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Claire Wang, Francis Sakita, Spencer Sumner, Frida Shayo, Zebadia Martin, Winnie Msangi, James Munisi, Elly Mulesi, Ayshat Aboud, Janet Bettger, Hayden Bosworth & Julian Hertz

# Sustainability and normalization of an intervention to improve evidence-based myocardial infarction care in Tanzania

*Claire Wang*[1] (claire.wang609@duke.edu)
*Francis M Sakita*[2,3] (francis.sakita@gmail.com)
*Spencer Sumner*[1] (spencer.sumner@duke.edu)
*Frida M Shayo*[4] (frishahappy@gmail.com)
*Zebadia Martin*[5] (zebadiamartin@gmail.com)
*Winnie Msangi*[5] (winniewilbard@gmail.com)
*James J Munisi*[6] (jamesmunisi92@gmail.com)
*Elly Mulesi*[5] (ellymulesi@gmail.com)
*Ayshat M Aboud*[7] (ay93_mj@hotmail.com)
*Janet P Bettger*[8,9] (janet_bettger@med.unc.edu)
*Hayden B Bosworth*[10] (boswo001@duke.edu)
*Julian T Hertz*[8,11] (julian.hertz@duke.edu)

* Corresponding author: Claire Wang; Duke University School of Medicine, Durham, NC 27710, Email: claire.wang609@duke.edu.

[1] Duke University School of Medicine, Durham, North Carolina, USA
[2] Kilimanjaro Christian Medical Centre, Moshi, Tanzania
[3] Kilimanjaro Christian Medical University College, Moshi, Tanzania
[4] Department of Emergency Medicine, Kilimanjaro Christian Medical Centre, Moshi, Tanzania
[5] Department of Emergency Medicine, Muhimbili University of Health and Allied Sciences, Dar es Salaam, Tanzania
[6] Tanga Regional Hospital, Tanga, Tanzania
[7] Mnazi Mmoja Hospital, Zanzibar, Tanzania
[8] Duke Global Health Institute, Duke University, Durham, North Carolina, USA
[9] Duke Clinical Research Institute, Duke University, Durham, North Carolina, USA
[10] Department of Population Health Sciences, Duke University, Durham, North Carolina, USA
[11] Department of Emergency Medicine, Duke University, Durham, North Carolina, USA



**Abstract**

Background

The Multicomponent Intervention to Improve Acute Myocardial Infarction Care (MIMIC) was developed to address gaps in AMI diagnosis and treatment in northern Tanzania. Although initial implementation was promising, many quality improvement interventions are not sustained after research support ends, especially in resource-limited settings. Few studies in sub-Saharan Africa have prospectively assessed organizational capacity for sustainability or normalization after external support concludes, limiting understanding of longer-term implementation trajectories in emergency care. Evaluating sustainability capacity and normalization is essential for understanding the long-term impact of implementation research. We evaluated these outcomes for the MIMIC intervention in a Tanzanian emergency department following a pilot implementation trial.

Methods

We conducted a cross-sectional survey of all full-time emergency department clinicians (n=35) at Kilimanjaro Christian Medical Centre (KCMC) using two validated implementation science tools: the Clinical Sustainability Assessment Tool (CSAT) and the Normalization MeAsure Development (NoMAD) questionnaire. The CSAT assesses seven domains, with higher scores reflecting greater perceived sustainability capacity. The NoMAD measures four constructs, with higher scores indicating stronger normalization. For each domain, scores were summarized descriptively (means, standard deviations) and compared across provider type (doctors vs. nurses) and role (champions vs. users) using Welch's t-tests or Mann-Whitney U tests as appropriate based on normality.

Results
All 35 eligible clinicians (100%) completed the survey. Mean CSAT domain scores ranged from 5.81 (SD 1.04) for *Organizational Context and Capacity* to 6.73 (SD 0.47) for *Outcomes and Effectiveness* (scale 1-7). Mean NoMAD scores were uniformly high and clustered within a narrow range from 4.26 (SD 0.51) for *Collective Action* to 4.69 (SD 0.42) for *Cognitive Participation* (scale 1-5). Domains related to perceived clinical benefit, individual engagement, and feedback scored highest, whereas organizational context and financial support scored comparatively lower. In subgroup analyses, no statistically significant differences were observed by provider type (doctors vs. nurses) on either instrument; similarly, champions and routine users did not differ significantly across CSAT or NoMAD domains.

Conclusions
This study is among the first to apply the CSAT and NoMAD tools to evaluate a quality improvement intervention in sub-Saharan Africa. Findings indicate high capacity to sustain MIMIC and strong normalization at KCMC, as reflected by consistently high mean domain scores across both instruments, although formal thresholds for these measures have not yet been established. Strengthening organizational capacity and long-term support, particularly financing and team coordination, may further enhance capacity for ongoing implementation.

