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National versus International Asbestos Fibre Counting Schemes: Comparison between the Spanish Interlaboratory Quality Control Programme (PICC-FA) and the Asbestos Fibre Regular Informal Counting Arrangement (AFRICA)

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An interchange of eight asbestos reference slides was planned informally between the Spanish national proficiency testing scheme, PICC-FA, and its international counterpart, AFRICA. The fibre counting levels, the reference values and the differences in performance assessments for individual counts and laboratories were analysed to test the level of agreement between the schemes. Comparisons were based on the proportions of fibre counts within and outside limit values. Discrepancies were found between schemes in the classification of counts, with the position of the limits of satisfactory performance being the most important factor of disagreement. The AFRICA limits are over twice as wide as the PICC-FA limits, though only 17% of the counts are affected by this large difference. There were not found to be significant differences in the assessment of the performances of Spanish laboratories—87.5% would have achieved a satisfactory classification in both schemes. A possible new approach to harmonizing proficiency testing schemes is discussed. © **1998 British Occupational Hygiene Society. Published by Elsevier Science Ltd.**

INTRODUCTION

Several national and international proficiency testing schemes for asbestos fibre counting laboratories are currently operating with different types of test samples and different methods of laboratory assessment (International: PAT, AFRICA, AIA, National: RICE (U.K.), PICC-FA (Spain), ACQCS (France), AFIC (Belgium), QFR (Germany),...) (LeBel, 1992). It is not unusual for asbestos-counting laboratories to take part in more than one of these schemes.

Hypothetically, the differences between schemes could give discrepancies in the evaluation of laboratory performance. This possibility could be the cause of misunderstandings, and should be avoided. However, it would not be easy to address this difficulty if the general laboratory performance levels or the types of samples are widely different between one scheme and another. This study aims to compare two proficiency testing schemes, one national (the Spanish national scheme, PICC-FA) and one international (AFRICA), with a view to establishing the extent of counting differences and the feasibility of harmonizing the performance criteria.

The Programa Interlaboratorios de Control de Calidad de Fibras de Amianto (PICC-FA) is the proficiency testing scheme for asbestos fibre counting laboratories in Spain. The scheme has been run successfully since 1988 by the Instituto Nacional de Seguridad e Higiene en el Trabajo (INSHT). PICC-FA provides laboratories with a measure of their performance with reference to the national mean (Arroyo, 1990 and Arroyo, 1991). Accreditation is required by law in Spain for asbestos counting laboratories, so any laboratory interested in obtaining accreditation must participate in PICC-FA.

The Asbestos Fibre Regular Informal Counting Arrangement (AFRICA) began in 1984, and has become a recognised proficiency testing scheme for asbestos fibre counting internationally (Crawford *et al.*, 1992; Crawford, 1989). AFRICA is operated by the Institute of Occupational Medicine (IOM) in Edinburgh, U.K. The IOM also conducts the larger Regular Interlaboratory Counting Exchanges (RICE), which has been the national asbestos fibre counting scheme for the United Kingdom since 1984,

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and currently has about 240 participating laboratories.

An interchange of asbestos reference slides between PICC-FA and AFRICA was planned informally. Reference slides from AFRICA were included in a routine PICC-FA circulation in which twenty Spanish laboratories were involved.

In this paper we present the results obtained from the study of the data generated on these slides by the PICC-FA and AFRICA schemes. The nature of the reference values, the performance assessment criteria and the laboratory performances have been considered.

DESCRIPTION OF THE SCHEMES

Operation of the schemes

Both PICC-FA and AFRICA are designed to test the proficiency of laboratories which use the phase contrast optical microscopy method for the measurement of airborne asbestos fibre concentrations. Test samples consist of fibre-bearing membrane filters permanently mounted on microscope slides. These slides are circulated around small groups of laboratories. Microscopists at each laboratory evaluate the slides, normally using an approved method such as the European Reference Method (as described by the Health and Safety Executive (1990) and the INSHT (1987)) to produce a *fibre density* (*i.e.* the number of fibres per square millimetre of filter surface) for each slide. The results are sent to the scheme co-ordinator for analysis and assessment.

About 25 laboratories have participated in PICC-FA since it was established. These laboratories include governmental departments, asbestos product manufacturers and private laboratories. The membership of AFRICA currently (1997) comprises 33 laboratories from 18 countries throughout the world. As in the PICC-FA membership, a variety of organizations is represented.

