# Evaluating Multiple Perspectives of a Connected Health Ecosystem

Noel Carroll[1,2], Marie Travers[2] and Ita Richardson[1,2]
[1]*ARCH, Centre for Applied Research in Connected Health, University of Limerick, Limerick, Ireland*
[2]*Lero, The Irish Software Engineering Research Centre, University of Limerick, Limerick, Ireland*

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Abstract: Connected Health is an emerging model of care that engages technology to improve patient care and (re)habilitation. It encourages self-efficacy by developing client-centred care pathways and evidence-based interventions to reduce the need for hospital-led care and empower patients in their homes. It also promotes improved 'connectivity' between healthcare stakeholders by means of timely sharing and presentation of accurate and pertinent information about patient status. Connected Health initiatives can achieve this through smarter use of data, devices, communication platforms and people. However, there are few efforts which have established an evaluation model to encapsulate and assess the value and potential impact of Connected Health solutions from multiple stakeholders' perspectives. We examined information systems (IS) and health information systems (HIS) literature to identify whether a model could apply to Connected Health. However, many of the evaluation models are narrow in focus but have influenced our development of the Connected Health Evaluation Framework (CHEF). CHEF offers a generic approach which encapsulates a holistic view of a Connected Health evaluation process. It focuses on four key domains: end-user perception, business growth, quality management and healthcare practice.



## 1 INTRODUCTION

Societal and demographic changes, coupled with economic challenges, have driven the need for us to reconsider how we deliver health and social care in our community (Rodrigues et al., 2012). Healthcare places considerable financial burdens on both public purse and personal finance. In addition, due to demographical shifts, there is a growing demand for care to be delivered in a more personalised context, delivering 'smart' solutions via technological devices. Connected Health is an emerging and rapidly developing field which has the potential to transform healthcare service systems by increasing its safety, quality and overall efficiency.

While considered a disruptive technological approach in healthcare, Connected Health is used by different industries in various sector contexts (for example, healthcare, social care and the wellness sector). Thus, various definitions exist with different emphasis placed on healthcare, business, technology and support service providers, or any combination of these.

Within the research community, Connected Health is not well defined and remains an ambiguous concept. The ECHAlliance (2014) group promote the concept of Connected Health to act as "the umbrella description covering digital health, eHealth, mHealth, telecare, telehealth and telemedicine". In addition, Caulfield and Donnelly (2013) defines of Connected Health as "a conceptual model for health management where devices, services or interventions are designed around the patient's needs, and health related data is shared, in such a way that the patient can receive care in the most proactive and efficient manner possible". The key here is the connectedness and the manner in which technological solutions enable healthcare solutions. In addition, the FDA (2014) describes Connected Health as "electronic methods of health care delivery that allow users to deliver and receive care outside of traditional health care settings. Examples include mobile medical apps, medical device data systems, software, and wireless technology". Thus, as technological solutions seek to enable new healthcare relationships and partnerships, there is a growing interest in examining information and communications technology (ICT) to support the development of Connected Health. Connected Health has been defined by Richardson (2015) as "*patient-centred*



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*care resulting from process-driven health care delivery undertaken by healthcare professionals, patients and/or carers who are supported by the use of technology (software and/or hardware)"*. Therefore Connected Health can be considered to be a socio-technical healthcare model which extends healthcare services beyond healthcare institutions. We capture this in the term '*ecosystem*'. A Connected Health Ecosystem implies that we to strike a balance between the various requirements and dynamics associated with different stakeholder groups in a modern healthcare sector. For example, this can include primary care, secondary care, payers, policy makers, pharmacies, clinicians, patients, family members, innovators, public officials, patient groups, academics and entrepreneurs collaborating to experiment, develop protocols and tests, and evaluate new Connected Health service solutions.

As technological solutions seek to enable such connectivity between healthcare stakeholders (Hebert and Korabek, 2004), there is a growing interest in examining how Information and Communication Technology (ICT) enables Connected Health solutions. If health technology is not designed, developed, implemented, maintained, or used properly, it can pose risks to patients. Therefore, a continuous evaluation lifecycle is critical for various stages of the service lifecycle. However, healthcare technology, such as the case with Connected Health, lags behind in presenting evidence-based evaluation on the contribution of ICT in supporting healthcare services (for example, Heathfield et al., 1998; Fineout-Overholt et al., 2005; Misuraca et al., 2013; Tuffaha et al., 2014).

This paper offers an overview of some of the key evaluation frameworks in e-health and information systems (IS) and investigates how these can contribute towards the evaluation of Connected Health. Bridging these efforts, we propose a Connected Health Evaluation Framework (CHEF). CHEF also plays on the fact that we need to evaluate all of the 'ingredients' before we can learn of the potential impact of Connected Health technology.

## 2 OBJECTIVE & APPROACH

Connected Health is emerging as a solution which offers significant promise in how healthcare can deliver accessible care with improved safety and patient outcomes. Connected Health encompasses terms such as wireless, digital, electronic, mobile, and tele-health and refers to a conceptual model for health management where devices, services or interventions are designed around the patient's needs.

