Operationalizing the RE-AIM framework to evaluate complex interventions: lessons learned from the Integrated Research on Acute Malnutrition (IRAM) study

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I. Introduction of the RE-AIM evaluation framework

The use of theories, models and evaluation frameworks to design and evaluate interventions has now taken center stage in implementation science. The RE-AIM framework[1] is one of the most used frameworks to plan and evaluate the implementation of interventions [1]. RE-AIM framework is not only useful for researchers but also allows program implementers to broaden and structure their analysis to strengthen program implementation, design a performant monitoring and evaluation framework or conduct implementation research. The framework's key dimensions are reach and effectiveness (at an individual level), adoption and implementation (at actor, staff, system, or policy/other levels), and maintenance (both at individual and actor/staff/system/policy levels) (**Box 1**). The utilization of the RE-AIM framework is not limited to assessing if a program reaches satisfactory levels of each dimension, but also aims at understanding the barriers and facilitating factors of each dimension. Furthermore, it recommends identifying which subgroups of actors or settings demonstrate good or poor adoption and implementation and to assess which subgroups of program beneficiaries benefit most from good intervention reach and effectiveness.

Whereas most experience with RE-AIM comes from public health and behavioral studies conducted in high-income countries, the framework has been increasingly used for programs and interventions implemented in low-and middle-income countries and in a variety of thematic fields. Furthermore, the framework has been extensively used to assess the implementation of interventions consisting of few components. For the assessment of multi-component interventions, one way of applying RE-AIM to is first decompose the multi-components intervention into single components or activities and evaluate every component separately. However, such complex interventions can consist of intervention components or services that are either sequenced, layered, or integrated which may require an extension of the existing RE-AIM framework to evaluate the interaction between intervention components or services.

This technical brief provides an example on how RE-AIM was operationalized by the Integrated Research on Acute Malnutrition (IRAM) which assessed the implementation and impact of a complex intervention package. The IRAM intervention aimed at strengthening various services along the continuum of care of child wasting in Mali. IRAM defined the continuum of care of child wasting as a series of services offered

[1] The website https://RE-AIM.org offers a variety of manuals and toolkits to implement the framework.

by different providers at various levels of care (household, community, facility) that cover the prevention of wasting, the screening for wasting, the referral of cases to treatment services, the admission and treatment of cases, and the post-treatment follow-up and prevention of relapse. We first show how RE-AIM was applied on single IRAM intervention components and services. We then highlight a few limitations that we encountered with RE-AIM for a complex intervention package and propose how to extend RE-AIM for interventions or services that are sequenced, layered, or integrated.

Box 1: Defining the dimensions of the RE-AIM framework

Reach refers to the participation and representativeness of the target population. It relates to defining and identifying the target population and to assess the proportion of the target population exposed to the intervention. Example indicators include the proportion of the target population that participates in a program or service, characteristics of these participants and the barriers or facilitating factors to participation.

Effectiveness refers to the effects of the intervention or specific program services on primary or secondary outcomes. These can be both positive and negative. Subgroup analyses can further assess if the observed effect is homogeneous or modified by characteristics of the target population.

Adoption refers to the uptake of the program activities by agencies and actors tasked with the implementation of intervention. Adoption can be evaluated both at setting (e.g., percent of hospitals that adopted a new intervention) and at actor level (e.g., percent of staff that adopted a new intervention). Further analysis can assess barriers to adoption and characteristics of settings or individuals associated with adoption.

Implementation refers to the extent to which a program is implemented as intended. This dimension assesses the intervention agents' fidelity to the various elements of an intervention's key functions and components, including consistency and frequency of delivery of the intervention as intended. Evaluating implementation includes assessing actors' adherence to the intervention protocol, mapping and understanding possible adaptations that occurred and monitoring the quality-of-service delivery.

