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SMARTPHONE: A POWERFUL MICROSCOPIC DEVICE TURNED MALARIA DETECTOR

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ABSTRACT

Accurate and rapid diagnosis is crucial in combating parasitic diseases that causes millions of deaths worldwide. Even thought one could detect malaria through a Smartphone? Dr.SAI SIVA GORTHI, from the department of instrument and applied physics. they converted a Smartphone into a powerful microscopic device that eliminates the various stages of blood testing to detect malaria .They replaced the phone camera with high resolution optics of a microscope .The Smartphone also has software that studies the image captured through the microscope and tells even a layman whether it has the malaria virus or not . it requires a tiny amount of blood as a sample. Scientist in Britain have now developed a Smartphone attachment called XRAPID ,that turns the phone into a 200 –power microscope ,while the attached app –BASED ON FACIAL RECOGINITION SOFTWARE –quickly detects the parasitic protozoa in the blood smear .It is a handheld device that detected in 30 mins.

INTRODUCTION:

Malaria is a life threating diseases caused by parasites that most often infect a subject via transmission from a female mosquite bite {anopleles]. Following infection ,the parasite begins invading the host's red blood and liver cells ,modifying the biochemistry and structural properties of cells .

SMARTPHONES BECOMING TOOLS FOR DIAGNOSING MALARIA:

Mobile phones and smartpnone have brought enormous convenience and sizable impact to modern society ,as depicted by a wide range of smartphone are a more advanced form of mobile phones,with fully functional computing capabilities and user friendly featuressuch as personal information management application ,compact digital cameras, global positioning system [GPS] navigation ,Due to these powerful built in sensors, smartphone are setting their roots into the medical field as an alternative to diagnostics purposes According to the world Health Organization ,almost 600,00 people died of malaria in 2013-2019 ,making this mosquites borne disease one of the deadliest in the world .the saddest aspects mostly young children .

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Scientists in Britan have now developed a smart phone attachment called XRAPID, that turns the phone into 200 –power microscope ,while the attached app based on facial recognition software –quickly detect the parasitic protozoa in the blood smear . This app was developed by Jean Viry Babel is the CEO of IANXEN company diagonis can be done by separate the red blood cells from the rest –the white blood cells ,the platelets –and start looking each of the red blood cells, individually.It provides reliability of up to 98 % .The only additional equipment required is an ordinary glass lab slide – called a 'slate'. There's only one button ,which is called 'Diagnose 'put it on the slate and put it on the dried blood ,and press diagnose and it tells yes or no .

'SMART DIAGNOSIS' OF PARASITIC DISEASES BY USE OF SMARTPHONE:

The conventional diagnosis involves collecting blood samples, subjecting them to clinical microscopy in a lab by experts with the results being available in a day or two. Such tests require lab equipment and experts, and consume much time. Other detection methods like Rapid Diagnostic Tests (RTDs) give fast but only qualitative results. The device developed at IISc on the other hand gives both qualitative and quantitative results by automating the process of clinical microscopy, all within a device that can be held in one's hand. Whats more, it does not require any skilled manpower to conduct the tests. The tests can be conducted by a layman. A very small sample of blood - less than a drop - is used in the device that will test each cell in the blood. While a visual of the qualitative test is immediately available, the quantitative parasitaemia levels are processed in about 30 minutes. The process Explaining how the device works Dr Gorthi said: "The handheld instrument has a common optical reader...a replaceable microfluidic cartridge, Each time a new test is to be performed, these cartridges are pre-loaded with the required set of reagents to perform automated on-chip processing of the blood sample. Consequently, the affected blood cells display morphological features that are different from normal cells. So, just by looking at the cell images on the LCD display of the device, one can tell whether the cell is infected or not. The algorithms we have developed run on a smart phone-like platform and do this evaluation automatically," he explained. With modification to the device, it can be used as a "generic platform" that can give a diagnosis of other diseases that use clinical microscopy as a basis of detection, added Dr Gorthi. Incubated at the Robert Bosch Centre for Cyber Physical Systems (RBCCPS) at IISc, the device got the 'Best Innovator's Pitch' award recently, given by the Biotechnology Industry Research Assistance Council (BIRAC) under the Government of India. Dr Sai Siva Gorthi, said that the device might be in the market in three years. According to World Malaria Report, 2013 of the World Health Organisation, the estimated need for diagnostic tests for suspected cases of malaria is more than one billion every year.

