Evolution of a national urine quality assurance programme: the Australasian experience, 1981-1983

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SUMMARY A national interlaboratory quality assurance programme for quantitative urine analysis has been conducted over the past three years in Australasia under the auspices of the Royal College of Pathologists of Australasia and the Australian Association of Clinical Biochemists.

Analysis of urine calcium has consistently improved over the three year period whereas urine protein analysis has consistently declined. Based on the findings in 1983, it is considered that urine sodium, potassium, creatinine, phosphate, glucose, and chloride are currently being measured satisfactorily by Australasian laboratories, while the analyses of urine proteins, urate, oxalate, 5-hydroxyindoleacetic acid and 4-hydroxy-3-methoxymandelic acid still require substantial improvement.

All analyses performed in the clinical biochemistry laboratory should be assessed through interlaboratory quality assurance survey. A plethora of such surveys of regional, national, and international natures exist for those analytes in serum or plasma which are the major source of work for the clinical biochemist. In contrast, there are few reports on the design and execution of quality assurance surveys concerned with the performance of analysis of other body fluids. Although quantitative analysis of urine represents a minor but nevertheless important component of the workload of most laboratories, there are, with the exception of the urine surveys of the College of American Pathologists,¹⁻³ few reports on quality assurance programmes for analytes in this biological fluid. In 1980 a small scale regional survey of the performance of quantitative analysis of urinary analytes was therefore carried out in South Australia as a necessary prerequisite to the future establishment of an Australasian urine quality assurance survey.⁴

Under the auspices of the Australian Association of Clinical Biochemists and the Royal College of Pathologists of Australasia, a programme was instituted in 1981 to assess the standard of performance

of the quantitative analysis of 10 urinary constituents throughout Australasia.⁵ The constituents surveyed were sodium, potassium, osmolality, urea, creatinine, calcium, phosphate, urate, proteins, and glucose. The programme was also designed to provide rapid feedback to participants on their comparative performance and included novel features such as the use of target values, allowable limits for total laboratory error, linearly related analyte concentrations for all samples distributed, and computer generation of graphic interim and final reports.

In 1982, the Australasian Urine Programme was similarly conducted,⁶ with the range of analytes surveyed being extended to include chloride, oxalate, 4-hydroxy-3-methoxymandelic acid (HMMA), and 5-hydroxyindoleacetic acid (5HIAA).

In 1983 a further survey was conducted in order to provide continuing review of the standard of performance of urine analyses.⁷ The range of analytes was further extended to include amylase (EC 3.2.2.1).

Through the evolution of the Australasian Urine Programme over the past three years, a number of analytical problems have been highlighted and the standard of performance achieved by laboratories for certain urine chemistries has improved substantially. This paper summarises the programmes implemented and the results obtained over the three years and reviews the progress made towards attempting to raise the standard of performance of

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Table 1 *Participants in the Australasian urine programmes: 1981-1983*

State or country	No of laboratories		
	1981	1982	1983
New South Wales	32	35	33
Northern Territory	1	2	2
Queensland	14	11	13
South Australia	5	4	6
Tasmania	3	5	4
Victoria	19	24	24
Western Australia	4	5	7
New Zealand	8	9	11
Total	86	95	100

quantitative urine analysis in Australasia. Summary reports of each year's results have been made available to participants and published in national professional journals.⁵⁻⁷

Material and methods

PARTICIPANTS

A total of 86, 95, and 100 laboratories participated in the 1981, 1982, and 1983 surveys respectively. A breakdown of participants by state and country is shown in Table 1. Of the 100 laboratories that participated in the 1983 programme, 58 participated in the 1981 programme, 69 in the 1982 programme, and 47 in all three programmes.

SURVEY SAMPLES

Before the start of each survey participants were required to complete a questionnaire concerning the methods, instruments, standards, and quality control materials used in analysis and on the units and reference ranges used in reporting results.

During each year, at roughly two to three monthly intervals, 12 samples (in three batches of four), six samples (in three batches of two), and six samples (in three batches of two) were sent in 1981, 1982, and 1983 respectively to all participants together with a detailed instruction sheet and colour coded result sheets.