Maintenance is defined as the long-term effects of the intervention as well as the sustained implementation of intervention activities beyond the implementation phase of the intervention. Assessing maintenance of a program is typically done by collecting data several months or years after the program was concluded. When such assessment is not possible an assessment of the actors'

II. Case study IRAM Mali- Description of intervention package

The IRAM study in Mali assessed the impact of an integrated package of interventions aimed at preventing child wasting, early detection of wasting, supporting outpatient treatment of child wasting, and the prevention and early-detection of post-treatment relapse. The study was conducted from May 2021 to February 2022 in the Koutiala region in Mali. The program was implemented by World Vision Mali with support from UNICEF Mali. For an overview of the main findings of the IRAM evaluation we refer to the IRAM Mali policy note. [2]

Half of the health center catchment areas (n=22) in the Koutiala region (comparison group) received the support of the pre-existing community care groups (CCG) offering preventive behavior change communication on infant and young child feeding (IYCF) practices, child health and water, hygiene, and sanitation (WASH) practices and active screening of wasting in the community. The other half of the health center catchment areas (n=20; intervention group) received the IRAM intervention package that consisted of:

- Strengthened CCG

The number of CCG was increased to be proportional to the size of the population of each village. CCG members were tasked to conduct monthly home visits to deliver preventive services and screen children for wasting. In addition, monthly group meetings with caregivers were held to deliver group BCC on child IYCF practices, WASH and to organize nutrition or cooking demonstrations promoting the use of nutrient-dense ingredients.

- Preventive services

The preventive package included individual counseling offered during home visits and group BCC during group meetings on child IYCF, child health and WASH. During the monthly contacts, caregivers with children 6-17 months of age received a monthly ration of 30 sachets (20g) of small-quantity lipid-based nutrition supplements (SQ-LNS). Recent meta-analyses have shown that SQ-LNS reduces child stunting, wasting, and anemia and promotes early child development [3,4,5]. Caregivers of children that were identified with wasting were not given SQ-LNS but were referred to the existing outpatient treatment programs (OTP) for moderate (MAM) and severe (SAM) acute malnutrition.

- Screening for wasting

CCG members were tasked to screen children for wasting at any contact using mid-upper arm circumference (MUAC) tapes. In addition, CCGs introduced the family-led MUAC screening approach to ensure regular screening of children 6 to 59 months of age by family members. For this purpose, child caregivers and any other family member expressing an interest were provided with colored MUAC tapes and were trained to their use by CCG members during home visits and monthly group meetings. CCG members also explained the interpretation of the colors and encouraged caregivers to bring children identified with MAM or SAM to the nearest health center or community health worker to be admitted to treatment services.

- Support to the national protocol for SAM and MAM OTP

The national OTP protocols for uncomplicated SAM and MAM were followed in both study groups. In the intervention group, CCG members were tasked to conduct at least two home visits every month to the households of children enrolled in the MAM/SAM. These visits served to encourage caregivers to adhere to the treatment protocol and to prevent default from treatment. In both study groups, community health workers were trained to implement SAM and MAM OTP in addition to the existing OTP services delivered by first-line health services. CCG were also solicited to conduct fortnightly home visits to households with children recently discharged from treatment to prevent or detect possible relapse.

III. Operationalization of RE-AIM by IRAM Mali

We operationalized RE-AIM by defining indicators for each intervention component for the five dimensions of the framework (**Table 1**). The first step was to list all individual intervention components from prevention, screening, and treatment of wasting by actor and frame their pathway to impact. The next step was to compile indicators representing each RE-AIM dimension for each intervention component. As a last step, necessary data sources and data collection were identified. IRAM used various data sources to compile RE-AIM indicators. Between May 2021 and November 2021, a sample of 2,300 children 6 months of age was enrolled in a study cohort and followed by monthly home visits until February 2022. These data were primarily used to assess the reach and effectiveness dimensions. An additional survey in a sample of CCG members allowed to appreciate the reach of training and supervision activities by NGO and health center staff and to assess the adoption of the intervention activities by the CCG members. The maintenance dimension could not be properly assessed through post-intervention assessment because of budgetary restrictions. Instead, we asked community leaders, health staff, NGO, and community workers how the maintenance of ongoing activities could be assured and what adaptations this would require.

Qualitative data was collected through in-depth interviews of caregivers, CCG members, health center staff, CHW and community leaders to assess barriers and facilitating factors of the RE-AIM dimensions and were cross-checked with quantitative cohort and survey data.

