

Cost-effective on-site screening for anaemia in pregnancy in primary care clinics

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Objective. To determine the feasibility, accuracy and cost of developing a system of on-site screening for anaemia in pregnancy in primary care clinics.

Setting. Mobile clinic team in Hlabisa health district, KwaZulu-Natal.

Methods. Four hundred and forty-nine consecutive women attending antenatal clinics were screened for anaemia (haemoglobin < 10 g/dl) using copper sulphate solution; the results were compared with true haemoglobin levels as determined by an automated analyser. Three hundred women had haemoglobin concentration estimated with a portable haemoglobinometer and results compared with those from the automated analyser.

Results. Screening with copper sulphate solution was highly sensitive (95.7%) but had low positive predictive value for anaemia (37.2%). Haemoglobin concentration estimated by haemoglobinometer correlated highly with results from the analyser ($r = 0.82$; $P < 0.0001$), and the mean difference in concentrations between the two methods was 1.1 g/dl. The average cost of screening all women with copper sulphate solution (6 cents/sample) and determining the true concentration in those screened as possibly anaemic (R2.64/sample) was 72 cents per woman. The cost of using an automated analyser was R6.20 per sample.

Conclusion. Combined use of copper sulphate solution and a haemoglobinometer is a feasible, accurate and cost-effective way of screening for and diagnosing anaemia in pregnant women, on-site, in primary care clinics.

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Screening for anaemia in pregnancy is integral to antenatal care, as anaemia contributes to both adverse pregnancy outcome for the fetus and increased risk of maternal death.¹ Most women in South Africa receive their antenatal care at clinics that do not have laboratory facilities close by. Many clinics are rural and isolated, and some mobile clinic points

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are only visited monthly. Blood is usually taken at the initial visit and transported to a laboratory for estimation of the haemoglobin concentration and to perform Rhesus and syphilis serology. Results are returned days or weeks later depending on local circumstances.² For some mobile clinics in rural areas, this delay may be as long as a month.

On-site screening for anaemia in primary care clinics is desirable, as it would allow therapy to be instituted immediately. However, on-site screening, as well as being quick and convenient for the midwife, also needs to be accurate and reliable. Furthermore, those identified as probably anaemic still require a diagnostic test to determine actual haemoglobin concentration, because although mild anaemia could be treated at the clinic, more severe anaemia might require referral. Is there a strategy that allows rapid, accurate and cheap screening for and diagnosis of anaemia, at primary care clinics?

Copper sulphate solution, although routinely used by blood transfusion services to screen for anaemia, does not quantify haemoglobin concentration. Portable haemoglobinometers, although they quantify haemoglobin concentration, are expensive, may require a power source (which many clinics in South Africa do not have) and also require maintenance.

The aim of this study was to determine the feasibility, accuracy and cost of developing a system of on-site screening for anaemia in pregnancy that uses a copper sulphate solution to screen all women, and a haemoglobinometer to quantify haemoglobin concentration in those screened as possibly anaemic.

Methods

Setting

The Hlabisa health district of northern KwaZulu-Natal is largely rural and remote. The maternity service comprises Hlabisa Hospital, 8 primary care clinics, and 20 mobile clinic points. Antenatal care is provided to around 8 000 women each year. A recent community survey³ estimated that 95% of women in the district had received antenatal care during their previous pregnancy.

Screening with copper sulphate

For this feasibility study one mobile clinic team, serving 14 clinic points across the district, was selected. A copper sulphate solution with specific gravity 1.048 (Clinical Science Diagnostics, Halfway House, South Africa) was used to screen 449 consecutive women booking for antenatal care. Venous blood was taken from the antecubital fossa with a 5 ml syringe. Prior to storing blood in tubes for transport to the Hlabisa laboratory, one drop of blood was dropped into the copper sulphate solution from a height of 1 - 2 cm above the surface. The momentum of the drop carries it through the surface and the drop then gradually slows. If the drop of blood is more dense (> 10 g/dl haemoglobin) than the solution, it will continue to fall; if the drop is less dense (< 10 g/dl), it will then rise back through the solution. If the density of the blood and the solution are equal (10 g/dl), the drop will slow, stop for a few seconds and then disperse while slowly sinking. Anaemia was defined as a haemoglobin

concentration of less than 10 g/dl as determined by an automated haematology analyser (Sysmex).

Haemoglobinometer

A β -haemoglobin photometer (HemoCue, HemoCue AB, Sweden) was used to estimate the haemoglobin concentration in 300 different consecutive women attending the same clinic. A drop of blood is drawn up by capillary action into a microcuvette which is then placed in the haemoglobinometer. The result, to one decimal place, is displayed on the unit 45 seconds later. No technical skills are required. This unit is battery or mains powered and is quite robust.

Laboratory methods

Blood was placed in an EDTA tube, stored in a cool box containing ice packs and taken to the laboratory the same day. There it was stored at 4°C until haemoglobin concentration was estimated with the Sysmex analyser (CA Milsch, Johannesburg) within 48 hours. The concentration of haemoglobin determined by the Sysmex was considered the 'gold standard' and results obtained from copper sulphate solution and the haemoglobinometer were compared with it.

