RELIABILITY OF WHITE BLOOD CELL COUNT

The reliability of the cell count was determined by comparing the results obtained using the thick film technique with those obtained in the laboratory with a Coulter counter in 161 samples (131 venous and 30 capillary samples) from 88 patients. To assess within laboratory variability, eight specimens were put through two Coulter counters (model D and Sx). The table shows that the mean absolute differences between counts is about the same whatever method is used. To assess reproducibility 32 preparations were made from a single specimen and were examined by the thick film method. The coefficient of variance (SD/mean $\times 100$) was 5.4%. Corresponding values for Coulter counters and Neubauer chambers are 4% and 16%, respectively,* so it is unlikely that the thick film method is any less reproducible than the method with Neubauer chambers ($p < 0.005$). Validity, sensitivity, specificity, and randomness (of white cell distribution in thick films) were all satisfactory on formal testing. Further details are available from the author.

Staining and microscopy take less than five minutes for each sample. As no absolute values are available for the white blood count, accuracy is hard to define.† In white cell counting aiming at pinpoint accuracy does not make sense, as the count varies considerably in the same person even over short periods of time because of stress, eating, day-light, exercise, and the coming of afternoon.*

OTHER TECHNIQUES IN BEDSIDE HAEMATOLOGY

The Neubauer chamber method of determining the white blood count is open to large errors, despite apparently scrupulous pipetting and accurately ruled counting chambers. When tried in general practice it was time consuming, and unreliable results were obtained. Some experienced haematologists can predict a high or normal count from the ordinary blood film, but, with my limited experience I found this method to be unreliable at times.

Other "instant" stains have been available for several years. Because they are alcohol based—for example, Haemafast by Immuno—they

Mean absolute difference between counts according to method

	SD	Mean absolute difference	r	Regression equation
SD	($\times 10^{11}$)			
Venous samples	1.1 (1.56)	0.00*	0.96	$y = 0.8x + 1.8$
Thick film versus Coulter	1.0 (0.95)	0.01*	0.97	$y = x + 0.9$
Coulter model Sx versus model D	1.5 (1.7)	0.06*	0.66	$y = 0.6x + 3$
Thick film versus Coulter				

r = correlation coefficient.
* $p < 0.005$.

automatically fix the specimen. This makes the thick film technique impossible, as the fixative on the haemoglobin requires an aqueous stain. Alcohol based stains are also liable to be more capricious, perhaps because they are more susceptible to the large swings in temperature encountered in a general practitioner's "black bag". Bedside methods for estimating the haemoglobin are currently being investigated—for example, using the fact that a drop of blood will either float or sink in solutions of copper sulphate of known strength, depending on the haemoglobin content.

SOURCES OF ERROR

Sources of error include: (a) using finger marked slides (prevents adherence of the thick film); (b) using capillary tubes of the wrong bore. Even batches of the correct Hawksley tubes are apt to contain "rogues" (too big or too small), which need discarding; (c) forgetting to extend the eye piece out of the plane of the microscope (by 2 cm); if different microscopes are used a different number of squares may need to be counted. Find out by trial and error if capillary tubes should be coated with edetic acid if blood is taken into them directly from finger prick, and not through a paediatric EDTA bottle; (d) errors in counting (see fig 3), and, of course, human error. Blood temperature and Hb content are not significant variables.

Conclusion

This work suggests that it is feasible to measure white cell and differential counts at the bedside in general practice. It is not suggested that all patients with pre-existence of undetermined origin in general practice need such an investigation at the bedside, and nor should it be thought to compete with laboratory haematological investigations (which provide essential "quality control"). In selected cases, however, this new facility can greatly enrich a doctor's bedside performance by providing immediate and objective evidence that may confirm or refute his clinical diagnoses.

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Details about the supply of the McArthur microscope and reagents may be obtained from me. If their use is intended as a short practical course might be arranged to teach and discuss methods.