Considering the emerging nature of Connected Health, there are few attempts to develop evaluation frameworks to guide how to investigate the impact of Connected Health technologies. To address this gap, we formulate the following research question:

***Which technology evaluation models can support the evaluation of Connected Health solutions?***

To explore this question, we undertook a literature review with a particular emphasis on information systems (IS) and healthcare IS (HIS) evaluation literature.

## 3 IS & HIS EVALUATION MODELS

The process of evaluation serves a number of fundamental objectives. Within a healthcare context, evaluating the impact of IS is important to understand the dynamic nature of technology and its ability to improve clinical performance, patient care, and service operations (Meltsner, 2012). Therefore, evaluation offers us the ability to learn from past and present performance (Friedman and Wyatt, 1997) with a view to improving process, care (Leveille et al., 2012), economics (Dávalos et al., 2009; Van Ooteghem et al., 2012) and healthcare satisfaction for the future (Kuhn and Giuse, 2001; Van Bemmel and Musen, 1997).

Identifying various methods of evaluation throughout the IS literature enables us to build on the current knowledge and identify techniques to improve healthcare systems (Yusof et al., 2006) which support the emergence and evidence-base of Connected Health innovation. We build on the work of O'Leary et al., (2015) in adopting a generic approach to untangle the complexity of evaluating Connected Health innovation.

There have been several well-cited evaluation models across the IS and healthcare field which we can examine with a view of developing a Connected Health Evaluation Framework (CHEF). Various evaluation approaches on IS were developed with different outlooks including technical, sociological, economic, human and organisational. A number of frameworks also explicitly focus on HIS evaluation.

Our selection criteria were based on the search for information system evaluation models which adopts multiple perspectives of assessment. We discovered that many of the models were too narrow

Table 1: Summary of IS Evaluation Frameworks.

| Framework | Clinical | Technical | Economic | Human | Organisational | Regulation |
|---|---|---|---|---|---|---|
| **4Cs Model** | ✓ | ✖ | ✖ | ✓ | ✓ | ✖ |
| **CHEATS Model** | ✓ | ✓ | ✖ | ✓ | ✓ | ✖ |
| **TEAM** | ✖ | ✓ | ✖ | ✓ | ✓ | ✖ |
| **ITAM** | ✖ | ✓ | ✖ | ✓ | ✓ | ✖ |
| **IS Success Model** | ✖ | ✓ | ✓ | ✓ | ✓ | ✖ |
| **TAM** | ✖ | ✓ | ✖ | ✓ | ✖ | ✖ |
| **HOT-fit Model** | ✖ | ✓ | ✖ | ✓ | ✓ | ✖ |
| **Integrated Model** | ✓ | ✓ | ✖ | ✓ | ✖ | ✖ |
| **RATER Model** | ✖ | ✓ | ✖ | ✓ | ✓ | ✖ |
| **Search Engine Success Model** | ✖ | ✓ | ✓ | ✓ | ✓ | ✖ |

in focus and only address a specific element of information systems which would not be suitable for the generic nature of Connected Health. We summarise these perspectives as follows:

- **Clinical:** medical practice, based on observation, interaction and treatment of patients;
- **Technical:** the application of hardware and software devices to connect healthcare service operations in a more efficient manner;
- **Economic:** understanding the processes that govern the production, distribution and consumption of goods and services which impact on healthcare;
- **Human:** training, personnel attitudes, ergonomics and regulations affecting employment and patient experience in healthcare. This can also examine the evolution of social behaviour and development through the influence of both internal (e.g. attitudes, emotion, or health status) and external factors (e.g. service availability or economics of care);
- **Organisational:** the nature of the healthcare organisation, its structure, culture and politics affect an evaluation;
- **Regulation:** a mechanism to sustain and focus control which is often exercised by a public agency over activities that are valued by the healthcare community and its stakeholders.

We examine these key factors in a number of HIS and IS evaluation models and summarise their primary focus in Table 1.

Table 1 examines various factors which are considered in evaluation ranging from clinical, technical, economic, human, organisation and regulation. This indicates that there is a lack of a holistic evaluation approach on healthcare which must be addressed in Connected Health to deliver innovative and perhaps 'disruptive' solutions (Christensen et al., 2000; Schwamm, 2014). There have been some efforts to evaluate HIS including clinical decision support systems.

## 3.1 HOT-fit Model

Yosof et al., (2006) proposed the Human, Organization and Technology-fit (HOT-fit framework) which was developed from a literature review on HIS evaluation studies. A review of the literature revealed that while specific instances of the evaluation of healthcare technology exists (Mathur et al., 2007; O'Neill et al., 2012), there is no evidence of a generic evaluation model which can be applied to Connected Health to provide a holistic view of its potential impact.

## 3.2 4Cs Model

The 4Cs Evaluation Framework steers away from the technical issues of evaluation and using a social interactionist perspective, it examines how human, organisational and social issues are important for service design, development and deployment. The 4Cs framework examines issues associated with *communication, care, control,* and *context* based on medical informatics (Kaplan, 1997; Kaplan, 2001).

