# PRACTICE OBSERVED

## *Practice Research*

# Evaluation of portable haemoglobinometer in general practice

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### Abstract

**The HemoCue system for estimating haemoglobin was evaluated within urban general practice. It gave excellent results when used within a laboratory environment (on 103 paired samples) but disappointing ones when evaluated by practice nurses within general practice (on 235 paired samples). The most likely source of error was inadequate mixing of the blood specimens before sampling, which might be obviated by using a rotating mixer. It is emphasised that equipment intended for use in general practice should be evaluated under normal working conditions envisaged.**


### Introduction

Estimating a patient's haemoglobin concentration has become an important part of general practice. General practitioners can either use local laboratory "direct access" facilities or invest in a portable "office" haemoglobinometer. The former obviously ensures both reliability and accuracy at no cost to the general practitioner. Nevertheless, there is a case for encouraging greater use of haemoglobinometry within primary care. Firstly, an immediate result is possible. Secondly, a full blood count and examination of a stained blood film are often unnecessary when screening for anaemia, when a haemoglobin result alone would suffice. General practice use of a haemoglobinometer could also avoid delivery problems, delay in sample analysis, and the need for patients having to travel to laboratories. Other advantages include avoiding the need for venepuncture and cost savings for the hospital laboratory services.

The HemoCue system for haemoglobinometry requires only 10 μl of whole blood, and a microprocessor displays haemoglobin results within 60 seconds.[1] Manual control is limited to an on/off switch. Portable and designed for use in primary care, it has not been formally evaluated in British general practice,[2,3] although its use has been described by Loose *et al.*[4]

This study is an evaluation of the HemoCue in two settings: a hospital laboratory and operated by trained laboratory staff and a general practice health centre and operated by practice staff.

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### Methods

#### LABORATORY CONDITIONS

Medical laboratory scientific officer staff working in a regional hospital laboratory analysed 103 samples with the HemoCue and with a standard automated full blood count method (ELT 800 WS: Ortho Diagnostic Systems Ltd). The samples were a random selection of specimens originating from the hospital and surrounding general practices.

#### GENERAL PRACTICE CONDITIONS

All full blood count samples originating from three urban general practices based in a health centre (combined list size roughly 14 000) were studied from mid-November 1985 to mid-May 1986. Venepunctures were performed by one of two practice nursing sisters for surgery attenders and by the general practitioners on home visits. Microcuvette subsamples (10 μl) were taken from the 4 ml full blood count samples and tested with the HemoCue; the remainder of the sample was sent to the regional hospital laboratory by a "same day" delivery service. Before the study the HemoCue machine (the same one as used in the hospital) was calibrated against the local laboratory standard reagents, and the two practice nurses who performed all the analyses received instruction in its use. Each week the calibration of the HemoCue was rechecked with a standard microcuvette.

### Results

Figure 1 shows a comparison of haemoglobin concentrations estimated in 103 paired samples with the HemoCue and the automated method under

laboratory conditions. The correlation (r) is 0·99 with a slope of 0·98 and an axis intersect of 0·11. Figure 2 shows a comparison of HemoCue results with laboratory results under health centre conditions in 235 full blood count samples. The mean haemoglobin concentration according to the HemoCue was 137 g/l (range 64-192) with a standard deviation (SD) of 23. The corresponding laboratory figures were mean 135 (SD 17) and range 78-180. The correlation (r) was 0·61 with a slope of 0·81 and an axis intersect of 2·83.

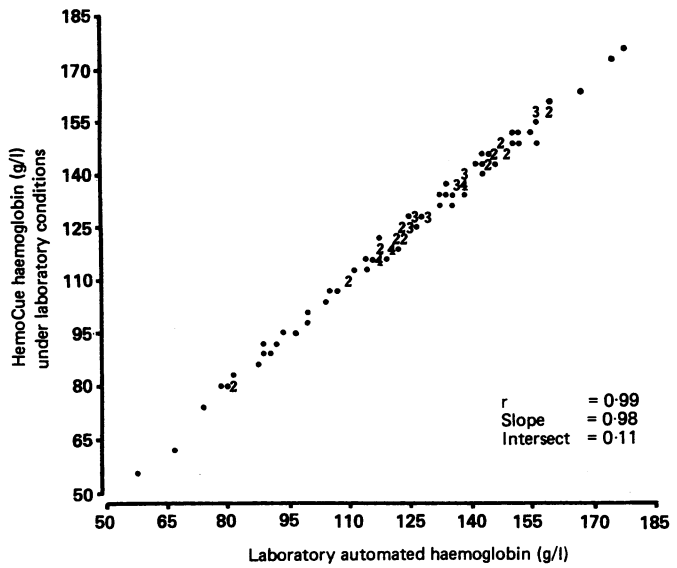


FIG 1—HemoCue results tested under laboratory conditions: relation to results obtained with standard method.

