Alder Hey Children's NHS
NHS Foundation Trust

Biochemistry Laboratory Handbook

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1. General Information

The Biochemistry laboratory forms part of the Department of Laboratory Medicine (Pathology) which is part of the Division of Medicine at Alder Hey Children's NHS Foundation Trust

Clinical Biochemistry (also known as Clinical Chemistry or Chemical Pathology) is the study of the chemical and biochemical processes of the body in their relation to disease. Biochemistry staff use a variety of complex analyses to diagnose and monitor children with a wide range of acquired and inherited disorders.

The department is staffed by a team of scientific, technical and support staff who provide an interactive clinical analytical service. The majority of the staff are members of professional associations which have an important role in the setting of professional standards and standards of analytical performance. The laboratory is accredited to UKAS ISO 15189 standard. Please click here for a link to our accreditation certificate on the UKAS site: https://www.ukas.com/wp-content/uploads/schedule_uploads/00007/9091-Medical-Single.pdf

Continuing professional development (CPD) is supported by membership of professional bodies and societies such as the Institute of Biomedical Science, the Association for Clinical Biochemistry and Laboratory Medicine, The Royal College of Pathologists and the Society for the Study of Inborn Errors of Metabolism which assist staff in maintaining an up to date clinical knowledge for the department. The department is a stakeholder member of the Metabolic Biochemistry Network and all qualified members of laboratory staff are registered with the Health Care Professions Council.

2. Using the Handbook

The handbook outlines pre-analytical guidance for both internal and external users of laboratory services provided by the Pathology Laboratories. It seeks to provide information to users when requesting tests and includes:

• Details of services provided

• Laboratory contact details and opening hours

• Instructions for completing sample and request form information

• Arrangements for transporting samples to the laboratory

• Point of care testing

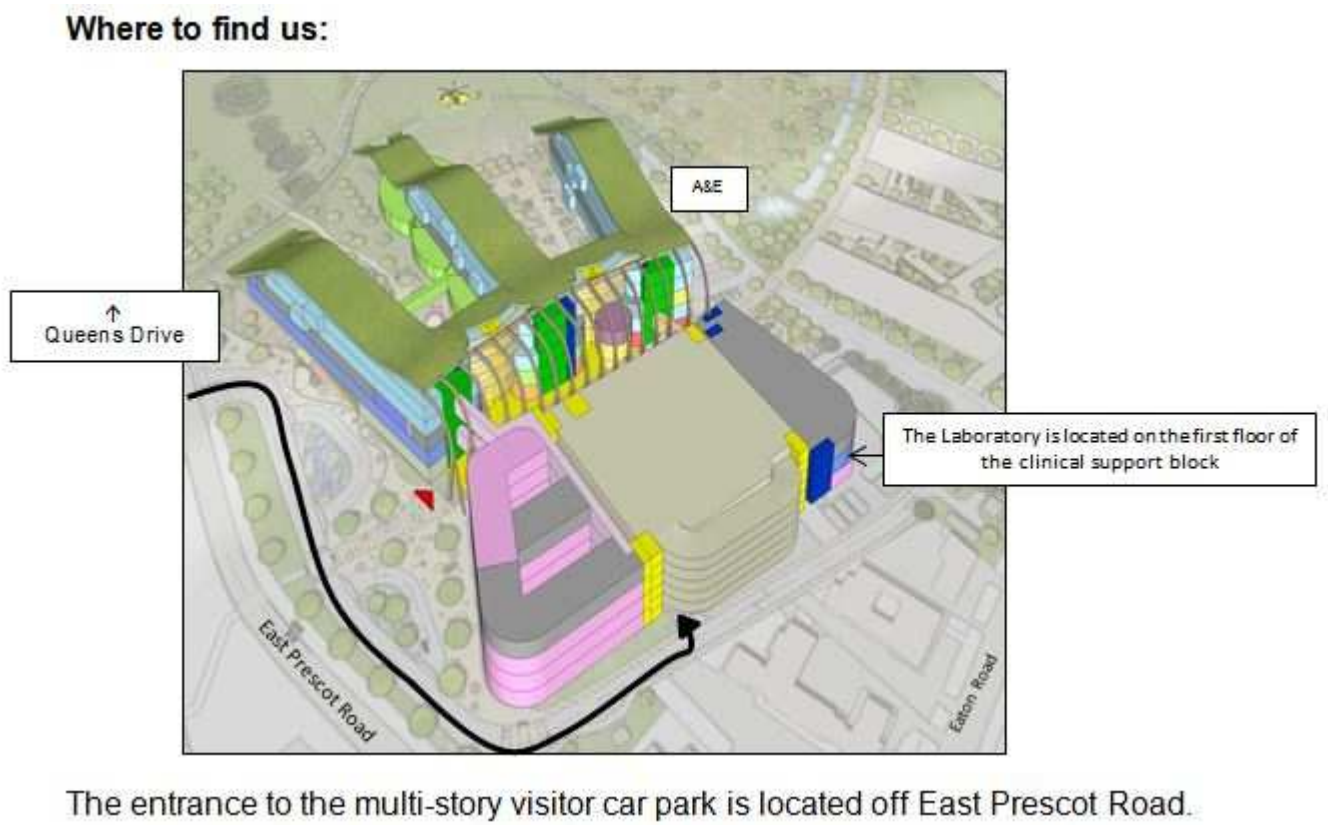
• Repertoire of tests and sample requirements

3. Where to find us

The laboratory is situated on the first floor of the main hospital building and can be accessed via the entrance at the side of the lecture theatre, at the end of the mezzanine (above WH Smith). All visitors should report to the reception desk.

External visitors to the laboratory should exit the atrium via the rotating doors next to WHSmith. There is an intercom button that connects to specimen reception next to the double doors to the right.

Please note that phlebotomy is carried out within the Outpatients department, not at the laboratory.



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4. Key Contacts

Head of Department	Catherine Collingwood	0151 252 5598
Lead Biomedical Scientist	Chris Chesters	0151 252 5561
Quality Manager	Pam Ashton	0151 239 3615
Duty Biochemist	Interpretation & advice	0151 252 5486 duty.biochemist@alderhey.nhs.uk dutybiochemist.alderhey@nhs.net

Clinical Scientists		
Catherine Collingwood	Consultant Clinical Scientist	0151 252 5598
Darren Powell	Consultant Clinical Scientist	0151 252 5486
Suzanne Armitage	Senior Clinical Scientist	0151 282 4739
Antony Beardsmore	Senior Clinical Scientist	0151 252 5486
Laura Walker	Senior Clinical Scientist	0151 252 4700
Biomedical Scientists		
Chris Chesters	Lead Biomedical Scientist	0151 252 5561
Andy Hodgkinson Louise Simpson	Senior Biomedical Scientists (Routine Biochemistry)	0151 252 5488
Debbie Riley Lis Smith	Senior Biomedical Scientists (Metabolic Biochemistry)	0151 252 5487
Paul Coakley	Senior Biomedical Scientist (Newborn Screening)	0151 252 5489

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5. Laboratory Opening Hours

The laboratory is open 24 hours per day, seven days per week. However outside of normal working hours (Monday to Friday 0900h – 1730h) a restricted range of tests is available.

6. Making requests

All samples must be accompanied by a completed request form. Requests for inpatients should be made via Meditech where possible. If Meditech is unavailable a paper downtime form must be used. Both the sample and the request ***must*** contain a minimum of the following information:

- Full name of the patient (or Baby, Twin One/Two, Triplet One/Two/Three etc. if forenames have not been given)
- Date of Birth
- Hospital number or NHS number

Please also provide:

- Date and time of sample collection
- Gender
- Name and contact details of the requesting doctor
- Name of the person collecting the sample
- Location (ward/department) to which results are to be sent.
- Sample type
- Tests requested
- Clinical details including any medication

Clinical details and the patient's age are particularly important in paediatric requesting so that laboratory staff may:

- Understand the reason for the request
- Interpret the results appropriately
- Consider the need for further investigations
- Advise and assist the clinical staff concerning the results obtained.

The information on the sample and request form must be compatible.

Consent
It is the responsibility of the requesting clinician to obtain consent for the collection of specimens. For certain tests (e.g. genetic testing) written consent may be required in addition to the request form.

High Risk Samples
High risk samples must be double bagged and identified with a biohazard sticker on both the sample and request from. Medical staff must indicate on the request form if the sample to be sent to the laboratory might carry a risk of Category 3 infection.

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7. Transport of samples

Samples should be transported to the laboratory as soon as possible after collection. Please contact the Duty Biochemist for information on appropriate sample storage if samples are to be stored prior to transport to the laboratory.

7.1 Within the hospital

Samples collected within the hospital should be transported to the laboratory via the air tube system or delivered to the laboratory reception by hand. Samples transported on foot should be transported in an opaque red specimen transport box.

7.2 Samples transported from external sites

Routine diagnostic samples should be transported in sealed specimen containers, covered with absorbent material in sufficient quantity to absorb the contents of the container(s), and placed inside a plastic specimen bag which in turn is placed inside rigid, opaque packaging in line with UN3373 regulations. When multiple sample containers are placed in single secondary packaging, they should either be individually wrapped in absorbent material or separated to prevent contact between them. Sample packages should be labelled with the UN3373 symbol. The package should also be labelled with the words “Diagnostic Specimen” and the name and address of the referring laboratory.

Category A infectious substances

Please note that Category A infectious substances are assigned to UN 2814 regulations and must be packaged in accordance with UN Packaging Instructions PI620 (road/ rail) or PI602 (air). Further information is available via the Health and Safety Executive website.

Where specimens are transported frozen on dry ice, the dry ice must be placed outside the plastic specimen bag and packages clearly identified with a dry ice identification symbol:

If samples are transported in wet ice, the ice must be placed outside the plastic specimen bag and the packaging must be leak-proof.

Please also enclose a completed request form including:

- Full name of patient

- Date of Birth
- Name and location of requesting clinician
- Tests requested
- Clinical details including details of any medication

8. Acceptance Criteria

Samples that do not meet the minimum acceptance criteria for labelling outlined in section 6 will be rejected. The sample will be discarded and Meditech will be updated to reflect that the sample was unsuitable for analysis. An incident will be created by the laboratory.

Samples that are not transported in a timely fashion or under the wrong temperature conditions, as described in section 16 for each test, will be analysed. A comment will be appended to the report stating how test results may be affected or whether a repeat sample may be required.

Samples that are received into the laboratory with insufficient sample to complete all analyses requested will be reviewed by an HCPC registered scientist. A decision will be made based on the clinical details regarding what tests can be analysed. A comment will be entered into Meditech against all those tests that could not be analysed. (QNS- quantity not sufficient)

9. Protection of Personal Data and Information

Personal data and information on request forms is required in order for the laboratory to operate and may be stored on laboratory computer files. The intent of the laboratories is to ensure that any personal data and information is treated lawfully and in accordance with the NHS requirements concerning confidentiality and information security standards. To this end we fully endorse and adhere to the Trust Data Protection Policy, the requirements of which are primarily based upon the Data Protection Act 2018 which is the key piece of legislation covering security and confidentiality of personal information.

10. Services Provided

10.1 Routine Biochemistry

The routine section of the laboratory provides a service to inpatients and outpatients at Alder Hey and is equipped with state of the art automated analytical instruments. The section is manned at all times. The results of most routine tests are available within 24 hours and are routinely transmitted electronically to within the hospital and to GP surgeries.

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10.2 Metabolic Biochemistry

We also provide a specialist Metabolic Biochemistry service for the diagnosis and monitoring of patients with inborn errors of metabolism. It is important that requests for the investigation of inborn errors of metabolism are accompanied by adequate clinical information including medication being taken at the time of sample collection. If the relevant clinical information is detailed, the laboratory should be contacted by letter or telephone.

