Emerging Challenges and Opportunities in Medical Microbiology

Infectious diseases continue to be a major cause of mortality, morbidity and economic loss in Southeast Asia. In India, estimated 38% of all deaths are due to infectious diseases. Given the confluence of several environmental, economic and health system-related factors that are conducive for the propagation of these diseases, it is likely that in near future, the global health shall be severely impacted by infectious diseases.

The repertoire of infectious diseases is also gradually increasing. More than 35 new pathogens have been identified in the past four decades. This era belongs to discovery of new viruses – most of which originated from animals. It is estimated that currently, there are around 1415 pathogens around us, of which 217 are viruses.

Emerging Challenges and Opportunities

The dynamic situation in the world of microorganisms warrants exciting and critical role by medical microbiologists. Challenges that need immediate attention of medical microbiologists include (i) emerging viral infections and global public health, (ii) biosafety, biosecurity and bioterrorism, (iii) quality management and (iv) antimicrobial resistance (AMR).

Emerging Viral Infections and Global Public Health

The greatest achievement ever of humanity has been eradication of smallpox. During the 20th century, it is estimated that smallpox was responsible for 300–500 million deaths. Till the 1980s, polio crippled an estimated 350,000 children every year. The disease now remains endemic in only three countries – Afghanistan, Nigeria and Pakistan. The investment of $9 billion since 1984 has been critical to this success. It has already generated net benefits of $27 billion.

In spite of monumental successes against these two viruses, the past four decades can easily be called as the era of viruses. Eighteen new viruses have been identified during this period. Twelve of these viruses have originated from animals. Eleven of these have assumed serious global importance especially.

Severe acute respiratory syndrome (SARS) virus caused first pandemic of this century. It caused 8098 cases and 774 deaths. The virus moved rapidly to 26 countries from Hong Kong through international travel. SARS resulted into 40% reduction in tourism-related activities in Asia. Real cost to East Asia exceeded $50 billion out of a worldwide total of at least $150 billion.

SARS was followed by influenza due to H5N1 subtype that affected human beings as well as poultry. The Asia poultry industry suffered a loss of more than 10 billion USD. While the world anticipated a pandemic with influenza H5N1 virus, it was hit by H1N1 subtype pandemic that killed more than 18,000 people.

Middle East respiratory syndrome coronavirus and other subtypes of influenza viruses (H5N8, H5N7, etc.) appeared without any warning in small geographical areas with potential of spreading across the world.

Ebola epidemic in Africa continued the global attention on viral diseases. On 8th August 2014, the World Health Organization (WHO) declared that the Ebola epidemic was a Public Health Emergency of International Concern (PHEIC). PHEIC is an instrument of the International Health Regulations (IHR) – a legally binding agreement signed by 194 countries. PHEIC is defined as an extraordinary event that constitutes a public health risk to other nations through the international spread of disease, requiring a coordinated international response. More than 28,000 cases of Ebola, around 11,000 died and loss of 2 billion USD was inflicted on three African countries (Guinea, Liberia and Sierra Leone). Apart from Global Chaos, cumulative gross domestic product (GDP) loss in these three countries is estimated to exceed 12%.

However, now, the world wishes to be better prepared through IHR (2005) through enhanced virological diagnostic capacity and mapping all viruses of mammals on this earth. The latter is an ambitious plan which cannot be accomplished without active contribution of the medical microbiologists.

Role of medical microbiologists for diagnosis of viral infections

In every laboratory, a microbiologist can play a role in identifying a new, rare or uncommon pathogen and bring it to the notice of public health authorities. These local actions have global implications. Every pandemic starts from a single case. It is important to establish, expand and continuously update and improve virological diagnostic services in terms of quality and speed. Pure microbiological outcomes need to be shared with users – either in clinical medicine or public health.

Several global initiatives are coming up that aim to strengthen and facilitate virological diagnostic services. Medical microbiologists should stay informed about these, develop proposals to draw strength from them and also actively contribute to global public health. While undertaking diagnostic and research, it is obligatory to ensure that viruses do not escape from laboratory environment.
**BIOSAFETY, BIOSECURITY AND BIOTERRORISM**

Escape of pathogens from laboratories to communities or laboratory-acquired infections (LAIs) are results of weak biosafety principles and practices in laboratories. There have been several instances of escape of pathogens including some from the biosafety level 3 laboratories. These include:

- Smallpox 1978, UK\(^{14}\)
- SARS
  - Taiwan, 2003\(^{15}\)
  - China, 2004\(^{15}\)
  - Singapore, 2003\(^{15}\)
- Anthrax, 2006, 2009 and 2014.\(^{16}\)

Other LAIs have been recorded frequently. The pathogens that cause LAI are usually those that are prevalent locally and transmissible through practices in the laboratories, especially percutaneous injuries, respiratory infections through centrifuges and mouth pipetting. Percutaneous injuries are important because of frequency of their occurrence and severity of diseases caused by them including HIV and hepatitis viruses.

HIV infection associated with exposure to contaminated blood or body fluids probably causes the greatest concern. The risk of HIV transmission after a percutaneous exposure to HIV-infected blood has been estimated to be \(\sim 0.3\%\), and the risk has been estimated to be \(\sim 0.09\%\) after exposure to a mucous membrane.\(^{17}\)

Data on occupational transmission of HIV from the period of 1981–1992 revealed that 25% of these healthcare workers were laboratory workers.\(^{18}\) It is also estimated that more than 1 billion cuts and percutaneous injuries take place in laboratories every year. The odd ratio for a laboratory worker to acquire hepatitis C virus infection is 2.2, and he is at four times higher risk for hepatitis B virus infection as compared to adults in general population. Laboratory programme with a strong infrastructure and good laboratory practices is essential to minimise LAI.

