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POCT in developing countries

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ARTICLE

Point of Care Technology (POCT) means acquiring clinical parameters from the place where the patient is, thus generating faster test results leading to a faster turnaround time. However, improvements in patient outcomes depend on how healthcare delivery professionals and system utilize faster turnaround times. Thus, POCT, by itself, does not lead to better clinical outcomes. Throughout the last two decades, advances in POCT have been impressive, but its impact on developing countries depends on the present healthcare infrastructure. Presently, in most developing countries, POCT is delivered in remote locations or Physicians chamber or Hospital setup of Emergency rooms, Operation Theaters, ICU. It is applied for therapeutic aid (for treatment of certain diseases like diabetes or myocardial infarction), preventive measures (for targeted screening in high-risk groups) or surveillance measures (monitoring of routine blood parameters). There are several challenges in implementing POCT

like poor patient demographics, lack of workforce, training, lacking healthcare infrastructure, reluctance in physicians to accept new technology and certain technological limits. Although it may take time, solutions to these challenges will lead to a proper implementation of POCT in the developing nations. Further, integrating it with mobile phone technology will lead to higher acceptance and application. The boom of POCT will depend on the overall improvement and capacity building in the healthcare infrastructure of developing nations.

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INTRODUCTION

Point-of-care testing (POCT) is a rapidly growing diagnostic tool that has improved delayed testing challenges in resource-limited settings worldwide, especially in areas with the unavailability of modern laboratory equipment and trained human resources [1]. The objective of POCT is to provide a rapid test result for prompt clinical decisions to improve the patient's health outcomes. It can be used in primary health care (PHC) clinics, outpatient clinics, patient wards, operating theatres, clinical departments, mobile clinics, and even small peripheral laboratories [2]. POC diagnostics are easy to use devices managed by laboratory staff and other health care professionals with basic training [3]. The World Health Organization (WHO) has provided the ASSURED (Affordable, Sensitive, Specific, User-friendly, Rapid and robust, Equipment-free and Deliverable to end-users) guideline, which forms the basis of the development of POC devices globally [4].

The POCT market is projected to reach 38 billion USD by 2022 from 23 billion USD in 2017, with a Compound Annual Growth Rate (CAGR) of 10% during the forecast period [5]. Several factors like the increasing incidence of target diseases, the high prevalence of infectious diseases, especially in developing countries, and increasing preference for healthcare from home across the globe contribute to the significant growth of POCT devices worldwide [6].

TYPES OF POCT TECHNOLOGY

In 1956, Singer and Plotz developed the lateral flow or Lateral Flow Immunoassay (LFIA) technology from the latex agglutination test [7]. This technology over the years has evolved significantly and has proven to be the most straightforward and most successful diagnostic POCT platform. Briefly, this technology uses paper, polymer, nitrocellulose or any other composite substrate membrane with the ability to separate, capture and detect the parameter(s) of interest [8]. Since the LFIA components can transport fluid (blood, serum, urine) via capillary actions, the need for using external pumps is obviated. Various formats can be used to develop an LFIA, depending on the need [9]. The immense growth of LFIA has probably been due to the vital need for preventive measures against communicable diseases, the requirement for the development of practical screening tools to manage an early diagnosis of diseases like cancer and the absence of low-cost devices with minimal mantainence requirements [10].

Although LFIA based techniques have facilitated the rapid and effortless point-of-care diagnosis of several diseases, a significant limitation in their application is due to their over-simplicity, which establishes the requirement of more complex devices capable of providing accurate diagnosis [11]. Significant advancement of microfluidic technologies and its applications have been observed in the field of laboratory diagnosis over the last 25 years [12]. This technology allows the creation of small-sized automated diagnostic devices that may complement the existing lateral flow immunoassay devices and may prove to be ideal POCT tools of the future due to their certain

advantages over LFIA [13]. These advantages include the possibility of using complex multiplexing, having different types of sequential sample pre-conditioning steps, advanced reagent storage, incorporation of simultaneous steps of addition, mixing and washing of reagents, ability to perform centrifugation at various speeds and the option to integrate various detection strategies which may eventually lead to higher sensitivity and clarity. Microfluidics has provided encouraging results in several diagnostic application like routine chemistry, immunological assays, flow cytometry and molecular diagnostics [14].

