

Laboratory Practice at the Periphery in Developing Countries

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Abstract

An effective national health service structure requires a comprehensive programme for primary health care in peripheral and rural areas. This is especially important in under-resourced countries where facilities are sparse, the population is widely dispersed and transport is limited. Haematology has a key role in diagnosis and patient management by selecting tests for their clinical relevance and utility for the specific circumstances, and ensuring their technical reliability when used in health clinics and point-of-care testing. WHO has proposed a basic menu of tests in three categories: (a) tests such as haemoglobin screen which can be performed by nurses, midwives, health-aides or community doctors, (b) tests such as haemoglobinometry, microhaematocrit and microscopic examination of stained preparations which can be performed by a technician or laboratory assistant in a health centre, (c) tests requiring greater technical expertise of a laboratory technician or trained doctor. The peripheral health clinics and district laboratories must be familiar with the guidelines on standardized methods for collecting and storing specimens and transporting them to a regional laboratory or a reference centre. A training syllabus should be provided at the health centres and district laboratories, and this should include on-site instruction from supervisors and access to training manuals and distance-learning material. A co-ordinated programme of quality assurance and standardization of test methods should be established by a reference centre or national health authority with a network which encompasses all laboratories and health clinics undertaking any tests. Each regional laboratory should foster lower level laboratories or clinics within its neighbourhood. Of particular concern is the reliable diagnosis and management of anaemia. WHO reports indicate that 40% of the world population suffer from anaemia, especially affecting pregnant women, and a high proportion of infants and children in developing countries. The Haemoglobin Colour Scale (HCS) was recently developed for WHO as a simple, cheap and portable device which reads haemoglobin within 1 g/dl of the true value. It has been validated in a number of studies and is now manufactured commercially in accordance with WHO specifications under control of a WHO Collaborating Centre. It has an important potential role in the resource-limited environment where anaemia screening presently usually depends on unreliable clinical examination.

An effective national health service structure requires a comprehensive programme for primary health care in peripheral and rural areas. This is especially important in under-resourced countries where facilities are sparse, the population is widely dispersed and transport is limited. Haematology has a key role in diagnosis and patient management by selecting tests for their clinical relevance, their utility for the specific circumstances, and their technical reliability when used by health-care workers in clinics and for point-of-care testing. In developing countries a peripheral service usually comprises a Health Centre or a Dispensary/Health post which is staff-

fed by a single person who may perform simple laboratory tests in addition to their clinical activities. But this must be looked at, not in isolation, but as part of a network hierarchy which may vary to some extent between countries, but in general will follow the following structure:

- Peripheral
 - Dispensary with single health care worker
 - Health Centre (rural or local urban community)
 - Primary level hospital (rural)
- Intermediate
 - District Hospitals
 - Regional Hospitals

National - Reference laboratory/tertiary hospital

1. Test Selection

The selection of tests must be determined by their ability to provide positive assistance in diagnosis and to provide the clinician with sufficient evidence to decide on appropriate treatment or to alter the current treatment. The tests which are selected for public health purposes, e.g. for disease monitoring, will depend on the local epidemiological situation.

The particular techniques chosen for the tests will depend on what equipment is available, its initial capital cost and cost of reagents and maintenance, ease of performance, level of expertise/technical training required. Clinical reliability is determined by assessing performance compared with that of a reference method on the basis of clinical interpretation, taking account of the limits of precision and accuracy that are necessary for clinical purposes.

Cost effectiveness is paramount. In many countries administrators make decisions for laboratories at central level. But it is important for workers on site to influence these decisions as only they can assess whether the tests adequately support the specific public health or clinical needs, whether laboratory results are utilized effectively by the clinicians and indeed whether the tests serve any purpose at all if resources for treatment are not available? Bates (2001) provided a formula to calculate cost effectiveness: $[100A/C \times 100/B]$, where A=cost/test, B=quality of test and C=clinical usefulness of test in practice.

A guideline document from WHO (1998a) proposed categories of test which should be available at the different levels of the hierarchy:

- (a) At health centres and dispensaries: Category A tests which can be performed by nurses, midwives, health-aides or community doctors. These consist of simple haemoglobin estimation; antibody screening test for malaria (also dipstick urinalysis for proteins, glucose, blood, nitrites, ketones and bilirubin).
- (b) At larger health centres and small district hospitals: Category B tests which can be performed by a technician or laboratory assistant after specific training. These are haemoglobinometry by a dedicated photometer or simple spectrometer, microhaematocrit and MCHC, leucocyte count by haemocytometer counting chamber, Haemoglobin S solubility test (where relevant), microscopic examination of Romanowsky-Giemsa stained blood films for blood-cell morphology, for leucocyte differential count and for estimate of platelet count. Binocular microscopes are essential with a dry X40 lens for routine blood film morphology and for examination of stool and urine, whilst an oil-immersion x100 lens is required for identification of blood parasites.
- (c) At larger district or regional hospitals: Category C tests require greater technical expertise i.e. a lab-

oratory technician or trained doctor able to carry out automated blood counts, G6PD screen, haemoglobin electrophoresis, basic clotting screen, cross-matching and antibody screening.

