ECONOMIC ANALYSIS OF SUSTAINABLE EHEALTH IMPLEMENTATION IN DEVELOPING COUNTRIES: A SYSTEMATIC REVIEW

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ABSTRACT

The economic strategies are described as one of the key factors of long-term sustainability of eHealth implementation. The limited amount of budget and the short project duration of donor organizations present a threat to the large-scale and sustainable eHealth implementation in developing countries. The purpose of this study is to uncover the impact of economic factors on the long-term sustainability of eHealth implementation in developing countries.

The economic factors of eHealth refer to financial issues such as the availability of sustainable funding, affordability of technology, cost-effectiveness, cost-minimization and return on investment (ROI). The economic evaluation in healthcare aims at comparing the costs and outcomes of two or more health interventions. The popular economic evaluation techniques in healthcare include cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and cost-utility analysis (CUA). Studies indicated that economic factors influence the large-scale implementation and sustainability of eHealth projects.

A comprehensive systematic review of three databases (Science direct, PubMed, SAGE journal) was conducted. The search terms e-Health, eHealth, econom*, finance* and fund* were used to identify studies published between 2007 and 2017. A Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) approach were followed in this study.

The trend analysis showed studies that address the economic factors of eHealth have grown considerably in the past decade. 411 unique studies were identified after the removal of duplications, non-English texts and studies without full texts. Finally, 15 studies met the inclusion criteria. The majority (85%) of 411 articles were excluded because they failed to address the economic evaluation aspects of eHealth.

The result of this study showed that 9 of 15 (60%) of selected studies reported the economic attractiveness of eHealth interventions indicating the potential promise of eHealth to benefit a wider group of stakeholders. We found no economic evaluation studies from developing countries on eHealth systems in this review. This suggests the greater need for economic evaluation of eHealth interventions in developing countries. Finally, the research highlighted the complexity of the economic evaluation of eHealth interventions and the need for a comprehensive economic evaluation approach.

Key words: eHealth; Economic factors; Sustainability; Cost-effectiveness; Cost-benefit analysis; Developing Countries.

INTRODUCTION

The challenges associated with sustainability and uptake of eHealth systems are still unresolved issues that require further analysis and intervention (Bergmo 2015). eHealth, as defined by World Health Organization (WHO), is the use of Information and Communications Technology (ICT) for health. The economic strategies are described as one of the key factors for a long-term sustainability of eHealth implementation (De Rosis & Nuti 2017). The financial model of eHealth implementations in the developing countries differs from the developed world in terms of the amount, source and period of funding. The implementation of eHealth in developing countries is typically driven by the non-governmental organizations (NGOs) and private players (Quaglio et al. 2016; Jahangirian & Taylor 2015). However, donor-funded projects pose a strong hindrance to interoperability and standardization of eHealth system pushing high the overall cost of eHealth implementation (Schweitzer & Synowiec 2012). The limited amount of budget and the short project duration of donor organizations presented a threat to the long-term sustainability and large-scale implementation of eHealth (Quaglio et al. 2016). The purpose of this study is to uncover the impact of economic factors on the long-term sustainability of eHealth implementation in developing countries. The consideration of the financial factors associated with eHealth implementation as early as possible may significantly support the scale-up and sustainability of technology in the later phase of implementation, especially in developing countries where there is a budget limitation.

The implementation of eHealth is anticipated to reduce the healthcare cost; however, evidence shows that technological innovations have tended to drive the healthcare unit cost upwards in the developed world (Schweitzer & Synowiec 2012; Da´valos et al. 2009). The 25.9 billion dollars of financial incentives launched in the USA to support the “meaningful use” of electronic health systems accelerated the broad use of Electronic Health Records (EHRs) by the hospitals (Stroetmann et al. 2015). Similarly, incentives such as reimbursement schemes, free computers and software, grants and ultimately pay-for-performance played a key role in the diffusion of eHealth systems in the UK (Stroetmann et al. 2015). Stroetmann et al. (2015) concluded that financial incentives can facilitate the use of EHR but it does not ensure sustainable use of EHRs. The high investment and incentive costs are hardly affordable by the developing countries to facilitate the adoption of eHealth.

The eHealth implementation success significantly differs between Electronic Medical Records (EMR) implementation in high-income countries (HIC) and low-income countries (LIC) as a result of resource availability which is linked to economic factors and efficiency of existing paper-based workflows (Driessen et al. 2013). For the 2018 fiscal year, the World Bank classified developing countries or LIC as countries with GNI per capita $1,005 USD or less in 2016 (the World Bank 2017). The economic affordability of the countries is one of the major differences between developed and developing countries in terms of implementing sustainable eHealth (Hebert 2011). The total health expenditure of LIC in 2014 was only 5.8% of GDP compared to the health expenditure of the HIC (12.3% of GDP) (The World Bank 2017). The per capita total expenditure on health at average exchange rate was $37 USD for LIC which was significantly less than HIC ($5,266 USD) in 2014 (The World Bank 2017). The financial category was one of the eight major barriers of eHealth implementations as discussed in the systematic review study of electronic medical records acceptance by physicians (Boonstra & Broekhuis 2010). Financial issues of eHealth implementation refer to initial investment costs, ongoing maintenance costs, uncertainty over return on investment (ROI), cost-effectiveness, cost-

minimization, and availability of financial resources (Boonstra & Broekhuis 2010; Stroetmann et al. 2015).

