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Chapter

mHealth-Based Microfluidic Lab-on-a-Chip for International Health Security

Mirza Abdul Aleem Baig

Abstract

The increasing threats of emerging and reemerging infectious disease outbreaks demand research and development (R&D) of effective and fit-for-all-purpose tools and technologies for international public health security. Recent advances in biomedical engineering, mostly related to the convergence of communication and network technology in health, i.e., mobile health with microfluidic Lab-on-a-Chip technology can improve the international public health crises and employ in international public health security. Lab-on-a-Chip technology is now commonly found in most research centers, hospitals, and clinics where health care infrastructure is weak, and access to quality and timely medical care is challenging. Microfluidic devices—also known as Lab-on-a-Chip (LoC)—are an alternative for accessible, cost-effective, and early detection medical trials. The mHealth-based microfluidic LoC technology has been under rapid development, and they are becoming influential tools in a wide range of biomedical research and international public health applications. The perspective in this chapter demonstrates a potentially transformative opportunity for the deployment of mHealth with LoC with the fabrication protocols and their potential for strengthening and improving the international public health security. This attempt is not conclusive and exhaustive, and it is anticipated that such a discussion will enable the exchange of ideas between biomedical engineering, microfluidic LoC technology professionals, international public health, and health security experts.

Keywords: biomedical engineering, mobile health (mHealth), microfluidic, Lab-on-a-Chip, international public health security

1. Introduction

Emerging and reemerging infectious diseases, and their pandemic potential, pose a challenge to international public health security in the twenty-first century that cannot be overlooked [1]. Though the historical threat to international security by epidemic diseases is not new, the threat has increased in recent years and is growing rapidly. Infectious disease emergencies can arise with little notice and have serious detrimental and lasting effects on international public health security [2]. In the past century, we have seen international health emergencies such as the 1981 influenza pandemic that killed approximately 50–100 million people [3], the

emergence of the deadly SARS coronavirus, and the 2013–2016 Ebola epidemic in West Africa [4] that resulted in more than 28,000 cases and 11,000 deaths and had devastating impacts on international health security, as just a few exemplar. Correspondingly, before 1970, only nine countries had experienced severe dengue epidemics; however, at present, dengue fever has affected more than 100 countries in tropical and subtropical regions [5]. It was estimated by the World Health Organization (WHO) that approximately 150 million dengue infections occur annually, with a 30-fold increase in global incidence observed over the past 50 years [6]. Reemergence of mosquito-borne infections such as chikungunya, zika, more virulent forms of malaria, and new more severe forms of viral respiratory infections has also evolved in recent years. Historically, literature on health and security has been scarce, and only in the past few years, a body of literature on health and security emerged. At the nexus of health and security lies many poignant examples of the growing threat of biological weapons, the negative impact of naturally occurring infectious diseases, and the migration and proliferation of emerging and reemerging infectious diseases to nonendemic areas that fabricate a strong case for including health concerns in the international public health security debate. Though international public health and health security traditionally occupied separate domains, in recent years, the imperative fusion between them has been recognized by policymakers and security and defense analysts in both developed and developing countries [7].

1.1 International public health security

International public health security is pretty new topic, and it has recently taken on a new urgency for policymakers and health security and defense analysts. The field of international public health security is an important one, closely related to people's lives, and essential for societies and countries to grow and develop. Traditionally, environmental health emergencies, humanitarian emergencies including natural and human-made disasters, conflicts and complex emergencies, civil strife, or human health rights violations constitute what has been considered the main threat to health security [8, 9]. Correspondingly, pandemics and epidemics also killed countless millions throughout human history. The 1918 flu pandemic killed 50–100 million, which is more than the combined total casualties of World War I and II [10]. In our time, highly virulent infectious diseases have not only repeatedly swept through human societies, causing death, economic chaos, and political and social disorders, but also placed sudden and intense demands on international public health security. In many countries, millions of people are suffering from avoidable health problems. Improvements to health and medical services are therefore emerging as a major priority in many countries, where many people continue to suffer due to common diseases such as HIV/AIDS, diabetes, and cancer, including tropical diseases, such as malaria, dengue fever, respiratory diseases, etc. [11]. Today, such diseases remain a serious international public health threat. According to the world health report released by the World Health Organization (WHO), noncommunicable diseases (NCDs) are responsible for approximately 71% of global deaths, with the leading causes being lower respiratory infections, HIV/AIDS, diarrheal diseases, and tuberculosis (TB) [12]. **Table 1** illustrates the top 10 leading causes of death in three categories, i.e., worldwide, low-income countries, and high-income countries. Many diseases need immediate attention and require new health technologies for their prevention and on-time diagnosis. One such promising solution can now be thought of because of the recent advances in the mobile health (mHealth) and Lab-on-a-Chip (LoC) technologies. On-going

