Context Sensitive Health Informatics: Redesigning Healthcare Work
C. Nøhr et al. (Eds.)
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doi:10.3233/978-1-61499-794-8-134

Health Informatics and Technology for Integrated Elderly Care in the Context of Hong Kong: A Case Study

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Abstract. The aging population creates tremendous pressure to healthcare. To resolve, scholars recognized the solution to this challenge is integrated care. To facilitate integrated care, health information technologies (HIT) is a critical enabler. This paper will first review how technology enhanced integrated care, and review on the existing literatures in system effective use and the three key external factors that enable HIT implementation. Applying Burton-Jones and Volkoff's contextualized theories of effective use of HIT to understand the role of health informatics and technology in the unique context of Hong Kong, we have conducted a case study research to identify the levers for improving HK integration of care through HIT.

Keywords. Context sensitive, integrated care, elderly care continuum, health informatics and technology, case study research, system effective use

Introduction

As one aged and health gradually deteriorates, different levels and types of care are required to maintain his/her quality of life. Different professions interplay in the provision of care as the interconnecting properties of different attributes. For example, it is suggested by many that social isolation is negatively associated with multiple attributes, including quality of life, life satisfaction, mental and physical health status, cognitive ability and mortality, as reviewed by Czaja in a recent article [1]. More recently, the model of integrated care arose as its effectiveness being reviewed [2]. Integrated care, which definition reviewed by Armitage and colleagues [3], is a continuity of care from within the healthcare system expanding to include social services. It is being recognized by many as the solution to the aging challenge [4] [5].

While service-to-client/patient shifted from one-to-one to many-to-one, it also implies the information of a client/patient would be shared among the inter-professional team with appropriate consensus. As such, relationship of HIT and better care is obvious. Decisions on diagnostics, therapeutics and other interventions relies on understanding of clients/patients within the integrated care team. Scholars argue that a common health information technologies (HIT) platform plays an important role as to catalyze integrated care.

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This paper firstly addresses the progress of the field of integrated care, highlighting Burton and Volkoff's Contextualized Theories of Effective Use [6], which serves as framework for understanding HIT for integrated care in the context of Hong Kong.

Literatures for the 3 enabling factors for implementing HIT for integrated care are also reviewed. In the high level analysis of 3 levels of care, not only HIT in the general context of Hong Kong will be evaluated, the specific context of HIT of services across the elderly care continuum provided by two non-governmental organizations (NGOs) will also be discussed.

1. Literature review

1.1. Importance of HIT in integrated care, and research gaps

HIT, particularly in an aged population, is a major enabler for aging in place [7]. Liaw, Taggart, Yu, Lusignan, Kuziemsky, & Hayen [8] recognize the role of data in integrated care, emphasizing "a need to collect and manage complete, correct, consistent and timely information about the cycle of care, risk factors, disease indicator, quality of life and patient satisfaction". In an US survey study, Audet, Squires & Doty [9] supported the role of HIT in integrated care with the reported use. Their findings suggested there is a higher rate of electronic medical records adoption, multifunctional HIT, electronic information exchange, and electronic access for patients in primary care physicians involved in an integrated delivery system or share resources with other practices.

Despite the importance of HIT is being recognized, the development and application of HIT still have much to be done. In a review of literature of HIT and delivery of elderly care published between 1990 and 2008 by Koch & Hägglund [10], it is recognized the field of information and technology lacks cross-disciplinary research to different stages of the aging process.

In the follow, research on the application of HIT in the context of Hong Kong elderly care will be reported. The current paper will begin with a review of literature on enablers of HIT implementation, followed by a review of the Burton-Jones and Volkoff's contextual theories of system effective use. The challenges for implementing, and eventually effectively using the HIT system in the context of HK will be presented and discussed within the Burton-Jones and Volkoff's contextual theories.

1.2. Three Enablers for Implementing HIT

Based on literature on HIT implementation, we have identified three enabler for HIT implementation: 1) Incentivizing policy, 2) flexible technological infrastructure and 3) practice-driven human factor engineering [11].

