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Abstract: A compendium of impact assessment (IA) frameworks are available to understand the impact of ICT4D initiatives in Low Income Countries. However, existing frameworks do not adequately address the unique challenges of IA for ICT4D, especially the multi-level and time variant characteristics of the IA. To address these challenges, we propose the use of Theory of change (ToC) as a generic framework for IA of ICT4D projects. Based on the seminal work by Weiss [8], we argue that ToC can be viewed both as a methodology and a deep critical reflection process. We demonstrate the ToC approach for IA using a case study of an ICT4D project for LICs.

Keywords: ICT4D, CMES, Theory of Change, Impact Assessment

1   Introduction

The importance of information and communication technologies (ICT) for the Low Income Countries (LICs) is well recognized by the United Nations (UN). The UN 2030 Agenda for Sustainable Development states that "the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies" [1]. Billions of US dollars are invested each year in ICT for Development (ICT4D) projects across different development sectors such as agriculture, health, education, environment, and natural resources. Yet, the question of whether these projects have achieved their intended development goals remains largely unanswered. The evaluation of development impact of ICT4D projects is thus a principal concern [2].

As a multiple-level and time-variant concept, impact assessment (IA) of ICT4D projects face many challenges. First, although the immediate outcomes (e.g., micro-level behavioral changes associated with the ICT4D project) are often easier to measure, the macro-level contributions and long-term development goals of ICT4D projects are arguably more difficult and costlier to assess. The difficulties are due to the challenges in establishing a direct link between the ICT intervention and its actual contribution towards the project's development goals [3]. Second, the scope and focus of assessment changes over time [2]. Many intermediate changes take place within the ICT4D project cycle. Therefore, longitudinal studies are the better way to conduct IA of ICT4D projects [4]. However, undertaking long term IA requires adequate resources, funding, time, and staffing capacities, which may not be readily available. Third, although ICT4D projects center around technological artifact, their impact may have great social, economic, and political implications. Resulting implications could be so complex that any related social and behavioral change needs to be assessed against a moving baseline [4]. Additionally, in many cases the impact is intangible, making it difficult to develop appropriate indicators for the IA of the ICT4D intervention.

A compendium of IA frameworks have been used by ICT4D practitioners, policy-makers, and consultants to understand the impact of ICT4D initiatives in LICs. Heeks and Molla [2] reviewed 11 popular IA frameworks, among which only two frameworks are generic in the assessment of ICT4D projects. The rest of frameworks have more specific focus on a particular development issue (e.g., gender equality), a particular ICT4D technology (e.g., telecentre), or a particular academic discipline (e.g., communication studies). Among the two generic IA frameworks, the cost-benefit analysis (CBA) approach focuses only on the financial performance of the ICT4D project, and does not address the more complex social, economic, and political implications. However, CBA adds rigor to IA by explicitly linking inputs and outcomes along with the underlying assumptions [2]. The other generic IA framework, project goals approach, simply assesses the ICT4D project against its goals by identifying indicators

and appropriate methods to measure indicators to assess the goal achievement. While this approach clearly focuses on ICT4D project impact, and offers greater flexibility in its implementation, it only focuses on ICT4D project goals which may be in danger of techno-centrism. Both generic frameworks do not consider the multiple-level and time variant characteristics of the IA.

The theory of change (ToC) approach has been adopted by many NGOs to manage international development programs [5]. It has been used for strategic planning, communicating change process to internal and external stakeholders, monitoring programs, and IA [6]. In the last area, ToC has been used in inferring causal relationships between changes that have taken place and the activities that the program undertook, tracking changes, and demonstrating the impact [7]. ToC requires the articulation of the impact and assumptions underlying the impact, elaboration of development context, identification of interventions and outcomes, and determination of the causal links among interventions, outcomes, and impact. All these are crucial for the long-term IA of ICT4D projects. In an attempt to adopt ToC in ICT4D impact evaluation, Flor [3] used ToC as a tool to establish links between ICT interventions and Millennium Development Goals (MDGs). Guided by ToC, he drew a pathway to change map for different development sectors that used ICT to achieve one of the many MDGs. However, as a process tool, Flor [3] only presented a partial view of ToC. He acknowledged that the output of the study, the change pathway map, can serve as the basis for evaluating impact of ICT interventions, but that alone does not address IA.