Rank	Worldwide	Low-income countries	High-income countries
1	Heart disease	Lower respiratory infections	Heart disease
2	Stroke	Diarrheal diseases	Stroke
3	Chronic obstructive pulmonary disease	Heart disease	Alzheimer's disease
4	Lower respiratory infections	HIV/AIDS	Lung cancers
5	Alzheimer's disease	Stroke	Chronic obstructive pulmonary disease
6	Lung cancers	Malaria	Lower respiratory infections
7	Diabetes	Tuberculosis	Colon caners
8	Road injury	Preterm birth complications	Diabetes
9	Diarrheal diseases	Birth asphyxia and trauma	Kidney diseases
10	Tuberculosis	Road injury	Breast caner

Table 1.
The top 10 leading causes of death [12].

research in these technological fields leads to the rapid emergence of such devices that can prove to be very useful for improving the international public health and employed in health security.

1.2 Mobile health (mHealth)

mHealth is defined as the use of mobile communication and network technologies, i.e., smartphones, tablet PCs, and PDAs, for health service [13]. In broad, it is the employ of handy gadgets that are having ability of improving health and quality of care. mHealth is an evolving and swiftly rising field that holds the potential to play an imperative part in the transformation of healthcare and increase the quality of care. mHealth cover a range of hi-tech solutions, such as measure of vital signs, i.e., heart beating rate, blood sugar level, blood pressure, temperature of body, activities of brain, etc. [14]. The widespread use of mobile devices has offered a novel approach to address many health-related challenges. The mobile devices and mobile networks can be present in resource-limited regions where medical equipments are either unavailable or insufficiently portable for wide deployment. According to the data released by International Telecommunication Union (ITU), 96.8% of the people worldwide are mobile-cellular telephone subscribers, and 62.9% of them are active mobile-broadband users [15, 16]. The statistic in **Figure 1** shows the total number of mobile phone users worldwide from 2015 to 2020. In 2019, the number of mobile phone users was forecast to reach 4.68 billion [17]. The penetration of mobile devices in many regions has surpassed many other infrastructures, i.e., electricity, paved roads, and advanced healthcare resources. Such increasing accessibility of mobile devices can provide opportunities to transform the international public health and health security.

Smartphones have been increasingly adapted in various healthcare applications in recent years [18], and according to applications, the use of mHealth-based healthcare practice can be divided into two categories, as demonstrated in **Table 2** in vivo test and in vitro test. Similarly, out-of-clinic smartphone use covers most of the software applications and the corresponding devices, external wearable sensors, for the daily monitoring of the health and wellness. On the other hand,

