The prevalence of anaemia depends on the definition: an example from the Aboriginal Birth Cohort Study

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Background

Iron-deficiency anaemia is the most common nutritional deficiency. The definition of anaemia can be based on either haemoglobin or haematocrit concentration.

Cutoffs to define anaemia using each parameter are given by both the WHO and the US CDC **(Table 1)**.

The two sets of cutoffs are derived differently.

- The current American cutoffs are based on the 5th centile of the distribution from NHANES III calculated after excluding those with other evidence of iron deficiency or haemoglobinopathies.
- It is unclear how the current WHO cutoffs were derived, although the value for children 5-14 years refers to a paper from NHANES II that excluded those with iron deficiency and the haematocrit cutoffs appear to have been calculated from the haemoglobin cutoff using a standard conversion.

Objective:

Using data from the Aboriginal Birth Cohort Study, we examined

- the relationships between the current WHO and US cutoffs for peri-pubertal children and
- the impact of the choice of criterion on the assessment of anaemia prevalence.

Methods

The participants of the Aboriginal Birth Cohort Study are 686 out of 1238 children born at the Royal Darwin Hospital between January 1987 and March 1990 with mothers self-identifying as Aboriginal.

Recruited children were re-seen between December 1998 and March 2001.

- A full blood count including haemoglobin and packed cell volume (haematocrit) was done using a MAXM Hematology Flow Cytometer (Beckman Coulter, US) but no biochemical tests of iron deficiency were done.
- Growth was assessed by calculating height-for-age and weight-for-age z-scores based on the 1978 references using EpiInfo.

Statistical methods

Anaemia was defined in four ways, using the WHO and US cutoffs based on each of haemoglobin and haematocrit (WHO, 2001; CDC 1998).

- Differences in the prevalence of anaemia among the age-sex groups were tested using chi-square and an alpha of 0.05.

To investigate whether the observed variation in prevalence was due to variation in the location of the WHO cutoffs in the underlying age-sex frequency distribution, we calculated z-scores and their associated centiles using published data.

- The location of the WHO cutpoints on the NHANES II distributions (Yip et al, 1984) were calculated because this was referred to in the WHO documentation.
- The location of the WHO cutpoints based on haemoglobin on the NHANES III distributions (Looker et al, 1997) were also calculated as the US cutpoints were derived using this distributions to remove any effect due to using different references.

All analyses were done using Stata 8 (College Station, TX) and Excel.

Results

Of the 686 children initially recruited, 572 were seen and blood samples were obtained on 523 children. For the current analysis, we excluded 4 children aged 8 years and 2 children aged 14 years to reduce any effects relating to small numbers at extreme ages.

Demographic, growth and haematological characteristics of the children are shown **(Table 2)**. None of the children had macrocytosis on visual inspection of the slide.

- The prevalence of anaemia depends on the definition that is used. For the total group, it could be presented to policy makers as low (6%) or as high (24.4%) **(Table 3)**.
- The choice of definition alters which group is identified as the highest priority for targeting **(Fig 1)**. Using the WHO criteria, girls aged 12-13 years would be the target group, whereas all three groups would be targeted equally if the US criteria are used.

The reason for these differences is apparent when the WHO cutoffs are compared to the NHANES II or III distributions **(Table 4)**.

- The WHO cutoffs do not have a constant z-score either within age-sex groups for one index or between the two indices.
- Calculations (not shown) indicate that this variation also occurs in other age/sex groups.
- Consequently, the expected prevalence of values below the cutoffs would vary across the groups even if the study population had an identical distribution to the reference distribution.

Discussion

The major reason for the discrepancies between the two sets of criteria is that the WHO cutoffs defining anaemia appear to be set at different centiles for different age-sex groups and for the two parameters. This introduces confounding by age and sex when comparing the prevalence of anaemia within populations and between populations.

- The WHO cutoffs vary between the 2.5th centile and the 12th centile when compared to the NHANES II distribution.
- Consequently, in a population with the same haematocrit distribution as the non-iron deficient reference, girls have an expected prevalence of 12% compared to an expected prevalence of 2.5% in children aged 9-11.
- The discrepancy becomes more exaggerated as the study population average departs from the reference average.

We conclude that our total study population has an excess prevalence of anaemia of 19.5% using haemoglobin (i.e. 24.5%-5%=19.5% from Table 3), or 14.7% (i.e. 19.7%-5%) using haematocrit, above the 5% expected by definition.

The variation in anaemia prevalence based on the WHO cutoffs observed in our population subgroups can be largely attributed to the inconsistent location of the cutoffs rather than any true variation between the groups. Therefore we do not think that teenage girls have an excess prevalence of anaemia compared to the other groups.

