

eHealth-as-a-Service (eHaaS): The industrialisation of health informatics, a practical approach

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Abstract— With the introduction of the Personally Controlled Health Record (PCEHR), the Australian public is being asked to accept greater responsibility for their healthcare. Although well designed, constructed and intentioned, policy and privacy concerns have resulted in an eHealth model that may impact future health information sharing requirements. Thus an opportunity to transform the beleaguered Australian PCEHR into a sustainable on-demand technology consumption model for patient safety must be explored further. Moreover, the current clerical focus of healthcare practitioners must be renegotiated to establish a shared knowledge creation landscape of action for safer patient interventions. To achieve this potential however requires a platform that will facilitate efficient and trusted unification of all health information available in real-time across the continuum of care. As a conceptual paper, the goal of the authors is to deliver insights into the antecedents of usage influencing superior patient outcomes within an eHealth-as-a-Service framework. To achieve this, the paper attempts to distil key concepts and identify common themes drawn from a preliminary literature review of eHealth and cloud computing concepts, specifically cloud service orchestration to establish a conceptual framework and a research agenda. Initial findings support the authors' view that an eHealth-as-a-Service (eHaaS) construct will serve as a disruptive paradigm shift in the aggregation and transformation of health information for use as real-world knowledge in patient care scenarios. Moreover, the strategic value of extending the community Health Record Bank (HRB) model lies in the ability to automatically draw on a multitude of relevant data repositories and sources to create a single source of practice based evidence and to engage market forces to create financial sustainability.

Keywords—eHealth; eHaaS; cloud computing; personal health records; as-a-service; health record bank; industrialisation

I. INTRODUCTION

In some respects eHealth has fallen short of its potential to transform healthcare [3-5]. Although the goal of eHealth programs is to increase the efficacy of healthcare, the complexities of delivering technology-driven coordinated quality care coupled with stakeholder acceptance have emerged as significant obstacles to adoption. While there is room for debate about the efficacy of eHealth technologies, political imperatives shared by policy makers across the globe are driving eHealth agendas. The increasing complexity of

healthcare processes, a consumer approach to healthcare and a focus on patient safety and service productivity improvements [6] is providing impetus for significant government investments in eHealth programs. In this connection with the introduction of the Australian PCEHR (Personally Controlled Electronic Health Record) program, the National eHealth Transition Authority (NEHTA) have implemented an open standards infrastructure that aspire to common thematic priorities of international eHealth programs. Be that as it may, the implementation of the PCEHR has resulted in poor adoption and criticism from stakeholders with concerns about transparency, accountability (for example, privacy, confidentiality and information security), and limited functionality. A literature review explores the proposition of encapsulating eHealth interventions in an 'as-a-service' framework enabling healthcare organisations to combine quality patient care management with stakeholder value propositions in a scalable and cost effective manner. Moreover, the real value in patient data lies not just in the collection of data but in the integration of human-centred information into clinical processes within the framework of a commoditised data-driven approach to the delivery of care. Developing eHealth-as-a-Service (eHaaS) as a data-driven extension to the integrated community health record bank model proposed by Yasnoff, Sweeney and Shortcliffe [7] will establish contextually relevant decision support modalities encouraging universal stakeholder engagement. More importantly, the opportunity to industrialise core eHealth technologies and competencies for developing countries where limited access to capital and operational funds severely restrict their participation in eHealth programs is strong.

Additionally, when examining the outcomes of the PCEHR questions relating to sociotechnical factors concomitant with analogous eHealth programs begin to emerge for example; at the micro-level, what are the inter-personal factors such as individuals' attitudes and concerns and the material properties of the technology; at the meso-level what are the operational drivers and tensions of implementation such as readiness and resources; and at the macro-level what are the socio-political forces [8]. Additionally, patient attitudes and values play a significant role in their expectations, adoption and use of a personal health record. While privacy remains a key factor in adoption, it is one of many influences including the patient's socioeconomic and cultural factors and current state of health.