10.3 Newborn Screening

The laboratory screens for a range of 9 conditions (see Newborn Screening web page). Dried blood spot samples should be collected on day 5 of life, day 0 being the birth date for the neonate. In mitigating circumstances samples can be collected between days 6 and 8. Results are transmitted electronically to the appropriate Child Health Record Department for entry into the Child Health Computer and checking against birth lists. Positive cases are referred for further investigation and treatment as appropriate.

Please find the internal Newborn Screening Handbook at https://alderhey.nhs.uk/download_file/view/4979 ; a link to the Newborn Screening page on the Trust intranet may be found here http://intranet/ClinicalSupport/SitePages/Newborn%20Screening.aspx

Further up to date information on newborn screening for patients and health care professionals is available via the UK Newborn Screening Programme Centre website.

10.4 Point of Care Testing (POCT)

Laboratory staff are available to provide advice on the operation of equipment that is used on the ward or at home for biochemical testing e.g. blood gas analysers and glucose meters. Advice is provided regarding methodology and limitations of the tests, patient preparation, interpretation, training, support, troubleshooting, quality assurance, risk management, health and safety and infection control.

When considering the use or purchase of POCT equipment, please contact the department for advice. It is essential that there is the closest possible liaison with the laboratory relating to all aspects of Point of Care testing in order that the best possible results are achieved.

11. Clinical advice and interpretation

Advice on the planning and interpretation of biochemical investigations is available at all times. Between Monday and Friday 0900h to 1730h please contact the Duty Biochemist (0151-252-5486, Ext 2486). Outside of these times the on-call Clinical Scientist consultant can be contacted via the hospital switchboard (0151-228-4811).

12. Turnaround times

Results for the majority of routine tests are available within 24 hours. Results are transmitted electronically to wards and GP surgeries. Many of the metabolic tests offered by the laboratory are complex and turnaround times are therefore generally significantly

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longer than for routine tests. However, we are always happy to prioritise analyses if appropriate. If a metabolic test is required urgently, please contact the Duty Biochemist (0151 252 5486) during normal working hours, or the Biochemist on call (via the hospital switchboard 0151 228 4811) outside of normal working hours.

13. Quality

We have an established quality management system and aim to continually improve the service that we provide. The laboratory holds accreditation with United Kingdom Accreditation Service (UKAS), the UK's national accreditation body.

The quality of laboratory results is ensured by internal quality control procedures, and assured by participation in external quality assessment (inter-laboratory comparison) schemes. All reports issued by the department are clinically validated by a HCPC registered Clinical Scientist. Previous results for each patient are reviewed to determine whether results represent a new clinically urgent situation, and interpretive comments are added as necessary. Significantly abnormal results that require clinical action are telephoned to the requesting doctor.

14. Common interferences

Users should be aware that samples collected by capillary puncture from children are more prone to interference than samples collected by venipuncture in adults. The most common interferences are haemolysis, lipaemia and jaundice. All samples are routinely checked for the common interferences and the affected tests are indicated on the final report. Haemolysis commonly occurs as a result of damage to cells during capillary blood sampling and potassium results are falsely increased in haemolysed samples. Delays of more than a few hours in sample transport to the laboratory can also result in erroneous results for some analytes, e.g. potassium and glucose.

15. Requesting additional investigations

Freshly collected samples are preferred for analysis however the majority of routine samples are stored at -20^{o}C for approximately 1 week after receipt in the laboratory. The availability to add further tests to a sample will depend on the sample type, volume of sample available and stability of the analyte requested. The tests included in the table below are known to be unstable and cannot be added after the indicated time period.

Test	Time limit for additional request
Bicarbonate	24 hours
Bilirubin	6 hours
PTH	8 hours
Complement C3	3 days
Immunoglobulin A	1 week
Immunoglobulin G	1 week
Immunoglobulin M	1 week
Procalcitonin	48 hours

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To request additional tests after the sample has been collected please contact the laboratory (0151 252 5488 or internal extension 2488). A completed paper request form for the additional test(s) will be required before further analysis can take place. The written request should contain full patient demographic information, the additional tests required and the identity of the requester.
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16. Suggestions, problems and complaints

In order to improve the service you receive from the laboratory, it is helpful to us if you keep us informed of any laboratory-related problems which have been detrimental to good clinical practice.

As the user of the service, you may be able to offer suggestions about our procedures, requirements for new services or changes in practice which may be helpful to you. Please direct comments to the Quality Manager or the appropriate Consultant. Regular User Group meetings for laboratory users within the Trust and for GPs are held to ensure that the requirements of users of our service are met by obtaining feedback and recommendations on quality improvements. For details of the User Group meetings please contact Julie Roberts (julie.roberts@alderhey.nhs.uk). The GP representative for the Laboratory User Group is Dr Rob Barnett (rob.Barnett@liverpool-lmc.org.uk).

We aim to provide the very best service, but unfortunately we may not always get it right and sometimes things go wrong. It is important that we are informed about problems with our service as soon as possible. Please contact the Head of Department, preferably by direct visit or telephone as soon as an issue is identified. In the absence of the Head of Department, refer the matter to another member of staff and write to either the Head of Department or the Quality Manager. Patient queries and concerns can be addressed via the Trust Patient Advice Liaison Forum (PALS, pals@alderhey.nhs.uk, 0151 252 5374). Formal complaints can be made via the Trust Complaints Service (complaints@alderhey.nhs.uk)

Wherever possible the matter will be dealt with on the same day but not all issues can be resolved immediately, and some may be more serious or require a longer period of investigation and assessment within the department. Details of all complaints are recorded and reviewed at our monthly Laboratory Medicine Governance Committee meetings. If a written complaint is received, a written reply will be provided.

17. Repertoire and sample requirements

Sample Type / Container:
The sample type required for each test is listed along with the required specimen container. Various specimen bottles are available. In most cases only small amounts of blood (<1.5mL) are required, and a small 1.3 ml tube can be used. For the majority of routine tests it is possible to use either a Lithium Heparin (orange top) or a clotted sample (plain tube). However for some tests only clotted (plain) samples give reliable results. For some tests special preservatives or ultra-clean tubes must be used. If several investigations are being undertaken please use an appropriate number of small sample

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bottles or use the large bottles. The proportion of plasma recovered from a large tube is often less than can be recovered from two small tubes. For sample volumes < 2.5 mL it is preferable to use two of the small tubes.

Profiles:

It is usually advantageous to request profiles of test to maximise use of small sample volumes. The following groups of tests can be requested as profiles. The minimum sample volumes for profiles of tests is given below but it is always helpful for us to receive additional blood in case of technical problems.

Profile	Analytes	Volume
Bone	Calcium, Adjusted Calcium, Phosphate, Alkaline Phosphatase, Magnesium, Albumin	0.5 ml
Lipid	Total Cholesterol, Triglyceride, LDL, HDL	1.0 ml
Liver Function Tests (LFT)	Total Bilirubin, Alkaline Phosphatase, AST, ALT, Albumin, Total Protein	0.5 ml
Thyroid	TSH, Free T4	1.3 ml
Urea and Electrolytes	Sodium, Potassium, Chloride, Bicarbonate, Anion Gap, Urea, Creatinine	0.5 ml

Reference Range Terminology :

The reference ranges are those applied at Alder Hey and do not necessarily apply to other laboratories. Others are obtained from the literature. Reference ranges are traditionally 95% limits i.e. 2.5% of normal individuals will have results above the upper limit and 2.5% will have results below the lower limit.

Age categories of Reference Ranges :

Some of our ranges are specific to a general category of paediatric patient:

Neonate Under 28 days
Infant 28 days to 1 year.
Child 1 year to 14 years

The alphabetical list of tests below includes information on the type of sample container, volume of sample required, any special collection conditions, and reference ranges. The quoted reference ranges are those which are on the laboratory computer systems so that in general appropriate age-related reference ranges are provided with the report.

Samples referred to other laboratories

If a test that is not offered at Alder Hey is required, we may need to send samples to other laboratories. Results from external laboratories are returned to Alder Hey laboratory and

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are entered into the Alder Hey patient record. A list of the referral laboratories that we use is available on the Laboratory section of the Alder Hey website:

www.alderhey.nhs.uk/labmedicine

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Test	ACTH
Sample type	EDTA
Sample volume	1 mL
Special requirements	9am sample preferred Send sample to the lab on ice immediately after phlebotomy.
Turnaround time	3 – 5 working days
Reference range	9am sample : 2 – 11 pmol/L
Source of reference range	1

Test	Acylcarnitines
Sample type	Blood spot
Sample volume	2 spots
Special requirements	Clinical details (such as fasting status, hypoglycaemia and relevant drug history) must be provided with all metabolic requests.
Turnaround time	5 working days
Reference range	Qualitative report

Test	Adrenaline	
Sample type	Random urine or 24 hour urine collected into bottle containing acid	
Sample volume	3 mL if random sample	
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)	
Turnaround time	5 working days	
Reference range	0 – 1 year	<0.23 umol/mmol creatinine
	1- 2 years	<0.05 umol/mmol creatinine
	3 – 4 years	<0.05 umol/mmol creatinine
	5 – 10 years	<0.06 umol/mmol creatinine
	>11 years	<0.04 umol/mmol creatinine
Source of reference range	2	

Test	Alphafetoprotein (AFP)
Sample type	Plain
Sample volume	0.5 mL
Special requirements	
Turnaround time	1 working day
Reference range	See Appendix 1
Source of reference range	3, 4

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Test	ALT (Alanine Amino Transferase)	
Sample type	Lithium Heparin	
Sample volume		
Special requirements	Included in liver profile	
Turnaround time	24 hours	
Reference range	0 - 1 month	9 – 44 IU/L
	>1month - 6 years	9 – 36 IU/L
	6 - 14 years	8 – 36 IU/L
	> 14 years	<40 IU/L
Source of reference range	5	

Test	Albumin	
Sample type	Lithium Heparin	
Sample volume		
Special requirements	Included in bone profile	
Turnaround time	24 hours	
Reference range	0 – 2 months	30 – 45 g/L
	>2 months - 5 years	37 – 53 g/L
	5 – 8 years	40 – 56 g/L
	8 – 14 years	38 – 58 g/L
	14 – 16 years	40 – 60 g/L
	>16 years	35 – 55 g/L
Source of reference range	6	

Test	Albumin:Creatinine ratio (ACR)
Sample type	Urine
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Reference range	In adults proteinuria defined as ACR >30 mg/mmol (significant proteinuria >70), with levels ~3mg/mmol indicating microalbuminuria in diabetics.
Source of reference range	

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Test	Alkaline Phosphatase (ALP)		
Sample type	Lithium Heparin		
Sample volume			
Special requirements	Included in bone and liver profile		
Turnaround time	24 hours		
Reference Range	0 – 7 Days	70 – 345 IU/L	
	8 day – 3 months	93 – 680 IU/L	
	>3 months – 6 months	92 – 758 IU/L	
	>6months – 1 year	98 – 562 IU/L	
	>1 year – 18 months	97 – 360 IU/L	
		Female	**Male**
	>18 months – 9 years	87 – 323 IU/L	
	>18 months – 10 years		87 – 323 IU/L
	>9 - 11 years	93 – 367 IU/L	
	>10 - 12 years		70 – 360 IU/L
	>11 - 12 years	89 – 408 IU/L	
	>12 - 13 years	77 – 362 IU/L	91 – 405 IU/L
	>13-14 years	67 – 293 IU/L	82 – 442 IU/L
	>14-15 years	55 – 185 IU/L	77 – 410 IU/L
	>15-16 years	46 – 144 IU/L	63 – 316 IU/L
	>16 years	38 – 123 IU/L	
	>16 - 18 years		55 – 236 IU/L
	>18 years	38 – 123 IU/L	
Source of reference range	41		