The shortage of funding and health professionals' willingness to use eHealth is often referred as the main challenge to sustaining and increasing the uptake of eHealth services (Bergmo 2015). In order to ensure the cost-effectiveness of eHealth interventions, Naversnik & Mrhar (2014) proposed a cost-sharing scheme between the payer and provider that helps to avoid a potential loss to the provider and high treatment cost to the payer. Despite the financial constraints in LIC, the role of economic factors in the long-term sustainability of eHealth systems did not get enough research attention in developing countries. This study aims at answering how the sustainable implementation of eHealth is influenced by the economic factors in developing countries through a systematic review.

The successive sections present the theoretical background of health economic evaluation techniques and a systematic review methodology applied in this study. The findings of the study are presented in the results section under three sub-categories, i.e., promising, inconclusive and unfavourable outcome reports.

HEALTH ECONOMIC EVALUATION TECHNIQUES

The economic evaluation in healthcare aims at comparing the costs and outcomes of two or more health interventions (McCabe 2009). In the economic evaluation of eHealth, measuring costs appear more direct than valuing health outcomes (Bergmo 2015). The economic evaluation in health care differs in their approach to measuring outcomes (McCabe 2009). The two popular economic evaluation techniques in healthcare are cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) (Bergmo 2015; McCabe 2009). The need for economic evaluation of eHealth is high, because of insufficient scientific evidence to reach a generalizable conclusion for eHealth investment decisions (Schweitzer & Synowiec 2012; Bergmo 2015). The economic evaluation techniques in health care are summarized in Table 1.

Table 1: Summary of economic evaluations in health care (Bergmo 2015).

Type of analysis	Aggregation of consequences
Cost-benefit analysis (CBA)	CBA measures the consequences in monetary terms expressed as a net benefit, that is, benefits minus costs. CBA answers the following question: Is the new eHealth service worthwhile?
Cost-effectiveness analysis (CEA)	CEA measures the consequences as health changes, for example, blood glucose levels, wound size, disability days avoided, and life years gained. CEA establishes which of two or more alternatives is less costly for at least as much benefit, more effective for equal or lower costs, or is more effective and more costly (in a cost per unit of effect).
Cost-utility analysis (CUA)	CUA measures the consequences as "healthy years," for example, as quality-adjusted life years (QALYs). CUA establishes which of two or more alternatives is less costly for at least as much benefit, more effective for equal or lower costs, or is more effective and more costly (in a cost per QALY).

Cost-benefit analysis (CBA)

CBA compares the total expected costs of an intervention against the total expected benefits to verify if the benefits surpass the costs of intervention (McCabe 2009). In CBA, a monitory value is attached

to benefits and costs and adjusted for the time value of money (Bergmo 2015; McCabe 2009). The effort of assigning monitory values to health outcomes and non-resource benefits is often difficult; hence CBA is rarely used in healthcare evaluation (Bergmo 2015).

Cost-effectiveness analysis (CEA)

CEA is a method for determining the gains in health using a natural unidirectional index of outcomes, for example, blood glucose level and wound size, relative to the costs of different health interventions (McCabe 2009). The aim in CEA is to achieve better benefit which is measured as health changes at a lower cost (Parsi et al. 2012). It involves determining costs and assigning values to the outcomes. The CEA is necessary to evaluate the sustainability of eHealth technology (Parsi et al. 2012). The two types of CEA are standard CEA and cost-utility analysis (CUA) (Bergmo 2015). In standard CEA, the costs per unit of health (i.e., quality-adjusted life years [QALY]) is calculated for a given intervention and compared to current practice (Bergmo 2015; Naversnik & Mrhar 2014). QALY represents the combination of the duration of life and the health-related quality of life (McCabe 2009). The conditions of cost-effectiveness treatment are (Parsi et al. 2012:565):

- Added health benefit at an equal or lower cost than the alternative treatment;
- Added health benefit is worth an additional cost
- Saving cost that is more valuable than the health benefit lost.

Cost-utility analysis (CUA)

CUA measures the difference in the expected health outcomes of two interventions in terms of QALY and compares with the difference between the expected costs of achieving a health benefit to calculate the incremental cost-effectiveness ratio (ICER), money/QALY gained (Bergmo 2015; McCabe 2009). A cost-effective intervention has ICER value below a predetermined threshold (Naversnik & Mrhar 2014). CUA allows decision makers to compare the value of interventions for different health issues which cannot be addressed by CEA (McCabe 2009). The failure of QALY to capture the differences in the process characteristics of interventions is one of the limitations of CUA (McCabe 2009).

Cost-minimization analysis (CMA)

Another economic evaluation technique that compares the cost of alternative interventions that have equal health outcomes is CMA (Bergmo 2015). It is usually difficult to establish a similar level of health outcomes from two or more health interventions which make CMA less practical method of economic evaluation (Bergmo 2015). CMA focuses on the cost side of eHealth intervention and can be useful if the goal of the economic evaluation is to select the least costly system to deliver health service (Bergmo 2015).