PICC-FA samples are real-life samples taken from textile production, friction material production and from asbestos removal operations. AFRICA samples are nowadays a mixture of high density industrial samples, mainly from chrysotile textile production, and low density 'clearance' samples obtained during asbestos removal from buildings. At the time of the work described in this paper, however, AFRICA was limited to the high density industrial samples; eight of these samples were circulated around both schemes to generate the data on which this paper is based.

Although the schemes have similarities in their statistical protocols, there are differences in the criteria for determination of the reference values and in the widths of the bands of 'satisfactory' performance. Table 1 lists the definitions of reference values and performance assessment limits in the two schemes.

Definition of reference values

The reference value may be described as the best estimate of the true value. In a method as subjective as fibre counting, it is particularly difficult to arrive the 'true' value. It is customary to use some measu of the average of the fibre density estimates of a nu ber of participating laboratories. AFRICA n defines each of its reference counts as *the median at least* 15 *counts*, whereas PICC-FA has chosen *arithmetic mean, excluding outlying counts* (using Dixon method to identify outliers). Both estimates the average have been shown to be effective, a indeed it would be acceptable to use other measu of the average of counts from participating labo tories. In both programmes, the laboratories' resu are presented in a format where they are 'normaliz with respect to their reference values (a normaliz result being the ratio of laboratory count to referer count).

Table 1. Characteristics of the AFRICA and PICC-1 schemes

Scheme	Reference value R (Fibres/mm^2)	Control limits normalized resul (X/R)
AFRICA	R_A median	0.65–1.55 (inner 0.50–2.00 (outer
PICC-FA	R_P mean	0.65–1.35

Performance assessment limits

Each scheme has a set of performance assessm limits which, used in conjunction with the referer counts, defines 'satisfactory' counting performan The limits for 'satisfactory' performance may described in terms of the normalized values. Hen the limits are 0.50–2.00 in AFRICA, and 0.65–1.35 PICC-FA. AFRICA employs an additional, *inner* of performance assessment limits, namely 0.65–1. These are regarded as representing the bound between simply 'satisfactory' and 'good' performan However, as the primary distinction is between 'sa factory' and 'unsatisfactory' performance, this pa will consider first the outer AFRICA limits, althou some comparisons will also be referred to the in AFRICA limits.

PICC-FA, along with some other proficiency te ing schemes such as the French national fibre count scheme (Kauffer, 1989), uses indices for laborat performance, namely the *interlaboratory* and *in laboratory indices*. The interlaboratory index fo laboratory in a given round is the mean of the l oratory's normalized results-expressed as a p centage-giving a comparison between it and other l oratories. The intralaboratory index is the coeffici of variation of the laboratory's normalized resu again as a percentage, and therefore gives a meas of the variability within the laboratory. In the pres study, we have calculated these indices in order t readers familiar with this system may relate the res to their own experience.

Assessment of participants' performances

In PICC-FA a laboratory is classified as 'satisfactory' when at least 75% of its counts on 32 consecutive samples are within the performance limits. The RICE scheme uses the same definition. AFRICA, an informal scheme, considers laboratories to have performed satisfactorily in a round when 75% of its counts on the 8 slides seen in that particular round are within the outer performance limits.

Using their respective performance assessment criteria, PICC-FA classifies an average of 85% of its participants as satisfactory, while AFRICA rates about 90–95% as satisfactory.

RESULTS AND DISCUSSION

The slides had been included in earlier AFRICA exchanges during the period 1987–1992. They circulated within different batches, and counts were contributed by almost 60 different laboratories. The number of available counts in the AFRICA data varies considerably from one slide to another, from as few as 5 counts on slides numbers 3 and 6 to 50 counts on number 7, depending on how long they had been in the scheme.

For the purpose of this study the eight AFRICA slides, previously checked on ageing or other failures, were distributed, along with PICC-FA slides, into several batches (with 2 or 3 slides in each batch). The batches then formed a routine PICC-FA circulation in which 20 Spanish laboratories took part. These laboratories had no knowledge of the presence of the AFRICA slides, in order to avoid any special attention being given to them. Each sample was evaluated between 19 and 30 times during the circulation among the Spanish laboratories. The circulation took place in the period 1993–1994.

