Public Health Microbiology and Disease Surveillance systems; from Pasteur to Web 2.

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ABSTRACT

The surveillance and control of communicable disease continues to be a major public health priority in Sudan and nearby countries. Poor laboratory infrastructures, and the lack of a public health laboratory focus at district level, are two factors that hinder progress in this area. This paper reviews the impediments to laboratory progress. It describes the components that are required for effective public health laboratories, integrated at district level with the hospital laboratory. Diagnosis of meningitis, cholera, shigella, and water quality, and the processing of clinical samples including accurate antimicrobial sensitivity testing are the priorities. These can be achieved with basic microbiology techniques, if adequate laboratory support and facilities are provided.
In the following paper, the use of open access internet applications are described to integrate the results output from laboratories into a real time, local or regional, disease surveillance and reporting system.

INTRODUCTION

As countries throughout Africa and the Middle East strive towards attaining the Millennium Health Targets [(1)], it is timely to look across the whole health economy to see where the main constraints to progress and achievement exist.

Within the area of infection and communicable disease control, a very evident problem exists. It is possible to sit in Khartoum, or El Obeid, or Dongola, and "Google" to find the sequence of the Ebola genome, or an electronic update of the global spread of swine flu, but to obtain reliable antimicrobial sensitivity data from your local laboratory may not be so easy. Microbiology has lagged behind not just the advances in medicine (we still use techniques that Pasteur would recognise), but in the *priorities of health systems*. A visit to the microbiology laboratory of a hospital outside of the central or regional capital can be a rather depressing experience. Bored technicians, culture plates covered with dust, out of date antibiotic discs, and a microscope that will not focus. Yet if we are dealing with a *Shigella* outbreak, or have a major problem with resistant infections in the hospital, it is data from that laboratory on which we depend. At the other end of this gloomy picture we have, with the World Wide Web, the ability to transmit infection data in real time from the periphery to the centre, and analyse and map the data electronically, enabling rapid and effective control interventions.
This article, and one to follow it, will consider how these two ends of the technology spectrum, stretching from the methods of Pasteur to the internet, can be brought together. They will describe the strategies that are needed to develop a reliable, effective, and sustainable public health laboratory network, and how this can be integrated into a 21st century disease surveillance, reporting, and control programme.

PUBLIC HEALTH MICROBIOLOGY:

What is it, and is it effective?

The distinction between "Public Health Microbiology" and "Clinical Microbiology" has often resulted in two parallel but dis-similar

strategies in laboratory provision to the health services. Traditionally, public health laboratories have been associated with the microbiological diagnosis of food and water, other environmental investigations, and, depending on their resources and skills, the investigation of disease outbreaks. Clinical microbiology laboratories are usually hospital based (though some may be private), and investigate a different range of pathogens. Specialist and reference laboratories, such as the "Stack lab" in Khartoum, may have the facilities for the diagnosis of special pathogens, including virology, and be the link to external laboratories for investigations such as viral haemorrhagic fevers. Figure 1 shows the range of investigations that are required within different laboratory levels.

Although syndromic surveillance has a role to play in disease investigation, the importance of adequate laboratories to identify new public health or hospital infection problems has been described in several local studies. These studies have included the public health aspects of poor water quality in marginal areas of Omdurman[2] , the first report of MRSA in Khartoum[3], antimicrobial resistance in *Shigella dysenteriae*[4], and the role of laboratories in the management of meningitis epidemics in 1999 and 2004[5,6]. A study in Cameroon [7] emphasised the importance of accurate laboratory diagnosis in an epidemic of bloody diarrhoea. What was presumed to be *Shigella* was in fact haemorrhagic *E.coli* 0157. This diagnosis required both different public health interventions, and different patient management. Inappropriate antimicrobial use could have increased the risk of haemolytic uremic syndrome. Clinical diagnosis alone would not differentiate the two conditions.

CURRENT LABORATORY SERVICES:

The difficulties faced by microbiology services in many parts of Africa have been addressed by a number of reviews and at a number of meetings and conferences. Important recent reviews have been those of Petti et al [8] and Bates and Maitland[9].
The principal findings from these reviews include the following:

- Inadequate Health Care infrastructure
- Lack of equipment and consumables
- Lack of ongoing training for laboratory staff
- Insufficient quality control
- Lack of clinician interest in laboratory function

These reviews are primarily concerned with the organisational and management aspects of laboratories, and the problems they highlight are common to many resource limited regions, and are well known to all those working in the laboratory sector.

Programmes to improve laboratory services have been initiated internationally by EMRO [10] and AFRO [11], by bilateral aid programmes including CDC [12], European, and Arab state donors, and regionally by AMREF.

