Original Article

Use of single-nucleotide polymorphism in assessment and management of tuberculosis by using Geo Informatics System

Abstract

Background: Approximately one-third of the world's population is infected with the bacteria that cause tuberculosis (TB). 99.9% of human DNA is similar and 0.1% dissimilar; this is because of single-nucleotide polymorphism (SNP). **Aims:** SNPs are the efficient way of identifying the genes implicated to common complex diseases. These SNPs are helpful in assessment and management of TB by using GIS system. **Materials and Methods:** In this article, particular SNPs relevant to TB is obtained from F-SNP database which is helpful in making SNP profile of TB patients, having coded information (different types of SNP) of each individual. This coded information is used to make SNP medical card of each individual. **Results:** If the SNP information made available on the GIS, it can be used by physicians, health care providers, and government to find out genetic origin of TB, susceptibility of patient toward them, and drugs to treat them. Physicians can use the SNP medical card as a powerful tool in designing the individual drug and dosage regimen and prediction of drug ADR related to particular patient. **Conclusion:** SNP medical card can be used as a powerful tool for combating TB in developing country like India.

Key words:

F-SNP database, Geo Informatics System, single-nucleotide polymorphism, SNP profile, SNP medical card, tuberculosis

Introduction

One-third of the world's population is infected with the bacteria that cause tuberculosis (TB), *Mycobacterium tuberculosis*. One in 10 of those infected are estimated to progress to active TB disease. Thus, TB is a significant cause of morbidity and mortality and causes ~2 million deaths annually.[1,2] Various programs are been running to eradicate TB from India, such as National Tuberculosis Eradication Program (NTPE) and Revised Tuberculosis Control Program (RNTCP), but still it seams a herculean task to remove it from our country. Specifically, several polymorphic-derived deletions and point mutations of the human homologue of the murine natural resistance–associated macrophage protein 1 (NRAMP1) gene,[3] the vitamin D receptor (VDR) gene,[4] the interleukin (IL)-1 gene cluster,[5] and the IL-10[6] and tumor necrosis factor (TNF)-a[7] genes have been associated with susceptibility or resistance to TB in different ethnic groups, although none of these genetic associations has been shown to have any relevant functional effect on the containment of *M. tuberculosis* by the host immune system.

Recent advancement in pharmacogenomics provides various promising approaches in medical fields. Nowadays, genetic basis of treating diseases is widely in use and have a great future. Discovery of drugs and drugs to be prescribed to the patient is done recently by reading patient DNA sequence.[8] For example, polymorphisms in the cytochrome P450 CYP2C9 with warfarin dose requirement and risk of bleeding complications.[9] After the completion of Human Genome Project (HGP), mapping of DNA sequence helped in deciphering the various enigmas of disease origin and their treatment. One of its fruit is SNP which is a point variation in the base pair sequence in DNA. It has been found that 99.9% of human DNA is similar and 0.1% dissimilar this is because of single-nucleotide polymorphism (SNP).[10]

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In the HGP, more than 1.4 million of SNPs in the human genome have being identified.[11] The SNPs are the efficient way of identifying the genes implicated in common complex diseases such as CNS disorders, cancer, cardiovascular diseases, Type I diabetes, and multiple sclerosis.[12] Pluralities of database are been available on the Internet which contains SNP information relevant to particular disease. This will give a new dimension in the health system. But still this technique has not reached to the masses becoming one of the major follies in the health system.

Geo informatics system

Geo Informatics System (GIS) is a system of hardware, software, and procedures to facilitate the management, manipulation, analysis, modeling, representation, and display of geo-referenced data to solve complex problems regarding planning and management of resource.[13] Nowadays, GIS has been used in health area especially in epidemiology and public health.[14,15] It has been used in mapping disease spread, determining areas of prevalence, and identifying the population at risk. This science and technology has abilities such as receiving and transferring the data between sources, organizing data, timely receiving and showing, processing, and merging various data and their ability of offering multipurpose services.

GIS in public health management

GIS is now been applicable in health field also like determination of the number of private health practitioners in India.[16] Many diseases occur in human society, but policies and regulations will help in preventing the lessening of disease occurrence. To map and monitor the time and location of disease happening, the special data are collected which are in the form of point representing regions along with disease statistics.[17] The relationships between the intensity of the disease and causing factors will be modeled using geo-statistical tools in GIS. Such models will be used to prioritize not only the affecting factors of diseases but also the action and regulation required for controlling the disease. Furthermore, appropriate disease history is available which provides a proper medication to the patient.