1.2.1. Incentivizing Policies as an Enabler for Implementation

Policy, regulation and financial model should provide incentives for medical and social professionals to adopt HIT. An interview study by Sheikh, Sood, and Bates [12] examined the US HITECH Act, and their findings suggested to achieve a radical transformation, HIT initiatives should align with financial reform initiatives. In another study, it is found that output-based financial model has provided lower, if not negative incentive on the adaptation of better HIT than value-based incentive system [13].

1.2.2. Flexible technological infrastructure as an Enabler for Implementation

In an integrated care system, data are very likely to come from disparate sources. Therefore, knowledge of different professions and the associate clinical concept has to be integrated as to support the information exchange.

In the UK, Wilson and colleagues [14] commented the importance of a common language and evaluate the diverse outcome of Single Assessment Processes (SAP) in four individual sites, suggesting the demands of a "whole-systems approach". In Australia, Liaw and colleagues [8] illustrate how an ontological multi-attribute approach improves accuracy in diagnosis of Type 2 Diabetes register by integrating EHR information. A unified context is required. Infrastructure designed not just focused on the present but also allows legacy data to be used and reused is essential. Torjesen [15] also provides evidence of better clinical decisions enhanced by increased information shared between emergency physicians and general practitioner. In a recent interview study by Gagliardi and Dobrow [16], similar challenges are articulated by participants at organizational, professional and individual levels. A lack of infrastructure to support collaboration is reported [16], highlighting the IT systems are often disintegrated and unable to share the information.

1.2.3. Practice-driven human factor engineering as an Enabler for Implementation

Not only the technological issues have to be resolve, human factors are also recognized as one of the key issues closely correlated to usability. Role of psychologists and human factors engineers (HFE) are acknowledged by Czaja [1]. While the former can help in the design of training and instructional support, the latter can add value to relief barriers by their expertise in incorporate knowledge in abilities, preferences, needs and limitation to system designs, as well as tasks and environment [1]. In Taha and colleagues' study of patient EHR portals, HIT professionals are encouraged to take a user-centered design approach, considering the complexity of the system, difficulties in the use, user's technology skills and knowledge in health literacy [17].

1.3. Burton-Jones and Volkoff's Contextual Theories of Effective Use of HIT

Even with incentivizing policy, flexible technological infrastructure and practice-driven human factor engineering to enable implementation of HIT, the effective use of HIT is nevertheless context-specific and involves a number of factors across multiple levels.

In a recent article by Burton-Jones and Volkoff, an explanatory, context-specific theory of system effective use theorized by *affordance network* and *affordance actualization* was proposed [6]. In brief, affordance refers to "the possibilities for goal-directed action provided by an object in relation to a goal-oriented actor" [18] . In their model of effective use for a community care Electronic Health Record (EHR), they had described 9 affordances in 3 levels of care, namely, input, access, clinical decision making for simple case, team decision-making, coordination, clinical decision-making for complex case, monitoring, reporting, managerial decision-making. The 3 levels of care are categorized as individual's specific needs, distinctive wholes, and categorized populations. Care for the individual's specific needs can be described as symptom-based, while care for the distinctive wholes are often known as person-centered care. Care for the categorized populations are often discussed in policy, system and organization level.

Three dimensions in affordance actualization (the process between salient affordance to achievement of immediate concrete outcome) are reviewed, *accuracy*,

consistency and *reflection-in-action (clinical relevance)*, which are interrelated and influencing each other.

To elaborate, in their contextual theory, *accuracy*, "how well information in or derived from the data holding reflects the reality it was designed to measure"[19], is further categorized into *truth*, *whole truth*, and *nothing but the truth*. *Consistency*, the "amount of variation that would occur if repeated measurements were done"[19], is evaluated by *utilization*, *place*, *form*, *amount* and *meaning*. Lastly, *reflection-in-action (clinical relevance)*, which Burton-Jones and Volkoff described as behaviors with a notion of practice-based rationale, is categorized to *patient*, *clinical and co-worker workflow*, and *the studied HIT workflow*.