In 1981, all survey samples were generated in the laboratory of the survey organisers from a single lot of Ortho Control Urine I (Ortho Diagnostics, Raritan, NJ 08869). An appropriate number of vials were reconstituted with a defined volume of reconstitution material to generate a series of samples with linearly related concentrations. After reconstitution, 10 ml aliquots were dispensed into labelled plastic tubes, and these liquid samples were then distributed to participants by air cargo.

In 1982 vials of lyophilised urine quality control material, to be reconstituted by the participating laboratory, were distributed by the survey organ-

isers, together with appropriate reconstitution instructions. By varying the volume of distilled water used for reconstitution, a further set of linearly related samples was generated from a second single batch of Ortho Control Urine.

In 1983 survey material was prepared, to the specifications of the survey organisers, by the Commonwealth Serum Laboratories (Parkville, Victoria 3052); such material was totally human in origin. Vials of lyophilised material, each containing 25 ml, together with appropriate reconstitution instructions were sent in kit form directly by the Commonwealth Serum Laboratories to all participants. The samples were again linearly related.

RETURN OF RESULTS

In each survey result sheets were required to be returned to the survey organisers by a previously set cut off date; data received were entered into a computer data base, which held the laboratory code number and method data of each participant. Over the three years, on average, an 80% return of results was achieved by participating laboratories.

GENERATION OF INTERIM REPORTS

About two weeks after the nominated date for return of results, individual reports, as described in detail previously,^{5,8} were sent to each laboratory.

TARGET VALUES

In 1981 and 1982 target values were, in general, assigned to the base material by replicate analysis performed at three selected reference laboratories in South Australia using a number of different methods and instrumental techniques. Since, as shown in Table 2, the target values obtained were almost identical to the consensus mean obtained from all results excluding outliers (defined as results greater than ± 3 SD from the overall mean), we decided to use the truncated consensus mean as the target value in 1983.

ALLOWABLE LIMITS OF ERROR

Allowable limits for total laboratory error⁹ were set as described previously⁵⁻⁷ and are listed, for ease of reference, in Table 3.

SUMMARY REPORT

At the end of each survey a written report, together with a statistical summary, was sent to all participants. By using linearly related samples it was possible to analyse the results of a particular laboratory using linear regression analysis. The results from each participant were compared with the target value for each analyte and the line of best fit then determined. The lowest and highest samples distri-

Table 5 *Quality control material used in the Australasian urine programmes: 1981-1983 (percentages)*

Analyte	No of responses			Commercial urine			In-house urine			Commercial serum			Commercial aqueous			None used		
	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983
Sodium	72	73	86	48	63	60	6	3	1	34	25	31	5	3	1	7	4	6
Potassium	72	73	86	48	63	60	6	3	1	34	25	31	5	3	1	7	4	6
Osmolality	53	48	57	32	35	46	—	2	—	38	31	37	21	27	16	9	2	2
Urea	69	61	65	43	44	48	1	2	3	46	44	46	1	2	—	6	5	2
Creatinine	84	72	85	46	56	53	6	1	2	43	37	40	—	—	—	5	3	5
Calcium	81	68	81	35	56	48	2	—	1	57	41	47	4	1	—	2	1	4
Phosphate	74	62	75	32	47	44	1	—	1	59	48	52	3	2	—	4	3	3
Urate	72	67	78	38	46	44	—	—	—	56	48	51	3	1	—	4	4	5
Proteins	76	66	77	48	59	57	—	—	5	39	24	31	—	—	—	8	9	6
Glucose	34	29	36	42	48	33	1	—	—	53	48	61	1	—	—	3	3	6
Chloride	—	42	42	—	55	45	—	—	—	—	38	52	—	2	—	—	5	2
Oxalate	—	17	16	—	24	25	—	41	50	—	—	—	—	—	—	—	35	25
HMMA	—	25	42	—	88	86	—	4	10	—	—	—	—	—	—	—	8	5
SHIAA	—	28	36	—	79	78	—	11	11	—	—	—	—	—	—	—	11	11
Amylase	—	—	70	—	—	6	—	—	—	—	—	89	—	—	—	—	—	6

Table 6 *Range of analyte concentrations for urine survey samples 1981-1983 (consensus means for lowest and highest concentrations of analyte)*

