

**Audit And Feedback Strategy in Maternal And Child Health  
Services in A Low-Resourced Setting – A Process and Impact  
Evaluation of the IDEAs Strategy in Central Mozambique**

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## **Abstract**

### **Audit And Feedback Strategy in Maternal And Child Health Services in A Low-Resourced Setting – A Process and Impact Evaluation of the IDEAs Strategy in Central Mozambique**

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Audit and feedback strategies have been used to improve healthcare quality. Scarce evidence exists on audit and feedback implementation processes and their potential to improve delivery of maternal and child health services in low-resource health systems. The Integrated District Evidence to Action (IDEAs) is a multi-component audit and feedback strategy designed to improve the implementation of maternal and child guidelines in Mozambique and was implemented in 154 health facilities across 12 districts in Manica and Sofala provinces between 2016 and 2020. This dissertation aims to evaluate the implementation process of IDEAs and report implementation outcomes, evaluate the effectiveness of IDEAs on health service outcomes, and examine the association between measures of implementation fidelity and the strategy's effectiveness.

In process evaluation, the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework was used to guide the definition and measurement of implementation outcomes. Reach was defined as the proportion of pregnant women attending IDEAs facilities.; adoption as

the proportion of facilities initiating audit and feedback meetings; implementation as fidelity to the strategy components (readiness assessments, meetings (frequency, participation, action plan development); and targeted financial support and supervision); and maintenance as intervention sustainment at 12, 24, and 54 months. We found high reach, adoption, and maintenance. Implementation fidelity was high for all strategy components with the exception of implementation of readiness assessments and action plans.

The impact evaluation assessed 1) ten service delivery outcomes across antenatal, maternity, postpartum, childcare, and reproductive health services and 2) five service readiness outcomes (medicines, infrastructure, equipment, care, and staffing availability). We used propensity score matching to minimize bias and a controlled interrupted time series with a negative binomial mixed effects model for analyses of improvements in service delivery outcomes. We created composite scores for each domain of service readiness outcomes and employed a difference-in-difference analysis using an ordinal mixed effects model to assess score improvements. Significant associations were found with the monthly number of first at-risk child appointments (IRR = 1.06 [1.04, 1.07]), first PCR tests for HIV-exposed children (IRR= 1.02 [1.01, 1.03]), new contraceptive users (IRR = 0.95[0.94, 0.96]), women starting long-lasting contraceptives (IRR= 0.94 [0.93, 0.95]), availability of infrastructure (OR= 5.84 [1.32, 25.88]) and essential care (OR = 0.13 [0.03, 0.54]). Null effects were found on six of the remaining ten service delivery outcomes.

To explore fidelity and its association with effectiveness, we used the conceptual framework for implementation fidelity to guide the descriptive assessment of adherence to the IDEAs strategy components. An exploratory principal component analysis was applied to develop the primary measures of fidelity. Regression modeling was used to study patterns of association between these fidelity measures and the previously described outcome measures (1) ten service delivery

outcomes and 2) five service readiness outcomes). High fidelity was found in 12 out of 15 measures of fidelity. The principal component analysis identified four main components interpreted as "measure of audit and feedback structure," "measure of participation," "measure of insufficient supervision," and "measure of unsatisfactory completion of micro-interventions". In regression modeling, service delivery measures were positively associated with participation, supervision, and degree of micro-intervention completion and negatively associated with more action plans and problems identified in meetings. For readiness outcomes, delivery of essential care was positively associated with participation and micro-intervention completion, and staff availability was negatively associated with the number of supervisions.

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## **DEDICATION**

To whom who sustains me, my almighty God, for the constant presence and infinite love

To my family, for the endless support

## **CHAPTER 1: Introduction**

Living beyond the first 28 days of life remains a major achievement in most low and middle-income countries (LMICs) [1]. Around 2.4 million neonatal deaths and 2.0 million stillbirths occur yearly worldwide, with 98% of these occurring in LMICs [2]. Reductions in neonatal mortality have been slower than under-5 child mortality, with the highest risk of death being at or around the time of birth, requiring a rapid response from health providers to prevent death [3]. The leading causes of newborn deaths include prematurity, birth asphyxia and trauma, sepsis, and other infectious diseases [4]. Determinants of neonatal mortality encompass multiple socioeconomic and environmental factors (such as income status, geographical location, and mother's education), and the health system's capacity to respond [4].

Global efforts exist to reduce neonatal mortality. Sustainable Development Goal (SDG) three states that achieving good health and wellbeing for all is to end preventable deaths of newborns and under-5 children, with all countries aiming to decrease the neonatal mortality rate (NMR) to below 12 per 1000 live births by 2030 [5]. The Every Newborn Action Plan, endorsed at the 67<sup>th</sup> World Health Assembly in 2014, defined a target of 10 or fewer newborn deaths per 1000 live births by 2035 [6]. Strategic objectives of Every Newborn Action Plan include strengthening and investing in care during labor, birth, and the first day and week of life; improving the quality of maternal and newborn care; strengthening health systems to optimize the organization and delivery of care, the workforce, commodities, and innovation; reaching every woman and newborn to reduce inequities; harnessing the power of parents, families, and communities; and improving data for decision making and accountability [6,7].

It is estimated that increasing the coverage and quality of preconception, antenatal, intrapartum, and postnatal interventions could avert 71% of neonatal deaths by 2025 [8,9]. Preconception interventions include delaying the age of the first pregnancy, increasing unmet needs for family planning (FP), and improving pregnancy nutritional status. Antenatal interventions include maternal immunization; screening and management of infections in pregnancy; as well as diagnosis and management of pregnancy complications and pre-existing chronic diseases. Interventions delivered during the labor period include obstetric care, skilled delivery, and management of preterm labor and post-term pregnancy, among others. Immediate newborn care comprises immediate neonatal drying and stimulation, warming, umbilical cord hygiene, breastfeeding, vitamin K administration, and neonatal resuscitation. For tiny and ill newborns, preventing hypothermia and managing respiratory distress syndrome, pneumonia, and sepsis are critical interventions.

It is clear that there are a multitude of evidence-based interventions (EBIs) to prevent neonatal deaths, and these EBIs are part of most national practice guidelines; however their inconsistent delivery continues to represent a lost opportunity to bend the needle on this preventable mortality [8]. In other words, there is a failure to translate what is known to work into practice, or a “know-do gap” [10]. Across primary health care settings, inadequate adherence to standardized guidelines continues to contribute to negative health consequences [11].

To respond to these challenges, many implementation strategies are implemented to improve the quality of maternal and child health (MCH) care. These strategies include continuing education and quality assurance programs (such as distribution of educational materials, in-service training, audit and feedback, reminders, educational meetings, local consensus processes, problem-based

learning, supervision, education outreach visits, and mass media); organization of care strategies (such as integration of services, systems improvement, changes in medical record systems); financial interventions (such as provider incentives); and community-level strategies (such as training midwives, traditional birth attendants, and community health workers)[12,13].

Audit and feedback (A&F) involves providing a provider with a summary of their performance over a specified period, and it is a strategy commonly used to promote the implementation of guideline-based care [14]. A&F is widely used as a strategy to improve professional practice as a single strategy or as a component of a multifaceted quality improvement (QI) intervention [15]. The rationale underpinning A&F strategies is that it prompts health providers to change their practice when given performance feedback, showing that their clinical practice is sub-optimal compared to a desired target. Despite being widely used, uncertainty remains regarding both the effectiveness of A&F in improving healthcare practice and the characteristics of this strategy that lead to greater impact. A Cochrane review of 140 studies on A&F showed a median risk difference (RD) of 4.5% (interquartile range-IQR 0.5% to 16%) absolute increase in health professionals' compliance with desired practice. The same review also found an RD of negative 0.4% (IQR -1.3% to 1.6%) improvement in dichotomous patient-level outcomes and 17% (IQR 1.5% to 17%) improvement for continuous patient-level outcomes [16,17]. The conclusion of the review was that the effect of A&F on professional practice and patient outcomes ranges from little or no effect to a substantial effect, that A&F is most effective when baseline performance is low; when the source of A&F is a supervisor or colleague; when feedback is provided multiple times both in a written and verbal format, includes clear targets, is documented in an action plan, and the recipient are non-physicians [15,16]. However, these results are primarily from

randomized controlled trials in high-income countries, and little is known about the effectiveness of A&F in LMIC health settings [16].

A&F has been applied in LMICs to promote adherence to antibiotic guidelines, with moderate evidence of effectiveness [18]. In a review of 44 studies on the effectiveness of interventions to change professional behavior to bring evidence into practice in LMICs, 15 described A&F strategies [19]. This review found that clinical audits effectively improved compliance, although the studies were considered weak designs. Multifaceted interventions were found to be more effective than single interventions (audits combined with local consensus or peer review and targeted training, for example). Improvements were more likely to be observed when the audit design was appropriate to local health system cultures, when those who needed to implement change were engaged in the process, and when actions were feasible given the availability of resources and existing practices. Rapid improvements were also found when the government introduced A&F as a quality assurance tool with a clear allocation of resources. Almost all studies showed improvements in the short term, but the effects were not sustained [19].

In Mozambique, a country with limited resources and a high disease burden, neonatal mortality remains a public health problem, and the NNR is currently estimated to be 28 deaths per 1,000 live births [20]. However, the utilization of maternal and child health services in Mozambique is high, with an estimated 93% of pregnant women attending their first antenatal care (ANC) visit, 73% giving birth in a health facility, and 76% of children ages 12–23 months receiving the third pentavalent vaccination [21]. Despite this high utilization, the quality of evidence-based obstetric care is still poor [22,23]. Local evidence reveals that weakness in the supply chain, staff shortage, high staff turnover, high staff workload, lack of data collection forms, inappropriate

infrastructure to deliver interventions, lack of awareness of guidelines and protocol implementation, and resistance to following procedures are among barriers for implementing the evidence-based clinical practice [24]. The implementation of QI initiatives is not new in Mozambique. Bugalho and Bergstrom investigated the implementation of a perinatal audit in Maputo Central Hospital between 1982 and 1991 and found a reduction of 20% in perinatal mortality and 60% in intrapartum fetal mortality attributable to the audit process [25]. A Standard-based Management and Recognition (SBM-R) QI approach in maternal, newborn, and child health programs was implemented in 95 health facilities of all health system levels in Mozambique between 2009 and 2014 and found an estimated 24% improvement in compliance with standards [26]. Cavicchiolo et al. [27] evaluated the implementation of a QI program in the neonatal intensive care unit of the Beira Central Hospital, the second-largest hospital in the country, aiming to improve infrastructure, availability of equipment, and use of clinical protocols. The study reported reduced neonatal mortality from asphyxia, sepsis, and prematurity during the intervention period [27].

Existing evidence suggests that A&F can effectively change health providers' practices.

However, most evidence is from controlled trials in high-income settings, and little is known about operationalizing A&F efficiently and effectively [28,29]. Therefore, it is crucial to further research A&F in resource-constrained settings, including how to implement A&F strategies at scale in order to guide context-specific adaptations and enhance their potential effectiveness.

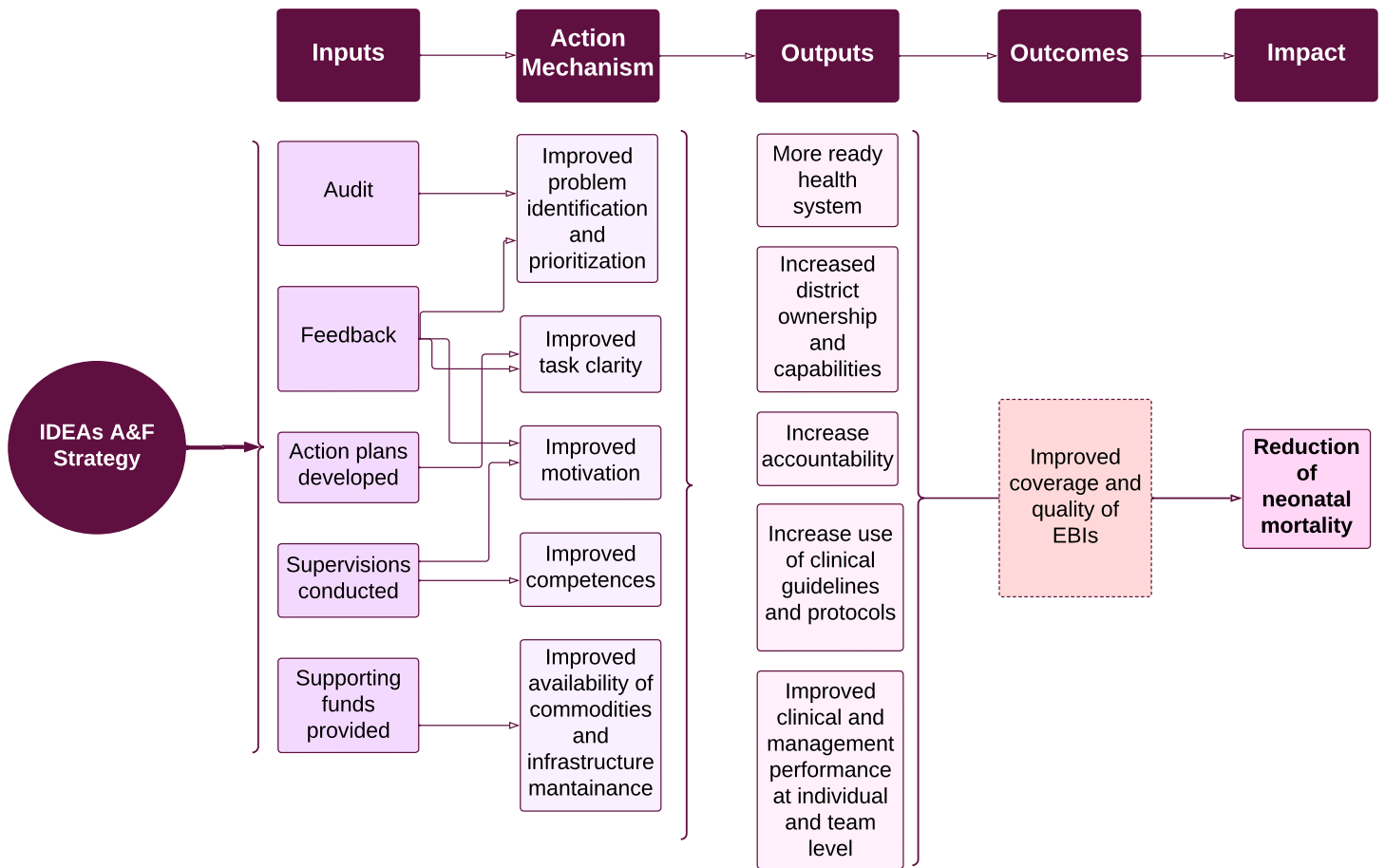
The Integrated District Evidence to Action (IDEAs) program is a multi-component, enhanced A&F implementation strategy that aims to improve the coverage and quality of a bundle of existing evidence-based interventions targeting major causes of neonatal mortality. In the IDEAs program,

A&F is modified by involving health managers across province, district, and frontline health workers instead of exclusively engaging frontline clinicians. In addition, the program is enhanced by systematically collecting health service readiness data and providing routine district-to-facility supportive supervision with flexible funding to support the implementation of action plan activities. Funded by the Doris Duke Charitable Foundation and the National Institutes of Health, IDEAs was implemented between October 2016 and December 2020 in two provinces across 12 districts in central Mozambique. The goal was to determine the effectiveness of the IDEAs intervention strategy, led by district management teams, to serve as a foundation for national scale-up.

The present dissertation evaluates the IDEAs strategy. Specifically, the first objective is to evaluate the implementation process and report implementation outcomes based on the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework. The second objective is to evaluate the impact of IDEAs on health service outcomes by applying a quasi-experimental design. The third is to examine the implementation fidelity of IDEAs and link it with its effectiveness with the use of the implementation fidelity framework, applying a principal component analysis and regression modeling. The ultimate goal of this work is to add knowledge and understanding about implementing A&F strategies in a complex health system in a low-resourced setting by using lessons learned from the Mozambique case.

Below, I present the conceptual framework of the IDEAs strategy:

**Figure 1. IDEAs strategy conceptual framework**



## **CHAPTER 2: Implementation Outcomes of the Integrated District Evidence-to-Action (IDEAs) Program to Reduce Neonatal Mortality In Central Mozambique: An Application of the RE-AIM Evaluation Framework**

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## **ABSTRACT**

### **Background**

Scarce evidence exists on audit and feedback implementation processes in low-resource health systems. The Integrated District Evidence to Action (IDEAs) is a multi-component audit and feedback strategy designed to improve the implementation of maternal and child guidelines in Mozambique. We report IDEAs implementation outcomes.

### **Methods**

IDEAs was implemented in 154 health facilities across 12 districts in Manica and Sofala provinces between 2016 and 2020 and evaluated using a quasi-experimental design guided by the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework. Reach is the proportion of pregnant women attending IDEAs facilities. Adoption is the proportion of facilities initiating audit and feedback meetings. Implementation is the fidelity to the strategy components, including readiness assessments, meetings (frequency, participation, action plan development), and targeted financial support and supervision. Maintenance is the sustainment at 12, 24, and 54 months.

### **Results**

Across both provinces, 56% of facilities were exposed to IDEAs (target 57%). Sixty-nine and 73% of pregnant women attended those facilities' first and fourth antenatal consultations (target 70%). All facilities adopted the intervention. Ninety-nine percent of the expected meetings occurred with an average interval of 5.9 out of 6 months. Participation of maternal and child managers was high, with 3076 attending meetings, of which 63.5% were from the facility, 29.4%

from the district, and 7.1% from the province level. Ninety-seven percent of expected action plans were created, and 41 specific problems were identified. “Weak diagnosis or management of obstetric complications” was identified as the main problem, and “actions to reinforce norms and protocols” was the dominant subcategory of micro-interventions selected. Fidelity to semiannual readiness assessments was low (52% of expected facilities), and in completing micro-interventions (17% were completed). Ninety-six and 95% of facilities sustained the intervention at 12 and 24 months, respectively, and 71% had completed nine cycles at 54 months.

## **Conclusion**

Maternal and child managers can lead audit and feedback processes in primary health care in Mozambique with high reach, adoption, and maintenance. The IDEAs strategy should be adapted to promote higher fidelity around implementing action plans and conducting readiness assessments. Adding effectiveness to these findings will help to inform strategy scale-up.

## BACKGROUND

The Sustainable Development Goals call to end preventable deaths of newborns and children under five, with all countries aiming to reduce neonatal mortality to 12 or fewer deaths per 1,000 live births and under-five mortality to 25 or fewer deaths per 1,000 births by 2030 [20]. In 2020, more than 5 million children died before age five, and 47% of those deaths occurred during the neonatal period—the first 28 days of life—even without the increase in mortality attributable to COVID-19 [20]. Sub-Saharan Africa has the highest neonatal mortality rate in the world at 27 deaths per 1,000 live births, contributing 43% of the global share of neonatal deaths [20]. In Mozambique, a country with limited resources and a high disease burden, neonatal mortality remains a significant public health problem, with a rate of 28 deaths per 1,000 live births in 2020 [20].

Research suggests that increasing the coverage and quality of preconception, antenatal, intrapartum, and postnatal evidence-based interventions globally by 2025 could avert 71% of neonatal deaths, saving approximately two million lives per year at a low cost [8]. Furthermore, available interventions can reduce the major cause of neonatal mortality—preterm, intrapartum, and infections-related deaths—by 58%, 79%, and 84%, respectively [8]. Examples of these interventions include maternal immunization, screening and management of infections, preventive treatments for malaria, emergency obstetric care (EmOC), and immediate procedures for neonatal care [8,9].

Countries with high neonatal mortality, including Mozambique, have clinical practice guidelines to implement these interventions along the continuum of care in health facilities and at the

community level. Despite these guidelines, implementation is inconsistent, with only 47% of recommended care provided by providers 1/11/24 9:41:00 AM. Additionally, the coverage and quality of evidence-based interventions are uneven in low-resource countries, primarily due to poor service readiness (lack of financial, material, and human resources), lack of provider training, weak provider awareness of current clinical guidelines [24,30,32], lack of accountability of provider performance, and poor leadership and management capacity [33,34].