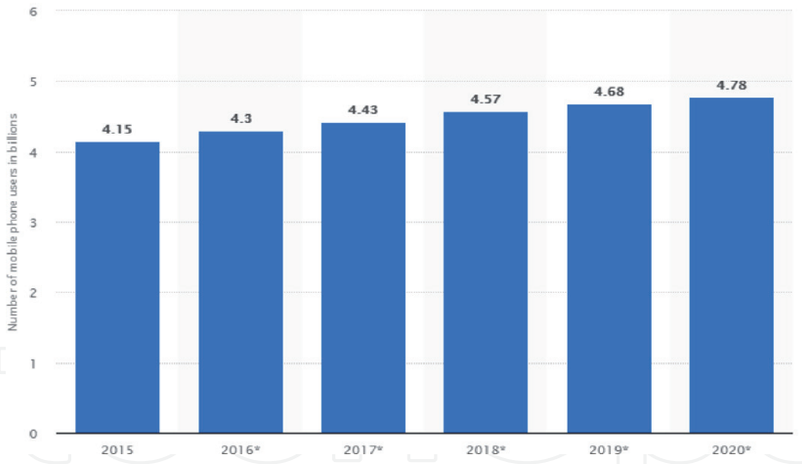

Figure 1.
The number of mobile phone users worldwide from 2015 to 2020 [17].

Category	Explanation	Examples	
In vivo test	Test that does not require sample consumption; biological signals are converted to electrical signals by various sensors.	Test with built-in sensor	Use the built-in sensors, such as camera, to collect human body or environmental signals
		Test with extra sensor	Use extra sensors, such as an ultrasound probe, to collect human body or environmental signals
In vitro test	Test that requires sample consumption; biological components or organisms are detected from samples, such as blood, sweat, etc.	Tube strip and specimen inspection	Take a specimen of bodily fluid and directly inspect the result using the built-in camera or microscope connected to a smartphone
		Microfluidic testing	Take a specimen of bodily fluid and use microfluidic technique to perform complicated biochemical tests and visualize the result using a smartphone

Table 2.
Categories of smartphone-based test [14].

the in-clinic applications of smartphones involve the diagnostics of specific types of diseases and are supposed to help make clinical decisions [19, 20]. For example, a single-channel electrocardiograph (ECG) can be integrated at the back case of an iPhone and a plug-and-play blood pressure monitor can wirelessly link to a smartphone. Smartphones, equipped with a computer-like platform and various types of sensors, have several properties promoting their uses in in vivo and in vitro test [14]. This confirms that mobile and network technologies are becoming widely accessible even in resource-limited areas lacking adequate healthcare facilities.

1.3 Microfluidic Lab-on-a-Chip technology

The idea of a technology for a device unifying data acquisition and measurement together with sensing and analysis and a response to analysis result was brought into practice for the first time in 1979. By the late 80s and early 90s, Lab-on-a-Chip technology experienced a fast development of total analysis microsystems (uTAS)

[21–24]. These systems were formerly designed for improving chemical separation techniques, particularly capillary electrophoresis, and were later applied in experiments with biological materials [25], DNA and RNA, cells and bacteria, proteins, etc., motivated by the potential market for biomedical research [26]. Microfluidic-based biosensors, primarily dedicated to the detection of biomolecules such as proteins, enzymes, peptides, and DNA, are proposed in the biomedical field as tools to monitor cell behavior on a miniaturized scale, with high sensitivity and resolution and low costs [27]. By detecting cellular analytes, electrical activities, and chemical and physical signals transmitted by the cells, microfluidic-based biosensors provided insights into cellular activities and responses in real time [28]. As a result, microfluidic-based biosensors—also known as Lab-on-a-Chip (LoC) devices—became more and more popular.

LoC devices are promoted for biomedical, biotechnology, chemical, and environmental monitoring applications as a response to the necessity of time effective, low cost, automated laboratory tests by integrating one or more functions in one miniaturized device, such as sample transport, reagent mixing, heating, evaluation, analysis, and synthesis [29–32]. LoC technology integrates microfluidic and electronic components onto the same chip for the development of hybrid devices to reduce laboratory processes in a manner competitive to bench-top instruments [22]. LoC technology emphasizes integration, chip programmability, increased sensitivity, minimal reagent consumption, sterilization, and efficient sample detection and separation. A typical LoC device contains microchannels, which not only allow liquid samples to flow inside the chip, but also integrates measuring, sensing, and actuating components such as microvalves, micromixers, microelectrodes, thermal elements, and optical apparatuses [23]. Microfluidic-based LoC devices have also become very attractive nowadays as they force the development of personalized devices for point-of-care treatments, and enable the fabrication of the next generation of portable and implantable bioelectronic devices [24]. Due to their biosensing capability and embedding concept, the microfluidic-based LoC systems are attractive platforms for developing implantable bioinspired sensors that can be integrated with communication and network technology [33].