Analyte	1981			1982			1983		
	Low	High	Midpoint	Low	High	Midpoint	Low	High	Midpoint
Sodium (mmol/l)	76	248	162	129	251	190	20	115	68
Potassium (mmol/l)	32	103	68	28	52	40	19	91	55
Osmolality (mmol/kg)	441	1463	952	491	965	728	106	896	501
Urea (mmol/l)	213	702	458	171	329	250	21	471	246
Creatinine (mmol/l)	7.3	23.6	15.5	6.4	12.0	9.2	2.1	18.9	10.5
Calcium (mmol/l)	2.62	8.74	5.7	1.10	2.07	1.6	1.17	3.72	2.45
Phosphate (mmol/l)	12.3	40.0	26	13.7	25.8	20	4.9	17.7	11.2
Urate (mmol/l)	0.52	1.74	1.1	0.56	1.01	0.8	1.59	2.49	2.04
Proteins (g/l)	0.36	2.17	1.27	0.31	0.55	0.43	0.10	1.88	0.99
Glucose (mmol/l)	0.7	23.2	12	9.7	19.3	14.5	0.5	17.9	9.2
Chloride (mmol/l)	—	—	—	117	227	172	24	130	77
Oxalate (mmol/l)	—	—	—	0.16	0.25	0.21	0.11	0.46	0.29
HMMA (μ mol/l)	—	—	—	60	96	78	11	140	76
SHIAA (μ mol/l)	—	—	—	63	108	86	36	177	107
Amylase (U/l)	—	—	—	—	—	—	60	680	370

based calibrants seen in 1982 did not continue in 1983 and, for most analytes, the use of such material became even higher than in 1981.

QUALITY CONTROL MATERIALS

The range of quality control materials used is shown in Table 5. In addition, equine serum and spinal fluid quality control materials have been used as such for the analysis of proteins; we believe that such materials should not be used. As with calibration materials, the positive trend in 1982 towards laboratories using urine materials for quality control in preference to serum materials was reversed in 1983. It is incomprehensible that a large proportion of participants consistently continues not to use any form of quality control to monitor analytical performance; this is particularly of concern for the analysis of urinary oxalate, where the standard of performance is poor.

OVERALL STANDARD OF PERFORMANCE

At the end of each survey the following were calcu-

lated: the number of laboratories participating; the classification of methods used and the number of laboratories using those methods; the total number of results submitted; the number and percentage of blunders (defined as those results outside the target value $\pm$ three times the allowable limits of error); the number and percentage of unacceptable results (defined as those results outside the allowable limits of error); and the imprecision and bias, ranked at various intervals or percentiles.

Using the wealth of data available to the survey organisers, an attempt has been made to draw objective conclusions on the overall standard of performance of each analysis over the three year period. Owing to the fact that (a) the survey material used was of differing origins, (b) the range of analyte concentrations for the survey samples was very different from one year to the next, as shown in Table 6, and (c) the laboratories participating in each survey were not the same, this task has proved rather difficult. Throughout the evolution of the urine programme, however, identical allowable limits for total laborat-

Table 7 Percentage of unacceptable results in the Australasian urine programmes for all participants and for the 47 laboratories that participated in all three surveys

Analyte	Percentage of unacceptable results					
	All laboratories			47 laboratories		
	1981	1982	1983	1981	1982	1983
Sodium	8	17	6	7	16	4
Potassium	7	10	12	6	10	9
Osmolality	30	30	25	28	24	26
Urea	45	27	28	45	20	26
Creatinine	17	4	11	14	5	8
Calcium	51	25	22	52	23	22
Phosphate	25	26	15	19	25	12
Urate	38	37	82	39	38	83
Proteins	37	39	54	33	30	51
Glucose	13	21	4	18	17	2
Chloride	—	14	5	—	16	4
Oxalate	—	62	48	—	66	58
HMMA	—	39	41	—	36	40
5HIAA	—	43	36	—	50	28

Table 8 Trends in analytical performance observed over a three year period

Trend	Analyte
1 Consistent improvement over three years	Calcium
2 Steady progress over three years	Potassium, osmolality
3 Improvement from 1981 to 1982, which has been maintained	Urea, creatinine
4 Improvement from 1982 to 1983	Sodium, phosphate, glucose, chloride, oxalate, 5HIAA
5 Consistent decline over three years	Proteins

ory error, as defined in Table 3, have been used for each survey. We therefore consider that the percentage of unacceptable results represents an appropriate parameter to observe trends in overall analytical performance over the three year period. The percentages of unacceptable results submitted for all participating laboratories and for the selected group of 47 laboratories that have participated in all three urine surveys are shown in Table 7. The trends in analytical performance observed, which are similar for all laboratories compared with the group of 47 laboratories that participated in all three surveys, are summarised in Table 8.