A shift to a patient controlled model may also deliver greater complexity for patients negatively impacting adoption as evidenced in other sectors for example retail and telecommunications [9]. Lastly, what has emerged from the PCEHR project is the significant role practitioner attitudes play in adoption and use. Practitioner concern about information ownership and governance, stakeholder transparency and more importantly, patient control and access to the patient's medical information have served to slow adoption of the PCEHR. In this context patient-controlled is not necessarily patient-centered if patients have the capability to delete or hide important information potentially impacting on the quality of care provided by the practitioner

The research program seeks to address these and related questions in order to establish a holistic sociotechnical lens for the examination of current state and future state information unification frameworks and technology consumption models. This in turn will guide the development of innovative care process models (evidence based vs. data-driven vs. expert opinion) and a recommendation for an adaptive data-driven approach to collect and make available individualised recommendations for patients at the point of care.

Accordingly, this paper offers a critical view of the implications for industrializing healthcare informatics by firstly describing the method for the literature review used to distil key concepts and identify common themes. Secondly, establish and refine the proposition that the development of a data-driven framework founded on the community health record bank model will encourage universal stakeholder engagement. Thirdly, describe a holistic eHealth 'as a service' framework unifying longitudinal patient data from disparate sources. This will underpin an examination of the implications for the adoption of a standardised approach to the delivery of *core* eHealth products and competencies. Finally, seek to understand the benefits that a data-driven approach will deliver in the form of individualized care establishing the imperative for pursuing scientific discourse in this area.

II. METHOD

A preliminary literature review was undertaken as a means to develop and contextualise a theoretical framework underpinning the adoption of the eHaaS construct. The intent is to distil key concepts and identify common themes in order to consolidate an understanding of the socio-technical aspects of knowledge sharing, data unification and value creation in a complex and dynamic ecosystem. Developing an informed perspective of how the eHaaS construct might be established as an appropriate platform for industrialising healthcare informatics was strengthened by searches of Web of Science, PubMed, SpringerLink, ProQuest, JAMA, IEEE Xplore, Google Scholar. Search terms relating to 'health record', 'health record bank', 'personal health record', 'PHR', 'EHR', 'PCEHR', 'health information bank', 'health information exchange', 'HIE', 'ehealth', 'health IT', 'health information technology', 'HIT', 'data-driven', 'decision support', 'DSS', 'CDS' 'cloud', 'big data', 'SOA' were used. This review draws on descriptive information from published and grey literature published in the period between 1995 and 2014.

III. DISCUSSION

With over 150 articles accessed the review does not offer an exhaustive overview of all references. However, it does provide conceptual perspectives on future directions for sharing and adding value to health information and establishes a potential research agenda within the complex and dynamic technology and social frameworks inherent in healthcare.

A. *Establishing a proposition for universal stakeholder empowerment*

Healthcare is first and foremost a service. To that end, high quality service delivery is as much about art as it is about science. Striking that all important balance between the two requires the orchestration of art that is concerned with a stakeholder's perception of usability and value, and science that appeals to the functionality and capability of the underlying systems. There is growing evidence that enthusiasm by health leaders and policy makers for new technologies is not always reflected by adoption and utilisation in practice [10]. Moreover, it is argued that a focus on technology over the formulation of a well-defined value proposition have resulted in many ehealth project failures [11]. Steinbrook [12] advances the theoretical benefits of patient controlled health records citing a reduction in costs and medical errors, improved coordination and quality of care and better stakeholder communications. However, Steinbrook [12] observes that the practical benefits have not yet emerged, a perspective supported by Gunter and Terry [13] who assert the PHR model like many emerging Internet-based health-related services, tend to exhibit limited functionality, and lack permanence. While a connection to national and international health policy is drawn through the recognition that consumer engagement is critical to quality improvement and cost containment, a study based on interviews with healthcare professionals in the U.S. provide valuable insights into the importance of practitioner engagement and endorsement for successful stakeholder adoption of PHR systems [14]. When coupled with privacy and security concerns, patient confidence and trust, practitioner liability and risk concerns [15], the digital divide, information ownership, transparency and policy implications [16], financial sustainability and information quality [7] it becomes clear that the implementation of an appropriate technology-led model meeting the expectations of all stakeholders is a complex undertaking.