The utilization of maternal and child health services in Mozambique is high. In 2015, an estimated 93% of pregnant women attended a first antenatal care (ANC) visit, 73% gave birth in a health facility, and 76% of children ages 12–23 months received the third pentavalent vaccination [21]. Compliance with clinical guidelines can be improved by implementing structural changes and strengthening leadership and management across different health system levels [35,36], facilitating improvements in health service utilization and neonatal outcomes.

Audit and feedback (A&F) is an evidence-based implementation strategy used in healthcare settings to systematically evaluate individual professional practice or performance based on targets or standards and improve health professionals' compliance with guidelines [16].

However, more evidence is needed on how to use A&F most effectively [28]. Most studies on A&F use a randomized controlled trial design and have been conducted in high-income settings and demonstrate small to moderate effectiveness [16,37,38]. Uncertainty remains about the potential impact of A&F in low-income settings where the disease burden is higher, health systems are weaker, and baseline implementation of clinical practice guidelines has considerable space for improvement. Further evidence generation is needed from these settings, where more significant effects can be expected.

The Integrated District Evidence to Action (IDEAs) program is a multi-component A&F implementation strategy that aims to improve the coverage and quality of a bundle of existing evidence-based interventions targeting major causes of neonatal mortality. Funded by the Doris Duke Charitable Foundation and the National Institutes of Health, IDEAs was implemented between October 2016 and December 2020 in two provinces across 12 districts in central Mozambique. The goal was to determine the effectiveness of the IDEAs intervention strategy, led by district management teams, to serve as a foundation for national scale-up.

The Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework is one of the most frequently applied implementation science frameworks [38–40]. RE-AIM was developed to guide research in complex real-world settings and has great potential to provide detailed, nuanced information on whether and how quality improvement interventions succeed [41,42]. Reach describes the absolute number, proportion, and representativeness of individuals willing to participate in the intervention. Effectiveness describes the impact on selected outcomes. Adoption captures the absolute number, proportion, and representativeness of settings and intervention agents willing to initiate a program. Implementation represents the intervention agents' fidelity to the components of an intervention's protocol, including consistency of delivery as intended, time spent, and associated costs. Maintenance refers to the extent to which a program or policy becomes institutionalized or part of routine organizational practices and policies [40,41]. Guided by the RE-AIM framework, we report on the IDEAs A&F implementation process and outcomes in this article. We hope our findings will help inform and improve the IDEAs program's future replication, adaptation, or scale-up.

## **METHODS**

### **Program description**

The IDEAs program is designed to improve health service delivery by identifying clinical performance gaps and enabling maternal and child (MCH) nurses to monitor, evaluate, prioritize, and adapt solutions to improve compliance with Ministry of Health (MOH) guidelines targeting major causes of neonatal mortality. IDEAs is a multi-component implementation strategy that conducts routine health service readiness assessments (SRAs); applies an A&F process that engages MCH managers at facility, district, and province levels to review performance and develop solutions that address identified gaps; and supports ongoing district-to-facility supportive supervision and provision of flexible funding to support implementation of these identified solutions (*micro-interventions*, defined here as solutions selected, implemented, or adapted at the health facility level, not requiring significant financial resources). IDEAs cycles are iterative, repeated every six months.

### **Steps involved in the IDEAs implementation strategy**

#### **Step 1: Facility and district service readiness assessment**

Before the semiannual A&F meeting, standardized assessment tools ( the World Health Organization Service Availability and Readiness Assessment -SARA[43], program questionnaires, observation, and registry review) were applied in three randomly selected, rotating facilities within each district to assess 1) structural readiness to deliver perinatal clinical intervention, including staffing levels, training, availability of essential commodities, equipment

and supplies, and data quality, and to assess 2) process quality (provider knowledge and ability to apply clinical guidelines; patient satisfaction, and observation of use of provider time).

### **Step 2: Audit and feedback meeting**

MCH managers from the facility, district, and provincial levels participated in semiannual A&F meetings. Auditing data from routine health information systems and SRAs was used to compare performance relative to goals. Feedback was provided in both graphical and tabular formats, allowing visualization of secular trends of service indicators. Each facility and district team presented their performance metrics, followed by a group discussion to interpret results, identify barriers to guideline adherence, and develop action plans highlighting priority problems, specific and measurable targets, and resources required to implement micro-interventions (Figure 2).

### **Step 3: Targeted facility support**

At each district A&F meeting, three facilities were selected based on the performance of service delivery indicators (one high-performing and two low-performing) to receive up to two supervision visits per cycle. A modest monthly financial support (US\$1,250) was allocated to the district to support action plan implementation in selected health facilities. During supervision visits, action plans were reviewed, barriers to guideline implementation were identified, and technical assistance to address context-specific barriers was provided. Provincial and district MCH managers were responsible for monitoring, evaluating, and recording the degree of success (proportion of micro-intervention implemented successfully) by the health facilities (Figure 2).

### **Study setting**

Manica and Sofala provinces are located in central Mozambique and have a combined population of >4.5 million inhabitants [44,45]. The IDEAs implementation strategy was

implemented in all 154 primary health facilities across 12 districts, representing >70% of the population in both provinces (Table 1). Intervention districts were selected based on their large population size, robust health facility network, and geographic accessibility to maximize resource investment. Districts were selected as the intervention unit because they are logical disseminating agents, can access resources to meet health facility needs, have the authority to implement management decisions within subordinate health facilities, and have a broad reach across the health system.

### **Study design**

The IDEAs strategy applied a quasi-experimental study design guided by the RE-AIM framework. All dimensions of the RE-AIM framework were used to plan, evaluate, and report the IDEAs strategy. RE-AIM guided the selection and definition of implementation outcomes (reach, adoption, implementation fidelity, and maintenance) reported in the present manuscript and the methodology to evaluate the strategy's effectiveness on service and readiness outcomes (reported elsewhere). In examining the implementation process, descriptive statistics and qualitative document reviews were used for data extraction and reporting on implementation outcomes. The effectiveness will be assessed using a controlled time series analysis.

### **Data analysis: RE-AIM measures**

#### ***Reach***

The targeted reach for the IDEAs intervention strategy was 57% of health facilities and 70% of pregnant women and newborns across both provinces. For facilities reached, we divided the number of IDEAS facilities by the total number of public sector primary care health facilities in

Manica and Sofala. For the population reached, we use two indicators (first and fourth ANC visits). We divided the total number of ANC visits between 2017 and 2020 in IDEAs facilities by the total number of ANC visits in all facilities in both provinces. These two indicators were selected to describe the first contact of women with the health facility and their retention in care. We used the health information system and project assessments as data sources for selecting facilities and extracting the number of ANC visits.

### ***Adoption***

We defined adoption as the proportion of districts and facilities that initiated the IDEAs intervention. Our target was that 95% of districts and facilities would adopt the intervention. We used A&F meeting reports and program data to verify the participation of each district and facility.

### ***Implementation***

We examined the fidelity of the implementation strategy in each district. We used program assessments, action plans, and supervision data to report the following measures: (1) The number and frequency of A&F meeting cycles; (2) The number of participants in A&F meetings; (3) The number and frequency of SRAs, (4) The selection of health facilities based on performance, (5) The number of action plans elaborated, (6) The content of action plans (identified problems and proposed micro-interventions), (7) The number and frequency of supervision visits, (8) Financial support to implement action plans, and (9) The proportion of micro-interventions implemented successfully.

Based on the IDEAs timeline and predetermined intervals between A&F meetings, we expected each district to conduct a series of nine A&F meetings (cycles) between October 2016 and December 2020.

Analyzing action plan content over time was challenging as each facility identified problems relevant to its context, leading to heterogeneity of action plan descriptions. We subsequently grouped similar problems (written differently but with the same meaning or intent), resulting in a list of 41 specific, mutually exclusive problems that micro-interventions were designed to address.

Micro-interventions were initially grouped into six general categories and 23 specific subcategories delineated prior to the study based on a previous pilot experience (Table 2). After removing two unused subcategories from the “health services organization” category, 21 subcategories remain in the final categorization.

### ***Maintenance***

Three time points were predetermined to evaluate maintenance: 12, 24, and 54 months. We measured the proportion of health facilities sustaining the IDEAs strategy as designed (i.e., holding A&F meetings at least semiannually) at 12 and 24 months and the proportion of health facilities completing meetings at 54 months. Our target was for 90% of health facilities to have implemented the intervention at 12 months, more than 80% at 24 months, and more than 70% completing nine cycles of meetings at 54 months. We counted the months between the first and last A&F meetings for each district and facility and evaluated their participation at each time point.

## **RESULTS**

### **Reach**

Facilities: 277 public primary health care facilities were registered in the health information system in both provinces during the study period. Of those, 154 facilities (56%) were exposed to the IDEAs intervention.

Population: 698,683 pregnant women attended the first, and 491,536 attended the fourth ANC visit between January 2017 and December 2020 at IDEAs facilities, compared with 318,253 and 183,933 in non-intervention facilities in Manica and Sofala province, indicating that 69% and 73% of pregnant women and newborns received first and fourth ANC visits in facilities exposed to the IDEAs strategy.

### **Adoption**

Adoption was 100%, with all 154 health facilities in the 12 districts initiating A&F meetings. However, 13 health facilities in Barue district initiated meetings in the second cycle (out of nine possible cycles), and four facilities in Beira, Gondola, and Vanduzi districts initiated meetings even later (in the seventh and eighth meeting cycles).

### **Implementation fidelity measures**

#### ***Audit and feedback meetings***

One hundred-seven district A&F meetings occurred during the study period, out of an expected 108. Of the 154 facilities included in this study, 109 (71%) completed all nine A&F cycles, while

45 (29%) completed fewer than nine (34 conducted eight, seven conducted seven, two conducted two, and two conducted one cycle).

Based on the number of facilities and participants from multiple health system levels (facility, district, province), the program expected a minimum of 1512 participants over nine cycles.

However, 3076 MCH managers participated in A&F meetings during the study period. Of these, 64% (n=1954) were from health facilities, 29% (n=905) were from district management teams, and 7% (n=217) were from the provincial health departments.

The average interval between meetings was 5.9 months (ranging from 5.3 in Barue to 6.2 in Buzi district), close to the target interval of six months. The duration of each meeting was five days, with the first three days reserved for preparation (data organization, performance matrix elaboration, and presentation rehearsals) and the remaining two days for presentations, discussions of service performance, and elaboration of action plans.

### ***Frequency of health service readiness assessments***

The goal was to assess readiness in 36 facilities per semiannual cycle in a rotating approach. In practice, there were delays in starting the assessments, and the original sample of 36 was reduced to 24 facilities (2 facilities per district per cycle). By the end of the study, 52% (n=168) of the expected facilities were assessed.

### ***Selection of health facilities based on performance***

Per protocol, during each A&F meeting, the district selected three health facilities—one high-performing and two low-performing—for a total of 321 selections (214 low-performing, 107 high-performing) across the implementation period. By the end of the study period, 128 of the 154 health facilities (83%) had been selected at least once (some were selected multiple times

over the nine cycles), totaling 309 (96% of expected) selections (n=206 low-performing, n=103 high-performing). The number of times each facility was selected during the study varied from zero to seven. Thirty-seven health facilities switched from high-performing to low-performing, or vice versa, between cycles; 28 were selected as high-performing, 63 as low-performing, and 26 were not selected at any point.

### ***Elaboration of action plans and identification of problems and micro-interventions***

Based on the number of health facilities participating in each A&F meeting, we expected 1294 action plans to be developed. By the end of the study period, 1257 (97% of expected) action plans had been developed.

A total of 10,967 problems were identified in all 12 districts during the nine A&F meeting cycles (Figure 3A). After grouping these problems based on similarity, we developed a list of 41 distinct problems identified by facility managers. Most problems were identified during the first two cycles, with a drop in the number in subsequent cycles (Figure. 3A and 3B). Facilities participating in each district A&F meeting tended to identify the same problems, as seen by the difference between the cumulative number and number of distinct problems (Figure 3).

Nhamatanda, Buzi, and Dondo districts in Sofala province identified the highest proportion of problems (14%, 12%, and 10%, respectively), and Mossurize, Gondola, and Chimoio districts in Manica province identified the lowest proportion (6%, 5%, and 4%, respectively).

In our analysis of the distribution of problems by MCH services, the majority of problems identified were related to antenatal care (46%), followed by maternity (24%), at-risk child consultations (13%), family planning (10%), and postpartum (7%) services.

When ranking all 41 distinct problems, the cumulative proportion of the top 10 was 73%, as illustrated in Figure 4.

The following descriptive analysis focuses on the top 10 ranked problems by district and by cycles of A&F.

The top problem consistently identified in eight of the 12 districts and six of the nine cycles was “weak diagnosis or management of EmOC”. When it was not identified as the main problem in a district, it was substituted with “low coverage of the fourth ANC visit,” “low coverage of the first ANC visits before 12 weeks of pregnancy,” or “low coverage of the second or fourth dose of IPTp,” respectively. In cycles where weakness in EmOC was not the main issue, “low coverage of the first ANC visits before 12 weeks of pregnancy” was the substitute.

While most problems were identified in multiple districts and cycles, some were more restricted. For instance, “lack of sphygmomanometer” was listed as a priority only in Chimoio district and during the first cycle. Similarly, “weak diagnosis or management of neonatal asphyxia” was identified as a priority only in Beira and the second cycle.

### ***Overall proposed micro-interventions***

The micro-interventions proposed in the action plans were categorized into six predefined general categories and ranked as follows: Inter- and intra-institutional coordination and collaboration (47%); Information, Education, and Communication (IEC; 27%); commodity stock management (8%); information system management (7%); community involvement (6%); and organization of health services (5%) (Figure 5). In addition, 21 subcategories were predefined.

Within these subcategories, “reinforcement of norms and protocols (29%)” was the top selection, followed by “patient education (13%)” (Figure 5).

Table 3 shows the distribution of categories of micro-interventions proposed to address the top 10 problems identified. Micro-interventions in the IEC category were selected primarily to address "weak attendance of partners in ANC". In contrast, micro-interventions in the intra- and inter-institutional Coordination and collaboration category were mainly selected to address "weak diagnosis or inclusion of other risk factors in CCR" and "weak diagnosis or management of EmOC". Participants selected community involvement activities to address issues such as "low coverage of the first ANC visits before 12 weeks of pregnancy" and "low promotion and use of long-lasting family planning methods". The health services organization category was primarily selected to address the "weak attendance of partners in ANC" and the "weak diagnosis or management of EmOC". Improvements in the management of commodities stock were mainly proposed to address "low coverage of the second or fourth dose of IPTp" and "weak delivery of supplements in ANC".

### ***Supervision after A&F meetings***

Health facilities selected to receive supervision visits were identified during A&F meeting, with each facility receiving up to two supervision visits per 6-month cycle. One hundred-forty-one (92%) health facilities received 535 supervision visits during the study period. Of all supervision visits, 342 (64%) were double visits (first and follow-up), and 36% were single visits. The number of supervision visits varied between 38 in Buzi and 51 in Manica and Sussundenga districts and between zero and ten per facility.

Four of the 128 health facilities selected based on their performance received no supervision visits (one low-performing and three high-performing). Of the 63 health facilities selected as low-performing only, the average number of visits was 3.7 (range, 0 to 10); of the 37 health facilities selected as either low-performing or high-performing, the average number of visits was 5.2 (range, 2 to 10); and of those selected only as high-performing, the average number of visits was 2.6 (range, 0 to 6).

The average time between an A&F meeting and the first supervision visit was 2.4 (1.6 to 4.1) months and 3.7(2.9 to 4.6) months between a meeting and the second supervision.

#### ***Financial support to implement action plans***

A monthly amount of \$1,250 was provided to each district to support implementing action plan activities in selected facilities. All districts received this support as planned. Districts were responsible for allocating resources to health facilities according to their perceived priority in terms of needs.

#### ***The proportion of micro-interventions successfully implemented***

By the end of the study period, 1851 (17%) micro-interventions were recorded as being implemented successfully. Fewer micro-interventions were reported to be implemented successfully early in the process, but this improved substantially over time (ranging from 0.6% in the first cycle to 46% in the eighth cycle). Among districts, the proportion of successfully implemented micro-interventions varied between 7% in Vanduzi and 33% in Dondo. Overall, districts in Sofala presented better reports compared with those of Manica.

#### **Maintenance**

A&F meetings were conducted over 51 months (October 2016 to December 2020), and supervision visits occurred over 54 months (October 2016 to March 2021).

Of the 154 participating health facilities, 96% (n=148) and 95% (n=146) sustained the intervention at 12 and 24 months, respectively. At 54 months, 71% (n=109) had completed all nine A&F meeting cycles.

Figure 6 summarizes the findings based on the RE-AIM domains used in this process evaluation.

## **DISCUSSION**

The IDEAs strategy was designed to support achieving the Sustainable Development Goal target 3.2, focusing on reducing newborn and child mortality. The strategy utilized MCH managers to lead an A& F process aiming to improve the implementation of evidence-based interventions targeting causes of neonatal mortality by identifying and solving facility-level gaps related to the delivery of services according to MOH guidelines. The number of districts and facilities exposed and adopting IDEAs was close to the proposed targets, indicating that the program was successfully introduced and implemented in most primary healthcare facilities across 12 Manica and Sofala provinces districts.

Most facilities completed the intended nine cycles of A&F meetings. However, a handful of facilities did not complete all cycles due to a variety of reasons, such as competing activities during scheduled A&F meetings that prevented MCH managers from participating (e.g., health

campaigns, MOH visits, or other supervision visits), as well as unavailability of MCH managers due to vacations, maternity leave, and sickness.

Notably, the participation of MCH managers was high across all levels (provincial, district, and facility) in all 107 cycles, and most participants were from the facility level. This distribution in participation was important because changes needed to improve guideline compliance focus on the service delivery (facility) level. The presence of district and provincial managers was essential for reinforcing the accountability of healthcare providers and harmonizing operational recommendations to implement action plan activities, as described in a separate qualitative study conducted at an earlier stage of the strategy [46].

Positive intervention fidelity was also verified in the duration and frequency of meetings for most districts. However, Barue and Mossurize districts presented the shortest average intervals between meetings (5.3 and 5.5 months, respectively), which could potentially reduce opportunities to implement action plan activities.

The selection of facilities based on performance to receive supervision visits and financial support also had high fidelity, as most facilities had the opportunity to receive supportive supervision.

Identifying and specifying problems and micro-interventions improved over time as part of the action-planning process. A higher number of problems were identified in the first two cycles, and poorly specified micro-interventions were proposed during this period, posing challenges in monitoring their implementation. As a result, around the fourth cycle, the IDEAs team

recommended that district teams limit the number of problems per facility to five to improve problem prioritization, specification, and implementation of micro-interventions.

Many identified problems were repeated across different facilities within the same district. This repetition could be attributed to the fact that health facilities faced similar challenges, or it could be due to the group setting of the meetings, which may have influenced participants to think similarly when developing action plans.

The consistent identification of the same problems across multiple meeting cycles suggests that these issues persisted or that the definition of the problem was too broad. For example, the “weak diagnosis or management of EmOC” issue was prioritized in all nine A&F cycles when data from all districts were aggregated. However, different facilities may have observed varying degrees of weaknesses in different components of EmOC. While some issues might have been partially addressed, these levels of detail were not reflected in the listed problems. A better specification of the problems and examination of specific indicators are necessary to better understand progress in addressing these issues. Conversely, identifying a problem in just one cycle may indicate that the issue was resolved or that other problems were deemed a higher priority in subsequent cycles.

We also analyzed whether alignment existed between the identified problems, proposed micro-interventions, and the existing literature or formal guidelines and found successful alignment.

For instance, the main problem identified in A&F cycles was weak diagnosis and management of obstetric complications, a well-documented weakness in Mozambique [47,48] as in many other low-resource settings [49,50]. Specific actions written in action plans to address this issue included reinforcing the use of partograms to monitor labor, recording the entire case history of

patients, conducting complete physical examinations of all pregnant and postpartum women upon entry into the maternity ward and before discharge, and providing on-the-job training in EmOC. These actions are all recommended in national norms for childbirth, newborn care, and obstetric complications in Mozambique [51].

Poor fidelity was observed in conducting semiannual SRAs before A&F meetings and in reporting micro-interventions implemented successfully. Readiness assessment delays resulted from challenges in elaborating the assessment protocol, delays in IRB approval, and failure to rapidly synthesize results to feed back into the A&F meeting after conducting the readiness assessment. Given the delays and high cost, this component was not supported throughout the study. We believe that the impact of not having SRA before each A&F meeting was minimal because MCH managers were knowledgeable about the availability of resources based on other sources, such as supervision visits and routine facility reports.

