# Low cost carbon monoxide monitors in smoking assessment

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Measurements of carbon monoxide exposure are valuable both for confirming non-smoking claims[1] and as a quantitative guide to inhalation.[2] It has also been reported that feedback of carbon monoxide concentrations may enhance the efficacy of a general practitioner's advice to stop smoking, suggesting a widespread potential application in primary care and hospital outpatient settings.[3] The concentration of carbon monoxide in end expired air after breathholding correlates closely with carboxyhaemoglobin concentrations,[4][5] but the necessary measuring equipment has hitherto proved too expensive for many potential users. Recently carbon monoxide monitors costing less than £400 have become available. We have compared results from two of these (Bedfont Instruments' EC50 and the National Coal Board's COTracer*) with results from the standard expired air carbon monoxide monitor (Ecolyzer 2000) and with blood carboxyhaemoglobin concentrations.

## Subjects, methods, and results

Seventy two people provided expired air for measurement with the three carbon monoxide monitors and a sample of venous blood. These subjects comprised a mixture of colleagues and new attenders at the Maudsley Hospital smokers' clinic. A further 75 people attending outpatient clinics at King's College Hospital provided expired air samples only. Heparinised venous blood samples were taken as described previously and analysed for carboxyhaemoglobin on a IL 282 CO-Oximeter.[4] End tidal expired air carbon monoxide concentrations were measured after 20 seconds' breath holding. In the case of the Ecolyzer and COTracer, both of which incorporate a pump for sample capture, subjects exhaled through a non-return valve into a length of anaesthetic tubing, and the alveolar sample for analysis was aspirated from the proximal end through a manometer line. The EC50 is supplied with a non-return valve that fits directly to the body of the instrument. The subject exhales through the valve and sample capture is by diffusion. Alcohol filters were fitted to all three monitors. They were fitted externally to the Ecolyzer and COTracer; the EC50 is supplied with an internally mounted filter. The three monitors
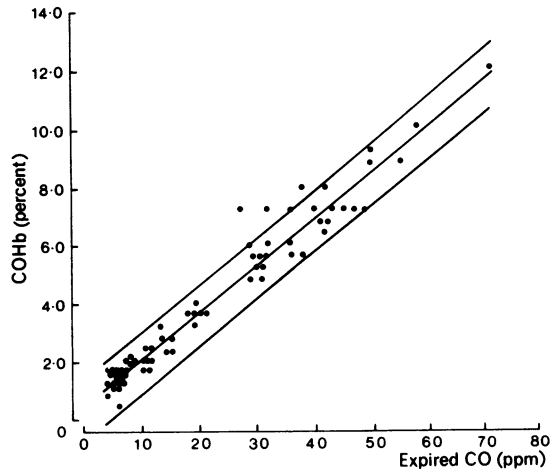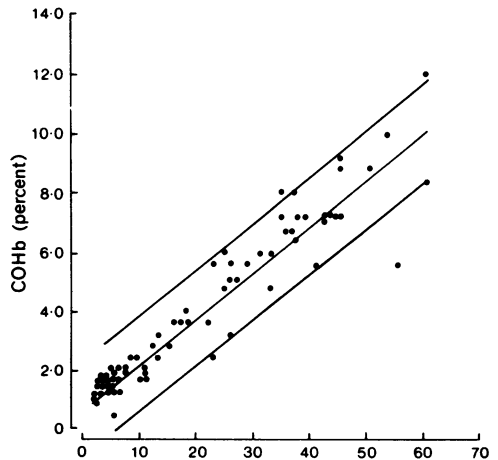
Carbon monoxide concentrations in expired air plotted against blood carboxyhaemoglobin. The slopes of the regression are shown with 95% confidence intervals for prediction of carboxyhaemoglobin from an individual expired air measurement. The upper panel shows values obtained with the EC50 (second reading) and the lower panel those from the COTracer. Regression equations are:
$COHb = 0.63 + 0.16$ (EC50) and $COHb = 0.45 + 0.16$ (COTracer).

were calibrated weekly with a mixture of 100 ppm carbon monoxide in air.

Two successive readings were taken with the EC50 to check the possibility that asymptotic readings might not be reached after a single exhalation when sample capture is by diffusion.

Expired air carbon monoxide concentrations measured by EC50 and by COTracer monitors correlated closely with carboxyhaemoglobin concentration (r = 0·95 and 0·98, n = 75 (see figure)), as did the Ecolyzer (r = 0·98, n = 75). The relationship with carboxyhaemoglobin concentrations (which ranged from 0·3% to 12%) was linear over this range; the slopes of the regression lines for the two instruments were identical and similar to the slope previously reported for the Ecolyzer.[4] The results show that, as an approximate guide, the percentage of carboxyhaemoglobin is given by dividing the expired air reading by 6. The second reading on the EC50 was somewhat higher than the first (mean values 17·3 and 15·7 ppm; p < 0·001), confirming that diffusion sampling may not yield an asymptotic value with one exhalation.

Readings from the three expired air monitors were highly correlated with each other but, as has recently been pointed out,[6] such high correlations may be consistent with considerable variation between measurements on different instruments; for example, the "limits of agreement" between the EC50 and the COTracer were ±7 ppm.

## Discussion

Our results indicate that the EC50 and COTracer carbon monoxide monitors give an acceptably accurate guide to carboxy-haemoglobin concentrations over the range of values encountered in smokers and non-smokers. Their performance is similar to that of the Ecolyzer, but is achieved at a fraction of the cost. A further advantage of these devices is that they are compact and battery operated. Little drift in calibration was observed during several weeks. Our data were gathered in subjects without appreciable impairment of lung function, but previous work has shown that expired air measurements are a valuable guide to carboxyhaemoglobin even in patients with emphysema.[4]

Monitoring carbon monoxide concentrations can be an unbiased indicator of smoking habit in settings where smoking has an important impact on clinical outcome and where self reports may not always be accurate.[7] It may also be a helpful means of communicating the reality of smoking risks to the patient. We conclude that reliable and low cost carbon monoxide estimation is now available and should be applied in health care and health education settings.

## References

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