Contributions to the literature
Few studies have jointly used CSAT and NoMAD to assess both organizational capacity for sustainability and normalization in real-world clinical settings; this study demonstrates the complementary value of using both tools in tandem.
Provides early evidence on the use of structured tools to assess determinants of sustainment of multicomponent interventions following a trial, without external support.
Contributes to the limited literature on organizational capacity for sustainability in sub-Saharan Africa, particularly within emergency care settings in low-resource environments.

Keywords: Implementation Science; Sustainability; Normalization Process Theory; emergency department; LMICs; Tanzania; sub-Saharan Africa; myocardial infarction

**Background**
Acute myocardial infarction (AMI) is a leading cause of death globally, contributing to an estimated 3 million deaths annually.(1) While high-income countries have achieved significant reductions in AMI mortality through early diagnosis and use of evidence-based treatments,(2,3)

low- and middle-income countries—which now account for over 80% of global cardiovascular disease deaths—continue to face major challenges in AMI recognition and care.(4)

In Tanzania, AMI is frequently under-diagnosed and under-treated. In a northern Tanzanian emergency department (ED), we found that nearly 90% of AMI cases are missed during routine care, and fewer than 25% of patients with AMI receive recommended treatments such as aspirin.(5-7) These gaps in care likely contributed to a 30-day mortality rate of 43% among AMI patients—one of the highest AMI mortality rates ever reported worldwide.(6)

To address these challenges, we developed the Multicomponent Intervention to Improve Acute Myocardial Infarction Care (MIMIC). Adapted from Brazil's ACS-BRIDGE program and contextualized for the northern Tanzanian setting using the ADAPT-ITT framework,(7,8) MIMIC was evaluated in a one-year, single-arm pilot trial at Kilimanjaro Christian Medical Centre (KCMC) in northern Tanzania. The intervention led to substantial improvements in key care metrics, including rates of ECG and troponin testing, AMI identification, and evidence-based treatment with aspirin, clopidogrel, and heparin.(9-11)

While findings were encouraging, many quality improvement interventions are not sustained after the study period ends due to challenges like limited institutional support, staff turnover, and poor integration into daily workflows.(12) Sustaining interventions is difficult even in high-resource settings; for example, one review found that a third of quality improvement projects in the UK National Health Service were not maintained in real-world clinical settings after one year.(13) Poor sustainability of quality improvement interventions can lead to diminished care quality, worse patient outcomes, and inefficient use of both financial and non-financial resources.(14,15) Accordingly, there is growing emphasis on assessing both the organizational capacity required for long-term sustainability and the degree to which interventions become embedded in routine practice.(16) These constructs complement traditional early-phase implementation outcomes by examining whether interventions can persist and routinize beyond short-term implementation-effectiveness trials. Organizational capacity for sustainability reflects the conditions that support continued delivery.(17) Normalization described the work by which interventions become integrated and routinized in everyday clinical practice.(18)

We aimed to evaluate the longer-term organizational capacity for sustainability (via CSAT) and normalization processes (via NoMAD) of MIMIC following the conclusion of the one-year pilot trial. To do so, we conducted a follow-up survey among providers at KCMC using two validated implementation science tools: the Clinical Sustainability Assessment Tool (CSAT) and the Normalization MeAsure Development (NoMAD) questionnaire. CSAT measures perceived organizational capacity to sustain interventions across seven domains, reflecting the conditions that support sustained delivery rather than observed sustainment outcomes.(17) NoMAD, grounded in Normalization Process Theory, assesses the work individuals and teams do to embed and integrate an intervention into routine practice over time, including how they make sense of it (coherence), engage with it (cognitive participation), enact it in daily workflows (collective action), and appraise its ongoing use (reflexive monitoring).(18,19) By administering CSAT and NoMAD, we sought to characterize the conditions and processes supporting ongoing delivery of MIMIC, and to identify factors that may strengthen long-term implementation.

## Methods

### *Setting*

This study was conducted at KCMC, a 630-bed tertiary referral hospital located in the urban center of Moshi, northern Tanzania, serving as a catchment area of over 15 million people. The

ED provides 24-hour acute care and is staffed by doctors, clinical officers, and nurses, all of whom are fluent in English and Swahili. The ED has essential diagnostic capacity for AMI care, including electrocardiography and both point-of-care and laboratory-based troponin assays, and maintains access to core evidence-based treatments such as aspirin, clopidogrel, heparin, nitrates, beta-blockers, statins, and thrombolytics. Advanced cardiac services, including percutaneous coronary intervention and cardiac surgery, are not available, and there are no practicing cardiologists on site. The emergency department operates in a high-volume, resource-limited environment with variable staffing patterns, high clinical workload, and infrastructural constraints that may affect the long-term sustainment and routinization of quality improvement efforts.