2. Methodology: technology identification process

Because international public health security is a relatively new topic of interest and inquiry, one would not expect to find a well-established body of literature surrounding this theme. However, to identify potentially relevant technology solutions for international public health security, I conducted a horizon scan to understand the mHealth-based microfluidic Lab-on-a-Chip technology that could benefit international public health security. In order to identify potential transformative technology, I reviewed non-peer-reviewed gray literature, technology reviews, and peer-reviewed scientific literature for recent development in the LoC technology and fabrication protocols. Searches were conducted through PubMed, Google, Google Scholar, and Web of Science databases.

3. Fabrication protocols and chip materials

There are many fabrication protocols and materials for prototyping LoCs. A design framework can be used with these fabrication materials and methods in recourse-limited settings, discussed in the following section.

3.1 Photolithography

Photolithography is one of the earliest and still one of the most popular methods for fabricating LoCs. The photolithography and etching method for fabricating mask and LoCs relies on the traditional photo developing method. The process involves using negative or positive photoresists. Photoresists are exposed to high intensity UV-wavelengths through masks and spin coated. In photolithography, there are mask and mask-less methods. Mask-less photolithography can be achieved by methods whereby light is spatially modulated and light patterns can be manipulated at every pixel. In photolithography, before etching with chemicals, a UV resist can be used to spin coat chemicals and focused UV light can be beamed onto the photoresist [34].

3.2 Softlithography

In softlithography, the reverse master is designed and fabricated in such a way as to have protruding patterns on its surface. It can be the positive or negative image of a target LoC. Silicon, PMMA, or a chemical-coated PDMS can be made to bear the master image. One of the benefits of softlithography is that it can be used to fabricate LoCs with three-dimensional microfluidics channels and also to form microstructures, including channels, and submacrostructures, including cell-culture chambers [29, 30, 35]. Softlithography technique is convenient, straightforward to apply, accessible to a wide range of users, and low-cost nonphotolithographic-based approach for micro and nanofabrication. Some softlithography techniques are: microcontact printing (μCP), microtransfer molding (μTM), replica molding (REM), micromolding in capillaries (MIMIC), and solvent-assisted micromolding (SAMIM). **Table 3** compares the advantages and disadvantages of conventional photolithography and softlithography [29].

3.3 Microembossing

Microembossing, also known as microtransfer molding or hot-embossing, is the process by which the configuration of microfluidic channels is transferred onto

	Photolithography	**Softlithography**
Definition of patterns	Rigid photomask	Elastomeric stamp or mold
Materials that can be patterned directly	Photoresists	Photoresists
	SAMs on Au and SiO_2	SAMs on Au, Ag, Cu, GaAs, Al, Pd, and SiO_2 Precursor polymers Polymer beads Sol-gel materials Conducting polymers Colloidal materials Organic and inorganic salts Biological macromolecules
Surfaces and structures that can be patterned	Planar surface Two-dimensional structures	Both planar and nonplanar Both two-dimensional and three-dimensional structures
Resolution	100 nm	From 30 nm to 1 μm

Table 3.
Comparison between photolithography and softlithography [21–24, 29, 30, 33–35].

the thermoplastic material. The polymer material is pressed with a heated barrel so that the material becomes soft and molted. By applying pressure and heat onto the polymer sheet, the shape is then transferred from metal press to the sheet. To transfer microscale patterns inexpensively, the hot-embossing method can be used. Such a method is affordable, assessable, and available even to resource-constrained laboratories for the production of disposable LoCs [31].

