A Model for the Introduction of Ayurvedic and Allopathic Electronic Health Records in Sri Lanka

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***Abstract*—Fully integrated electronic health records (EHR) provide healthcare providers and patients access to records across a health care system and promise efficient and effective provision of health care. However, fully integrated records have proven to be very expensive and difficult to establish. Currently. EHR's have been developed largely to accommodate Western medicine events. These barriers impact on the introduction of EHR's in Sri Lanka, where health budgets are already stretched and Ayurvedic medicine is routinely practiced alongside Allopathic medicine. This article identifies requirements for EHR in the Sri Lankan context and advances a model for the introduction of EHR's that suits that context. The model is justified by drawing on insights and experiences with EHR in Western nations.**

Keywords— Electronic Health Record; Ayurvedic medicine;

I. INTRODUCTION

Electronic Health Records (EHR) are digital records of health events that are integrated across health care providers and enable professionals and patients to access and share records [1]. EHR's have been associated with the efficient delivery of health care and patient safety [2]. Analytics on EHR's have been used to predict mortality [3], diagnose kidney disease [4, 5], assess cardiovascular disease risk [6], and many other applications.

The introduction of EHRs has been attempted in difference countries with various degrees of success. Healthcare providers in Jordan have transferred paper records to EHRs to find that the lack of integration severely restricts their clinical benefit [7]. The Australian government spent over $AUD1billion to develop integrated, personally controlled electronic health records (PCEHR) that residents could opt to access [8]. Following poor uptake, an 'opt-out' policy is being trialed at selected sites to determine if this increases engagement. In Brazil, agreement on what data should be included in an EHR has proven difficult as their national, unified health record is rendered ineffective by thousands of local variations in the data collected [9]. In the United States, the HITECH Act provides financial incentives for providers to deploy EHR's for clinically useful purposes. Some $US30 billion has been allocated to funding the meaningful use provisions however, most indicators of the programme's success refer to participation and adoption metrics and do not measure quality, efficiency, or patient safety benefits of an EHR [2]. In Sri Lanka some hospitals and general practitioners have digital records [10].

Features of the Sri Lankan healthcare landscape that impact on a model for the introduction of an EHR include the prevalence of indigenous medical systems, including Ayurvedic, Siddha, and Unani medicine. According to Mukherjee et al [11] over 400,000 physicians predominantly in India and Sri Lanka practice Ayurvedic medicine. Although patient management systems customized for Ayurvedic medicine are emerging [12], few practitioners or hospitals use clinical software so Ayurvedic digital records are far from commonplace and integrated Allopathic/Ayurvedic records integrated EHR do not yet exist. Consensus on terminological standards for Ayurvedic medicine lags behind allopathic standards, such as SNOMED-CT (www.ihtsdo.org/snomed-ct).

Attitudes prevalent amongst Sri Lankan patients, including the placement of importance on seeking quality health care, changing practitioners readily, and the diligent reporting unexpected deaths, all contribute to a high life expectancy despite economic constraints [13]. Currently, in Sri Lanka many patients maintain their own paper records. It is not unusual for patients to arrive at a consultation with a brief case documenting past health events for the health care professional to peruse. Despite rising public health care costs [14], the quality of care in public hospitals exceeds that in private hospitals and is on a par with expensive private hospitals throughout Asia [15]. Sri Lanka is a developing nation with a gross domestic product per capita less than one tenth that of Australia, yet has a life expectancy only 7 years below the Australian figure [16].

Barriers to the introduction of EHR for Ayurvedic medicine can be classified into the six main categories that Garavand et al identify as barriers to the introduction of EHRs in allopathic medicine: economic, legal behavioral, human, technical, and organizational [17]. In this article, a model for the introduction of EHRs in Sri Lanka is presented that accommodates legal, economic, behavioral, technical, and organizational barriers in the Sri Lankan context. Requirements for a model of EHR deployment in Sri Lanka grouped by the six categories outlined in the next section. Following that a model is outlined.