Reporting the extent to which micro-interventions were completed was sub-optimal, especially at the beginning of the program, due to challenges in monitoring the large number of poorly specified micro-interventions. Additionally, comparing this indicator between the two implementing provinces found better documentation of micro-intervention implementation in Sofala than in Manica province, suggesting that MCH managers from these provinces had different levels of experience in evaluating action plan implementation. One possible explanation for the differences could be that Sofala had prior experience with a similar implementation strategy piloted before the expansion to include Manica province [52].

Quality improvement strategies for maternal and child health have been studied in other developing countries [53,54]. For A&F in particular, the bulk of evidence available reports on

the effectiveness, mostly from high-income settings where the magnitude of the effect varied between a -17% to 49% improvement in professional practice and null effects for improvements in distal health outcomes [15,38]. While we agree that it is essential to assess the effectiveness of new strategies, we want to highlight in this manuscript the need for evaluating and reporting implementation processes of A&F in practice in a resource-constrained setting. By gaining this knowledge, we can develop data-driven and contextual strategies to enhance service delivery and quality of care. For instance, in the case of the IDEAs strategy, we identified priority problems, including weaknesses in clinical practice and challenges in implementing micro-interventions, indicating that other well-known bottlenecks affecting health services need to be studied and targeted, including health workers shortages, clinical skills gaps in the management of care, absence or stock-outs of essential commodities and supplies, weak leadership, and inadequate resource allocation [55] and that other strategies, such as training of nurses in EmOC and direct funding of health facilities instead of districts, should be considered to add to the A&F strategy.

## **LIMITATIONS AND STRENGTHS**

This evaluation has several limitations. First, it is essential to note that no statistical inference is made as the evaluation focuses solely on describing the implementation process and outcomes; the strategy's effectiveness in improving availability and quality of services will be reported in a separate manuscript. Second, population reach was evaluated using indirect indicators of pregnant women using antenatal services. Third, our approach to categorizing problems and micro-interventions based on predetermined categories could potentially obscure important details about these components. Lastly, this study took place in only two provinces of central Mozambique, and therefore, it may not be appropriate to generalize the results to other locations. Despite these limitations, the study also has notable strengths. We applied the RE-AIM

framework to plan, evaluate, and report the implementation process and impact of the IDEAs strategy. RE-AIM is a well-recognized and widely used framework in implementation science, and its use provides clarity on how strategies are being designed and evaluated, allowing meaningful comparisons between similar studies.

Additionally, the detailed description of a 4.5-year implementation process and its outcomes enabled highlighting the perspectives of MCH managers related to priority challenges and strategies to overcome them, as well as to detect weaknesses in the components of the IDEAs strategy in responding to those challenges. This information is valuable in recommending refinements or adaptations to improve implementation fidelity and in discussing the strategy's potential impact on improving health outcomes. Moreover, the cyclical nature of the IDEAs strategy offered an opportunity to build the capacity of MCH managers in Manica and Sofala in using data for learning and decision-making and in proposing tailored evidence-based interventions towards improvements of readiness and quality of care, contributing to the global effort of improving health service delivery to reduce neonatal mortality.

Based on the lessons in implementing IDEAs, we recommend refinements of the strategy components to improve fidelity in implementation, namely, remove the semiannual SRA component or reduce its frequency and only assess a sub-sample of SRA items that are related to indicators examined in the A&F meetings. This approach would improve practicality and reduce the costs of conducting SRAs. In the A&F meetings, each facility should elaborate its action plan separately from other facilities to avoid potential replication in identified problems and solutions, as the definition of problems and micro-interventions need to be specific to the individual health facility context. Additionally, it is crucial to explore the challenges in implementing micro-interventions, specifically the availability of resources and clinical competencies. In the IDEAs

case, understanding the impact of funding to the districts to support health facility action plan implementation and reasons for weakness in clinical practice are essential to improve the design of the strategy or identify other strategies that can be added to A&F.

## **CONCLUSION**

This report demonstrates that MCH managers can lead Audit and Feedback processes in primary health care in Mozambique. The IDEAs program reach, adoption, and maintenance were aligned with targets. Implementation fidelity was optimal in most components except conducting semiannual readiness assessments and evaluating micro-intervention completion. These components of the intervention should be refined to improve fidelity. Hopefully, our findings and recommendations can inform future replication, adaptation, or scale-up of A&F strategy in Mozambique or similar settings.

### **Competing interests**

The authors declare that they have no competing interests.

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### **Authors contributions**

AD, KS, QF, SGL, SG, RE, BW, BWE, and GS conceived the idea of the study.

IR, DU, ST, EB, and OA coordinated data collection. AG, JM, JC, AC, CS, and NM conducted data collection. AD prepared the data and wrote the manuscript. All authors reviewed and approved the manuscript.

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**Table 1: IDEAs program setting**

<b>Province</b>	<b>Neonatal mortality rate (2019-2020)<sup>a</sup></b>	<b>IDEAs districts</b>	<b>Population (2021)<sup>b</sup></b>	<b>District coverage<sup>c</sup></b>	<b>N° of IDEAs facilities</b>	<b>Health facility covere<sup>d</sup></b>
<b>Manica</b>	31 per 1000 live births	Chimoio	456775	10%	6	2%
		Manica	257191	5%	17	6%
		Mossurize	230705	5%	11	4%
		Gondola	224603	5%	10	4%
		Barue	217254	5%	13	5%
		Sussundenga	195258	4%	13	5%
		Vanduzi	130893	3%	9	3%
<b>Sofala</b>	33 per 1000 live births	Beira	696515	15%	15	5%
		Nhamatanda	318380	7%	17	6%
		Dondo	223484	5%	15	5%
		Buzi	201 710	4%	15	5%
		Gorongosa	202043	4%	13	5%
		<b>Total</b>	<b>3.354.811</b>	<b>71%</b>	<b>154</b>	<b>56%</b>

(a) Countrywide surveillance data (provincial estimates). District neonatal mortality rate is not available.

The national neonatal mortality rate is 23 per 1,000 live births [56];

(b) Provincial Statistical Data 2021; (c) Percentage based on the population of both provinces; (d)

Percentage of health facilities based on the total facilities of both provinces. For Manica and Sofala provinces, the combined total population is 4.702.874, and the combined number of health facilities is 277.

**Table 2: Categories and subcategories of micro-interventions proposed in action plans**

<i>General category</i>	<i>Specific subcategory</i>
<i>Information, Education, and Communication (IEC) for health</i>	<ol style="list-style-type: none"> <li>1. Education of patient’s activities</li> <li>2. Community education activities</li> <li>3. All other activities related to IEC for patients</li> </ol>
<i>Health services organization</i>	<ol style="list-style-type: none"> <li>4. Activities related to changes in patient flow</li> <li>5. Activities related to changes in service schedules</li> <li>6. All other activities contributing to the improvement of health facilities organization</li> </ol>
<i>Commodities stock management</i>	<ol style="list-style-type: none"> <li>7. Actions to improve medicine management</li> <li>8. Actions to improve management of medical and surgical supplies</li> <li>9. All other activities related to the management of materials and goods for the regular operation of health facilities</li> </ol>
<i>Information system management</i>	<ol style="list-style-type: none"> <li>10. Data record improvement activities</li> <li>11. Data quality audit activities</li> <li>12. Health information system file improvement activities</li> <li>13. Activities related to the regular sending of information</li> <li>14. All other activities contributing to improvements in the availability, quality, and use of data</li> </ol>
<i>Inter- and intra-institutional Coordination and collaboration</i>	<ol style="list-style-type: none"> <li>15. Intra-institutional coordination activities</li> <li>16. Actions to strengthen compliance with clinical standards and protocols</li> <li>17. Actions related to the discussion of clinical cases and institutional deaths</li> <li>18. On-the-job training activities</li> <li>19. All other activities contributing to the quality of healthcare</li> </ol>
<i>Community involvement</i>	<ol style="list-style-type: none"> <li>20. Coordination and collaboration activities with the community</li> <li>21. Community involvement in the management and organization of healthcare services</li> </ol>

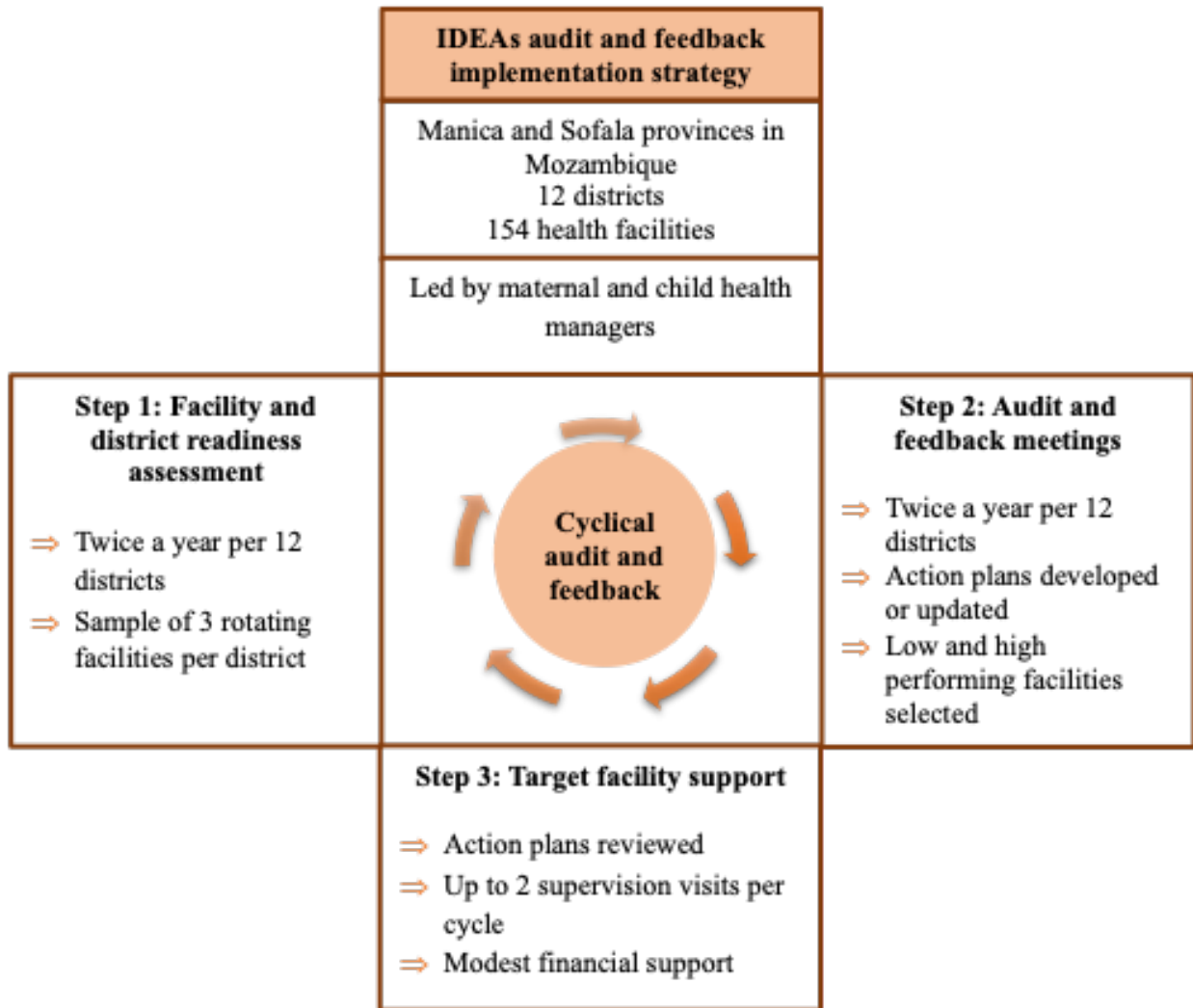
**Table 3: Distribution of micro-interventions proposed to address the top 10 problems**

General Category & Subcategory of micro-interventions	Top 10 problems identified in A&F meetings									
	1. <i>Weak diagnosis/management of EmOC</i>	2. <i>Low coverage of 2nd/4th dose of IPTp</i>	3. <i>Low coverage of 4th ANC</i>	4. <i>Low testing/retesting of HIV or syphilis</i>	5. <i>Low coverage of 1st ANC &lt; 12 weeks</i>	6. <i>Weak diagnosis/inclusion of other risk factors in CCR</i>	7. <i>Weak attendance of partners in ANC</i>	8. <i>Low coverage of PCR &lt; 8 weeks of life</i>	9. <i>Low promotion/use of long-acting methods of FP</i>	10. <i>Weak delivery of supplements in ANC</i>
<b>Information, Education &amp; communication</b>	<b>4%</b>	<b>18%</b>	<b>47%</b>	<b>11%</b>	<b>53%</b>	<b>7%</b>	<b>70%</b>	<b>35%</b>	<b>67%</b>	<b>6%</b>
a. Education of patient's activities	48%	50%	52%	5%	26%	92%	18%	98%	55%	63%
b. Community education activities	32%	20%	22%	4%	49%	4%	18%	1%	20%	13%
c. Other IEC activities for patients	20%	30%	26%	91%	25%	4%	64%	0%	25%	23%
<b>Health Services Organization</b>	<b>8%</b>	<b>1%</b>	<b>2%</b>	<b>1%</b>	<b>2%</b>	<b>1%</b>	<b>10%</b>	<b>1%</b>	<b>2%</b>	<b>1%</b>
a. Activities related to changes in patient flow			6%	11%	13%		72%		10%	
b. Activities related to changes in service schedules		9%								
c. Other activities to improve facility organization	100%	91%	94%	89%	88%	100%	28%	100%	90%	100%
<b>Commodities stock management</b>	<b>2%</b>	<b>16%</b>	<b>0%</b>	<b>7%</b>	<b>0%</b>	<b>0%</b>	<b>1%</b>	<b>2%</b>	<b>5%</b>	<b>14%</b>
a. Actions to improve medicine management	6%	30%	75%	6%		50%	83%		17%	69%
b. Actions to improve surgical supplies management	14%								79%	
c. Other activities related to the management of materials and goods for the regular operation of the facility	80%	70%	25%	94%	100%	50%	17%	100%	3%	31%

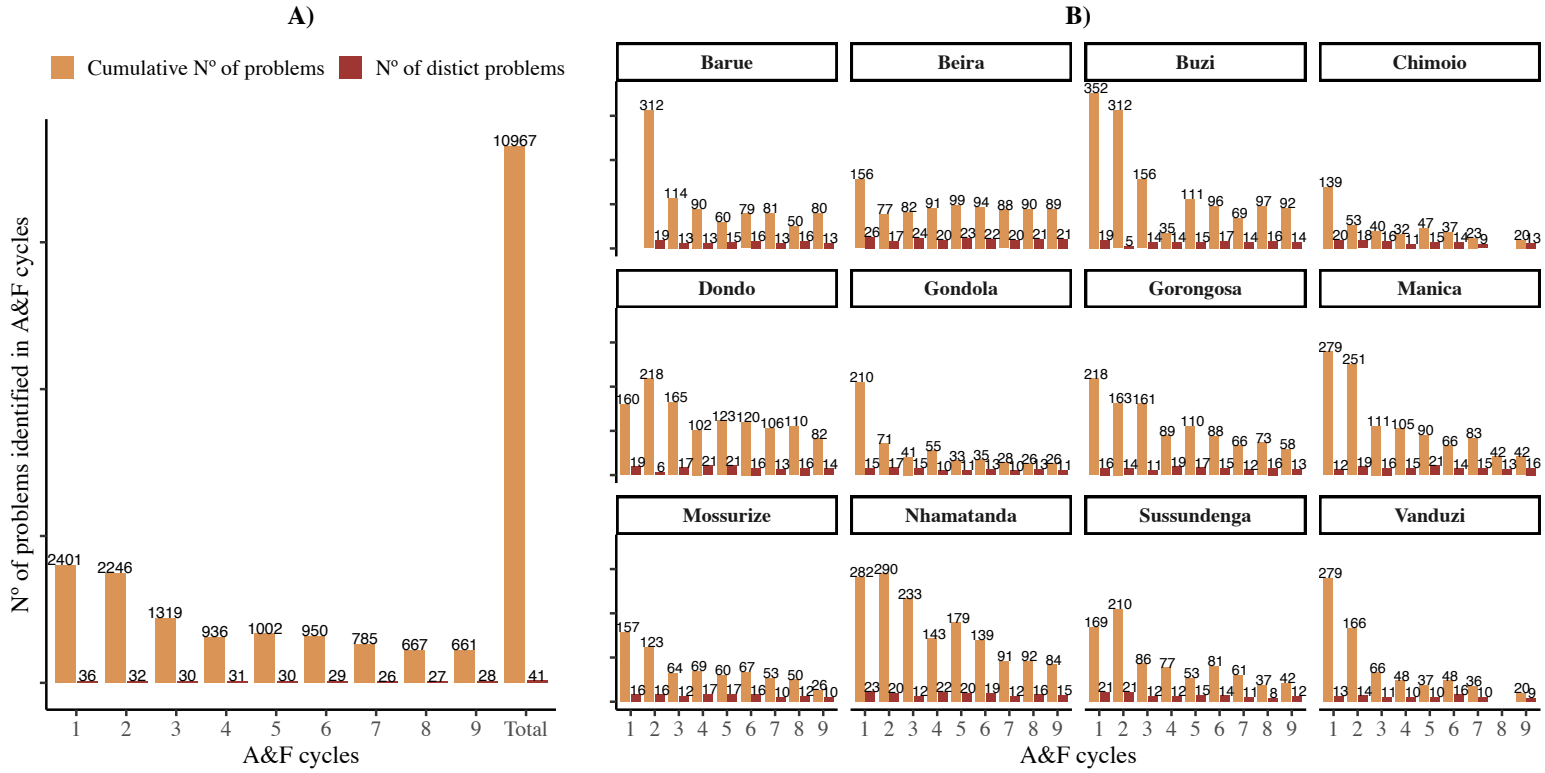
<b>Information system management</b>	<b>4%</b>	<b>25%</b>	<b>5%</b>	<b>2%</b>	<b>2%</b>	<b>2%</b>	<b>2%</b>	<b>4%</b>	<b>1%</b>	<b>29%</b>
a. Data record improvement activities	79%	40%	36%	31%	31%	57%		59%	67%	42%
b. Data quality audit activities	5%	12%	4%	6%	6%	29%	25%		33%	20%
c. HIS file improvement activities		1%								1%
d. Activities related to the regular sending of information		1%	23%							
e. Other activities to improve the availability, quality, and use of data	16%	46%	36%	63%	63%	14%	75%	41%		37%
<b>Inter- and intra-institutional Coordination and collaboration</b>	<b>81%</b>	<b>36%</b>	<b>31%</b>	<b>78%</b>	<b>17%</b>	<b>84%</b>	<b>4%</b>	<b>53%</b>	<b>12%</b>	<b>50%</b>
a. Intra-institutional coordination activities	2%	4%	3%	1%	17%	24%	31%	16%	9%	5%
b. Actions to strengthen compliance with clinical standards and protocols	40%	68%	58%	96%	58%	60%	38%	53%	42%	89%
c. Actions to discuss clinical cases or institutional deaths	18%	0%	1%	0%		0%				0%
d. On-the-job training activities	19%	26%	35%	1%	16%	1%		8%	32%	5%
e. Other activities to improve the quality of patient care (includes additional supervision)	21%	2%	3%	2%	9%	14%	31%	23%	17%	1%
<b>Community Involvement</b>	<b>1%</b>	<b>4%</b>	<b>13%</b>	<b>0%</b>	<b>25%</b>	<b>5%</b>	<b>13%</b>	<b>4%</b>	<b>13%</b>	<b>0%</b>
a. Coordination and collaboration activities with the community	47%	62%	47%		45%	11%	53%		9%	
b. Community involvement activities in the management and organization of HF	53%	38%	53%	100%	55%	89%	47%	100%	91%	100%

Note Table 3: Where is 0%: the value is less than 0.5%. IEC: Information, Education, and Communication; IPTp: Intermittent preventive treatment for malaria; PCR: polymerase chain reaction; CCR: at-risk child consultation; ANC: antenatal care; HIS: Health information system; HF: Health facility; EmOC: Emergency obstetric care