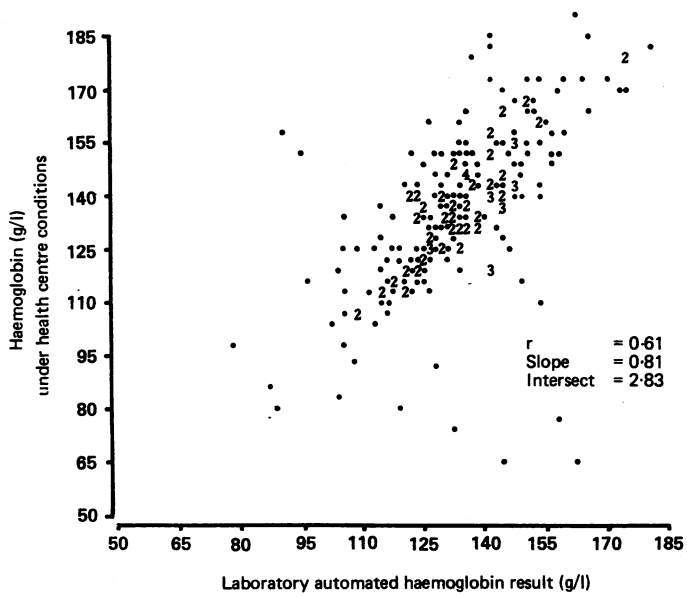


FIG 2—HemoCue results tested under health centre conditions: relation to results obtained with standard laboratory method.

The local laboratory reference ranges for haemoglobin are 155 (25) g/l in men and 140 (25) g/l in women. The HemoCue and laboratory results may therefore be classified as "low," "normal," or "high" according to these ranges (three children and six pregnant women within the 235 patients were classified by taking account of the separate reference ranges for childhood and for pregnancy) (table). From this classification the false positive rate for the HemoCue when used in the health centre with respect to the laboratory was 8·1% and the false negative rate 3·4%. The overall sensitivity (with respect to high and low haemoglobin values) was 88·5% with a specificity of 77·6%.

*Haemoglobin concentrations measured with HemoCue in general practice (classification according to laboratory reference ranges) compared with laboratory results*

| HemoCue haemoglobin result | Laboratory haemoglobin result | | | |
|---|---|---|---|---|
| | High | Normal | Low | Total (%) |
| High | 1 | 8 | 0 | 9 (4) |
| Normal | 1 | 178 | 7 | 186 (79) |
| Low | 0 | 11 | 29 | 40 (17) |
| Total | 2 (1%) | 197 (84%) | 36 (15%) | 235 (100) |

Laboratory reference ranges (SD): men 155 (25) g/l, women 140 (25) g/l.
False positive rate 8·1%, false negative rate 3·4%, sensitivity 88·5%, specificity 77·6%.

Throughout six months' use in the health centre the HemoCue did not require recalibration or suffer any breakdown. Comparative costs between the use of a portable haemoglobinometer and a hospital laboratory were estimated as follows. In 1986 the reagent cost per full blood count sample for a laboratory was about 7p compared with the microcuvette cost per haemoglobin sample of 25p for the HemoCue. Nevertheless, a realistic total cost per full blood count sample in a commercial laboratory might be £5, and the equivalent estimated total cost for the HemoCue 48p per sample (this assumes a capital cost of £434 spread over five years, insurance costs of £18 annually, repair charge of £50 spread over five years, and 500 samples a year with a microcuvette cost of 25p).

There is a potential saving to a local laboratory if haemoglobin estimates are performed in primary care. A health centre which requested 500 full blood counts annually, over half of which need only be haemoglobin estimations, might be expected to save a local laboratory the expense of analysing between 200 and 300 full blood count samples annually by purchasing a haemoglobinometer. There is also likely to be some saving on transport costs. It is difficult to estimate the financial effect of underuse of high cost laboratory equipment. The impact of reduced workload on laboratory staffing requirements is open to speculation.

## Discussion

The potential benefits to general practitioners and their patients of having an "on site" method of rapidly determining the haemoglobin concentration are obvious. The case for greater use of such equipment rests on two factors: cost and accuracy of results. If the costing estimates for using a haemoglobinometer from this study are representative then there might be a strong financial argument for suggesting that general practitioners should make greater use of haemoglobinometers. Whether the purchase and running costs of such machines are undertaken by hospital laboratories and their staff or whether the costs should be borne by general practitioners themselves is likely to be a sensitive medicopolitical issue.

The correlation of results between HemoCue haemoglobin estimations performed by medical laboratory scientific officers in a laboratory and the automated laboratory results was excellent. When used under standard conditions the HemoCue is obviously an accurate method of determining the haemoglobin concentration. Nevertheless, the correlation of results when the HemoCue was used by the practice nurses within the health centre was disappointing. Our correlation value of 0·61 compares with others of 0·96,[2] 0·99,[3] and 0·99,[4] although in a school nurse's office a correlation coefficient of only 0·63 was obtained.[3] Hence apparently operator error is responsible for the disappointing results in general practice. This so called operator error occurred despite the extensive experience the practice nursing sisters in the health centre had of clinical and side room procedures, as well as of research projects.