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II. Requirements For a Model

A. Economic requirement

Economic barriers are those that relate to cost of transitioning to, and sustainably maintaining electronic health records. As the review by Garavand [17] illustrates, economic barriers include adequate return on investment to entice stakeholders to acquire hardware, software and network connectivity required to run digital records. In many countries, governments have offered financial incentives for the medical professional to adopt new information technologies. For instance, a range of incentives were available for decades to British general practitioners to purchase personal computers, with patient management software [18]. Extravagant government incentives for technology adoption are unlikely to be affordable in Sri Lanka therefore the cost of transitions from minimal digital records to ubiquitous use must be borne by providers and patients. Consequently, a model to establish and sustain digital records is required that is financially sustainable.

B. Behavioural requirement

Behavioral challenges include issues related to the attitudes, adoption and use of digital records [17]. A key requirement in the behavioral category involves the incorporation of Ayurvedic, Allopathic, and other health system data into the record. Benefits inherent in the establishment of digital Ayurvedic records, particularly for developing countries, has been identified [19, 20]. Practitioners from allopathic and other traditions may not necessarily practice integrated medicine but desire to have access to a record of interventions performed by other modalities.

C. Legal requirements

Requirements in the legal category include privacy and security provisions. Lessig identifies four types of constraints that regulate digital activity: social norms, law, economic factors, and technological mechanisms [21]. Privacy of health records is regulated by legislation in many jurisdictions (e.g. Health Records Act of Victoria Australia), and implanted using technological devices, including access control and encryption, are relied upon heavily. However, these mechanisms impede access, are computationally expensive, and can be circumvented by sophisticated attacks [22].

A framework advanced for health records by Grunwell et al [23] provides technological mechanisms to log and track every access. This approach does not impede access or substantially add to computational processing as access and authentication methods do however is simple to implement. Automated access tracking enables rapid, virtually immediate, detection of breaches that, along with regulatory mechanisms that have legislative force, have the potential to provide practically feasible regulation of privacy.

D. Technical requirements

According to Steele, technical requirements fall into the following types of categories [24]: **type of connectivity** (standalone, tethered, fully connected), **mode of data integration** (patient centered, interlinked), **tools** (web based, mobile, standalone), **data location** (centralized, distributed), **service provider** (patient payee, provider payee, government payee), and **source of data** (provider, patient, third party).

Sri Lanka has a high subscription to mobile networks, whereas landline based internet connectivity is not widespread [25]. This suggests that PC based patient management systems that are accessible on mobile devices are more likely to be readily adopted. This suggests that architectures that commence with standalone connectivity and build up to more integrated connections over time provides an affordable entry point. Currently, most patient management systems for mobile devices are extensions of expensive, proprietary systems however Aminpour et al advances a strong case for open source systems, particularly for developing nations [26].

In the Australian context, EHR data remains distributed, in the data storage repositories managed by each healthcare provider or organization. This distributed database architecture adds dramatically to implementation complexity and costs. In the Sri Lankan context, data is not currently stored in digital form by most health care providers, so a transition to a centralized repository is unlikely to attract objections from providers as in the Australian context. Centralized data repositories enables the deployment of health record bank architectures reported by Yasnoff [27] and discussed below.

EHR systems differ technically based on the funding source for the record's service provider. In Australia, a great degree of the cost of running the PCEHR is borne by the government. Costs associated with the hardware and software required to collect data for the record is largely borne by health care providers who have been enticed with incentives over the years. The record is intended to be free for patients. As mentioned above, this model is not as suitable for Sri Lanka as government health budgets are relatively constrained. Therefore, a model is required where patients and providers share costs. This point is discussed further below.

An important category of technical requirements involves the development of standards that are essential for EHR developments. Requirements related to standards, discussed next, span technical and organizational requirements. Standards relevant for electronic health records include standards for EHR architectures, terminological standards, messaging standards [1]. ISO/TS 18308 specifies a reference architecture for electronic health records that includes specifications for the representation of data, privacy and security and ethical issues. According to that standard, data is represented using a hierarchy of classes illustrated in Table 1.