Shabo [17] offers a model that concentrates on the interests of all stakeholders across the continuum of care by establishing independent entities to facilitate a non-centric electronic health record (EHR) model. Shabo argues that practitioners should not adopt the de-facto role of "long-term record keepers" but rather make this information available to stakeholders through a non-centric independent health record bank (IHRB). Thus, the sole responsibility of the IHRB is the management of lifetime EHRs thereby maximising the utility of health information across the continuum of care. The notion of IHRBs is not new, the concept first introduced by Dr. Bill Dodd in the late 1990's as the independent 'Health Information Bank' emulates a commercial banking model [18]. The concept has since been built on by others with notable commercial and non-profit examples including Dossia.org, Microsoft HealthVault

and Google Health with varying levels of success [15]. However, the non-centric socio-economic-medico-legal model proposed by Shabo establishes the IHRB as a third party participant ensuring objectivity in the management of lifelong EHRs.

Equally, Yasnoff, Sweeney and Shortliffe [7] have taken the basic IHRB concept and applied it to the current U.S. health information technology landscape. They offer a model that is predicated on a community organisation approach with patients playing a gatekeeper role for a copy of all their personal and private health information. Yasnoff, et al. argue that this type of approach will resolve privacy issues, increase stakeholder cooperation (supported by U.S. legislation in access to private health information), deliver improved financial sustainability and enable coexistence with institutions that maintain their own local copies [7]. A refinement of the community health record bank model proposed by Yasnoff et al highlights the potential for achieving the critical mass necessary to encourage universal stakeholder engagement. Importantly, the model allows the consumption of information technology within the healthcare domain to shift in focus from technology to service.

B. eHealth-as-a-Service – an model for technology consumption in healthcare

Healthcare organisations must re-evaluate traditional boundaries due to the complexity of eHealth technologies necessary for collaboration and co-creation [19]. eHealth-as-a-Service (eHaaS) offers an alternative stakeholder-centric construct that establishes the PCEHR as the keystone of a holistic eHealth ‘as a service’ framework unifying longitudinal patient data from disparate sources. The building blocks of an eHealth system, personal health records (PHR), electronic medical records (EMR) and Electronic Health Records (EHR) are encapsulated in the eHaaS framework with the interconnections comprising human behaviour and information flow a principle design consideration [2]. As key value propositions, data enrichment, co-creation and discovery require a platform that will encourage cooperation and

collaboration across organisational boundaries as evidenced by social media platforms. Fig. 1 shows a stakeholder centric model positioning the EHR at the locus of a data-driven information ecosystem.

Consensus in the literature postulates that a significant challenge for delivering large-scale programs is ‘one size does not fit all’ [20, 21]. For that reason the authors contend that

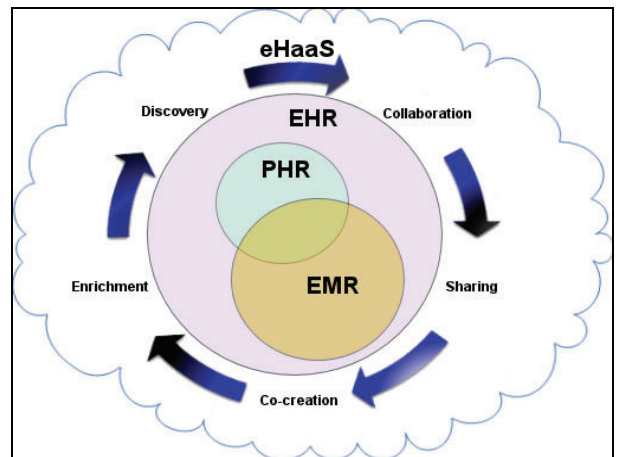


Fig. 1. A stakeholder-centric model, adapted from [2].

“cloud computing” constructs, specifically Software-as-a-Service (SaaS) that often includes hosting and infrastructure services and is recognised for its efficacy in other domains, may be observed successfully in healthcare settings. In simple terms, eHaaS will establish low cost, scalable capability for the delivery of service models designed to individual stakeholder requirements as an extension of the health record bank (HRB) model proposed by Yasnoff [7].