Table 9 summarises the conclusions concerning overall analytical performance, as at 1983, based on the premise that the findings in 1983 reflect culmination of three years work towards improved analytical performance and the criteria that (a) <15% of

unacceptable results indicates that an analysis is performed satisfactorily, (b) 15–35% of unacceptable results indicates that analysis requires further improvement, and (c) that >35% of unacceptable results indicates that analysis is performed poorly. As a direct consequence of the results obtained in the Australasian urine programme, working parties have been established in 1983 by the Scientific and Technical Committee of the Australian Association of Clinical Biochemists with the specific aim of improving the performance of both urinary oxalate and HMMA analyses.

The overall data obtained over three years concerning the imprecision and bias of each analyte surveyed are shown in Tables 10 and 11. The median imprecision and bias obtained by all laboratories, the imprecision and bias obtained by the top 10% of all participating laboratories, and the median imprecision and bias obtained by the 47 laboratories participating in all three surveys is provided. The median value is considered to reflect "average" laboratory performance. As detailed earlier, since the range of analyte concentrations for the urine survey samples has been very different from one year to the next, imprecision and bias are expressed not only in absolute terms but also as coefficients of variation (CV%) and coefficients of bias (CB%) respectively, such terms being defined as:

$$CV = \frac{SD}{\text{Midpoint of analyte concentration range}} \times 100\%$$

$$CB = \frac{\text{Bias}}{\text{Midpoint of analyte concentration range}} \times 100\%$$

Analytical goals for the imprecision of 10 of the urinary analytes surveyed have been derived by a number of approaches.⁶ The most stringent analytical goals obtained from such approaches are shown for each analyte in Table 12. Stevens and Cresswell¹⁰ have previously advocated that the imprecision, expressed as one standard deviation, achieved by the top 10% of participating laboratories should be used as a target for imprecision for all laboratories. By comparing the standard of imprecision achieved by the top 10% of laboratories (Table 10) with the analytical goals, it can be seen that the analytical goals can be achieved, and in some instances have been surpassed, by this group of laboratories for urine sodium, potassium, osmolal-

Table 9 Standard of analytical performance, based on 1983 findings

Criterion	Comment	Analyte
<15% unacceptable results	Perform satisfactorily	Sodium, potassium, creatinine, phosphate, glucose, chloride
15–35% unacceptable results	Require further improvement	Osmolality, urea, calcium
>35% unacceptable results	Require substantial improvement	Proteins, oxalate, 5HIAA, HMMA, urate