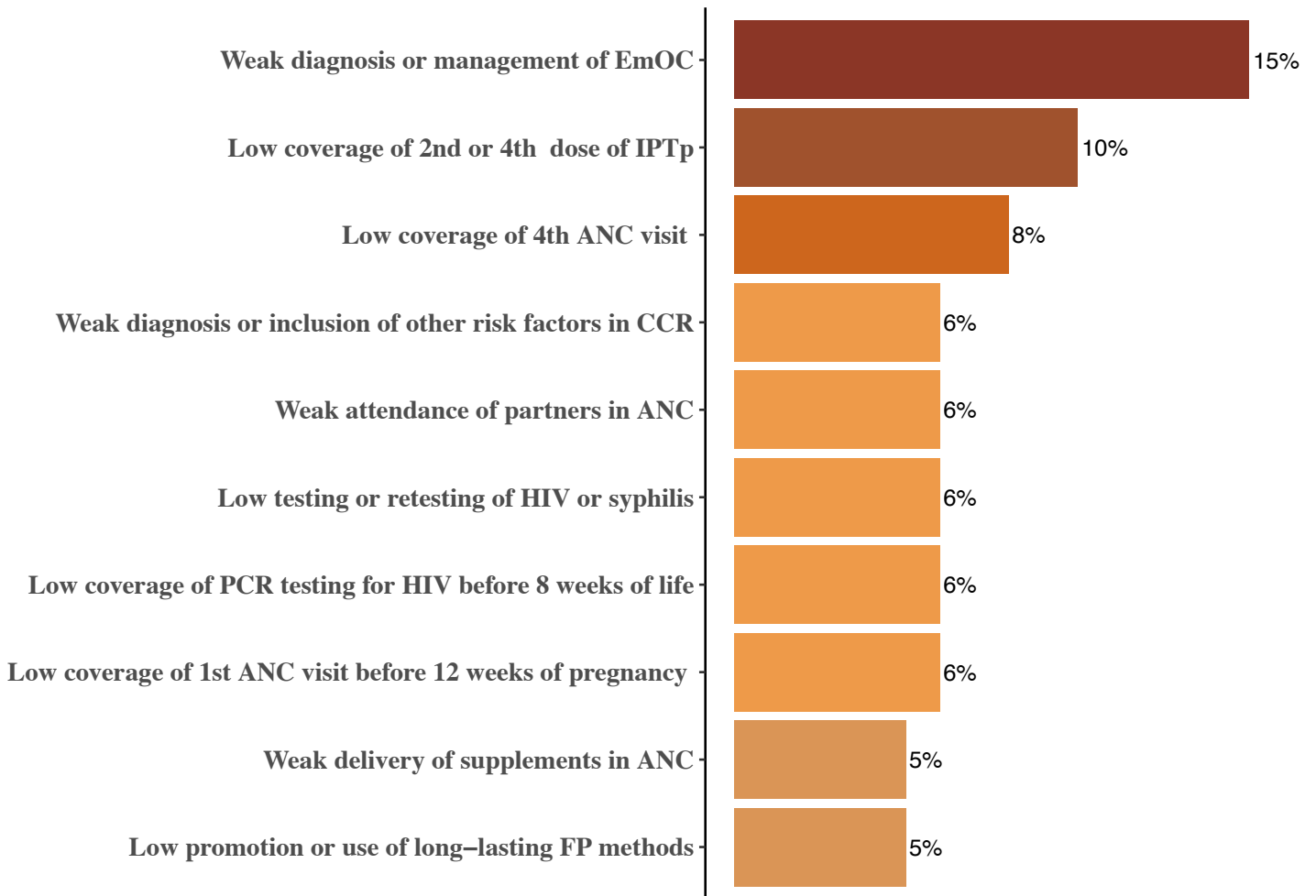
**Figure 2: Steps of the IDEAs audit and feedback strategy**



**Figure 3: Number of problems identified in audit and feedback. (A) Overall and (B) By district**

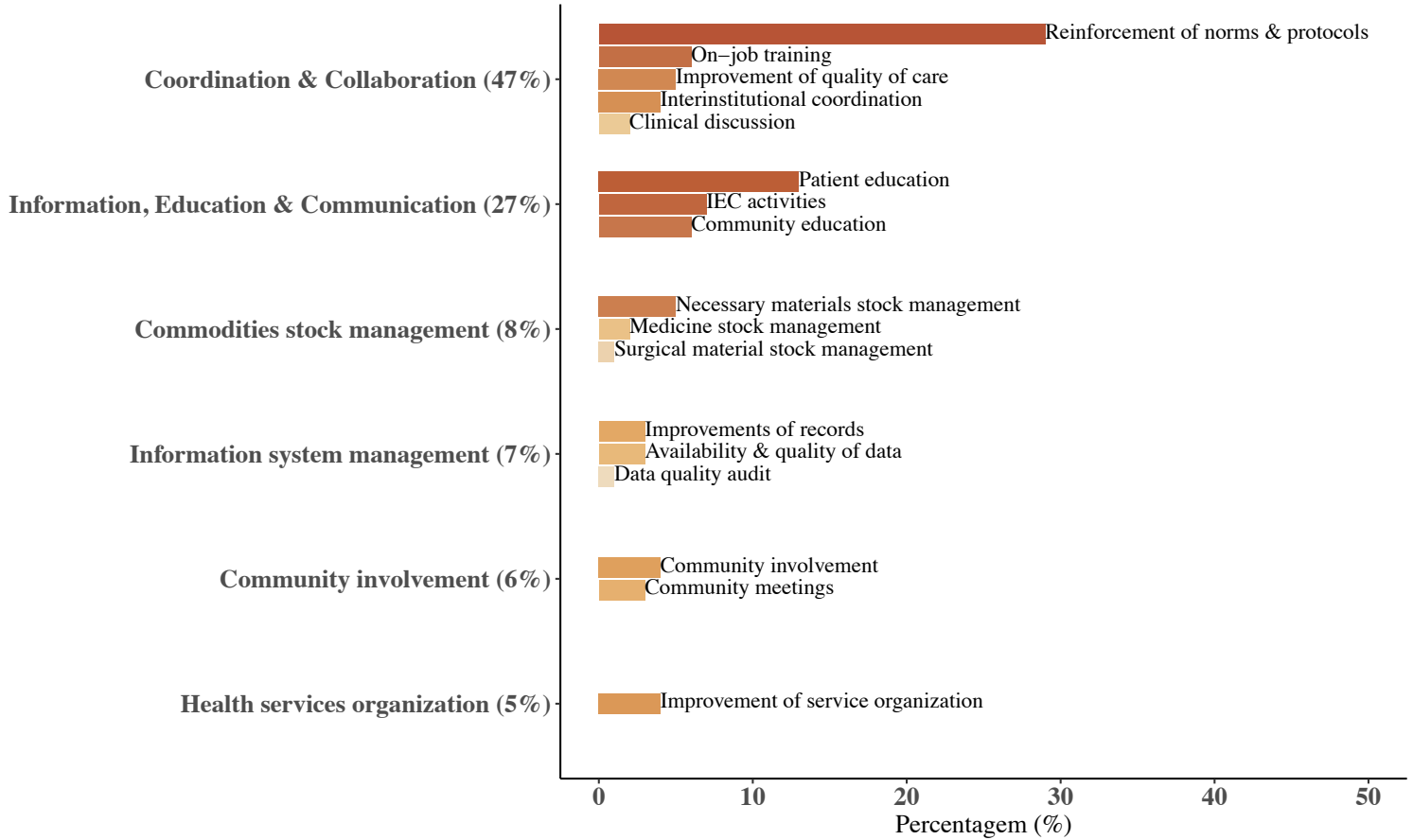


**Figure 4: Rank of ten priority problems identified in A&F meetings**



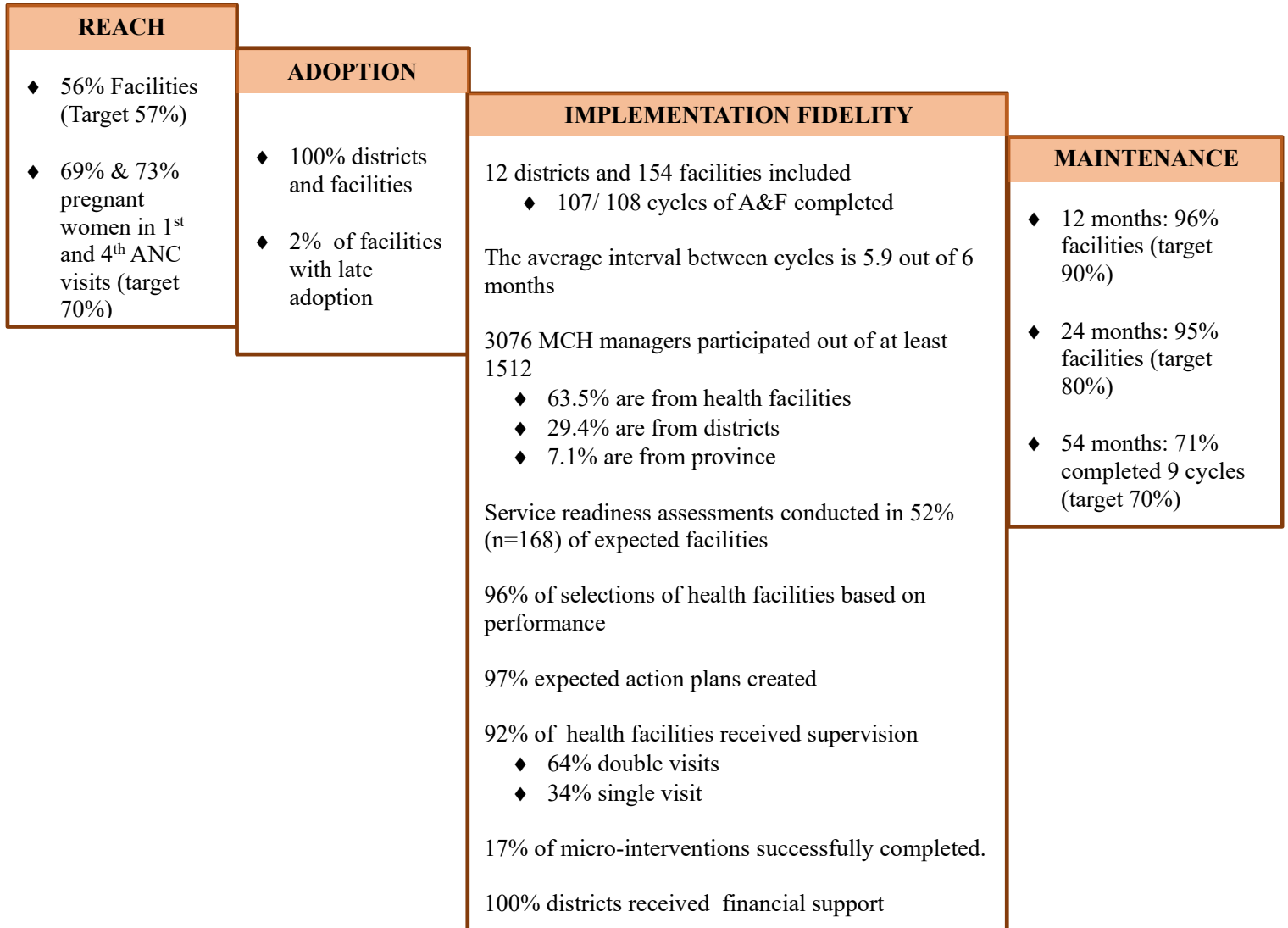
Note figure 4: EmOC: emergency obstetric complications; IPTp: intermittent preventive treatment for malaria; CCR: *consulta da criança de risco* (“at-risk child consultation” in Portuguese); ANC: antenatal care; PCR: polymerase chain reaction; FP: family planning.

**Figure 5. Distribution of general categories and subcategories of micro-interventions proposed in A& F meetings**



Note Figure 5: The following four subcategories with less than 1% were omitted in the figure: “regular sending of data,” “patient flow,” “health information system file improvement,” and “changes in service schedules.”

**Figure 6: Summary of findings based on four RE-AIM domains**



# **CHAPTER 3: Can Audit And Feedback Improve Health Service Readiness And Delivery Outcomes In A Low-Resource Setting? Effectiveness Results of the IDEAs Strategy From Central Mozambique**

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## **ABSTRACT**

### **Introduction**

Scarce evidence exists on the impact of audit and feedback in low-resource contexts. We evaluated a multi-component audit and feedback strategy – the Integrated District Evidence-to-Action (IDEAs) - on Mozambique's maternal and child health (MCH) service outcomes.

### **Methods**

The IDEAs strategy was implemented in 2016-2020 across two provinces, 12 districts, and 154 primary-level health facilities in Mozambique. We assessed 1) ten service delivery outcomes across antenatal, maternity, postpartum, childcare, and reproductive health services and 2) five service readiness outcomes (medicines, infrastructure, equipment, care, and staffing availability). We used propensity score matching to minimize bias and a controlled interrupted time series with a negative binomial mixed effects model for service delivery analysis, presenting incidence ratios (IRR) with 95% confidence intervals (95% CI). For service readiness outcomes, we created composite scores for each domain and a difference-in-difference analysis using an ordinal mixed effects model, reporting odds ratios (OR) and 95% CI.

### **Results**

Significant associations were found with first at-risk child appointments (IRR = 1.06 [1.04, 1.07]), first PCR tests for HIV-exposed children (IRR= 1.02 [1.01, 1.03]), new contraceptive users (IRR = 0.95 [0.94, 0.96]), women starting long-lasting contraceptives (IRR= 0.94 [0.93, 0.95]), availability of infrastructure (OR= 5.84 [1.32, 25.88]) and essential care (OR = 0.13 [0.03, 0.54]). No significant associations were found between IDEAs and six of 10 service

delivery outcomes (women with a fourth dose of preventive malaria treatment; women protected with tetanus vaccine; women with four+ antenatal visits; deliveries with active management of the third stage of labor; first postpartum consultations and fully vaccinated children) and on medicine, equipment, and staffing availability.

## **Conclusion**

IDEAs were associated with improvements in selected indicators from child-at-risk services and available infrastructure. Null and sub-optimal effects suggest refining and adapting strategy components to target clinical and readiness outcomes in low-resource settings more directly.

## **KEY MESSAGES**

### **What is already Known?**

Most evidence of audit and feedback on clinical practice are from randomized controlled trials from high-income settings in which small to moderate effects are reported. Uncertainty exists on the potential of audit and feedback to improve health provider practice and outcomes in low-resourced contexts.

### **What are the findings?**

Our findings showed mixed results. The strategy was associated with significant improvements in some indicators of child at-risk services and the availability of infrastructure components. Family planning and essential care indicators demonstrated sub-optimal effects. Antenatal, intrapartum, postpartum, healthy childcare service indicators and availability of medicine, equipment, and staffing were unaffected by the strategy.

### **What do the findings imply?**

Strategy components should be refined and adapted to impact readiness and service outcomes directly. In low-resource settings, understanding the challenges of implementing interventions suggested in audit and feedback processes is crucial for designing and applying context-specific strategies to optimize impact on health outcomes.

## **BACKGROUND**

The third Sustainable Development Goal (SDG) aims to end all preventable deaths under five years of age [57]. Neonatal deaths account for 47% of all under-five deaths worldwide [58]. While progress has been made, efforts are needed to achieve the SDG target of 12 or fewer neonatal deaths per 1000 live births by 2030 [58]. Survival rates for newborns vary greatly depending on the region, with sub-Saharan Africa having the highest neonatal mortality rate at 27 deaths per 1000 live births in 2020 [59]. A multitude of complex factors contributes to avertable neonatal deaths, including maternal characteristics, community-level determinants (such as access to healthcare, clean water, and proper nutrition during pregnancy and after birth), health systems factors (such as availability of resources, and quality of obstetric and pediatric care), and societal aspects associated with political stability and armed conflicts [60]. Notably, most causes of neonatal deaths are preventable and curable, including preterm and intrapartum complications, postpartum sepsis, and infectious diseases [61].

Clinical practice guidelines standardize treatment plans and help healthcare providers make evidence-based clinical decisions [62]. The potential benefits of guidelines include enhanced consistency in healthcare providers' practice, increased efficiency, and reduced morbidity and mortality. Despite these benefits, adherence to evidence-based guidelines is suboptimal [62,63] due to lack of guideline awareness and their content among providers, lack of time to fully apply guidelines, lack of resources and materials to implement guidelines, limited integration of guideline recommendations into organizational structures and processes, and provider resistance [63–65].

Audit and feedback (A&F) is an implementation strategy that summarizes clinical performance (audit) over a specific period and the provision of this summary information (feedback) to individual practitioners, teams, or health organizations [66]. A&F is frequently used to change health provider behavior and improve the quality of care [66]. A&F provides objective data on discrepancies between current practice and target performance, as well as comparisons of performances across health teams, and by identifying performance gaps, can influence action by encouraging providers and teams to minimize performance discrepancies [17]. Prior studies on the effectiveness of A&F on clinical practice have shown variable (IQR of 0.5-16%), small to moderate effects in provider compliance to guidelines, without increasing impact over time [17,67]. Most A&F evaluations are from randomized control trials in high-income settings [12], and uncertainty remains about the potential benefits of A&F in low-income settings where the disease burden is higher, health systems are weaker, and baseline clinical practice guideline application has considerable space for improvement. Further evidence on the effects of A&F is needed from these settings.

In Mozambique, a country with limited resources and a high disease burden, neonatal mortality remains a public health problem, with a neonatal mortality rate of 28 deaths per 1,000 live births [20]. Utilization of maternal and child health (MCH) services in Mozambique is high, with an estimated 93% of pregnant women attending their first antenatal care (ANC) visits, 73% giving birth in a health facility, and 76% of children ages 12–23 months receiving the third pentavalent vaccination [21]. Despite this high utilization, the quality of evidence-based interventions delivered at or around the time of birth remains sub-optimal in Mozambique [22,23].

The Integrated District Evidence to Action (IDEAs) program tested a multi-component A&F implementation strategy that aimed to improve the coverage and quality of a bundle of existing evidence-based interventions targeting major causes of neonatal mortality. IDEAs hypothesized that iterative A&F cycles would directly improve routine use of clinical guidelines at the facility level while also enhancing health system readiness to support care provided by health providers, leading to improvements in the coverage and quality of service provision and reducing newborn mortality. This manuscript reports results from the quasi-experimental effectiveness evaluation of IDEAs in improving service readiness and service delivery outcomes targeting major causes of neonatal mortality in central Mozambique.

## **METHODS**

### **Program description**

The IDEAs strategy is designed to improve health service delivery using A&F tools that identify service gaps, address multi-level barriers and facilitators for delivery, and enable health workers to prioritize and test interventions to improve the application of Ministry of Health (MOH) guidelines for neonatal health. The IDEAs implementation strategy has been previously described (manuscript under review). Briefly, IDEAs is an iterative three-step process of 1) health system readiness assessment; 2) A&F meetings to identify gaps and develop action plans (comprised of 'micro-interventions' or solutions identified, specified, and implemented at the health facility level); and 3) mentorship and funds to support plan implementation (Figure 7). Meetings are held for each district, uniting facility MCH leads with district and provincial supervisors to test a scalable model that could integrate into the Mozambique health system.

Implementation of the IDEAs strategy was led by district MCH managers, targeting MCH nurses at the facility level and supported by managers at the provincial level. Cycles are designed to be semiannual and were implemented between October 2016 and December 2020.

### **Steps involved in the IDEAs implementation strategy (Figure 7)**

*Step 1: Facility and district service readiness assessment.* Before each bi-annual five-day A&F meeting, the study team applied standardized service readiness assessment tools at three health facilities per district to assess structural readiness to deliver guideline-based care (such as staffing levels and availability of essential commodities, equipment, and supplies).

*Step 2: Audit and feedback meeting.* Facility, district, and provincial MCH managers participated in semiannual A&F meetings, auditing data from routine health information systems (RHIS) and service readiness assessments and comparing performance relative to goals. Feedback is provided in graphical and tabular formats, and secular trends and performance measures are visualized. Each facility and district team presents its performance, followed by a group discussion to interpret results, identify barriers to guideline adherence, and develop action plans highlighting priority problems, specific and measurable targets, and resources required to implement micro-interventions.

*Step 3: Targeted facility support.* At each district A&F meeting, three facilities are selected based on the performance assessment (one high-performing and two low-performing) to receive up to two supervision visits per cycle from district and province supervisors. Modest monthly financial support (US\$1,250) was provided to the districts to facilitate action plan implementation and supervision. During supervision visits, supervisors reviewed action plans, identified barriers to guideline implementation, and provided technical assistance to address context-specific barriers.

