Measuring the value for money from digital health interventions in low–resource contexts

COST OUTCOMES RESEARCH METHODOLOGY

Background

An analysis of existing evidence suggests there is a growing base of peer-reviewed literature that links digital health interventions to health system outcomes in low–resource contexts. However, while many health areas rely on models to infer broader impact from peer-reviewed literature and clinical trials, few modelers have imputed the impact of replicating and scaling research findings around the health system impact of digital health interventions. The following is a replicable method for quantifying potential health impact for digital health interventions, using a combination of peer-reviewed literature and modeling best practices.

Tested on the evidence demonstrating how digitalizing last-mile electronic logistics management information systems (LMIS) improves health commodity stock availability, this approach uses data from peer-reviewed academic publications to estimate health impact based on the Lives Saved Tool (LiST). LiST is a modelling program in the Spectrum software package that analyses how increases in the coverage of specific health commodities prevent additional deaths and affect mortality rates over time. In this approach, the example used is of an intervention digitalizing last-mile LMIS, which are information management systems which support communication and distribution of commodities between different part of the health system.[1] This methodology links the LiST model evidence base, which estimates changes in mortality in under-five populations from scaling up coverage of specific health commodities, and the growing evidence base demonstrating significant reductions in medical commodity stockouts following digitalization of last-mile supply chains. This presents a replicable method for digital health researchers to connect peer-reviewed literature on the impact of different digital health interventions with the LiST model or other modelling tools.

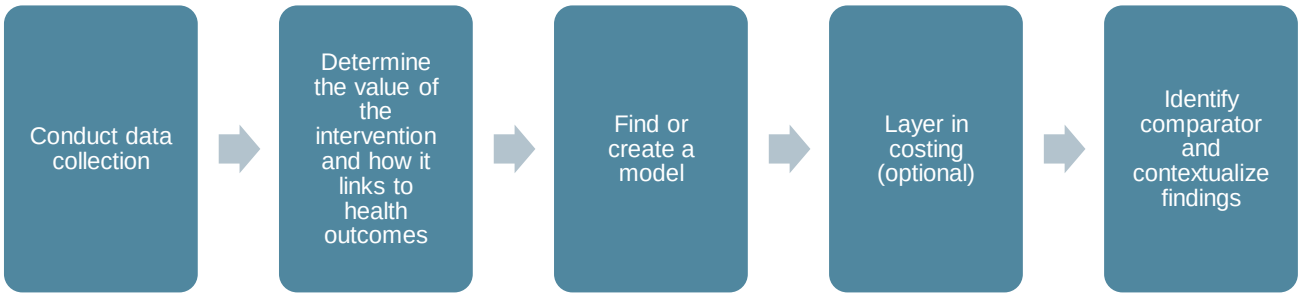
Throughout this methodology, we present a generic approach which can be replicated for different digital health interventions. In addition, we noted how this approach was applied in our example based on measuring health impact and value for money for a digitalized LMIS intervention.

Approach

To conduct a cost outcome analysis of digital health interventions in low–resource contexts, a common methodological framework includes a series of steps. **Figure 1** outlines the standard methodological approach for evaluations of impact and cost which begins with conducting data collection for the analysis and identifying the measurable value that is attributable to a digital health intervention. The data collection will inform the appropriate measurement of inputs to be

used in a modeling approach. For the example of a digitized LMIS system, the key value was reduction in stockouts of health commodities. A model should be identified or built which can utilize these inputs to estimate the health impact of interest. If there are resources and data available on the costs of the digital health intervention, this can be used to conduct cost outcomes research. Finally, the impact of the intervention should be contextualized relative to the status quo or other alternate interventions and limitations of the analysis should be addressed.

Figure 1. Methodological steps to conduct digital health impact analysis



Step 1: Conduct data collection

The World Health Organization (WHO) Classification of Digital Health Interventions provides a comprehensive landscape of different types and illustrative examples of digital health implementations.[2] Reference documents such as these can provide a useful foundation for identifying appropriate digital health interventions to be evaluated. Evidence should be gathered to understand the potential value of the intervention and the resulting health impact. In general, data collection may involve primary data from implementations, secondary data from peer-reviewed studies, or a combination.