3.4 Injection molding

In injection molding fabrication protocol, the injection of molten thermoplastic involves under high pressure into a heated closed master mold, followed by cooling until the thermoplastic solidifies, and subsequent demolding the replica from the master mold. For industrial scale manufacturing of macroscopic objects in thermoplastics that has been adopted for micromanufacturing, injection molding is a well-established technique [32].

3.5 PDMS Lab-on-a-Chip

PDMS (polydimethylsiloxane) is a straightforward, adaptable, and low-cost polymer that can be used to fabricate LoC by the softlithography. Research laboratories commonly use PDMS for LoC prototyping, which is one of the least resource demanding fabricating methods. PDMS is also broadly utilized on the grounds that it is simple and shabby to create PDMS LoCs [36]. Moreover, LoC made of PDMS takes preferred standpoint of the simple mix of shudder miniaturized scale valves for quick stream switch and penetrability of air for cell-and-tissue-culture-LoCs [37]. Commonly utilized for LoCs prototyping, PDMS demonstrates extreme impediments for modern generation. The properties of PDMS are surprisingly close to that could be obtained from glass and plastic. The cross-linking of many of these polymer chains makes a structure that is flexible and reversibly deformable. **Table 4** summarizes the physical properties of PDMS, and **Table 5** compares polymer and glass as substrate for chemical and biomedical applications [36]. Many of properties demonstrate that the PDMS is very desirable for fabricating microfluidic LoCs.

3.6 Thermoplastic-polymers Lab-on-a-Chip

Irrespective of the opportunity that it is a little bit more uncertain and expensive to actualize than PDMS, thermoplastics are great contender for the manufacture of LoCs. Thermoplastic polymers are generally utilized by specialists to manufacture LoCs. Polymethyl methacrylate (PMMA), given its transparency, can be used as the positive tone photoresist in X-ray lithography and e-beam lithography processes [38]. Cyclic-olefin Copolymer (CoC) polymer is a popular fabrication material for various applications, including lenses and medical devices. CoC can also be used for the 3D printing of microfluidic LoC devices. PolyCarbonate (PC), which is more inert to chemical solvent than PDMS therefore, can be useful for some LoC applications where PDMS are not suitable for the required LoC applications. However, fabricating LoCs using PC requires investment intensive high-pressure embossing micromachining tools. Poly vinyl alcohol (PVA) is used for fabricating sophisticated LoCs with three-dimensional polymer microstructures. PVA can be dissolved in water but not in solvents, so they can be used as sacrificial materials. One more type of polymer not directly used for fabricating LoCs but still useful for biomedical application is Parylene. Parylene allows the transmission of waves in the visible spectrum, and it is not porous and can be coated onto electronics to prevent it from

Property	Characteristic	Consequence
Optical	Transparent UV cut-off = 240 nm	Optical detection from 240 to 1100 nm
Electrical	Insulating Breakdown voltage = 2 × 107 v/m	Allows embedded electrical circuits Electrophoresis possible on contained fluid
Mechanical	Elastomeric Young's modulus typically 750 kPa	Conforms to surfaces Facilitates release from molds
Thermal	Insulator Thermal conductivity 0.2 W/(m K) Thermal expansion coeff. 310 μm/(m°C) Can withstand 200°C	Does not allow the dissipation of optical absorption heating or electrophoretic resistive heating Can be autoclaved for sterilization
Permeability	Impermeable to liquid water Permeable to gases and nonpolar solvents	Contain aqueous solutions in channels; allow gas transport through material bulk Incompatible with many organic solvent
Reactivity	Inert Oxidized by plasma exposure	Unreactive toward most reagents, including ethanol Surface can be etched Can be modified to be hydrophilic and also reactive toward silanes Can be permanently bonded
Toxicity	Nontoxic	Can be implanted in vivo Supports mammalian cell cultures

Table 4.
Physical properties of PDMS [36].