Comparison of observed counting levels between the two sets of laboratories

The counts (fibres.mm^{-2}) given by the Spanish laboratories in PICC-FA and those obtained from the AFRICA data are graphically represented in Fig. 1. The distribution of counts is shown by boxplots. A box represents the interquartile range, and within it the median is marked. The samples show similar patterns of variation in both schemes.

The distribution of counts on each sample was examined by using a Kolmogorov-Smirnov goodness-of-fit test for normal and lognormal distributions of density (Table 2). The fibre densities in most sample-scheme combinations approximated to normal distributions; a lognormal distribution of density was not observed to be a better fit. For the present paper, the important point is that both sets of counts fit the same type of distributions. Furthermore, the statistical tests we will use later do not need assumptions of normality.

A statistical summary is given in Table 3. The median, the mean excluding outliers (according to the Dixon test), the number of counts and the coefficient of variation have been calculated for each of the eight slides, separately for the AFRICA and PICC-FA counts. These same data with the combined total counts on each slide are also indicated, and will be used later in this paper. Slide numbers 3 and 6, having

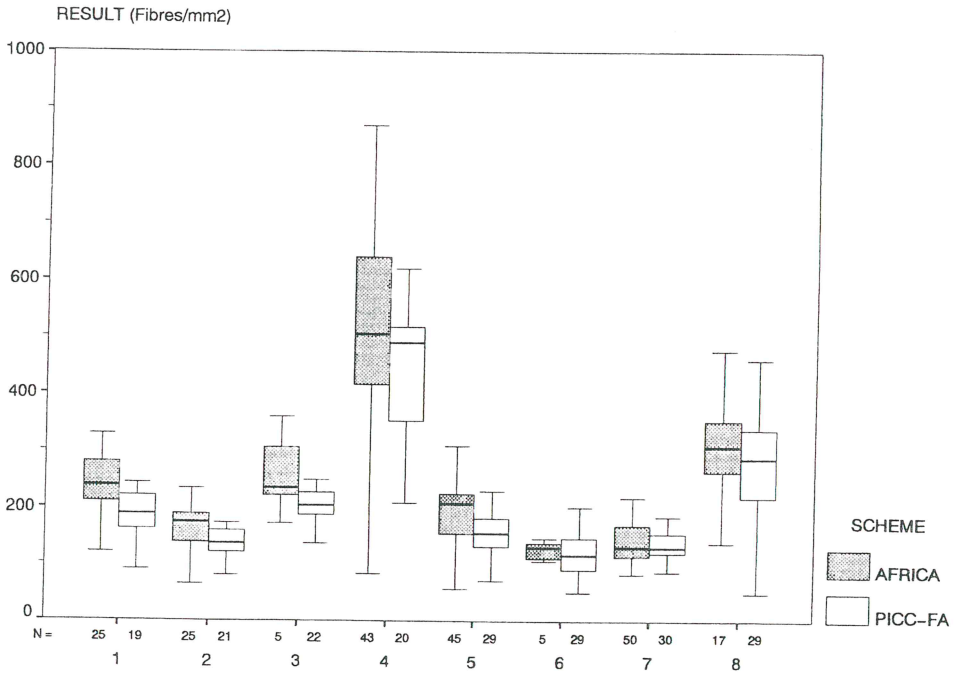

Fig. 1. Sample results in the AFRICA and PICC-FA schemes.

Table 2. Kolmogorov-Smirnov test for normality of counts distributions

		Normal		Log-normal	
Sample	Counts	Kolmogorov-Smirnov Z	2-Tailed P	Kolmogorov-Smirnov Z	2-Tailed P
1	AFRICA	0.89	0.40	0.72	0.68
	PICC-FA	0.84	0.47	0.66	0.77
	Total	1.11	0.17	0.68	0.74
2	AFRICA	0.93	0.35	0.72	0.68
	PICC-FA	0.79	0.56	1.02	0.25
	Total	0.89	0.40	0.96	0.32
3	AFRICA	0.51	0.96	0.42	0.99
	PICC-FA	0.81	0.52	1.06	0.21
	Total	0.81	0.53	0.89	0.41
4	AFRICA	0.92	0.37	1.12	0.16
	PICC-FA	0.89	0.41	1.03	0.24
	Total	1.14	0.15	1.34	0.06
5	AFRICA	1.56	0.02	1.13	0.15
	PICC-FA	0.66	0.77	0.66	0.77
	Total	1.57	0.01	1.10	0.18
6	AFRICA	0.47	0.98	0.47	0.98
	PICC-FA	0.52	0.95	0.39	0.99
	Total	0.45	0.99	0.49	0.97
7	AFRICA	0.86	0.45	1.04	0.22
	PICC-FA	0.88	0.42	1.32	0.06
	Total	0.99	0.28	1.36	0.05
8	AFRICA	0.80	0.54	1.13	0.15
	PICC-FA	0.83	0.49	1.21	0.10
	Total	1.02	0.25	1.49	0.02