Test	Amikacin
Sample type	Lithium Heparin
Sample volume	0.5 mL
Special requirements	Please indicate whether peak (post-dose) or trough (pre-dose) level and whether on once daily, neonatal or renal regime and whether patient has cystic fibrosis.
Turnaround time	24 hours
Therapeutic range	***Children >1 month and normal renal function (over 44 weeks corrected gestational age)*** Trough Level : < 3 mg/L
	Neonates Trough level (taken within 2 hours before the 3rd dose is due) <8 mg/L Peak level (1 hour after the 3rd dose is given) 20 – 30 mg/L
Source of reference range	42

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Test	Amino acids
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	Fasting sample preferred. Clinical details (such as fasting status, hypoglycaemia and relevant drug history) must be provided with all metabolic requests.
Turnaround time	10 working days
Reference range	See Appendix
Source of reference range	8

Test	Amino acids
Sample type	Urine
Sample volume	1 mL
Special requirements	Clinical details (such as fasting status, hypoglycaemia and relevant drug history) must be provided with all metabolic requests.
Turnaround time	10 working days
Reference range	See Appendix
Source of reference range	8

Test	Amino acids
Sample type	CSF
Sample volume	0.5 mL
Special requirements	Please send with plasma sample collected at the same time. Clinical details (such as fasting status, hypoglycaemia and relevant drug history) must be provided with all metabolic requests.
Turnaround time	10 working days
Reference range	See Appendix
Source of reference range	8

Test	Ammonia	
Sample type	Lithium Heparin	
Sample volume	0.5 ml	
Special requirements	Venous or freely flowing sample needed. Avoid capillary samples. Transport to laboratory on ice. Separate within 15 minutes of phlebotomy.	
Turnaround time	24 hours	
Reference range	Preterm neonate	<150 umol/L
	Term neonate	<100 umol/L
	Infant / child	<40 umol/L
Source of reference range	58	

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Test	Amylase
Sample type	Lithium Heparin
Sample volume	0.5 mL
Special requirements	Any high results should be checked on a VENOUS sample due to potential for contamination from saliva.
Turnaround time	24 hours
Reference range	16 – 108 IU/L
Source of reference range	

Test	Amylase
Sample type	Urine
Sample volume	0.5 mL
Special requirements	
Turnaround time	24 hours
Reference range	1 – 17 U/h (Adult range)
Source of reference range	Manufacturers ranges (Abbott)

Test	Antibiotics
Sample type	Lithium Heparin
Sample volume	0.5 mL
Special requirements	Please indicate whether peak (post-dose) or trough (pre-dose) level and whether on once daily, neonatal or renal regime and whether patient has cystic fibrosis
Turnaround time	24 hours
Reference range	
Source of reference range	42

Test	Anion Gap
Sample type	Lithium Heparin
Sample volume	0.5mL
Special requirements	Calculated as part of U&E [(Na + K) – (Cl + HCO_3)]
Turnaround time	24 hours
Reference range	4 – 16 mmol/L
Source of reference range	

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Test	AST (Aspartate Amino Transferase)	
Sample type	Lithium Heparin	
Sample volume		
Special requirements	Part of liver profile	
Turnaround time	24 hours	
Reference range	0 – 1 month	23 – 73 IU/L
	1 month– 6 years	15 – 58 IU/L
	6 – 14 years	12 – 41 IU/L
	>14 years	<37 IU/L
Source of reference range		

Test	Beta-Hydroxybutyrate (3-hydroxybutyrate)	
Sample type	Plain	
Sample volume	0.5 mL	
Special requirements	If possible, sample should be collected whilst the patient is hypoglycaemic (plasma glucose <2.6 mmol/L). Samples should be transported to the laboratory on ice as soon as possible.	
Turnaround time	2 weeks	
Reference range	During hypoglycaemia (Plasma glucose < 2.6 mmol/L)	1500 – 3000 umol/L
	Post-prandial	Can be as low as 25 umol/L
	For more information regarding result interpretation, refer to the MetBioNet Best Practice Guidelines for the investigation of hypoglycaemia in infants and children (www.metbio.net/metbioguidelines.asp)	
Source of reference range	44	

Test	Bicarbonate	
Sample type	Lithium Heparin	
Sample volume	0.5mL	
Special requirements	Included in U&E. There is significant loss of bicarbonate when the blood occupies less than half of the volume of the tube (30% decrease within 30 minutes and 40% decrease after 2 hours.	
Turnaround time	24 hours	
Reference range	0 – 7 days	18 – 27 mmol/L
	7 days – 2 months	19 – 27 mmol/L
	>2 months – 2 years	16 – 24 mmol/L
	>2 years	18 – 29 mmol/L
Source of reference range		

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Test	Bilirubin – total	
Sample type	Lithium Heparin	
Sample volume	1 ml	
Special requirements		
Turnaround time	24 hours	
Reference range	Neonate	Depends on age and gestational age of baby (see NICE Guideline for jaundice in newborn babies under 28 days, www.nice.org.uk/guidance/cg98/evidence
	Child	<15 umol/L
	Adult	<15 umol/L
Source of reference range	45 (Neonate guidelines)	

Test	Bilrubin – conjugated
Sample type	Lithium Heparin
Sample volume	1 ml
Special requirements	
Turnaround time	24 hours
Reference range	<10 umol/L
Source of reference range	

Test	Blood Gases			
Sample type	Capillary Gas tube			
Sample volume	0.2 mL			
Special requirements	Sample must be delivered to the laboratory immediately following collection. **Blood gas samples must not be transported in the pod as results can be affected.**			
Turnaround time	10 minutes			
Reference range	pH	Neonate	7.31 – 7.47	
		Child	7.35 – 7.45	
	Base Excess	Neonate	-2.5 to +2.5 mmol/L	
		Child	-2 to +2 mmol/L	
	pCO_2	Neonate	3.8 – 6.5 kPa	kPa = mmHg x 0.133
		Child	4.7 – 6.0 kPa	
	pO_2	Neonate	4.3 – 8.2 kPa	
		Child	10.7 – 14.0 kPa	
	Standard Bicarbonate	Neonate	18 – 26 mmol/L	
		Child	22 – 26 mmol/L	
Source of reference range	30, 65			

Test	Bone profile
Sample type	Lithium Heparin
Sample volume	1 mL
Turnaround time	24 hours
Reference range	See individual tests
Source of reference range	

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Test	C3	
Sample type	Plain (EDTA unsuitable)	
Sample volume	0.5 mL	
Turnaround time	24 hours	
Reference range	Cord blood	0.59 – 1.21 g/L
	1 month	0.55 – 1.28 g/L
	2 months	0.61 – 1.55 g/L
	3 months	0.66 – 1.36 g/L
	4 months	0.64 – 1.82 g/L
	5 months	0.66 – 1.74 g/L
	6 months	0.76 – 1.78 g/L
	7 – 10 months	0.78 – 1.73 g/L
	11 months	0.76 – 1.87 g/L
	12 months	0.87 – 1.81 g/L
	2 years	0.84 – 1.76 g/L
	3 years	0.80 – 1.78 g/L
	4 – 5 years	0.89 – 1.73 g/L
	6 – 8 years	0.91 – 1.61 g/L
	9 -10 years	0.92 – 2.03 g/L
	10 – 12 years	1.10 – 1.98 g/L
	12 – 14 years	1.04 – 1.92 g/L
	14 – 18 years	0.90 – 1.88 g/L
	Adult	0.86 – 1.84 g/L
Source of reference range	9, 10, 11	

Test	C4	
Sample type	Plain	
Sample volume	0.5 mL	
Turnaround time	24 hours	
Reference range	Cord blood	0.09 – 0.30 g/L
	1 month	0.09 – 0.33 g/L
	2 months	0.10 – 0.37 g/L
	3 months	0.10 – 0.35 g/L
	4 months	0.11 – 0.50 g/L
	5 months	0.09 – 0.47 g/L
	6 months	0.11 – 0.55 g/L
	7 – 10 months	0.12 – 0.48 g/L
	11 months	0.16 – 0.51 g/L
	12 months	0.16 – 0.52 g/L
	2 years	0.12 – 0.44 g/L
	3 years	0.13 – 0.47 g/L
	4 – 5 years	0.17 – 0.42 g/L
	6 – 8 years	0.16 – 0.42 g/L
	9 -10 years	0.13 – 0.52 g/L
	10 – 12 years	0.19 – 0.56 g/L
	12 – 14 years	0.18 – 0.46 g/L
	14 – 18 years	0.18 – 0.42 g/L
	Adult	0.19 – 0.59 g/L
Source of reference range	10, 11, 12	

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Test	Calprotectin
Sample type	Faeces
Sample volume	Walnut sized
Special requirements	
Turnaround time	5 working days
Reference range	<50 ug/g
Source of reference range	Manufacturers ranges (Phadia AB, Uppsala, Sweden)

Test	Caeruloplasmin	
Sample type	Teklab trace metal free tube (Request also includes copper). If Teklab tubes are unavailable an alternative serum/plain tube may be accepted.	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	5 working days	
Reference range	0 – <2 months	0.07 – 0.24 g/L
	2 – <6 months	0.14 – 0.33 g/L
	6 months – <1 year	0.14 – 0.39 g/L
	1 – <8 years	0.22 – 0.43 g/L
	8 - <14 years	0.21 – 0.40 g/L
	14 – <19 years Male	0.17 – 0.35 g/L
	14 - <19 years Female	0.21 – 0.43 g/L
Source of reference range	59	

Test	Calcium (included in bone profile)		
Sample type	Lithium Heparin		
Sample volume			
Special requirements			
Turnaround time	24 hours		
Reference range	0 – 1 week	1.75 – 2.99 mmol/L	**Adjusted Calcium :** For albumin <40 g/L = measured Ca + 0.02(40 - albumin) For albumin >40 g/L = measured Ca – 0.02(albumin - 40)
	1 week – 2 y	2.20 – 2.79 mmol/L	
	2 – 16 y	2.15 – 2.74 mmol/L	
	>16 y	2.25 – 2.74 mmol/L	
Source of reference range			

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Test	Calcium:creatinine ratio	
Sample type	Urine	
Sample volume	1 mL	
Special requirements	For investigation of Familial Hypocalciuric Hypercalcaemia (FHH) calculate Calcium:Creatinine clearance ratio: Ca:Cr clearance ratio = [Urine Ca x Plasma Cr] / [Plasma Ca x Urine Cr} Ratio <0.01 is suggestive of FHH Ratio >0.02 suggestive of Primary Hyperparathyroidism	
Turnaround time	24 hours	
Reference range	Pre-term neonate	2.20 ± 1.74 mmol/mmol Creatinine
	Full term neonate	0.46 ± 1.73 mmol/mmol Creatinine
	< 1 year	<1.5 mmol/mmol Creatinine
	1 – 2 years	<1.25 mmol/mmol Creatinine
	2 – 5 years	<1.0 mmol/mmol Creatinine
	5 – 10 years	<0.7 mmol/mmol Creatinine
	>10 years	<0.6 mmol/mmol Creatinine
Source of reference range	16	

Test	Carboxyhaemoglobin
Sample type	Capillary gas tube / Lithium Heparin
Sample volume	0.2 mL (Capillary sample) If Li/Hep tube, must be full to the top
Special requirements	If Li/Hep tube, must be full to the top
Turnaround time	10 minutes
Reference range	<2 %
Source of reference range	66