In sum, according to Burton-Jones and Volkoff, the use of HIT cut across the levels of 1) needs/symptoms, 2) whole person and his/her journey as a person, and 3) population. The use of HIT in these three levels are for the purpose of data capture, monitoring, reporting, decision making and clinical delivery. For the use of HIT effective, Burton-Jones and Volkoff posited that one has to enhance the accuracy, consistency and clinical relevance of the data use during capture, monitoring, reporting, decision making and clinical delivery.

To better understand the implementation and use of HIT in the unique context of HK, a qualitative research study was conducted with case study methodology. The research findings are reported below.

2. Method

2.1. Research question

Responding to Burton-Jones and Volkoff's study, the research team is particularly interested in examining whether the system effective use contextual theory would be applicable in the context of Hong Kong elderly integrated care. The research team also aimed at extending the contextual theory to incorporate three external enabling factors of successful implementation of HIT. This paper hopes to contribute to provide a review of current status of HIT usage in the Hong Kong medical and social system, and provides insight of necessary improvement in achieving a successful implementation of HIT leading to a better care.

2.2. Setting

Unlike Canada which Burton-Jones & Volkoff studied, the Hong Kong public medical and social care are monitored by different authorities i.e. a disintegrated system. Under the Food and Health Bureau, the Hospital Authority monitors public hospitals, general out-patient clinics and specific out-patient clinics, while the Department of Health manages other public health facilities. On the other hand, the subvented social services are provided by NGO, regulated by Social Welfare Department (SWD).

Two local NGOs (NGO Y and NGO Z) with many similarities in terms of the types of service provided across the care continuum within their hospital cluster were studied. The service provided within a cluster of the two NGOs are summarized in table 1.

2.3. Research design

This paper will adapt a case study research approach. The case study method is considered to be a relevant approach in understanding the context of a complex phenomenon in greater details. This paper firstly describes a list of issues relevant to accuracy, consistency and reflection-in-action observed in Hong Kong regarding to HIT.

This paper then evaluates the 3 levels of care (individual's specific needs, distinctive wholes, categorized populations) addressing the process of data input, access to data, decision-making and coordinating in the context of Hong Kong representatively. The paper also incorporates the external enabling factors to provide solutions.

2.4. Data collection

The general context (level of categorized populations) is reviewed based on 1) publicly available information as of May 2017 from Hong Kong government and 2) observations from the research team's collaboration with various local medical and social partners.

The study of specific context (level of individual's specific needs and distinctive wholes) is reviewed via a retrospective study of the 2 local NGOs through attachment, informal discussions, and data and database(s) investigation between 2016 February to 2016 November, and between 2016 July to 2017 April respectively.

The research team had collaborated with the above 2 local NGOs representatively with the common goal of optimizing service outcome in an evidence-based manner. The research team had granted access to the main local data systems within the 2 local NGOs of the studied service units at operational level. To specific, four data systems currently in use/previously used by NGO Y, and 4 data systems currently in use/previously used by NGO Z were studied.

Table 1. Number of service across the elderly care continuum by service type.

Service type	NGO Y in hospital cluster A	NGO Z in hospital cluster B
District Elderly Community Centre (DECC)	1	0
Neighbourhood Elderly Centre (NEC)	2	2
Support Teams for the Elderly (STE)	1	0
Integrated Home Care Services (IHCS)	1	1
Enhanced Home and Community Care Services (EHCCS)	1	0
Pilot Scheme on Community Care Service Voucher for the Elderly (CCSV) (Phase 1)	1	0
Pilot Scheme on Community Care Service Voucher for the Elderly (CCSV) (Phase 2)	0	1
Day Care Centre/Unit for the Elderly (DEs/DCUs)	1	1
Care and Attention Homes for the Elderly	1	0

3. Findings

The following summarize the list of issues related to maintaining accuracy, consistency and clinical relevance being observed at the population, whole person and need-specific levels. Reference to different evidence-based enablers of HIT implementation were made when relevant.

3.1. Practitioners not familiar with the use of HIT

It is noticed that hard copy remains to be the most used form of documentation. Information are kept at a case-by-case level by each individual practitioners. It is also observed that practitioners are also not familiar, particularly for the social professionals, to make decision based on data. The computer skills and willingness to adapt HIT is still at infantry.