Table 10 Imprecision obtained over three years in Australasian urine programme

Analyte	Median imprecision of all laboratories						Median imprecision of 47 laboratories						Top 10% imprecision of all laboratories					
	SD			CV			SD			CV			SD			CV		
	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983
Sodium (mmol/l)	2.8	3.9	1.4	1.7	2.1	2.1	2.6	3.9	1.5	1.6	2.1	2.2	1.1	0.9	0.6	0.7	0.5	0.5
Potassium (mmol/l)	1.1	0.8	1.4	1.6	2.0	2.5	1.0	1.0	1.4	1.5	2.5	2.5	0.7	0.3	0.4	1.0	0.8	0.4
Osmolality (mmol/kg)	9.8	7.6	5.8	1.0	1.0	1.2	9.8	5.4	5.8	1.0	0.7	1.2	4.2	2.6	2.5	0.4	0.4	0.5
Urea (mmol/l)	25.3	11.0	13.8	5.5	4.4	5.6	23.5	11.0	13.9	5.1	4.4	5.7	7.2	3.7	4.8	1.6	1.5	2.0
Creatinine (mmol/l)	0.68	0.29	0.44	4.4	3.2	4.2	0.66	0.30	0.41	4.3	3.3	3.9	0.3	0.1	0.1	1.9	1.3	1.8
Calcium (mmol/l)	0.33	0.07	0.09	5.8	4.4	3.7	0.35	0.07	0.10	6.1	4.4	4.1	0.1	0.02	0.03	1.8	1.3	1.2
Phosphate (mmol/l)	1.36	1.06	1.05	5.2	5.3	9.4	1.19	1.35	0.85	4.6	6.8	7.6	0.5	0.4	0.3	1.9	1.9	2.8
Urate (mmol/l)	0.15	0.07	0.48	13.6	8.8	23.5	0.14	0.07	0.52	12.7	8.8	25.5	0.04	0.02	0.16	3.6	2.5	7.8
Proteins (g/l)	0.10	0.04	0.11	7.9	9.3	11.1	0.10	0.03	0.09	7.9	7.0	9.1	0.04	0.01	0.04	3.2	2.3	4.0
Glucose (mmol/l)	0.1	0.5	0.4	0.8	3.4	4.3	0.1	0.5	0.3	0.8	3.4	3.3	0.02	0.21	0.15	0.2	1.5	1.0
Chloride (mmol/l)	—	27	1.6	—	1.6	2.1	—	—	—	—	—	—	—	1.2	0.52	—	0.7	0.5
Oxalate (mmol/l)	—	0.03	0.05	—	12.9	15.5	—	—	—	—	—	—	—	0.01	0.02	—	4.8	6.8
HMMA (μ mol/l)	—	10.3	13.8	—	13.2	18.2	—	—	—	—	—	—	—	3.9	4.7	—	5.0	6.2
5HIAA (μ mol/l)	—	12.6	13.3	—	14.7	12.4	—	—	—	—	—	—	—	2.4	5.8	—	2.8	5.5

SD = standard deviation.

CV = coefficient of variation.

Table 11 Bias obtained over three years in Australasian urine programme

Analyte	Median bias of all laboratories						Median bias of 47 laboratories						Top 10% bias of all laboratories					
	Bias			CB			Bias			CB			Bias			CB		
	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983
Sodium (mmol/l)	3.8	6.1	2.0	2.3	3.2	2.9	3.7	6.0	2.0	2.3	3.2	2.9	1.4	1.3	0.6	0.9	0.7	0.5
Potassium (mmol/l)	1.7	1.5	1.5	2.5	3.8	2.7	1.2	1.6	1.3	1.8	4.0	2.4	0.6	0.6	0.2	0.9	1.4	0.0
Osmolality (mmol/kg)	15.8	18.5	7.5	1.7	2.5	1.5	17.3	15.3	7.3	1.8	2.1	1.5	7.7	4.3	2.4	0.8	0.6	0.0
Urea (mmol/l)	25.8	12.5	11.0	5.6	5.0	4.5	25.8	10.0	10.1	5.6	4.0	4.1	8.3	4.6	4.4	1.8	1.8	1.0
Creatinine (mmol/l)	1.19	0.41	0.60	7.7	4.5	5.7	1.06	0.33	0.38	6.8	3.6	3.6	0.29	0.12	0.09	1.9	1.3	1.2
Calcium (mmol/l)	0.54	0.11	0.10	9.5	6.9	4.1	0.58	0.10	0.11	10.2	6.3	4.5	0.11	0.03	0.03	1.9	1.8	1.2
Phosphate (mmol/l)	1.70	1.36	0.95	6.5	6.8	8.5	1.48	1.35	0.69	5.7	6.8	6.2	0.42	0.38	0.28	1.6	1.9	1.0
Urate (mmol/l)	0.29	0.21	0.48	26.4	26.3	23.5	0.28	0.22	0.51	25.5	27.5	25.0	0.06	0.06	0.21	5.5	7.5	10.1
Proteins (g/l)	0.22	0.08	0.13	17.3	18.6	13.1	0.18	0.7	0.12	14.2	16.3	12.1	0.04	0.02	0.05	3.1	4.7	5.0
Glucose (mmol/l)	0.7	1.3	0.3	5.8	9.0	3.3	1.0	1.0	0.2	8.3	6.9	2.2	0.10	0.21	0.11	0.8	1.4	1.0
Chloride (mmol/l)	—	4.8	2.0	—	2.8	2.6	—	—	—	—	—	—	—	1.3	0.6	—	0.8	0.5
Oxalate (mmol/l)	—	0.05	0.07	—	22.4	24.5	—	—	—	—	—	—	—	0.01	0.02	—	3.8	6.9
HMMA (μ mol/l)	—	12.1	20.0	—	15.5	26.3	—	—	—	—	—	—	—	4.0	4.7	—	5.1	6.9
5HIAA (μ mol/l)	—	19.0	16.0	—	22.1	15.0	—	—	—	—	—	—	—	3.3	6.4	—	3.8	6.9