Objective

This article attempts to provide better curing of the TB patient in the two distinctive areas of health, i.e., epidemiology and health care. It provides patient-oriented medication as the user will view and control the map features directly through the Internet. By providing SNP information available on the individual medical card and on the GIS system will help us getting relevant medical information of a wide range of TB patients resulting in proper health facilities. Moreover, also assist health care providers and physicians for quick and easy medication of the patient.

Problems in health GIS

Many reasons are offered for the lack of incorporation of GIS technologies. The majority of these are concerned with the end users of GIS and a lack of consideration of their needs.[19,20] Another reason for the less popularity of GIS than other application software is the time required to learn and understand its functionality is very much.[18,20]

Furthermore, GIS may be viewed as an undemocratic technology,[21] as it may broaden the gaps between the powerful and less empowered people because of difficulty to access the data and technology by the poor. Those in power will use the surveillance capabilities to which other sectors of the population do not have access.[22] Participatory GIS is a field of study and application that has emerged from the criticism of GIS and power structures. Participatory GIS or community integrated GIS refers to a methodology that allows systems (GIS) to address the needs of people who are concerned with participation in decision making.[23]

Materials and Methods

Medical card

Medical or smart card is a plastic card in the size of a credit card that one or more chips are used in it as aggregated services. There can be also be one or more technologies, such as magnetic strips, bar codes, biometric information, and image recognition, which will be done by machines, used in it. The combination of common plastic cards and a microprocessors allows large information to be stored, processed, and accessible online and offline.

Types of smart cards

There are two of smart cards: (1) Memory cards that only include nonoverflowable memory and some processes in order to provide security and (2) CPU cards which include a CPU and overflowable too.[24]

Amount of data stored in medical cards

Smart card will store more data than the normal cards (magnetic strips), and by storing encoding algorithms, they will also improve the security of transfers. The data stored on an IC chip are transferred by means of an electronic mojule that is connected to a terminal or a card reader device or by a magnetic field.[24]

Functionality of cards
Operating system

The new pattern and programming in the operating system of medical card is CardJava.[25] This operating system is made by Sun Microsystem Company. Other operating systems that will be named as developed for smart cards are MULTOS (Multi-Application Operating System) and SmartCard for Windows. [26]

Programming language

Many programming language (Application Programming Interface) have been developed for smart cards. Some of them are GlobalPlatform/OpenCard/SC-PC/CT-API.

Medical card security

All data and passwords stored on the card can be erased or modified by an unusual voltage supply, heating, UV light supply, and physical attacks. These threats can remove the security code or erase the data stored. So the card will be secured by providing Operating System security, PIN number, and Software security.

Preparation of a card

SNP discovered in the HGP and the newly discovered SNPs are stored in the SNPs like Functional single nucleotide polymorphism (F-SNP) and will act as markers in the search for the origin of TB.[27] F-SNP database integrates information obtained from 16 bioinformatics tools and databases about the functional effects of SNPs.[28] Another distinguishing feature of the F-SNP database is its integration of human disease databases to facilitate identification of potential disease-causing SNPs as genetic markers in association studies.[29] The current version of the F-SNP database contains the functional information for 559,322 SNPs in 18,282 genes relevant to 85 major human diseases.[27] So F-SNP provides us a good database where we will extract good information about the particular SNP.

In this process, SNP of individual person is identified. Particular SNPs relevant to particular disease will be obtained from F-SNP database which will be helpful in making SNP profile of each individual. SNP profile has the coded information (different types of SNP) of a particular patient. According to the profile, SNP medical card of each individual is produced which comprises coded information as a unique identity of the patient. It will be helpful in revealing medical history from centralized database, genetic origin of disease, susceptibility of patient toward the disease, and drugs to treat them.

SNP profile on the basis of SNPs will be made. Groups may be formed on the basis of different SNP profile. According to these SNP profiles, we will produce identification cards/medical cards of each group uniquely. These medical cards are having some coded information of SNP and unique identity of patient. This identity may be used to track the medical history of the patient from centralized database. The SNP information is made available on the Internet or GIS database where the data are stored and can also be manipulated. According to the number of people it uses, it has been divided into two categories, i.e., on community basis and on individual basis [Figure 1].