MEASURING COSTS AND BENEFITS OF EHEALTH

Measuring costs

In 2015, the eHealth expenditure in the Italian healthcare sector was 1.34 billion Euros, which was 1.2% of the national GDP (De Rosis & Nuti 2017). The eHealth investment is growing globally. The direct health technology costs and non-health technology costs are the two cost categories of eHealth

interventions (Bergmo 2015; Schweitzer & Synowiec 2012). The direct health technology costs include initial investment, change management, human resources, training and maintenance of technology (Parv et al. 2012; Schweitzer & Synowiec 2012). The implementation of eHealth incurs fixed costs such as equipment costs and variable costs such as a monthly or yearly leasing cost of connectivity (Bergmo 2015). The cost analysis of several studies failed to address the costs of essential infrastructure, personnel, maintenance and network connectivity costs associated with the implementation and operation of electronic discharge communication tool (Sevick et al. 2017). The healthy time lost due to illness is assumed to be relevant non-health care costs in eHealth interventions (Bergmo 2015). The non-healthcare costs associated with eating disorder includes costs related to transportation, social service and absence due to illness and loss of productivity at work or premature death (Aardoom et al. 2016). The increasing variable costs associated with scale-up should be considered in the cost analysis of eHealth interventions (Paganini et al. 2017). Hebert (2011) recommended eHealth implementation budget of a country including one-time investment costs and ongoing maintenance and support expenses should not exceed 1% of the annual health budget of the country.

Measuring benefits

The benefits of EHR are categorized into direct, indirect and intangible benefits (Parv et al. 2012). Some of the potential benefits of eHealth intervention in terms of reducing costs and increasing efficiency of healthcare service include facilitating patient information record, remote diagnostics, disseminating health information, training staff, disease surveillance, appointments and scheduling follow-ups (Schweitzer & Synowiec 2012). The benefits of eHealth interventions can be discussed from the perspective of three key stakeholders groups, i.e., patient, provider, and other stakeholder or society (Parv et al. 2012; Schweitzer & Synowiec 2012). The eHealth benefit to a patient includes improved medical effectiveness, better quality of healthcare services, continuity of employment or income generation, reduced travel and better-informed patient (Parv et al. 2012; Schweitzer & Synowiec 2012). The providers' benefit from eHealth intervention may include the reduced burden of healthcare services, better-informed professionals, accurate and fast diagnosis, and improved productivity of healthcare professionals (Parv et al. 2012; Schweitzer & Synowiec 2012). Other stakeholder groups such as patient relatives may benefit from eHealth interventions by avoiding communicable diseases, reducing transportation cost and lowering absenteeism from work (Schweitzer & Synowiec 2012).

In summary, measuring the costs benefits of eHealth intervention requires a compressive approach to include the initial and ongoing investment costs. Although it may not be always simple, valuing the direct and indirect health benefits of eHealth intervention from the perceptive of key stakeholder groups is important to accurately evaluate the cost-effectiveness of eHealth interventions.

METHODOLOGY

For this research, we have searched the abstract, title and keyword of ScienceDirect, title and abstract of PubMed, and abstract of SAGE journal databases to identify eligible studies that meet the search criteria. The last search for all databases was performed in October 2017. Peer-reviewed journal articles were the focus of this systematic review study. To ensure the transparent and complete reporting of systematic reviews, the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) approach is followed in this study (Liberati et al. 2009).

In the preliminary searches, we noticed that both “eHealth” and “e-Health” are used interchangeably in the academic literature. Hence we used both eHealth and e-Health as search terms to address electronic health systems. The economic factors are represented by search terms such as econom*, finance* and fund*. We used the advanced search option on all three databases. The search for all periods in the three databases indicated that the term “e-Health” is slightly more popular than “eHealth” in the academic journals. However, in the past 10 years (2007-2017), the term eHealth has gained popularity than e-Health. We used both terms and connected them with the Boolean operator “OR” to include all studies that used either of the terms. The final search phrase was [eHealth OR “e-Health”] AND [econom* OR finance* OR fund*]. The search term “econom*” is used to include phrases such as economic or economy; “financ*” is included to address financial or finance related studies; “fund*” is used to incorporate terms such as fund, funding, funder and funded. Table 2 shows the detail search algorithm used for the three databases. The identified articles were imported into Mendeley reference database and the duplications were removed.

Table 2: Details of Search algorithm.

Database	Search phrase	Searched in	Publication dates	Access type
SAGE journals	[[Abstract eHealth] OR [Abstract "e-Health"]] AND [[Abstract econom*] OR [Abstract financ*] OR [Abstract fund*]]	Abstract	2007 - 2017	All content
ScienceDirect	TITLE-ABSTR-KEY(eHealth OR "e-Health") and TITLE-ABSTR-KEY(econom* OR financ* OR fund*)	Abstract, Title, Keywords	2007 -Present	All Journals in All sciences
PubMed	((eHealth[Title/Abstract] OR "e-Health"[Title/Abstract]) AND (econom*[Title/Abstract] OR financ*[Title/Abstract] OR fund*[Title/Abstract]))	Abstract/Title	10 years	Full text

Eligibility criteria are necessary to the evaluation of the review’s validity, applicability and comprehensiveness (Liberati et al. 2009). The studies published in the past 10 years from 2007 -2017, and studies reported in English were included in this study. Moreover, only studies available in full text were selected. The type of articles included in this study addressed issues of sustainable funding, affordability, cost-effectiveness, cost-utilization, cost-benefit analysis, return on investment (ROI), cost-saving, and cost-minimization of eHealth technology. The selection decisions were made based on the title and abstract of the papers. The full-paper review was performed on studies that met the inclusion criteria and studies that were not conclusive from their titles and abstracts.

