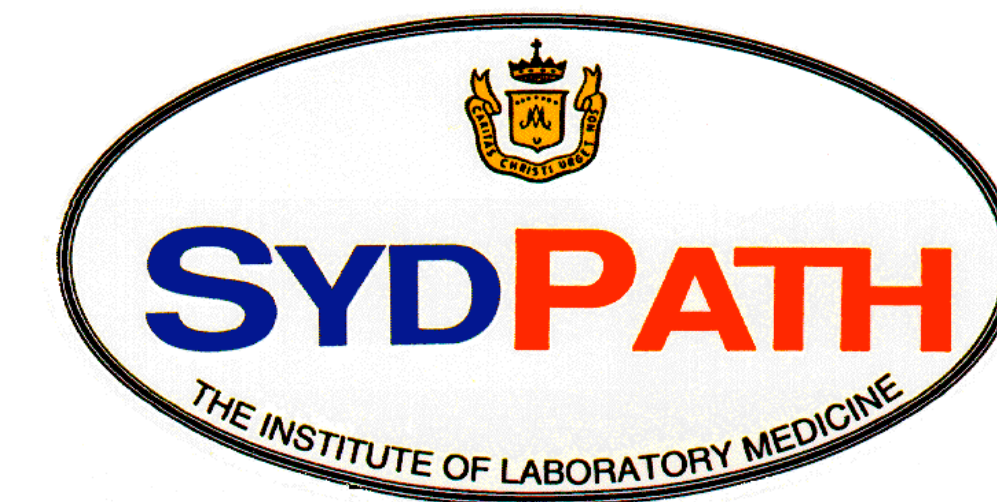




# Drug Reporting Units: a Correctable Source of Potential Clinical Errors



**Graham RD Jones**

Department of Chemical Pathology, St Vincent's Hospital, Sydney, Australia.  
gjones@stvincents.com.au

## Introduction and Aim

The use of different units for transferring data can result in serious, costly errors (see story at right).

Variation in the units used for reporting pathology results has the potential to cause medical errors if results are interpreted against decision points expressed with different units. For example a paracetamol concentration of 300 mg/L 4 hours after ingestion (toxic range) may not lead to N-acetyl cysteine therapy if interpreted against a nomogram expressed in umol/L.

Therapeutic drug concentrations may be reported in mass units, eg ug/L, or molar units, eg mmol/L. It has been noted that there is lack of uniformity in the units used for reporting serum drug concentrations in Australian and New Zealand laboratories.

The aim of this study is to examine the extent of variability in the units used for reporting therapeutic drug concentrations in Australia and New Zealand.

## Data Source

Data was obtained from the RCPA Chemical Pathology QAP with a data extraction program.

The units used to submit data for therapeutic drug concentrations was extracted for the following programs:

- General Serum Chemistry and Therapeutic Drugs
- Special Drugs

For most therapeutic drugs two reporting options are available, one for mass units and one for molar units. The number of laboratories submitting results in each type of unit was determined for Australian and New Zealand laboratories.

Additionally the following sources on drug information were reviewed to assess the units used:

- MIMS
- Australian Medicines Handbook (AMH)
- Therapeutic Guidelines (TG)



## NASA's metric confusion caused Mars orbiter loss

September 30, 1999  
Web posted at: 1:46 p.m. EDT (1746 GMT)

(CNN) -- NASA lost a \$125 million Mars orbiter because one engineering team used metric units while another used English units for a key spacecraft operation, according to a review finding released Thursday.



For that reason, information failed to transfer between the Mars Climate Orbiter spacecraft team at Lockheed Martin in Colorado and the mission navigation team in California. Lockheed Martin built the spacecraft.

## Results

The frequency of use of molar and mass units for drug measurements for all laboratories is shown in the table.

It can be seen that there is no predominant unit system in use in Australia and New Zealand.

Some drugs are reported completely in molar units (methotrexate, lithium) and some completely in mass units (gentamicin, amikacin, tobramycin).

For many drugs there are significant number of users for each system leading to a high potential for medical error..

The reference material commonly provides both unit types although a preference for mass units is seen for some drugs.

Note that the anti-rejection drugs cyclosporin, tacrolimus, mycophenolate and sirolimus are not included as the QAP only accepts mass units.

The RCPA Manual ([www.rcpamanual.edu.au](http://www.rcpamanual.edu.au)) provides only molar units for lithium, only mass units for vancomycin, cyclosporin and the aminoglycosides and both units for other drugs listed at the site.

## Mass v Molar Units

### Points in favour of mass units

- ❖ Drugs are prescribed in mass units
- ❖ Experimental clinical pharmacology literature is largely in mass units.
- ❖ For some drugs the molecular weight is uncertain.
- ❖ International literature, especially from the USA, is in mass units.