Applying the RE-AIM framework, we were able to highlight implementation challenges which were not readily captured in the initial M&E plan. For example:

- RE-AIM allowed the evaluation team to identify that some activities suffered from low reach because the adoption by CCG members was only partial, and adaptation to implementation was insufficient. CCG members declared being unable to conduct the monthly home visits because this workload was incompatible with their livelihood activities. This resulted in low reach of BCC (<15%), despite some BCC being delivered instead during monthly gatherings.
- The lack of impact of intervention (effectiveness dimension) on caregiver IYCF, health and WASH knowledge and practices was linked to both the low reach of BCC and the inconsistent implementation of the BCC activity due to insufficient capacity of the CCGs and the lack of material (only one flip chart for BCC available per CCG of 12 members).
- The adoption of family-led MUAC by trained caregivers remained below 50%. The main reason provided by caregivers was that they were uncertain how and when to measure their child's MUAC. This finding aligned with that of structured observations of the CCG activities that found that CCGs mainly emphasized the measurement of MUAC itself but provided little information on the importance of screening regularly and on the actions to undertake if the MUAC measurement would indicate MAM or SAM (implementation dimension of family-led MUAC).

Table 1 Operationalization of RE-AIM to evaluate the implementation of IRAM Mali

	Operationalization	Data sources
Reach	**NGO/Health center staff related activities** • % CCG trained by NGO and health center staff • % CCG supervised monthly by NGO and health center staff	• Lists of CCG participants to training • CCG survey (n=120)
	CCG related services • % caregivers receiving home visits by CCG members • % caregivers participating in monthly group meetings with CCG • % caregivers of non-wasted children receiving monthly SQ-LNS • % caregivers receiving monthly BCC from CCG • % caregivers who received training in family-led MUAC • % children screened for wasting by CCG • % children enrolled in OTP receiving home visits by CCG • % children discharged from OTP receiving home visits by CCG	• Longitudinal cohort study in 1,150 intervention households
	OTP treatment services • % children with MAM/SAM enrolled in OTP • % caregivers adhering to OTP schedule	• Longitudinal cohort study in 1,150 intervention households • Treatment coverage surveys • OTP registers (adherence)
	Additional analysis • Reasons for (not) participating or not being exposed to the above services	• Mixed methods: cohort data and in-depth interviews with caregivers and CCG members on barriers and facilitators • Free-listing and pile-sorting of barriers and facilitators by groups of caregivers
Effectiveness	**Main analysis** • Prevalence of wasting (primary study outcome) • Incidence of wasting (# of emerging cases of wasting over time) • BCC related outcomes: caregiver knowledge on IYCF, health and WASH; caregiver IYCF and WASH practices; immunization coverage • Family-led MUAC related outcomes: percent of children screened by family led-MUAC referred and admitted to OTP (self-referral) • Treatment related outcomes: MAM/SAM OTP recovery rate • Post-treatment relapse related outcome: % children relapsed three months post-treatment **Additional analysis** • Effect modification analysis to understand in which subgroups of caregivers-child pairs the intervention was more or less effective	• Longitudinal cohort study in 2,300 households comparing intervention to control group
Adoption	• Percent of CCG members conducting home visits, organizing monthly group meetings, distributing SQ-LNS, introducing Family-led MUAC to caregivers, screening of children, referring MAM and SAM children to OTP	• CCG survey (n=120) • Free-listing of activities by CCG members
	• Percent of health centers and community health workers offering SAM/MAM OTP	• Monthly visits to health centers and CHW
	• Percent of caregivers who were instructed to Family-led MUAC and who received a MUAC tape screening their children monthly	• Longitudinal cohort study in 1,150 intervention households