Smith and Kalra have identified that homeopathic consultations can be captured using the ISO/TS 18308 standard [28]. Table 1 illustrates that 18308 EHR architecture classes can feasibly apply for Ayurvedic records however, systematic studies are required to ascertain how Ayurvedic digital records can be represented using the 18308 standard.

The standard for Allopathic medical concepts emerging internationally is SNOMED-CT. This involves over 300,000 concepts organized in 19 main hierarchies and includes relationships across hierarchies. As Waxler-Morrison found many concepts involved in an Ayurvedic consultation are similar to those in Allopathic consultations [29]. However,

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there are critical differences. The concept of Prakriti [30] in Ayurvedic medicine has no obvious classification in SNOMED-CT. Attempts to extend SNOMED-CT to accommodate Traditional Chinese Medicine concepts have begun [31] and similar attempts are required for Ayurvedic medicine.

TABLE I. ISO/TS 18308 HIERARCHY

Class	Description	Example
EHR Extract	Part or all of a record for an individual	
Folders	High level organization of the EHR	Per episode
Compositions	Set of entries for a clinical care session	Diagnoses, Test results
Sections	Headings reflect flow of information	
Entries	Clinical statements observations	High risk of cardiac autonomic neuropathy
Clusters	Multi-part entries	Test battery e.g. Ewing Test
Elements	Variables	Body weight
Data values	Data types	100kg

The openEHR standard (www.openehr.org) is being developed to represent the pragmatics of medical practice [32]. The central Archetypes in openEHR have been defined for many hundreds of Allopathic medical concepts however this has not been attempted for Ayurvedic medicine. The openEHR framework is the basis for the European Electronic Health Record Communication and given the rise in medical tourism from Europe to Sri Lankan Ayurvedic clinics in recent years, [33] openEHR archetype development is likely to be useful for the emergence of an EHR [34].

The application of messaging standards for use in the Sri Lankan context is also required for the emergence of an EHR. The main messaging standards in Allopathic medicine, Health Level 7 was initially developed to enable US hospital sub-systems to exchange clinical data. HL7 (Health Level-7) provides a standard template for the structure of a message that includes high level segments including patient identification (PID), specimen (SPM) and Observations (OBX). Fast Healthcare Interoperability Resources (hl7.org/fhir). Although, Gao illustrates that HL7 (version 2) use is growing in China, there is still doubt about the way in which HL7 segments are to be used in coding non-allopathic health care concepts [35]. Further, as Franz and Schelur note, data from new sources such as wearable sensors is required to be transferred using the HL7 messaging standard in order to ensure integration into health information systems though this is best done with the cut down version of HL7, FHIR (Fast Healthcare Interoperability Resources) currently gaining popularity. [36]

E. Human requirements

Human requirements involve issues including the congruency of individuals' educations and jobs with knowledge. Health informatics has struggled to be adopted in medical education programs in Canada [37]. In China, appropriately trained health informatics workers are in extreme short supply [38]. Health informatics education may also struggle to be embedded in the educational system in Sri Lanka rapidly leading to future labor shortages.

F. Organizational requirements

Organizational challenges relate to issues regarding the development of digital records, their integration with organizational policies and the development and use appropriate standards for their use [17]. A key organizational issue relates to responsibility for the development and maintenance of the integrated records. In most OECD countries, governments have taken the lead in driving the adoption of digital records by health care providers and in providing the technologies to enable secure integration of data from different providers into a single electronic health record. This process is facilitated in countries where governments are well resourced and control the provision of health care.

An alternate model, called the Health Record Bank has been advanced that is claimed to suit settings where governments are not in a position to control and drive EHR development [27]. In the Health Record Bank Alliance model (http://www.healthbanking.org/), health bank organizations compete to store patient data and offer associated services in a similar way that banks do with finances. To sign up to a health record bank, a patient transfers their records to the bank. The bank can offer various services associated with the data, including the facility to retrieve data from Ayurvedic providers and ultimately, to integrate data from Allopathic and other complementary medicine clinicians.