Other quantitative and qualitative tests for diagnosis of blood disorders and for critical control of therapy require the equipment and technical expertise which would normally be expected in a national reference centre or tertiary hospital. It is important for the staff at health centres and district hospitals to be aware of what types of specimen are required for special investigations beyond their capability, and to know how to collect them, how to prepare them for transport to the referral laboratory and how to ensure that they will not undergo excessive deterioration before reaching their destination (ISH/ICSH, 2002).

2. Training

It is the responsibility of senior haematologists in collaboration with national health authorities to ensure that appropriate training is provided for workers at each level (see below). This should include on-site instruction from supervisors and access to training manuals, attendance at courses, seminars and workshops, participation in a co-ordinated programme of quality assurance within a network which should be established by a central referral institution or national health authority. Distance-learning materials have an important role in education, and suitable technical training programmes should be developed with the collaboration of professional societies such as the International Society of Hematology, International Council for Standardization in Haematology and the International Association of Medical Laboratory Technologists.

2.1. Level 1

The key person at a health centre is the clinical officer who occupies a position between the nurse and the doctor. All categories of the clinical staff may perform a number of simple investigations and should receive adequate training to perform and interpret laboratory results as part of their syllabus for formal and continuing education. Training is divided into (1) preliminary basic instruction; (2) support and on-site instruction by supervisors and specialists during their visits which should last for at least three or four days at regular intervals; (3) continuing development by means of distance-learning exercises.

2.2. Level 2

Laboratory technicians will acquire the skills required for the provision of a medical laboratory diagnostic service at the primary health care level. The trainee will learn basic aspects of:

- human anatomy and physiology
- human pathology

- microbiology, the vectors and transmission of common infectious diseases
- immunology
- simple mathematics, chemistry and physics
- principles of microscopy
- purpose, principles, methodology, sensitivity, specificity and interpretation of a range of laboratory tests
- specimen collection, registration, storage and packaging for transport
- recording and reporting of laboratory test results
- preventive maintenance of equipment
- managerial skills, including personnel management, stock-keeping and ordering
- quality assurance
- laboratory safety
- requirements and methods of sterilization, disinfection and waste disposal
- professional ethics, including relationships with colleagues and patients, and maintaining confidentiality.

Formal training should be supplemented by informal and continuous training at the bench. On-site training of an interactive nature between the clinician and the laboratory worker should be encouraged and must be continuous, as this will be to their mutual benefit.

The training should be supervised and should lead to an examination which tests the knowledge and practical skills of the trainee, and if a satisfactory level has been achieved, will result in certification or registration as a technician by a statutory national body. There should be an opportunity for progression by further advanced training in a higher level laboratory towards qualification as a medical technologist.

The ultimate aim of the training programme is to eradicate all untrained staff. Laboratory aides who shows promise should have the opportunity for career advancement by following part of this training course, understudying a trained technician and carrying out some tests under direct supervision.

3. Quality Assurance

At every level of laboratory service it is essential to have an appropriate quality assurance programme in place. Quality management is concerned with the analytic test itself and also with the related functions. The latter include:

- (1) Pre-analytic proficiency in specimen collection and preparation for testing
- (2) Post-analytic proficiency for of the test result and to ensure that a correct report reaches the clinician promptly
- (3) Record keeping and documentation.

The analytic test is circumscribed by *Internal quality control*, *Standardization* and *External quality assessment*

3.1. Internal Quality Control (IQC)

This is a method to demonstrate reproducibility of results, and to check if there is any fluctuation or bias because of poor technique or if a defect has developed in an instrument, kit or reagent. It is an immediate check that allows the laboratory to decide whether the results are reliable enough for a report to be sent to the clinician. The methods to be used for IQC depend on the number of samples being tested at one time. The best known method used in the majority of laboratories is the *control chart*. This is a simple presentation on arithmetic graph paper of results for a particular test on identical samples of a stable specimen on consecutive days. If the test is well controlled the results will hover around the mean; several sequential results on one side of the mean, indicate a systematic drifting which needs to be checked; a result outside a 2SD limit indicates that a serious error or defect may have occurred - provided that the control material itself has not deteriorated. In sophisticated analyzers a control chart is usually incorporated in the instrument's automated processing. However, the principle can also be adapted as a manual procedure on the simple clinic tests, especially haemoglobinometry.

Control specimens are available commercially or can be manufactured by a laboratory with appropriate facilities. It is relatively easy to make stable reliable control preparations. Methods for this have been described in WHO publications which also give details of preparing and interpreting the control chart (Lewis, 1998). It is impractical to expect peripheral health centres to be able to produce their own preparations, but suitable material should be provided at regular intervals by a regional laboratory or central reference institute, or even by a district laboratory for the neighbouring clinics.