Why were the results so different for the same machine in two different settings? There are three possible explanations. Firstly, human error, such as wrongly reading the result, is unlikely. The nurses had been advised to recheck abnormal results twice, although with the same microcuvette. The second possibility is the presence of small air bubbles within the 10 µl sample drawn into the microcuvette by capillary action. The machine is, however, programmed to disregard results when absorption figures from the two different wavelengths differ widely. In addition, most air

bubbles are visible to the operator when blood is drawn into the microcuvette. The most likely source of error, or misleading results, would be poor mixing of the full blood count sample before analysis. The distribution of "outliers" in fig 2 supports this assumption. An erroneously high or low haemoglobin result would be obtained no matter how often the same microcuvette was placed in the machine. The absence of high or low outliers in the HemoCue results performed in a laboratory (fig 1) may be explained because all laboratory samples were thoroughly mixed on a rotating rack before sampling. The health centre does not possess a sample mixer and the practice nurses rotate each full blood count tube by hand. If a 4 ml whole blood sample were incorrectly mixed before withdrawal of a 10 µl microcuvette sample then falsely high or low haemoglobin results would be obtained depending on which part of the original 4 ml sample was subsampled.

The results of this study emphasise how important it is to evaluate equipment intended for use in primary care within primary care by primary care staff. Practices considering using a HemoCue, or any similar portable haemoglobinometer, should also use a rotating mixer for samples. An alternative would be to incorporate some kind of mixer on the haemoglobinometer itself, or to restrict the use of the machine to samples obtained by the finger prick method alone. The operating instructions should also be modified to reflect the importance of this potential error. Probably if the HemoCue was operated by junior hospital staff in ward side rooms similar problems to those encountered by the health centre staff would occur.

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# Appointment and mobility of general practitioners

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Changes in general practice partnerships are perceived as being undesirable; this, together with the current excess of doctors seeking practices over available vacancies, has caused a less than satisfactory procedure for selecting new principals to develop. This has reduced geographical mobility within general practice and resulted in increased personal stress and a lowering of morale. Consequently and paradoxically the likelihood of the partnership becoming unstable has increased.

## Changes in partnerships

Most general practitioners who have been principals for seveal years have experienced a partnership change because of retirement, death, or, increasingly commonly, a break up of the partnership. Partnership changes are expensive and worrying for all parties. They are expensive to the partners because solicitors have to be employed when the lease or property ownership is changed and to vet partnership agreements. Additionally, accounting becomes complex, primarily because of the rather chaotic and uninformative manner in which family practitioner committees make their payments and because of tax allowances relating to individual partners. Partnership changes are also expensive to the newcomer, who will have to buy a house and will often have to buy into the practice. Changes are worrying because of anxieties within the partnership that the new partner may "rock the boat," and the newcomer may wonder whether he has done the right thing and whether his appointment will be confirmed after a probationary period. These difficulties naturally deter doctors from contemplating frequent changes and do not encourage mobility within the profession.

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## Selection of new principals

As partnership changes are known to be difficult it is perhaps surprising that more care is not taken in making a mutually beneficial appointment. No doubt the fact that it is at present a seller's market has contributed to the tendency to take short cuts in advertising and selection, but I suggest that these short cuts are undesirable.

It is not unusual for an advertisement to give only two items of information—for example, "vacancy in four doctor practice in London. Apply with curriculum vitae and two references to box XYZ." Sometimes useless information is added: "usual attached staff" is akin to advertising a house "with roof." In a January edition of *Pulse* 14 out of 26 advertisements used a box number. Such sparse practice details make it difficult to formulate a meaningful application, and the use of box numbers makes it virtually impossible for further information to be obtained. Local trainees obviously may have foreknowledge and therefore a distinct advantage. In one area in the west country virtually all new principals are selected from the local training scheme (personal communication). Thus geographical mobility is again discouraged and a doctor's decision on where to spend his working life is moved back to the time when he begins vocational training.

Not only does an uninformative advertisement make it difficult for the applicant but it inevitably results in a huge number of applications. In other words, the valuable device of "self selection" is not brought into play and the chances of selecting a candidate who has doubts is increased. It is far easier to deal with 20 applications from serious applicants than with 100, many from doctors who might not want the job anyway.

Any selection process should begin with decisions about the type of person being sought. Some guidelines can be defined, but a complete description cannot be made; indeed, if too much detail is produced before selection there is a chance that no one will be found to fit the criteria and the person appointed will be considered to be second best. More importantly, the more applications the greater the perceived necessity to adhere rigidly to the criteria. This is also undesirable as suitable candidates may be passed over at an early stage of selection for some minor "fault."

Only three or four important points should be written down after long consideration and agreement by all the partners. Some characteristics—for example, the sex of the applicant—may be quite justifiable as a practice may wish to replace a retiring female partner with one of the same sex. Such an