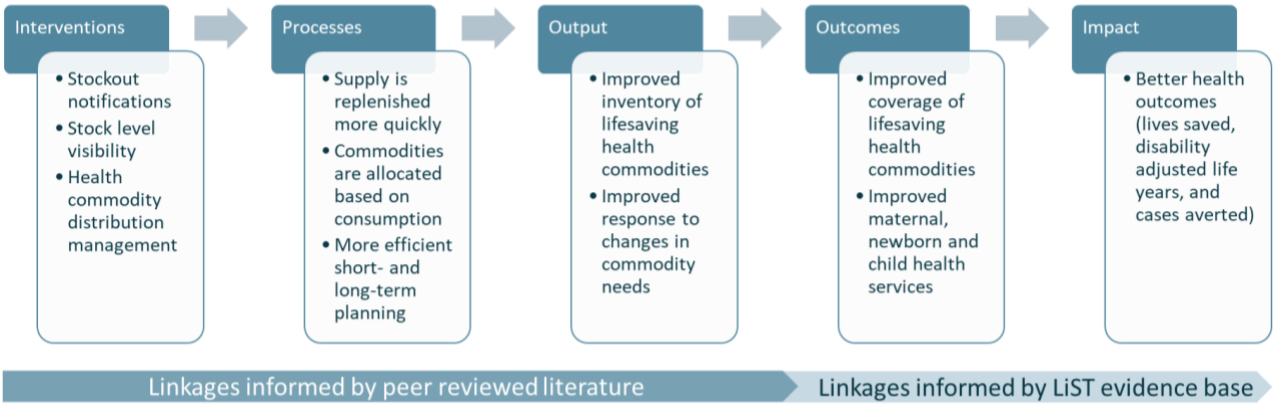
For the example in this analysis, a logistics management information system (LMIS) was selected as the WHO system category due to the availability of data. After reviewing data on LMIS systems in low–resource contexts, the key value articulated as an output of the intervention was reductions in stockouts of health commodities (see Step 2 below for more details). The literature review used source material from a variety of key documents, as well as PubMed and Google Scholar searches of peer-reviewed literature. Secondary data was augmented with primary data shared by implementers to determine a realistic range of the expected output of the intervention - improved inventory of lifesaving health commodities.

Step 2: Determine the value of the intervention and how it links to health outcomes

Based on the results of the data collection, the appropriate measurement of health impact should be identified. This may require creating an impact model to connect the digital health

intervention to health impact. An example of this type of impact model is shown in **Figure 2** which shows the evidence-informed link between digitized supply chain interventions and health impact. A key consideration in this step should be understanding what portion of the outcomes to attribute to the intervention and how to control for other confounding factors that impact the outcome of interest. The data collected will inform the appropriate numerical values to be used in the modeling of health impact, in addition to any scenario analysis which should be considered to account for uncertainty.

Figure 2. Impact model connecting digital health and improved health outcomes through LMIS



In the example in this analysis, reductions in stockouts were assumed to improve coverage of health commodities. The improved coverage then leads to better health outcomes, including child and newborn lives saved. Three scenarios were modeled, and each scenario was compared to a status quo (no changes in coverage) and assumed a 1:1 conversion between increased availability of health commodity and increased use of that health commodity based on the data collected in step 1. In addition, the time it takes for the digital health intervention launch, scale and have impact also needs to be considered. Given that the literature review and key informant interviews revealed rapid (<12-month) rollout processes for the digitalized last-mile LMIS, the example model in this analysis assumed a one-year timeline for scale-up to final coverage rate increases in base, optimistic, and conservative scenarios, and then held constant for the remainder of the forecast timeframe.

Step 3: Find or create a model

A model should be identified or custom built which can measure how digital health interventions can lead to impact. In the case of changes in medical interventions, various models exist to estimate changes in population-level health outcomes. A non-comprehensive list of publicly available models includes: the Maternal and Neonatal Directed Assessment of Technology (MANDATE) for maternal and neonatal interventions, Malaria Tools for malaria interventions,

Epidemiological MODeling software (EMOD) for a range of diseases including tuberculosis and typhoid, and the Spectrum Aids Impact Model (AIM) for HIV.

In this example, LiST (which is also part of the Spectrum software suite) was used for modelling lives saved in newborns and children based on changes in intervention coverage over a five-year period. The calculation for modelling lives saved in LiST is shown in **Figure 3**.[6]

LiST uses empirical evidence on the effectiveness of health interventions and proportion of deaths that can be averted by that intervention, referred to as the affected fraction.[7] Cause-specific mortality is calculated by multiplying number of births by overall mortality rates by the proportion of deaths estimated as being due to specific causes. Effectiveness is defined as the proportion of pathogen- or cause-specific deaths averted by a specific intervention. The LiST model eliminates potential double counting when scaling multiple interventions at once by using cause-specific mortality and applying additional interventions to the remaining residual deaths.[8] The model assumes that each death is due to a single cause and that each death can only be prevented once. LiST is validated by comparing measured mortality rates in low–resource contexts to mortality rates in calculated in LiST. More than 100 peer-reviewed publications have used LiST for program evaluation, strategic planning, and advocacy.[9]

Figure 3. Lives Saved Tool (LiST) impact calculation

Step 3: Layer in costing

Cost outcome research can be conducted by linking the impact analysis with available costing information related to the implementation to estimate the cost per health benefit achieved (e.g. lives saved). Typically, this is done using the additional or incremental cost and benefits of an implementation relative to the status quo. In many instances of digital health interventions, the status quo is no intervention.