*The MIMIC Intervention*

The MIMIC intervention was a multicomponent strategy designed to improve diagnosis and treatment of AMI in a low-resource emergency care setting. It included five core components: (1) a triage card placed on the stretchers of patients with potential AMI symptoms to prompt doctor consideration of the diagnosis; (2) a pocket reference card outlining evidence-based AMI care steps; (3) a web-based refresher training module on AMI diagnosis and treatment, required for all ED clinicians; (4) educational materials for patients, including printed pamphlets and visual messaging displayed in the ED waiting room; and (5) the appointment of doctor and nurse "champions" responsible for encouraging intervention uptake and coordinating implementation. All components were developed and refined using stakeholder input and context-specific adaptation and were delivered by KCMC ED staff during routine clinical care.(20)

The MIMIC pilot trial was conducted at KCMC between September 1$^{st}$, 2023, and August 31$^{st}$, 2024. During the pilot trial, MIMIC was implemented by the KCMC ED staff; given the positive results of the pilot trial,(9-11) the ED staff decided to continue implementing MIMIC as part of routine ED care.



*Participant Selection*

All full-time doctors and registered nurses employed in the KCMC ED between November 2024 and May 2025 were eligible to participate. Clinicians were included regardless of prior involvement in the MIMIC pilot trial, provided they were employed full-time in the ED at the time of survey distribution. At the time of the survey, the KCMC ED employed 18 full-time nurses and 17 full-time doctors. Of the 35 clinicians enrolled, 29 were present during the initial MIMIC pilot trial and continued through the follow-up period, while 6 joined the ED after the pilot trial had concluded.

*Study Procedures*

Participants were approached in person at work by a member of the research team during break periods. A brief explanation of the study's purpose and procedures was provided. Participation was voluntary, and written informed consent was obtained prior to survey administration. The survey was anonymous and self-administered on a tablet to minimize social desirability bias. All survey questions were provided in both English and Swahili. Participants received 5,000 Tanzanian shillings (approximately 2 USD) as compensation for their time. Completed surveys were stored in a secure, password-protected database accessible only to the research team.

*Survey*

The survey combined CSAT and NoMAD, two widely used implementation science tools with strong reliability and construct validity.(17,21,22) CSAT has been applied in resource-limited hospital settings,(22) while NoMAD has been used across diverse healthcare contexts to assess normalization.(21)

We administered the validated 21-item short version of the CSAT to minimize respondent burden while maintaining comprehensive assessment.(23) The tool includes 21 items across seven domains: *Engaged Staff and Leadership, Engaged Stakeholders, Organizational Context and Capacity, Workflow Integration, Implementation and Training, Monitoring and Evaluation,* and *Outcomes and Effectiveness*.(17,23) Items were rated on a 7-point Likert scale ranging from "not at all" (score of 1) to "to a great extent" (score of 7), with an optional "don't know" response. These domains were used to assess the ED's capacity to sustain MIMIC over time.

NoMAD includes 20 items aligned with four Normalization Process Theory constructs: coherence, cognitive participation, collective action, and reflexive monitoring.(18) Items were rated on a 5-point Likert scale from "strongly disagree" (score of 1) to "strongly agree" (score of 5) with optional "not relevant" and "don't know" responses. These items were used to evaluate the extent to which MIMIC had become embedded in routine clinical practice.

All emergency department clinicians were fluent in both English and Swahili. No content or scoring adaptations were made to either instrument. To ensure accuracy and comprehensibility, all survey items were translated into Swahili and back-translated into English by two bilingual study team members. Each question was presented side-by-side in both languages during survey administration.

Six supplementary questions addressed participants' roles, clinical experience, prior involvement in MIMIC, and perceived ability to influence ED workflows. The survey took approximately 15 minutes to complete. The full instrument is included as Additional file 1.

*Statistical Methods*

Survey responses were summarized using descriptive statistics. Total and domain-level scores for the CSAT and NoMAD were reported as means and standard deviations. CSAT scores were averaged within each of the seven domains to assess organizational capacity for sustainability.(17) NoMAD responses were similarly averaged within four constructs based on Normalization Process Theory.(21)

Although Likert-scale data are ordinal, we analyzed them as continuous to facilitate comparison across domains and in accordance with prior studies using these instruments.(20,23-25) This approach is supported by methodological evidence demonstrating that parametric tests yield robust and unbiased estimates for 5- and 7-point Likert scales.(26,27) Responses marked as "unable to answer" or "not relevant" were excluded from analysis. A total of 9 CSAT responses (1.2%) and 1 NoMAD response (0.1%) were excluded for this reason. To ensure scoring consistency, the NoMAD item *"The MIMIC intervention disrupts working relationships"* (Item 10) was reverse-coded so that higher scores indicate greater normalization, consistent with established scoring guidance.(25)

To evaluate differences by provider type, we compared doctors (including both general and emergency specialist physicians) and nurses (including all registered nurses). A parallel subgroup analysis compared designated champions with routine users.

