (952 m). Elsewhere in the world there are a number of cities at very high altitudes, and Mexico City is the largest of these. Others include La Paz, Bolivia, at 11 910 ft (3630 m); Quito, Ecuador, at 9222 ft (2811 m); Bogota, Colombia, at 8660 ft (2640 m); Johannesburg, South Africa, at 5740 ft (1750 m); and Tehran, Iran, at 3937 ft (1200 m).

Based on the corrections proposed by the CDC, as given in the table, the hemoglobin concentration of blood in Mexico City, at an altitude of 7347 ft (2239 m), should be about 10 g/L higher than the levels found in our studies at Kaiser or in the National Health and Nutrition Examination Survey (NHANES) III series. The results of Ruíz-Argüelles and colleagues are similar, but they show a distinct sex difference in the response to altitude.

Smoking also has a well-known effect on hemoglobin levels. We did not eliminate smokers from our series, because the number of smokers in the Kaiser population was too small to have a

Table 1. The effect of altitude on hemoglobin levels

Height above sea level, ft (m)	Effect on Hb, g/L		
	CDC ²	Ruíz-Argüelles et al ³	
		Male	Female
Less than 3000 (914)	0.0	—	—
3000-3999 (914-1219)	+ 2.0	—	—
4000-4999 (1219-1524)	+ 3.0	—	—
5000-5999 (1524-1828)	+ 5.0	—	—
6000-6999 (1829-2133)	+ 7.0	+ 4.0	+ 8.0
7000-7999 (2134-2438)	+ 10.0	+ 5.0	+ 14.0
8000-8999 (2438-2743)	+ 13.0	+ 11.0	+ 16.0
9000-9999 (2743-3048)	+ 16.0	—	—

— indicates not reported.

Table 2. The effect of smoking on hemoglobin levels

Characteristics	Hb, g/L
Nonsmoker	0.0
Smokers	+ 3.0
0.5-1 pack/d	+ 3.0
1-2 packs/d	+ 5.0
More than 2 packs/d	+ 7.0

material effect on hemoglobin levels. The effect of smoking on hemoglobin levels, as presented in the CDC report,¹ is summarized in Table 2.

Ernest Beutler and Jill Waalen

Correspondence: Ernest Beutler, 10550 N Torrey Pines Rd, La Jolla, CA, 92037; e-mail: beutler@scripps.edu.

References

1. CDC criteria for anemia in children and childbearing-aged women. *MMWR Morb Mortal Wkly Rep.* 1989;38:400-404.
2. Hurtado A, Merino C, Delgado E. Influence of anoxemia on the hematopoietic activity. *Arch Intern Med.* 1945;75:284-323.
3. Ruíz-Argüelles GJ, Sanchez-Medal L, Loria A, Piedras J, Cordova MS. Red cell indices in normal adults residing at altitude from sea level to 2670 meters. *Am J Hematol.* 1980;8:265-271.