only five AFRICA counts, were queried as being possibly less representative, but the samples were not rejected from the data analysis.

A quantitative comparison between the two sets of counts may readily be made by examining the data in Table 3. Significant differences are found regardless of how we compare the values. Comparing Mdn_A (i) and Mdn_P (iii), we get values for $t_{(df=7)} = 4.35$, $p = 0.003$; Sign test $p = 0.0078$. For the means $Mean_A$ (ii) and $Mean_P$ (iv), we get $t_{(df=7)} = 3.51$, $p = 0.010$; Sign test $p = 0.0078$. Similarly, significant differences would be observed between Mdn_A and $Mean_P$ or $Mean_A$ and Mdn_P, although in these cases we could not isolate the differences between counting levels from the differences between the statistics. The conclusion is that differences in the level of the counting between the two sets of laboratories have been observed. However, it is important to notice that the average difference, although significant, is also relatively small in relation to observed interlaboratory differences in either scheme. Note that the coefficients of variation range from 14% to 49%.

The differences in the level of counting lead to differences in the reference values given for the samples. If we considered the respective reference values, namely R_A (the median for the AFRICA counts) and R_P (the mean excluding outliers for the PICC-FA counts), we find that the mean ratio of R_A/R_P is 1.17 (standard deviation, $s = 0.11$), which means an average difference of 17%, AFRICA ref-

Table 3. Summary of results on each sample

	AFRICA counts				PICC-FA counts				Total counts			
Slide	Mdn_A (i) R_A	$Mean_A$ (ii)	N_A	CV_A	Mdn_P (iii)	$Mean_P$ (iv) R_P	N_P	CV_P	Mdn R_{AT}	Mean R_{PT}	N	CV
1	238	244	25	0.39	188	184	19	0.34	219	223	44	0.40
2	174	162	25	0.36	136	137	21	0.34	147	159	46	0.38
3	235	259	5	0.28	203	194	22	0.27	209	212	27	0.29
4	505	550	43	0.49	489	444	20	0.26	495	504	63	0.45
5	208	207	45	0.46	155	160	29	0.34	179	179	74	0.45
6	130	126	5	0.14	116	119	29	0.34	117	120	34	0.32
7	132	140	50	0.28	131	135	30	0.28	131	138	80	0.28
8	308	303	17	0.40	287	279	29	0.43	302	288	46	0.42

erence values being that amount higher than those of PICC-FA.

Performance assessment differences between schemes

PICC-FA performance assessment limits ($0.65R_P$–$1.35R_P$) are evidently less wide than those of AFRICA outer ($0.50R_A$–$2.00R_A$) or even AFRICA inner limits ($0.65R_A$–$1.55R_A$). The effect of these differences on the number of within-limit values could give some interesting information and it will be used in this work to make comparisons between schemes as discussed in the following sections.

Differences in assessments of individual counts

The first comparison of the differences in assessments was by individual counts. Beforehand, the assessment was done separately for both sets of counts to compare the performances of the schemes. The reference values R_A and R_P were applied to counts from AFRICA and PICC-FA laboratories respectively, to derive 'normalized values' (*i.e.* ratios of laboratory counts to reference counts). The classification of the normalised values as within limits (WL) or outside limits (OL) according to their own scheme were recorded in 2×2 tables. The proportion of counts obtained within the AFRICA outer limits is 89% and this is significantly higher than the proportion of WL values obtained in the PICC-FA scheme (79%) ($\chi^2_{Pearson} = 8.46$, $p = 0.003$). The proportion of counts obtained within the AFRICA inner limits is no different from the proportion of counts obtained within the PICC-FA limits (79% in both cases). If we consider that the proportion of WL values is an index of the performance of the schemes it can be concluded that the performance of PICC-FA is, in this respect, similar to the performance of the AFRICA inner limits.