The programme should also assure biosecurity of pathogens and steps to avoid their deliberate or accidental escape from the laboratory to obviate any misuse and harm to human health.

Key elements of laboratory biosafety programme are:

- Management for sustained administrative support
- Engineering for appropriate infrastructure
- Standard operating procedures for safe practices
- Personal protective equipment.

**Role of medical microbiologists for biosafety**

The responsibility for biosecurity and biosafety belongs to everyone who is working in any capacity within the laboratory. There has to be a systematic or programmatic approach, but the leadership must be assumed by medical microbiologists. Practical guidelines are widely available.\(^{19}\)

The biosafety programme should preferably be integrated in a quality management system of the laboratory that must be developed and implemented to minimise all categories of errors, especially diagnostic errors.

**QUALITY MANAGEMENT IN LABORATORY**

Frequency of laboratory diagnostic errors is huge. Singh et al.\(^{20}\) estimated that in samples processed from outdoor patients in the USA, almost 5% had diagnostic errors. Extrapolated to annual load, around 12 million such errors took place. Obviously, situation in laboratories in resource-starved countries shall be far worse, thus necessitating an effective quality management system.

The ISO defines a quality system as the organisational structure, responsibilities, procedures, processes and resources for implementing quality management.\(^{21}\) In any organisation, quality is ensured through a well-defined quality system which influences all the steps of the process of converting input (raw material: clinical or environmental material in laboratories) into an output (product: report in laboratories) through processing.

A quality system has the following key elements:

- Organisational management and structure
- Referential (quality) standards
- Documentation
- Training
- Monitoring and evaluation.

The overall responsibility for the design, implementation, maintenance and improvements in a quality system rests with the laboratory management who must make a commitment through quality policy and allocate resources for implementing quality. It should never be forgotten that quality costs but poor quality costs more. In any establishment, quality cost constitutes 10%–12% of total operational cost.

The quality system is only as good as the staff who actually works with it. No matter how good the quality system is on paper, if the theory cannot be translated into practice, quality cannot be achieved. Staff may need to be trained, and this training must include an understanding of why quality is important. Training should be competency based and must be followed by post-training support to enable staff to maintain high standards. Besides, quality assessment through internal and external audits (man-driven) and participation in internal and external quality assessment schemes (material-driven) should also serve to improve the quality.

**Role of medical microobiologist in assuring quality**

Quality should be made by central to our work. Medical microbiologists should strengthen laboratory quality system through key elements of ISO. It may be prudent to designate one of the staff members as the quality manager to assist top management in development and implementation of efficient quality system.

The quality system must pertain to all areas of our work including AMR.
**Antimicrobial Resistance**

AMR is recognised as the single biggest threat to humanity’s efforts in combating communicable diseases. Every year, AMR kills estimated 700,000 people worldwide. The European Union with a population of 500 million has estimated annual mortality of around 25,000 due to AMR. In the USA, an estimated 23,000 deaths occur every year, whereas Thailand has recently reported 38,000 people dying of consequences of AMR.

The recent UK report on AMR revealed alarming data that without global action to reduce AMR, around 10 million people would die every year from drug-resistant infections by 2050. That is more than currently die from cancer and eight times more people than die from road accidents.

Substantial economic loss to global economy is projected due to AMR. It is estimated that if the AMR issue is not addressed now, the world will produce around USD 8 trillion less a year by 2050, and a cumulative USD 100 trillion would be wiped off the world’s GDP over the next 35 years. The world’s GDP which is currently impacted by 0.4%–1.6% by AMR may go back by as much as 3.5%.

The past 5 years have seen AMR becoming far more important. The health ministers of the WHO South-East Asia, through their Jaipur declaration on AMR, gave a call for concerted action for prevention and control of AMR in the 11 countries of this region. In 2015, the WHO coordinated development of a global action plan against AMR through an extensive process of consultation. This global plan was endorsed by WHA in May 2015 as well as by FAO and OIE during the same year.

Several international political platforms, namely, G7, G20, G7 and world economic forum have also given calls to combat AMR. Para 26 of the declaration for implementation of sustainable development goals clearly articulates a commitment to contain AMR. In an unprecedented step, the united nations general assembly discussed AMR in 2016 and called for concerted global efforts against AMR.

**Role of medical microbiologists in mitigating antimicrobial resistance**

The magnitude of burden of AMR and trends for the impact of interventions can be assessed only through laboratory technologies by medical microbiologists. It is mandatory for medical microbiologists to generate quality data on resistance, study trends of resistance, feed data to users for antibiotic policy or rational use, be part of local, regional, national and international networks and actively contribute to Hospital Infection Control Committee.

**Conclusions**

Medical microbiologists have an important role to play in clinical medicine and practice of public health. They must assume this role with all sincerity and commitment. Time is ripe for them to broaden their vision, spectrum and role in global public health. They must also diversify into the domain of public health and have a better understanding of contributions they can make to IHR (2005). Within their own laboratories, key role needs to be played to strengthen the quality, biosafety and biosecurity. Medical microbiologists must aggressively contribute in combating AMR as they are essential in this national and global initiative.

It is time for them to rise to occasion and prove their utility.

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