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External quality assessment schemes for clinical chemistry in the United Kingdom

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Summary. - The system of UK national external quality assessment schemes (NEQASs) has been developed over more than 20 years, using logical criteria for scheme design and operation, and their usefulness is supported by evidence of continuing improved performance. The UK approach has built on the enthusiasm and knowledge of individual experts working to provide a fully integrated system of EQASs to facilitate the provision of reliable patient care.

Key words: external quality assessment, interlaboratory surveys, clinical chemistry, proficiency testing, decentralised testing.

Riassunto *(Schemi di valutazione esterna di qualità per la chimica clinica nel Regno Unito).* - Il sistema nazionale di valutazione esterna di qualità nel Regno Unito (UK-NEQAS) è in corso da più di 20 anni. Per la definizione e l'applicazione dello schema operativo sono stati utilizzati criteri logici la cui validità è provata da un costante miglioramento delle prestazioni dei laboratori. Il metodo di valutazione applicato nel Regno Unito è stato preso in considerazione e molto apprezzato da esperti che hanno proposto a livello internazionale un sistema integrato di schemi di valutazione esterna di qualità per garantire ai pazienti servizi di analisi cliniche affidabili.

Parole chiave: valutazione esterna di qualità, saggi interlaboratori, chimica clinica, valutazione di abilità, test decentrati.

Introduction

As described earlier [1], the United Kingdom (UK) has over the last 25 years developed a comprehensive system of external quality assessment schemes (UK NEQASs). Schemes for clinical chemistry and haematology [2] led this activity, with later diversification to include all of laboratory medicine [3, 4], and within clinical chemistry (Table 1) a network based on three major and several minor centres has developed. Subschemes (Table 2) at Wolfson Research Laboratories, Birmingham (WRL; also including international EQA schemes and training on behalf of the World Health Organization and International Atomic Energy Agency) have combined expertise in EQA with that of acknowledged scientific experts who contribute to scheme operation and the relevant Steering Committees, demonstrating commitment to centralisation of operation whilst retaining the most appropriate scientific advice [1, 4, 5]. UK NEQAS policy is for harmonisation of practice where appropriate, particularly within the field of endocrinology [6, 7].

Such harmonisation has been greatly facilitated by the development at WRL of a core computing system for EQA data processing. This [7] provides a common framework for any EQAS dealing with quantitative or non-quantitative results, with all the administrative facilities required for EQAS operation in a MUMPS database environment which is completely menu-driven and can be tailored to suit the organising centre's requirements. Any required data processing, scoring or report presentation modules can be provided, and the system has been adopted by almost all UK NEQASs in clinical chemistry and immunology. The flexibility of the system is further enhanced by its applicability not only to minicomputers but also to IBM or compatible single or multiuser PC systems; international transferability has been proved in Malaysia and Zimbabwe.

UK NEQAS general principles and fundamental requirements

Participation in UK NEQASs is voluntary and confidential, though laboratory accreditation will probably make participation obligatory, and the main objective of UK NEQASs is to provide an educational stimulus towards improvement [1]. UK NEQAS design reflects the WHO recommendations on EQAS design and purpose [8], and the schemes provide assessments of the overall state of the art (general standard of performance), of the effects of individual analytical procedures (method principles, reagents and instruments), and of the specimens distributed in addition to assessment of individual laboratory performance.

The main requirement for any EQAS is to establish and maintain the participants' *confidence* in the scheme, not only in EQAS operation but also the scientific validity of scheme design. Our experience indicates several fundamental requirements (Table 3) as prerequisites for success of an EQAS in promoting reliability of patient care through improved comparability of results from different laboratories. The theoretical basis of these requirements is exemplified by experience within the UK, supported by experience from other UK NEQASs and internationally.

Table 1.- UK NEQASs in clinical chemistry

Birmingham	UK NEQAS for general clinical chemistry & sub-schemes UK NEQAS for thyroid-related hormones UK NEQAS for extra-laboratory cholesterol UK NEQAS for urinary cortisol
Cardiff	UK NEQAS for steroid hormones UK NEQAS for therapeutic drug monitoring UK NEQAS for drugs of abuse
Edinburgh	UK NEQAS for peptide hormones, etc. UK NEQAS for tumour markers (I)
Guildford	UK NEQAS for trace elements
Nottingham	UK NEQAS for sex hormone binding globulin
Sheffield	UK NEQAS for special immunochemistry UK NEQAS for IgE UK NEQAS for tumour markers (II)

Fundamental requirements for EQAS design

The performance data reported to laboratories must be current, to ensure both motivation and ability to investigate any problems indicated by EQAS data. The UK NEQAS for general clinical chemistry has two-weekly distributions of single specimens (to yield independent data for cumulation), and reports should be received one week after specimen analysis (Table 4); each distribution should be completed before the next starts.