RECENT TECNOLOGY INVOLVED IN INDIA THAT DETECTS MALARIA IN 30 MINUTES:

1. Standalone smartphone technology.

Owing to high-magnification lenses and powerful image processors, a standalone smartphone (i.e., without use of any external enhancement such as a lens or a microscope) presents a useful tool for the diagnosis of parasitic diseases. For example, Meena and Bhatia used a smartphone for the first time to diagnose a cestode parasite in tomographic images and they used the smartphone to examine images of a small cysticercus (a larval stage of a cestode) that was otherwise invisible to the clinicians on visual examination Smartphone applications (apps) and algorithms present another use of smartphones as a standalone tool in the diagnosis of parasitic diseases, such as the interpretation of the rapid diagnostic test (RDT) results for malaria Although RDTs present an inexpensive point-of-care (POC) tool, their effective application in the diagnosis of malarial parasites could be impeded by an incorrect analysis of the results by a poorly trained end user). To avoid visual interpretation, a smartphone was used to image and transfer the results of the RDTs of malaria to a globally accessible Research Electronic Data Capture (REDCap) database for analysis using a specialized algorithm. Despite its slightly lower sensitivity, this method significantly reduced reporting errors and false-negative diagnoses compared to a method of visual interpretation In another study, the control line on an RDT for malaria was converted into a smartphone-readable quick response (QR) code A smartphone was deployed to capture RDT images and an associated app was used to perform image processing and recognition of QR codes to determine the concentration of histidine-rich protein 2 (a *Plasmodium falciparum*-specific protein). The detection limit of the assay was 0.966 nM (~543 parasites per µl) compared to that of the World Health Organization (WHO) benchmark testing for an RDT (500 parasites per µl) for low parasitemia, suggesting that this method needs modification to increase its sensitivity. Overall, these smartphone-based diagnostic techniques allow automated identification, secured record keeping, and quality assurance that could be highly useful in malaria surveillance programs.

Although thousands of smartphone apps are currently being used in the health care industry, there is limited information available on apps for the diagnosis of parasites. (NC State University) is an example of one such a freely downloadable app for smartphonesThis app provides basic information on identification (pictures of male, female, and juvenile ticks) and management (disease biology, personal protection, tick removal, etc.) of selected ticks and tick-borne diseases for a common user. Similar smartphone apps could be developed regionally as well as globally for socioeconomically important parasites and could present great assistance for the diagnosis and management of parasitic diseases.

Lens-mounted smartphone “microscopy”.Mounting a simple, portable lens on a smartphone camera can provide a powerful handheld microscope for the identification of parasites. The lens size determines the spatial resolution and field of view (FOV), as smaller lenses have a smaller FOV but greater spatial resolution and vice versa Bogoch et al. constructed a handheld microscope by mounting a 3-mm ball lens to a smartphone camera, and used it for the identification of soil-transmitted helminths (STH) and *Schistosoma* eggs in urine and stool samples of school-aged children). Although this device showed low to moderate sensitivities and specificities and had a small FOV that produced inferior quality images this is an inexpensive and portable microscope. With improved sensitivity, this could be invaluable in the field diagnosis of STH infection in developing countries.

In order to increase the resolution of lens-mounted smartphone microscopy, Switz et al. applied a reversed camera lens to a smartphone to produce a large FOV (~10 mm^2) with a resolution of ≤5 µm for better quality images of STH eggs in stool samples A major issue in imaging parasitic eggs is their scattering at different focal depths in a three dimensional (3D) plane. Sowerby et al. addressed this issue by mounting a 12-mm double convex objective lens on a smartphone camera to image *Ascaris lumbricoides* eggs and create composite images using a software program, Overall, external lens-mounted smartphone microscopes are portable, inexpensive, and operate without constant electricity needs, which make them a field-deployable tool in parasitic diagnosis in resource-constrained regions of the world.

2. Smartphone-assisted microfluidic technology.

Due to their high throughput, easy handling, parallelism, and sensitivity, the use of microfluidic lab-on-a-chip devices (LOCDs) has greatly increased in medical diagnostics Smartphones offer tremendous potential for *in vitro*measurements of biochemical reactions in LOCDs. For instance, Stemple et al. recently introduced a handheld smartphone-assisted LOCD for the detection of a *P. falciparum*-specific protein, HRP-2 Anti-HRP-2-conjugated submicrobeads were mixed with 10% whole blood sample in a microfluidic LOCD. A smartphone was deployed for illumination of the sample followed by the detection of the scattered light. Using scattering/absorption characteristics of the sample, the system was able to measure as low as 1 pg/ml of HRP-2 from blood in 10 min

In another study, Liu et al. described an integrated microfluidic chip with a smartphone recorder for the identification of *Anopheles* sppThe microfluidic device allowed DNA extraction followed by target DNA amplification using loop-mediated isothermal amplification (LAMP). The amplified products were excited with a DNA-intercalating dye and the fluorescence signal was detected with a smartphone camera. This multiplex system could be used for parallel identification of several mosquito species. Such a sophisticated smartphone-based LOCD could be highly useful not only in the onsite diagnosis of parasites but also in the quick recording of test results and geographic location for quality control.