In this research, we propose the use of ToC as a generic framework for ICT4D project IA. Based on the seminal work by Weiss [8], we argue that ToC should not be viewed only as a tool and methodology to map the sequence of changes of an ICT intervention from its outputs to outcomes. It should also be viewed as a deep critical reflection process in IA to help ICT4D researchers and practitioners to make their assumptions more explicit, and understand how and why change might happen as an outcome of an ICT intervention. We assume that the ICT4D project has followed best practices in its implementation, such as involving all stakeholders and key project champions, designing ICT interventions for a specific development goal and adapting it to the social context, involving end-users in the iterative design process, and focusing on impact and sustainability throughout the project's life circle [9]. In addition, we assume that the project has completed implementation and is in the monitoring and evaluation phase. The rest paper is organized as follows. We first review ToC and discuss the rationale for adopting ToC for ICT4D project IA in Section 2. We then describe the key elements in adopting ToC for ICT4D project IA in Section 3, followed by a case study to demonstrate on how ToC can be adopted for IA in Section 4. In Section 5, we present the conclusion and future research.

2 Theory of Change

1.1 What is Theory of Change?

Theory of change (ToC) emerged in mid 1990s as part of theory-based evaluation of community development programs [8]. Since then, ToC has been widely adopted by non-governmental organizations (NGOs), international foundations, and evaluators in the development sector [6, 7]. Weiss [8] defines the theory of change as a theory of how and why an initiative works. In practice, it has been viewed as a process mapping methodology that describes a sequence of events that lead to a particular desired outcome [10]. It has also been viewed as a deeper reflective process to explore why and how change happens [5]. Yet, these different views and definitions are all grounded in the idea that the beliefs and assumptions underlying an intervention can be expressed in terms of a phased sequence of causes and effects such as a program theory [11].

ToC is not a fixed methodology. It allows flexibility for people to work with it according to their needs. However, there is consensus on the basic elements that make up ToC [7]. These elements include: (1) desired long-term goals; (2) the context for the change initiatives; (3) interventions that are used to bring the change; (4) a path way of change that illustrates the relationships between immediate and intermediate change outcomes that are necessary and sufficient to reach the long-term goals; (5) assumptions that explain the change process, (6) indicators as means to measure the success at each step in the pathway of change; and (7) narrative summary.

1.2 Rationale for ToC for ICT4D Impact Assessment

Since its conceptualization from the fields of community development and program evaluation, ToC has increasingly become mainstream in the international development field because it enables organizations to explore and represent changes in a way that reflects the systemic understanding of the complex program development process [5]. It fits the same aim of ICT4D IA, which is to explicitly describe how and why ICT interventions produced by the ICT4D project contribute to its development goals. In fact, ToC has been recognized as an important part of the theoretical foundations of ICT4D [9]. Additionally, methodological credentials of ToC has been tested and validated from two long-standing areas: program theories and development practices [5]. It is simple and easy to follow with substantial guidance and literature available on the best practices related to ToC.

Adopting ToC addresses many challenges associated with the multi-level and time-variant ICT4D IA. First, it explicates the context of the ICT4D project including social, political, institutional, and technological issues. A desired attribute of IA is that it takes into account the complexity of social setting and context for which the intervention is designed [4]. An IA that is based on ToC avoids the trap of technological determinism, and at the same time inclusive of the social and behavioral changes brought by the technological intervention. Second, ToC requires laying out the pathway of change in as much fine detail as possible. Thus, it divides the complexity of change into multiple levels and allows the creation of direct links between the ICT intervention and the project's development goals. Third, ToC requires making all assumptions that underlie the ICT4D program explicit, defining methods to measure the change, and clearly articulating the goals [8]. It enables the ICT4D researchers and practitioners to not only strengthen the monitoring and assessment of the ICT4D project's progress or success, but also to report to external funding agencies, many of whom now require a ToC analysis. As the scope and focus of IA changes over time that longitudinal studies are often necessary along the pathway. For identifying indicators and designing methods to measure the change, ToC favors both quantitative and qualitative data with a strong focus on the triangulation of different research methods [7]. Such a research design allows researchers and practitioners to measure the intangible impact of the ICT4D intervention, along with the tangible outcomes.