3.2. Correlation

Any unexpected result of a test must be checked to see whether it can be explained on clinical grounds or whether it correlates with inter-related tests; e.g. a low MCHC must be confirmed by demonstrating hypochromic red cells on a blood film.

4. Standardization

Control preparations provide a measure of *precision*; the actual value obtained in the measurement is only required for comparison with the previous measurement on the same specimen. To ensure *accuracy* of a quantitative test it is necessary to use a calibrator with a stated and reliably measured value to calibrate an instrument, for checking an auto-calibrated instrument, and for checking a new method or for preparing a calibration curve to determine the linearity of the method and its upper and lower limits of reliability. Calibrators are made by reference laboratories and by commercial manufacturers; the most reliable preparations are based (directly or indirectly) on international standards, e.g.

WHO Biologicals, ICSH Standards, Certified Reference Materials from the Europe Community Bureau of Reference (for details of those relevant to haematology, see Lewis et al, 2001). These standards are expensive to prepare and are not intended to be used for daily control. They are likely to be beyond the budget of a peripheral clinic or district hospital, but regional and central laboratories should assist by providing preserved (ACD or CPD) blood samples, the values of which have been assayed by measuring them with an appropriate analyzer (spectrometer or automated blood cell counter) which has been calibrated by the international standards.

5. External Quality Assessment (EQA)

In contrast to IQC, EQA is a retrospective assessment of the performance on specified tests in comparison with the results from other laboratories. Participants in EQA schemes are provided with batches of survey specimens at regular intervals. They examine the specimens by their routine methods and return their results to the organizing centre where they are assessed and individual problems are identified. Regional and District hospitals are expected to participate in such national (NEQAS) schemes and also to help satellite laboratories by organizing mini-schemes based on the EQAS. If possible health centres should also participate but this is usually impractical because of the limited supplies of material for a survey. Instead, the same principle should be used, albeit in a limited way, with the assistance of a district or higher level laboratory which should serve as a co-ordinating centre, providing test samples to the participants, analyzing the results, advising them on performance and helping to address problems. The supervisors referred to earlier would be expected to undertake this function.

Some central laboratories also take part in an international scheme (IEQAS) which is sponsored by WHO and was established with the ultimate goal of having a national EQAS in every country (Lewis, 1988). One can envisage a network from the tertiary centre of excellence down to rural dispensaries, all linked into NEQAS, each level advising and training the next level down, and thus ensuring that all laboratories and clinics in a country perform well, giving a reliable service, each within its limitations. It is important to reassure those working in relative isolation that they are not alone and they have the means of improving and advancing their contributions to the health services of their country. The contribution of technicians or laboratory assistants doing basic tests with limited equipment is no less important than that of staff of sophisticated central laboratories, provided that they use their limited resources with skill. They will derive job satisfaction if they are assured that they are providing reliable and meaningful test results for the benefit of patient care.

6. Anaemia Detection and Management

WHO reports indicate that 40% of the world popula-

tion suffer from anaemia. (WHO 1998b) The main causes are iron deficiency, malaria, folate deficiency, thalassemia and haemoglobinopathies, worm infestations, chronic infectious diseases. More than half of the pregnant women and a high proportion of infants and children in developing countries suffer from anaemia (Montresor et al 2000). Many patients are seen only late in their disease, with anaemia of such severity that blood transfusion may be necessary. Thus, early detection of anaemias is a high priority. In rural areas where laboratory facilities are not available, anaemia is usually diagnosed from clinical symptoms and signs such as pallor of the conjunctiva, tongue, palms and nail beds, but accurate interpretation of these signs depends on effective training and even then is often unreliable (Monstresor et al, 2000; Ingram & Lewis, 2000). Thus, a more reliable estimation of haemoglobin is an essential prerequisite for appropriate prevention and treatment of anaemia, management of malaria, strategies for safe motherhood and child health. For a long time the World Health Organization has been aware of this need. Over the years many methods have been proposed, but most of these have been found to be unreliable, and those which are reliable are costly.

The Haemoglobin Colour Scale (HCS) was recently developed for WHO as a simple, cheap and portable device (Lewis et al, 1998). Its use has been validated in several studies including antenatal clinics and blood transfusion centres, which have shown that haemoglobin can be read with the HCS by most health workers within 1 g/dl (10g/l) of the laboratory measurement, and that it can reliably identify anaemia in clinical terms as *mild* (10-<12 g/dl), *moderate* (8-<10 g/dl), *marked* (6-<8 g/dl), *severe* (4-<6 g/dl), or *critical* (<4 g/dl) (Ingram & Lewis, 2000; Lewis & Emmanuel, 2001). The Scale and the test strips are now manufactured by a commercial firm* in accordance with the WHO specifications under control of a WHO Collaborating Centre. Undoubtedly, the HCS has an important potential role in the resource-limited environment where screening for anaemia and its treatment are essential components of a health care service.

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