Test	Carnitine
Sample type	Lithium Heparin / Plain
Sample volume	1 mL
Special requirements	
Turnaround time	10 working days
Reference range	15 – 53 umol/L
Source of reference range	17

Test	Catecholamines
Sample type	24 hour urine collected into bottle containing acid or random urine
Sample volume	3 mL if random urine
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)
Turnaround time	5 working days
Reference range	See adrenaline, noradrenaline, dopamine
Source of reference range	

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Test	Chloride (included in U&E profile)
Sample type	Lithium Heparin
Sample volume	0.5mL
Special requirements	
Turnaround time	24 hours
Reference range	100 – 110 mmol/L
Source of reference range	

Test	Cholesterol	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Reference range	Newborn	1.1 – 2.6 mmol/L
	6 months	2.3 – 4.9 mmol/L
	1 year	2.5 – 4.9 mmol/L
	2 – 14 years	3.1 – 5.4 mmol/L
	Adult	3.1 – 6.5 mmol/L
Source of reference range	18	

Test	Coeliac Disease screen (TTG)	
Sample type	Plain	
Sample volume	1 mL	
Special requirements	Testing for coeliac disease is accurate only if the patient has a gluten containing diet for a minimum of 6 weeks before testing. Sample haemolysis (H index >1) may lead to a falsely low TTG concentration.	
Turnaround time	7 working days	
Reference range	Negative	0 – 7 U/mL
	Equivocal	7 – 10 U/mL
	Positive	>10 U/mL
Source of reference range	68, 69	

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Test	Copper	
Sample type	Teklab trace metal free tube. If Teklab tubes are unavailable an alternative serum/plain tube may be accepted.	
Sample volume	1 mL	
Special requirements		
Turnaround time	5 working days	
Reference range	<6 days	1.4 – 7.2 umol/L
	6 days – 5 years	12.6 – 23.6 umol/L
	6 – 9 years	13.2 – 21.4 umol/L
	10 -14 years Male Female	 12.6 – 19.0 umol/L 12.9 – 18.9 umol/L
	15 – 18 years Male Female	 10.1 – 18.4 umol/L 11.3 – 25.2 umol/L
	Adult (≥19 years)	11.0 – 20.0 umol/L
Source of reference range	7, 19	

Test	Copper	
Sample type	Urine	
Sample volume	Random sample (5 mL) or 24 hour collection	
Special requirements		
Turnaround time	5 working days	
Method	Platform: ThermoFischer Scientific iCAP- Q ICP-MS Method: Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	
Reference range	Child	<1.0 umol/day
		<0.9 umol/24h
	After penicillamine	<12.5 umol/day
Source of reference range	7	

Test	Cortisol	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements	9am sample preferred. Diurnal variation with higher ranges in the morning.	
Turnaround time	1 working day	
Reference range	9am	140 – 500 nmol/L
	Midnight	<50 nmol/L
Source of reference range	47	

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Test	C-Peptide
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	Samples should be obtained when the patient is hypoglycaemic (blood glucose <2.6 mmol/L) or fasting. A sample for glucose collected at the same time is required for interpretation of results. Samples must be transported to the lab on ice
Turnaround time	4 working days
Reference range	190 – 900 pmol/L
Source of reference range	1

Test	Creatinine (included in U&E profile)		
Sample type	Lithium Heparin		
Sample volume	0.5 mL		
Special requirements			
Turnaround time	24 hours		
Reference range	<14 days		29 – 94 umol/L
	14 days - <2 months		19 – 79 umol/L
	2 months - <4 years		20 – 52 umol/L
	4 - <6 years		27 – 57 umol/L
	6 - <8 years		29 – 61 umol/L
	8 - <10 years		35 – 66 umol/L
	10 - <12 years		38 – 71 umol/L
	12 – 14 years	Male	44 – 81 umol/L
		Female	40 – 80 umol/L
	14 – 16 years	Male	51 – 104 umol/L
		Female	47 – 88 umol/L
	>16 years	Male	46 – 102 umol/L
		Female	49 – 81 umol/L
Source of reference range	20		

Test	Creatine Kinase (Creatine Phosphokinase)
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Reference range	Adults 24 – 195 IU/L
	May be higher in the first few months of life. Spurious increase due to muscular injection, exercise or seizures (muscle spasm)
Source of reference range	

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Test	CRP
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Reference range	0 – 8 mg/L
Source of reference range	

Test	CSF Glucose
Sample type	Fluoride
Sample volume	0.5 mL
Special requirements	Blood sample for glucose should be collected at the same time
Turnaround time	24 hours
Reference range	CSF glucose should be approximately 60% of plasma levels. A CSF/plasma ratio <0.66 may be significant.
Source of reference range	

Test	CSF Protein	
Sample type	Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Reference range	0 – 2 months	0.2 – 1.1 g/L
	2 – 4 months	0.1 – 0.8 g/L
	>4 months	0.1 – 0.4 g/L
Source of reference range	64	

Test	CSF Lactate
Sample type	Fluoride
Sample volume	0.5 mL
Special requirements	
Turnaround time	24 hours
Reference range	1.11 – 2.81 mmol/L
Source of reference range	

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Test	Dopamine	
Sample type	Urine	
Sample volume	3 mL random sample or 24 hour urine collected into bottle containing acid	
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)	
Turnaround time	5 working days	
Reference range	0 – 1 year	<1.8 umol/mmol
	1- 2 years	<1.5 umol/mmol
	3 – 4 years	<0.9 umol/mmol
	5 – 10 years	<0.8 umol/mmol
	>11 years	<0.7 umol/mmol
Source of reference range	2	

Test	Ethanol (alcohol)
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Reference range	Peak levels occur 30 – 60 min after ingestion. In adults coma can occur at levels approximately 300 mg/dL.
Source of reference range	

Test	Ferritin	
Sample type	Lithium Heparin / Plain	
Sample volume	1 mL	
Special requirements	Ferritin may be increased due to acute phase response.	
Turnaround time	24 hours	
Reference range	4 days - <15 days	99.6 – 717 ng/mL
	15 days - <6 months	14 – 647.2 ng/mL
	6 months - <1 year	8.4 – 181.9 ng/mL
	1 year - <5 years	5.3 – 99.9 ng/mL
	5 years - <14 years	13.7 – 78.8 ng/mL
	14 years – 19 years (Female)	5.5 – 67.4 ng/mL
	14 years - <16 years (Male)	12.7 – 82.8 ng/mL
	16 years – 19 years (Male)	11.1 – 171.9 ng/mL
Source of reference range	59	

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Test	Flecainide
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	
Turnaround time	5 working days
Reference range	200 – 800 ug/L Target range is for a trough level. Time taken to reach steady state is >3 days.
Source of reference range	48

Test	Follicle Stimulating Hormone (FSH)		
Sample type	Lithium Heparin / Plain		
Sample volume	0.5 mL		
Special requirements			
Turnaround time	1 working day		
Reference range	Adult male		2 – 8 IU/L
	Adult female	Follicular phase	2 – 6 IU/L
		Mid-cycle	6 – 12 IU/L
		Luteal phase	1 – 6 IU/L
Source of reference range	1		

Test	Free Fatty Acids
Sample type	Plain
Sample volume	0.5 mL
Special requirements	Sample should be collected whilst the patient is hypoglycaemic (plasma glucose <2.6 mmol/L). Samples should be transported to the laboratory on ice as soon as possible.
Turnaround time	2 weeks
Reference range	500 – 900 umol/L during hypoglycaemia For more information regarding result interpretation, refer to the MetBioNet Best Practice Guidelines for the investigation of hypoglycaemia in infants and children (www.metbio.net/metbioguidelines.asp)
Source of reference range	44

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Test	Galactose -1-Phosphate Uridyl Transferase (Gal-1-PUT)	
Sample type	Lithium Heparin whole blood (not separated)	
Sample volume	0.5 mL	
Special requirements	Assay is not reliable for 120 days following blood transfusion. Stable for 2 days at 4°C	
Turnaround time	5 working days	
Reference range	Normal	20 – 36 u/g Hb
	Normal	14 - 20 u/g Hb (Slightly low Gal-1-PUT activity. This may be due to delayed sample transport and is unlikely to be of clinical significance)
	Gal/Normal	8 – 14 u/g Hb (Excludes classical galactosaemia but may be consistent with a carrier state)
	Duarte/Normal	4 – 6 u/g Hb
	Classical Galactosaemia	<4 u/g Hb
Source of reference range		

Test	Gamma-Glutamyl Transferase (Gamma-GT)	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Reference range	0 – 1 month	0 – 271 IU/L
	1 – 2 months	0 – 155 IU/L
	2 – 4 months	0 – 93 IU/L
	4 months – 15 years	0 – 50 IU/L
	>16 years	11 – 50 IU/L
Source of reference range		

Test	Gentamicin
Sample type	Lithium Heparin
Sample volume	
Special requirements	Please indicate whether peak (post-dose) or trough (pre-dose)level and whether on once daily, neonatal or renal regime and whether patient has cystic fibrosis or endocarditis.
Turnaround time	24 hours
Therapeutic range	***Children >1 month and normal renal function (over 44 weeks corrected gestational age)*** Trough Level : < 1 mg/L
	Neonates Trough level (collected within 2 hours before 3rd dose is due) <2 mg/L Peak level (1 hour after 3rd dose is given) 5 – 10 mg/L
	Endocarditis Trough (pre-dose): <1 mg/L Peak level (1 hour post dose) 3 – 5 mg/L
Source of reference range	42

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Test	Glucose	
Sample type	Fluoride	
Sample volume	0.5 mL	
Special requirements	Fasting sample preferred. Important to follow the order of draw (see intranet) as glucose tube additive may contaminate Li Heparin samples leading to falsely high potassium results.	
Turnaround time	24 hours	
Reference range	Fasting	2.6 – 6.1 mmol/L
	Random	2.6 – 11.0 mmol/L
	Random glucose >11.1 mmol/ l or fasting glucose >7.0 mmol/L with symptoms is diagnostic of Diabetes Mellitus.	
Source of reference range	49	

Test	Glycated Haemoglobin (HbA1c)	
Sample type	Fluoride / EDTA / Lithium Heparin	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	2 working days	
Reference range	Non-Diabetic	20 – 42 mmol/mol
	Target for patients with Diabetes	<48 mmol/mmol
	42 mmol/mol=6% DCCT aligned 48 mmol/mol=6.5% DCCT aligned	
Source of reference range	50	

Test	Glycosaminoglycans (GAGs)		
Sample type	Urine		
Sample volume	10 mL		
Special requirements	Early morning urine sample preferred A qualitative report for heparan, dermatan, keratan and chondroitin sulphate (MPS chromatography) is also provided. Chromatography will only be carried out if total GAGs >20mg/L.		
Turnaround time	1 month		
Reference range	0 – 5 months	15.2 - 52	mg/mmol Creatinine
	6 – 12 months	15.1 – 31.4	
	1 year	9.1 - 29.9	
	2 – 3 years	7.7 – 21.3	
	4 – 5 years	7.6 – 14.4	
	6 – 7 years	5.7 – 12.9	
	8 – 9 years	5.2 – 11.6	
	10 – 14 years	3.4 – 10.6	
	15 – 19 years	1.5 – 6.7	
	>20 years	1.5 – 5.1	
Source of reference range	21		

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Test	Growth Hormone
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	Random Growth Hormone measurement is of limited value. Contact the laboratory for advice Ext 2486, 0151 252 5486.
Turnaround time	1 working day
Reference range	No reference range for random levels.
Source of reference range	