As part of our investigation, we were interested in the level of agreement or disagreement between PICC-FA and AFRICA in the classification of any single count. Thus, all the counts for each slide were considered as a single set of data regardless of their origin and assessed twice using the performance criteria of both schemes. The reference values R_{AT} and R_{PT} were applied (Table 3), as appropriate to each count to derive the normalized values, which are graphically presented in Fig. 2. Figure 2(a) represents the overall results for the eight slides evaluated according to the criteria of AFRICA and Fig. 2(b) represents this same results evaluated according to the PICC-FA criteria. The performance assessment limits are also shown: 0.50–2.00 for class 2 and 0.65–1.55 for class 1 AFRICA-style assessments, 0.65–1.35 for assessments based on PICC-FA criteria.

The level of agreement in result classification was determined by a cross-tabulation (Table 4). Firstly, we made the comparison of PICC-FA with AFRICA outer limits finding that 351 of a total of 414 cases get the same classification in both schemes. This does not mean a significant agreement (Kappa = 0.47) (Fleiss, 1981; page 218), but cames from the fact that there are 63 values affected by the different position of the control limits between schemes. The lack of symmetry is also evident: the 63 cases are all cases classified WL in AFRICA while they are classified OL in PICC-FA, and there is no case classified OL in AFRICA that becames classified WL in PICC-FA. The McNemar test reveal that this asymmetry is very significant ($\chi^2_{McNemar} = 61.02$, $p < 0.0001$) (Table 4a). Regarding the comparison between PICC-FA and the AFRICA inner limits, we find that the level of agreement increases dramatically: 394 cases receive the same classification (Kappa = 0.86). The asymmetry still appears, although reduced: 19 out of 20 cases classified WL in AFRICA become OL in PICC-FA while only one case classified OL in AFRICA becomes WL in PICC-FA ($p < 0.0001$) (Table 4b). These findings reveal that the main cause of discrepancies is the position of the control limits and that the observed differences in the references values do not have a significant effect.

Effects of the differences of performance assessment criteria

To predict the possibility of harmonization we analyzed the number of WL counts resulting from the different combinations of reference values and assessment limits, using the overall combined data (Table 5).

Regarding the performance assessment limits, it is clear that the number of WL counts increases as the width of the control limits increases, but it is important to make some observations. For example, the PICC-FA limits are two decimal points (about 22%) narrower than AFRICA inner limits, yet only a decrease of 15–20 WL counts (4–5% of the total number of counts) are observed. Likewise, the AFRICA outer limits are actually eight decimal points (about 114%) wider than the PICC-FA limits, yet only 63–65 (15–16%) of the counts are affected by this large difference in limits.

PERFORMANCES OF THE SPANISH LABORATORIES AS ASSESSED BY THE TWO METHODS

The last comparison of differences in assessments was by laboratories. The criteria for assessment of participants' performance in both schemes has been described above.

The possible disagreements between PICC-FA and AFRICA in the laboratory performance classification were investigated. This could be regarded as an example of differences in classification between a typical national and an international proficiency testing scheme. For this purpose, only laboratories which counted all 8 of the samples were taken into account. Unfortunately, performances of the AFRICA laboratories could not be assessed individually because none of those laboratories had counted all eight of