## 3.3 CHEATS Model

Another model which evaluates the use of ICT in healthcare includes the CHEATS framework (Shaw,

2002). It evaluates healthcare through six core areas:

- **Clinical:** focusing on issues such as quality of care, diagnosis reliability, impact and continuity of care, technology acceptance, practice changes and cultural changes;
- **Human and Organisational:** focusing on issues such as the effects of change on the individual and on the organisation;
- **Educational:** focusing on issues such as recruitment and retention of staff and training;
- **Administrative:** focusing on issues such as convenience, change and cost associated with health system;
- **Technical and Social:** focusing on issues such as efficacy and effectiveness of new systems and the appropriateness of technology, usability, training and reliability of healthcare technology.

## 3.4 Team

Another model which evaluates HIS is the Total Evaluation and Acceptance Methodology (TEAM). This offers an approach based on systemic and model theories (Grant et al., 2002) and identifies three key IS evaluation dimensions in biomedicine:

- **Role:** evaluates IS from the designer, specialist user, end user and stakeholder perspective;
- **Time:** identifies four main phases which provide relative stability of the IS;
- **Structure:** distinguishes between strategic, tactical or organisational and operational levels.

## 3.5 IS Success Model

From an Information Systems (IS) perspective, there are also several well cited evaluation frameworks which we examined. For example, the IS Success Model (DeLone and McLean, 1992; Delone and McLean, 2003) examines the success of IS from a number of different perspectives and classifies them into six categories of success (DeLone and McLean, 2003). The model adopts a multidimensional framework which measures independencies between the various categories (Figure 1):

- Information
- System and service quality
- Use (intention to)
- User satisfaction
- Net benefits

These dimensions suggest that there is a clear relationship between the six categories and influences the success of the IS (i.e. net benefits). The net benefits influence user satisfaction and use of the information system.

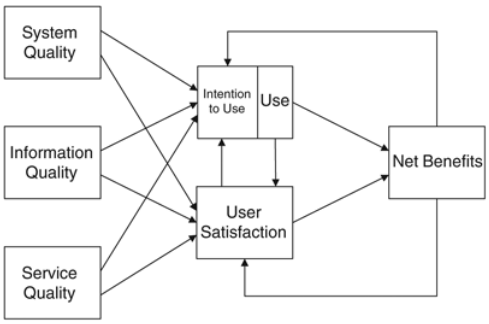


Figure 1: IS Success Model (DeLone and McLean, 2003).

## 3.6 Tam

The Technology Acceptance Model (TAM) examines how users accept the use of technology though a number of important influential factors (Davis, 1989). Among these factors are (see Figure 2):

- The perceived usefulness (U) of the technology;
- The perceived ease-of use (E) of the technology.

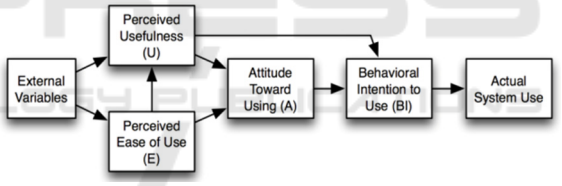


Figure 2: Technology Acceptance Model (Davis, 1989).

TAM suggests that these factors determine people's intention to use a technology. While TAM provides an excellent approach to examining people's acceptance of technology, it is limited in explanatory terms (Gregor, 2006) of technological 'value'.

## 3.7 Search Engine Success Model

In a similar vein, Carroll (2014) extends the IS Success Model to develop the Search Engine Success Model and examines the complex task of evaluating the impact of search engine technology on users. The independencies between the components build upon Delone and McLean IS Success Model but include a more comprehensive view of the value co-creation relationship between the organisation and end-user. From a Connected Health perspective, this model illustrates the cyclical

nature of establishing trust to generate and sustain net benefits. The model adopts a multidimensional framework which measures independencies between the various categories (Figure 3):

- Information
- System and service quality
- Use (intention to)
- Technological capabilities
- Quality of experience
- User expectation
- User satisfaction
- Cognitive reasoning
- Knowledge generation
- Net benefits through a co-creation relationship

## 3.8 ITAM

Adopting a similar outlook on technology evaluation, Dixon (1999) presents a socio-technical evaluation model which examines the behavioural aspects of technology using the IT Adoption Model (ITAM). ITAM provides a framework for using implementation strategies and evaluation techniques from an end-user's perspective (i.e. fit for purpose, user perceptions of innovation usefulness and ease of use, and adoption and utilisation). Related research also focuses on consumer health behaviours and their adoption of medical technologies. For example, Wilson and Lankton (2004) examines consumer acceptance of HIS to support patients in managing manage chronic disease.

## 3.9 Integrated Model

Wilson and Lankton (2004) integrated the use of TAM to extend the model which became known as the Integrated Model (Figure 4). Their Model merges the perception of technology's usefulness (PU) with extrinsic motivation (EM) in a PU-EM scale and perception of a technology's ease of use (PEOU) scales. The key factors of this model evaluate healthcare technology by examining the:

- Perception of a technology's usefulness (PU);
- Perception of a technology's ease of use (PEOU);
- Behavioural intention (BI) to use the technology;
- Intrinsic motivation (IM);
- Extrinsic motivation (EM) to determine BI.