The proceedings from the AFRO 2008 meeting [11] "Strengthening Public Health Laboratories in the WHO African Region: A Critical need for Disease Control" are relevant to all regions where resources are limited, and communicable diseases and infections remain major public health problems. They describe the complimentarity of clinical and public health laboratories in disease surveillance, prevention and control. The report identifies the same limitations in laboratory services as in the reviews above. The report then goes forward with recommendations for action, in particular to "Develop a comprehensive national laboratory policy", and that "the challenge for national public health laboratory services is to improve patient management and disease surveillance, control and prevention."

While there have been many laboratory initiatives in the past two decades, they have had a varying degree of sustainability. This is partly because the "agenda" may be determined by the perceived priorities of the donors, rather than the host country's priority needs of their populations. An example of this is the global donor strategy to fund laboratories for HIV diagnosis, but not supporting the broader role of laboratories in disease diagnosis and control or clinical management.

One of the problems with each new donor initiative on laboratory support is often the assumption that nothing exists already. It is preferable to work with the current laboratory system, however inadequate, and concentrate on priority areas, whether they be training, supplies, quality control etc, to make the existing system more functional. Such inputs are more likely to be sustainable in the longer term.

DEVELOPING THE PUBLIC HEALTH LABORATORY NETWORK:

At a WHO consultation meeting in 2003, the problems faced by many countries with limited laboratory resources were addressed in a new and strategic manner. In particular, it concentrated on the central role of a public health laboratory network, from the periphery to the central, national laboratory.

Figure 1 illustrates the components of such a Public Health Laboratory network. The focal point of the network and the main "blockage" in the system is the district / regional hospital laboratory.

At the centre, the National Laboratory is well structured to act as the central laboratory for the country. At the other end of the network are the peripheral health centre laboratories. They may do malaria films and basic haematology but will not normally have the sustainable resources to provide a wider range of microbiology investigations. There have been considerable developments in "rapid" diagnostic tests for communicable disease diagnosis which may have a role at the periphery. The most widely used of these for public health has been the latex agglutination test for meningitis. Immunodiagnostic and molecular (polymerase chain reaction, PCR) tests have been developed with higher specificity and sensitivity. The tests that have shown promise in the field include an immunodipstick for meningitis (Niger)[13], with a sensitivity of 89% and specificity of 62%, a PCR test for meningitis (Burkina Faso)[14], sensitivity 100% and specificity 70%, and an immunodipstick for cholera (Guinea Bissau)[15], sensitivity 97%, specificity 71%. While these tests may show promise in the future, none are sufficiently field tested to be used routinely at field level at present, and "traditional" microbiology is the basis of sustainable laboratory improvement.

THE STRUCTURE OF THE DISTRICT PUBLIC HEALTH LABORATORY:

The remainder of this paper will focus on how district laboratories can be strengthened for this public health as well as clinical role, and the second paper in this series will describe how these laboratories can be incorporated in an effective, real time, disease surveillance system.
One model for these laboratories is the former UK Public Health Laboratory Service (PHLS) district laboratory. Clearly the diseases investigated may

Figure1. Laboratory requirements for public health disease diagnosis and surveillance.