THE PAST AND PRESENT OF POCT IN DEVELOPING COUNTRIES

In the 1970s, the development of the human pregnancy test was the initial application that drove POCT platform development. Several rapid tests for detecting communicable diseases like Tuberculosis, Hepatitis-B, HIV were developed in dipstick format and were used in developing nations. Later, immunochromatographic strips were also introduced for POC based diagnosis, and the technology has witnessed several evolutions [15]. These rapid tests have become very popular in developing nations with diverse applications, including infectious diseases, cancer, and cardiac diseases.

Several study groups have evaluated the potential of microfluidics as a POCT tool, especially in developing nations' resource-limited environment. A mission named Diagnostics for All's (DFA) was initiated by George Whitesides and his team at Harvard University (2007) to expand diagnostic modalities in developing nations. The group focuses on developing cheap, easy and rapid point of care tests with minimal workforce/training requirements based on patterned paper technology. The group has reported a device for monitoring of drug-induced hepatotoxicity in individuals at risk. The device performance characters showed linear values of liver function indicators with CV <10% [16].

In South Africa, the application of a centrifugal microfluidic technique for POCT was evaluated by Hugo et al. [17]. They reported ways by which several functions employed in testing could be integrated into the centrifugal microfluidic platform for various diagnostic applications. Research groups and industries are also working on the development of a lab-on-a-chip for the diagnosis of malaria. On evaluation by a third party, a sensitivity and specificity of 96.7% and 100% respectively was reported for the prototype device. Jing et al. have reported the use of microfluidics in the diagnosis of Tuberculosis [18]. Several work is ongoing in the development of POC devices for the detection of other infectious diseases. However, most of these devices are unsuitable for developing nations as their development remains in a nascent stage without any clinical trials to validate them.

ISSUES IN POCT IMPLEMENTATION IN DEVELOPING COUNTRIES

The developing countries face several challenges and barriers in setting up appropriate infrastructures for Point of Care Testing facilities [19]. One of the significant challenges is the absence of regulatory standards for introducing POCT methods to various markets. Further, there is a shortage of qualified personnel trained in various POCT methods. In most developing countries, healthcare experts' ratio to the general population is relatively low, indicating an apparent healthcare training discrepancy. Finally, there is also an issue regarding pre-existing infrastructures, which varies across different countries and the arrangement or availability of financial resources to complete the newer diagnostic applications' purchase. It is especially relevant for the countries where the budget allocated for healthcare is considerably less in

proportion to the overall budget, making the share for diagnostics even lower. Due to the paucity of funds towards research and development of newer advanced POCT methods, there is a scarcity of POCT devices and their implementation relative to their urgent requirement in healthcare [19].

FUTURE PERSPECTIVES

It is of utmost importance that regulatory challenges are overcome while implementing new POC tools. Several microfluidic techniques have promising yet unproved potentials to aid in the POCT domain. Thus, although time-consuming in nature, regulatory processes become essential to guarantee the validity, reliability, and effectiveness of POCTs [20]. In places with the unavailability of complex laboratory instruments and personnel, the Clinical Laboratory Improvement Amendments of 1988 (CLIA) has provided the requirements needed to regulate POC devices' use. The CLIA-waiver requirements to be considered while developing and validating a new POCT device with the intent to use in developing nations have been generalized by Chin et al. [21]. The requirements are:

a. The test must be self-contained and automated, permitting the usage of unprocessed specimens
b. The test should not require technical training
c. The test should give easily interpreted results
d. The test must be robust to handle several variabilities in storage conditions, test performing timings and others.

CONCLUSION

Compared to developed nations, developing countries have many healthcare issues, making them more vulnerable to the harmful consequence of infectious and non-communicable diseases. The mortality rates from infectious diseases like Malaria, AIDS, Tuberculosis are typically higher in developing countries owing to the poor healthcare infrastructure. In the past decade, non-communicable diseases have imposed a more considerable public health burden with high morbidity and mortality in developing nations with limited resources. With such a high disease burden and strong demand, POCT devices' availability is quite limited in most developing countries. It leads to an urgent need for the research and development of newer, advanced, reliable and easy-to-implement POCT methods and devices which should also be of low cost and maintenance. Although the success of POCT in developing countries, so far, is primarily due to the contribution of lateral flow assay strips, the emerging role of microfluidics, nanotechnology and device fabrication may open up new vistas and lead to the establishment of an ideal diagnostic POCT tool of the future. Availability and implementation of such technology may quickly diminish the disease impact in these resource-limited regions and reduce the overall public health burden, especially in laboratory-free settings.

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