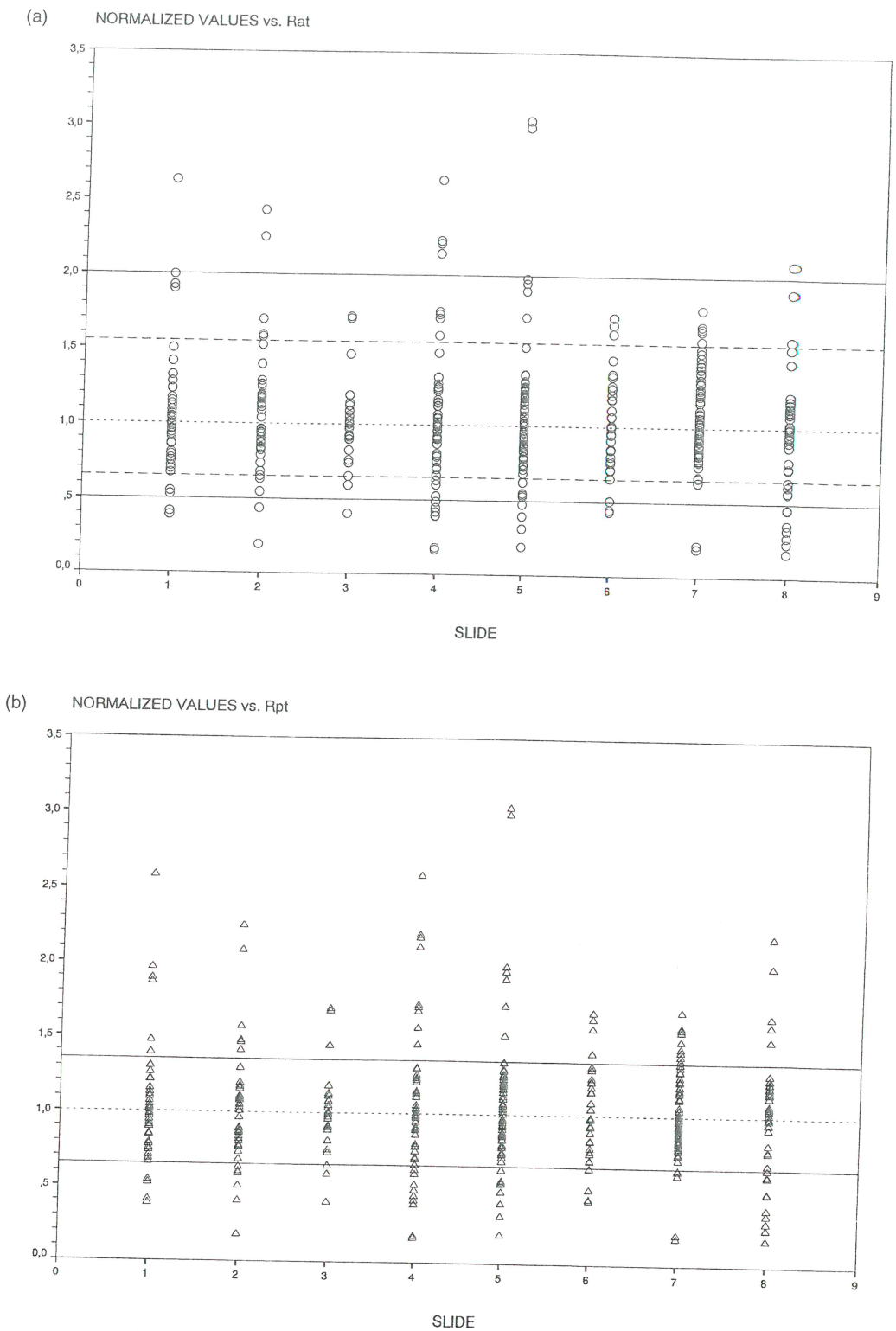

Fig. 2. Total results assessed by AFRICA (a) and PICC-FA (b) schemes.

the slides. The evaluation of performance of the 16 Spanish laboratories matching this requirement is summarized in Table 6.

The inter- and intra- laboratory indices, the percentage of 'WL' results, and the 'satisfactory' (S) or 'unsatisfactory' (NS) classifications were compared, using the performance assessment criteria for both schemes, although laboratory performance assessment in PICC-FA is evaluated on the results from 32 samples, whereas only 8 samples' data were available

Table 4. Comparison of results assessments (WL or OL) between schemes

		(a) AFRICA outer limits WL	OL	Total
PICC-FA limits	WL	314	0	314
	OL	63	37	100
	Total	377	37	414
		(b) AFRICA inner limits WL	OL	Total
PICC-FA limits	WL	313	1	314
	OL	19	81	100
	Total	332	82	414

Table 5. Summary of WL counts with PICC-FA and AFRICA criteria

	PICC-FA	Control limits AFRICA inner	AFRICA outer
Reference value	0.65-1.35	0.65–1.55	0.50–2.00
R_{PT} (PICC-FA criteria)	314 (76%)	329 (79%)	377 (91%)
R_{AT} (AFRICA criteria)	312 (75%)	332 (80%)	377 (91%)

here. Furthermore, we will consider only the outer AFRICA limits.