## **Study design**

We employed two separate quasi-experimental study designs to evaluate the effectiveness of the IDEAs program [68,69]. To assess IDEAs' impact on service delivery outcomes, we conducted a controlled interrupted time series analysis (ITS), while the impact on service readiness was evaluated through a difference-in-difference (DID) approach.

## **Study setting**

Intervention health facilities were located in Manica and Sofala provinces in central Mozambique, with a combined population of over 4 million inhabitants [70]. The IDEAs strategy was implemented in 154 primary-level health facilities across 12 districts, which represents 63% and 43% of primary healthcare facilities in Manica and Sofala, respectively (Table 4). To maximize the potential impact of resource investment, intervention districts were selected based on their large population size, robust health facility network, and geographic accessibility. Districts were chosen as the intervention unit as they are the logical disseminating agents for delivering interventions to subordinate facilities, can access resources to meet health facility needs, and have the authority to implement management decisions within health facilities in their districts.

## **Health facility sample**

Two samples of facilities were used to conduct our analyses of the IDEAs intervention's impact on 1) service delivery outcomes and 2) service readiness (Figure 8).

Service delivery outcomes sample (Figure 8A): Service delivery outcomes sourced from the routine health information system (RHIS) were compared between 154 intervention facilities and 349 control facilities from the neighbors Zambezia and Tete provinces (Figure 8A). The inclusion criteria for control facilities included being a public sector health facility providing primary health care services and having data available on selected outcomes since October 2016.

Service readiness sample (Figure 8B): Prior to implementation, 12 control districts were selected from Zambezia, Tete, and Sofala provinces, matched 1:1 to intervention districts based on district population size, facility network, and geographic attributes (e.g., urbanicity and distance from the provincial capitals). Within each district, three public sector health facilities were selected, including the highest volume facility in each district, plus two additional randomly selected units (totaling 36 intervention and 36 control facilities).

## **Data sources**

Health facility monthly data on service delivery outcomes were extracted from the Mozambique MOH's RHIS (the *Sistema de Informação de Saúde para Monitoria e Avaliação – SIS-MA*) covering the period from October 2016 through December 2021. Service readiness data on the availability of medicines, infrastructure, essential care, equipment, and clinical staff were collected by project study teams through four annual health facility assessments across 72 health facilities (36 intervention and 36 control sites) using the World Health Organization Service Availability and Readiness Assessment (SARA) tool [43].

## **Study variables**

### *1) Service delivery outcomes*

The selection of service delivery outcome indicators was guided by multiple criteria, including 1) evidence of their theoretical relationship to neonatal mortality reduction [8,9,71], 2) being a focus of audit and feedback during the IDEAs meetings, and 3) their availability in the RHIS. Monthly counts of ten indicators from antenatal care, maternity, postpartum, child consultations, and family planning were extracted from the RHIS for each health facility, including the number of 1) pregnant women with a fourth dose of intermittent preventive treatment for malaria (IPTp); 2) pregnant women with a second-to-fifth dose of tetanus vaccine; 3) pregnant women with a fourth or more antenatal care visit; 4) deliveries with active management of the third stage of labor; 5) first postpartum consultations; 6) fully vaccinated children; 7) first at-risk child appointments; 8) first PCR tests for HIV-exposed children; 9) new users of contraceptive methods, and 10) women starting long-lasting methods of family planning. This last indicator was created by aggregating the counts of the three long-lasting contraceptive methods (intrauterine device, implant, and injectable Depo Provera).

## 2) *Service readiness outcomes*

We created composite measures for each of the following domains, using the list of items available in the SARA tool for each domain: Medicine availability, infrastructure availability, services provided, and equipment availability. The list of items used to create composite scores is detailed in Table 5. In summary, fifteen items were included to create composite scores for essential medicines, which were selected based on the World Health Organization's list of priority life-saving medicines for women and children [72]. For infrastructure availability, six groups of items describing the availability of communications, power supply, basic amenities, processing of equipment for reuse, and infection control were included. Sixteen items were

included to create composite scores for services provided, focusing on those delivered at or around the time of birth with a known influence on neonatal mortality. Twenty-eight items were used to create the composite score for the availability of essential equipment, also selected given their relationship with neonatal mortality prevention and according to the SARA list of items for these categories (Table 5) [43]. Counts were used to describe the availability of human resources, specifically the number of MCH nurses. We focused only on MCH nurses because they are the principal cadre of professionals providing MCH services in primary care in Mozambique and are directly linked with the IDEAS strategy.

Composite scores for each health facility were estimated by dividing the observed available items by the total number of possible items for each category. For instance, the total possible number of items for the essential medicines domain is 15; for a health facility with eight items available, the medicine score for that facility would be  $8/15 = 0.53$ . The resulting composite scores are discrete and inappropriate to treat as continuous variables; therefore, we preserved the ordinal nature of the score using statistical techniques for ordinal outcomes.

### 3) *Explanatory variables*

For our analysis of service delivery outcomes, we included the following covariates: Facility location (rural or urban), type of facility (rural health center, urban health center, rural hospital, district hospital), provincial per capita GDP, Covid-19 pandemic period (as a binary variable of prior to or after Covid-19 mitigation policies were put in place - cutoff in March of 2020), and MOH catchment area size. Health facility location and the count of maternal and child nurses were included in our analysis of service readiness outcomes.

## Statistical analysis

### *Analysis of impact on service delivery outcomes*

We applied a controlled interrupted time series (ITS) analysis covering the period October 2016 through December 2021 to estimate the impact of the IDEAs program on service delivery outcomes. Data on study outcomes prior to October 2016 were not included due to the MOH's adoption of a new RHIS based on the DHIS2 (District Health Information Software 2) [73] and the resulting data inconsistencies.

A total of nine IDEAs cycles were completed during the intervention period. Because of the complexity of the intervention and its iterative nature, we believe it is unlikely that the IDEAs strategy led to observable improvements during the first two cycles. Therefore, we parametrized 63 months of available data in the time series analysis as follows:

- October 2016 through August 2017 (11 months) as the pre-intervention period,
- September 2017 through December 2020 (40 months) as the intervention period,
- January 2021 through December 2021 (12 months) as the post-intervention period.

Therefore, the ITS model for service delivery analysis has three segments of changes in slopes and no immediate change segments – see the formula below:

$$Y_{jt} = \beta_0 + \gamma X_{jt} + \beta_1 \text{time.pre\_intervention}_{jt} + \beta_2 \text{time.intervention}_{jt} + \beta_3 \text{time.post\_intervention}_{jt} + \beta_4 \text{treatment}_{jt} + \beta_5 \text{pre\_intervention} * \text{treatment}_{jt} + \beta_6 \text{intervention} * \text{treatment}_{jt} + \beta_7 \text{post\_intervention} * \text{treatment}_{jt} + \beta_8 \sin \frac{2\pi \cdot \text{time}}{12} + \beta_9 \cos \frac{2\pi \cdot \text{time}}{12} +$$

Where:

j = facility; t = time

$\beta_0$  = Baseline level of the outcome at time = 0

$\beta_1$  = A continuous variable indicating time in months from the start of the observation period is the mean change each month before the intervention.

$\beta_2$  = Is a continuous variable counting the number of months during the intervention (is 0 before), is the change in slope comparing intervention to pre-intervention

$\beta_3$  = Is a continuous variable counting months after the intervention (is 0 before), is the change in slope comparing the post-intervention to the intervention period.

$\beta_4$  = Is a variable indexing treatment (1) versus control (0), measures the difference in the outcome level prior to intervention, comparing treatment to control.

$\beta_5$  = Measures the difference in slope between treatment and control sites before intervention.

$\beta_6$  = Measures the difference in slope between treatment and control during the intervention period, which is the effect of the intervention.

$\beta_7$  = Measures the difference in slope between treatment and control in slope after the intervention period.

$\beta_8$  and  $\beta_9$  are sine and cosine for capturing seasonality.

$\gamma$  is the vector of coefficients, and X is a matrix of covariates

nurses, total beds, and health facility catchment area. We assessed the balance of the control and intervention groups by visualizing the distribution of propensity scores and comparing descriptive statistics. After matching, 150 intervention facilities and 300 control facilities were included in the analysis (Table 6).

A truncated negative binomial generalized linear mixed effect model using template model builder (TMB) implemented in the glmmTMB library was applied to model the data of nine service delivery outcomes given that they are counts and do not include zeros [75]; the exception is for the counts of women starting long-lasting methods of family planning, in which we fit a standard negative binomial. A random effect for the matched pair of facilities and the covariates listed above were added to the model. We report the exponentiated coefficients as incidence rate ratios (IRR) and their 95% confidence intervals.

Sensitivity analysis was conducted by removing observations beyond six times the standard deviation of the outcome means in the matched data. The results did not meaningfully change the direction, magnitude of coefficients, or the conclusions.

#### *Analysis of impact on service readiness*

We applied difference-in-difference (DID) analysis to assess the impact of the IDEAs program on service readiness. Four time points of district readiness assessments were available, with an irregular frequency between them. We used the first assessment as the baseline and the average of three subsequent assessments as the intervention period, expressed in the following formula:

$$Y_{jt} = \beta_0 + \gamma X_{jt} + \beta_1 time_{jt} + \beta_2 treatment_{jt} + \beta_3 time_{jt} * treatment_{jt} + u_{jt} + \varepsilon_{jt}$$

Where:

$j$  = health facility;  $t$  = time

$\beta_0$  = Baseline level of the outcome at time =0

$\beta_1$  = Is 1 after baseline and 0 before, measures the relative change in the control group.

$\beta_2$  = 1 for treatment and 0 for control, measures the odds in treatment compared to the control group at baseline.

$\beta_3$  = Is the effect of DID. It measures the change in odds of the treatment group above and beyond the change in odds in the control group.

$\gamma$  is the vector of coefficients, and  $X$  is a matrix of covariates

$u_{jt}$  = Is the random effect for matched pair of facility

$\varepsilon_{jt}$  = Error term

Cumulative link mixed models from the ordinal package were used to account for the ordinal nature of the composite scores for the following readiness domains: Medicine, equipment, infrastructure, and essential care [76,77]. For the staffing domain, we use a Poisson model. A random effect for the facility and covariates previously described were added to the models. We present odds ratios (OR) and 95% CI for composite readiness score outcomes and IRR and 95% CI for staffing. All analyses were performed in R version 4.2.2.

## RESULTS

Table 6 describes the distribution of covariates in facilities in unmatched and matched data at baseline (October 2016). Most facilities are rural health centers located, on average, more than 50 kilometers from the referral health facility. Intervention facilities tend to have a slightly higher number of MCH nurses, include more health posts, and are more likely to be located in an urban center than controls.

### Results of the analysis of IDEAs impact on service delivery outcomes

Figure 9 presents the IRRs for time slopes from the adjusted analyses. Next, we describe the intervention's effect, measured by the interaction between intervention time and treatment. Detailed results of the unadjusted and adjusted analysis are presented in Appendix 2.

We observed significant positive associations for two outcomes: The first at-risk child consultation (IRR=1.06 [95% CI, 1.04, 1.07]) and the first PCR testing for exposed HIV children (IRR=1.02 [95% CI, 1.01, 1.03]). In summary, we observed a monthly increase of six percentage points in the counts of first at-risk child consultations and two percentage points in the first PCR test performed in intervention facilities compared with control facilities.

Our analysis found non-significant associations between IDEAs and six service delivery outcomes: The fourth dose of preventive treatment for malaria (IRR=1.00 [95% CI, 0.99, 1.01]); the second-to-fifth dose of tetanus vaccine (IRR =1.00 [95% CI, 0.99, 1.01]); the fourth antenatal care visit (IRR=0.99 [95% CI, 0.98, 1.01]); active management of the third stage of labor (IRR=1.00 [95% CI, 0.99, 1.00]); the first postpartum consultation (IRR=0.99[95% CI, 0.98, 1.00]); and fully vaccinated children (IRR=1.00 [95% CI, 0.99, 1.01]).

Our analysis found significant negative associations for two outcomes: New users of contraceptives (IRR= 0.95 [95% CI, 0.94, 0.96]) and women initiating long-lasting contraceptives (IRR= 0.94 [95% CI, 0.93, 0.95]), respectively. In summary, we observed a monthly reduction of five percentage points in the counts of new users of contraceptives and six percentage points in the initiation of long-lasting contraceptives in intervention facilities compared with control facilities.

Figure 10 presents time series plots of observed (points) data and model trends (lines) for all ten service delivery outcomes in intervention and control facilities as rates per thousand people.

## **Results of the analysis of IDEAs impact on service readiness outcomes**

Our analysis on IDEAs impact on service readiness outcomes found that the odds for better infrastructure availability were 5.84 times greater in intervention facilities compared with control facilities (OR=5.84 [95% CI, 1.32, 25.88]), whereas the odds of better availability of essential care services were 0.87 times less likely in intervention facilities compared with control facilities (OR=0.13 [95% CI, 0.03, 0.54]) (Table 7). Our analysis found a null effect of the intervention on the availability of essential medicines (OR=2.61 [95% CI, 0.66, 10.29]), essential equipment (OR=1.20 [95% CI, 0.31, 4.64], and MCH staffing (IRR=1.09 [95% CI, 0.82, 1.45].

## **DISCUSSION**

This manuscript reports on the results of a quasi-experimental evaluation of the IDEAs A&F strategy – a cyclical implementation strategy led by public health facility MCH managers in 12 districts in Mozambique that aimed to improve routine application of MOH guidelines targeting major causes of neonatal mortality as well as strengthen health system readiness to deliver these guidelines. Our analysis found mixed results on IDEAs impact on service delivery and service readiness outcomes. In the ITS analysis of IDEAs' association with service delivery outcomes, the intervention was associated with improvements in at-risk child care outcomes, was not associated with changes in antenatal care, maternity, postpartum care, or well-child service outcomes, and was negatively associated with family planning outcomes. In our DID analysis on service readiness outcomes, IDEAs were associated with improved infrastructure availability a reduction in the availability of essential care services, and not associated with changes in the availability of essential medicine, essential equipment, or staffing.

The observed association between IDEAs and improvements in at-risk child outcomes may highlight the robust vertical resources for HIV services compared with other services that may be inequitably distributed across health facilities. The observed null effects across most service delivery and readiness outcomes may indicate that the strategy did not directly influence changes in those indicators, which may be linked to poor alignment and/or implementation of planned micro-interventions due to a lack of resources and inefficient oversight of these actions. Though the IDEAs strategy included the provision of moderate, flexible funding to districts to support the implementation of facility-level micro-interventions, these funds may have targeted infrastructural improvements (including items such as communications, transportation, power supply, and infection control infrastructure) instead of funding purchase essential medicines or hire additional staff (which are typically procured at national or provincial levels and is beyond the scope of districts' procurement capacity). Additionally, the modest funding provided by IDEAs may have been insufficient to move the needle on service readiness needs in an underfunded health system with high disease burden and patient loads.

We observed associations of the intervention with attenuated improvements in the availability of essential care services for pregnant women and newborns and family planning indicators. Reasons for sub-optimal results in essential care scores might include a lack of resources (which could explain the lack of improvements in the availability of essential medicines, equipment, and human resources) the need to reinforce clinical supervision and strengthen clinical training in obstetric care management. This point is reinforced by the list of problems identified in IDEA's A&F meetings in which “weak diagnosis and management of obstetric complications” was consistently identified as a priority in all districts (data not shown).

The observed reduction in family planning indicators across both intervention and control facilities may be associated with external factors that affected these services in many low-income countries during the intervention period. As an example, the United States ‘Global Gag Rule’ which prohibits non-US-based non-governmental organizations (NGOs) from providing, referring for, or counseling on abortion as a method of family planning, did fracture the provision of sexual and reproductive health by reducing contraceptive service availability, accessibility and providers training in LMICs [78–80]. Additionally, multiple studies have reported negative trends in providing family planning services in LMICs during the COVID-19 pandemic, including Mozambique [81,82]. Indeed, our analysis demonstrates that there was a monthly reduction of nine percentage points in new contraceptive users and a three percentage point reduction in initiation of long-lasting contraceptives in IDEAs intervention facilities during the COVID period (Appendix 2). Although these external factors are real, it is unclear why the decrease in observed family planning delivery indicators was greater in intervention than control facilities.

Similar to our study, existing evidence on the impact of A&F on clinical outcomes shows mixed results. A Cochrane review of 49 A&F studies found a risk difference of -0.4% (IQR -1.3% to 1.6%) decrease in patient outcomes (for studies with dichotomous outcomes) and 17% (IQR 1.5% to 17%) improvement in patient outcomes (for studies with continuous outcomes) [16,38]. However, most of these studies are randomized control trials from high-income countries [15,16,38,83]. A systematic review of strategies to improve the quality of maternal and child healthcare in low and middle-income countries included ten reviews on A&F, in which nine detected small to moderate effects on professional practice, and one revealed ineffectiveness with a magnitude of effects ranging from -17% to 49% change. For effects on health outcomes, no

statistically significant differences were found in one review included in the overview [12]. Another review stated that complex areas such as disease management, adherence to guidelines, and diagnosis appear less affected by A&F; in contrast, prescription and preventive care activities are more likely to change with A&F strategy due to differences in the complexity of the levels of decision-making for providers in these areas of care [84].

## **LIMITATIONS AND STRENGTHS**

This evaluation has a number of limitations. First, to assess IDEAs effects on service delivery outcomes, our evaluation relied on aggregate monthly facility-level count data that are not ideally suited to assessing improvements in the application of clinical guidelines, nor were we able to measure changes in neonatal mortality. Ideally, our assessment of service delivery outcomes would include more granular assessments of the application of MOH guidelines at the facility level. However, in the absence of these data (and given resource constraints precluding setting up such a system – like an electronic health record system – for this study), we relied on RHIS data that we acknowledge has limitations. Data on selected outcomes before October 2016 were unavailable in the system, and as a result, our time series began concurrently with the initiation of the intervention. We expect the effects of this to be minimal given that the periodicity of the IDEAs intervention was semiannual, and if there were any effects, they would mostly likely be conservative, biasing results towards the null. We were also unable to assess the intervention impact on neonatal mortality due to the lack of reliable facility-level mortality data or community survey data during the analysis period. Nevertheless, routine health information

systems have strengths, such as their availability and representativeness throughout the Mozambique public sector health network and potential for improvement [85].

In addition, residual confounding may exist, although propensity score matching and adjusting for covariates are robust to addressing this source of bias. Our analysis of service readiness outcomes relied on only four data points (four annual cross-sectional readiness surveys), which may have reduced our power to detect changes in service readiness associated with the intervention. Furthermore, our service readiness measures are composite outcomes, which may obscure improvements in individual components of the aggregate outcome. Finally, given the quasi-experimental design of this study, care should be taken in attributing causality of observed results to the study intervention.

Despite these limitations, this study has important strengths. The intervention was delivered by district health teams and implemented in 12 districts and over 150 health facilities, providing relevant results to guide further scale-up of the intervention in Mozambique. The strong quasi-experimental design that includes appropriate controls and robust analytic techniques addresses multiple sources of bias. Additionally, most service delivery outcomes included in the study were linked to the principal issues identified by district MCH managers during A&F meetings, and assessing improvements in these targeted indicators is appropriate for evaluating the IDEAs intervention. Finally, we have evaluated a strategy implemented in a pragmatic, real-world practice setting in a resource-limited environment, narrowing the evidence gap about the effectiveness of A&F processes outside of high-income contexts.

## **Implications to practice**

The analysis of the IDEAs implementation process showed that the strategy allowed MCH managers to identify problems and propose micro-interventions at the primary health facility level (data not shown). However, implementing micro-interventions identified in action plans requires adequate resource availability, clinical supervision tailored to the identified problems and solutions, and close monitoring of proposed activities. Although the IDEAs design includes modest district funding and selective health facility supervision to support action plan implementation, our results suggest that the strategy needs to be refined and adapted to maximize improvements in service delivery and readiness outcomes. We recommend considering allocating funding or required resources at the level where the problems are identified to facilitate using those resources to solve context-specific challenges. This approach will require administrative support to health facilities to manage resources effectively. The supervision component must also be tailored to reinforce clinical practice with a strong focus on managing obstetric care, which likely implies including highly skilled professionals in supervision teams.