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Impact of audit on preventive measures

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Abstract

The results of two reviews of practice records for information about various preventive measures are reported. The reviews were conducted two and a half years apart in the same 29 practices, on roughly 6000 records on each occasion. The first review was carried out during a postgraduate education course involving audit. Two main analyses were undertaken: one concerned with the entire record sample and the other with the individual practice results. Important and substantial improvements were shown in both analyses, which were spread throughout the practices and were not confined to practices at the lower end of the range simply "catching up." The change between the reviews in the mean recorded rates for cervical cytology was 56% to 64%; for rubella immunity 26% to 40%; for polio immunity in adults 15% to 21%; for completed primary immunisation 88% to 78%; for recorded blood pressure 53% to 61%; and for smoking information 22% to 30%. Improvement has been steady but the rate of improvement, especially for recording blood pressure and rubella immunity, has increased since the postgraduate education course.

Introduction

We published the results of a review of 8522 records conducted in 38 practices that had been undertaken as part of a course in continuing education for general practitioners organised by the Thames Valley Faculty of the Royal College of General Practitioners in 1980.¹ The material obtained concerned recorded information about cervical cytology, blood pressure, smoking habits, and immune status. We drew attention to the wide variation among practices and highlighted areas in which improvement was desirable. Participants in the course considered the implications of the findings in discussion groups, for which each doctor was given the group results and the results for his own practice.

We now report the results from a repeat review of records sampled two and a half years later in 29 of the original 38 practices. The sampling procedure and method of review were the same in both studies and practices were asked to use the same staff. The follow up review was not planned when the first review was undertaken, the idea arising 12 months after the first study was completed.

Method

A sample of 200 to 250 medical records was extracted by each of the participants according to the following instructions:

- Start with A and withdraw every third record until you have

collected 10 records. Records should be withdrawn regardless of age, sex, adequacy, or thickness. As each is withdrawn insert a marker in the filing system.

- Repeat the task in B, C, and so on, until the entire filing system has been sampled (in letters such as Q and X, where there may not be 10 records, simply withdraw a third of the total).

- Separate from the total batch of records those that are incomplete—for example, those for patients recently registered and for whom the record folder has not yet arrived.

The remaining records were divided by sex and age and examined for information on: cervical cytology (women aged 30-59); rubella immune status (women aged 15-39); primary immunisation (boys and girls aged 1-9); polio immune status (men and women aged 20-39); blood pressure record (men aged 40-69); smoking habits (men and women aged 40-59).

Whole sample analysis:—The whole sample was analysed to show the overall recording rate for each preventive measure. The rates for the two reviews were compared using χ^2 tests to evaluate differences.

Analysis by practice:—For fear that any pronounced movement might be attributed to a large movement in a few practices, the data were also analysed for each practice. For each preventive measure the recording rate of each practice was calculated for each of the two reviews. The hypothesis that the performance of the practices had improved was tested with Wilcoxon's matched pairs signed ranks test.

RESULTS

The sample from the 29 practices comprised 6561 records in 1980 (first review) and 6518 in 1982 (second review). The composition by age and sex of the two samples was similar. Some information was obtained regarding the nine doctors who did not repeat the survey. One had stopped practice for maternity reasons, one had divided the practice and gone single handed, and one had emigrated. Two declined to repeat it because of the amount of work required and four gave no reason. The results in the first review for these nine practices were compared with those for the 29 practices who participated in the second review, with a Mann Whitney test. No statistically significant differences were found for any of the preventive measures studied.

WHOLE SAMPLE ANALYSIS

Cervical cytology (table IV):—The number of women who had had recent cervical smears showed a highly significant improvement. The proportion of women examined in the past five years increased from 56% to 63%, and the proportion never examined fell from 36% to 24%. The improvement was most appreciable in the age group 30-39 years.

Recorded immunisation (table IV):—Rubella immunity was based on a record of rubella antibodies or of recorded immunisation. Primary immunisation was defined as three injections of triple vaccine (DPT) or Dip-Tet Vaccine (D & T) plus three doses of polio vaccine. The proportion of women examined in the past five years increased from 27% to 40%. Improvement was highly significant in each of the three age groups. Improvement in completed primary immunisation from 69% to 78% comes from significant reductions in both the partially immunised and non-immunised groups. Improvement in recorded immunity to polio in adults was pronounced in only the group 20-39 years.