Test	HDL Cholesterol
Sample type	Plain
Sample volume	0.5 mL
Special requirements	
Turnaround time	24 hours
Reference range	>1.17 mmol/L
Source of reference range	18

Test	Homocysteine
Sample type	Plain / EDTA / Lithium Heparin
Sample volume	2 mL
Special requirements	Plasma/Serum should be separated from cells and frozen within 30 minutes of collection. At room temperature homocysteine increases by 5-15% per hour if left on cells. If centrifugation is not possible the increase can be reduced by keeping the sample on ice.
Turnaround time	10 working days
Reference range	5 – 14 umol/L
Source of reference range	22

Test	Homocystine	
Sample type	Lithium Heparin	
Sample volume	2 mL	
Special requirements	If required as part of the amino acid profile plasma samples must be precipitated with sulphasalicylic acid within 30 minutes of phlebotomy (See Appendix 3) Please contact Biochemistry department Ext 2487, 0151 252 5487	
Turnaround time	10 working days	
Reference range	Plasma	Not present
	Treated homocystinuria	<10 umol/L
	Urine	<2 umol/mmol Creatinine
Source of reference range		

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Test	Homovanillic Acid	
Sample type	24 hour urine collected into bottle containing acid or random urine	
Sample volume	3 mL if random urine	
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)	
Turnaround time	5 working days	
Reference range	0 – 1 year	<22 umol/mmol creatinine
	1 – 2 years	<17 umol/mmol creatinine
	3 – 4 years	<16 umol/mmol creatinine
	5 – 10 years	<10 umol/mmol creatinine
	>11 years	<7.7 umol/mmol creatinine
Source of reference range	23	

Test	Human Chorionic Gonadotrophin (HCG)
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	
Turnaround time	1 working day
Reference range	0 – 10 IU/L
Source of reference range	1

Test	IgE (Total)	
Sample type	Plain / Lithium Heparin	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	7 working days	
Reference range	0 – 1 year	0 – 10 kU/L
	1 – 5 years	0 – 15 kU/L
	5 – 10 years	0 – 20 kU/L
	10 years – adult	0 – 30 kU/L
	Upper limits are median levels below which there is a low probability of atopic disease	
Source of reference range		

Test	IgE (Specific Antigens)
Sample type	Plain / Lithium Heparin
Sample volume	0.5 mL
Special requirements	
Turnaround time	7 working days
Reference range	<0.35 KUa/L
Source of reference range	

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Test	IGF1		
Sample type	Lithium Heparin / Plain		
Sample volume	0.5 mL		
Special requirements			
Turnaround time	1 working day		
		Male	Female
Reference range	0 – 3 years	<2 – 16.8 nmol/L	2.4 – 22.4 nmol/L
	4 – 6 years	2.9 – 27.0 nmol/L	4.6 – 30.2 nmol/L
	7 – 9 years	5.2 – 33.2 nmol/L	7.4 – 36.0 nmol/L
	10 – 11 years	8.9 – 41.1 nmol/L	15.3 – 58.2 nmol/L
	12- 13 years	18.6 – 65.8 nmol/L	22.1 – 68.5 nmol/L
	14 – 15 years	23.0 – 65.9 nmol/L	24.8 – 64.5 nmol/L
	16 – 18 years	22.5 – 65.9 nmol/L	24.7 – 55.8 nmol/L
Source of reference range	63		

Test	Immunoglobulins (A, G, M)
Sample type	Plain (EDTA unsuitable)
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Reference range	See Appendix 5
Source of reference range	

Test	Insulin
Sample type	Plain
Sample volume	1 mL
Special requirements	Samples should be obtained when the patient is hypoglycaemic (blood glucose <2.6mmol/L) or fasting. A sample for glucose should be collected at the same time.
Turnaround time	4 working days
	Detectable insulin during hypoglycaemia (plasma glucose <2.6 mmol/L) is suggestive of hyperinsulinism. For insulin resistance determine fasting glucose (mg/dL) : insulin (mU/L) ratio. Normal >4.5
Source of reference range	25

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Test	Iron		
Sample type	Lithium Heparin / Plain		
Sample volume	1 mL		
Special requirements	Iron may be decreased due to acute phase response.		
Turnaround time	24 hours		
Reference range		Male	Female
	10 days - 1 year	3.0 - 20.0 umol/L	4.0 - 19.0 umol/L
	1 - 3 years	4.0 - 21.0 umol/L	4.0 - 23.0 umol/L
	3 – 6 years	4.0 - 25.0 umol/L	4.0 - 24.0 umol/L
	6 – 10 years	5.0 - 25.0 umol/L	4.0 - 24.0 umol/L
	> 10 years	5.7 - 30.2 umol/L	4.7 - 28.3 umol/L
Source of reference range	19		

Test	Lactate (Plasma)
Sample type	Fluoride (yellow tube)
Sample volume	1 mL
Special requirements	Transport to laboratory on ice. Sample must be centrifuged within 15 minutes of sample collection.
Turnaround time	24 hours
Reference range	0.7 – 2.1 mmol/L
Source of reference range	

Test	Lactate (CSF)
Sample type	Fluoride (yellow tube)
Sample volume	0.5 mL
Special requirements	
Turnaround time	24 hours
Reference range	1.11 – 2.81 mmol/L
Source of reference range	

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Test	Lactate Dehydrogenase	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Method	Lactate dehydrogenase forward enzymatic reaction with UV detection.	
Reference range	1 – 3 years	500 – 920 IU/L
	4 – 6 years	470 – 900 IU/l
	7 – 9 years	420 – 750 IU/L
	10 – 11 years	380 – 770 IU/L
	12 – 13 years	380 – 750 IU/L
	14 – 15 years	390 – 730 IU/L
	16 – 19 years	340 – 670 IU/L
	Adult	297 – 537 IU/L
Source of reference range	26	

Test	LDL Cholesterol	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements	Not valid for samples with triglyceride >4.5 mmol/L Triglycerides are altered by statin treatment, where the equation significantly underestimates LDL	
Turnaround time	24 hours	
Method	Calculated using Friedwald equation: LDL = total cholesterol - (HDL + (triglycerides / 2.2))	
Reference range	<19 years	<2.85 mmol/L
	>19 years	<3.00 mmol/L
Source of reference range	18	

Test	Lead
Sample type	Whole blood collected into special tube
Sample volume	0.5 mL
Special requirements	Special tube required (manganese tube). Please contact laboratory (Ext 2487)
Turnaround time	3 weeks
Method	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)
Reference range	<0.24 umol/L If blood lead exceeds 2.17 umol/L, the case should be discussed with the National Poisons Information Service (0344 892 0111).
Source of reference range	60

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Test	Lipids (Total Cholesterol, Triglycerides, LDL, HDL)
Sample type	Lithium Heparin / Plain
Sample volume	1 mL
Special requirements	Fasting sample preferred
Turnaround time	24 hours
Reference range	For reference ranges see individual tests
Method	See individual tests
Source of reference range	18

Test	Liver Function Tests (ALT / AST / ALP / Bilirubin / Albumin / Total Protein)
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Method	See individual tests
Reference range	For reference ranges see individual tests
Source of reference range	

Test	Luteinising Hormone (LH)	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	1 working day	
Reference range	Male	2 – 10 U/L
	Female Follicular Phase Midcycle Luteal Phase	 3 – 8 U/L 20 – 80 U/L 1 – 6 U/L
Source of reference range		

Test	Macroprolactin
Sample type	Lithium Heparin / plain
Sample volume	0.5 mL
Special requirements	Please request prolactin. Macroprolactin request may be added by the Duty Biochemist following clinical validation if Prolactin >700 mU/L is not explained
Turnaround time	1 week
Method	Solid-phase, two-site sequential chemiluminescent immunometric assay following PEG precipitation
Reference range	Provided with report
Source of reference range	

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Test	Magnesium	
Sample type	Lithium Heparin	
Sample volume	0.5 mL	
Special requirements	Included in bone profile	
Turnaround time	24 hours	
Method	Isocitrate dehydrogenase enzymatic reaction with UV detection	
Reference range	0 – 1 month	0.60 – 1.00 mmol/L
	>1 month	0.70 – 1.00 mmol/L
Source of reference range	67	

Test	Magnesium
Sample type	24 Hour Urine
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Method	Isocitrate dehydrogenase enzymatic reaction with UV detection
Reference range	3.3 – 5.0 mmol/24 hours
Source of reference range	

Test	Manganese
Sample type	Whole blood collected into special tube
Sample volume	1 mL
Special requirements	Special tube required. Please contact laboratory (Ext 2487)
Turnaround time	3 weeks
Method	Platform: ThermoFischer Scientific iCAP- Q ICP-MS Method: Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)
Reference range	4 – 12 ug/L Toxic >19.8 ug/L
Source of reference range	

Test	Methaemoglobin
Sample type	Capillary gas tube
Sample volume	Full tube
Special requirements	Sample must be delivered to the laboratory immediately following collection. **Samples must not be transported in the pod as results can be affected.**
Turnaround time	10 minutes
Reference range	<1.52%
Source of reference range	65

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Test	Methotrexate
Sample type	Lithium Heparin / Plain **Collection tubes with separator gel are not recommended**
Sample volume	0.5 mL
Special requirements	Please include the phone number of the requesting ward to enable prompt notification of the result. Specimens collected from patients who have received glucarpidase (carboxypeptidase G2) as a high dose methotrexate rescue therapy should not be tested for at least 48 hours following the last dose of glucarpidase. These specimens have increased concentrations of DAMPA, a methotrexate metabolite which is known to cross-react with the methotrexate antibody used in this assay.
Turnaround time	24 hours
Reference range	24 hours post infusion <150 umol/L 42h post infusion <1 umol/L 48h post infusion <0.4 umol/L
Source of reference range	51

Test	Mucopolysaccharides
Sample type	Urine
Sample volume	10 mL
Special requirements	Early morning sample preferred
Turnaround time	1 month
Method	Thin layer chromatography
Reference range	See Glycosaminoglycans. A qualitative report for heparan, dermatan, keratan and chondroitin sulphate is provided
Source of reference range	Qualitative report

Test	Non-Esterified Fatty Acids (Free Fatty Acids)
Sample type	Plain
Sample volume	0.5 mL
Special requirements	Sample should be collected whilst the patient is hypoglycaemic (plasma glucose <2.6 mmol/L) and arrive at the laboratory within 2 hours of collection.
Turnaround time	1 month
Reference range	500 – 900 umol/L during hypoglycaemia For further information regarding result interpretation, refer to the MetBioNet Best Practice Guidelines for the investigation of hypoglycaemia in infants and children (www.metbio.net/metbioguidelines.asp)
Source of reference range	44

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Test	Noradrenaline	
Sample type	3 mL random sample or 24 hour urine collected into bottle containing acid	
Sample volume	3 mL if random urine	
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)	
Turnaround time	5 working days	
Reference range	0 – 1 year	<0.25 umol/mmol creatinine
	1 – 2 years	<0.20 umol/mmol creatinine
	3 – 4 years	<0.15 umol/mmol creatinine
	5 – 10 years	<0.14 umol/mmol creatinine
	>11 years	<0.11 umol/mmol creatinine
Source of reference range	2	

Test	Oestradiol	
Sample type	Lithium Heparin / Plain	
Sample volume	1.0 mL	
Turnaround time	1 working day	
Reference range	Male	0 – 150 pmol/L
	Female Follicular phase Mid-cycle Luteal phase	 70 – 800 pmol/L 500 – 1200 pmol/L 100 – 500 pmol/L
Source of reference range	1	