Low incentive is observed for practitioners to improve the situation. The SWD only requested NGOs to submit summary statistics. Also, documentation in hard copy are audited at site visit. Under this practice, hard copy remains to be the most used form of documentation as the fulfillment of SWD regulation, which increases the difficulties in information exchange.

Not only it has imposed risk and high cost in maintaining an accurate and consistence information, it also reflected HIT is not embedded in practitioner's workflow, i.e. little reflection-in-action.

3.2. The black box of HIT infrastructure design

In the 2 studied NGOs, the issue on architectural infrastructure of the data system not known by the end users is also reflected. The difficulties in use creates further resistance in the adaptation. Also, the HIT system adapted by social services are often pre-made by vendors that are not familiar with the dynamic workflow. This has created issues not only in lacking flexibility in making changes as to best fit local use, but also not fit-for-purpose.

For example, knowing one's clinical history is likely to assist in making a better decision, which importance of time should not be neglected. In addition to the overwriting issue discussed previously, most data systems used in the studied NGOs were capturing information recorded and updated at different time, yet stored in the same datasets. However, it is observed often either the time log of each variables are not available, or the documentation practice is not standardized/unclear. This has caused difficulties in interpretation, affecting the accuracy in forecasting and planning.

3.3. Limitation of an overwriting data system

Another issue in the category *reflection-in-action* is the system design not fitted the practitioner's workflow. It is common to have an overwriting data system in elderly social care, imposing difficulties in reviewing the performance over time. In the 2 studied NGOs, majority of data systems in use overwrite datasets containing client profile, including demographics, clinical information, and functional/psychosocial assessments. As a result, frontline clinician either relies on hard copy to study the history of client/patient, or has to manually extract data on a regular basis, creating extra workload in storage, integration and increase potential error.

The current practice not only damage the effectiveness and efficiency at operational level, particularly in planning multidisciplinary care, it also imposes difficulties in projecting upcoming needs for resources allocation when client history are not designed to be exported.

3.4. Little, if any, data quality assurance

With high difficulties and complexity in using HIT as well as limited by the current practice, little effort have been made to data integration, and the associated reality check. High rate of discrepancies further discourage the use of HIT, particularly for cross-domain use in providing care of each client holistically. Little attention has been paid to ensure data quality, particularly for the accuracy and consistency across databases and datasets.

The following illustrated two examples of cross-domain data discrepancies in NGO Y from a common set (n=258) of clients from DECC user registered on or before 2016 September and active STE user at 2016 August. Under Hong Kong's policy, STE is a service attached to DECC i.e. two service sharing the same centre, and often with some overlapping workforce. The data system used in NGO Y's DECC is the current data system in use for the documentation of member registration, while the STE data system is a government built system for the ease of reporting annual statistics.

Date of birth, one of the common variable between the two data systems, is discussed here with a focus in accuracy and consistency. The reason for using date of birth to demonstrate the issue in data quality has the following logic: 1) many elderly service had a specific target group bounded by the service mandate, 2) age is one of the risk factor in frailty, 3) date of birth is a piece of unchanged information with reference to time.

However, comparing data of this cohort stored in NGO Y's data systems, 19.38% (n=50) were found to have a different date of birth documented. To specific, 4.26% (n=11) had a different year of birth documented, while 15.5% (n=40) had a different month of birth and 15.5% (n=40) had a different day of birth.

Another examples of data discrepancies can also be seen in documentation of chronic diseases (heart disease and hypertension/hypotension). The following will make use of the nature of chronic illnesses, which chronic illness will persist for a long time.

Among the 258 common group of clients between the two services, 159 individuals first joined STE then DECC, and 99 first joined DECC then STE. The information of chronic disease are only documented at intake of service. 36 out of 159 individuals first joined STE were documented as heart disease patient, but this information were not recorded in 50% (n=18) of them in the DECC data system; 94 out of 159 suffers from hypertension/hypotension, yet 28.72% (n=27) were not recorded in the DECC data system.