Normality of domain scores was assessed using the Shapiro-Wilk test and visual inspection of Q-Q plots. For the doctor-nurse comparison, only the *Collective Action* and *Overall NoMAD Score* domains met normality assumptions ($p > 0.05$ for both groups); for the champion-user comparison, only *Collective Action* met normality criteria. Accordingly, Mann-Whitney U tests were designated as the primary analyses for all domains, with Welch's t-tests reported only for domains meeting normality assumptions. One p-value per domain is displayed in tables (primary test); cells derived from Welch's t-tests are denoted by a superscript †. A $p$-value < 0.05 was considered statistically significant.

Given the use of CSAT and NoMAD in a novel population from a low-resource emergency setting, we assessed the internal consistency of each instrument and its individual domains in our setting using Cronbach's alpha. Statistical analyses were performed using R Statistical Software (version 4.5.1; R Core Team 2024).

*Ethics*

Ethical approval for this follow-up study was obtained from the Tanzania National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/2436), Kilimanjaro Christian Medical Centre (Proposal 893), and the Duke Health Institutional Review Board (Pro00090902). All procedures adhered to the ethical principles outlined in the Declaration of Helsinki (2000 revision). Written informed consent was obtained from all participants prior to survey administration. Materials were available in both English and Swahili to ensure participant understanding, and participation was voluntary. Respondents could decline or withdraw at any time without penalty.

*Reporting guidelines*

This manuscript was prepared in accordance with the StaRI checklist for reporting implementation studies and the STROBE checklist for observational studies. The completed checklists are provided in the Supplementary Materials (Additional file 2 and Additional file 3).

**Results**

*Participant Characteristics*

All 35 emergency department clinicians completed the survey, including 18 nurses (51%), 15 general doctors (43%), and 2 emergency specialist doctors (6%). The mean age was 32.7 years (SD 6.9), and participants reported an average of 3.4 years (SD 2.7) of clinical experience. Most participants (n=29, 83%) reported delivering the MIMIC intervention as part of their routine clinical duties, while the remaining six (17%) served as champions (Table 1).

*CSAT Scores*

CSAT scores reflect perceived organizational capacity for sustainment—that is, sustainment readiness and conditions supporting ongoing delivery. In our study, CSAT domain scores, rated on a 7-point Likert scale, indicated high perceived capacity to sustain the intervention. Scores ranged from 5.81 (SD 1.04) for *Organizational Context and Capacity* to 6.73 (SD 0.47) for *Outcomes and Effectiveness* (Figure 1). Domains reported here correspond to CSAT's seven

determinant areas, each interpreted as higher organizational capacity when mean scores are higher. Item-level response distributions are shown in Additional file 4.

Figure 1. CSAT Domain Scores
All items are scored 1 to 7; higher values indicate greater perceived organizational capacity for sustainment within each CSAT domain.

NoMAD Scores
Conceptually, NoMAD indexes the work people do to embed an intervention across four domains (coherence, cognitive participation, collective action, and reflexive monitoring). In our study, NoMAD domain scores, rated on a 5-point Likert scale, reflected strong normalization of the MIMIC intervention into routine clinical practice in the KCMC ED context. Scores were highest for Cognitive Participation (mean 4.69, SD 0.42) and Reflexive Monitoring (mean 4.50, SD 0.43), followed by Coherence (mean 4.46, SD 0.55) and Collective Action (mean 4.26, SD 0.51). Item-level response distributions are shown in Additional file 5.

Three general normalization items, rated on a 10-point Likert scale, were analyzed separately in accordance with prior literature.(19,21) Participants reported high familiarity with the MIMIC intervention (mean 8.97, SD 1.67), perceived it to be well normalized in current practice (mean 9.31, SD 1.41), and anticipated continued normalization in the future (mean 9.11, SD 1.69) (Figure 2, Panel B). These three 1-10 items are part of NoMAD's validated "general normalization" ratings and are reported separately from the 20 subscale items per scoring guidance. Full distributions are presented in Additional file 6.