Table 12 Analytical goals for the imprecision of quantitative urine analyses

Analyte	Analytical goal
Sodium (mmol/l)	0.7
Potassium (mmol/l)	0.5
Osmolality (mmol/kg)	2.5
Urea (mmol/l)	3.6
Creatinine (mmol/l)	0.4
Calcium (mmol/l)	0.1
Phosphate (mmol/l)	0.7
Urate (mmol/l)	0.1
Proteins (g/l)	0.01
Glucose (mmol/l)	0.06

ity, creatinine, calcium, and phosphate. Furthermore, imprecision, in SD terms, has continued to improve for urine sodium, osmolality, and phosphate.

Over the three year period more than 5% of results submitted were classed as blunders, in at

least two of the three years, for the analyses of osmolality, urea, calcium, urate, proteins, oxalate, and 5HIAA. As well as being due to inherently poor analytical technique, blunders were mainly attributed to transcription, dilution, or calculation mistakes. For osmolality we recommend that attention should also be paid to calibration with a material which has an analyte concentration similar to that of routine urine specimens. For urate it was evident that some laboratories were not aware that urate precipitates in an acidic urine and, as a result, did not take the preanalytical precaution of alkalinising urine specimens submitted for urate analysis.¹¹

COMPARISON OF INDIVIDUAL METHODS FOR EACH ANALYTE

A critical assessment of the suitability of individual methods for routine laboratory use has been attempted using the data summarised in Table 13.