Test	Oligosaccharides
Sample type	Urine
Sample volume	20 mL
Special requirements	
Turnaround time	1 month
Method	Thin layer Chromatography
Reference range	Qualitative report
Source of reference range	

Test	Organic Acids
Sample type	Urine
Sample volume	10 mL
Special requirements	Clinical details (such as fasting status, hypoglycaemia and relevant drug history) must be provided with all metabolic requests.
Turnaround time	7 working days
Method	Gas chromatography separation with mass spectrometry detection
Reference range	Qualitative report
Source of reference range	n/a

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Test	Osmolality
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Method	Freezing point depression
Reference range	275 – 296 mOsm/kg
Source of reference range	

Test	Osmolality
Sample type	Urine
Sample volume	1 mL
Special requirements	
Turnaround time	24 hours
Method	Freezing point depression
Reference range	Normal concentrating ability in children >450 mOsm/kg
Source of reference range	

Test	Osmolality
Sample type	Faeces
Sample volume	2 mL
Special requirements	Sample must be liquid
Turnaround time	24 hours
Method	Freezing point depression
Reference range	Large osmolar gap between measured and calculated osmolality (e.g. >100 mOsm/kg) suggests osmotic diarrhoea
Source of reference range	

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Test	Paracetamol
Sample type	Lithium Heparin
Sample volume	1 mL
Special requirements	Collect sample 4 hours post ingestion. Please see the Trust paracetamol guidelines at http://intranet/DocumentsPolicies/Documents/Paracetamol%20Overdose%20Guideline.pdf
Turnaround time	24 hours
Method	Aryl acrylamidase enzymatic reaction with spectrophotometric detection
Reference range	Trust guidance available (“Medical management of paracetamol overdose” on the intranet)
Source of reference range	52

Test	Parathyroid Hormone (PTH)
Sample type	Lithium Heparin / Plain
Sample volume	1 mL
Special requirements	Send sample to the laboratory as soon as possible after collection. Also send sample for calcium measurement.
Turnaround time	24 hours
Method	Two-step chemiluminescent microparticle immunoassay
Reference range	1.1 – 6.9 pmol/L
Source of reference range	1

Test	pH
Sample type	Urine
Sample volume	5 mL
Special requirements	
Turnaround time	10 minutes
Method	Sterilab Analyticon Urilyzer 100 with combiscreen test strips
Reference range	If patient is acidotic, urine pH should be <5
Source of reference range	

Test	Phenobarbitone	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements	Pre-dose sample Time to reach steady state is approximately 7 – 9 days	
Turnaround time	24 hours	
Method	Homogeneous particle-enhanced turbidimetric inhibition immunoassay	
Reference range	Therapeutic range Toxic	15 – 40 mg/L >60 mg/L
Source of reference range		

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Test	Phenylalanine	
Sample type	Lithium Heparin	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	4 working days	
Method	High-performance Liquid Chromatography with UV detection	
Reference range	PKU patient on diet <12 years >12	 120 - 360 umol/L 120 - 600 umol/L
	Pregnant PKU	120 – 360 umol/L
Source of reference range	53	

Test	Phenylalanine (Home monitoring for known PKU patients)	
Sample type	Blood Spot	
Sample volume	1 spot	
Special requirements	Blood spot must be of good quality	
Turnaround time	3 working days	
Method	Liquid chromatography with Tandem Mass Spectrometry detection	
Reference range	PKU patient on diet <12 years >12	 120 - 360 umol/L 120 - 600 umol/L
	Pregnant PKU	120 – 360 umol/L
Source of reference range	53	

Test	Phenytoin	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements	Pre-dose sample Time taken to reach steady state is approximately 7 days in a neonate, 4 days in a child.	
Turnaround time		
Method	Homogeneous enzyme immunoassay	
Reference range	Therapeutic range Toxic	10 – 20 mg/L >20 mg/L
Source of reference range		

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Test	Phosphate (included in bone profile)	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements		
Turnaround time	24 hours	
Method	Phosphomolybdate enzymatic reaction with colourimetric UV detection	
Reference range	0 - 7 days 7 days - 2 years 2 - 5 years 5 - 8 years 8 - 12 years 12 - 16 years > 16 years	1.36 - 2.91 mmol/L 1.36 - 2.26 mmol/L 1.13 - 2.20 mmol/L 1.00 - 2.03 mmol/L 0.97 - 1.94 mmol/L 0.81 - 1.51 mmol/L 0.74 - 1.55 mmol/L
Source of reference range	28, 29	

Test	Phosphate	
Sample type	Urine	
Sample volume	5 mL	
Special requirements	For Tubular Reabsorption of Phosphate (TRP), a blood sample collected at the same time is required. Use nomogram to calculate TmP/GFR. Relates plasma PO_4 to tubular reabsorption of phosphate (TRP): $TRP = 1 - \frac{U_{phosphate} \times P_{creatinine}}{P_{phosphate} \times U_{creatinine}}$	
Turnaround time	24 hours	
Method	Phosphomolybdate enzymatic reaction with colourimetric UV detection	
Reference range	0 – 1 month 1 month – 2 years 2 – 12 years 12 – 16 years >16 years	1.45 – 3.00 mmol/L 0.87 – 2.03 mmol/L 1.03 – 1.80 mmol/L 0.90 – 1.70 mmol/L 0.74 – 1.2 mmol/L
Source of reference range	40	

Test	Potassium (included in U&E profile)	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements	Separate plasma if there is likely to be a delay of >4 hours before analysis	
Turnaround time	24 hours	
Method	Indirect ion-selective electrode	
Reference range	<28 days >28 days	4.0 – 6.2 mmol/L 3.5 – 5.5 mmol/L
Source of reference range		

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Test	Potassium	
Sample type	Urine	
Sample volume	1 mL random urine or 24 hour collection	
Special requirements		
Turnaround time	24 hours	
Method	Indirect ion-selective electrode	
Reference range	Neonate	<2.3 mmol/kg/24 hours
	Child	<2.0 mmol/kg/24 hours
	Adult	25 – 100 mmol/24 hours
	In hypokalaemia a **potassium/creatinine ratio** on a random urine <1.5 suggests poor intake, redistribution or extra-renal losses. A ratio >1.5 suggests renal losses – acid base status and BP are then useful in the differential diagnosis. (IJKD, 2008; 2:115-22).	
Source of reference range	39	

Test	Prolactin	
Sample type	Lithium Heparin / plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	1 working day	
Method	Solid-phase, two-site sequential chemiluminescent immunometric assay	
Reference range	Male	0 – 350 mU/L
	Female	0 – 500 mU/L
	Macroprolactin request may be added by the Duty Biochemist following clinical validation if Prolactin >700 mU/L is not explained	
Source of reference range	1	

Test	Protein (Total)	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements		
Turnaround time	24 hours	
Method	Biuret test with UV detection	
Reference range	0- 2 months	54 – 74 g/L
	2 months – 2 years	62 – 83 g/L
	2 – 8 years	65 – 87 g/L
	8 – 12 years	67 – 92 g/L
	12 – 14 years	62 – 87 g/L
	14 – 16 years	64 – 90 g/L
	>16 years	65 – 85 g/L
Source of reference range		

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Test	Protein
Sample type	Urine
Sample volume	24 hour urine or 1 mL random urine
Special requirements	
Turnaround time	24 hours
Method	Turbidimetry and UV detection
Reference range	<50 mg/24 hours
Source of reference range	

Test	Protein	
Sample type	CSF	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Method	Turbidimetry and UV detection	
Reference range	0 – 2 months	0.2 – 1.1 g/L
	2 – 4 months	0.1 – 0.8 g/L
	>4 months	0.1 – 0.4 g/L
Source of reference range	64	

Test	Reducing substances
Sample type	Faeces
Sample volume	
Special requirements	Samples should be frozen within 2 hours of collection and stored at -20°C. If sucrose malabsorption is suspected please make a specific request.
Turnaround time	3 working days
Method	Benedict's test followed by thin layer chromatography
Reference range	Qualitative report
Source of reference range	

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Test	Reducing substances
Sample type	Urine
Sample volume	5 mL
Special requirements	Samples should be frozen within 2 hours of collection and stored at -20ºC.
Turnaround time	3 working days
Method	Benedict's test followed by thin layer chromatography
Reference range	Qualitative report
Source of reference range	

Test	Salicylate	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements		
Turnaround time	24 hours	
Method	Salicylate hydroxylase enzymatic reaction with spectrophotometric detection	
Reference range	Therapeutic range Mild poisoning (if symptoms) Moderate poisoning Severe poisoning	200 – 300 mg/L <300 mg/L 300 – 700 mg/L >700 mg/L
Source of reference range	54	

Test	Selenium	
Sample type	Teklab trace metal free tube. If Teklab tubes are unavailable an alternative serum/plain tube may be accepted.	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	5 working days	
Method	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)	
Reference range	0 – 2 years 4 – 4 years 4 – 16 years >16 years	0.2 – 0.9 umol/L 0.5 – 1.3 umol/L 0.7 – 1.7 umol/L 0.8 – 2.0 umol/L
Source of reference range		

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Test	Sodium (included in U&E profile)	
Sample type	Lithium Heparin	
Sample volume	1 mL	
Special requirements		
Turnaround time	24 hours	
Method	Indirect Ion-selective electrode	
Reference range	Neonate Child	132 – 142 mmol/L 135 – 145 mmol/L
Source of reference range		

Test	Sodium	
Sample type	Urine	
Sample volume	24 hour urine or 1 mL random urine	
Turnaround time	24 hours	
Method	Indirect Ion-selective electrode	
Reference range	Neonate Child Adult	<4.4 mmol/kg/24 hours <3.7 mmol/kg/24 hours 100 – 200 mmol/kg/24 hours
	Should be interpreted in relation to sodium intake. In hyponatraemia urine sodium <20 mmol/L suggests non renal losses, dilutional or low intake; urine sodium >20 mmol/L indicates renal losses, SIADH, resetting of osmostat or endocrine disturbance.	
Source of reference range		

Test	Sulphite
Sample type	Urine
Sample volume	5 mL
Special requirements	Sample must be sent to the laboratory on ice immediately after collection.
Method	Macherey-Nagel Quantofix Sulfite semi-quantitative test strips
Reference range	Negative
Source of reference range	

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Test	Sweat Test	
Sample type	Sweat	
Sample volume	Minimum 15µL, based on sweat production rate of 1g/m^2/minute over 30 minutes	
Special requirements	Please telephone Ext 2487 (0151 252 5487) for appointment. Sweat tests are not recommended in neonates <7 days of age.	
Turnaround time	1 working day	
Method (Sweat Chloride)	Coulometric titration	
Reference range	Chloride	
	<6 months	
	Low probability of CF	<30 mmol/L
	Intermediate	30 – 60 mmol/L
	Suggests CF	>60 mmol/L
	> 6 months	
	Low probability of CF	<40 mmol/L
	Intermediate	40 – 60 mmol/L
	Suggests CF	>60 mmol/L
	Higher values may be seen >10 years	
Source of reference range	32	

Test	Tacrolimus
Sample type	EDTA whole blood
Sample volume	0.5 mL
Special requirements	
Turnaround time	Test performed twice weekly by Haematology. Please telephone 0151 252 5490 (Ext 2490) for further information
Method	Chemiluminescent Microparticle Immunoassay
Reference range	Test performed by Haematology. Please telephone 0151 252 5490 (Ext 2490) for further information
Source of reference range	NA

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Test	Testosterone	
Sample type	Lithium Heparin / plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	1 working day	
Method	Solid-phase, two-site sequential chemiluminescent immunometric assay	
Reference range	Male (post puberty) Female (>1 year)	9 – 40 nmol/L 0 – 3.5 nmol/L
Source of reference range	1	