A health record bank trial reported by Yasnoff [27] demonstrated that technology required for the operation of the health banks is currently stable and feasible. However, integration with allopathic and other records requires a great deal of sophistication and will challenge and redefine existing terminological, messaging, and inter-operability standards.

III. A MODEL

A model advanced for the introduction of Ayurvedic electronic records has been outlined in [39] and is now presented in this section. The model assumes ubiquitous access to reliable mobile phones by physicians and patients. The transition from minimal digital Ayurvedic records to ubiquitous use is unlikely to be achieved in a single, rapid phase, particularly without considerable government investment. The model advanced here assumes four phases;

1. **Smartphone entry of Prakriti assessment** by Ayurvedic physicians for sharing with patients. Widespread use of this App provides the setting for the emergence of Phase 2
2. **Dhosa App with Additional patient data**. Extension of the Phase 1 Dhosa App to include additional patient data. Similarly widespread use of the App with additional patient

data leads to Phase 3 – the emergence of Health Record Bank providers;

3. **Health Record Bank Providers** emerge to enable patients to securely transfer their data from their mobile phones to specialized bank providers. This leads to the emergence of Phase 4 systems, integrated electronic health records
4. **Integrated EHRs** Enhancement of the Phase 3 system to include Allopathic health records

The model includes a smartphone Application that physicians can use to store, retrieve and share a patient's Dhosa. There are virtually no barriers to entry for this simple App so that, in accordance with *Uses and Gratification Theory* [40], patients and physicians will adopt the App if there is a purpose the user wants to achieve. For the Prakriti assessment, physicians and patients can be assumed to want to store the assessment for rapid retrieval at subsequent consultations. With greater uptake, the technical and business case for enhancements strengthens promising the emergence of software development houses that generate revenue from a large pool of users regularly using the App. This can pave the way for the emergence of the second phase; toward Ayurvedic digital records. The first phase, the Dhosa App is presented next.

A. *Dhosa App*

Ayurvedic physicians assess connection each person uniquely has with the universe, known as Prakriti. Prakriti is described on three dimensions (Dhosas) called Kapha, Vata and Pitta and typically documented with linguistic descriptors, such as Kapha with Kapha-Vata, in a patient's paper health record. Stranieri et al [39] advance a visual grid designed for mobile device rapid entry and display of a Prakriti assessment. The underlying assumption is that if a Dhosa can be readily entered into the Ayurvedic clinician's phone, it can also be easily transmitted to the patient's smartphone for sharing with other healthcare professionals. The transmission would ideally be implemented wrapped in a HL7 or FHIR message, Figure 1 illustrates the visual grid.

The patient's birth Dhosa, detected by deep pressure pulse analysis can be stored in addition to the patient's Dhosa at points in time. Mobile devices and internet connectivity is already ubiquitous, relatively inexpensive, and robust in Sri Lanka. An App that stores only the Prakriti assessment at different points in time is simple yet useful, and should present minimal barriers to entry into digital records.

The initial development of the App does not require large resource outlays and can be expected to be developed by software development companies given the large numbers of Ayurvedic clinicians and patients. The App can be expected to gratify the need that physicians currently have to record a patient's Dhosa, and retrieve the assessment on subsequent consultations. The Prakriti data can be transmitted to the patient's device by SMS messaging. A one press touch screen that implements the grid in Figure 1 enables the assessment to be recorded more accurately in less time than is the case with existing paper based, linguistic terms.