Table 13 Comparative performance of individual methods

Analyte	Method	No of laboratories			Results submitted			Percentage unacceptable			Imprecision (median SD of all laboratories)			Bias (median bias of all laboratories)		
		1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983	1981	1982	1983
Sodium	All	82	91	94	916	485	510	8	17	6	2.8	3.9	1.4	3.8	6.1	2.0
	Flame photometry—direct	59	61	41	656	320	214	9	18	4	3.0	3.9	1.0	4.2	6.1	2.0
	Flame—continuous flow	9	8	9	96	47	50	9	15	12	3.2	3.6	1.5	3.7	6.2	1.3
	Ion selective electrode	7	16	32	80	85	180	1	14	6	2.3	1.2	1.6	1.5	3.4	1.9
Potassium	All	82	91	94	918	486	508	7	10	12	1.1	0.8	1.4	1.7	1.5	1.5
	Flame photometry—direct	59	62	41	656	325	214	6	9	9	1.3	0.8	1.2	1.1	1.3	1.4
	Flame—continuous flow	9	8	9	98	47	50	21	15	6	3.9	1.0	1.4	3.3	1.3	1.8
	Ion selective electrode	7	16	32	80	85	178	3	13	15	0.9	0.8	1.6	1.5	2.1	1.4
Osmolality	All	58	60	64	622	311	347	30	30	25	9.8	7.6	5.8	15.8	18.7	7.5
	Freezing point depression															
	Knauer	9	9	5	100	43	26	39	49	38	15.9	9.0	—	15.7	19.0	—
	Fiske	11	12	11	112	56	59	32	34	31	13.5	9.3	5.8	23.1	24.7	7.1
	Advanced	24	20	27	263	117	146	23	15	15	8.1	4.2	5.0	13.4	10.1	6.6
	Osmette	5	8	9	52	47	52	14	26	13	4.6	7.1	4.3	14.1	18.6	6.2
Urea	Vapour pressure	6	8	5	64	35	30	28	63	63	10.6	10.0	9.6	14.4	27.3	12.2
	All	70	74	76	741	384	391	45	27	28	25.3	11.0	13.8	25.8	12.5	11.0
	Diacetyl monoxime	36	32	31	382	170	166	45	21	26	25.5	10.7	11.8	23.3	10.0	9.2
	Urease	20	27	24	227	140	121	50	32	33	28.6	15.3	22.0	32.3	12.2	21.9
Creatinine	Urease/conductivity	3	5	9	32	30	52	28	33	19	—	26.5	10.2	—	12.2	9.8
	All	83	90	96	922	478	514	17	4	11	0.68	0.29	0.44	1.19	0.41	0.60
	Jaffe—kinetic	39	45	46	436	236	251	17	6	14	0.61	0.29	0.42	1.25	0.50	0.61
Calcium	Jaffe—end point	38	33	33	422	177	177	16	3	6	0.71	0.32	0.42	1.13	0.37	0.50
	All	79	81	91	858	427	488	51	25	22	0.33	0.07	0.09	0.54	0.11	0.10
	Cresolphthalein complexone	30	33	34	325	176	182	60	37	29	0.39	0.09	0.16	0.62	0.18	0.14
	Methyl thymol blue	4	8	9	44	42	53	71	19	17	—	0.05	0.10	—	0.12	0.07
	Atomic absorption	27	26	23	287	132	124	50	18	21	0.30	0.05	0.08	0.80	0.10	0.11
	Corning titrator	11	8	12	112	41	65	25	12	14	0.13	0.04	0.04	0.38	0.03	0.09
	Calcette titrator	2	4	3	20	22	14	35	14	0	—	—	—	—	—	—
Phosphate	All	75	75	82	771	394	433	25	26	15	1.36	1.06	1.05	1.70	1.36	0.95
	Phosphomolybdoanadate	8	5	5	96	24	26	12	38	12	0.96	—	—	1.02	—	—
	Phosphomolybdate reduction	60	64	67	603	341	357	25	26	15	1.34	0.96	1.05	1.73	1.31	0.83
Urate	All	77	82	86	890	421	436	38	37	82	0.15	0.07	0.48	0.29	0.21	0.48
	Phosphotungstate reduction	31	28	26	392	149	136	24	23	82	0.17	0.09	0.39	0.15	0.12	0.50
	Uricase	38	46	49	418	236	249	52	45	82	0.14	0.05	0.54	0.39	0.25	0.46
	Metal complex reduction	1	1	—	4	6	—	75	83	—	—	—	—	—	—	—
Proteins	All	80	96	93	848	452	488	37	39	54	0.10	0.04	0.11	0.22	0.08	0.13
	TCA/ponceau S	17	15	18	186	86	95	25	19	43	0.14	0.03	0.08	0.21	0.06	0.09
	TCA/biuret	5	4	7	56	22	40	39	27	70	0.05	—	0.12	0.11	—	0.19
	SSA/biuret	4	4	1	46	23	6	44	26	50	0.06	—	—	0.22	—	—
	SSA turbidimetry	22	25	17	213	126	79	41	78	75	0.12	0.04	0.14	0.46	0.23	0.31
	TCA turbidimetry	20	19	16	211	103	91	39	24	57	0.10	0.04	0.10	0.32	0.07	0.13
Glucose	Coomassie blue	5	6	12	60	30	61	25	20	49	0.15	0.01	0.18	0.10	0.06	0.14
	All	44	44	45	355	229	229	13	21	4	0.1	0.5	0.4	0.7	1.3	0.3
	Glucose oxidase	9	13	7	65	72	42	2	13	5	0.1	0.4	0.3	0.7	1.2	0.3
	Hexokinase	6	10	10	65	51	50	2	29	2	0.1	0.7	0.2	0.3	0.9	0.3
	O ₂ rate—Beckman	7	11	12	67	66	67	2	21	1	0.1	0.5	0.4	0.3	1.4	0.3
Chloride	O ₂ rate—Yellow Springs	5	2	2	51	12	10	37	8	0	0.5	—	—	0.6	—	—
	All	—	57	57	—	228	273	—	14	5	—	2.7	1.6	—	4.8	2.0
	Silver titration	—	35	29	—	172	153	—	6	3	—	2.2	1.4	—	3.4	1.8
	Mercury titration	—	9	—	—	41	—	—	22	—	—	2.7	—	—	8.1	—
Oxalate	Thiocyanate/nitrate	—	8	9	—	42	42	—	36	10	—	4.2	2.2	—	8.3	1.4
	All	—	12	17	—	52	80	—	62	48	—	0.03	0.05	—	0.05	0.07
HMMA	All	—	32	40	—	142	204	—	39	41	—	10.3	13.8	—	12.1	20.0
	Oxidation to vanillin	—	18	19	—	80	105	—	36	30	—	11.9	12.8	—	19.4	16.2
	p-nitroaniline	—	4	7	—	20	36	—	25	50	—	—	8.2	—	—	24.1
5HIAA	All	—	30	34	—	150	168	—	43	36	—	12.6	13.3	—	19.0	16.0
	Nitrosanaphthol	—	22	23	—	115	116	—	44	38	—	12.4	12.3	—	20.3	17.0

The number of laboratories and results submitted do not add up to the respective totals, owing to the fact that "miscellaneous" methods for each analyte are not included in the table.