Data analysis

Data entry and analysis were by means of Epi-Info version 6.02 (Centers for Disease Control, Atlanta, USA). Results are reported as sensitivity, specificity, positive predictive value and negative predictive value, with their 95% confidence intervals. The correlation coefficient and scatterplot were obtained with the BMDP package (BMDP Statistical Software, Los Angeles).

Results

Copper sulphate screening

The prevalence of anaemia among the 449 women screened with copper sulphate (Table I) was 10.5%. This screening strategy was sensitive (95.7%) and reasonably specific. However, the predictive value of screening as anaemic (37%) was poor because several samples with a true haemoglobin \geq 10 g/dl were screened as < 10 g/dl. However, 326 (73%) samples from women with haemoglobin \geq 10 g/dl would correctly not have been sent to the district laboratory for further examination using this approach. The two samples wrongly screened as > 10 g/dl both had true haemoglobin concentrations of 9.4 g/dl.

Table I. Copper sulphate screening compared with Sysmex haemoglobin analyser

Copper sulphate	Sysmex		Totals
	Hb < 10 g/dl	Hb \geq 10 g/dl	
< 10 g/dl	45	76	121
\geq 10 g/dl	2	326	328
Totals	47	412	449

Sensitivity (95% confidence interval) = 95.7% (84.3 - 99.3%).
Specificity = 81.1% (76.8 - 84.7%).
Positive predictive value = 37.2 (28.7 - 46.5%).
Negative predictive value = 99.4% (97.6 - 99.9%).

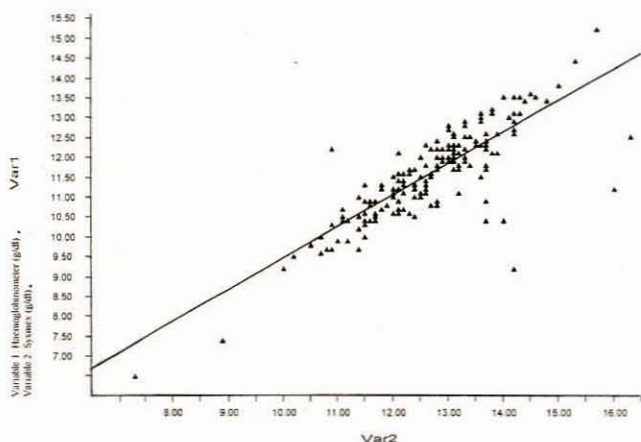


Fig. 1. Scatter plot of haemoglobin concentrations by haemoglobinometer and Sysmex.

Haemoglobinometer

Among the 300 samples tested with the haemoglobinometer, the prevalence of anaemia was 5%. The correlation (figure) between the results obtained on site and in the laboratory was high ($r = 0.82$, $P < 0.0001$). The mean haemoglobin concentration estimated on site (11.5 g/dl, SD 1.1) was lower than that estimated in the laboratory (12.7 g/dl, SD 1.2). The mean difference between the paired tests was 1.1 g/dl (SD 0.7) with a range of -1.3 to 5.0; in 48% of cases the difference was 1.0 g/dl or less and in 88% it was 1.5 g/dl or less.

Costs

The cost of estimating haemoglobin concentration with a Sysmex analyser is around R6.20 per sample,⁴ compared with 72 cents per sample if all samples are first screened with copper sulphate solution (6 cents per sample) and if those estimated < 10 g/dl (25% in this study) are then tested with the haemoglobinometer (R2.64 per sample).

Discussion

This study shows that the combined use of copper sulphate solution supplemented with a haemoglobinometer, is a feasible, accurate and cost-effective way of screening for and diagnosing anaemia in pregnancy on site in primary care clinics.

With this strategy, most women without anaemia will be correctly screened out by the copper sulphate solution, and those who are possibly anaemic will have their true haemoglobin concentration measured. This can then be acted upon, according to local protocols, with only severe cases being referred for further examination and investigation.

This is not a trivial issue. Anaemia contributes to maternal and perinatal mortality.¹ On-site screening ensures that anaemia is diagnosed at the initial visit, and that therapy or referral is instituted immediately. On-site testing, which can

be done anywhere, offers the opportunity to reduce unnecessary morbidity and mortality. Apart from absolute cost-savings, which are considerable, the opportunity costs of switching to on-site screening are noteworthy. Testing antenatal specimens in this district requires several hours of laboratory time each week — time that could probably be more usefully spent on other tasks.

Antenatal clinics in KwaZulu-Natal currently screen for Rhesus antibodies on site, and it is technically quite feasible to screen for anaemia, as shown here, and for syphilis.⁵ This approach could put an end to delays in receiving results,³ the need to retake specimens because of haemolysis and delays in initiating therapy.⁶ In response to these findings, the mobile clinic team now does on-site screening and testing for anaemia, syphilis and Rhesus antibodies, and the service is being expanded across the district.

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