	Operationalization	Data sources
	Additional analysis • Reasons for implementing one or more of the proposed activities including barriers and facilitators to adoption	• CCG survey (n=120) and in-depth interviews with CCG, health center, and NGO staff • Free-listing and pile-sorting of barriers and facilitators by CCG • In-depth interviews with health center staff and CHW responsible for OTP
Implementation	• Completeness of services delivered by CCG during home visits and group meetings with caregivers • Quality and consistency of BCC delivered by CCG • Quality and consistency of screening and referral by CCG • Quality of training of caregivers in family-led MUAC by CCG • Correct targeting of non-wasted children to deliver SQ-LNS • Correct messaging when distributing SQ-LNS (e.g., on continuous breastfeeding) • Correct measurement of MUAC by caregivers (family-led MUAC) • Quality and consistency of OTP services	• Shadowing of CCG members during home visits • Structured observations of group meetings (n=15) • In-depth interviews with CCG, caregivers, health center staff, CHW, NGO staff • Structured observations of MUAC measurements in a subsample of caregivers (longitudinal cohort study in 1,150 intervention households) • Structured observations of 15 OTP services (n=15)
Maintenance	• Barriers and facilitators to sustained activities • Necessary (additional) conditions to ensure maintenance	• Free-listing and pile-sorting of barriers and facilitators by CCG • In-depth interviews with CCG, caregivers, health center staff, CHW, NGO staff, and community leaders

IV. Introducing coherence to RE-AIM for the evaluation of complex interventions

In the previous section, we evaluated each individual intervention component in terms of Reach, Effectiveness, Adoption, Implementation and Maintenance. Doing so, we identified a few limitations of the framework. Applying RE-AIM to each intervention component from a complex intervention would only suffice if no interactions between the intervention components are expected. However, in case of IRAM, this assumption did not hold because many prevention, screening and treatment services interacted with each other. To our knowledge, RE-AIM does not provide specific dimensions or guidance to assess interactions between intervention activities.

For IRAM we identified three types of complex interventions: **sequenced interventions**, **layered interventions**, and **integrated interventions**. While it can be argued that the evaluation of the interactions between such interventions can be assessed under each of the RE-AIM dimensions, the importance and complexity of these interactions may require an extension of the RE-AIM framework to analyze the interplay between multiple intervention components. For this purpose, we introduce a novel dimension called **coherence** that emphasizes the need to apply RE-AIM jointly to multiple interventions that are either sequenced, layered, or integrated (**Box 3**).

Box 3: Defining the coherence dimension as an extension to RE-AIM

Coherence refers to the interactions between intervention components or services, and how these interactions impact the reach, effectiveness, adoption, implementation, and maintenance of a complex intervention package, and of each individual components of this package. Coherence should be seen as a cross-cutting dimension that allows to compile indicators for each of the RE-AIM dimensions considering the interaction between interventions.

In this section, we discuss examples (**Box 4-6**) of each type of complex intervention for IRAM showing the added value of assessing coherence between intervention components.

Sequenced interventions

IRAM defined sequenced interventions as those where the outcome of one intervention/service implies the admission or eligibility to a subsequent intervention or service. A first coherence assessment of sequenced interventions is to assess whether the outcomes of the first intervention are well aligned with the eligibility of the second intervention. Furthermore, to assess how the first intervention of a sequence impacts the subsequent intervention RE-AIM indicators should be defined conditional on the performance of the first intervention. Box 4 shows an example of how coherence was introduced to the IRAM study to evaluate sequenced interventions.

Box 4: IRAM example of sequenced interventions

In Mali, MAM and SAM children are admitted to treatment services based on low MUAC (115mm≤MUAC<125mm for MAM and MUAC<115mm for SAM) or Weight-for-Height Z-score (-3≤WHZ<-2 for MAM and WHZ<-3 for SAM) or the presence of edema. However, screening by CCG volunteers is limited to MUAC and the presence of edema as criteria. Such misalignment between admission and screening criteria can, at least partially, explain why treatment coverage remains below expectation because MAM and SAM children with low WHZ-score, but with a normal MUAC (≥125mm) and no edema, will remain undetected in the community and will not be referred to treatment services. A context-analysis conducted prior to the IRAM intervention using national SMART survey data from 2015-2019 found that this subgroup of children with only a low WHZ<-2 represents about 50% of all MAM and SAM children in Mali.

A comprehensive evaluation of the sequence of screening, referral, and treatment IRAM assessed the proportion of children screened and identified with MAM or SAM that were enrolled in treatment services in addition to determining total MAM and SAM treatment coverage. In case very few children identified with MAM and SAM were admitted to treatment services, it would imply that the effectiveness of the screening and referral activity may have been poor, which directly impacted the reach of the subsequent SAM and MAM treatment activity.