Scoring systems [3, 5] have proved invaluable in simplifying the presentation of cumulative performance information, to facilitate and make more reliable its interpretation by individual laboratories. Such systems must be robust and reliable and be independent of other participants' performance so scores can be compared (for both individual laboratories and the overall situation) over time to monitor improvements, and across geography to assess relative performance in different schemes. Systems such as standard deviation differences (SDDs, "Z scores") are *not* suitable for this purpose, whereas the variance index (VI; Table 5) [5, 9] and BIAS/VAR (Table 6) [6, 10] systems are; these provide an assessment of individual laboratory bias and its variability, and the VI system also of total error.

The specimens distributed must be appropriate for the intended purpose. The factors to be considered include species of origin, additives or preservatives, and presentation (usually liquid or lyophilised), the main concerns being any lack of stability or commutability or other matrix effects which might prejudice the assessment of laboratory or method performance. For immunological analyses of hormones or specific serum proteins, liquid

Table 2. - UK NEQAS for general clinical chemistry and sub-schemes, 1992

UK NEQAS for	Participants	Distributions/ year	Analytes	Established
General clinical chemistry	650	24	20 (from 25)	1969
Lead in blood	120	24	2	1973
Neonatal screening	55	6 (6 specimens)	2	1980
Specific proteins	310	12	6	1980
Salicylate & paracetamol	310	12	2	1984
Urinary catecholamine & metabolites	150	6 (2 specimens)	6	1987 (transferred)
Glycated haemoglobin	220	6 (3 specimens)	3	1990 (transferred)
Urinary albumin	130	4 (3 specimens)	3	1990

Table 3. - Fundamental requirements of successful EQAS design to promote participants' confidence

Frequent surveys
Rapid turnround time
Cumulative scoring system
Reliable specimens
Valid target values
Informative, intelligible reports

Table 4. - Timescale for distributions in UK NEQAS for general clinical chemistry

	Day	Activity
1	Thursday	Specimen despatch
2	Friday	Specimen receipt
		Analysis by participant
12	Monday	Deadline for results receipt Data entry
13	Tuesday	Data processing and checking
14	Wednesday	Report printing Report despatch

human serum specimens are used (with preservatives where necessary). For practicability general clinical chemistry uses lyophilised specimens, predominantly of animal origin though performance for albumin is assessed only on human-based specimens; as a further precaution against inappropriate assessment, method-related designated (target) values are used in this scheme. Effectively all UK NEQASs use consensus values as designated values, though these are *not* automatically assumed to be correct. Wherever possible these designated values are validated [14] using studies of reproducibility, recovery of added analyte and baseline security in analyte-free material, and also external collaborative studies with other EQASs. Such collaboration, previously informal, e.g. [13], is increasing particularly with support from the European Community [15].

The final link in stimulating improvement is to provide reports which are informative yet understandable by participants. Use of cumulative scoring systems is of assistance, but clear and structured reports are essential and laser printers have assisted considerably (Fig. 1).

Assessment of performance

The use of scoring systems and structured report formats also facilitates a rational approach to performance assessment in a hierarchical manner. The VI system (Table 5) exemplifies such interpretation.

The OMRVIS, an indicator of overall total error, indicates whether a laboratory has major difficulties. Examination of MRVISs for each analyte (as indicators of total error) should permit identification of analytes with the greatest difficulties relative to the state of the art. At this stage participants must use professional judgement, with particular consideration of internal quality control and other management information, to determine whether or not action is required. If so, the more detailed scores MRBIS and SDBIS (as indicators of bias and variability of bias respectively; analogous to the BIAS and VAR scores) yield valuable information regarding the underlying problem. Though scores provide an excellent means of data reduction and simplified interpretation of performance at this stage, they are an oversimplification of the situation and there is no substitute for re-examination of the laboratory's individual results and their relationship to designated values (Fig. 2).