Figure 2. Summary of NoMAD Scores.
Panel A. NoMAD Domain Scores
All items are scored from 1 to 5; higher values represent greater normalization for that subscale. The item "disrupts working relationships" (Collective Action domain) was reverse coded so that higher scores reflect greater normalization.
Panel B. General Normalization Item Scores
All items are scored from 1 to 10.
For "familiarity," higher scores indicate the intervention feels more familiar.
For "current" and "future" normalization, higher scores indicate greater perceived normalization.

*Internal Consistency*
Internal consistency of domain scores was assessed using Cronbach's alpha. Among CSAT domains, alphas ranged from 0.54 to 0.83 (overall = 0.91). Among NoMAD domains, alphas ranged from 0.61 to 0.84 (overall = 0.89). Cronbach's alpha values for the full instrument and each domain are presented in Table 2.

Table 2. CSAT and NoMAD Cronbach's alpha by domain

*Provider and Role Comparisons*
Across provider cadres, ratings were generally similar. Nurses reported slightly higher mean (SD) Workflow Integration scores than doctors (6.76 (0.45) vs. 6.20 (0.93); $p = 0.051$), but this difference did not reach statistical significance on the primary test. No other CSAT domains

differed significantly by provider type. NoMAD domain scores and general normalization items (familiarity, current and future normalization) likewise showed minimal variation between doctors and nurses (Table 3).

In the champion-user comparison, mean (SD) scores across all CSAT and NoMAD domains were similar between groups, with no statistically significant differences observed (Supplemental Table 2).

Table 3. CSAT and NoMAD Scores: Comparison of Nurse vs. Doctor Responses

**Discussion**

Our findings suggest that MIMIC demonstrates high perceived organizational capacity for sustainability and strong normalization processes in routine emergency care at KCMC. High scores across CSAT and NoMAD domains reflect strong sustainment readiness and perceived capacity to support continued use, as well as widespread normalization among providers. Domains related to perceived clinical benefit, compatibility with existing workflows, and individual engagement scored especially well, underscoring that MIMIC continues to be seen as valuable, aligned with clinical priorities, and well-integrated into clinical routines within this setting.

Several features of the MIMIC intervention likely contributed to these high scores. Its iterative, participatory design involving frontline KCMC providers ensured alignment with local workflows and responsiveness to site-specific barriers to AMI care.(20) Low-cost, intuitive tools, such as color-coded triage cards, pocket reference guides, and discharge checklists, were supported by visible clinical reminders and weekly case-based audits, enhancing provider engagement and reinforcing practice change. The intervention also emphasized shared responsibility between nurses and doctors, with designated champions from both cadres auditing AMI care and ensuring implementation of all MIMIC components.(20) Collectively, these characteristics—workflow fit, perceived clinical value, collective ownership, and continuous feedback—align closely with CSAT and NoMAD constructs and likely underlie the strong perceptions of MIMIC as both sustainable and normalized in routine care.

While most domains showed minimal variation by provider type, workflow integration scores trended higher among nurses compared with doctors. Although this difference did not reach statistical significance, this pattern may be consistent with nurses' central role in delivering key components of the intervention, including triaging patients for AMI symptoms, distributing educational materials, and reinforcing clinical reminders at the bedside, as well as greater day-to-day exposure to MIMIC-related activities. Differences in daily responsibilities and proximity to implementation tasks may shape how integrated the program feels to different provider groups.

Similarly, champions and routine users reported comparable CSAT and NoMAD scores, with no statistically significant differences observed. This pattern is consistent with the MIMIC design, in which champions primarily facilitated audit-feedback and reinforcement while delivery of core components was broadly distributed across clinicians. High fidelity to these components in the pilot trial likely supported diffusion of practices beyond designated champions, yielding similar perceptions of capacity to sustain and normalization across roles.

Despite overall strong results, lower scores in domains tied to organizational context and team-level coordination highlight areas for improvement. Item-level responses in these domains showed greater variability and more neutral ratings, particularly regarding perceived availability of financial resources, adequacy of training, and alignment of task assignments with staff skills. Notably, the items with the fewest respondents strongly agreeing on both the CSAT and NoMAD pertained to financial resources. The relevant CSAT item encompassed time, space, and funding needed to achieve intervention goals; responses to the NoMAD item regarding the availability of "sufficient resources" were similarly mixed. These findings echo challenges observed during the pilot trial—staffing variability, resource constraints, and gaps in coordination across roles—and are consistent with broader health system financing constraints in Tanzania, where public facilities often operate with tightly constrained budgets and limited flexibility to support initiatives beyond core services .(9-11) Thus, strong provider perceptions of sustainability capacity and normalization should be interpreted alongside resource and coordination constraints that CSAT and NoMAD explicitly capture as contextual determinants.