Layered interventions

Layered interventions can be defined as parallel interventions implemented by different actors addressing similar outcomes in the same target population. Layered interventions can intensify the exposure of a target population to the intervention because different actors offer the same activity or service. However, in other settings different layers of a similar intervention are intended to reach different subgroups of the target population. In such case, coherence between layered interventions can be evaluated in terms of complementarity, especially in terms of reach and effectiveness. **Box 5** shows an example of how coherence was introduced to the IRAM study to evaluate layered interventions.

Box 5: IRAM example of layered interventions or services

The IRAM intervention tasked CCG volunteers to actively screen children for wasting at any contact with caregiver-child pairs. CCG volunteers also distributed MUAC tapes to households and trained caregivers and any other household member to measure their children's MUAC weekly (Family-led MUAC approach). CCG would explain the meaning of the colors of the MUAC tape and encourage caregivers to bring their child to the available treatment services when the MUAC tape would show a yellow (MAM) or red (SAM) result. The active screening by CCG and the family-led MUAC approach can be seen as layered interventions. In IRAM, the introduction of family-led MUAC to households offered a complementary way of ensuring screening coverage independent of the contact frequency with CCG members. IRAM assessed the complementarity dimension by assessing the proportion of children screened in the past month by i) caregiver only, ii) CCG only and iii) both actors. It was of particular interest to assess the marginal contribution of family-led MUAC in addition to the ongoing active screening by CCG. If both layered screening services would prove to cover the same target population with little to no unique marginal contribution, a program may decide to invest all effort in just one of the layered interventions.

Integrated interventions

Integrated interventions can be defined in different ways. The most basic definition of an integrated intervention package is that it consists of different intervention components or services that are delivered at the same time and place, and by the same actor or platform. Intervention components or services can differ in terms of complexity, appeal to target beneficiaries and mode of delivery (in groups or individually). Moreover, the delivery of one component or service can positively or negatively affect the delivery of another intervention or service triggering positive or negative synergies depending on how well the implementation of these activities were planned and organized. In the case of integrated interventions coherence can we translated to both assessing the completeness of the delivery of multiple interventions and the occurrence of positive and negative synergies in terms of the RE-AIM dimensions between the interventions. **Box 6** shows an example on how the coherence dimension was introduced to the IRAM study to evaluate integrated interventions.

Box 6: IRAM example of an integrated intervention package

The IRAM program tasked CCG members to offer BCC, screen children for wasting and distribute SQ-LNS to non-wasted children. This integrated package was primarily offered through a monthly meeting at a central location within the community. By only organizing one monthly meeting, the number of attendees however often reached 50-70 caregivers per session. Whereas the SQ-LNS distribution register of the CCG specifically asked to register the screening result before distributing the SQ-LNS, the monitoring of the BCC group activity was collected in a separate BCC register and was not properly integrated with screening and SQ-LNS distribution. Structured observations of several group sessions unveiled that while screening and distribution were organized at one side of the venue, only smaller groups of caregivers participated in group BCC at the other side of the venue. The CCG volunteers organizing the group meeting were at times overwhelmed by the large groups of attending caregivers, mainly interested in securing their monthly ration of SQ-LNS. As a consequence, the BCC could not be offered to everyone. From these observations, we concluded that there was a negative synergy between BCC delivery and the screening and distribution of the SQ-LNS. This limited coherence between intervention services is likely responsible for the lack of impact of the IRAM BCC on caregiver knowledge and practices related to IYCF, child health and WASH.

IV. Conclusion

RE-AIM is well-established evaluation framework that allows for a comprehensive evaluation of the implementation of interventions. However, we found that for complex interventions such as IRAM, the evaluation would benefit from extending the RE-AIM framework with the additional of coherence. including the new dimension of **coherence**. This cross-cutting dimension adds to a comprehensive evaluation by zooming into the interactions between intervention components or services. Introducing the dimension of coherence to RE-AIM provided valuable insights in the dynamic of the multiple interventions delivered by IRAM along the continuum of care of child wasting in Mali.

V. References

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