Graphical presentations of data are invaluable both to scheme organisers (responsible for initial advice to participants apparently experiencing problems) and to the Advisory Panel [1].

These provide assessment of changes in performance with time, as in Fig. 3 illustrating progressive decrease (improvement) in OMRVIS over the first two years of a laboratory's participation in the scheme. Much more valuable, however, is the relationship of the laboratory's results to designated values, shown in Fig. 2 for a laboratory with variable bias for sodium (shown later to be due to imprecision of manual serum dilution prior to flame photometry).

Extra-laboratory assays

Within the UK, as elsewhere within Europe, more laboratory medicine investigations are undertaken closer to the patient, not only in hospitals but also in primary care. Surveys in the UK had demonstrated that glucose assay using reflectance meters in hospitals was unsatisfactory [16]. More recent surveys [17] confirmed the existence of similar difficulties for cholesterol assay in primary care physicians' offices, occupational health departments, pharmacies and other situations in the community (Fig. 4). We have rejected the concept of national EQASs for glucose assay, as the primary concern should be continuity of patient care at the local level. Thus it is the laboratory's responsibility to assist, advise and control such systems through provision of education, maintenance and training on a continuing basis, with comparison of results on clinical materials to ensure the most appropriate service for individual patient care. Such liaison often involves the operation of a local EQAS, and we are using our expertise to produce a package, comprising a protocol with recommendations on appropriate materials, software for data processing, result presentation and interpretation.

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UK EQAS for General Clinical Chemistry

UKEQAS for General Clinical Chemistry, Department of Clinical Chemistry Queen Elizabeth Hospital, BIRMINGHAM B15 2TH, U K
FAX 021-414-1179

Distribution: **414** Date: **4-Feb-91** Laboratory :

Specimen: **Randox Multi-Sera Normal, lot 047SN**

560 laboratories returned results for this distribution

	Designated value	Result	BIS	MRVIS
Sodium (mmol/L)	138.90	**139**	+5	**90**
Potassium (mmol/L)	4.46	**4.5**	+28	**57**
Urea (mmol/L)	6.42	**6.1**	-87	**36**
Glucose (mmol/L)	6.26	**6.1**	-34	**45**
Calcium (mmol/L)	2.375	**2.33**	-47	**29**
Phosphate (mmol/L)	1.468	**1.5**	+28	**38**
Urate (mmol/L)	0.322	**0.33**	+33	**74**
Creatinine (umol/L)	163.7	**164**	+2	**63**
Bilirubin (umol/L)	27.42	**26**	-27	**19**
Total protein (g/L)	63.30	**63**	-12	**39**
Cholesterol (mmol/L)	4.90	**5.0**	+27	**42**
Magnesium (mmol/L)	0.863	**0.86**	-4	**24**
Total glycerol (mmol/L)		**1.0**		
Osmolality (mosmol/kg)	354.07	**350**	-40	**58**
ASAT [AST] (U/L)	43.1	**49**	+109	**70**
ALAT [ALT] (U/L)				
LD (U/L)	97.3	**105**	+60	**116**
CK (U/L)	205.3	**239**	+89	**47**
ALP [Alk Phos] (U/L)	172.4	**195**	+85	**109**
GGT (U/L)	56.2	**54**	-25	**24**

No scoring for total glycerol ('triglyceride'): exploratory survey
PLEASE NOTE THAT THE DEADLINE FOR RESULTS RECEIPT IS 1100h