### Points in favour of molar units

- ❖ The agreed communication terminology for therapeutic drugs by IFCC and IUPAC is molar units.
- ❖ Most measurement systems, eg immunoassay, identify the relative number of molecules rather than the mass of the drug.
- ❖ Molar units allow assessment of stoichiometry.

## Discussion

The SI system was adopted in Australia in 1960 with the aim of ensuring uniformity of units in all areas. The National Measurement Institute ([www.nmi.gov.au](http://www.nmi.gov.au)) is the highest body supervising SI units in Australia, but provides no statement on the use of units for concentrations of substances.

The RCPA issued a Broadsheet in 1986 recommending the use of molar units for drug measurements, however this has not had the hoped-for unifying effect. The College on-line manual supports mixed units recognising current practice.

There are arguments in favour of both mass and molar units (see above), however for the primary goal of reducing the risk of interpretation errors, the choice of units is less important than the adoption of a single unit for each drug. The use of non-standard formats, ie 10<sup>-4</sup>M for methotrexate should especially also be discouraged.

A capable body with input from all stakeholders, including pathologists, relevant clinical groups, pharmacologists, publishers and regulatory bodies (eg TGA), is required to assess the drug units in use in Australia and New Zealand and provide guidance for the future. A combination of mass and molar units may be required to minimise unnecessary changes from the current status.

## Conclusions

This variability in drug units used for reporting has the potential to cause patient harm if a result is separated from its original report and interpreted against alternate units.

There are arguments in favour of both molar and mass units for reporting drug concentrations but a resolution is needed for each drug to ensure standardisation in this important area of laboratory testing.

## Acknowledgement

I thank Jan Gill and the staff of the RCPA Chemical Pathology QAP office for technical assistance and support.

AACB Annual Scientific Meeting, Hobart, 2006

Drug	QAP	Total numbers	Mass Units	Mass units (%)	SI units	SI units (%)	MIMS	AMH	Therapeutic Guidelines
Methotrexate	TDM	19	mg/L	0%	umol/L	100%	10 <sup>-6</sup> M, 10 <sup>-7</sup> M, 10 <sup>-8</sup> M	NA	NA
Lithium	GC	163	mg/dL	0%	mmol/L	100%	mmol/L	mmol/L	mmol/L
Digoxin	GC	248	µg/L	28%	nmol/L	72%	ng/mL (nmol/L) <sup>a</sup>	ug/mL	NA
Phenytoin	GC	140	mg/L	31%	µmol/L	69%	ng/mL (nmol/L) <sup>a</sup>	mg/L (umol/L)	umol/L & mg/L
Carbamazepine	GC	127	mg/L	31%	µmol/L	69%	ng/mL (nmol/L) <sup>a</sup>	mg/L (umol/L)	umol/L & mg/L
Valproate	GC	123	mg/L	33%	µmol/L	67%	ng/mL (nmol/L) <sup>a</sup>	mg/L (umol/L)	umol/L & mg/L
Theophylline	GC	86	mg/L	35%	µmol/L	65%	ng/mL (nmol/L) <sup>a</sup>	mg/L (umol/L)	umol/L & ug/mL
Phenobarbitone	GC	60	mg/L	33%	µmol/L	67%	ng/mL (nmol/L) <sup>a</sup>	mg/L (umol/L)	umol/L & mg/L
Salicylate	GC	96	mg/L	45%	mmol/L	55%	ug/mL, ng/mL <sup>b</sup>	NA	NA
Paracetamol	GC	236	mg/L	39%	µmol/L	61%	ug/mL <sup>c</sup>	NA	NA
Quinidine	TDM	5	mg/L	40%	umol/L	60%	mg/L (umol/L)	mg/L (umol/L)	NA
Lignocaine	TDM	6	mg/L	50%	umol/L	50%	umol/L (umol/L)	NA	NA
Amiodarone	TDM	11	mg/L	64%	umol/L	36%	ug/mL	mg/L	NA
Vancomycin	GC	139	mg/L	96%	µmol/L	4%	mg/L	mg/L	NA
Gentamicin	GC	206	mg/L	97%	µmol/L	3%	ug/mL	mg/L	mg/L
Amikacin	TDM	19	mg/L	100%	umol/L	0%	ug/mL	mg/L	mg/L
Tobramycin	TDM	43	mg/L	100%	umol/L	0%	ug/mL	mg/L	mg/L

TDM: data from Therapeutic Drug Program. GC: Data from General Chemistry and Therapeutic Drug Program.

NA no reference to serum concentrations available

<sup>a</sup> molar units not provided with all data.

<sup>b</sup> data for Asasantin SR (ng/mL), Solprin (ug/L) and Cardiprin (ug/mL) only

<sup>c</sup> serum concentrations only supplied for indicating metabolism in slow release preparations