3 ToC for ICT4D Project Impact Assessment

In this section, we describe how ToC can be adopted as a generic framework for ICT4D project IA. As mentioned previously, we assume that the ICT4D project is in the stage of monitoring and evaluation. As an antecedent, it is assumed that an ICT4D project is initiated to target clearly defined long-term goals, and that the project followed best practices in the design and implementation of the project outputs (i.e., the ICT solutions). Because a generic IA framework should be flexible to different situations and adaptable to the different context, we do not consider the ToC for ICT4D IA as a fixed sequence of process that one should follow. Instead, we use the ToC to guide the IA planning and implementation based on the seven elements mentioned previously. Within each element, ICT4D researchers and practitioners can reflect and learn from their own experience, or bring in IA methods or best practices that are shared by other international development or program evaluation studies. Next, we elaborate each element separately. It should be noted that although these elements are presented in a sequential order, they are often interweaved in the IA process and may not be separated in the narrative summary.

1.1 Long-term goals

There should be clearly stated long-term goals. Within the context of ICT4D, the long-term goals should be associated with achievable project-based goals [3]. The long-term goals are not micro-level behavioral changes associated with the introduction of ICT initiatives, but related to broader development goals. The SDGs represents the single most important agenda shaping many ICT4D interventions ([9]. For the ICT4D project to reach a broader impact in the developing world, it should suit and align with the SDGs.

1.2   Context for the ICT4D project

The context for the ICT4D project and its related ICT interventions are explicitly described, including the problem statement, all social, political and economic conditions surrounding the problem space, and different actors that would influence a change. As highlighted in many evaluation studies, it is important to gather all contextual knowledge about the project to ensure that the ToC is built around the accurate local context [12]. This ensures plausibility (i.e., the extent to which the goal outlined in the ToC is realistic) and do-ability (i.e., the extent to which the goal is achieved within the project's scope, resources, and time), two important attributes of a good ToC [13] .

Because we assume that the ICT4D project engages key stakeholders and project champions, there exists opportunities for partnerships among the multiple stakeholder groups to refine ToC based IA. Stakeholder partnerships will help to ensure the efficiency and effectives of IA when resources and interests are shared [14]. Below are some of useful guiding questions from the literature [5, 9].

First find, "who is the project aiming to support, and why?" If needed, prioritize key issues faced by the target group. Next set of questions should be related to identifying groups or stakeholders that would influence the expected change leading to desired development goals. It will also beneficial to rank the groups in their importance to determine who would influence change positively, negatively, or both. Third, ask: "what problems are the project trying to solve?" A clearly stated problem statement identifies issues and challenges that can be solved by an ICT intervention. Fourth, questions should focus on the social, political, intuitional, and economic conditions around the problem space. These conditions serve as important inputs for constructing the ToC, especially in defining assumptions and developing indicators. Finally, questions should also be asked to understand the internal and external factors preventing change, and how these risks may be mitigated.

1.3   Interventions

Academically speaking, ToC is not a general theory on how change occurs, but a "theory" specified to an intervention [3]. Within the ICT4D context, the interventions are the ICT solutions that are designed to achieve desired outcomes. The IA process will likely discover problems or unintended outcomes that are caused by some of the interventions and not specified within the ToC. In such cases, the ICT4D project team may have to go back to the analysis and design phase to redesign the ICT solution or create a new solution.

1.4   Pathway for Change

This element is the mapping between a phased sequence of causes and effects underlying the ICT interventions. It connects preconditions necessary to achieve a long-term goal and explains why the preconditions are necessary and sufficient. An ICT intervention produces a set of products or services, which can be referred as ICT outputs. These outputs may lead to an immediate or intermediate outcome, an effect that is caused by the intervention. These outcomes may be linked to a long-term goal and show positive or negative impact of ICT intervention on the goal. The mapping process should take into consideration impacts of the project in the immediate short term and in the long term; context and conditions that would lead to the outcomes; sustainability of the outcomes; who and what needs to change to achieve the outcomes; and factors, relationships, or approaches that may potentially influence different level of outcomes [15].