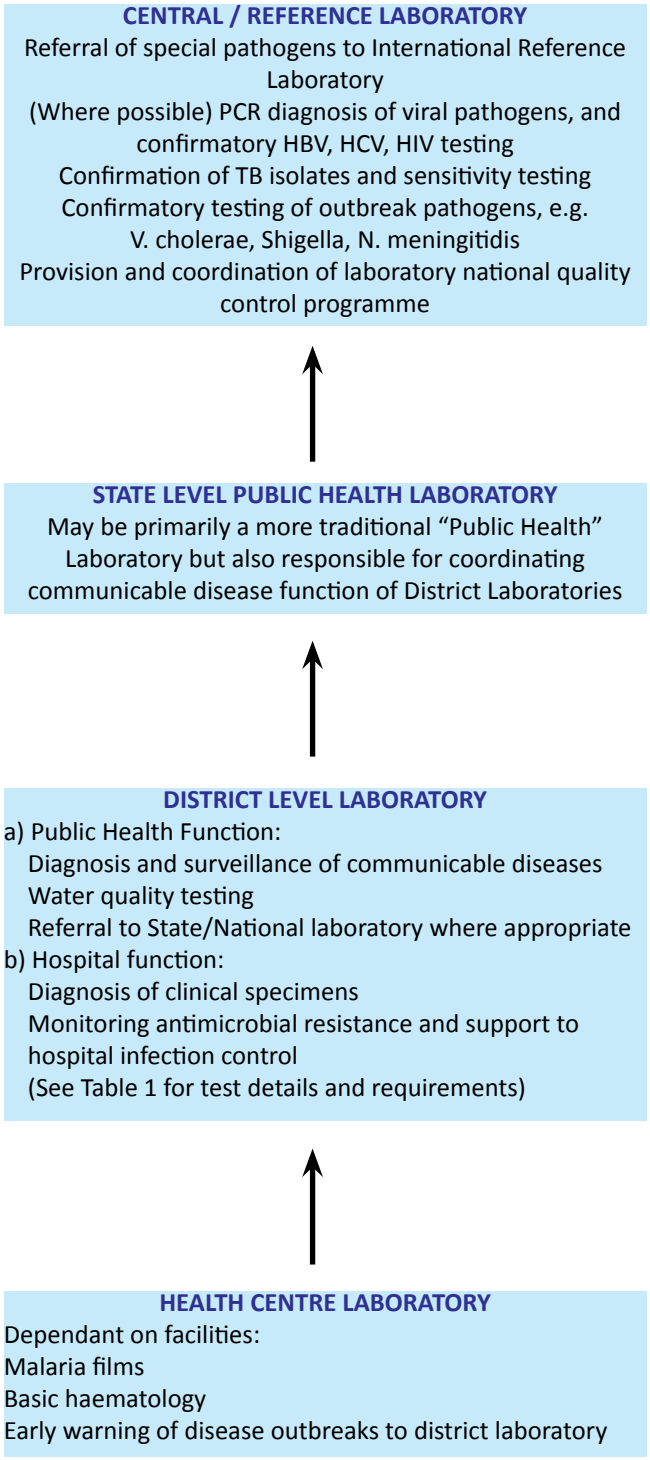

Table 1: Diagnostic requirements of a district hospital/public health laboratory.

DISEASE / INVESTIGATION	METHODS	REQUIREMENTS
PUBLIC HEALTH		
Cholera	Culture	TCBS media Oxidase 01/0139 antisera
Shigella	Culture ID and Sens	MacConkey/XLD media KIA agar Ap Chlor Cip discs
Salmonella	Culture ID and Sens	XLD Media , KIA agar S.typhi/paratyphi antisera Antibiotic discs
N. meningitidis	CSF Gram stain/agglutination	Sentinel csf samples transported (media) to National Laboratory
Tuberculosis	Z/N microscopy of sputum (in cooperation with National TB programme)	Selected sputum samples sent to NL for ID confirmation and sensitivity testing
Water coliform testing	44 ' Culture	Membrane filters Media
Suspected VHF	Refer to National Lab	
CLINICAL LABORATORY		
Blood cultures	Gram stain, Culture, ID and sens	Blood culture diphasic bottles, other agars, basic diagnostic reagents antibiotic discs
Urine	As above	Agar etc as above
Wound swabs (both surgical and trauma)	As above	As above
Sputum/respiratory samples	As above plus ZN stain	As above plus some TB samples to National lab

be different, as will the resource set up, but the strategy of providing a district level laboratory that serves both the district hospital, and the local public health needs, AND is part of national public health network, is a viable model. The value of this model is now very apparent since the PHLS system has been disbanded; with a small number of regional Health Protection Agency laboratories which are too remote from the community level, but not large enough to play the role of a small version of the national laboratory.

Table 1 shows the components of such a laboratory that would meet both the district level requirements for public health, and provide the required diagnostic role for the district hospital.

This range of laboratory tests and disease diagnosis is within the capacity of any microbiology laboratory with a microscope and incubator, basic supplies of slides, Petri dishes etc, and consumables including media, stains, antibiotic discs, and a limited number of other reagents. This includes most district hospital laboratories. It can be seen that the requirements for the public health function and clinical function are similar, and having laboratories providing the dual function is absolutely possible. Indeed, because it will increase the number of specimens processed by

the laboratory, it will help to maintain the expertise and quality assurance of the laboratory.

The "tipping point" is the ***structure*** in which the laboratory functions, or does not function. If the laboratory is never visited by clinicians, its role within the hospital will simply be to turn out reports, which may or may not be looked at, and it will play no role in hospital epidemiology. If it is not linked into a regional and national disease surveillance network its potential function as a public health laboratory will not be achieved, and much of the activity of the laboratory will be wasted.

While most attention is necessarily paid to developing laboratories for the investigation of current disease problems, the occurrence of emerging and re-emerging infections adds further urgency for effective laboratories incorporated into a disease surveillance network [16, 17].

FUTURE DEVELOPMENTS:

The availability in the last year of internet data handling through freely available applications such as Google Docs, provides the facilities for district and regional level public health teams to set up web based disease surveillance networks, without the expense or local IT professional expertise that has previously held such developments back. The second article in this mini series will describe how the public health role of the laboratory can be incorporated into a real time regional disease surveillance and control network using internet applications and mobile phone technology.

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