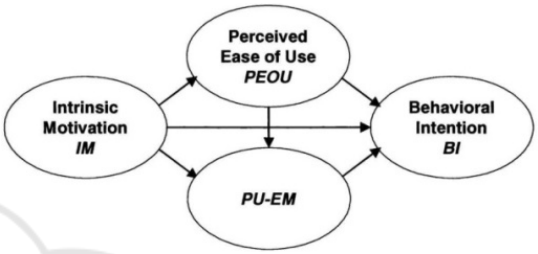


Figure 3: Integrated Model (Wilson and Lankton, 2004).

The five dimensions identified using the Integrated Model can also provide a useful lens to understand the impact of technology in Connected Health, particularly the influential factors on IT-enabled innovation and the adoption of solutions.

Identifying gaps in health service sectors is important to enhance the overall quality of the service delivery and identify how Connected Health solutions can address these gaps.

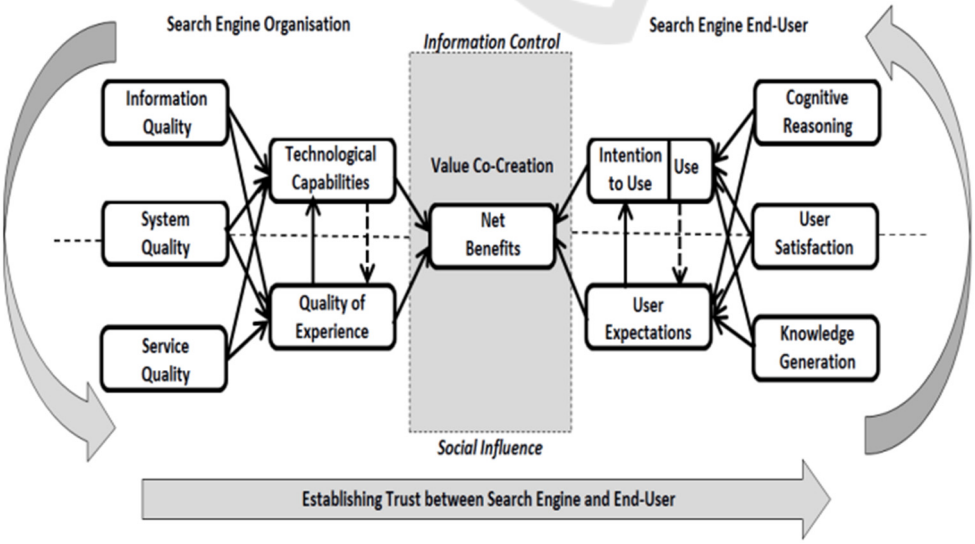


Figure 4: Search Engine Success Model (Carroll, 2014).

### 3.10 RATER Model

There are a number of methods which evaluate the quality of services with a view of identifying areas to prioritise service improvements. For example, the RATER Model (Zeithaml et al., 1990) offers a simplified version of the SERVQUAL model (Parasuraman et al., 1988) using five key customer service issues (Table 2). They focus on five dimensions to analyse and improve service offerings. The five key dimensions can also support the development of a service plan to improve service delivery and are particularly apt in Connected Health solutions.

Table 2: Key Dimensions within the RATER Model.

| Dimension | Description |
|---|---|
| **Reliability** | Ability to provide dependable service, consistently, accurately, and on-time. |
| **Assurance** | The competence of staff to apply their expertise to inspire trust and confidence. |
| **Tangibles** | Physical appearance or public image of a service, including offices, equipment, employees, and the communication material. |
| **Empathy** | Relationship between employees and customers and the ability to provide a caring and personalised service. |
| **Responsiveness** | Willingness to provide a timely, high quality service to meet customers needs. |

### 3.11 Intervention Mapping

Other initiatives which may support the evaluation of Connected Health solutions include the Intervention Mapping Framework (IMF). The IMF provides a systematic and rigorous approach that can be used to develop and promote health programmes. It achieves this through developing theory-based and evidence-based health promotion initiatives. These initiatives may be incorporated into a Connected Health evaluation, particularly from a patient-focused perspective.

### 3.12 Research Gap

From our literature review, we can conclude that evaluating the value of HIS is a complex task. This is also confirmed by a recent report on '*The Value of Health Information Technology: Filling the Knowledge Gap'* (Rudin et al., 2014) which draws similar conclusions in that the majority of evaluation articles are limited. They state that evaluation articles use "*incomplete measures of value and fail to report the important contextual and implementation characteristics that would allow for an adequate understanding of how the study results were achieved*", and provide a conceptual framework using three key principles for measuring the value of healthcare IT as follows:

- Value includes both costs and benefits;
- Value accrues over time;
- Value depends on which stakeholder's perspective is used.

These principles suggest that a core focus of an evaluation strategy ought to focus on 'value' and how this can be represented from various stakeholders' perspectives. Other models discussed above referred to this as 'net benefits' or 'value co-creation'. In summary, while the frameworks explored in this report evaluate various aspects of HIS and IS they do not provide a holistic view of healthcare technology and cannot be successfully applied to support the board nature of Connected Health.