There are several useful approaches to facilitate the construction of the change pathway. Outcome mapping, a methodology for planning, monitoring, and evaluating social change initiatives, provide a set of tools to design and gather the outcomes, define and presents changes, identify actors that influence the change, and stakeholders roles related to participation and accountabilities [16]. Although outcome mapping approach does not explain why and how changes occur, it complements ToC as a useful tool to formally involve stakeholders and strategic partners when creating the pathway for change [5]. Backward Mapping is a process in ActKnowledge's approach to ToC[1]. The process begins with a long-term goal and builds the change pathway "backwards" by identifying preconditions, and ends at the earliest changes (i.e. the immediate outcomes). A more generic process mapping approach can also be used to build out the change process by repeatedly asking "when what happens" from the start of the ICT

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[1] www.theoryofchange.com

intervention, till the project's long-term goals are reached. All assumptions in the process should be documented, discussed, and sorted [7].

The output of this element is usually a change pathway map. The map provides a visual representation of the logic model of ToC and is useful to communicate the conceptual analysis of the change process. Creating a map of how different types of outcomes relate to each other can help clarify what the project intends to do [17], and guide those engaged in the change process to see big picture quickly without having to read through a complex plan [18].

1.5 Assumptions

In the ToC literature, assumptions come in a variety of meanings. In its original definition, assumptions are about what to change and how change would take place [8]. It is similar to the 'hypothesis" in the general theory in academics, where the ToC is to test whether the assumptions will hold in the change process. Weiss [8] argues that not all theoretical assumptions of ToC are possible to test because some statements of ToC may be too general for testing, and an alternative explanation may arise from the data collected.

Another type of assumption explains why one outcome leads to another in the pathway for change, or specific choices of activities along the pathway. Some assumptions can be "… accepted as true or as certain to happen, without proof.[2]" These assumptions are not testable. Another type of assumptions is related to the broader operational context of a program or project [6]. All assumptions about how an ICT intervention would lead to the long-term goals should be explicated. The quality of the ToC rests on explicit, realistic, and transparent assumptions [7]. Because assumptions are deeply held perceptions that are taken for granted in the context of the intervention program, explicating assumptions can be challenging and requires a critical thinking approach that involves interacting with stakeholders and past experience with ICT4D projects. Since different assumptions are likely emerge from the study context, discussing the different structures of belief among the participants and stakeholders will ensure consensus among them [8].

1.6 Indicators

In addition to mapping all immediate and intermediate outcomes, ICT4D researchers and practitioners need to develop research plans and indicators to measure the extent to which each outcome has taken place. The change pathway map created in the previous section should include specific indicators at each level of change [5]. They not only provide evidence on the extent to which each outcome is achieved, but also ensure that a ToC can be tested if wisely chosen.

There are many challenges and issues associated with developing indicators of impact. To the extent that ToC presents the change in a causal-effect structure, there is inherent propensity to develop quantitative indicators that can be measured and analyzed statistically, especially when sponsors and participants also find quantitative data more credible than qualitative data [8]. This is a key problem of measurement in the ToC implementation. Qualitative analysis can be equally compelling, since it allows not only rich narratives that documenting intangible changes, but also the modification of assumptions in the assessment process [8]. Additionally, quantitative indicators have limited capabilities to capture complex relationships and reasons behind social changes that may be brought by the ICT intervention [4]. Therefore, we argue for a balanced set of quantitative and quality indicators when using ToC for IA.

Choosing indicators as measurable evidence of change is a unique notion. Many learning and monitoring processes and development frameworks use indicators as evidence-based measures of the success. For example [15] uses indicators as an integral part of IA strategy in the Communication for Development (C4D) framework. International development studies have always used indicators to measure the impact of development interventions [19]. Developing and implementing indicators for ToC can benefit from the cumulative knowledge of these different processes and frameworks. For example, the ActKnowledge's ToC process[1] recommended including four components for each indicator: population (i.e., who or what is to reach the goal), target (i.e., how many among the population are needed to reach the goal), threshold (i.e., how much percent of the target population needs to change

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[2] Assumption. *In oxforddictionaries.com*. Retrieved from https://en.oxforddictionaries.com/definition/assumption

or to what level), and timeline (i.e., by when the goal needs to be reached). These predisposed recommendations may be good guidelines in elucidating ToC indicators, but they lack the flexibility and richness to explain the multiple-level and time variant impacts within the ICT4D context.

