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Design of Biomedical Informatics Framework for Personalized Medicine in Healthcare Organizations

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Abstract

To implement personalized medicine effectively at organizational level, it is vital to identify, organize, integrate and leverage multi-dimensional patient data from heterogeneous and distributed resources within an organization. This paper presents the design of a novel informatics framework, to identify, organize and integrate patient's clinical, genomics and environmental data from existing clinical and biomedical resources, and to explore how this patient's data can be leveraged by informatics tools to achieve the goal of personalized medicine.

Keywords:
Personalized Medicine; Data Warehousing; Risk Assessment

Introduction

The new era of life sciences has brought many promising innovations to improve healthcare and personalized medicine is one of them. It is an advancing field of healthcare that is based on each patient's unique clinical, genomics and environmental profiles; thus providing individualized care and treatment using integrated, coordinated and evidence based approach. Using a case study of a hospital and research center, preliminary requirement analysis was performed. The needs of utilizing latest approaches of translational and personalized medicine were observed for the hospital to improve quality of patient care services; and the needs of improved biomedical data storage, analysis and interpretation methods were observed for the research center to develop a centralized biomedical research data platform. Based on these requirements, this paper presents the design of a novel biomedical informatics framework for Integrating Clinical, Genomics and Environmental Data (ICGED), which provides a roadmap for personalized medicine by integrating and utilizing patient's data from existing clinical and biomedical resources in an organization.

Framework

Objectives

Our framework is aimed to serve the following purposes:

- Identification, organization and integration of patient's data from diverse organizational resources
- Development of a centralized platform for data provision
- Data analytics, mining and interpretation
- Transformation of existing data into meaningful information
- Knowledge extraction from the available information

This framework is targeted for the following stakeholders:

- Healthcare professionals for finding patient's information to be used for individualized and tailored care and treatment.
- Biomedical researchers and investigators for utilizing existing information and using it for further research studies.

Information Resources Used by Framework

Our framework is built on holistic approach of utilizing and integrating following existing clinical and biomedical information resources within the organizational structure (see Figure 1). Some main resources identified using our case study includes, but are not only limited to, the following: electronic health records (EHR) / clinical information systems (CIS), ancillary / auxiliary information systems, disease registries, biobank, and bioinformatics research databases.

Categories of Patient's Data Used in Framework

Using available resources, our framework aims to extract following patient's data: clinical, demographics, lifestyle, phenotype and -omics (Figure 1).

Design of Tools Provided by Framework

Our framework suggests the following tools that can integrate and leverage multi-dimensional patient's data from various resources to provide approach of personalized medicine.

Data Integration and Analysis Tools (DIAT)

To implement the DIAT, Informatics for Integrating Biology and the Bedside (i2b2) [1] data warehouse (star schema) can be built by extracting and integrating the clinical and genomics data from different resources, such as clinical information system, biobank and disease registries (see Figure 1).

Risk Assessment and Prediction Tools (RAPT)

To implement the RAPT, data can be extracted from different resources, e.g. EHR and existing patient's disease and genetic registries, (see Figure 1). Using the machine learning algorithms [2], models for disease prediction can be constructed.

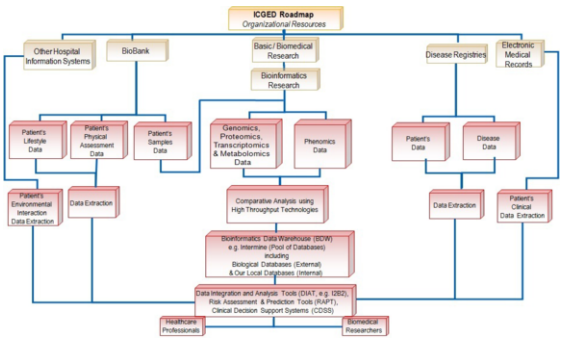

Figure 1 – Design of Informatics Framework for Integrating Clinical, Genomics and Environmental Data (ICGED)

Clinical Decision Support Systems (CDSS)

Using EHR, applications like SMART [3] and customized RAPT (see Figure 1), the decision support features can be implemented and used in the clinical practices.

Bioinformatics Data Warehouse (BDW)

The literature contains several examples of biological data warehouses, e.g. InterMine [4] that can be implemented by integrating various heterogeneous biomedical data formats.

Discussion

Though the future of personalized medicine is promising, but there are several challenges and barriers associated with it. In terms of implementation, there are always challenges of data standardization, quality, accuracy and ownership. Also, the technical issues must be dealt for data implementation aspects, such as extract, transform and load (ETL) process, data interoperability and data governance associated with data warehouses and analysis tools [5]. The revolution of big data is continuously changing the ways of analyzing and interpreting the data in precision medicine [6] that must be considered. In addition, the challenges of data interoperability, data harmonization and fine-grained data access are some other important aspects for future precision medicine [7]. In terms of economics, risk assessment, cost-benefit analysis, insurance policies and reimbursement issues should also be carefully weighed [8]. The consideration of ethical aspects [9], such as security, privacy and confidentiality related to the use of multi-dimensional patient's data is a sine qua non; moreover social and legal questions [9] in using genomic information in patient care practices are still a big challenge for personalized medicine and must be addressed by the future research.

Conclusions

This paper presented a biomedical informatics framework that utilizes and integrates patient's data from existing clinical and biomedical resources in an organizational setting. It provided a novel approach for identification of various patient information resources, extraction of different types of patient's data from these resources, and leveraging the patient's combined profiles through the DIAT, RAPT, CDSS and BDW tools in order to achieve the goal of personalized medicine.

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