On community basis

It involves a large-scale use of GIS where the evaluation of spreading and detecting of epidemic disease will be done. SNP information are made available on the GIS which will be used by physicians, health care providers, and government to find out various drug-related aspects such as genetic origin of disease, susceptibility of patient toward that disease, drugs to treat them, and vaccination in the epidemics.[30] Moreover, the above information provides data and so helps health policy makers and policy implementers to provide physical and financial help to the particular region relevant to particular SNP groups [Figure 2].

On individual basis

SNP medical card will also act as a powerful tool for the physician so that it is easy for them to design the individual drug and dosage regimen, predicting ADR of drug related to particular patient,[31] helpful in conducting individual patient vaccination, and immunization program especially for those person on which normal vaccine is ineffective.[32,33] Allergies related to particular drug shown only in some patients will also be predicted. For instance, SNP medical card is also helpful in getting information about the inheritance of disease[34] [Figure 2].

Results

Single nucleotide polymorphism will provide a promising future for Tuberculosis management. Therefore, SNP with GIS seem to display a great promise for the near future because further improvements may lead to enhanced
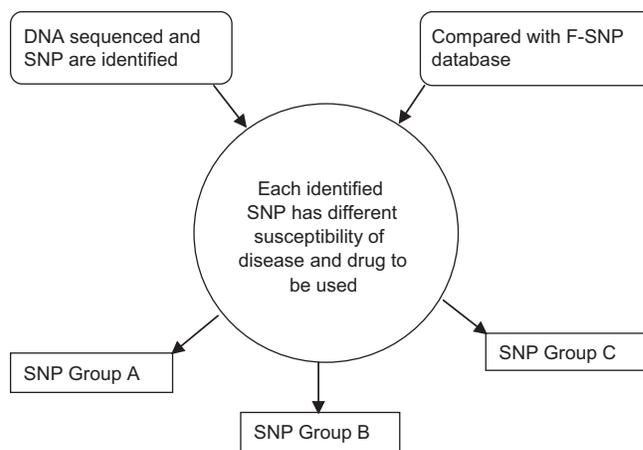

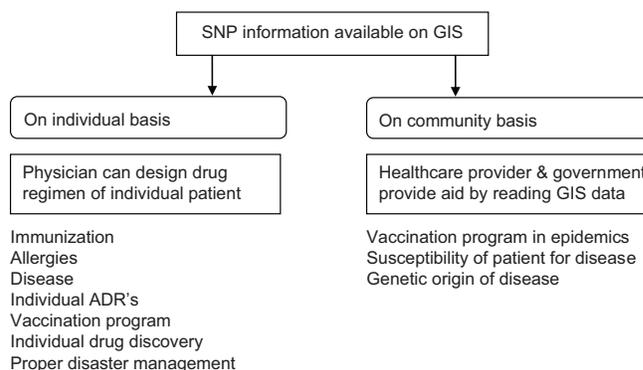**Figure 1:** Division of people according to their SNP profiles

Figure 2: Uses of SNPs on individual and community basis

efficiency which is needed in the challenging field of disease assessment and management.

Discussion

In India, GIS has been used in decision support to control malaria in koraput district in Orissa.[35] If we have a vigil on the present health care management, some of the well developed countries have contributed a lot in this field. GIS has been applicable in many European countries and have improved a lot. But in developing country like India, where only 2% of its budget is spent on the health system, it is a very difficult to successfully start and run this system on a grand scale. Finding individual SNP, formation of medical card, data storage, and data management on GIS requires a substantial amount of financial aid, sophisticated and technical workers, and efficient management system. But still in India GIS has been used like investigation of diarrohea by using GIS in a village of southern India.[36] Moreover, GIS has been used in water supply and sanitation practices in villages of India.[37] The study aims to create a comprehensive geospatial database linking health status of rural populations along with their social, cultural, and environmental characteristics. Using this information, a community health index that will predict the health outcome of communities for a given set of physical and social factors will be devised. This information will then be provided back to community representatives and district and state policy makers to effect policy changes at the peripheral levels.

Conclusion

According to the mentioned issues, it can be concluded that GIS-based medical card will be suitable equipment for patient medical record. In addition to saving on expenses and human force, they provide better managing of distribution, control, and guidance in health and medical services weather in the medical section or in facilities, equipment, and services offering centers. Apart from medical and clinical tools, national programs such as NTEP and RNTCP for such a huge country as India also need state of the art management and planning tool. Furthermore, it provides the ability of recognition, definition, and good performance in short span of time.

Acknowledgment

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