With the aim of developing a more universally adoptable framework for multiple perspectives of Connected Health, we propose the Connected Health Evaluation Framework (CHEF). The need for such an approach was also highlighted by Rudin et al., (2014) who raise concerns regarding evaluation in healthcare: "*unfortunately, we have found that few studies include both costs and benefits in their definitions of value. Most studies look at only short-term time horizons, which ignore many of the downstream benefits of the HIT, and many studies don't even explicitly state to whom the value is accruing.*" We set out to address this gap using CHEF.

## 4 CHEF

This section presents the Connected Health Evaluation Framework (CHEF). The development of CHEF (Figure 5) is influenced by both the strengths of current HIS/IS models and the limitations of these models which emerged from the literature review. In addition, while economics and regulation often shape innovation, both have been largely overlooked in many of the evaluation models we identified.

'Healthcare net benefits' are presented at the core of CHEF. CHEF is comprised of four main layers for Connected Health, broadly addressing clinical, business, users and systems with a view to determine how these co-create value. Each of the categories supports specific Connected Health operations across all service lifecycle stages, ultimately generating healthcare net benefits. For example:

**Business Growth:** as part of the overall healthcare service strategy phase, this focuses on

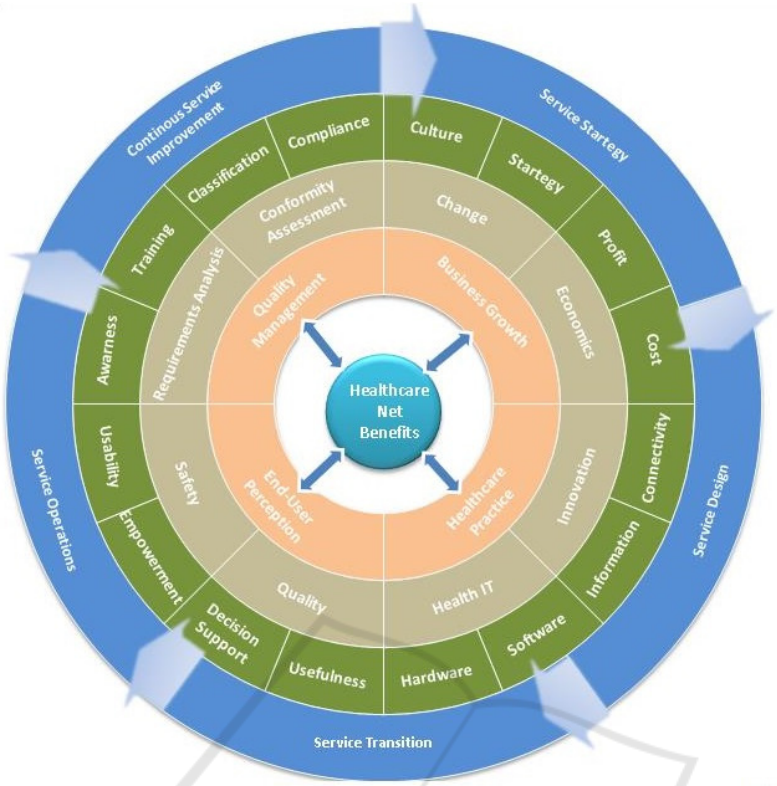


Figure 5: Connected Health Evaluation Framework (CHEF).

driving change and economics in healthcare and organisational market share. Particular emphasis on evaluation focuses on the cultural and strategy change for introduction Connected Health innovations. While introducing Connected Health innovation, an economic evaluation should be undertaken to examine the potential profits and costs associated its implementation.

- **Healthcare Practice:** as part of both the healthcare service design and transition phases, this focuses on health IT and innovation and how it alters practice/clinical pathways (O'Leary et al., 2014). From a technological perspective, an evaluation is carried out on both the hardware and software capability to deliver a Connected Health solution. In addition, the innovativeness of altering healthcare practice is evaluated from a socio-technical and ethnography viewpoint. This allows the examination of the impact of delivering information in a new format and whether it enhances the overall connectivity of healthcare stakeholders.
- **End-user Perception:** as part of both the healthcare service transition and operations phases, this focuses on safety and quality of healthcare innovation for a user's perspective (e.g. a doctor, a patient or carer). This phase evaluates the safety and quality of Connected Health solutions. From a safety viewpoint, an evaluation may be carried out on the usability and level of empowerment a solution may provide in order to provide a balance in empowerment and safety. From a quality viewpoint, we can evaluate whether Connected Health technologies have led to improved healthcare decision-making and enhanced usefulness of technological innovations.
- **Quality Management:** as part of both the healthcare service operations and continuous service improvement phases, quality management focuses on technical and regulation requirements and conformity assessment. This phase can evaluate the requirements of healthcare stakeholders to generate awareness of Connected Health innovation and to support users through improved training programmes. In addition, an evaluation may also assess the organisation's conformity with medical device regulations in terms of technology classification and compliance. This also informs how an organisation can realign their service strategy – and the service lifecycle continues through a continuous improvement philosophy.

Within each of these subcategories, we will identify key metrics (Rojas and Gagnon, 2008) associated with the evaluation of Connected Health solutions. As part of our future work, we will identify operational key metrics for each category and its components to support Connected Health innovation. The outer layer of CHEF comprises of various service lifecycle stages and highlights the need to identify value points in each of the service lifecycle phases.