	Polymers	Glass
Manufacturing costs	Lower costs than glass, especially in mass volume	More expensive to manufacture as fabrication process is more complex
Fabrication complexity	Simple fabrication process	Time-consuming and expensive, and usually wet chemistry is used
Clean room facilities	Cleanroom environment is necessary	Cleanroom facilities are required
Operation temperature	Narrow range due to the low glass transition temperature	Wider range of operation temperature than polymer
Optical properties and fluorescence detection	Higher autofluorescence in the UV end of the spectrum and lower transparency than glass	Superior optical property than glass
Compatibility with organic solvents or strong acids	Generally not compatible with most organic solvents	Excellent resistance to solvents and acids
Permeability to gases	Higher gas permeability relative to glass	Does not met the gas permeability requirements for some biological applications
Geometrical flexibility	More flexibility for geometrical designs with a wide selection of different cross-sections; high aspect ratio and arbitrary wall angle	Limited to two-dimensional design due to isotropic nature of etching process. Less flexibility in cross-sections than polymer

Table 5.
Comparison between polymer and glass as the substrate of microfluidic LoC systems for biomedical and chemical applications [36].

corroding and avoiding electrical short circuiting [34]. For specific applications, some exploration groups acquired great outcomes with thermoplastic-polymers LoCs, and since it is feasible to integrate microelectrodes into these polymers, thermoplastic polymers are having evident opportunity for the industrial development of some LoCs [39].

3.7 Silicon and glass Lab-on-a-Chip

The earliest LoCs were fabricated in silicon, and it appears like a significant characteristic decision since smaller scale innovations depend on the micromachining of silicon [35]. These days' scientists do not frequently utilize silicon for LoC, for the most part since silicon is costly, not optically nontransparent, and requires a spotless room. Moreover, the electrical conductivity of silicon makes it difficult to use for LoC operations. Still, silicon is relevant choice for the industrialization of some LoC applications. Analogous to silicon, glass is also the earliest fabrication material for LoCs. Glass is a hard material to fabricate chip but a useful material due to its inertness and transmutability of wavelengths in UV, IR, and visible regions [40]. However, fabricating LoCs in glass requires hazardous chemicals and lengthy time intervals, expensive facilities. From an exploration perspective, the creation of glass LoCs requires clean rooms and specialists with solid information of microfabrication techniques.

4. Advantages of microfluidic Lab-on-a-Chip technology

Globally, every country confronts parallel challenges in keeping its inhabitants healthy and preventing the cross-border spread of infectious diseases. Biomedical engineers, synthetic chemists, and biologists along with public health professionals are evaluating the potentiality of microfluidic LoC technology in the context of international public health security. In recent years, certain applications have emerged, from the detection of infectious diseases to diagnostics for international public health [41]. Several on-chip clinical assessments have also appeared include cell analysis, cytometry, blood analysis, nucleic acids amplification, genetic mapping, enzymatic assays, peptide analysis, protein separation, toxicity analysis, and bioassays [42]. In the area of drug research, the LoC devices have gradually became significant with the prominence on cell targeting, clinical trials, drug synthesis, pharmaceutical formulations, and product management process [43]. The LoC devices are found promising in the analysis of drugs and determination of optimal dosages. This is especially useful for testing the synergistic effect of combined drugs [44]. In recent past, microfluidic LoCs presented an exclusive prospect to replicate natural veins for testing nanoparticles as drug carriers for targeting cells or, moreover, presented opportunities for investigate in vitro metabolism of biological cultures [45].

Compactness, portability, modularity, embedded computing, automated sample handling, low electronic noise, limited power consumption, and straightforward integration of various components are some notable technical advantages of LoC devices [46]. Furthermore, LoC devices are capable of supporting a wide range of processes such as sampling, routing, transport, dispensing, and mixing, mostly with reduced moving or spinning mechanisms [47]. Due to their small size, the LoC devices offer precise fluidic transportation via the use of electrokinetics or micropumping, efficient separation of the liquid samples, and precision in the measurement of samples [48]. Likewise, the LoC devices can reduce the time of synthesis of a product and the time of analysis of a sample because of the small fluidic volumes

that they handle. LoC devices can also measure samples with greater precision, with their capability of controlling the chemical reactions through efficient control of the reactants concentration [49].