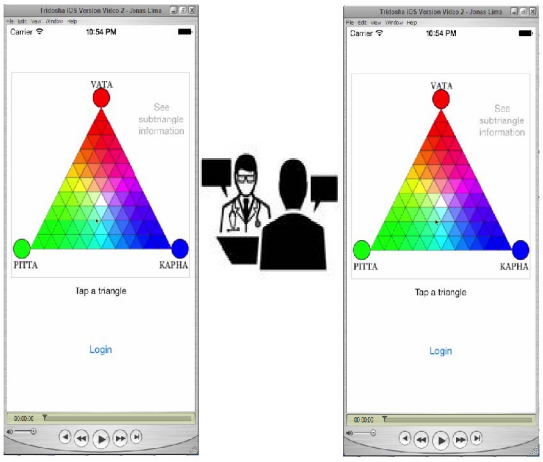

Fig. 1. Tridhosa App.

B. *Dhosa App with Additional Patient Data*

During Phase 1, smartphone entry of Prakriti assessment is undertaken by Ayurvedic physicians for sharing with patients. This phase is characterized by the availability of mobile applications (Apps) that enable Ayurvedic clinicians to rapidly record the patient's Dhosa. Phase 2 involves the extension of Phase 1 to include the facility for Ayurvedic and Allopathic clinicians to record a broad range of data about patients and their treatment in addition to the Dhosa. The App for this phase handles a great deal more data, so it needs to be more sophisticated. Terminology standards become more important. Security using access control and encryption becomes more pressing. Processes to back-up the data, perhaps on Cloud repositories, also become more important. An information accountability framework for privacy is not yet warranted because the information sharing is predominately between each patient and a small number of physicians. However, implementing the accountability measures warrants that the culturally dependent privacy of patient information will not be shared without accurate authentications. Access to more data about a patient can be clinically useful, particularly if mechanisms for the efficient display and retrieval of past data can be developed. Simply being able to retrieve past treatments provided to patients can help a clinician in treatment planning.

C. *Health Record Bank Providers*

Health Record Bank Entities can be expected to emerge to help patients store and manage their data. To sign up to a health bank (Phase 3), a patient transfers their smartphone record to the bank. The bank can offer various services associated with the data, including the facility to retrieve data from Ayurvedic and Allopathic hospitals and ultimately, to integrate data from allopathic and other complementary medicine clinicians. During this phase, standard vocabularies can be expected to emerge, championed by the health record bank providers. The record bank pilot project described by Yasnoff [27] struggled to find sufficient capitalization and customer uptake to maintain the development required. In the model, customer uptake can be expected to be substantial if Phase 1 and 2 have advanced sufficiently, because these phases have created a need for patients to manage their data.

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D. Integrated EHR's

During Phase 4, comprehensive inter-operability across all medical systems can be expected to emerge as health record bank companies compete for patient members. This level of inter-operability requires many issues to be addressed, including the development and integration of terminological standards, standard representations of clinical practice, rigorous clinician registration, and a harmonization of security and privacy principles. Phase 4 describes a context where diverse medical systems are not necessarily integrated but co-exist [21].

IV. Conclusion

The transition toward a virtual record of every health event an individual experiences from before birth to after death represents an ideal that promises to enhance the quality and efficiency of health care. Electronic health records are particularly important given the global health care crisis characterized by a shortage of health care professionals and the rise of chronic conditions [41]. The design, implementation and use of EHRs has proven to be extremely expensive and typically beyond the reach of developing nations including Sri Lanka. In addition, the Sri Lankan health care system includes Ayurvedic, Unani and Siddha medical systems for which EHR architectures and approaches do not yet exist, and the use of information technologies by practitioners is minimal.

A model for transitioning patients and practitioners toward electronic health records in the Sri Lankan context is presented. The model involves minimal government investment and includes phases where the technical, business and clinical case is established in a step-wise manner over time. The first phase involves the use of a visual, representation of a Prakriti assessment that Ayurvedic practitioners can transmit to their patients using mobile phones. Other phases build on the transmission of data between patient and physicians to eventually lead to a sufficiently strong business case for the sustainability of health record bank approach to EHR deployment. Future research aims to establish a pilot programme to test the model in Sri Lanka.

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