Targeted strategies such as strengthened leadership engagement, clearer delineation of team-based roles, and enhanced interprofessional training may help bolster institutional support and promote long-term capacity to maintain delivery. Given the modest full cost of the MIMIC intervention reported in the initial MIMIC pilot trial (approximately 1324 USD annually, most of which was attributed to champion stipends),(28) relatively small and predictable resource streams or structured institutional support, such as protected time for champions, may help strengthen organizational readiness for sustainment and further bolster normalization of the intervention. Leveraging existing task-sharing structures in Tanzania, which already support nurse-led emergency care activities, may further strengthen determinants of sustainment by distributing key responsibilities across cadres. Practical approaches could include standardizing nurse-initiated ECGs for patients with chest pain or dyspnea, formalizing triage nurse responsibility for placing AMI triage cards, incorporating clinical officers into routine audit and feedback activities, and rotating selected champion duties across a small group of trained providers. These strategies may help maintain core MIMIC functions without substantial new resources. Alignment with ongoing Ministry of Health efforts to strengthen emergency care systems and with donor-supported quality-improvement platforms may also offer feasible avenues for continued support. While integration into national guidance would require additional evidence, incremental incorporation into local protocols and workflows, paired with blended support from facility budgets and targeted donor resources, may represent pragmatic capacity-building steps in a resource-constrained environment.

The overall domain-level patterns observed in our study are consistent with prior studies using CSAT and NoMAD.(17,21,29-31) Across contexts, CSAT domains assessing leadership support, perceived benefit, and workflow integration often score highest, while organizational infrastructure and team coordination show greater variability, particularly in resource-limited environments.(17,22,31) Similarly, NoMAD evaluations in low-resource settings mirror our findings: the PACE program in Tanzania reported strong provider engagement and feedback mechanisms but lower scores in team coordination due to staffing and supply constraints.(30) A dementia care study likewise found high provider buy-in but emphasized infrastructure and interprofessional coordination as critical to sustainability.(29) These parallels reinforce that

sustained normalization depends on both integration into clinical routines (NoMAD) and the organizational conditions that enable sustainment (CSAT), with resource availability a key determinant of continued delivery.

We found high Cronbach's alpha values for both CSAT and NoMAD, indicating strong reliability and internal consistency. These results closely mirror the original validation findings reported by Malone et al. (2021) and Finch et al. (2018),(17,21) which were conducted in the United States and the United Kingdom, respectively. As is typical for multidimensional implementation measures, domains with fewer or conceptually diverse items (e.g., *Organizational Context and Capacity*; *Reflexive Monitoring*) yielded lower alpha values, while the full scales demonstrated robust internal consistency.(19,23) The slightly lower CSAT alphas likely reflect the combination of short subscales with few items and the modest sample size ($n = 35$), both of which are known to attenuate reliability estimates.(32,33) Overall, these results support the reliability of both instruments for assessing organizational capacity for sustainability and normalization in the Tanzanian healthcare context.

To our knowledge, this study represents one of the earliest applications of the CSAT and NoMAD instruments in emergency medicine and among the first efforts to apply them in implementation research in sub-Saharan Africa. Use of these instruments proved feasible, relevant, and informative in our setting, as demonstrated by complete participation from eligible clinicians and consistent, interpretable responses across both tools. Researchers conducting implementation work elsewhere in the region should consider these tools to assess long-term organizational capacity for sustainability and normalization—two often-overlooked outcomes, particularly in resource-limited acute care settings where such data remain scarce.

This study had several strengths. First, it assessed sustainability after active implementation support ended, offering rare insight into post-trial intervention persistence. Second, the combined use of CSAT and NoMAD provided a complementary evaluation of current integration and organizational capacity for sustainability. Third, inclusion of both nurses and doctors allows for comparison across provider groups, and the 100% response rate (35 of 35) enhances internal validity and minimizes response bias.

Several limitations should also be noted. First, while CSAT and NoMAD capture key dimensions of implementation processes, they are best interpreted alongside complementary data sources. Prior work highlights the value of mixed-methods approaches—such as qualitative interviews or direct observation—to capture contextual nuances.(19,34) A qualitative study exploring provider perspectives on long-term MIMIC sustainability is ongoing and will be published separately. Second, the cross-sectional design limits our ability to assess temporal trends or infer causality; longitudinal data may better characterize how normalization evolves in response to staffing changes or workflow adaptations. Third, the study was conducted at a single emergency department with a modest sample size, limiting generalizability. Fourth, social desirability bias may have skewed responses toward favorable answers. However, independent, tablet-based survey administration likely reduced this bias and facilitated candid responses. Additionally, recall bias is possible, particularly among clinicians who did not participate in the initial trial and may have relied on second-hand information or retrospective impressions of implementation processes. Finally, neither the CSAT nor NoMAD has been evaluated to

determine whether higher scores predict future sustainability or normalization;(16,24) this lack of established predictive validity is a limitation of both the instruments and our study. Despite this, the high response rate and consistent domain-level patterns in our study suggest that these instruments captured meaningful provider perceptions, which are important precursors to sustained adoption.(31) These results provide insight into perceived sustainability capacity and normalization processes at this stage of implementation and offer an early indication of sustainment potential within this context. Ongoing analyses of MIMIC's long-term impact on AMI care delivery will help confirm their predictive validity, addressing a key evidence gap in implementation science.(16,24)