The service lifecycle phases play a critical role in aligning the service development process and the market opportunities (Figure 6). The Connected Health environment addresses healthcare technology requirements to enhance the level of healthcare service offerings. Connected Health can potentially address unfulfilled needs in healthcare as a result of external forces and various demographic drivers. Many of these drivers are also opening new market opportunities which enable Connected Health solutions to improve healthcare service maturity through enhanced service performance. The value of Connected Health solutions includes an improved quality of experience and usefulness in technological solutions to deliver healthcare.

While acknowledging that technology can provide healthcare solutions, it is equally important to question at each phase of the service lifecycle, for example "*what problem does information solve?"* (Postman, 1992) and "*what is the problem to which this technology is a solution?*" (Postman, 1999). Postman's question applies equally well to the Connected Health field as a basic evaluation question. Building on this, it is critical that as a starting point, and before we can successfully identify value in Connected Health, the current healthcare system is modelled, for example, actor interaction, value stream mapping, resource exchange, service bottlenecks, workflows, organisational structures and mapping the healthcare solutions market landscape.

CHEF offers an approach to guide the evaluation process. Thus, the two key aspects as we move forward in Connected Health evaluation can be derived in:

- Ensuring the systems, devices and services meet the health and social needs of users through evidence-based research;
- Developing innovative patient-centred technological solutions to empower people to effectively manage their health and wellness in the home and community (Delbanco et al. 2012).

In addition, from a Connected Health perspective, evaluation must be conducted to assess its impact across the broad spectrum of care services. The scope of CHEF explicitly acknowledges the broad scope and existence of different stakeholders. CHEF will facilitate evaluations through an assessment process designed to provide:

- A holistic view of a healthcare system;
- Tailored analysis of healthcare service lifecycle;
- Performance metrics on service operations and patient-focused analytics;
- Scorecard and benchmark tools to assess

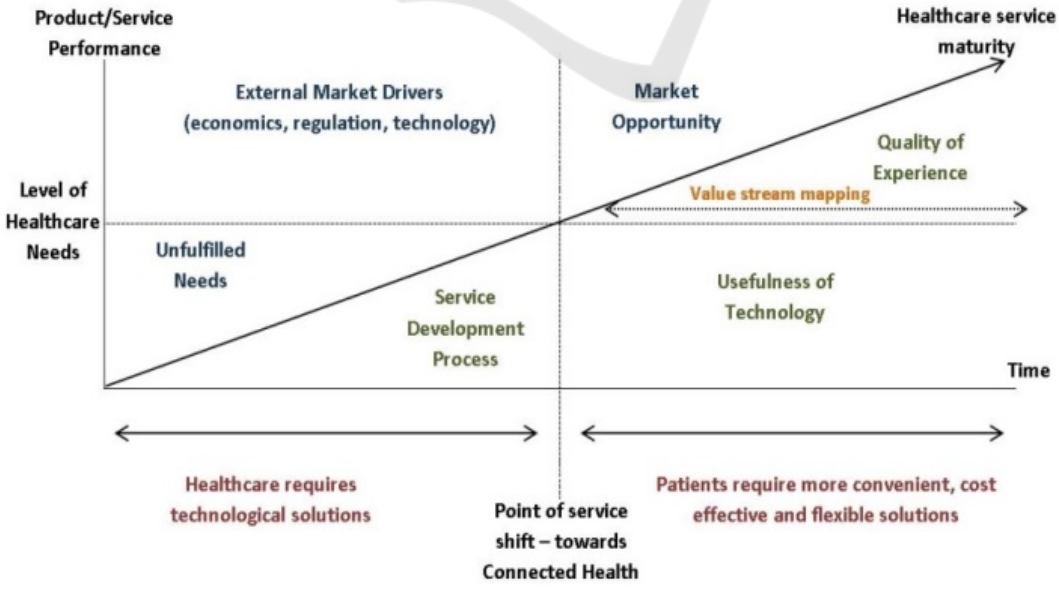


Figure 6: Connected Health Environment.

healthcare technological integrations, healthcare interventions and healthcare providers.

These will also form part of our research strategy in our quest to develop a CHEF and apply it to various healthcare products and services and derive core evaluation metrics. There is a clear correlation between Connected Health functionality and healthcare net benefits from multiple perspectives. CHEF will be further validated through continued industry engagement and Connected Health technologies to accommodate the rapid growth of healthcare IT solutions.

CHEF can also promote innovation by guiding evaluation at all stages of the health IT product lifecycle and encouraging organisations to consider the complex socio-technical ecosystem in which healthcare products are developed, implemented, and used. Particular interests include the quality systems in place to govern Connected Health data management, access to clinical information, stakeholder communication, knowledge management and patient privacy. Regulations and conformity assessment supports the technology evaluation processes from a health and safety perspective. We believe that CHEF will also support organisation in examining potential risks posed by Connected Health functionality and in comparing them to the potential net benefits, for example, developing a benefit-risk profile. In addition, by meeting the regulatory evaluation of a medical device, conformity assessment will evaluate whether they present challenges to Connected Health innovation. Combined, CHEF promotes the need to incorporate Connected Health evaluation at various stages using quality management principles, adopt continuously revised standards and harness a learning and continual improvement environment to improve patient safety.