Test	Theophylline (aminophylline)	
Sample type	Lithium Heparin	
Sample volume	0.5 mL	
Special requirements	For IV theophylline see Trust Aminophylline Monitoring Pathways on intranet. For oral theophylline sample should be collected 5 days after starting oral treatment and at least 3 days after any dose adjustment. A blood sample should usually be taken 6 hours after an oral dose of a modified-release preparation or after 1 hour if on liquid (contact Pharmacy for further advice).	
Turnaround time	24 hours	
Method	Enzyme immunoassay	
Reference range	Target	10 – 20 mg/L
	Toxic	>20 mg/L
Source of reference range	55	

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Test	Thyroid Function Tests (TFT, includes TSH and Free T4)		
Sample type	Lithium Heparin		
Sample volume	1.3 mL		
Special requirements			
Turnaround time	24 hours		
Reference range	See individual tests (TSH, Free T4, Free T3)		
Test	**Thyroid Stimulating Hormone (TSH)**		
Method	Chemiluminescent microparticle immunoassay		
Reference range	0 – 1 day 1 – 2 days 2 – 3 days >3 days	2.4 – 33 mU/L 1.6 – 18 mU/L 0.6 – 10 mU/L 0.3 – 3.8 mU/L	
Source of reference range	33		
Test	**Free T4**		
Method	Chemiluminescent microparticle immunoassay		
Reference range	< 2 weeks 2 weeks – 1 month >1 month	10 – 30 pmol/L 10 – 25 pmol/L 9 – 19 pmol/L	
Source of reference range	34		
Test	**Free T3**		
Method	Chemiluminescent microparticle immunoassay		
		Male	Female
Reference range	4 days - <1 year 1 - <12 years 12 - <15 years ≥15 years	3.56 – 7.48 pmol/L 4.29 – 6.79 pmol/L 4.44 – 6.65 pmol/L 3.46 – 5.92 pmol/L	3.56 – 7.48 pmol/L 4.29 – 6.79 pmol/L 3.84 – 6.06 pmol/L 3.55 – 5.70 pmol/L
Source of reference range	59		

Test	Thyroid Peroxidase Antibodies (TPO)
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	
Turnaround time	5 working days
Method	Chemiluminescent microparticle immunoassay
Reference range	<6 IU/L
Source of reference range	Manufacturers ranges (Abbott)

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Test	Tissue Transglutaminase (TTG)	
Sample type	Plain	
Sample volume	1 mL	
Special requirements	Testing for coeliac disease is accurate only if the patient has a gluten containing diet for a minimum of 6 weeks before testing. Sample haemolysis (H index >1) may lead to falsely low TTG concentrations.	
Turnaround time	7 working days	
Method	EliA Celikey IgA Fluoroenzymeimmunoassay	
Reference range	Negative Equivocal Positive	0 – 7 U/mL 7 – 10 U/mL >10 U/mL
Source of reference range	68, 69	

Test	Tobramycin	
Sample type	Lithium Heparin	
Sample volume	0.5 mL	
Special requirements	Please indicate whether peak (post-dose) or trough (pre-dose) level and whether on once daily, neonatal or renal regime and whether patient has cystic fibrosis.	
Turnaround time	24 hours	
Method	Particle-enhanced turbidimetric inhibition immunoassay	
Therapeutic range	***Children >1 month and normal renal function (over 44 weeks corrected gestational age)***	
	Trough (18-24 hours after dose given)	<1 mg/L
	Neonates (<1 month)	
	Trough (within the 2 hours before the 3rd dose is due)	<2 mg/L
	Peak (1 hour after the 3rd dose is given)	5 – 10 mg/L
Source of reference range	42	

Test	Transferrin	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24 hours	
Method	Immunoturbidimetry	
Reference range	**0 – <9 weeks** **9 weeks – 1 year** **1 – <19 years**	**1.04 – 2.24 g/L** **1.07 – 3.24 g/L** **2.20 – 3.37 g/L**
Source of reference range	59	

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Test	Triglycerides			
Sample type	Lithium Heparin / Plain			
Sample volume	0.5 mL			
Special requirements	Fasting sample preferred			
Turnaround time	24 hours			
Method	Glycerol Phosphate Oxidase 4-point enzymatic reaction with colourimetric detection			
Reference range		**Acceptable**	**Borderline**	**High**
	0 – 9 years	<0.85 mmol/L	0.85 – 1.12 mmol/L	>1.12 mmol/L
	10 – 19 years	<1.02 mmol/L	1.02 – 1.46 mmol/L	>1.46 mmol/L
Source of reference range	18			

Test	Urate (Uric Acid)	
Sample type	Lithium Heparin / Plain	
Sample volume	0.5 mL	
Special requirements	If patient is on Rasburicase therapy the sample must be sent to the laboratory on ice as soon as possible after collection	
Turnaround time	24 hours	
Method	Uricase end-point enzymatic reaction with spectrophotometric detection	
Reference range	Neonate Child Adult male Adult female	120 – 420 umol/L 120 – 390 umol/L 119 – 416 umol/L ********** umol/L
Source of reference range	36	

Test	Urate (Uric Acid)	
Sample type	Urine	
Sample volume	1 mL	
Special requirements		
Turnaround time	24 hours	
Method	Uricase end-point enzymatic reaction with spectrophotometric detection	
Reference range	Neonate 0 – 5 years 5 – 10 years >10 years	0.34 – 1.95 mmol/mmol creatinine 0.27 – 1.01 mmol/mmol creatinine 0.18 – 0.67 mmol/mmol creatinine <0.68 mmol/mmol creatinine
Source of reference range	37, 38	

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Test	Urea (Included in U&E profile)	
Sample type	Lithium Heparin / Plain	
Sample volume	1 mL	
Turnaround time	24 hours	
Method	Urease enzymatic reaction with spectrophotometric detection	
Reference range	Neonate Child	1.0 – 5.0 mmol/L 2.3 – 6.4 mmol/L
Source of reference range		

Test	Urea & Electrolytes (U&E)
Sample type	Lithium Heparin / Plain
Sample volume	0.5 mL
Special requirements	Includes Sodium, Potassium, Chloride, Bicarbonate, Urea, Creatinine, Anion Gap.
Turnaround time	24 hours
Method	See individual tests
Reference range	See individual tests
Source of reference range	

Test	Urea & Electrolytes (U&E)
Sample type	Urine
Sample volume	1 mL
Special requirements	Includes Sodium, Potassium, Urea, Creatinine.
Turnaround time	24 hours
Method	See individual tests
Reference range	See individual tests
Source of reference range	

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Test	Vancomycin	
Sample type	Lithium Heparin	
Sample volume	0.5 mL	
Special requirements	Please indicate whether peak (post dose) or trough (post dose) level and whether on once daily, neonatal or renal regime and whether patient has cystic fibrosis.	
Turnaround time	24 hours	
Method	Particle-enhanced turbidimetric inhibition immunoassay	
Therapeutic range	Trough	10 – 15 mg/L
	For severe infections or reduced sensitivity	15 – 20 mg/L
	Toxic	>20 mg/L
Source of reference range	61	

Test	Vitamin A (Retinol)	
Sample type	Lithium Heparin / plain	
Sample volume	0.5 mL	
Special requirements	Samples must be protected from light Grossly haemolysed samples are unsuitable for analysis	
Turnaround time	3 weeks	
Method	High-Performance Liquid Chromatography (HPLC) with UV detection	
Reference range	1 – 6 years	0.7 – 1.5 umol/L
	7 – 12 years	0.9 – 1.7 umol/L
	13 – 19 years	0.9 – 2.5 umol/L
Source of reference range	19	

Test	Vitamin D (25-Hydroxy Vitamin D)	
Sample type	Lithium Heparin / plain	
Sample volume	0.5 mL	
Special requirements		
Turnaround time	24h for standard method (immunoassay) 2 weeks for Mass Spectrometry (see below).	
Method	Chemiluminescent microparticle immunoassay(standard method) For patients on Vitamin D2 (Ergocalciferol) supplements 25-OH Vitamin D2 and D3 will be measured by Tandem Mass Spectrometry.	
Reference range	**Total Vitamin D (25-OH Vitamin D2 + 25-OH Vitamin D3)**	
	Deficient	<25 nmol/L
	Insufficient	25 – 50 nmol/L
	Adequate	>50 nmol/L
Source of reference range	56	

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Test	Vitamin E (Tocopherol)
Sample type	Lithium Heparin / plain
Sample volume	0.5 mL
Special requirements	Samples must be protected from light Even slight haemolysis can cause a significant negative bias for Vitamin E results
Turnaround time	3 weeks
Method	High-Performance Liquid Chromatography (HPLC) with UV detection
Reference range	6.9 – 41.5 umol/L
Source of reference range	57

Test	VMA (Vanillylmandelic Acid)	
Sample type	24 hour urine collected into bottle containing acid or random urine	
Sample volume	3 mL if random urine	
Special requirements	Random samples must arrive at the laboratory within 30 minutes of collection (please inform laboratory staff when sending a sample)	
Turnaround time	5 working days	
Method	High-Performance Liquid Chromatography (HPLC) with electrochemical detection	
Reference range	0 – 1 year 1 – 2 years 3 – 4 years 5 – 10 years >11 years	<15 umol/mmol creatinine <12 umol/mmol creatinine <7.5 umol/mmol creatinine <7.0 umol/mmol creatinine <7.0 umol/mmol creatinine
Source of reference range		

Test	Zinc
Sample type	Teklab trace metal free tube. If Teklab tubes are unavailable an alternative serum/plain tube may be accepted.
Sample volume	1 mL
Special requirements	Sample must be collected into trace metal free tube
Turnaround time	5 working days
Method	Inductively-Coupled Plasma Mass Spectrometry (ICP-MS)
Reference range	9.6 – 18.0 umol/L
Source of reference range	

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18 References

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Appendix 1 AFP Reference Ranges

Serum AFP values of term babies without additional factors associated with AFP elevation (*n*=524).

Units = IU/mL

AGE		AFP (mean)	AFP (95.5% interval)	Half-life (t½)
0 d		34,600	7,570 - 158,153	
1 d		30,205	6,593 - 137,746	
2 d		26,368	5,769 - 119,972	
3 d		23,018	5,002 - 104,491	
4 d		20,094	4,397 - 91,008	
5 d		17,542	3,838 - 80,182	5.1
6 d		15,314	3,351 - 69,997	
7 d		13,369	2,925 - 61,105	
8 – 14 d	(1 – 2 wk)	7,746	1,228 - 48,876	
15 – 21 d	(2 – 3 wk)	3,014	477 - 19,015	
22 – 28 d	(3 – 4 wk)	1,159	262 - 5,237	
29 – 45 d	(4 – 6 wk)	346	25 - 4,776	14
46 – 60 d	(6 wk – 2 m)	148	13 - 1,656	
61 – 90 d	(2 – 3 m)	66	5.0 - 867	28
91 – 120 d	(3 – 4 m)	30	2.5 - 346	
121 – 150 d	(4 – 5 m)	17	1.7 - 179	42
151 – 180 d	(5 – 6 m)	11	1.0 - 107	
181 – 720 d	(6 m – 2 y)	6.6	0.7 - 72	

Reference:

Blohm MEG, Vesterling-Hörner D, Calaminus G, Göbel U. Alpha$_1$-fetoproteins (AFP) reference values in infants up to two years of age. *Pediatr Hematol Oncol* (1998) **15:** 135-142.