The within limits differences have little effect on the critical requirement for satisfactory performance. Fourteen of the 16 laboratories (87.5%) would have achieved a satisfactory classification in both schemes. This percentage is a figure typical of the actual classifications awarded in the routine running of PICC-FA. Of the two remaining laboratories, one would be clearly unsatisfactory in both schemes, leaving only one laboratory (6% of the total) with conflicting assessments (satisfactory according to AFRICA, but unsatisfactory in PICC-FA). This difference is again clearly the result of the less stringent limits employed in the AFRICA scheme.

CONCLUDING DISCUSSION

Discrepancies in the classification of results between two different asbestos fibre counting performance assessment schemes, PICC-FA (Spanish) and AFRICA (international), have been found in this study, in which the fibre counts of eight reference samples were assessed in accordance with the criteria of both schemes. 15% of counts (of a total of 414) would have been classified differently between one scheme and another. The differences between the two methods of calculating the reference counts were shown not to be important. The reason for the discrepancies in results' classification lies mainly in the setting of the width of the performance assessment limits.

On the basis of this study, it is concluded that discrepancies could be expected between other asbestos fibre counting assessment schemes with higher degrees of dissimilarity than PICC-FA and AFRICA. It is recognized that there may be good reasons historically for differences between schemes, but it is surely desirable that schemes testing the same analytical method-optical fibre counting in the present case-should have, as far as is practicable, harmonized. The question is what aspects have to be harmonized?

The harmonization of limits opens the question of

Table 6. Performance of the Spanish laboratories as assessed by AFRICA and PICC-FA methods

Lab	Inter index (1) PICC-FA	AFRICA	Intra index (2) PICC-FA	AFRICA	% 'WL' results PICC-FA	AFRICA	Classification PICC-FA	AFRICA
1	−1	−15	20	17	87.5	87.5	S	S
2	−4	−18	17	16	100	100	S	S
3	11	−4	29	31	87.5	100	S	S
4	−5	−17	16	20	100	100	S	S
5	−52	−57	23	25	12.5	12.5	NS	NS
6	8	−7	22	23	87.5	100	S	S
7	5	−10	13	13	100	100	S	S
8	−10	−23	18	20	87.5	100	S	S
9	2	−11	17	22	100	100	S	S
10	−4	−17	13	14	100	100	S	S
11	11	−3	29	34	87.5	100	S	S
12	46	26	33	31	37.5	100	NS	S
13	11	−5	13	11	100	100	S	S
14	24	6	14	7	87.5	100	S	S
15	32	15	43	46	75	87.5	S	S
16	−10	−23	23	21	87.5	100	S	S
Mean values	±21	±20	23	24	83.6	93.0		

(1) Inter index = (Mean of Normalized Results × 100) − 100
(2) Intra index = Coefficient of Variation of Normalized Results × 100.

what limits are the more appropriate? It is important to bear in mind that the aim of a performance assessment scheme for asbestos fibre counting is to reduce and control the variability of results. With narrower control limits, less variability is permitted, and the participants are thus encouraged to achieve better performance. Moreover, the proportion of within-limits values must be large enough to include a majority. In other words, the control limits of the schemes must be in accordance with the performance of the participants. So, the harmonization of the schemes based on the use of identical performance limits-*i.e.* to work with the same variability-does not seem to be the best item to begin with, since that would take no account of the relative performances of different groupings of laboratories. A better approach could be to regulate the proportion of within-limits values to be achieved by the performance assessment schemes. It is suggested that organizers of proficiency testing schemes should seek agreement on this point. Moreover, this approach does not require modifications to the internal organization of the schemes, and agreement on a suitable figure should therefore be reached relatively easily. The laboratories' performance assessment criteria is other important issue to be harmonized, specially for those schemes linked to accreditation programs. It should be aimed in further stages.

Participation in AFRICA is restricted for practical reasons to a small number of laboratories per country, so this simple interchange has also been useful in allowing the Spanish laboratories to measure their performances against international standards, demonstrating that laboratories with satisfactory performance in the national scheme would achieve satisfactory performance in the international scheme. International schemes based on circulations of permanent slides would be enhanced by sample contributions from national schemes and it would be an indirect way for all laboratories to participate in a mutually recognised proficiency testing scheme.

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