Your OMRVIS : 47

Average OMRVIS

All participants : 56

Size Group I : 61
Size Group II : 53
Size Group III : 49

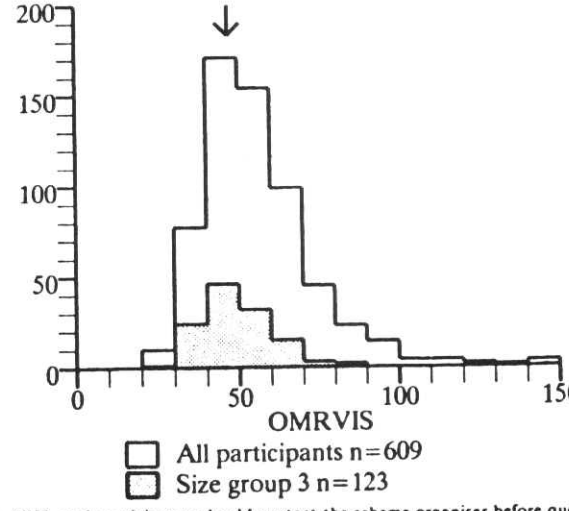

Fig. 1. - Primary page of a participant's report in the UK EQAS for general clinical chemistry.
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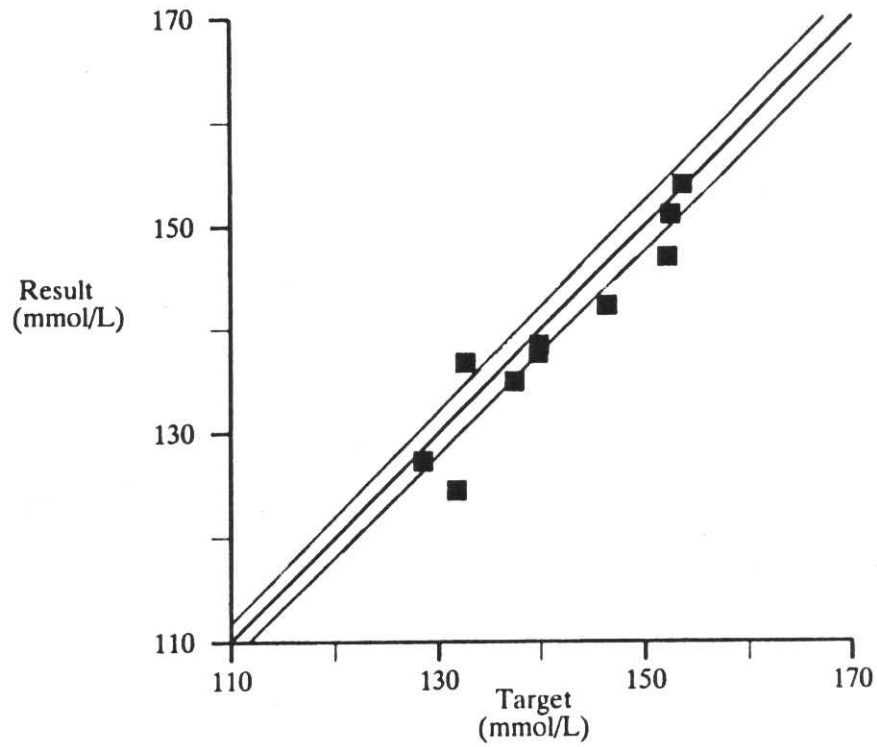
UK EQAS for General Clinical Chemistry

Distribution: 377 Identity:

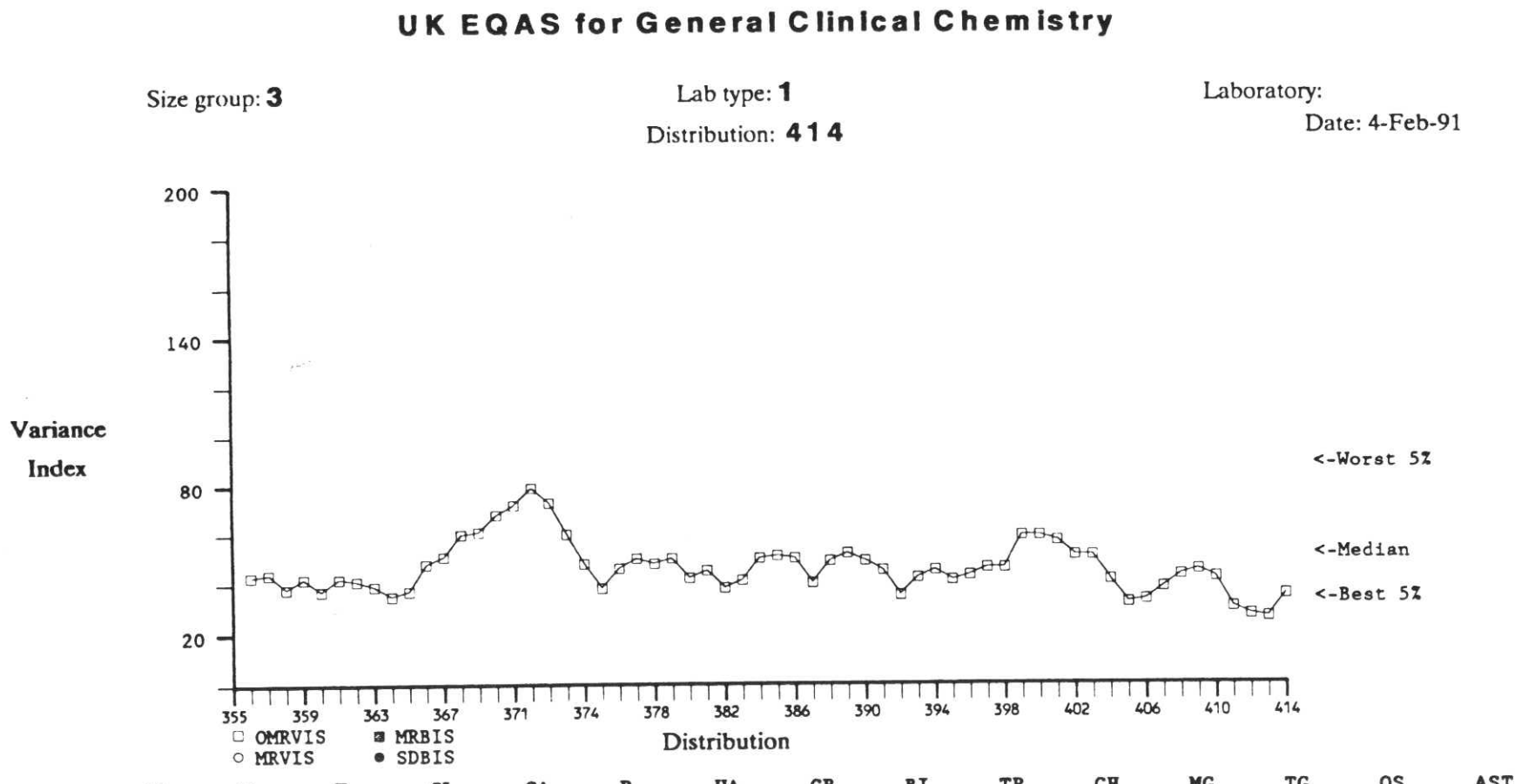
Sodium (mmol/L)



MRVIS: 115 MRBIS: -99 SDBIS: 112

Result	Target
124.50	131.73
142.30	146.37
135.00	137.36
137.70	139.75
147.00	152.12
136.80	132.65
151.10	152.46
138.50	139.82
127.30	128.41
154.00	153.55

Fig. 2. - Relationship of a participant's results for sodium to designated values over 10 distributions in the UK EQAS for general clinical chemistry, showing variable bias.



	NA	K	U	GL	CA	P	UA	CR	BI	TP	CH	MG	TG	OS	AST
MRVIS	64	41	28	25	26	99	27	17	36	26	29	37			23
MRBIS	-1	+11	+18	-5	-12	+93	+23	-14	-36	+21	+29	-34			+13
SDBIS	80	56	33	33	26	76	21	13	24	27	20	30			25

	ALT	LD	CK	ALP	GG
MRVIS			27	58	27
MRBIS			-8	+58	+27
SDBIS			35	32	11

Fig. 3. - Progressive improvement in an individual participant's performance (OMRVIS; Table 5) in the UK EQAS for General Clinical Chemistry over a period of about two years, giving current performance for individual analytes in the scheme.

WRL Extra-laboratory Cholesterol EQAS

WRL Extra-laboratory Cholesterol EQAS, Department of Clinical Chemistry Queen Elizabeth Hospital, Edgbaston, Birmingham B15 2TH, United Kingdom. Phone 021-472-1311 ext 3172 Fax 021-414 1179