Once defined, indicators need to be operationalized so that a research plan can be developed to gather data for the measurement. ICT4D researchers and practitioners can choose from a variety of methods and techniques to operationalize the indicators. For example, if an assumption of change in ToC fits within other existing theoretical or conceptual frameworks, such as the widely used technology acceptance model in Information Systems research, existing quantitative scale instruments can be adapted to measure the change. If the assumption is related to that a person's behavior change is influenced by their attitude, where the attitude is influenced by their knowledge, the KABP (knowledge, attitude, behavior, and practice) approach [20, 21] may be used, usually including standardized written questionnaires. Experimental design can be carried by comparing changes of the pre-and-post intervention. There are also commonly used qualitative and mix-method approaches that can be adopted to operationalize indicators. Examples include participatory communication appraisal [22], rapid rural communication appraisal [23], ethnographic action research [24], and most significant change technique [25]. It is out of scope of this paper to provide details on the strengths and weaknesses of these methods and how to design the measurement instrument. Nevertheless, the examples provide give a variety of means to operationalize indicators to measure the success of the ICT intervention in ICT4D studies.

1.7 Narrative Summary

While change pathway map is useful to communicate the logic of change process, it only represents one aspects of ToC. A narrative summary of a ToC should explain the change pathway map and underlying assumptions succinctly, as well as the contextual background of the project. In the ICT4D IA process, the narrative summary should help the ICT4D project team to present a convincing case of how and why the ICT interventions are expected to achieve the project's long-term development goals. A well-written narrative summary can help convey the major elements of the ToC easily and quickly to external and internal stakeholders, and is an important documentation on the IA process.

4 Case Study – CMES Project

CME on Stick (CMES)[3] is a project that utilizes novel ICT interventions to deliver free and high-quality continuing medical education (CME) content to medical practitioners, including community health providers, nurses, midwives, first-year interns, residents, and physicians in LICs. The CMES project is guided by a Citizen-Centric Capacity Development (CCD) Framework (see Fig.1), including the design of two ICT solutions [26]. One of the key strengths of the CCD framework is that utilized citizen-centric requirement engineering to involve end-users and key stakeholders in the solution development. The second strength lies in its goal-oriented design and evaluation process, where achieving ICT-enabled development goal was targeted through the integration of social and technical constructs in the ICT-solution design and evaluation.
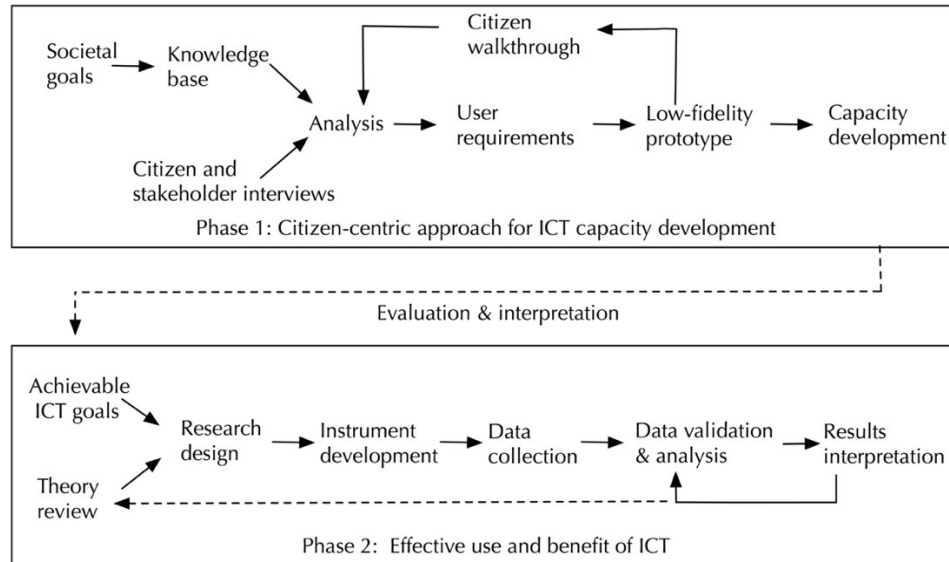
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[3] www.cmesworld.org