TCA = trichloroacetic acid.

SSA = sulphosalicylic acid.

Table 14 *Methods with poor and better performance, assessed by the percentage of unacceptable results*

Analyte	Method
Methods with poor performance	
Osmolality	Freezing point depression—Knauer Vapour pressure—Westcor
Calcium	Cresolphthalein complexone
Urate	Uricase
Proteins	TCA-biuret SSA-biuret TCA-turbidimetry
Oxalate	All methods
SHIAA	Nitrosonaphthol
Methods with good performance	
Sodium	Flame photometry—direct Ion selective electrode
Potassium	Flame photometry—direct
Creatinine	Jaffe—end point
Glucose	Glucose oxidase Hexokinase O ₂ rate—Beckman
Chloride	Silver titration

For abbreviations see Table 13.

Table 15 *Methods with poor and good performance characteristics, assessed by median imprecision and bias*

Analyte	Method
Poor imprecision and poor bias	
Osmolality	Vapour pressure—Westcor
Urea	Urease
Calcium	Cresolphthalein complexone
Good imprecision and good bias	
Calcium	Corning titrator
Proteins	TCA/Ponceau S
Poor imprecision (only)	
Chloride	Thiocyanate/nitrate
Poor bias (only)	
Osmolality	Fiske osmometer
Proteins	SSA turbidimetry
Good imprecision (only)	
Osmolality	Osmette osmometer
Good bias (only)	
Sodium	Ion selective electrode
Urate	Phosphotungstate reduction
Glucose	Hexokinase
Poor imprecision but good bias	
Proteins	Coomassie blue

For abbreviations see Table 13.

Two methods—namely, metal complex reduction for the analysis of urinary urate and sulphosalicylic acid turbidimetry for urine protein assay—are considered to be unsuitable for routine urine analyses. These two methods have, for two years in succession, had more than 70% of results submitted outside the allowable limits of error. Metal complex reduction was accordingly discontinued in the 1983 urine survey. In 1982 the high level of unacceptable results for the sulphosalicylic acid turbidimetric method was considered to reflect the fact that the

survey material, in that year, contained a small amount of bovine albumin. The continued high level of unacceptable results recorded by this method in 1983 using a totally human based matrix, however, raises serious doubts as to the validity of this method for routine analytical purposes.

Methods assessed as having shown poor performance and good performance, using the criterion that the percentage of unacceptable results, for at least two out of three years, was >35% or <10% respectively, are shown in Table 14.

Table 13 also shows the median imprecision and bias for individual methods. Such data were calculated for those method groups in which 36 or more results were submitted in a particular year. The median value was chosen, again, since it was considered to reflect the "average" performance of an individual method group. For the reasons outlined earlier in this paper, it is difficult to draw conclusions on the comparative performance of methods in terms of trends over a three year period. By comparing the differences in magnitude of the imprecision and bias, expressed in absolute terms, between individual methods within a given year, however, objective conclusions are possible.

Methods considered to show poor and good performance characteristics, in terms of imprecision and bias, are listed in Table 15. The criterion used for classifying methods into these categories was that if the median imprecision or bias or both of a particular method was 25% better (or worse) than the "all method" median imprecision or bias or both for a particular analyte for at least two out of the three years, then that particular method was deemed to display good (or poor) imprecision or bias or both respectively.

Throughout the Australasian urine quality assurance programme individual participants have been urged to examine critically the summary of their performance and assess the imprecision, inaccuracy, and linearity of their methods. At the end of the third year the survey organisers believed that the wealth of data generated from these surveys should be summarised in a manner which all laboratories could use positively to achieve a generally higher standard of performance in the future. We hope that this report facilitates this aim.

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