Similarly, 13 out of 99 individuals first joined DECC then joined STE were recorded having heart disease, yet 23.08% (n=3) were not reported in the STE system; 49 of them suffers from hypertension/hypotension, however 8.16% (n=4) were not reported in STE system.

The above two examples of data discrepancies may be due to "different truth" were captured, or caused by inconsistency in meaning, amount and form. In other words, inaccurate input, or error during transition of databases, different interpretation of classification schemes might be the explanation of the issues.

For example, the variable *date of birth* could be representing 1) self-reported date of birth, 2) date of birth documented in HKID, 3) date of birth in Chinese calendar, 4) the actual date of birth due to the error in the early stage of HKID establishment, 5) Some of the records might only captured to the year level. In the example of chronic disease, they might be representing 1) self-report diseases, 2) clinical judgement, 3) inconsistency in meaning, 4) inconsistency in items that will be recorded.

3.5. Data systems disintegrated and fragmented

Limited accessibility and fragmented data are another challenges in maintaining consistency. The following will review the data system in the 2 studied NGOs. Relevant data were obtained, yet not accessed by those can make good use of it. The following will further elaborate it with the observations in the 2 studied NGOs.

Despite having 9 services out of 8 different service type within the same hospital cluster, client data of NGO Y are not directly linkable at both frontline level and managerial level. If an individual had received multiple services from the same organization, the information transfer heavily relies on active request information transfer via fax or/and phone call, or self-report from client or his/her associate. Data are exportable from frontend at no additional cost.

On the other hand, in the case study of NGO Z which have 5 services of 4 different service type in the same hospital cluster, they have integrated information between them at both frontline and managerial level, which access varies among different role. Frontline staff will be informed if the client had registered previously in their organization and utilized particular services, however could not access to the records of the other service. At managerial level, they have access to review all information on a case-by-case level. Data are exportable from frontend with additional cost.

In both NGOs, backend access of all data across the care continuum are not available.

3.6. Segregated Medical and Social Care System

As reviewed previously, Hong Kong medical and social system is comparatively disintegrated to other countries like Canada. The multi-layered and sectionalized infrastructure prohibit information exchange, and impose barriers to integrated care. It is observed that despite collaboration between medical and social divisions occurred in case-by-case level, as of 2017, there is little, if any, formal common information platform between the both. The current information exchange among medical and social professionals heavily rely on fax and phone call.

Moreover, the different stage of HIT development prohibit cross-division decision making. It is being observed the two institutions had a different pace in HIT development. In Hong Kong, while importance of HIT in medical domain is recognized by fellow policy makers, service providers and academics, data in social services are often left behind, lacking consistency in utilization.

3.7. Financial incentives do not facilitate the use of HIT

In terms of financial model, 170 NGOs provide subvented social care, of which 165 NGOs are funded under an output-based financial system known as the Lump Sum Grant Subvention System. In brief, as stated in a review report on the system, the Lump Sum Grant Subvention System introduced in 2001 is a system that "recurrent funding is granted to NGOs in a lump sum (thus the name Lump Sum Grant, or LSG)", with an aim of NGOs would be given "greater autonomy and flexibility to deploy resources and re-engineer their services to meet changing social needs" [20]. The lump sum grant is backed up with the Funding and Service Agreement, including the output indicators, as well as the Service Performance Standards (SQS). Noted in SQS3, service unit are encouraged to maintain an accurate and current records, however does not require a written policies and procedures for record management [21].

In the work of Lluch & Abadie, they suggested negative association between HIT and the output-based financial model [13]. Financial reform with a focus of outcome-based model might be a possible solution to provide more incentives to the development of HIT.

4. Discussion

The previous section had summarized 7 items observed in the study of general context of Hong Kong and specific context in the 2 NGOs. These findings indicate that the evidence-based enablers of HIT implementation are lacking in the different elderly services we studied. More importantly, the lack of enablers such as incentivizing policy, flexible technological infrastructure and practice-driven human factor engineering has compromised the accuracy, consistency and clinical relevance for data capturing, monitoring, reporting, decision making and clinical delivery processes across the levels of needs/symptoms, the level of the whole person and the level of the population.