CHEF will enable organisations to identify poorly designed healthcare solutions, assess performance requirements, monitor human interaction (end-user) and identify potential gaps within a business strategy. In addition, CHEF offers a first step towards employing evaluation to extend the evidence-based foundation for Connected Health through the assessment of best practice and by identifying interventions and opportunities for improvement based on the CHEF evaluation and evidence gathered.

# 5 DISCUSSION & CONCLUSION

With significantly greater shifts in demographics and longevity, the cost of healthcare will show a corresponding increase. In an attempt to reduce these growing costs, governments typically attempt to reduce healthcare overheads, including staffing, patient contact time, consultation and scheduling various appointments. This can also create service bottlenecks which jeopardises the quality and safety of healthcare.

There is evidence that a paradigm shift to empower people to take more control of their own health is occurring. Technology innovation enables and aligns with these healthcare shifts, providing greater service efficiencies and effectiveness and supporting the reduction of costs. Connected Health presents an exciting approach towards redesigned healthcare delivery. However, the success of Connected Health will hinge on evaluation strategies to determine the real value or benefits (healthcare, quality of care, economics, etc.) associated with technological integration in healthcare service systems. This paper presents an overview of how existing evaluation frameworks in e-health and information systems can they influence Connected Health evaluations.

Bridging these efforts, we propose the CHEF which we will employ through industry engagement. Throughout our evaluation research, we also discovered that that concept of connectedness through IT-enabled healthcare is a complex socio-technical environment which is also impacted on various geography, socio-economic status, and technological competence – often influencing their attitudes to Connected Health innovation. Technology therefore plays a key role in fostering healthcare relationships given healthcare stakeholders a sense of being interconnected. Through evaluation processes, if we can develop a better understanding of the Connected Health network structure, we can begin to further evaluate the impact of IT innovation on a healthcare ecosystem.

CHEF is a first step in offering a holistic view of Connected Health and is a step towards an evaluation of healthcare technological innovations. As part of our future work, we will continue to collaborate with industry and academic members within ARCH - Applied Research for Connected Health Technology Centre. Through our multidisciplinary research team, we will extend this work and validate CHEF with various healthcare stakeholders and IT providers.

## ACKNOWLEDGEMENTS

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## REFERENCES

Carroll, N. (2014). In Search We Trust: Exploring How Search Engines are Shaping Society. International Journal of Knowledge Society Research (IJKSR), 5(1), 12-27.

Caulfield, B. M., and Donnelly, S. C. (2013). What is Connected Health and why will it change your practice?. QJM, hct114.

Christensen, C. M., Bohmer, R., and Kenagy, J. (2000). Will disruptive innovations cure health care?. Harvard business review, 78(5), 102-112.

Dansky, K.H., Palmer, L., Shea, D., Bowles, K.H. (2001). "Cost Analysis of Telehomecare". Telemedicine Journal and e-Health. September, pp. 225-232.

Dávalos, M.E., French, M.T., Burdick, A.E., Simmons, S.C. (2009). "Economic Evaluation of Telemedicine: Review of the Literature and Research Guidelines for Benefit–Cost Analysis". Telemedicine and e-Health, December, pp. 933-948.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, pp. 319-340.

Delbanco, T., Walker, J., Bell, S. K., Darer, J. D., Elmore, J. G., Farag, N., Feldman, H.J., Mejilla, R., Ngo, L., Ralston, J.D., Ross, S.E. Trivedi, N., Vodicka, E., Leveille, S.G. (2012). Inviting patients to read their doctors' notes: a quasi-experimental study and a look ahead. Annals of internal medicine, 157(7), 461-470.

Delone, W. H. (2003). The DeLone and McLean model of information systems success: a ten-year update. Journal of management information systems, 19(4), 9-30.

DeLone, W. H., and McLean, E. R. (1992). Information systems success: the quest for the dependent variable. Information systems research, 3(1), 60-95.

Department of Communications, Energy and Natural Resources (2011). Knowledge Society Strategy: Report on e-Health Developments in Ireland. Retrieved on 02/02/2015 from Website: http://tinyurl.com/lrs3aja.

Dixon, D. R. (1999). The behavioral side of information technology. International journal of medical informatics, 56(1), 117-123.

ECHAlliance (2014). Connected Health – White Paper. Retrieved on 09/03/2015 from Website: http://cht.oulu.fi/uploads/2/3/7/4/23746055/connected_health.pdf.

Fineout-Overholt, E., Melnyk, B. M., and Schultz, A. (2005). Transforming health care from the inside out: advancing evidence-based practice in the 21st century. Journal of Professional Nursing, 21(6), 335-344.

Friedman, C. P., Wyatt, J.C. (1997). Evaluation Methods in Medical Informatics. New York: Springer-Verlag.

Grant, A., Plante, I., and Leblanc, F. (2002). The TEAM methodology for the evaluation of information systems in biomedicine. Computers in Biology and Medicine, 32(3), 195-207.

Gregor, S. (2006). The nature of theory in information systems. MIS Quarterly, 30(3), pp. 611-642.