Blood pressure recording (table V):—The proportion of records containing a blood pressure recorded during the last five years increased from 52% to 61%, and the proportion for whom no recording was available for the last 10 years decreased from 40% to 31%.

There was a highly significant difference in the overall results between

TABLE I—Cervical cytology test in women aged 30-59

Age group (years)	First review			Second review			p value
	No. of women	No. tested	Percentage tested	No. of women	No. tested	Percentage tested	
30-39	308	42	14	44	32	72	NS
40-49	372	27	7	56	32	8	NS
50-59	506	25	5	62	57	11	0.01
30-59	1186	95	8	162	141	12	0.01

TABLE II—Rubella immune status in women aged 15-39 years

Age group (years)	First review		Second review		p value
	Subjects	Per cent protected	Subjects	Per cent protected	
15-19	511	14	519	24	0.05
20-29	651	15	655	22	0.001
30-39	518	35	243	52	0.001
15-39	1280	27	1217	40	0.001

TABLE III—Primary immunisation in boys and girls aged 1-9 years

Age group (years)	First review		Second review		p value
	Subjects	Per cent immunised	Subjects	Per cent immunised	
1-9	785	22	724	37	0.001

TABLE IV—Polio immune status of men and women aged 20-39 years

Age group (years)	First review		Second review		p value
	Subjects	Per cent immune	Subjects	Per cent immune	
20-29	962	9	987	12	NS
30-39	792	22	117	28	0.01
20-39	1754	15	1904	20	0.001

the two reviews. Improvement in the age group 40-49 years was highly significant and in the age group 50-59 significant in the age group 60-69 the difference was not statistically significant at the 5% level.

Smoking habits (table V):—In the first review 22% of all records examined contained some information about smoking compared with 30% in the second review, a highly significant difference. Examination by age and by sex showed significant improvements in men of both age groups and in women aged 50-59.

ANALYSIS BY PRACTICE

The results for each preventive measure are summarised in table VII. Highly significant improvements are evident for all measures, showing that the performances of the practices have improved and

TABLE V—Blood pressure record in men aged 40-69 years

Age group (years)	First review			Second review			p value
	No. of subjects	No. recorded	Percentage recorded	No. of subjects	No. recorded	Percentage recorded	
40-49	243	30	12	281	18	6	NS
50-59	360	40	11	406	9	2	0.05
40-59	603	70	12	687	27	4	0.01
40-69	947	40	4	1027	31	3	0.001

TABLE VII—Comparison of mean practice rates for records above and below the mean in first review

	Above mean in first review		Below mean in second review		p value
	Result: first review	Result: second review	Result: first review	Result: second review	
Cervical cytology in past five years	63	66	49	62	NS
No recorded cytology	34	33	51	37	0.01
Primary immunisation	64	87	53	70	0.01
Polio immunisation	19	21	10	20	0.01
Blood pressure recorded in past five years	60	74	40	62	0.01
No blood pressure recorded	44	40	26	32	0.01
Smoking information	32	37	21	36	0.01

analysis as in the analysis by practice and they are not restricted to a few practices at one end of the spectrum.

Are the changes part of a national trend? The number of cervical smears examined from women aged 35 and over increased from 1.1/m in 1978 to 1.2/m in 1980. This 10% increase is similar to that reported here, though the statistics are not directly comparable. Uptake rates for rubella immunisation have been improving greatly in teenage schoolgirls and the acceptance rate among 14 year olds now exceeds 80%. There are no comparable figures available for the frequency of detection of rubella antibodies measured routinely during antenatal consultations or as part of the surveillance of patients receiving family planning advice, both of which contributed to the improvement between the two reviews. The importance of blood pressure recording receives much publicity and one might expect improvement over a two year interval, though Ritchie and Currie failed to observe any improvement in a recent study of a limited sample of patient records.² There is no information available which permits comment on the result for smoking.

Are the changes attributable to more careful record keeping? Improvement was most pronounced in the studies where data were easy to obtain which suggests that improved record keeping did not make a major contribution. In particular, it is harder to search the records of older patients which are thicker, but the increases shown among them are not generally as great as those in the younger age group.