### **Implications for research**

Understanding how intervention fidelity influences its effectiveness is crucial to detecting which components of the IDEA's strategy (and other A&F interventions) are core and which elements can and should be adapted to enhance contextual appropriateness. Moreover, a deep understanding of barriers and facilitators for action plan implementation from the perspective of health system managers at the facility, district, and provincial levels will complement the evidence of this evaluation. Lastly, testing different combinations of A&F with other strategies and their relative impact on clinical and health system readiness outcomes is needed across

resource-limited settings to build the evidence base on this promising system-focused intervention.

## **CONCLUSION**

The IDEA's audit and feedback strategy presented mixed results. The strategy supported MCH managers to identify priority issues and propose local solutions and was associated with improvements in selected indicators from child-at-risk services and infrastructure availability. Sub-optimal and null effects in most indicators suggest a need for refining and adapting strategy components to target clinical and readiness outcomes more directly in a low-resource context.

## **Acknowledgments**

We would like to thank the Ministry of Health of Mozambique, Manica and Sofala provincial health departments, district MCH managers, and facility MCH nurses for collaborating in designing, implementing, and evaluating the IDEAs strategy.

## **Contributors**

AD, KS, QF, SGL, SG, RE, BW, BWE, and GS conceived the idea of the study.

IR, EB, AG, SC, and OA coordinated data collection. AD prepared the data. AD and OA designed the analysis. AD conducted the analysis and wrote the first draft of the manuscript. All authors reviewed the manuscript.

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## **Competing interests**

The authors declare that they have no competing interests.

Table 4: IDEAs program setting

<b>Province</b>	<b>Population (2017)<sup>a</sup></b>	<b>Total Districts (2021)<sup>b</sup></b>	<b>Districts with IDEAs</b>	<b>Total Health facilities (2021)<sup>b,c</sup></b>	<b>Health facilities with IDEAs</b>
Manica	1,911,237	12	7	126	79 (63%)
Sofala	2,221,803	13	5	174	75 (43%)
Total	4,133,040	25	12	300	154

<sup>a</sup>National population and housing census 2017; <sup>b</sup>provincial statistical data 2021; <sup>c</sup>Excluding provincial hospitals.

Table 5: List of items to create composite scores for readiness

<b>List of items included to create composite scores for availability of essential medicines</b>
<ol style="list-style-type: none"> <li>1. Antibiotics: Gentamicin, ampicillin, metronidazole, benzathine benzylpenicillin, procaine benzylpenicillin, ceftriaxone, cefixime, amoxicillin(infantile)</li> <li>2. Antihypertensives: Hydralazine, methyldopa</li> <li>3. Corticosteroids: Dexamethasone, hydrocortisone</li> <li>4. Intravenous rehydration solution: Sodium chloride, sodium lactate compound, glucose 5% compound</li> <li>5. Antimalarials: Artesunate, artemisinin combination therapy (ACT), quinine</li> <li>6. Oxytocin</li> <li>7. Magnesium sulfate</li> <li>8. Nifedipine</li> <li>9. Misoprostol</li> <li>10. Vitamin A (infant)</li> <li>11. Calcium gluconate</li> <li>12. Oral rehydration salts (ORS)</li> <li>13. Zinc</li> <li>14. Oxygen</li> <li>15. Tetanus vaccine</li> </ol>
<b>List of items included to create composite scores for availability of infrastructure</b>
<ol style="list-style-type: none"> <li>1. Communications: Functioning landline telephone, cellular, short-wave radio, computer</li> <li>2. Transportation: Functional ambulance or other vehicles for emergencies, fuel for the emergency vehicle</li> <li>3. Power supply: Electricity from any source, secondary backup source</li> <li>4. Basic amenities: Functioning toilet for outpatients, availability of water in the main source, privacy available for patients</li> <li>5. Processing of equipment for reuse: Electric autoclave, electric boiler or steamer, non-electric pot with cover for boiling/stem, a heat source for non-electric equipment</li> <li>6. Infection control: Cleaning running water, hand washer, alcohol-based hand rub, disposable latex gloves, waste receptacle with lid and plastic bin liner, sharps container, environmental disinfectant, disposable syringes with disposable needles, auto-disables syringes, guidelines for infection control</li> </ol>
<b>List of items included to create a composite score for services provided</b>
<ol style="list-style-type: none"> <li>1. Monitoring for a hypertensive disorder of pregnancy</li> <li>2. Provide ARV prophylaxis to HIV-positive pregnant women for PMTCT</li> <li>3. Monitoring and management of labor using partograph</li> <li>4. Administration of oxytocin injection immediately after birth to all women for the prevention of postpartum hemorrhage</li> <li>5. Parenteral administration of oxytocic for treatment of postpartum hemorrhage (IV or IM)</li> <li>6. Hygienic cord care (cut with a sterile item and apply disinfectant to tip and stump, and no application of other substances)</li> <li>7. Parenteral administration of antibiotics (IV or IM) for mothers</li> </ol>

8. Antibiotics for preterm or prolonged PROM (premature rupture of membranes) to prevent infection
9. Parenteral administration of magnesium sulfate for management of preeclampsia and eclampsia (IV or IM)
10. Injectable antibiotics for neonatal sepsis
11. Corticosteroids in preterm labor
12. Immediate and exclusive breastfeeding
13. Thermal protection (drying baby immediately after birth and wrapping)
14. Neonatal resuscitation with bag and mask
15. KMC (Kangaroo mother care) for premature/very small babies
16. Provide ARV prophylaxis to newborns of HIV-positive pregnant women for PMTCT

**List of items included to create a composite score for the availability of essential equipment**

1. Disposable latex gloves
2. Birth kit
3. Incubator
4. Infant weighing scale
5. Sphygmomanometer
6. Electric suction pump
7. Suction catheter for newborn
8. Resuscitation table for newborn
9. Newborn bag and mask size 1 for term babies
10. Newborn bag and mask size 10 for preterm babies
11. Oxygen delivery apparatus (key connecting tubes and mask/nasal prongs)
12. Oxygen bottles
13. Manual vacuum extractor
14. Partogram
15. Speculum
16. Thermometer
17. Rapid diagnostic test, HIV
18. Rapid diagnostic test, malaria
19. Rapid diagnostic test, syphilis
20. Syringes
21. Suture material with needles available
22. Hemoglobin color scale
23. Blood glucometer
24. Umbilical clamp
25. Intravenous kit
26. Examination light
27. Vacuum aspirator or D&C kit
28. Pinard stethoscope

Table 6: Baseline characteristics of study facilities in unmatched and matched data

VARIABLES	UNMATCHED BASELINE DATA			MATCHED BASELINE DATA		
	Control (N= 349)	Intervention (N=154)	Overall (N= 503)	Control (N= 300)	Intervention (N=150)	Overall (N=450)
MCH Personnel	2.46(4.44)	3.29(5.30)	2.71(4.73)	2.61(4.71)	3.29(5.30)	2.84(4.92)
Facility beds	7.19(12.5)	7.71(15.1)	7.35(13.3)	7.52(13.1)	7.89(15.3)	7.64(13.9)
Type of HF						
Rural Center	307(87.9%)	117(76.0%)	424(84.3%)	261(87.0%)	114(76.0%)	375(83.3%)
Urban Center	28(8.0%)	22(14.3%)	50(10.0%)	26(8.7%)	21(14.0%)	47(10.4%)
District Hospital	4(1.1%)	3(1.9%)	7(1.4%)	3(1.0%)	3 (2.0%)	6(1.3%)
Rural Hospital	4(1.1%)	2(1.3%)	6(1.2%)	4(1.3%)	2(1.3%)	6(1.3%)
Health Post	6(1.7%)	10(6.5%)	16(3.2%)	6(2.0%)	10(6.7%)	16(3.6%)
Location						
Rural	320(91.7%)	128(83.1%)	448(89.0%)	273(91.0%)	125(83.3%)	398(88.4%)
Urban	29(8.3%)	26(16.9%)	55(11%)	27(9.0%)	25(16.7%)	52(11.6%)
Distance From Province Health Department (Km)	240 (152)	118 ( 89.1)	203 (147)	206 (125)	118 (89.1)	177 (121)
Distance From Referral HF(Km)	59.6(66.1)	41.0(39.7)	54.0(60.0)	53.8(57.1)	41.0(39.7)	49.5(52.3)

Catchment	37300	34200	36400	36600	34300	35800
Area Size (Thousands Population)	(44900)	(38800)	(43100)	(44500)	( 39300)	(428000)
MCH: Maternal and child; HF: Health facility; SD: Standard deviation						

Table 7: Results of difference-in-difference analysis for service readiness outcomes

Model Coefficients	Outcomes				
	Medicine	Infrastructure	Equipment	Essential care	MCH-Staffing
	OR [95% CI]				IRR [95%CI]
Mean change in controls	0.30 [0.11, 0.83]	0.26 [0.09, 0.73]	0.95 [0.36, 2.49]	8.23 [2.83, 23.97]	0.85 [0.69, 1.05]
Difference at baseline	0.99 [0.31, 3.19]	0.32 [0.08, 1.22]	0.85 [0.25, 2.86]	4.11 [1.43, 11.81]	0.82 [0.55, 1.21]
Effect DID	2.61 [0.66,10.29]	<b>5.84 [1.32, 25.88]*</b>	1.20 [0.31, 4.64]	<b>0.13 [0.03, 0.54]*</b>	1.09 [0.82, 1.45]
Location (Urban)	0.14 [0.03, 0.66]	0.32 [0.06, 1.76]	0.61 [0.13, 2.96]	0.26 [0.08, 0.84]	2.71 [1.83, 4.00]
MCH Staffing	1.32 [1.19, 1.47]	1.30 [1.17, 1.45]	1.34 [1.20, 1.49]	1.14 [1.06, 1.22]	-----

DID: difference-in-difference; \*statistically significant at 0.05 level

Figure 7: Steps of the IDEAs audit and feedback

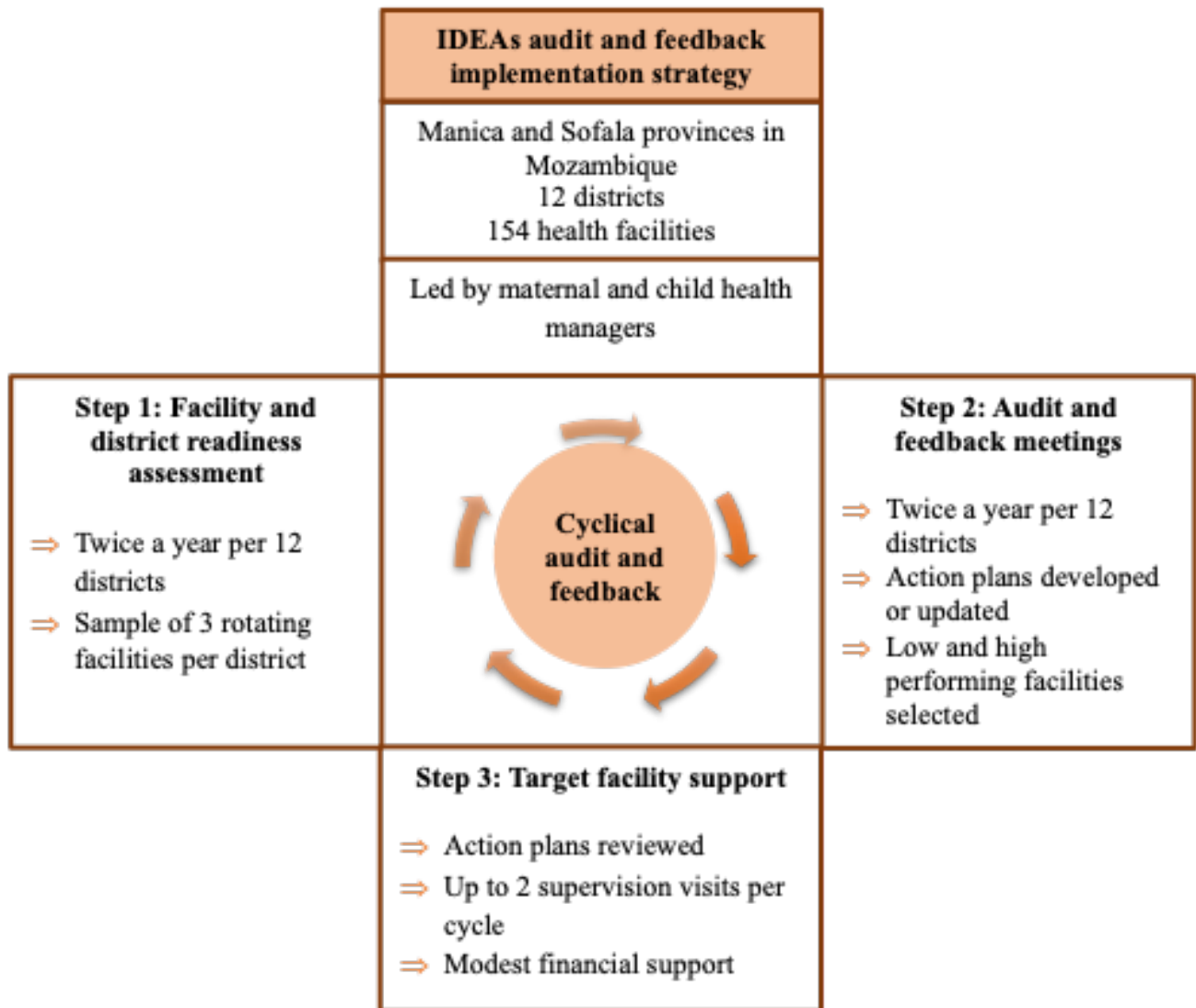


Figure 8: Sampling of facilities for service delivery outcomes and service readiness analyses

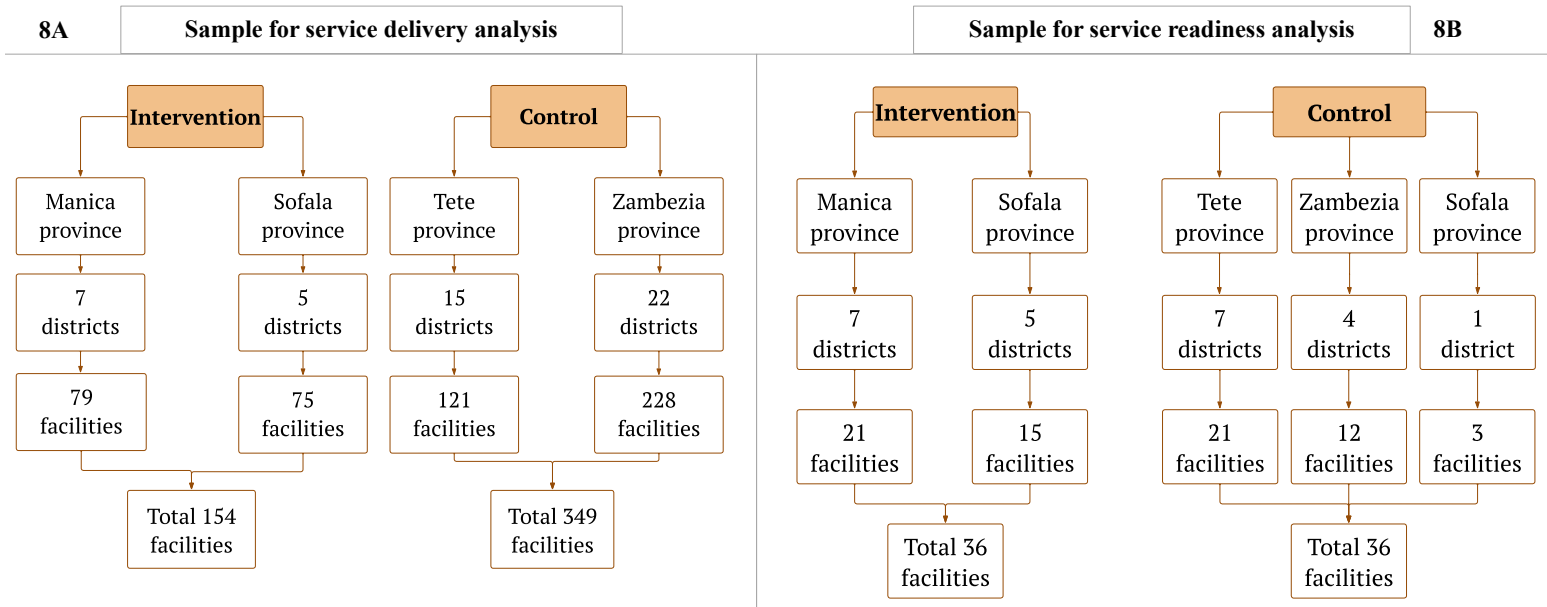


Figure 9: Incidence rate ratios (IRRs) of the slopes of adjusted models for service delivery outcome analyses