The information extracted from each of the included studies comprises

- The perspective of the study such as patient, health care professionals, societal or providers.
- The health economic evaluation techniques used, like CBA, CEA, CUA, and CUA.
- The type of eHealth application such as EMR, EHR, mHealth, telemedicine, and web-application.
- The area of intervention addressed by the eHealth like dermatology, depression disorder, diabetes, health record digitalization, or others.
- The place or country of study.
- The number of participants.
- Period of study.
- Research methodology.
- The outcomes of economic evaluation studies.

RESULTS AND DISCUSSIONS

The number of eHealth studies that address economic factors has grown from 3 studies in 2007 to 79 studies in 2017. The full period search for studies of eHealth economics published in ScienceDirect, PubMed, and SAGE journal showed that 90%, 80% and 82% of the total studies were published in the past decade respectively. The majority (83%) of eHealth economic studies available in these three databases were published in the past 10 years, hence the literature review focused on studies published between 2007 and 2017. The search on the three databases (ScienceDirect, PubMed, and SAGE journal) returned with a total of 527 articles that met the search criteria. After the removal of duplications, 453 distinct articles remained. We further excluded 22 articles that were non-English text and did not have full text. After reviewing the abstracts of all remaining 411 selected studies, we identified 70 studies for full-text analysis and 15 articles met the inclusion criteria. The majority (85%) of 411 articles were excluded because they failed to address the economic evaluation aspects of eHealth. The flow diagram in Figure 1 depicts the selection process of eligible studies in this research.

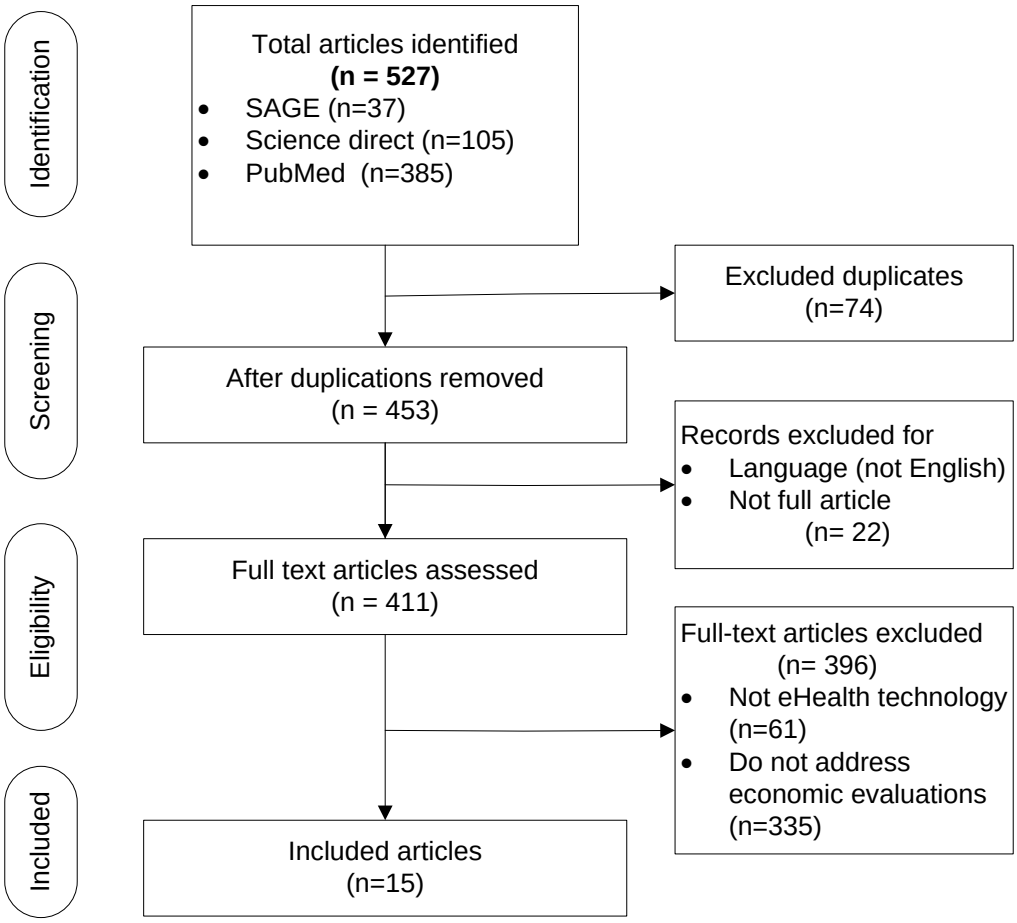

Figure 1: Flow chart for the identification of relevant studies.

The selected 411 studies were published in a total of 183 journals, and 126 (31%) of these studies were published in five journals (Table 3). The publication trend of selected studies shows an increase in the number of eHealth economic articles in the past 10 years. Four of 15 included articles were systematic review studies, whereas the rest (11) of selected studies were non-systematic studies.

Table 3: The journal representation of selected studies.

No	Name of Journals	Total Studies	Percent
1	Studies in health technology and informatics	50	12%
2	Journal of medical Internet research	24	6%
3	Telemedicine journal and e-health : the official journal of the American Telemedicine Association	21	5%
4	JMIR research protocols	16	4%
5	International journal of medical informatics	15	4%

Areas of eHealth interventions

The eHealth interventions in this systematic review supported wide range health challenges such as dermatology (psoriasis), depression disorder, eating disorder, patients at emergency care, type II diabetes patients, digitize paper documents, discharge process facilitation, migraine prediction, and prevention recurring ankle sprain.