Heathfield, H., Pitty, D., and Hanka, R. (1998). Evaluating information technology in health care: barriers and challenges. BMJ, 316(7149), 1959.

Hebert, M.A, and Korabek, B. (2004). "Stakeholder Readiness for Telehomecare: Implications for Implementation". Telemedicine Journal and e-Health. March, pp. 85-92.

Kaplan B. (1997). Addressing organizational issues into the evaluation of medical systems. J Am Med Inform Assoc.; 4(2): 94-101.

Kaplan, B. (2001). Evaluating informatics applications—some alternative approaches: theory, social interactionism, and call for methodological pluralism. International journal of medical informatics, 64(1), 39-56.

Kuhn, K. A., Giuse, D.A. (2001). "From Hospital Information Systems to Health Information Systems - Problems, Challenges, Perspective," Yearbook of Medical Informatics, 63-76.

Leveille, S. G., Walker, J., Ralston, J. D., Ross, S. E., Elmore, J. G., and Delbanco, T. (2012). Evaluating the impact of patients' online access to doctors' visit notes: designing and executing the OpenNotes project. BMC medical informatics and decision making, 12(1), 32.

Mathur, A., Kvedar, J.C. and Watson, A.J. (2007). "Connected health: A new framework for evaluation of communication technology use in care improvement strategies for type 2 diabetes," Current Diabetes Reviews, vol. 3, no. 4, pp. 229–234.

Meltsner, M. (2012). A patient's view of OpenNotes. Annals of internal medicine, 157(7), 523-524.

Misuraca, G., Codagnone, C., and Rossel, P. (2013). From practice to theory and back to practice: Reflexivity in measurement and evaluation for evidence-based policy making in the information society. Government Information Quarterly, 30, S68-S82.

O'Leary, P., Carroll, N., and Richardson, I. (2014). The Practitioner's Perspective on Clinical Pathway Support Systems. In Healthcare Informatics (ICHI), 2014 IEEE International Conference on (pp. 194-201). IEEE.

O'Leary, P., Carroll, N., Clarke, P. and Richardson, I. (2015). Untangling the Complexity of Connected Health Evaluations, IEEE International Conference on Healthcare Informatics 2015 (ICHI 2015) Dallas, Texas, USA, October 21-23.

O'Neill, S.A., Nugent, C.D., Donnelly, M.P., McCullagh, P., and McLaughlin, J. (2012). Evaluation of

connected health technology," Technology and Health Care, vol. 20, no. 4, pp. 151–167.
Parasuraman, A., Zeithaml, V. A., and Berry, L. L. (1988). Servqual. Journal of retailing, 64(1), 12-40.
Postman, N. (1992). Technopoly: The surrender of culture to technology. New York: Vintage Press.
Postman, N. (1999). Building a Bridge to the 18th Century: How the Past Can Improve Our Future. New York: Alfred A. Knopf Publishers.
Richardson, I. (2015). Connected Health: People, Technology and Processes, Lero-TR-2015-03, Lero Technical Report Series, University of Limerick.
Rodrigues, R., Huber, M., and Lamura, G. (2012). Facts and figures on healthy ageing and long-term care. Itävalta: European Centre for Social and Welfare policy and Research: Vienna.
Rojas, S. V., and Gagnon, M. P. (2008). A systematic review of the key indicators for assessing telehomecare cost-effectiveness. Telemedicine and e-Health, 14(9), 896-904.
Rudin, R.S., Jones, S.S., Shekelle, P., Hillestad, R.J. and Keeler, E.B. (2014). The Value of Health Information Technology: Filling the Knowledge Gap. The American Journal of Managed Care, Special Issue: Health Information Technology, Vol. 20, No. SP 17.
Schwamm, L. H. (2014). Telehealth: Seven Strategies To Successfully Implement Disruptive Technology And Transform Health Care. Health Affairs, 33(2), 200-206.
Shaw, N. T. (2002). 'CHEATS': a generic information communication technology (ICT) evaluation framework. Computers in biology and medicine, 32(3), 209-220.
Tuffaha, H. W., Gordon, L. G., and Scuffham, P. A. (2014). Value of information analysis in healthcare: a review of principles and applications. Journal of medical economics, 17(6), 377-383.
Van Bemmel, J.H. and Musen, M.A. (1997). Handbook of Medical Informatics. Springer-Verlag, Heidelberg.
Van Ooteghem, J., Ackaert, A., Verbrugge, S., Colle, D., Pickavet, M., and Demeester, P. (2012). Economic viability of eCare solutions. In Electronic Healthcare (pp. 159-166). Springer Berlin Heidelberg.
Wilson, E. V., and Lankton, N. K. (2004). Interdisciplinary Research and Publication Opportunites in Information Systems and Health Care. The Communications of the Association for Information Systems, 14(1), 51.
Yusof, M. M., Paul, R. J., and Stergioulas, L. K. (2006). Towards a framework for health information systems evaluation. In System Sciences, HICSS'06. Proceedings of the 39th Annual Hawaii International Conference on (Vol. 5, pp. 95a-95a). IEEE.
Zeithaml, V. A., Parasuraman, A., and Berry, L. L. (1990). Delivering quality service: Balancing customer perceptions and expectations. Simon and ssSchuster.