Most smartphone-based diagnostic devices have been tested in well-controlled laboratory conditions and only for tropical parasitic diseases. Further studies are required to explore the usefulness of such devices for the diagnosis of other important parasitic diseases in field conditions and on clinical specimens. Despite the portability of smartphone-based diagnostic tools, issues such as need for manual processing of samples and preparation of microscopic slides remain to be addressed. Limited battery capacity of smartphones is a major bottleneck for their field deployability in remote health care facilities, which can be solved by applying mobile charging devices with a car battery or solar power Internet prices can be high in low-income regions, which may hinder transfer of the diagnostic data to a reference laboratory. Lack of awareness and a tangible commercial market are the other major challenges for smartphone-based diagnostic devices, which could be addressed through integrated training and practical business plans. Sustained research and strong collaboration among researchers, clinicians, and the public sector are required in this context. Currently, there are no set standards and regulatory approval methods in place for commercialization of smartphone-based diagnostic devices, which warrants the urgent need for developing standard guidelines by professional associations/societies such as the World Federation of Parasitology, the World Association for the Advancement of Veterinary Parasitology, and the American Society for Microbiology. Moreover, these technologies require rigorous quality control and adequate field validation before deploying them in clinics. A consortium of experts could be of great help for quality assurance and enhanced usability of such technologies. Despite all these challenges, these devices have the technical capacity to meet the enormous diagnostic needs of developing countries with high prevalences of parasitic diseases.

CONCLUSIONS AND FUTURE IMPLICATION:

Smartphone microscopy is one of the most common applications of smartphones for the diagnosis of parasitic diseases. As an alternative, an inexpensive and portable ball-lens-mounted smartphone microscope presents a simple POC tool for the identification of STHs in community surveys The smartphone-assisted Foldscope and CellScope tools present attractive POC tools for the diagnosis of schistosomes, This could be explained by their small FOV or by irregular distribution of *Schistosoma* eggs in the excreta. To detect *Schistosoma* eggs in large field surveys with improved sensitivity, these devices could be trialed in conjunction with a specialized algorithm for automated The recent application of smartphone microscopy for the detection of pathogenic DNA presents a multiplex potential for parallel identification of several parasitic species in a high-throughput and short-time format.

Smartphone-assisted video microscopy is a recent advancement in parasite diagnostics. For instance, the CellScope Loa allowed the quantification of *L. loa* microfilariae in less than 2 min with a high sensitivity (100Such a device could potentially be applied for rapid field diagnosis of other blood-borne parasites, such as *Leishmania* and *Trypanosoma*

One of the advantages for using smartphone-based diagnostic tools is the use of dedicated algorithms and softwares for automated identification of parasites. For instance, the utilization of a specialized algorithm facilitated smartphone-assisted automatic detection of *G. lamblia* in large volumes of water in only 1 h compared to the conventional methods which may take 1 to 2 days Since waterborne parasitic diseases remain the second leading cause of death in children under age five in developing countries, this technology could be applicable for large-scale water testing in these regions. Most smartphone-based diagnostic devices have been tested in well-controlled laboratory conditions and only for tropical parasitic diseases. Further studies are required to explore the usefulness of such devices for the diagnosis of other important parasitic diseases in field conditions and on clinical specimens. Despite the portability of smartphone-based diagnostic tools, issues such as need for manual processing of samples and preparation of microscopic slides remain to be addressed. Limited battery capacity of smartphones is a major bottleneck for their field deployability in remote health care facilities, which can be solved by applying mobile charging devices with a car battery or solar power

Internet prices can be high in low-income regions, which may hinder transfer of the diagnostic data to a reference laboratory. Lack of awareness and a tangible commercial market are the other major challenges for smartphone-based diagnostic devices, which could be addressed through integrated training and practical business plans. The combined use of smartphones with inexpensive handheld microscopes and microfluidic devices offers a great opportunity for the advancement of portable diagnostic technologies to overcome the burden of many parasitic diseases in resource-constrained regions and offers researchers opportunities to develop similar technologies at affordable prices. Despite lower sensitivity than an established laboratory test, a smartphone-assisted onsite diagnostic test could be more useful to provide onsite "sample-to-answer" treatment to a patient infected with a parasitic disease, as this patient may not return to the clinic for the results of a laboratory test The future of smartphone-assisted diagnostic technologies is very promising and the widespread adoption of such technologies is anticipated in the near future for the accurate and rapid diagnosis of parasitic diseases in an easy-to-use format

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