Types of eHealth applications

The eHealth applications addressed in the selected studies included mHealth (4), telemedicine (1), EHR (6), and three studies addressed a combination of different eHealth applications; but one study (De Rosis & Nuti 2017) failed to specify the type of eHealth application. The six EHR systems supported financial systems (Akematsu & Tsuji 2010), emergency care summary (Jones et al. 2009), discharge communications (Sevick et al. 2017), general health record (Buccoliero et al. 2008; Parv et al. 2012), and disability health information (Noben et al. 2017).

Health economic evaluation techniques

Three of the fifteen studies used Randomized Control Trial (RCT), with two studies reporting the cost-effectiveness of eHealth interventions; whereas the evidence from one study was not conclusive (Parsi et al. 2012; Aardoom et al. 2016; Van Reijen et al. 2017). The trail-based evaluation is the most appropriate method to evaluate the cost-effectiveness of a particular eHealth intervention in a specific setting (Bergmo 2015). Four studies used a systematic review without conclusive results on the cost-effectiveness of eHealth interventions. Three case studies (Pagán et al. 2018; De Rosis & Nuti 2017; Buccoliero et al. 2008), two quantitative approach (Akematsu & Tsuji 2010; Noben et al. 2017), one cost-benefit analysis (Jones et al. 2009), one pilot efficacy trial (Naversnik & Mrhar 2013) and a qualitative study with a panel of experts (Parv et al. 2012) were used to present the economic evaluation outcome of eHealth interventions.

The place where the studies were executed

Out of fifteen included articles, four of them were based on a systematic review study. From eleven non-systematic review studies, nine studies were from Europe, one study (Parsi et al. 2012) from the USA and another study (Akematsu & Tsuji 2010) from Japan. Three of four systematic review studies (Elbert et al. 2014; Sevick et al. 2017; Paganini et al. 2017) reported the countries where the studies were executed except for one systematic review study (de la Torre-Diez et al. 2015). Three studies indicated European countries in their reviews, two studies were from North America, and only one systematic review included studies from Latin America, Asia, and Oceania countries. We found no

studies on the economic evaluation of eHealth interventions from developing countries. This highlights the high demand for studies of economic evaluation of eHealth systems in developing countries. Bergmo (2015) discussed that the economic evaluation of eHealth systems depends on the type of services provided and the context of local settings, such as infrastructure and technologies investment needs. The cost-effectiveness study is affected by the economic condition of the country which is directly related to the stakeholders willingness-to-pay (WTP) (Paganini et al. 2017). As a result, cost-effective eHealth interventions in developed countries may not be cost-effective in developing countries because of a big gap between the two settings in the value of stakeholders' WTP.

The outcomes of economic evaluation studies

The majority of studies (nine of fifteen studies, 60%) reported a promising evidence of eHealth economic benefits either in terms of cost-effectiveness, cost-savings or cost-minimization (Table 4 & Table 5). Five studies, of which four of them were systematic reviews, presented a mixed report without conclusive evidence on the cost-effectiveness of eHealth interventions (Table 6). One study concluded that the web-based employment intervention aimed at increasing the quality of life for disabled employees was not cost-effective. The outcome of the economic evaluation is discussed in detail as promising, inconclusive and unfavourable outcome reports.

Promising outcome reports

The result of two studies that used RCT method to evaluate the cost-utility and cost-effectiveness of eHealth intervention for eating disorder therapy and management of skin disease respectively, reported the cost-effectiveness of the interventions from the societal perspective (Table 4). The first study investigated the cost-utility of fully automated Internet-based intervention "Featback" with different levels (i.e., none, once a week, and three times a week) of therapist support in comparison to a waiting list for individuals with eating disorder symptom (Aardoom et al. 2016). Waiting list represents individuals who waited 5 months before receiving low-intensity therapist support with Featback (Aardoom et al. 2016). The finding showed no clear preferences in the Internet-based intervention with or without therapist support from the economic viewpoint; however, the Internet-based intervention seemed to be cost-effective in comparison to a waiting list (Aardoom et al. 2016).

The second study compared the cost-effectiveness of standard in-office care and an online patient-centred model for management of psoriasis, skin disease, from a societal perspective (Parsi et al. 2012). The result showed that the patient-centred online model appeared to be a cost-effective healthcare service delivery. For an approximately similar effectiveness level, the online patient-centred intervention costs $241.10 USD less per patient than in-office visits from a societal perspective (Parsi et al. 2012). The online patient-centred model empowered patients with psoriasis to capture and transmit skin images and medical history that reduce the time wasted through travel and waiting for face-to-face consultation of in-office care (Parsi et al. 2012).