The architectural core of eHaaS leverages cloud computing concepts, application programming interfaces (API) and a service oriented architecture (SOA) based platform to deliver a rich functionality required to support complex

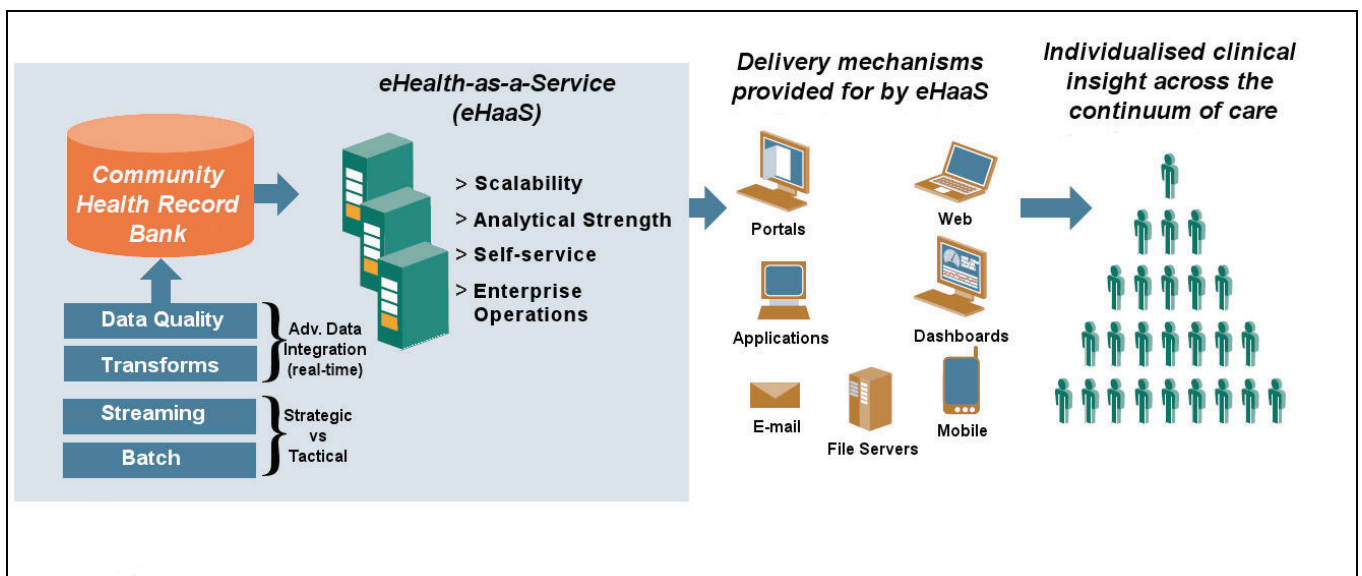


Fig. 2. eHaaS conceptual model adapted from [1].

multidisciplinary workflows. Similarly, the growing commoditisation of data requires a consolidation of cloud services that provide seamless and efficient access to health information from multiple platforms at any time from any location.

However, services must be aligned to operational requirements in order to create value specific to the individual needs of the stakeholders. Thus, at the operational level, eHaaS offers a framework for identifying service models that will facilitate value creation, collaboration and decision support across the continuum of care. In this context the opportunity to address diverse perspectives inherent in eHealth programs illustrate the potential for collaboration and co-creation leveraging eHaaS as depicted by Fig. 2.

The corollary of this is the industrialisation of health informatics with the adoption of a standardised approach to the delivery of *core* eHealth products and competencies. The World Health Organisation (WHO) have developed a National eHealth Strategy toolkit to support a collaboration between the health and ICT sectors [22]. It is the contention of this research program that the WHO toolkit identifies a set of eHealth applications and capabilities that are common across international boundaries and may be strengthened through the implementation of an eHaaS approach. In parallel, further benefits will be realised within an adaptive platform-as-a-service (PaaS) environment that promotes the development of individualised eHealth interventions leveraging standardised components and processes. Policy makers and healthcare leaders are uniquely positioned within a convergence of relevant technology and capability maturity models to advance the integration of technology into healthcare.