The finding that the WHO cutoffs vary in their location on the reference population distribution has some important implications.

- Firstly, comparisons of different population subgroups may lead to incorrect conclusions about which are the high priority target groups.
- Secondly, comparisons between populations that span more than one age-sex group will be affected because they will depend on the age-sex distribution within each group.

A further advantage of using, and specifying the basis of, the criteria is that survey data can be correctly interpreted and targets for program performance can be set appropriately.

Our findings raise questions about the way that some commonly used cutoffs to define anaemia have been set. These could potentially lead to incorrect exclusion of subgroups from intervention programs. We think that it would be useful for authors to report prevalence of anaemia using both the US and WHO cutoffs to generate discussion about whether it is time to revise the definitions.

Acknowledgements

We would like to acknowledge the children and their mothers and those who have worked on the study over the years. Funded by National Health and Medical Research Council of Australia, the Colonial Foundation and the Channel 7 Children's Research Foundation of South Australia Inc.

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Table 1. Cutoffs defining anaemia based on two haematological parameters from the WHO and the US for peri-pubertal children

Group	WHO cutoffs		US cutoffs	
	Haemoglobin <g/dL	Haematocrit <%	Haemoglobin <g/dL	Haematocrit <%
Children 9<12	<11.5	<34	≤11.9	≤35.4
Children 12-13	<12	<36	-	-
Boys 12-13	-	-	≤12.5	≤37.3
Girls 12-13	-	-	≤11.8	≤35.7

Table 2. Characteristics of the 517 children by age-sex group, Aboriginal Birth Cohort Study, Australia

Group	N	Mean	SD
Children aged 9-11 years			
Sex: % male	331	48.6	-
Haemoglobin, g/dL	331	12.6	1.0
Haematocrit, %	331	38.0	2.9
Boys aged 12-13 years			
Haemoglobin, g/dL	110	13.1	1.0
Haematocrit, %	110	39.5	3.1
Girls aged 12-13 years			
Haemoglobin, g/dL	76	12.6	1.1
Haematocrit, %	76	38.1	3.1

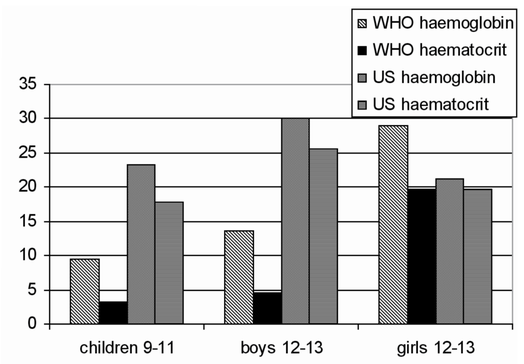
Table 3. The prevalence of anaemia using cutoffs defined for different parameters by different authorities, Aboriginal Birth Cohort Study, Australia

Parameter Anaemia based on	WHO cutoffs Prevalence (%)*	95%CI	US cutoffs Prevalence (%)#	95% CI
All children aged 9-13 years				
Haemoglobin	13.2	10.4-16.4	24.4	20.7-28.3
Haematocrit	6.0	4.1-8.4	19.7	16.4-23.4

Table 4. Location of the WHO anaemia cutoffs on the NHANES II and NHANES III distributions

Age	Survey distribution Median/ Mean	SD	WHO cutoffs Value	Z-score	centile
NHANES 11 Haemoglobin distribution (g/dL)					
Children 9-11	13.2	0.918	<11.5	-1.85	3.2
Boys 12-14	14.0	1.020	<12.0	-1.96	2.5
Girls 12-14	13.4	0.969	<12.0	-1.44	7.4
NHANES 11 Haematocrit distribution (%)					
Children 9-11	38.4	2.245	<34	-1.96	2.5
Boys 12-14	40.5	2.806	<36	-1.60	5.4
Girls 12-14	39.0	2.551	<36	-1.18	12.0
NHANES 11 Haemoglobin distribution (g/dL)					
Children 9-11	13.09	0.79	<11.5	-2.01	2.2
Boys 12-14	14.24	1.00	<12.0	-2.24	1.3
Girls 12-14	13.43	0.93	<12.0	-1.54	6.1

Figure 1. Prevalence of anaemia based on the WHO (1) and US (2) cutoffs for haemoglobin and haematocrit, by age and sex, Aboriginal Birth Cohort Study, Australia



WHO cutoffs: p<0.001 for difference among the three age-sex groups for both parameters.
US cutoffs: p>0.2 for difference among the three age-sex groups for both parameters.