The CBA of an electronic Emergency Care Summary (ECS) system and the CEA of a Web- and Mobile-health system to treat depression disorder showed promising economic benefits (Table 4). An electronic system of ECS in Scotland has improved patient safety by providing information about patients' medication, drug adverse reactions and allergies during patients' emergency care services (Jones et al. 2009). The ECS served 1.3 million people (25% of Scotland's population) with live medication information (Jones et al. 2009). The result of CBA indicated that it took seven years for a

cumulative benefit to exceed the cumulative cost of ECS (Jones et al. 2009). Another study on the cost-effectiveness of Improvehealth.eu showed attractive economic benefits in Slovenia (Naversnik & Mrhar 2013). Improvehealth.eu service is an eHealth system that supports the treatment of patients with a depression disorder through online- and phone-based care management performed by a trained psychologist (Naversnik & Mrhar 2013). The cost-effectiveness scenario analyses of Improvehealth.eu produced ICER values ranging between 1,000 Euro/QALY and 5,000 Euro/QALY, which is lower than the average WTP value of Slovenians, 30,000-45,000 Euro/QALY (Naversnik & Mrhar 2013). The high attrition rate (24 of 46 patients were not available at follow-up), use of cost data from the UK study and assumptions in the area of uncertainty can be viewed as the limitation of the study.

The promised economic gains of an electronic ECS system requires an increase in the number of system users which is very unpredictable especially in healthcare settings. Besides, the majority of ECS benefits (77%) were non-financial and 23% the benefits came from deployed finance (Jones et al. 2009). Similarly, the weak assumptions in the CBA and CEA of both ECS and a Web- and Mobile-health systems were the limitations of the studies.

Table 4: Promising economic benefits of eHealth based on CEA, CUA and CBA methods.

Author	Naversnik & Mrhar 2013	Aardoom et al. 2016	Parsi et al. 2012	Jones et al. 2009
Study perspective	Patient	Societal	Societal	Patients, Technology Providers, Health-care professionals
Evaluation techniques	CEA	CUA	CEA	CBA
eHealth type	Web- & Mobile-Health	Internet-based intervention (Featback)	Telemedince	Electronic Emergency Care Summary
Area of intervention	Depression disorder treatment	Eating disorder	Dermatology (psoriasis)	Patients at emergency care
Country	Slovenia	Netherlands	USA	Scotland
Participants	46 Patients	354 Participants	64 patients	1.3 million people
Study period	6 months	Not specified	24 weeks	2002 -2010
Methodology	Pilot Efficacy Trial/ Scenario analysis	RCT	RCT	Cost-benefit analysis
Results	Promising	Promising	Promising	Promising

Three studies reported the promissing benefits of eHealth intervention in terms of cost-minimization and cost-saving of medical expenditure (Table 5). A study compared the medical expenditure of 199 eHealth users and 209 non-user groups in Nishi-aziru, Japan indicated that the eHealth users group spend $156.88 USD per year (21.2% of average annual medical expenditure) less than non-user groups (Akematsu & Tsuji 2010). Furthermore, as the users utilize the system one more year, the medical expenditure of lifestyle-related illnesses reduced by $11.33 per year, which is about 1.5% of the average annual medical expenditures (Akematsu & Tsuji 2010).

In a different study of Wireless Body Sensor Network that predicted a migraine headache, a simulation was carried out targeting 2% (1,393,649) of the 15% migraine patients in Europe for a period of 10 weeks (Pagán et al. 2018). The simulation result of a case study predicted 32.6% energy saving from low-power technique and workload balancing policies of the intervention which was translated into a cost saving of €288 million when applied to 2% of European migraine patients (Pagán et al. 2018). Additionally, €1,272 million Euro savings were expected to be achieved from the benefits of migraine prediction (Pagán et al. 2018).

The third study considered a wider stakeholder group to assess the economic value of ESCAPE project, an ICT system to digitalize the clinical and administrative paper documents (Buccoliero et al. 2008). The study evaluated the reputation and operational efficiency of the organization, the values created to the patients, and the level of approval by the wider community of the region as a result of ESCAPE project (Buccoliero et al. 2008). Assuming the production of 272 000 external health reports a year and targeting 40% of patients to use the electronic system, the net value of the project to the organization in 5 years span at a discounted rate of 3.5% demonstrated slightly positive result (approximately €39,000 Euro gain) (Buccoliero et al. 2008). The reduction of mistakes, improvement in reporting, image improvement (hospital brand) and reduced waiting and service time were presented as intangible corporate benefits of the electronic system (Buccoliero et al. 2008). The evaluation of the social benefit of the electronic system showed a statistically significant reduction of the average waiting time for non-urgent reports from 23.4 to 17.1 hours (Buccoliero et al. 2008). The overall social benefit from the simplification of the document delivery, i.e., costs saved from the time required to pick up the report from the closest delivery office and travel expenses, was estimated to be approximately €4,072,826 Euro (Buccoliero et al. 2008).

Despite the potential of eHealth interventions to minimize health expenditure of patients, studies fail to address the cost implications of eHealth intervention to the healthcare organization. Healthcare providers bear two third of the overall costs of eHealth, but only sharing 6% of the benefits through improved efficiency (Parv et al. 2012). The National Health Service board of Scotland and the patients regarded as the main beneficiaries of ECS, each sharing approximately 40% of the benefits. The health-care professionals accrue the reminder of the benefits (Jones et al. 2009). Hence future studies need to follow a comprehensive economic evaluation of eHealth to address not only the economic benefits to the patient and society but also eHealth economic implication to the providers and healthcare professionals.

Table 5: Promising economic benefits of eHealth from the perspectives of key stakeholder groups.