C. Towards individualised healthcare – a data-driven approach

Retaining data in the form of a longitudinal patient record is a key element of an effective eHealth program. However, the capability to collect, manage and deliver individualised patient information is difficult to implement particularly when budgetary constraints are a key factor [23]. The WHO point out that while the use of electronic patient information systems is increasing, the focus of their utility is for aggregating patient summary data rather than individual patient information. “*The key to effective patient information systems is to retain the link between the individual and the data collected over time and to make those data available to multiple health care providers when needed*” (p.9) [23]. Moreover, the authors join with Chawla and Davis in their contention that a key contributor to the emergence of individualised healthcare may be attributed to a data-driven and networks-driven thinking approach [24].

Individualised healthcare is predicated on providing the ability for stakeholders to extract and distil meaningful information from a broad and pervasive digital landscape. Moreover, the cumulative value creation effect achieved by applying contextual knowledge as information feedback loops within a patient’s knowledge network emerges. As an integral component of the eHaaS construct, this knowledge network will grow in value over the life of the patient increasing the efficacy of predictive modelling, informing individualised

preventative and intervention strategies while contributing to population health and broader research efforts. In conjunction with the PCEHR these systems will intelligently integrate personal information with an individualised form of evidence for collaborative decision making and co-creation by the practitioner and patient [25] as shown in Fig. 3.

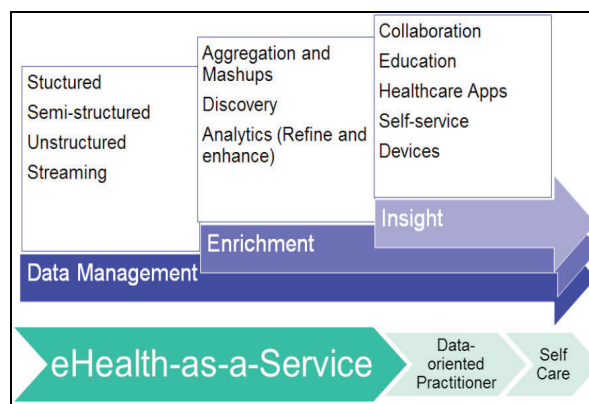


Fig. 3. eHaaS integration into Healthcare.

IV. COROLLARY OF THE eHAAS CONSTRUCT

Information and communication technologies have become central to health security, health services delivery and the transformation of health systems worldwide. The use of the Internet in healthcare delivery and associated protocols and, health information exchange is inevitable. Whether it is adopted technically, implemented politically, accepted socially and philosophically, the implications of ‘digital by default’ is the way forward for most.

Legislation to protect health information available digitally (e.g., via Internet), securing individual privacy and identity during transformation have far reaching implications for public health informatics. From stakeholders (e.g. patients, physicians, medical professionals and allied healthcare workers and healthcare administrators) prospective law reforms should be enacted with technologically measurable information accountability criteria to avoid and mitigate risk of becoming obsolete by accelerating technological advancement.

Consequently, eHaaS will become a technological useful construct for sustainable quality healthcare delivery and health information exchange via the Internet.

V. CONCLUSION

This paper offers conceptual perspectives on future directions for managing health information and establishes potential research streams within the complex technology and social frameworks inherent in healthcare. The findings from a preliminary literature review highlights that the promise of encapsulating eHealth interventions in an ‘as-a-service’ computing construct for industrialising core health informatics applications is strong. However, further work is required to realise the potential for a sustainable framework to extract value from the unification of human-centered data. It is clear that scientific discourse will lead to an understanding of the

socio-technical factors required for the adoption of a data-driven framework suitable for the Australian healthcare context. Future research efforts however must be grounded in the understanding that a priori characteristics do not adhere in the convergence of healthcare and technology which take place in a complex and dynamic context [26]. Future work will explore theoretical frameworks related to the validation and evaluation of eHealth systems. The use of accepted theoretical frameworks will provide a means for developing contextual insights into the interaction of stakeholders with technology. This in turn will facilitate improved engagement and adoption in the sharing of complete lifelong information across the continuum of care.

DISCLAIMER The view of this paper builds on early ideas published in the Jan-Feb 2014 edition of the IEEE eHealth Technical Committee (TC) Newsletter article titled “eHealth-as-a-Service (eHaaS): Empowering stakeholders universally”. The intention of this paper is to acknowledge the evolutionary development of the eHealth-as-a-Service construct.

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