Future research should evaluate the long-term clinical impact of MIMIC, its potential for national scale-up, and system-level strategies to support long-term adoption. Repeat assessments of sustainability and normalization—ideally at multiple time points—may help identify key inflection points and guide adaptive implementation support. Incorporating sustainability planning into routine operational processes may further support long-term integration. In addition, future work should explore sustainability capacity across diverse hospital settings in Tanzania. Our study was conducted at an urban tertiary referral center with relatively consistent access to core diagnostic tools and a dedicated emergency care workforce; sustainability capacity may differ in regional and district hospitals, including rural facilities, where staffing patterns, resource availability, and workflow structures vary. Evaluating MIMIC in these settings will help determine what adaptations may be needed to support implementation in facilities with more constrained resources and will be important for understanding the feasibility of broader scale-up across the health system.



**Conclusion**

The MIMIC intervention remained in active use and was perceived by clinicians as both exhibiting strong capacity for sustained delivery and normalized within emergency care workflows at KCMC following the conclusion of the pilot trial. These findings demonstrated the feasibility of sustaining a multicomponent intervention in a resource-limited setting when it aligned with clinical priorities and was reinforced by ongoing engagement. This study highlighted the utility of structured tools like CSAT and NoMAD for assessing early conditions supportive of ongoing delivery and normalization, particularly in low-resource acute care environments. Insights from this evaluation may inform efforts to strengthen the durability of similar interventions across LMIC health systems.

List of Abbreviations

**AMI** - Acute Myocardial Infarction
**CSAT** - Clinical Sustainability Assessment Tool
**ED** - Emergency Department
**KCMC** - Kilimanjaro Christian Medical Centre
**LMICs** - Low- and Middle-Income Countries
**MIMIC** - Multicomponent Intervention to Improve Acute Myocardial Infarction Care
**NoMAD** - Normalization MeAsure Development questionnaire
**NPT** - Normalization Process Theory
**USD** - United States Dollar

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**Additional files**

Additional file 1

- File format: XLSX
- Title: Combined CSAT and NoMAD Survey Instrument
- Description: Complete version of the survey used in this study, including all domain-level and general normalization items and response scales. This file contains the exact wording of each item, as presented to participants, and the corresponding response format.

Additional file 2

- File format: DOCX
- Title: StaRI Checklist for Reporting Implementation Studies
- Description: Completed Standards for Reporting Implementation Studies (StaRI) checklist for the current study, detailing adherence to recommended reporting items for implementation research.

Additional file 3

- File format: DOCX
- Title: STROBE Checklist for Reporting Observational Studies
- Description: Completed Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for the current study, outlining how the manuscript meets recommended reporting standards for observational designs.



Additional file 4

- File format: PNG
- Title: CSAT Domain Scores: Distribution of Likert-Scale Responses
- Description: Bar plots showing the distribution of Likert-scale responses (1-7) for each item within the seven CSAT domains, including Engaged Staff and Leadership, Engaged Stakeholders, Organizational Context and Capacity, Workflow Integration, Implementation and Training, Monitoring and Evaluation, and Outcomes and Effectiveness. Higher scores indicate greater perceived capacity for sustainability.

Additional file 5

- File format: PNG
- Title: NoMAD Domain Scores: Distribution of Likert-Scale Responses
- Description: Bar plots showing the distribution of Likert-scale responses (1-5) for each item within the four NoMAD domains: Coherence, Cognitive Participation, Collective Action, and Reflexive Monitoring. Higher scores reflect stronger normalization of the MIMIC intervention.

Additional file 6

- File format: PNG
- Title: Perceived Normalization of MIMIC: General Normalization Items of NoMAD

- Description: Bar plots showing distribution of responses to three general normalization items in NoMAD (rated 1-10), capturing participants' familiarity with the intervention, current normalization, and anticipated future normalization of MIMIC.