Fig. 1. Citizen-centric Capacity Development (CCD) Framework

The project was first deployed in Nepal in 2016. Since then, it has stepped from one continent to another by simple word-of-mouth as participants reach out to their global colleagues. It is currently active in seven LICs (i.e., Nepal, Dominican Republic, Guatemala, Ecuador, Antigua, St. Lucia, and Nigeria) across three continents. There are over 100 rural medical practitioners presently enrolled and a patient population base of 386,000 impacted. Expansion is scheduled to Uganda and South Pacific Oceania in 2019. While the doctors have acknowledged the usefulness of CMES solutions in improving their knowledge, the evidence is largely anecdotal. Although simplicity and low-cost of the solutions make CMES project easy to deploy, the project's long-term sustainability requires systematic monitoring and evaluation of actual impact towards the long-term goals. In this case study, we demonstrate how ToC can be used as a framework for the IA in the CMES project.

1.8   CMES Project Goal, Context, and Intervention

Continuing Medical Education (CME) activities draws from various academic disciplines such as adult learning, practice-based learning, continuing professional education, organizational change, development and behavior, and health services research [27]. Although there are different CME methods (e.g., printed or recorded materials, clinical practice guidelines, and interactive or online education) and activities (e.g., mentoring and opinion leaders, case-based training, audit and peer group discussions, educational outreach visits, etc.), attending conferences and reading printed materials are CME activities most commonly undertaken by medical practitioners. Unlike many developed countries, CME is particularly challenging in LICs as there is no external enforcement (from government bodies such as the National Board of Medicine) of the quality, standards, and participation in CME activities.

Medical practitioners in LICs fall behind on CME, not from lack of initiative but due to financial and infrastructure constraints. Interviews with medical practitioners worldwide indicate mentor shortages and unregulated CME requirements; lack of funds to attend conferences or buy CME programs; and lack of reliable electricity, up-to-date technology and internet connectivity as key challenges to CME. These challenges are further accentuated in rural parts of LICs. This results in localized medical practices with great disparities between urban and rural areas.

Within this context, the CMES project aims to provide local access to updated CME for medical practitioners who work in rural hospital and clinics in LICs, thereby enabling them to overcome many of the above-mentioned CME challenges. As part of the SDGs to be achieved by year 2030, the United Nations (UN) identifies healthy lives and well-being as essential to sustainable development (Goal 3 of the SDGs)[4]. Towards achieving this objective, the long-term goal of the CMES project is clearly articulated as "improve medical practitioner knowledge and skills,

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[4] https://www.un.org/sustainabledevelopment/health/

particularly in LICs." Correspondingly, the ICT intervention of the CMES project is a content management system for best practice medical education of medical practitioners.

The outputs of the intervention are two innovative ICT solutions - CMES and CMES-Pi, both allowing CME content to be downloaded at locations with intermittent electricity or Internet. CMES is a thumb-drive based application, enabling access to content on a charged device without the need for Internet. CMES-Pi is a raspberry-pi based offline server that provides real-time access to CME content at locations where it is installed. Medical practitioners access CME content stored on CMES-Pi through their mobile phones using an iOS or android CMES-Pi App, or through web browser on a computer. This means that implementation is possible at health clinics, primary health care centers, hospital emergency rooms, and medical colleges in rural and remote locations. The solutions are low cost (initial set up at each site is $10 per thumb drive, and $80 per CMES-Pi) and easy to maintain. CMES provides multiple media of learning (pdf and mp3 audio) and available in English and Spanish. It caters to the specific needs of health professionals in LICs, and serves a broad range of topics for all levels of health practitioners.