In the LMIS example, a paper-based version of a system is the status quo that is then digitalized. When looking at cost elements, the recommended categories of cost would include all phases of the implementation: project scoping and development, deployment, scaling and operations. For the LMIS example, an analysis on the total cost of ownership (TCO) of a model

LMIS implementation over five years was used as the cost inputs into the calculation of cost per life saved. As in this example where costs are incurred over multiple years, the time horizon should be clearly stated and the investment should be annualized. Costs were separated by capital expenditures (CapEx), one-time start-up costs, and operational expenditures (OpEx), ongoing and recurring costs over the life of the solution. OpEx can vary substantially by the timeframe of deployment, market maturity, and, the extent of shared resources (human and capital) devoted to the system, especially for costs associated with maintenance and support. Capturing OpEx costs for digital health is critical since these costs are often not well-understood or accounted for, which may lead to an under estimation of the full investment required to deploy solutions.

In the example presented here, a few considerations were made related to adjusting costs to ensure accurate analysis. Since the costs were collected retrospectively and the impact was modeled prospectively, costs were adjusted to current value using a Gross Domestic Product (GDP) deflator to account for inflation.[10] The analysis also needed to be adjusted for the net present value, or present value of future costs of implementation. Calculating net present value requires using a discount rate to account for the fact that money spent in the present is worth less in the future. A wealth of methodological guidance exists on choosing the appropriate discount rate; however, a 3% annual discount rate is consistent with global health evaluations.[11] Assumptions, including adjustments to the valuation of costs and benefits over multiple years, should be stated clearly in the costing analysis.

Step 4: Identify comparator and contextualize findings

Identifying comparators is a common evaluation principle to contextualize the results. Ideally, the value of a digital health interventions should be determined relative to the current standard or status quo, as well as to any other interventions that may be considered. Finding appropriate comparators is a unique challenge for the valuation of digital health technologies given the evidence is very limited. One approach is to contextualize findings relative to other evaluations using similar methods, such as other analyses using the LiST which allows for comparison of lives saved based on different digital and non-digital interventions.

Identifying comparators and contextualizing findings also requires a clear articulation of the limitations of the analysis. Limitations of the approach should be considered and discussed, with special attention towards the degree to which outcomes and impact can be attributed to the digital health intervention. The discussion of limitations should include how the analysis controlled for confounding factors which influence the coverage and impact of the intervention. There are many factors that contribute to the impact of digital health interventions, meaning the magnitude of change for a digital health intervention may be confounded by other changes or interactions in the health care system. To account for various sources of uncertainty, scenario or sensitivity analysis should be performed.

In the example of the LMIS analysis, there are many factors which influence the impact observed in the model. These factors include underlying population, health status, and existence of effective health interventions, which are accounted for in the LiST model and other health impact models. In this analysis, the underlying population and health status impacted the total potential of improving stock availability: the healthier the population, the less change was

possible due to improving access. In the countries included in this research, the analysis showed that increasing coverage of specific health commodities (such as pneumococcal and DPT vaccines and commodities for sepsis, pneumonia, and diarrhea treatment) have the greatest impact on health outcomes, in part because these commodities tackled some of the highest burdens of disease for these geographies. Higher baseline coverage of commodities in specific geographies can also lead to a reduced potential effect size in the model. Scenario analysis was performed to capture overall uncertainty in the analysis and provide ranged estimates.

Conclusion

This methodology provides a framework for conducting cost outcome research for digital heath interventions. The lack of evidence on the value for money of digital health in low–resource context requires greater collection, use and analysis of data, as well as tools and approaches to facilitate this analysis and contextualize findings to support decision-making and investment in global health solutions.

Finally, the example methodology described here indicates that implementing a digital health intervention with inventory management, stock level notification, and distribution functionality has the potential to reduce under-five child mortality by improving coverage of lifesaving health commodities. The full analysis, with detailed results, will be publicly available soon. In addition to this specific implementation example, this approach can be replicated and used to estimate different types of impact from a range of digital health interventions. For example, increase in coverage of health interventions could be estimated based on implementations of clinical decision support tools, health worker learning management systems, or patient mHealth applications to encourage care-seeking. While impact in this analysis was evaluated through lives saved, other types of health impact could also be evaluated including health outcomes (e.g. infections averted or disability adjusted life year averted). While not within the scope of these methods, health system outcomes (e.g. time saved or costs savings) could follow a basic similar approach.

We hope this can serve as a working document for stakeholders who are interested in this space. We look forward to any feedback regarding this proposed approach!

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