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Appendix 2 Amino Acid reference Ranges

A. Plasma amino acids

	From age								
AMINO ACID	Day 0	0-6m	6m	1y	2y	5y	6y	16y	Overall
Taurine	26-169	26-169		26-169		26-169			26-169
Aspartic			4-18		3-8		3-6	2-5	
Threonine	47-240	39-175		39-175		39-175			43-218
Serine	69-206	69-206		69-206		69-206			69-206
Asparagine									30-70
Glutamine	323-810	320-789		320-789		320-789			326-800
Proline	66-330	66-330		66-330		66-330			66-330
Glutamic acid	32-240	32-240		26-151		26-151			
Glycine	120-436	120-436		120-436		120-436			120-436
Alanine	112-592	112-592		112-592		112-592			112-592
Valine	65-290	101-317		101-317		101-317			79-313
Cystine			21-53		27-52		33-54	36-61	
Methionine/Homocitrulline	11-49	10-34		10-34		10-34			10-41
Isoleucine	20-91	20-91		20-91		20-91			20-91
Leucine	44-169	44-169		44-169		44-169			44-169
Tyrosine	22-103	30-89		30-89		30-89			29-92
Phenylalanine	25-80	30-65		30-65		30-65			30-76
Ornithine	29-171	31-130		22-93		22-93			24-154
Lysine	70-266	63-204		63-204		63-204			66-242
Histidine	43-111	43-111		43-111		43-111			43-111
Arginine	12-112	12-112		17-85		17-85			14-102
Tryptophan									40-79
Citrulline									19-36

Age-specific distribution of plasma amino acid concentrations in a healthy pediatric population Lepage *et al.* Clin Chem (1997) 43:12, 2397-2402

Carling RS, Multi Centre Age Related Amino Acid Reference Intervals for Cerebrospinal Fluid, Plasma and CSF:Plasma Ratios.

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B. Urine amino acids

	Age								
Amino acid	0-1m	1-6m	6-12m	1-2y	2-4y	4-7y	7-10y	10-13y	>13y
Taurine	8-266	6-89	9-123	12-159	13-200	17-230	18-230	18-176	16-180
Aspartic acid	2-12	2-16	3-12	3-10	2-8	2-8	1-9	1-10	2-7
Threonine	20-138	17-92	14-56	15-62	10-48	9-36	9-27	8-28	7-29
Serine	80-282	42-194	50-137	45-124	32-94	38-93	23-69	23-67	21-50
Asparagine	0-84	0-58	0-36	0-32	0-30	0-29	0-24	0-18	0-23
Glutamic	0-30	0-29	0-18	0-11	0-10	0-8	0-5	0-9	0-12
Glutamine	52-205	63-229	74-197	62-165	45-236	52-133	31-97	20-112	20-76
Proline	21-213	0-130	0-14	0-13	0-9	0-9	0-9	0-9	0-9
Glycine	283-1097	210-743	114-445	110-356	111-326	91-246	84-236	64-165	43-173
Alanine	75-244	72-206	36-162	41-130	33-115	27-92	17-65	21-62	16-68
Citrulline	0-11	0-10	0-8	0-7	0-6	0-5	0-5	0-5	0-4
Valine	3-26	4-19	6-19	7-21	6-20	3-15	3-15	3-17	3-13
1/2 cystine	24-78	13-48	12-29	10-26	8-30	8-22	8-21	7-23	6-34
Methionine	7-27	6-22	8-29	7-29	5-21	5-20	3-17	3-10	2-16
Isoleucine	0-6	0-5	0-6	0-6	0-5	0-5	0-6	0-6	0-4
Leucine	3-25	4-12	4-16	3-17	4-18	3-13	3-16	3-14	2-11
Tyrosine	6-55	12-52	11-54	13-48	10-30	9-35	7-26	6-25	2-23
Phenylalanine	4-32	7-28	11-28	10-31	7-21	6-26	5-20	5-17	2-19
Ornithine	0-19	0-13	0-8	0-8	0-7	0-7	0-6	0-6	0-5
Lysine	22-171	15-199	13-79	16-69	10-46	10-68	10-44	10-56	7-58
Histidine	80-295	72-342	92-278	87-287	68-255	61-216	45-184	43-159	26-153
Arginine	0-14	0-11	0-11	0-8	0-9	0-7	0-6	0-6	0-5
Tryptophan									0-30
Homocystine									0

Age related reference values for free amino acids in first morning urine specimens
Parvy *et al*. Clin Chem (1988) 34:2092-2095

C. CSF Amino Acids

	<6 months	6 – 12 months	1 – 5 years	> 5 years
Phenylalanine	4 – 27	5 – 15	5 – 15	5 – 15
Tyrosine	8 - 35	5 – 22	5 – 22	5 – 22
Valine	8 – 39	7 – 25	7 – 25	7 – 25
Leucine	7 - 33	6 – 21	6 – 21	6 – 21
Isoleucine	0 – 14	0 – 10	0 – 10	0 – 10
Glutamine	351 – 920	317 – 755	317 – 755	317 – 755
Glutamic Acid	0 – 37	0 - 16	0 – 16	0 – 16
Ornithine	2 – 13	3 – 11	1 – 7	1 – 7
Asparagine	2 – 20	2 – 20	2 – 20	2 – 20
Arginine	8 – 29	8 – 29	8 – 29	8 – 29
Citrulline	0 – 5	0 – 5	0 – 5	0 – 5
Lysine	12 – 35	12 – 35	10 – 30	10 – 30
Taurine	4 – 25	5 – 12	3 - 11	3 – 11
Cystine	0 – 4	0 – 4	0 – 4	0 – 4
Methionine	1 – 11	0 – 6	0 – 6	0 – 6
Alanine	18 - 59	13 – 41	13 – 41	13 – 41
Glycine	2 – 15	2 – 10	2 – 10	2 – 10
Proline	0 – 5	0 – 5	0 – 5	0 – 5
Threonine	21 - 115	12 – 55	12 - 55	12 - 55
Histidine	10 – 34	7 - 19	7 - 19	7 – 17
Tryptophan	0 - 3	0 - 3	0 - 3	0 - 3

Moat et al, Mol Genet Metab (2010) 101 (2-3), 149 and Carling RS, Multi Centre Age Related Amino Acid Reference Intervals for Cerebrospinal Fluid, Plasma and CSF:Plasma Ratios.

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3.1 CSF serine reference ranges

Age	Reference Range (umol/L)
< 2 weeks	43 – 74
2 – 3 weeks	41 – 70
3 – 4 weeks	39 – 68
1 - 2 months	38 – 66
2 – 3 months	36 – 62
3 – 6 months	35 – 60
6 – 9 months	33 – 56
9 – 12 months	31 – 54
12 – 18 months	30 – 52
18 – 24 months	29 – 50
2 – 3 years	28 - 48
3 – 5 years	27 – 46
5 – 10 years	25 – 43
10 – 15 years	23 – 39
15 – 20 years	22 – 37
> 20 years	21 – 35

Multicentre age-related reference intervals for cerebrospinal fluid serine concentrations: implications for the diagnosis and follow-up of serine biosynthesis disorders
Moat *et al*, Mol Genet Metab (2010) 101 (2-3), 149

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Appendix 3 Homocystine

Amino Acids are generally reasonably stable for 1-2 days in urine or separated plasma and we accept such samples for amino acid analysis by first class post. However, if homocystine is required the plasma must be separated from the cells and the protein precipitated with a special precipitant (obtained from the laboratory) within 30 minutes of phlebotomy, otherwise the homocystine binds to protein and is not detected. It is not necessary to precipitate the urine unless protein is present.

Procedure:

1. Allow the precipitation reagent to warm to room temperature.
2. Collect at least 0.5 mL blood into a Lithium Heparin tube.
3. Centrifuge the sample to separate the red cells and plasma
4. Pipette 100 µL of the plasma into a centrifuge tube and add 100 µL of the precipitating reagent. Mix well (vortex).
5. Place the sample in the fridge (4^{o}C) for one hour.
6. Centrifuge again and pipette the supernatant into a clean sample tube.
7. CAUTION – the precipitant is 10% (i.e. 10g / 100 mL) sulphosalicylic acid, and is corrosive. Handle with care.
8. Send the request and sample at ambient temperature by first class post / routine transport to the Biochemistry department, Adler Hey Children's Hospital, Eaton Road, Liverpool, L!12 2AP requesting amino acid analysis and state the need for reporting of the homocystine concentration.

The precipitant contains internal standards of norleucine and aminoethylcysteine and the buffers used in chromatography. It can be stored at 4^{o}C for up to six months.

The procedure given above has been written with infants and children in mind. The analyser requires 60 µL of precipitated sample. The procedure provides us with approximately 100 µL and therefore we have only one chance at analysing the sample. If more blood is available from older children / adults please consider preparing two aliquots in case of instrument. / technical failures.

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Appendix 4 Cystinuria

Ranges are in µmol / mmol creatinine.

Cystine :	
Normal	0.9 – 10
Heterozygote	7.1 – 85.4
Homozygote	141 – 428
Ornithine :	
Normal	1.1 – 17.3
Heterozygote	2.5 – 45.4
Homozygote	44 – 502
Arginine	
Normal	0 – 20
Heterozygote	0.5 – 26.4
Homozygote	30.8 – 2171
Lysine :	
Normal	4.5 – 55.4
Heterozygote	44.4 – 338
Homozygote	265 - 1957

Crawhall et al Ann Human Genet 33 (1969) 149

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Appendix 5 Immunoglobulin Reference Ranges

Reference Ranges in g/L

	IgA	IgG	IgM
Cord Blood	0.014 – 0.036	6.11 – 15.4	0.060 – 0.24
1 – 2 mth	0.013 – 0.53	2.41 – 8.7	0.19 – 0.83
2 – 3 mth	0.028 – 0.47	1.98 – 5.77	0.16 – 1.0
3 – 4 mth	0.046 – 0.46	1.69 – 5.58	0.23 – 0.85
4 - 5 mth	0.044 – 0.73	1.88 – 5.36	0.26 – 0.96
5 – 6 mth	0.081 – 0.84	1.65 – 7.81	0.31 – 1.03
6 – 7 mth	0.081 – 0.68	2.06 – 6.76	0.33 – 0.97
7 – 10 mth	0.11 – 0.90	2.08 – 8.68	0.32 – 1.20
11 – 12 mth	0.16 – 0.84	2.82 – 10.30	0.39 – 1.42
12 – 24 mth	0.14 – 1.06	3.31 – 11.6	0.41 – 1.64
2 3 – yrs	0.14 – 1.23	4.07 – 10.1	0.46 – 1.60
3 – 4 yrs	0.22 – 1.59	4.23 – 10.9	0.45 – 1.9
4 – 5 yrs	0.25 – 1.54	4.44 – 11.9	0.41 – 0.86
6 – 8 yrs	0.33 – 2.02	6.08 – 11.6	0.46 – 1.97
9 – 10 yrs	0.45 – 2.36	5.84 – 15.1	0.49 – 2.3
10 – 12 yrs	0.63 – 3.26	7.39 – 13.9	0.53 – 2.27
12 – 14 yrs	0.39 – 2.52	6.26 – 13.9	0.41 – 2.49
14 – 18 yrs	0.44 – 2.63	6.13 – 15.5	0.47 – 2.57
Adult	0.7 – 3.12	6.13 – 13.0	0.53 – 3.34

0 – 10 years Jolliff *et al* Clin Chem 28 (1982),126
10 – 18 years Liappis *et al* Klin Paed 195 (1983) 107
Adult Jolliff *et al* Clin Chem 28 (1982),126 converted from CDC to IFCC calibration by multiplication by 0.96 - Nov 1996

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