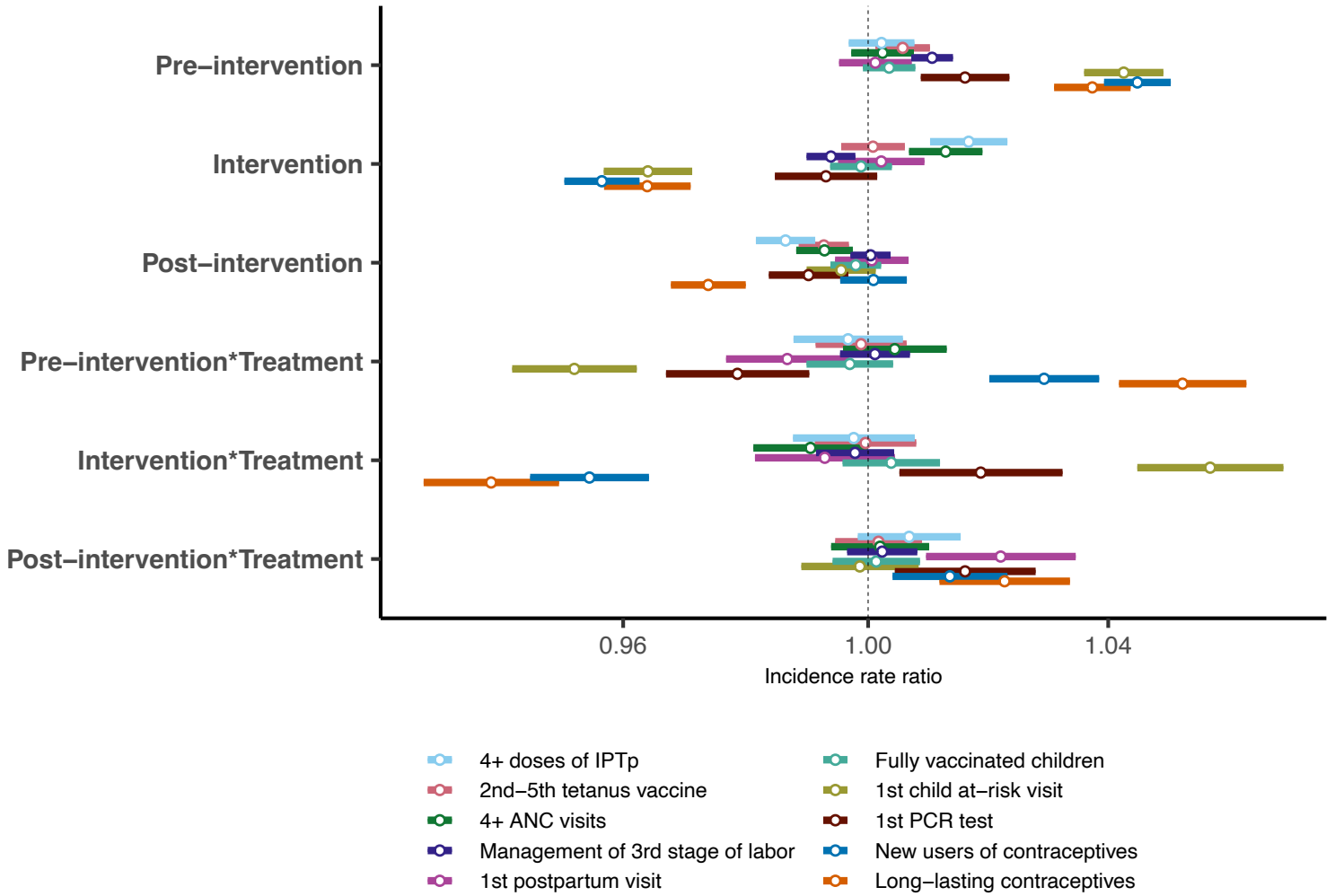
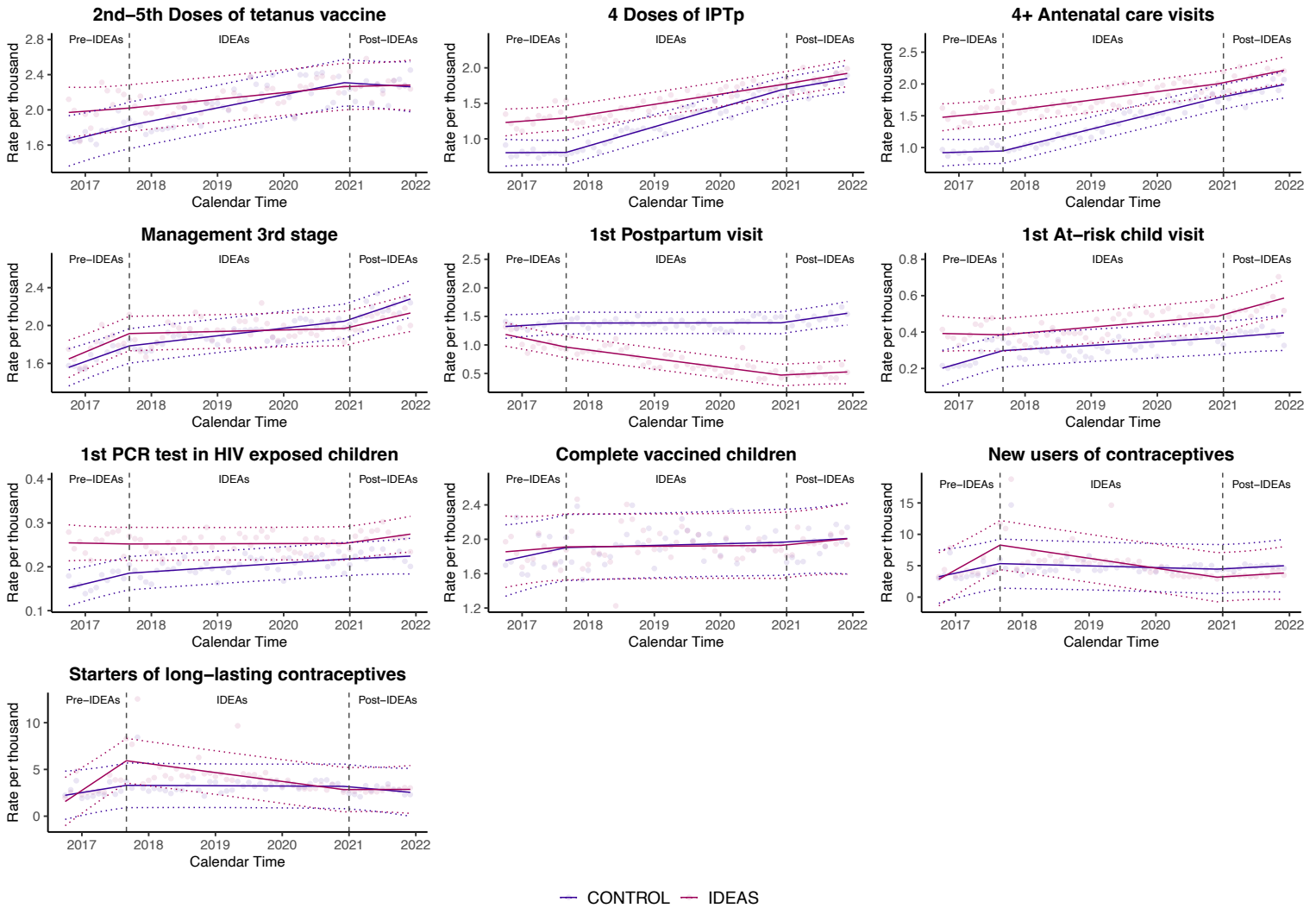


Figure 10: Time series plots for ten service delivery outcomes in intervention (IDEAs) and control facilities



# **CHAPTER 4: Exploring Fidelity And Its Influence On Effectiveness In An Audit And Feedback Strategy Implemented In A Low-Resource Setting: An Application Of Principal Component Analysis And Regression Modeling**

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# **ABSTRACT**

## **Background**

Assessing implementation fidelity—the degree to which a program is implemented as intended—is essential to understand whether poor outcomes are due to implementation problems or the design of an intervention. Few studies in health research have documented the association between implementation fidelity and effectiveness. In this study, we analyzed the associations between implementation fidelity and effectiveness of the Integrated District Evidence-to-Action (IDEAs) —a multicomponent audit and feedback strategy designed to improve the implementation of maternal and child clinical guidelines in Mozambique.

## **Methods**

IDEAs was implemented in 154 health facilities across 12 districts in Manica and Sofala provinces in Mozambique between 2016 and 2020. We used the conceptual framework for implementation fidelity to descriptively guide our analysis of IDEAs adherence. An exploratory principal component analysis was applied to extract the primary information of fidelity data. Regression modeling was used to study patterns of association between measures of fidelity and measures of effectiveness for 10 service delivery outcomes and 5 service readiness outcomes.

## **Results**

We describe adherence on 15 measures of fidelity, of which 12 had high fidelity. Poor fidelity was found in conducting service readiness assessments and completing micro-interventions from action plans. The principal component analysis identified four main components: (1) audit and feedback structure, (2) participation, (3) insufficient supervision, and (4) unsatisfactory

completion of micro-interventions. Service delivery measures tended to be positively associated with participation, supervision, and degree of micro-intervention completion and negatively associated with a higher number of action plans and problems identified during meetings. For the service readiness outcomes, delivery of essential care was positively associated with participation and micro-intervention completion, and staff availability was negatively associated with supervision.

## **Conclusion**

Poor implementation of micro-intervention appears to be the main factor for weak effectiveness results. Understanding the challenges of micro-intervention completion is crucial. We recommend adapting IDEAs to improve fidelity on micro-intervention completion, removing the service readiness assessments, and potentially adding other strategies. This study is an example of how to link fidelity measures with effectiveness to examine implementation processes in resource-constrained settings. Such an analysis facilitates the selection of optimal implementation strategies, accurate replication, and successful evidence transfer into practice.

## **Contributions to the literature**

- This paper brings an approach to examining associations between implementation fidelity and health outcomes by using implementation science frameworks and quantitative methods.
- It responds to the need to conduct and report implementation processes to understand the results of effectiveness studies and improve health strategies' design, implementation, and adaptation.
- It shows that audit and feedback strategies might have good results in higher-income settings and under controlled trials; however, implementing such strategies in low-resource settings must account for contextual health systems weaknesses, such as the availability of resources to implement planned actions for change.

## **BACKGROUND**

Reductions in neonatal mortality have been slower than for maternal and child mortality, with projections indicating that between 2018 and 2030, 27.8 million children will die in their first month of life if countries do not accelerate reduction [58]. The time of birth has the highest risk of death, requiring a quick response from healthcare providers [3].

Universal coverage of essential newborn and maternal health care interventions would reduce neonatal mortality by 71%, benefit women and children after the first month, and reduce stillbirths [86]. However, the packages with the most significant impact (clinical care around birth and care of tiny and ill babies) are not being efficiently implemented. Factors for low coverage of these packages include health workforce, financing, and service delivery quality [86].

In 2019-2020, national community surveillance data estimated a high rate of neonatal mortality in Mozambique, with 23 (95% CI:18-28) deaths per 1,000 live births [56]. Infections accounted for 62% of deaths, intrapartum-related events, including birth asphyxia and birth trauma, were responsible for 20% (95% CI:14-26) of deaths, and prematurity was responsible for 10% (95% CI:7-13) [56].

Skilled care at birth with evidence-based practices offered in a humane, supportive environment is needed to reduce preventable newborn morbidity and mortality [87]. Satisfactory quality of care requires the appropriate use of effective clinical and non-clinical interventions, strengthened health infrastructure, and optimum skills and attitudes of health workers, resulting in improved health and positive experiences for women and newborns [87].

Quality improvement strategies have been recognized as one of the tools to strengthen health systems and improve the quality of care in resource-poor settings [88–90]. The audit and

feedback (A&F) strategy, defined as a summary of clinical performance over a specified period of time, is widely used to improve professional practice [15,16]. During the A&F process, an individual's professional practice or performance is measured and compared to professional standards or targets. Most available evidence of A&F is from randomized control trials in high-income settings where the effects varied widely, ranging from minor to a substantial effect on professional behavior and no impact on patient outcomes [15,16]. Evidence suggests that feedback is most effective when it is delivered by a supervisor or respected colleague, presented more than once, features specific goals and action plans, focuses on settings with lower baseline performance, and is conducted with participants who are not physicians [15].

Integrated District Evidence to Action (IDEAs) is a multicomponent A&F implementation strategy designed to improve the implementation of maternal and child guidelines in Mozambique. Specifically, IDEAs aims to improve the coverage and quality of a bundle of existing evidence-based interventions targeting major causes of neonatal mortality. Funded by the Doris Duke Charitable Foundation and the US National Institutes of Health, IDEAs strategy was implemented between October 2016 and December 2020 in Manica and Sofala provinces across 12 districts and 154 primary healthcare facilities in central Mozambique. Maternal and child health (MCH) managers at the facility, district, and province levels were the leading agents in the IDEAs A&F strategy.

Implementation fidelity is defined as the degree to which program staff implement programs as intended [91]. Implementation fidelity serves as a potential moderator of the relationship between interventions and their outcomes, meaning it is a factor that may impact how far the intervention actually affects the outcomes [91]. Examining implementation fidelity is critical to the internal and external validity of implementation research. Accurate conclusions

about an intervention cannot be made without evaluating fidelity, as unknown factors may have influenced the outcome. Reporting on fidelity enables researchers in the field of implementation science to assess the extent to which the success of an intervention is influenced by the strategy used [92]. Such reporting facilitates the selection of optimal implementation strategies, more accurate replication, and, ultimately, a more successful transfer of evidence into practice [92]. However, little data is available on implementation fidelity [92]. The authors of this article seek to close this gap.

This article is part of a series of analyses that have been conducted on the IDEAs strategy. Previously, we evaluated implementation outcomes and the effectiveness of IDEAs on service readiness and service delivery outcomes guided by the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework, the results of which are published elsewhere [publication forthcoming]. Briefly, the results of that study showed high reach, adoption, and maintenance of the strategy. Implementation fidelity was high overall; out of 15 fidelity measures, 2 had poor fidelity, and effectiveness presented mixed results. The aim of the current study was to further explore fidelity measures and examine patterns of association between fidelity and effectiveness. The main idea is to identify which fidelity measures were central and may have influenced the results of the effectiveness of the IDEAs strategy.

## **METHODS**

The IDEAs strategy was designed to improve health service delivery and service readiness by identifying performance gaps based on facility indicators and by enabling MCH managers to

monitor, evaluate, prioritize, and implement micro-interventions (defined here as solutions selected, implemented, or adapted at the health facility level that do not require significant financial resources) to improve compliance with Ministry of Health guidelines targeting primary causes of neonatal mortality. Each intervention district conducted a total of nine A&F meeting cycles over a period of five days each. The cycles were iterative, occurring twice a year between October 2016 and December 2020. IDEAs strategy covered the following three steps:

*Step 1: Facility service readiness assessments*

Before the A&F meetings began, standardized assessment tools were applied in three randomly selected, rotating primary healthcare facilities within each of the 12 study districts. The assessment tools were adapted from the World Health Organization Service Availability and Readiness Assessment, program questionnaires, observation, and registry review [43]. These tools were used to assess (1) structural readiness to deliver perinatal clinical interventions, including staffing levels, training, availability of essential commodities, equipment and supplies, and data quality; and (2) process quality, including provider knowledge and ability to implement clinical guidelines, patient satisfaction, and observation of the use of provider time.

*Step 2: Audit and feedback meetings*

MCH managers from the facility, district, and provincial levels participated in A&F meetings twice a year. They used audited data from routine health information systems and service readiness assessments to compare performance at the facility level relative to goals. MCH managers then provided feedback on performance to their peers in both graphical and tabular formats, allowing visualization of secular trends of service delivery indicators. Each facility and

district team presented their performance metrics, followed by a group discussion to interpret results, identify barriers to implementing clinical guidelines, develop action plans highlighting priority problems, select context-specific micro-interventions, and set measurable targets and resources required to implement action plan activities.

*Step 3: Targeted facility support (supervision visits and financial support)*

Twice a year at each district A&F meeting cycle, three primary healthcare facilities were selected based on their performance of service delivery indicators (one high-performing and two low-performing) to receive up to two supervision visits per A&F meeting cycle. In addition, a modest monthly financial amount of US\$1,250 was allocated to each district to support action plan implementation in the selected health facilities. During supervision visits, district MCH managers reviewed action plans, identified barriers to guideline implementation, and provided technical assistance to address context-specific barriers. District MCH managers were also responsible for monitoring, evaluating, and recording the degree of success (i.e., the percentage of micro-intervention implemented successfully) by the health facilities.

Table 8 summarizes the IDEAs strategy based on the recommendation by Proctor et al. for the specification and reporting of implementation strategies [93].

**Study setting**

IDEAs strategy was implemented in Manica and Sofala provinces in central Mozambique, with a combined population of more than 4.5 million [44,45]. The A&F strategy was implemented in

154 primary healthcare facilities across 12 districts in central Mozambique, representing more than 70% of the population in both provinces (Table 9).

### **Study design**

For the present study, we used the following quantitative methods: descriptive statistics to report measures of fidelity, an exploratory principal component analysis (PCA) [94] of fidelity measures, and regression analysis to study the patterns of association between measures of fidelity and measures of effectiveness for service delivery and service readiness outcomes.

The IDEAs strategy applied a quasi-experimental study design guided by the RE-AIM framework. All dimensions of the RE-AIM framework were used to plan, evaluate, and report the IDEAs strategy. RE-AIM guided the selection, definition, and reporting of implementation outcomes and the methodology to evaluate the strategy's effectiveness on improving service and readiness outcomes, as reported elsewhere [publication forthcoming].

### **Data analysis**

#### **Measures of fidelity**

Table 10 lists the IDEAs strategy's fidelity measures based on the conceptual framework for implementation fidelity by Carrol et al [91]. Data on these measures were collected from program monitoring and evaluation documents.

The following 10 aggregated measures of fidelity per facility were selected for quantitative analysis: number of A&F meeting cycles, number of participants (province level), number of participants (district level), number of participants (facility level), number of action plans elaborated, number of distinct problems identified in action plans, number of supervision

visits, mean monthly time to the first supervision visit, percentage of micro-interventions completed, and number of times the facility was selected based on performance. Service readiness assessments were excluded because they were conducted in a sample of 36 facilities. Flexible funding was not included because there is no variation of this variable.

### **Measures of effectiveness**

The impact of the IDEAs strategy on service delivery and service readiness indicators has already been measured and is reported elsewhere [publication forthcoming]. We briefly describe how these measures were selected and the effectiveness results as follows.

#### *Service delivery indicators*

The selection of service delivery indicators was guided by multiple sources, including the existing evidence of interventions to reduce neonatal mortality [8,9,71], the list of priority issues identified during the A&F meetings (we attempted to match service indicators with priority issues), and the availability of data in routine health information systems.

Monthly counts of 10 indicators from antenatal care, maternity, postpartum, child consultations, and family planning were extracted from routine health information systems for each health facility. These indicators are counts of (1) pregnant women with a fourth dose of intermittent treatment for malaria; (2) pregnant women with a second-to-fifth dose of tetanus vaccine; (3) pregnant women with at least four antenatal care visits; (4) deliveries with active management of the third stage of labor; (5) first postpartum consultations; (6) fully vaccinated children; (7) first at-risk child appointments; (8) first polymerase chain reaction tests for HIV-

exposed children; (9) new users of contraceptive methods; and (10) women starting long-lasting contraceptives (e.g., intrauterine devices, implants, and injectables).

Results from the effectiveness analysis showed no impact on indicators 1 through 6, a positive impact on indicators 7 and 8, and a negative impact on indicators 9 and 10.

### *Service readiness indicators*

We created composite measures for the availability of essential medicine, infrastructure, equipment, and essential care, and we used count data for the number of staff available (MCH nurses). In summary, 15 items were included to create composite scores for the availability of essential medicine based on the World Health Organization's list of priority life-saving medicines for women and children [72]. For the infrastructure domain, six groups of items describing the availability of communications, power supply, basic amenities, processing of equipment for reuse, and infection control were included. For equipment and essential care, 28 and 16 items were included to create composite scores, respectively, according to the Service Availability and Readiness Assessment list of items for these categories [43]. Composite scores for each health facility were estimated by dividing the number of available items by the total number of possible items. For instance, the total possible number of items for medicine is 15. If a health facility has eight items available, the medicine score for that facility is  $8/15 = 0.53$ .

The analysis of the impact on readiness readiness indicators showed no impact on medicine, equipment, and staff availability, a positive impact on the infrastructure domain, and a negative impact on delivery of essential MCH care.

## **Analysis**

For the current study, we conducted two types of analysis: (1) PCA to extract the most essential information about fidelity measures and (2) regression analysis to detect patterns of association between fidelity and effectiveness. We report on the “patterns of association,” defined as the overall tendency of the direction of association between fidelity and effectiveness. We do not report on the actual coefficient of the regression model because the magnitude of the coefficients is not essential to answer the research question. However, the analysis is based on a statistically significant association at a 0.05 significance level.

### ***Exploratory analysis of fidelity measures with principal component analysis***

We conducted a PCA on 10 fidelity measures for all 154 study facilities. The raw data on fidelity measures includes counts, proportions, and means. To avoid variables with large variances producing larger loadings in the PCA analysis, we standardized all variables by subtracting the mean and dividing by the standard deviation [95–97]. The PCA was conducted based on a correlation matrix of the fidelity variables. The selection of the main components is based on the eigenvalue and the cumulative proportion of the variance, and they are interpreted based on the strength of the loadings (i.e., the correlation between a component and the fidelity variable).

### ***Regression analysis***

We conducted regression analysis on two sets of effectiveness indicators—for service delivery and service readiness.

First, we used the findings of the exploratory PCA to select fidelity variables for modeling. Then, we analyzed the Pearson correlation among selected fidelity measures to ensure a set of adequate indicators to include in our model. We aggregated the number of participants of

the three levels (province, district, facility) to just one variable, “total participants,” and excluded the variable that measures the number of times the facility was selected based on performance ( in PCA, we observed that this variable does not contribute much to the data).

Next, we applied a Poisson regression model to the monthly count data of each service indicator as an outcome and a continuous count of 51 months of the study period as a predictor to find the effect of overtime for each health facility. An offset with the logarithm of the facility catchment area was added to the model, and the model's coefficient was multiplied by 12 and exponentiated to be interpreted as an *annual effect*. Then, the annual effect was used in a generalized linear model with inverse variance weights to estimate the association with fidelity measures.

The *effect* on service readiness indicators was found by regressing the scores of availabilities of essential medicine, equipment, infrastructure, and care with the count of time of four service readiness evaluations in a quasibinomial model. For the availability of staff, we used a Poisson regression model. Then, the estimated effect was used as a predictor to study the pattern of association with fidelity measures in a linear model.

Both analyses were adjusted for location(rural/urban) and province, and all conducted in R software, version 4.2.2.

## **RESULTS**

### **Descriptive results on fidelity measures**

In Table 11, we report the extent to which each fidelity measure was achieved. Overall, we found optimal implementation fidelity in 12 out of 15 measures of fidelity for the IDEAs strategy. Two measures with poor levels of fidelity were related to conducting readiness assessments twice a

year among a sample of 36 facilities (52% achievement, irregular frequency) and the third was related to completing the implementation of micro-interventions from the action plans (17% achievement).

### **Results of exploratory analysis with PCA**

Figure 11 shows the scree plots of 10 components of the PCA, of which we selected the first four components that had eigenvalues equal and superior to 1 (Figure 1A). These components explained 82% of the total variance of the fidelity data: the first component explains 29%, the second 27%, the third 16%, and the last 10% (Figure 1B ).

We analyzed the PCA loadings (Table 12) to interpret the selected components [23,26]. The first component strongly correlates with the number of A&F meeting cycles, the number of action plans elaborated, and the number of distinct problems identified; therefore, we interpret this component as a *measure of the overall A&F structure*. Component 2 is significantly correlated with all three levels of participation, and therefore we interpret this component as a *measure of participation*. Component 3 correlates mostly with one value, which is decreasing supervision. This component can be viewed as a *measure of insufficient supervision* in certain health facilities. The last component is highly correlated with micro-interventions, that is, reduced micro-interventions completion, and can be interpreted as a *measure of unsatisfactory completion of micro-interventions* (Table 12).