1.9 CMES Change Pathway Map, Indicators, and Assumptions

Process mapping is used to delineate the immediate and intermediate outcomes of the intervention. ToC suggests that at least one or more observable and measurable indicator should be identified for each immediate and intermediate outcome. CMES project engaged participants and stakeholders early in the project who helped to explicate assumptions based on experience, practical knowledge, intuition, and intrinsic familiarity with the context of the study. Weiss [8] argued that underlying assumptions should also be clearly articulated, short of which outcome evaluation may not be credible or useful. The assumptions may be expressed in phrased sequences of cause and effect [11].

A ToC change pathway map can be used to present the outputs of ICT interventions along with the immediate and intermediate outcomes leading to explicitly stated long-term goals. It presents a big picture view that connects assumptions to outcomes, and identifies necessary and sufficient pre-conditions. The change pathway map also specifies indicators to measure the outcomes and long-term goal. Figure 2 shows the outcome map for CMES impact assessment. It is structured with a vertical logic upwards, starting with the intervention (at the bottom of the outcome map). The intervention is designed and implemented to achieve the long-term goal (at the top of the outcome map). As stated previously, the long-term goal of the CMES project is to improve knowledge and skills of medical practitioners in LICs, and the ICT intervention is a content management system which includes two outputs: CMES and CMES-Pi.
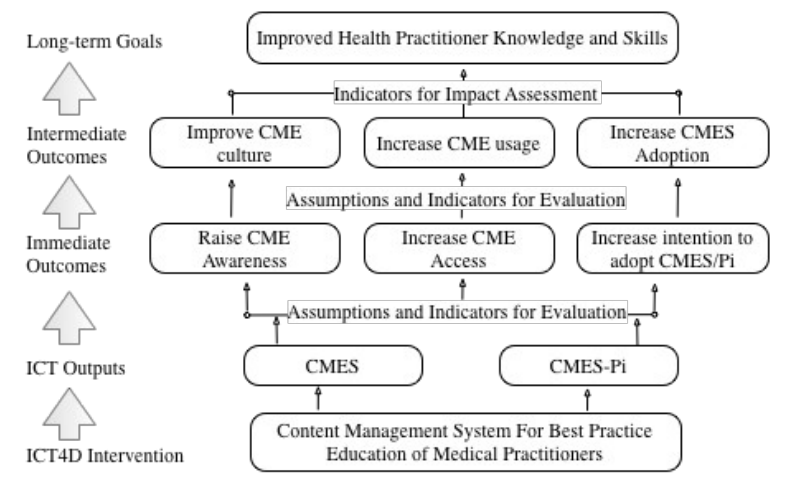

Fig. 2. Change Pathway Map for CMES Impact Assessment

Process mapping identifies three immediate outcomes - raise awareness, increase CME access, and increase intention among medical practitioners to adopt the CMES solutions. Due to the complexities of socioeconomic and

infrastructural problems, CME represents an overwhelming challenge in LICs. There exist few useful tools to effectively bridge the paucity of resources and access to CME, and little knowledge about how CME might be used to improve rural medical care and population health. Therefore, an immediate outcome targeted by the project was to raise awareness among medical practitioners about CMES solutions and they may enable assist in overcoming financial and infrastructure barriers to CME. A key assumption that forms the epistemological basis for immediate outcomes is - there is intrinsic motivation among participants to improve EM knowledge and skills.

To increase access to CME, an active on-the-ground campaign was undertaken in various LICs to identify clinics, primary care centers, and hospitals that are interested in CMES. Through rigorous effort of the project team members and with the assistance of various non-profit organizations in the medical field, the CMES solutions were deployed at 18 medical facilities across Asia, Sub-Saharan Africa, Latin America, and the Caribbean. Prior to deploying the solution, the team worked with the hospital administrator or person of authority at the location to thoroughly whet their interest in CMES, identify CME needs, determine the state of IT infrastructure, and their long-term commitment to improving CME culture. All doctors at participating locations are required to complete a screening survey before the site is finalized for CMES deployment. Researchers in the CMES project would then conduct on-site visits at most locations to implement the solution and provide training to the medical practitioners. The CMES team is available via Skype or WhatsApp to answer any questions, and visit locations for follow-up on a regular basis. The engagement of the CMES team aims to achieve the immediate outcomes of raising awareness of CMES, increasing access to CME, and increasing intention to adoption the CMES solutions.