Author	De Rosis & Nuti 2017	Buccoliero et al. 2008	Pagán et al. 2018	Akematsu & Tsuji 2010	Parv et al. 2012
Study perspective	Physicians, Patients, organizations, innovators, regulatory	Organizational, patient and society	Patients, Organizational	Patient	Societal
Evaluation techniques	Not specified	ROI and Cost-saving	Cost-saving	Cost-minimization/ Cost-saving	PENG evaluation
eHealth type	Not specified	EHR	Mobile cloud computing	EHR - Finance	EHR-
Area of intervention	Not specified	digitalize the clinical and administrative papers	Predicting migraine patients	Not specified	Type II diabetes
Country	Italy	Italy	European countries	Japan	Estonia
Participants	33 Participants	272,000 reports	2 migraine patients	412 Patients	Not specified
Study period	Sep 2014 - Mar 2015	2003- 2006 (Estimated)	10 weeks	1994-2006	Not specified
Methodology	Case study, Qualitative	Case study, Mixed	Simulation/ Case study	Quantitative	A panel of Expert
Results	Promising	Promising	Promising	Promising	Promising

Eventually, the Estonian EHR economic evaluation result showed that the estimated annual net benefit will surpass costs within three years (Parv et al. 2012). Starting from the third year, the annual benefits of EHR continued to grow with the increasing number of users until it reached the steady state in the seventh year (Parv et al. 2012). The main beneficiaries of the EHR system are society represented by the government who will contribute back through increased tax contribution as healthier workforces (Parv et al. 2012). A panel of experts' analysis concluded that despite considerable costs of EHR in Estonia, its potential benefits are high (Parv et al. 2012). A case study

involving 33 informants from key stakeholders group explored the possible strategies and financial mechanisms for successful long-term implementation of eHealth intervention in public health care (De Rosis & Nuti 2017). The importance of considering the initial investment and long-term financial plan in the current economic crisis and budget constraints was highlighted by informants (De Rosis & Nuti 2017). Informants from the firms mentioned that focusing on initial investment without considering ongoing costs, time-consuming public procurement process and short-term grant approach were mentioned as challenges to sustain eHealth solution (De Rosis & Nuti 2017). Since healthcare providers bear two third of the overall costs of eHealth interventions sharing only 6% of the benefits through improved efficiency (Parv et al. 2012), the economic evaluation must consider the perspective of key stakeholder groups and both initial and ongoing costs (De Rosis & Nuti 2017).

In summary, the majority (60%) of the studies reported attractive economic benefits of eHealth interventions. However, these studies are not without limitations. Five of nine selected studies that reported promising economic benefits evaluated the technologies from the perspective of only one stakeholder. The RCT method which is described as the most appropriate method to evaluate the economic benefits of eHealth was applied by only two of the nine studies that reported promising economic outcomes. Furthermore, the diversity of eHealth applications in evaluation studies, the difference in the perspective of the studies, the difference in the settings of the study make difficult to transfer the result to other settings. Some findings of positive benefits depend on the forecasted increasing utilization of eHealth intervention by end users, which may not be always true.

Inconclusive outcome reports

The result of four systematic reviews and one cost-effectiveness study presented a mixed report without conclusive evidence on the economic benefit of eHealth interventions (Table 6). The first systematic review identified four studies on the cost and cost-effectiveness of electronic discharge communication. Three of the four identified studies focused on the potential cost savings (Sevick et al. 2017). Only one of the four studies addressed the cost-effectiveness in terms of cost per clinical benefit but the study failed to measure meaningful clinical outcomes (Sevick et al. 2017). None of the studies reported on the costs of essential infrastructure, personnel, maintenance and network connectivity costs associated with the implementation and operation of electronic discharge communication tool (Sevick et al. 2017). The result of a systematic review was not conclusive to make a generalization to other settings or contexts (Sevick et al. 2017). Similarly, the second systematic review of 35 selected papers on cost-utilization and cost-effectiveness of eHealth concluded that the economic evaluation results were not conclusive because of limitation in the studies (de la Torre-Diez et al. 2015). Although the majority of the studies indicated the cost-effectiveness of telemedicine systems, few studies claimed that it is not explicitly conclusive (de la Torre-Diez et al. 2015). Furthermore, the study indicated that there is very little evidence about the effectiveness of mHealth and other eHealth systems in the literature (de la Torre-Diez et al. 2015).

The third systematic review study of the internet- and mobile-based interventions (IMIs) targeting depression classified interventions as cost-effective if the cost-effectiveness ratio was below a WTP value of €20, 000 – €30,000 per additional quality-adjusted life year (QALY) (Paganini et al. 2017). Six of the twelve eligible studies, that reported an incremental cost-utility ratio (ICUR) between €3,088 and €22,609 were found to be cost-effective (Paganini et al. 2017). Five studies were likely to be not cost effective (Paganini et al. 2017).

In the fourth systematic review study of systematic reviews and meta-analyses, 7 of 31 reviews (23%) indicated effectiveness in cost related or outcome measures, 13 reviews (42%) showed promising evidence, and 11 reviews (35%) concluded that there is no, limited, or inconsistent proof of evidence of cost-effectiveness (Elbert et al. 2014).

The fifth study focussed on the prevention of recurring ankle sprains and recruited a total of 220 athletes to evaluate the cost-effectiveness of a neuromuscular training (NMT) program delivered via a mobile App vs printed booklet. The result showed no significant difference in the cost-effectiveness of the interventions (Van Reijen et al. 2017). The study indicated that the preventative ankle sprains intervention either through App or Booklet could potentially reduce the current high total societal costs associated with ankle sprains treatment without a significant difference in the cost-effectiveness between the two interventions (Van Reijen et al. 2017).