### **Results on patterns of association from the regression analysis**

### *Service delivery indicators*

The directions of associations suggest that the number of participants, number of supervisions, and the percentage of micro-interventions successfully completed had a positive impact on service delivery indicators, whereas the number of action plans elaborated and problems identified had a negative impact (Figure 12).

### *Service readiness indicators*

A positive association was found between delivery of essential care and number of participants and implementation of micro-interventions; a Negative association was found between the number of staff available (MCH nurses) and the number of supervision visits (Figure 13).

## **DISCUSSION**

In this article, we describe various measures of implementation fidelity and their associations with measures of effectiveness for the IDEAs A&F strategy implemented in 154 primary healthcare facilities in central Mozambique. We used PCA to extract core information about fidelity variables. Based on this explorative analysis, we selected adequate variables in order to study patterns of association between measures of fidelity and measures of effectiveness for service delivery and service readiness outcomes.

Our analysis showed optimal fidelity for all but two measures: conducting service readiness assessments and completing the micro-interventions from the action plans. The PCA identified four main components: (1) the A&F overall structure, (2) participation, (3) insufficient supervision, and (4) unsatisfactory completion of micro-interventions. In studying the association between fidelity and effectiveness, we found positive associations with the number of

participants, supervision visits, and completion of micro-interventions, whereas we found negative associations with the number of action plans developed and the number of problems identified during A&F meetings.

These findings help to understand and explain the mixed effectiveness results of the IDEAs strategy. It seems clear that low fidelity in the completion of micro-interventions was the main factor contributing to weak effectiveness results, given that participation and supervision (positive influences on effectiveness) had high fidelity.

Negative associations with the number of action plans and the number of problems identified reinforce an obvious point—that in order to have an impact, the most crucial aspect of the A&F process is the implementation of solutions, not only the identification of problems.

The explanation for poor fidelity in two measures of the IDEAs strategy has been described elsewhere [publication forthcoming]. In summary, conducting readiness assessments as planned (twice a year in a sample of 36 facilities) was challenging because of delays in elaborating the assessment protocol, delays in IRB approval, and failure to rapidly synthesize results to feedback into the A&F meeting after the assessments. Moreover, the execution was costly, forcing the project team to reduce the sample of facilities to be assessed from 36 to 24.

Identifying and specifying problems and micro-interventions improved over time in the A&F process. During the first two A&F meeting cycles, many problems were identified, and poorly specified micro-interventions were proposed, which posed challenges in monitoring their implementation. Furthermore, Sofala province presented better micro-intervention completion results than Manica, suggesting differences in experience in evaluating action plan implementation between MCH managers in both provinces.

The PCA analysis allowed the use of a set of highly correlated fidelity variables to extract information about the main uncorrelated data components. This information was helpful in understanding which fidelity variables were adding information to the dataset and helped in the decision-making process regarding variable selection for regression modeling. Alternatively, we could use PCA scores of the four components to regress with effectiveness measures, but we chose not to do so because of challenges in interpretability.

In the regression model, we did not seek to identify the magnitude of association between each measure of fidelity and effectiveness because that information is unnecessary to answer our research question. Patterns of associations suggesting that participation, supervision, and micro-interventions are variables linked positively with effectiveness are aligned with the IDEAs conceptual model.

Few studies in health research have systematically documented implementation processes and measured fidelity, and there is no consensus on how to do it [92,98].

A review of primary and early secondary prevention programs found that only 39 out of 162 outcome studies specified procedures for fidelity documentation, and only 13 considered fidelity variations in analyzing program effects [99].

In a cross-sectional study, Narh-Bana et al. examined provider implementation fidelity to implementation of national guidelines on tuberculosis screening at HIV clinics in Ghana [100]. They used the conceptual framework of implementation fidelity to guide the analysis of the content and frequency in which healthcare providers implemented guidelines, reporting an overall median of 79% on provider scores. They also explored associations between fidelity and demographic characteristics and found positive associations with gender, profession, and education [100].

In a study of a continuum of care program for frail older adults in health and social care, Hasson et al. used the conceptual framework for implementation fidelity to examine the intervention's content, dose, coverage, and moderating factors [101]. They found that 16 out of 18 intervention components were always or most often delivered as intended in the program protocol. No link with effectiveness was reported. Hogue et al. examined the impact of treatment adherence and therapist competence on treatment outcomes in psychotherapy and reported a positive linear relationship between adherence and outcomes [102]. However, both of these studies were controlled trials.

## **LIMITATIONS AND STRENGTHS**

Our study has some limitations that need to be considered. First, we conducted an explorative PCA, and the selections and interpretation of components are subjective to the analyst's knowledge of the data. Second, we studied associations, and therefore no causal attributions can be made. We examined adherence to the strategy, but we acknowledge that other factors might moderate the degree of fidelity, including intervention complexity, facilitation strategies, quality of delivery, and participant responsiveness, as stated by Carroll et al. [91]. However, we did not evaluate these moderators. Despite these limitations, the study has notable strengths. We applied well-known frameworks to specify the IDEAs strategy and to describe its fidelity measures, which provides clarity about the strategy and allows meaningful comparison to similar studies. We used quantitative methods to examine core components in the fidelity variables so that we could better understand the effectiveness results and properly recommend necessary changes in the strategy design based on a context-specific analysis of the implementation process. This study contributes to the field of implementation science by

showing a potential way to monitor and report on fidelity measures and link them with effectiveness. Moreover, this study is an example of how we can use implementation science methods to examine implementation processes of strategies in constrained-resourced settings and draw context-specific conclusions.

Based on the implications of our findings, we recommend adapting the IDEAs strategy to improve fidelity around micro-intervention completion. This implies first studying the reasons for low implementation of micro-interventions. Based on our work evaluating the IDEAs strategy, future research areas should focus on the availability of resources to implement micro-interventions, levels of clinical skills of nurses in managing obstetric complications, quality of supervision, and use of flexible funds provided to the districts. The second recommendation is to remove the service readiness assessments because the execution was impractical and expensive. Lastly, in order to improve service delivery and service readiness outcomes, it might be worth considering adding other strategies to the A&F, such as training in obstetric care and direct allocation of resources to facilities.

## **CONCLUSION**

Poor implementation of micro-intervention appears to be the main factor driving effectiveness results. Understanding the challenges of micro-intervention completion is crucial. Based on our findings, we recommend adapting IDEAs to improve fidelity on micro-intervention completion, removing the service readiness assessments as one of the strategy components, and potentially adding other strategies to the audit and feedback to be able to influence service delivery and readiness outcomes more directly. This study is an example of how to link fidelity measures with effectiveness to examine implementation processes in resource-constrained settings. Such an

analysis facilitates the selection of context-specific strategies, accurate replication, and successful evidence transfer into practice.

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## **Competing interests**

The authors declare that they have no competing interests.

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## **Authors contributions**

AD, KS, QF, SGL, SG, RE, BW, and GS conceived the idea of the study. IR, ST, EB, and OA organized the data. AD prepared the data and wrote the manuscript. All authors reviewed and approved the manuscript.

Table 8: Specification of the IDEAs strategy

<b>DOMAIN</b>	<b>STRATEGY</b>
<b>Name</b>	Integrated District Evidence to Action (IDEAs)
<b>Definition</b>	Is a multicomponent A&F strategy is led by MCH managers and is composed of: (1) facility service readiness assessments, (2) A&F meetings, and (3) targeted facility support (supervision and financial).
<b>Actors</b>	MCH managers at the facility, district, and provincial levels.
<b>Actions</b>	<p>At the facility level: Participate in A&amp;F meetings, use data from routine health information system and service readiness assessment to evaluate gaps in facility service delivery performance, present performance to their peers and receive feedback, identify priority issues, and propose local micro-interventions written in action plans, and receive supervision visits.</p> <p>At the district level: Participate in A&amp;F meetings, conduct district-to-facility supervision, influence the allocation of flexible funding to health facilities to support action plan implementation, and evaluate micro-intervention completion.</p> <p>At the provincial level: Participate in A&amp;F meetings and supports supervisions</p>
<b>Action targets</b>	<p>MCH nurses at the service delivery level.</p> <ul style="list-style-type: none"> <li>- Have knowledge about the existing gaps in service delivery</li> <li>- Is under peer pressure to make changes</li> <li>- Implement clinical guidelines to improve performance</li> <li>- Is motivated because receives supervision, and support for action plan implementation</li> </ul>
<b>Temporality</b>	The IDEAs strategy was implemented between October 2016 and December 2020.

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<b>Dose</b>	<p>Service readiness assessments occurred twice a year, with a total of 9 assessments in a sample of 36 health facilities.</p> <p>A&amp;F cycles occurred twice a year at meetings lasting five days, with a total of 9 cycles in each district.</p> <p>Supervision visits: Up to two supervision visits during each A&amp;F meeting cycle for selected health facilities.</p>
<b>Implementation</b>	Reach, adoption, fidelity, maintenance.
<b>outcomes affected</b>	
<b>Justification</b>	Theory of planned behavior [103].

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Table 9: IDEAs program setting

Province	Neonatal mortality rate (2019-2020) <sup>a</sup>	IDEAs districts	Population (2021) <sup>b</sup>	District coverage <sup>c</sup>	Number of IDEAs facilities	Health facility coverage <sup>d</sup>
Manica	31 per 1,000 live births	Chimoio	456,775	10%	6	2%
		Manica	257,191	5%	17	6%
		Mossurize	230,705	5%	11	4%
		Gondola	224,603	5%	10	4%
		Barue	217,254	5%	13	5%
		Sussundenga	195,258	4%	13	5%
		Vanduzi	130,893	3%	9	3%
Sofala	33 per 1,000 live births	Beira	696,515	15%	15	5%
		Nhamatanda	318,380	7%	17	6%
		Dondo	223,484	5%	15	5%
		Buzi	201,710	4%	15	5%
		Gorongosa	202,043	4%	13	5%
		<b>Total</b>	<b>3,354,811</b>	<b>71%</b>	<b>154</b>	<b>56%</b>

(c) Countrywide surveillance data (provincial estimates). District neonatal mortality rate is not available. The national neonatal mortality rate is 23 per 1,000 live births [56];

(d) Provincial Statistical Data 2021;

(e) Percentage of the population covered by IDEAs health facilities (the combined total population in Manica and Sofala provinces is 4,702,874);

(f) Percentage of IDEAs health facilities (the combined total number of health facilities in Manica and Sofala provinces is 277).

Table 10: IDEAs measures of fidelity based of conceptual framework of implementation fidelity

Adherence	Measures of fidelity
Content	<p>Number of A&amp;F meeting cycles</p> <p>Number of action plans elaborated</p> <p>Content of action plans (identified problems and proposed micro-interventions)</p> <p>Number of service readiness assessments</p> <p>Number of supervision visits</p> <p>Proportion of flexible funding allocated to the districts</p>
Coverage	<p>Number of facilities and districts participating in A&amp;F</p> <p>Number of participants (facility, district, province) at A&amp;F meetings</p> <p>Number of facilities selected based on performance</p> <p>Proportion of micro-interventions implemented successfully</p>
Frequency	<p>Frequency of service readiness assessments</p> <p>Frequency of A&amp;F meeting cycles</p> <p>Frequency of supervision visits</p>
Duration	<p>Duration of A&amp;F meeting cycles</p> <p>Timing of supervision visits</p>

Table 11: Descriptive results on level of achievement of fidelity measures

<b>Adherence</b>	<b>Measures of fidelity</b>	<b>Proposed</b>	<b>Extent achieved</b>
<b>Content</b>	Number of A&F meeting cycles	108	107 (99%)
	Number of action plans elaborated	1294	1257( 97%)
	Content of action plans (identified problems and proposed micro-interventions)	At least one problem and micro-intervention in each action plan	100% achieved
	Number of service readiness assessments	324	<b>168 (52%) conducted</b>
	Number of supervision visits	At least one supervision visit for each facility selected based on performance	124/128 (96%) of selected facilities supervised. Average 3.7 supervision visits for low-performing facilities Average 5.2 supervision visits for those switching between higher- and lower-performing Average of 2.6 supervision visits for high-performing facilities
	Proportion of flexible funding allocated to the districts	100%	100%
	Number of facilities and districts participating in A&F	154 facilities/12 districts	100%
<b>Coverage</b>	Number of participants (facility, district, province) at A&F meetings	At least 1512 participants	Total of 3076 (>100%) 1964 (64%): Facility level 905 (29%): District level 217 (7%): Province level

	Number of facilities selected based on performance	321	Total of 309 (96%): 206 low-performing 103 high-performing
	Percentage of micro-interventions implemented successfully	100%	<b>17% implemented completely</b>
<b>Frequency</b>	Frequency of service readiness assessments	Twice a year	<b>Varied. Was Irregular</b>
	Frequency of A&F meeting cycles	Twice a year	Mean (5.9 months)
	Frequency of supervision visits	Up to two supervision visits per selected facility per A&F cycle (twice a year)	342 (64%) were double supervision visits (first and follow-up) 36% were single supervision visits
<b>Duration</b>	Duration of A&F meetings	Five days	Achieved 100%
	Timing for supervision visits	First supervision at least within three months after the A&F meeting. No timing was defined for the follow-up	An average of 2.4 months for the first supervision and 3.7 months for the follow-up

Table 12: Loadings of the PCA

Measures of fidelity	Principal Components			
	1	2	3	4
Cycles of A&F	<b>0.48</b>	0.01	0.37	0.03
Participants (province)	0.06	<b>0.51</b>	-0.2	0.14
Participants (district)	0.07	<b>0.53</b>	-0.13	-0.06
Participant(facility)	0.03	<b>0.54</b>	0.09	-0.14
Action plans elaborated	<b>0.46</b>	0.05	0.39	0.1
Distinct problems identified	<b>0.46</b>	-0.07	0.17	0.13
Number of supervisions	0.36	-0.17	<b>-0.44</b>	-0.35
Mean monthly time to first supervision	0.25	0.25	-0.37	0.23
Percentage of micro-interventions completed	-0.11	0.19	0.33	<b>-0.77</b>
Total selections based on performance	0.35	-0.18	-0.39	-0.39

Figure 11: Scree plots of fidelity measures

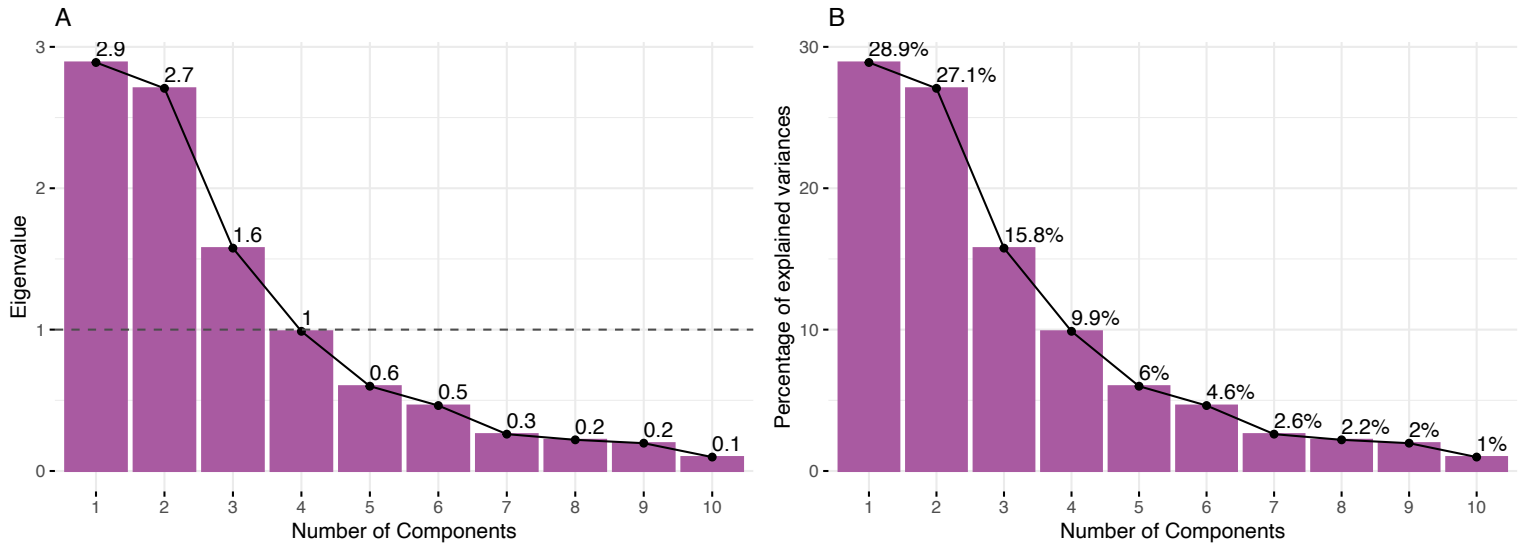


Figure 12: Patterns of associations between service delivery indicators and fidelity measures

Service delivery indicator	Measures of fidelity				
	Number of action plans elaborated	Number of problems identified	Number of total participants	Number of supervisions	Percentage of micro-interventions completed
Pregnant women receiving 2nd-5th dose of tetanus vaccine	Positive	Null	Positive	Positive	Null
Pregnant women with 4+ doses of preventive treatment for malaria	Null	Null	Positive	Null	Positive
Pregnant women with 4+ antenatal visits	Null	Null	Positive	Null	Null
Deliveries with active management of the 3rd stage of labor	Null	Null	Null	Null	Null
First postpartum consultations	Null	Negative	Positive	Null	Positive
Fully vaccinated children	Negative	Null	Null	Null	Null
First at-risk child appointments	Null	Null	Null	Null	Null
First polymerase reaction chain tests for HIV-exposed children	Negative	Null	Positive	Null	Positive
New users of contraceptive methods	Null	Null	Null	Positive	Negative
Women starting long-lasting contraceptive methods	Negative	Negative	Positive	Null	Null

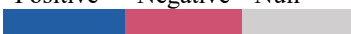
Positive    Negative    Null  


Figure 13: Patterns of associations between service readiness indicators and fidelity measure

Service readiness indicators	Measures of fidelity				
	Number of action plans elaborated	Number of problems identified	Number of total participants	Number of supervisions	Percentage of micro-interventions completed
Availability of essential medicine					
Availability of essential equipment					
Availability of essential infrastructure					
Delivery of essential care			Positive		Positive
Number of MCH nurses				Negative	

Positive	Negative	Null

## **CHAPTER 5: Overall Conclusions And Recommendations**

Achieving the SDGs target of reducing neonatal mortality to at least 12 deaths per 1000 live births requires implementing strategies to improve the quality of care in maternal, neonatal, and child health services. This dissertation evaluates an audit and feedback strategy led by maternal and child managers in a resource-constrained setting in Mozambique. The following conclusions are the most relevant from this work:

- 1) Maternal and child managers can lead audit and feedback processes in primary health care in Mozambique with high reach, adoption, and maintenance.
- 2) These managers can use data to identify gaps and propose local solutions to improve service outcomes. However, there is a need to refine the prioritization of problems and the specification of micro-interventions to facilitate monitoring and evaluation.
- 3) The main problem identified by MCH managers in the IDEAs audit and feedback strategy was weak diagnosis and management of obstetric complications.
- 4) IDEAs strategy implementation fidelity was generally high but could be improved with regards to putting into practice micro-interventions and systematically assessing health system readiness.
- 5) Participation, supervision, and completion of micro-interventions were identified as the core IDEAs strategy components.

- 6) The strategy presented mixed effectiveness results, and completion of the planned micro-interventions appears to be the main factor driving the observed results (weak completion of micro-interventions dictated weak impact).

## **Recommendations**

- Adapt and refine the IDEAs implementation strategy components to promote the completion of micro-interventions.
- Understand reasons for poor micro-intervention implementation by conducting qualitative assessments with MCH managers at facility, district, and provincial levels.
- Consider the removal of semiannual service readiness assessments from the strategy, given their implementation impracticality and high costs.
- Consider allocating resources directly to the level where action plans are implemented (the facility level).
- Test a combination of audit, feedback, and other strategies (for instance, clinical training in obstetric complications or adapted supervision focusing on clinical skills in obstetric care management should be considered).

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