Furthermore, we identified three intermediate outcomes that include - improve CME culture, increase CME usage, and increase adoption of CMES. Developing CME as a discipline specific culture requires nurturing and mentoring of junior medical practitioners by their seniors. In the absence of mandates established by governing bodies, as is the case in many LICs, medical practitioners have little or no incentive to purse CME. Unless they are willing and able to engage in CME, the "Good Health and Well-being" goal of the SDG will remain distant. Thus, a significant intermediate outcome is the social goal of developing CME culture among the practitioners at the participating locations. This outcome is closely linked to the outcomes of increased CME usage and increased adoption of the CMES solutions. The key assumptions for intermediate outcomes are - increasing CME awareness will improve CME culture; increasing access to CME will increase CME usage; intention to adopt CMES will increase CMES adoption.

The outcomes may be measured in relative terms or as absolute numbers. Indicators for practitioner mentoring include the frequency and number of CME content accessed by the practitioners, extend of education and training sessions undertaken by the medical practitioners at the location, and the nature of engagement of the participants with the CMES team. The CMES solution includes extensive logging features to track usage patterns (e.g., frequency of application launch, content synchronization, content views, and search behaviors). The logs are uploaded to a remote server whenever the CMES software determines the availability of Internet access. The logs provide varying degrees of assessment of CMES usage. CMES adoption will be assessed using a survey instrument. The instrument will be designed to analyze factors that influence the use and adoption of the CMES solutions.

In a synthesis of systematic reviews on CME effectiveness, Cervero and Gaines [28]) concluded positive impact of CME on physician performance and patient health outcomes. The CMES project scope established the long-term goal as improving practitioner knowledge and skills. Patient health outcomes were not included as a long-term goal as it is a highly contentious topic and heavily debated in the medical discipline. The key assumption for achieving the long-term goal of the CMES is that – the extrinsic motivators for CME use include normative (arising from relationships where other professionals share information about benefits and advantages), coercive (formal and informal pressure exerted by organization on practitioners to pursue CME), and mimetic (tendency to imitate the action of others) forces.

Both qualitative and quantitative methods can be used to evaluate the adoption, effective usage, and benefits of CMES for improving practitioner knowledge and skills. A survey instrument can be developed and sent to each participant. Narratives and comments can be solicited from the users to gauge whether the CMES program met expectations and CME needs, whether the intervention helped to develop and sustain CME culture, and how well the ICT solution served to overcome CME barriers. Qualitative in-person interviews will also help to determine whether and how the ICT intervention impacted practice, professional identity, and quality of patient care.

5   Conclusion and Future Research

Social benefits of ICT interventions are hard to evaluate for many reasons. Primary among them are misclassification of evaluation program by grouping it with other control variables, difficulty in disaggregating outcomes that can directly be linked to the intervention, and the highly intangible nature of the social benefits [3]. These challenges equally apply to the CMES project. Similarly, the social benefits of the CMES project may not be outwardly visible for a length of time, just as is the case with most ICT4D projects. Nevertheless, a systematic approach to continuously monitor and assess whether the immediate and intermediate outcomes are what were intended, and make timely corrections if they are off course. In the regard, ToC provides a sound framework to guide the IA planning and implementation of ICT4D projects. This research demonstrates the flexibility and adaptability of ToC for the IA of an ICT4D project in an LIC context.

The research makes many contributions. First, we highlight the challenges of conducting multi-level and time-variant IA of ICT4D projects, and propose the use of ToC as a possible solution. We provided rationale for how ToC can enable researchers to clearly articulate the context of the study and inherent assumptions, generate a change pathway map highlighting immediate and intermediate outcomes as a phased sequence of causes and effects, and develop indicators to assess the extent to which the outcomes are achieved. Second, we used a case study to show how ToC enable researchers to critically investigate how and why change might happen as an outcome of an ICT intervention. The approach identified indicators to measure outcomes while fully acknowledging the possibility that the scope and focus of IA may change over time. We are not aware of any other framework that provides the flexibility to conduct IA against a moving baseline, a crucial and overlooked fact in ICT4D research that has direct implications on the credibility and usefulness of the related findings.

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