**Declarations**

Ethics approval and consent to participate

Ethical approval for this follow-up study was obtained from the Tanzania National Institute for Medical Research (NIMR/HQ/R.8a/Vol. IX/2436), Kilimanjaro Christian Medical Centre (Proposal 893), and the Duke Health Institutional Review Board (Pro00090902). All procedures adhered to the ethical principles outlined in the Declaration of Helsinki (2000 revision). Written informed consent was obtained from all participants prior to survey administration. Materials were available in both English and Swahili to ensure participant understanding, and participation was voluntary. Respondents could decline or withdraw at any time without penalty.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

FMSakita, JPB, and JTH conceived the study; JPB and JTH obtained funding for the study; FMShayo, WM, HBB, and JTH designed the study; EM, AMA, and JTH created the surveys; FMSakita, JJM, JPB, ZM, and JTH supervised the study; SS, ZM and JTH curated the data; CW, SS, and JTH conducted the data analysis; CW and JTH drafted the manuscript; all authors reviewed the manuscript for critical scientific content; all authors approved of the final submitted manuscript.

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| Table 1: Participant Characteristics | |
|---|---|
| Measure | *N (%) or Mean (SD)*[1] |
| Gender | Female: 14 (40%) |
| | Male: 21 (60%) |
| Age (years) | 32.7 (6.9) |
| Years of Clinical Experience | 3.4 (2.7) |
| Role in MIMIC | Delivers MIMIC during routine ED work: 29 (83%)<br>Supervises MIMIC (Champion): 6 (17%) |
| | |
| Provider Type | Emergency specialist physician: 2 (6%)<br>General physician: 15 (43%)<br>Nurse: 18 (51%) |
| [1] Values are expressed as means (SD) for continuous variables or N (%) for categorical variables. | |

Table 2. CSAT and NoMAD Cronbach's alpha by domain

| **Domain** | **Cronbach's alpha** |
|---|---|
| **CSAT** | |
| Engaged Staff and Leadership<br>Engaged Stakeholders | 0.67<br>0.61 |
| Organizational Context and Capacity | 0.54 |
| Workflow Integration | 0.83 |
| Implementation and Training | 0.75 |
| Monitoring and Evaluation | 0.68 |
| Outcomes and Effectiveness | 0.70 |
| Overall CSAT | 0.91 |
| **NoMAD** | |
| Coherence | 0.84 |
| Cognitive Participation | 0.83 |
| Collective Action | 0.72 |
| Reflexive Monitoring | 0.61 |
| Overall NoMAD | 0.89 |

Table 3. CSAT and NoMAD Scores: Comparison of Nurse vs. Doctor Responses

| Domain[1] | Doctor[2] Mean (SD) | Nurse Mean (SD) | p-value[2] |
|---|---|---|---|
| CSAT | | | |
| Engaged Staff and Leadership | 6.12 (0.99) | 6.13 (1.09) | 0.787 |
| Engaged Stakeholders | 6.24 (0.92) | 6.44 (0.62) | 0.667 |
| Organizational Context and Capacity | 5.73 (1.04) | 5.9 (1.07) | 0.605 |
| Workflow Integration | 6.2 (0.93) | 6.76 (0.45) | 0.051 |
| Implementation and Training | 5.9 (1.37) | 6.33 (1.06) | 0.283 |
| Monitoring and Evaluation | 6.06 (1.09) | 6.55 (0.5) | 0.265 |
| Outcomes and Effectiveness | 6.65 (0.61) | 6.81 (0.29) | 0.679 |
| Overall CSAT Score | 6.12 (0.87) | 6.42 (0.47) | 0.508 |
| NoMAD | | | |
| Coherence | 4.4 (0.56) | 4.51 (0.56) | 0.443 |
| Cognitive Participation | 4.59 (0.48) | 4.79 (0.32) | 0.287 |
| Collective Action | 4.16 (0.6) | 4.35 (0.41) | 0.286† |
| Reflexive Monitoring | 4.51 (0.46) | 4.49 (0.41) | 0.987 |
| Overall NoMAD Score | 4.38 (0.46) | 4.51 (0.36) | 0.369† |
| General Normalization | | | |
| Familiarity with MIMIC | 9.18 (1.47) | 8.78 (1.86) | 0.402 |
| Current Normalization | 9.24 (1.48) | 9.39 (1.38) | 0.667 |
| Future Normalization | 9.18 (1.51) | 9.06 (1.89) | 0.999 |

[1] Doctor group includes both general and emergency specialist physicians.

[2] One p-value per domain is displayed, corresponding to the primary test used (Mann-Whitney U unless otherwise indicated by † for Welch's t-test).

Note: CSAT items were rated on a 1-7 scale; NoMAD domain items on a 1-5 scale; and general normalization items on a 1-10 scale. Higher scores indicate greater perceived sustainability capacity (CSAT) or normalization (NoMAD).