Table 6: Inconclusive evidence of eHealth economic benefits.

Author	de la Torre-Diez et al. 2015	Elbert et al. 2014	Sevick et al. 2017	Paganini et al. 2017	Van Reijen et al. 2017
Study Perspective	Literature	Literature	Literature	Literature	Patients
Evaluation techniques	CEA/ CUA /Sustinable funding	CEA (effectiveness)	Cost-analysis/CEA/CBA	CEA/ CUA	CEA/ ICER
eHealth type	eHealth, mHealth, Telemedicine	Home telemonitoring, Structured telephone support, Video-teleconferencing, Education, Self-management programs, Telerehabilitation, Telemedicine	Electronic discharge communication	Internet- and mobile-based interventions	Mobile App (mHealth)
Area of intervention	Not specified	Not specified	Discharge communication process	Depression disorder	Ankle sprain
Country	Not specified	Europe, North America, Asia, Oceania, Latin America	Canada, Germany, Norway, USA	United Kingdom, Australia, Germany, and Netherlands	Netherlands
Participants	35 Papers	31 Papers	4 literature	12 literature	220 athletes
Study period	Up to Feb 2014	2009-2012	Up to Oct 2015	2010-2017	12 months
Methodology	A systematic review	A systematic review	A systematic review	A systematic review	RCT
Results	Not conclusive	Not conclusive	Not conclusive	Not conclusive	Not conclusive

Generally, five of fifteen selected studies could not produce conclusive evidence on the cost-effectiveness of eHealth interventions. The potential of eHealth interventions to be cost-effective depends on the economic condition of the country which is directly related to WTP and the variable costs associated with scale-up (Paganini et al. 2017). The weak estimation methods, lack of RCT, lack of long-term evaluation studies, small sample sizes, and absence of quality data and appropriate methods were listed as the main limitations to the studies of eHealth economic evaluation (de la Torre-Diez et al. 2015). Sevick et al. (2017) also presented that the studies were old compared to the short lifecycle of ICT and the literature on the cost-effectiveness of electronic discharge communication tools were limited. Moreover, the detail costs associated with eHealth intervention such as infrastructure, maintenance, support and other on-going costs were not covered by the economic analysis (Jones et al. 2009).

Unfavourable outcome report

Finally, one study reported that web-based employment intervention was not cost-effective in terms of increasing quality of life (Noben et al. 2017). The study was conducted in Netherlands over the control group and the intervention group of 34 and 29 participants respectively on the web-based employment intervention that aimed at providing an easy access for interested people to ask

questions about disability, health and work (Noben et al. 2017). The four core elements of the web-based intervention included knowledge website, personal advice, feedback session and forum. Compared to the controlled group, the intervention group demonstrated lower score on the Work Ability Index (-0.51) and higher total costs (€483.8) (Noben et al. 2017).

CONCLUSIONS

Nine of fifteen (60%) selected studies in this research indicated the economic attractiveness of eHealth interventions and the potential promise of eHealth to benefit a wider group of stakeholders. However, this result cannot be transferred to different settings. The outcome of economic evaluations was influenced by the place where the studies were executed, the type of eHealth applications assessed, and the perspectives of the study. Moreover, the majority of selected studies were disease-specific which makes it difficult to generalize to other areas of health problems.

In this systematic review, we found no economic evaluation studies from developing countries on eHealth systems. The cost-effectiveness of eHealth intervention depends on the value of WTP, which is associated with the economic condition of the country. As a result, cost-effective eHealth intervention in HIC may not replicate the same result in the LIC settings. This suggests the greater need for economic evaluation of eHealth interventions in developing countries. Schweitzer & Synowiec (2012) showed that the need for economic evaluation of eHealth is great; especially in developing world where there are relatively few eHealth systems and little concrete economic data. The availability of reliable economic evaluation of eHealth systems may improve the decision of providers and government bodies towards the implementation of sustainable and large-scale eHealth programs.

This study highlighted the complexity of the economic evaluation of eHealth interventions. First, the economic evaluation technique should be able to address the fast-changing nature of eHealth technology in terms of the costs and benefits of technology. Second, the economic evaluation of eHealth system is specific to the economic settings of the country, the type of eHealth application, the type of health problems addressed by eHealth intervention, and the perspective of stakeholder groups. These factors add complexity to the economic analysis of eHealth interventions and make it unrealistic to extend findings of a study to different settings.

RECOMMENDATIONS

Future research studies on eHealth economic evaluation need to focus on the economic evidence of eHealth intervention in developing countries. Comprehensive research studies on this topic need to consider all initial investments and on-going costs, benefits to all key stakeholder groups, clearly identify types of eHealth applications and specify the settings for a place of study. A comprehensive economic evaluation of eHealth aids eHealth investment decision making and supports the long-term sustainability of eHealth implementation. The use of appropriate economic evaluation methods, like RCT, will improve the importance of the research outcomes in the future research studies. This research study can be further strengthened by including articles from a wide range of journals and other relevant non-academic reports from international organizations. Eventually, future economic evaluation studies should focus on a specific eHealth application to produce generalizable research results.

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