In the same way, the field of clinical medicine deeply benefited from microfluidic LoC technology as it suites for disease modeling and drug screening [50], tests for observing pandemics [51], glucose monitoring, diabetic control, diagnosis of diseases, and numerous other tests [22, 52]. LoC devices enhance numerous biomedical tests that entail mixing, analysis, and separation of samples, which usually consist of cell suspensions, nucleic acids, and proteins; analytical, electrical, or optical detection methods are also possible [53]. Key manufacturing advantages that make microfluidic LoC technology reasonable are: achievable mass production, affordable replacement cost, short time manufacture, simple quality tests, and broad range of supporting computer-aided design and simulation software tools [54]. However, the technical limitations such as size reduction, sample input rates, power consumption, chip reliability, and biocompatibility all still require further investigations in the design of microfluidic LoC technology [55].

5. Research potential of mHealth-based microfluidic Lab-on-a-Chip technology for international public health security

In era of international public health catastrophe, academia, industry, the R&D community, and governments must be stimulated as an interconnected group to promptly determine the obligatory biomedical engineering and international public health interventions. Achieving significant acceleration in R&D related to international public health security requires significant amount of new directions because it is critical to use the best technology, investigation, and development to strengthen international public health defense. However, the simplicity and system integration provided by microfluidic LoC technology for the implementation of multiple tasks, such as sample preparation, separation, amplification, and detection, have largely extended their use in biomedical and international public health applications [56, 57]. Examples of their uses are immunoassays with plasma generation for electrochemical detection, infectious disease diagnostics based on platforms that integrate sample preparation, PCR, integrated valves for DNA-based diagnosis, quantification, and biochemical analysis for the evaluation and quality control of DNA, RNA, proteins, and cells together with fluorescence or similar visualization methods [58, 59].

Microfluidic LoC technology is an excellent choice for integrating mHealth-based point-of-care devices in resource-limited settings, offering portable medical analysis without the need of costly and sophisticated equipment, and the fast obtention of results without involving an extensive knowledge of the diagnosis principle involved [60–64]. Several studies have proven the effectiveness of LoC devices as portable point-of-care diagnosis tools in the detection of infected microorganisms, biological analytes, and blood analysis [61, 62]. Microfluidic LoC systems can also be used for controlled, personalized drug delivery according to patient's response, extent of disease, and current conditions [63]. Besides, key advantages that mHealth-based microfluidic LoCs can offer for international public health are facilitating early-stage accurate diagnosis, maintaining better communication and monitoring of patients, enabling better tracking of disease outbreaks, and improving the epidemiological surveillance of diseases, which are predominantly challenging problems for international public health security.

6. Conclusion

It is widely discussed that microfluidic LoC technology has great potential to revolutionize the international public health field and possess the capability to give a boost to international public health security. There is a pressing need for new health technologies for diagnosing and treating avoidable international public health problems. mHealth-based microfluidic LoC technology still seem to be a dream especially in resource-limited settings. One of the biggest challenges in the field of mHealth-based microfluidic LoC is the translation from academic research to end-user products. While the field of microfluidic LoC technology has seen an exponential development in recent past, the launch of a commercialized platform that would revolutionize the concept of mHealth-based microfluidic LoC technology is still lacking. A bottleneck that hinders the adoption of microfluidic LoCs in international public health and mHealth applications remains due to the facility and skill requirement and knowledge gap. Despite barriers and challenging issues, many great opportunities are still waiting ahead. There are no "one size fits all" solutions for modeling complex international public health security problems "on a chip." Tackling the international public health security challenges in a way that yields meaningful advances will therefore require bringing together groups with diverse expertise in biomedical engineering, synthetic biologist and chemist, microfluidic LoC technology professionals, international public health, and health security experts.

Conflict of interest

The author declares that there is neither conflict nor financial interest. No writing assistance was utilized in the production of this manuscript.

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