Do the changes reflect the clinical situation or simply recording habits? This depends on the preventive measure considered. Cervical cytology records are usually laboratory results, so an increase will be mainly due to more smears having been taken. At the other extreme improved results for primary immunisation are probably due to more scrupulous record keeping. Rates for other measures reflect both causes—for instance, improved blood pressure records will partly be due to taking the blood pressure more often, and partly due to writing down the result, which is not always done if it is normal. Many doctors will consider that an improved recording rate for whatever reason is a noteworthy change, since preventive care cannot be carried out without good recording.

Is the improvement recent or has it been going on over a period of time? The groups studied were defined by age bands, so between 1980 and 1982 patients in the top two years of an age band pass out of it, those who were one or two years younger than the age band come in. If younger patients are being treated more rigorously, as would be expected especially for immunisation and cervical cytology—this would produce a

that the overall improvement is not due to a large improvement in a few practices. The change in performance has been further analysed for those practices whose results in the first review were above or below the mean rates. One would expect that it would be more difficult for recorders who did well in the first review to improve their results further, and any sampling error in favour of those practices in the first review would result in an apparent worsening of their results in the second review. Table VIII shows improvement for both groups. The change is greater for those who were below the mean in the first review, but it is notable that those who did better in the first review still showed improvement for every preventive measure studied.

Discussion

Important changes have occurred for all the preventive measures studied and those changes are unarguably for the better. The changes are as convincing in the whole sample

TABLE VI—Smoking information on men and women aged 40-59

Age (years)	Sex	First review		Second review		p value
		Subjects	Per cent information available	Subjects	Per cent information available	
40-49	M	359	26	347	37	0.01
40-49	F	373	25	370	31	0.05
50-59	F	354	17	366	26	0.01
40-59	M & F	1461	22	1472	30	0.001

TABLE VII—Analysis of practice

	No. of practices providing paired sets of data	Mean practice rates		T-p value*
		First review	Second review	
Cervical examination in past five years	29	56	64	75
No recorded cytology	29	30	23	61
Rubella immunisation	29	28	40	92.5
Primary immunisation	27	15	21	77
Polio immunisation	28	18	21	79
Blood pressure recorded in past five years	28	53	61	79
No blood pressure recorded	29	47	38	84
Smoking information	29	22	30	84

*Wilcoxon test $p < 0.05$, $p < 0.01$, $p < 0.001$.

change between the reviews which had really taken place over a longer period. By considering the differing rates at opposite ends of each age band, we estimate that this explains almost all the improvement in recorded polio immunisation in adults, most of the improvement in primary immunisation rates, and some of the improvement in cervical cytology and recorded rubella immunity. In contrast, where the recorded rates for older subjects are greater than for younger, as in the case of blood pressure, appreciable improvement between the reviews is more difficult to achieve. The improvement for the age groups 40-49 and 50-59 years is thus particularly important and indicates a convincing improvement in blood pressure recording occurring since the first review.

Have changes resulted from the postgraduate education course in 1980? The doctors attending the course, which was residential and required preparation, were well motivated and already disposed to improvement. This analysis was not carried out with an independent control group. It is therefore difficult to separate improvement resulting from the course from improvement for other reasons. Nevertheless, it is notable that for recorded rubella immunity and blood pressure in particular improvement was especially good in the past two years. Since 1981 similar studies have been carried out in other parts of Britain by three other well motivated groups of doctors. The results are similar to the first and not the second review.

The postgraduate course required each participant to carry out an audit beforehand. Individual and group results were provided for each doctor and the participants on the course divided in small groups to discuss methods of providing more effective preventive care. Practical ways of achieving high levels of recordings were shared. Opportunistic screening emerged as one effective approach, especially for monitoring blood pressure and smoking and for checking the rubella immune state particularly when patients consent for advice on contraception. There was also universal agreement about the need for well organised records, with each patient's preventive care state clearly summarised. We conclude that much of the improvement in the second review is due to the nature of the postgraduate course: the audit and peer group discussion.

We are grateful for the considerable effort of recording of the 29 practices who provided this material and in particular to the doctors listed below who co-ordinated these efforts within the practices. We acknowledge the statistical help of Dr K W Cross, department of social medicine (University of Birmingham), and to Mrs J Dainty of the Birmingham Research Unit.

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