Distribution: **14** Date: **16-Nov-90**

Specimen: **Specimens A14, B14 and C14** Analyte: **Cholesterol**

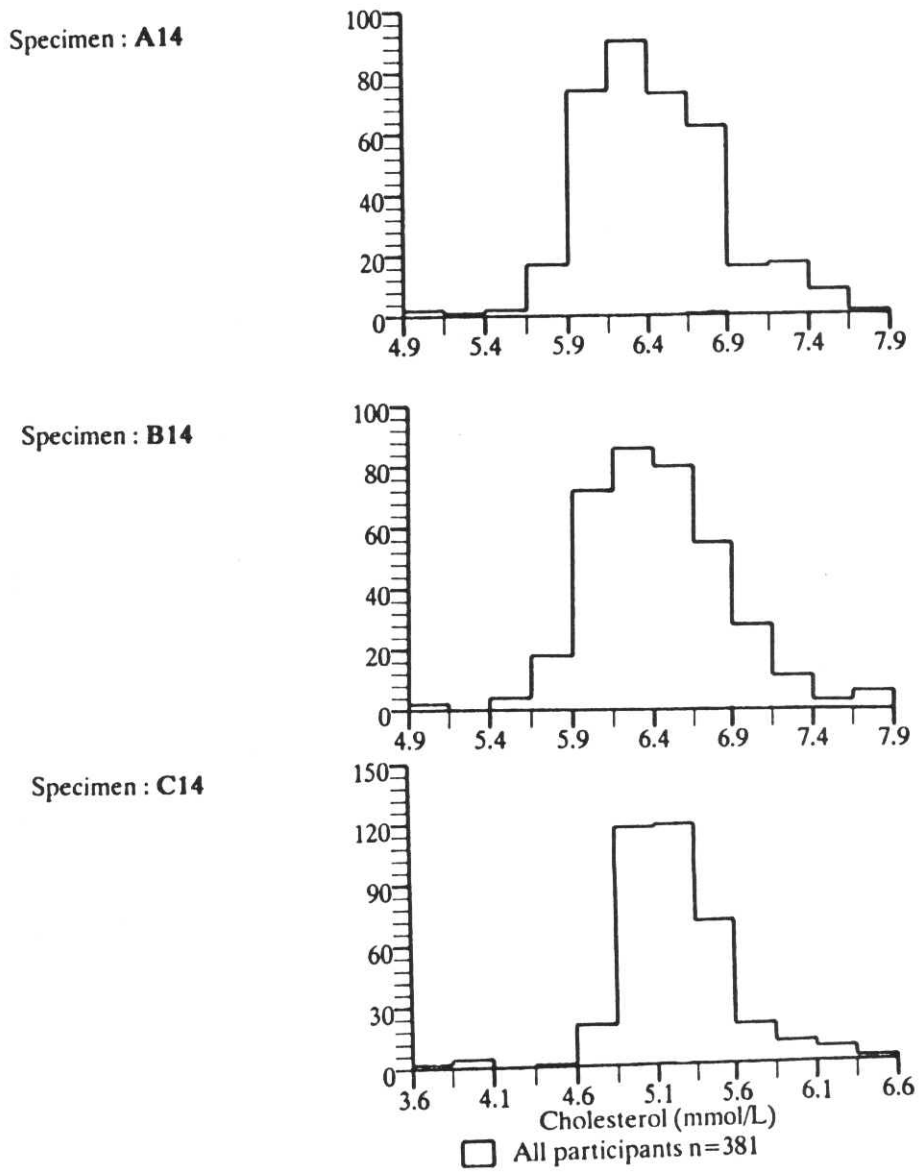


Fig. 4. - Frequency distributions of all participants' results, after exclusion of outliers, for the three specimens constituting survey 14 in the WRL extra-laboratory cholesterol EQAS.

Table 5. - The variance index (VI) scoring system, used by UK NEQASs in clinical chemistry

Bias index score (BIS):	$BIS = \frac{(x - DV)}{DV} \cdot 100 \cdot \frac{100}{CCV}$
Variance index score (VIS):	VIS = |BIS|
Mean running VIS (MRVIS):	MRVIS = mean of last 10 VISs for analyte
Mean running BIS (MRBIS) and standard deviation of BIS (SDBIS):	MRBIS = mean of last 10 BISs for analyte SDBIS = SD of last 10 BISs for analyte
Overall mean running VIS (OMRVIS):	OMRVIS = mean of last 40 (30) VISs

x = participant's result; DV = designated (target) value; CCV = chosen coefficient of variation for the analyte

Table 6. - The BIAS and VAR scoring system, used by UK NEQASs for hormones

The **cumulative bias (BIAS)** is the geometric mean of the trimmed bias values for all usable samples in the most recent 6 distributions
The **cumulative variability of bias (BIAS)** is the geometric coefficient of variation of the trimmed bias values for all usable samples in the most recent 6 distributions

Conclusions

The system of UK NEQASs has been developed over more than 20 years and their usefulness is supported by evidence of continuing improved performance [5, 9]. The UK approach has built on the enthusiasm and knowledge of individual experts working to provide a fully integrated system of EQASs to facilitate the provision of reliable patient care.

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