When three enablers identified by Leung, Chau, Lee, Chen, and Lee (2017) [11] are considered, it is clear that the design of HK's HIT in the community lack the human factor engineering that align the technology with practice such that practitioners in the community services are required to, or feel that they are required to acquire additional skills only related to the use of HIT but no relevant to their practice. In addition, our findings also indicate that there lacks flexible technology infrastructure to enable the implementation of HIT, as the practitioners we spoke to view HK's HIT infrastructure as a blackbox. Finally, the disintegration between medical and social care systems in HK and the lack of financial incentives for HIT implementation has further disable the implementation of HIT in HK's community services for elderly.

Furthermore, in Burton-Jones and Volkoff's contextual theory, in general, they had proposed effective use can be enhanced and maintained by accuracy, consistency and reflection-in-action in each process of affordance actualization. The following will discuss how these items are addressed in Burton-Jones and Volkoff's context-specific theories of effective use.

From their theory, in order to achieve better care for individual's specific needs i.e. symptom-based care, relevant data input and data access enable clinical decision-making. In the context of Hong Kong, this three components are not align. Previously the issue on practitioners not familiar with the use of HIT is being reviewed. This issue imposed 1) relevant data not being inputted in electronic copies, 2) challenges in access to data as limited by hard-copies. Similarly, the black box of HIT infrastructure design prohibit practitioners to access relevant data. The issues of an overwriting data system reflected the system design does not capture what data practitioners would be needed in making clinical decision making. Lacking a data quality assurance mechanism imposes risk in accuracy and consistency.

To achieve better care for the whole person, Burton-Jones and Volkoff identified key factors as determining appropriate team actions, well-coordinated care, and appropriate clinical decision made incorporate with the different needs. However, in the context of Hong Kong, the research team had recognized the data systems are disintegrated and fragmented. In addition, under the segregated medical and social data system, Hong Kong lacks a common information platform between the medical and social sectors for collaboration to provide integrated care. As described previously, it is

observed different pace of HIT development between the 2 sectors. The different culture of the use of HIT in the two sectors is a barrier to provide a person-centered care.

To achieve better care for a categorized population, Burton-Jones and Volkoff highlighted appropriate monitoring can improve understanding by appropriate reporting submitted, which can add value to an appropriate managerial decision making. Again, in the context of Hong Kong, the segregated of medical and social sectors impose challenges to care at population-wide level. Also, the financial incentives of social services do not facilitate the use of HIT.

4.1. Limitation and future direction

Like many others who conducted case study research, despite the research team examined our studied service units and sites comprehensively throughout a long period of time and have granted access to data system to the best of their understanding, the study is not a full picture as many information might be lost throughout historical transition and staff turnover of the site(s). It is hoped that in future, leaders of medical and social care would consider to have a thorough documentation of HIT at organization level, and extend it to a population level.

The study is also limited to a high-level analysis of the 3 levels of social care with reference to services provided by 2 NGOs in a different cluster within a similar time frame. In future, context-sensitive health informatics researchers are recommended to investigate the data systems of Hong Kong elderly care continuum in a greater details, preferably to be an analysis of all medical and social services in the same cluster.

5. Conclusions

It has no doubt the current services based on practice wisdom are high quality work on its own, yet exchange of information can support decision-making, particularly at the era of integrated care. The current situation of Hong Kong has been discussed using the contextual theory of system effective use. Three enablers for a successful HIT implementation in integrated care has been reviewed. Policy makers might wish to consider a reform in financial model as to provide more incentives for the development of HIT and to promote integrated care. Infrastructure design has to embed in the clinical workflow and fit-for-purpose, which Data Lake might be a better alternatives. As for human factors, the involvement of psychologists and human factors engineers could be useful in bridging gaps between users and vendors, as well as provide training to overcome the difficulties to adapt HIT.

6. Acknowledgement

This research was supported by the Research Grants Council Theme-Based Research Scheme (Ref.: T32-102/14N).

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