**Effect of Augmented Capacity Development Interventions (ACDI) on the performance of data quality in the Routine Health Information System (RHIS) among health workers in public health institutions of Gofa Zone, Southern Ethiopia: a cluster randomized controlled trial**

Bedilu Kucho Doka1, 2\*, Abebaw Gebeyehu Worku3, Keneni Gutema Negeri1, Dejene Hailu Kassa1

1School of Public Health, College of Medicine and Health Sciences, Hawassa University, Hawassa, Sidama, Ethiopia

2Health and Health Related Product Quality and Services Regulatory Authority, South Ethiopia Regional State Health Bureau, Jinka, Ethiopia

3John Snow Inc Research and Training Institute, Inc., Ethiopia Data Use Partnership, Ministry of Health, Addis Ababa, Ethiopia

\*Corresponding author: [bedilukucho54@gmail.com](mailto:bedilukucho54@gmail.com)

# **Abstract**

**Background:** Strengthening data quality in the routine health information system is vital for the performance of health service outcomes. However, implementation of the routine interventions to improve data quality in the existing health system has been found poor in Ethiopia. This study was aimed to examine the effect of Augmented Capacity Development Interventions (ACDI) on the performance of data quality in the routine health information system.

**Methods:** A two arm, parallel group, cluster-randomized control trial was implemented from July 1, 2023 to February 29, 2024 in public health institutions of Gofa Zone, Southern Ethiopia.. A total of 72 clusters of health institutions and 304 health workers (154 in the intervention group and 150 in the control group) were included in the study. The implemented interventions include training, supportive supervision, mentorship, and recognition. General Linear Mixed Model was applied for analysis.

**Results:** The data quality practice has significantly improved after the implementation of the ACDI packages (β = 0.17; 95% CI: 0.05, 0.30; p = 0.007). Encouragement (β = 0.53; (95% CI: 0.29, 0.77; p < 0.001), ease of data management (β = 0.14; 95% CI=0.07, 0.22, p < 0.001), information use (β = 0.15; 95% CI: 0.08, 0.23), p < 0.001), availability of written guideline (β = 0.14; 95% CI: 0.04, 0.24, p = 0.006), the combined effects of encouragement and training (β = 0.44; 95% CI: 0.23, 0.65; p = 0.010), and consistence use of tools (β = 11; 95% CI: 0.02, 0.21; p = 0.023 were significant predictors of the change in the data quality.

**Conclusion:** The ACDI packages implemented in this study effectively influenced data quality improvement. Key predictors of data quality practices included an encouraging system, ease of data management, written guidelines, supportive supervision, and training. Therefore, the interventions are recommended to be scaled up.

**Trial registration:** ID: PACTR202212472091194, registered on 14 December 2022.

**Keywords:** Augmented Capacity Development Interventions, Data quality, Routine Health Information System, Health workers, Public health institutions, Southern Ethiopia, Cluster randomized controlled trial

# **Introduction**

Routine health information system (RHIS) is the process of collection, interpretation, utilization, and dissemination of routine health data targeted to improve health system performance and health service outcomes (1). Data quality in health is a multifaceted concept commonly expressed in the dimensions of data accuracy, completeness and timeliness to generate reliable information for decision making process (2). The ultimate purpose of a RHIS is to produce quality information to be presented for an evidence-based decision making process (3).

In low- and middle-income countries, as revealed by scientific evidence, the overall health data quality was much below the expected national standard (4–6). In these countries, the performance of routine health data is challenged by poor data management skills, lack of commitment from managing bodies, shortage of monitoring and evaluation system, inadequate infrastructure, and shortage and high turnover of skilled staff (7–9). Therefore, the performance of existing health system interventions on RHIS has been found to be poor in the developing world (10).

Most studies in developing nations reported that the rate of routine data quality was far below the World Health Organization (WHO) standard of 90% (10–12). The completeness rate of District Health Information Software, version 2 (DHIS2) data was only 60% whereas under-reporting ranges between 10% − 60% according to a study in Nigeria (10). Data quality assessment in Mali indicated that the rate of data accuracy at the health facility level was 45% and timeliness of 27%. Data accuracy was 68% at the regional and 54% at the central levels (12).

A survey in the Tigray region of Ethiopia revealed that the data completeness rate of registration books and reports were 54% and 56%, respectively. Similarly, an internal consistency of the data was 39% (11). A finding from Oromia region of Ethiopia showed that timeliness was 70%, completeness was 86%, and accuracy was 48% (13). Another similar study carried out in Dire Dawa city of Ethiopia indicated that the level of data quality was 75% in health institutions (14). A study carried out in Southern Ethiopia indicated Antenatal Care (ANC) four visit, postnatal care and fully immunized were over reported as 24%, 21% and 16% respectively (15).

There is no individual intervention that could be operated separately to enhance the quality of data in RHIS, but the implementation of the combination of interventions is recommended to assure high quality of health data (16). A survey in Pakistan revealed that data accuracy has increased from 40% to 75% after implementation of DHIS platform as intervention (17,18). A study in Nigeria revealed improvements in data quality metrics after implementation of interventions. Accordingly, report completeness rate has improved from 72% to 82%, timeliness increased from 60% to 72%, the report content completeness increased from 62% to 68% (10).

A study in Northwest Ethiopia reported that data consistency has improved from 84.0% to 99.5%, data recording completeness from 69% to 96%, and that of report timeliness increased from 66% to 100% after implementation of intervention packages comprising training, supportive supervision and feedback provision (19). However, the study addressed only one primary hospital of the area where its representativeness is very limited.

Limited previous intervention studies were available on data quality in RHIS. Even though few studies were conducted previously, the interventions implemented were not comprehensive, with many focusing on just a few packages, such as training and guideline provision. These studies were done only on a single or very few facilities or districts; therefore, their representativeness is questionable. Still other studies were design-related limitations such as a lack of control groups and inability of considering variation of the nature of the outcome among health institutions.

Therefore, this study aims to evaluate the effect of Augmented Capacity Development Interventions (ACDI) on the performance of data quality in the RHIS among health workers in public health institutions of Gofa Zone, Southern Ethiopia region.

# **Methods**

## **Study Setting**

The study was carried out in health institutions of Gofa Zone, Southe Ethiopia region. According to the central statistical agency of Ethiopia, the current population of the Zone is approximately 713,854. Among these, 357,359 (50.1%) are men, and 356,495 (49.9%) are women, with a total of 145,684 households. A total of 1510 health professionals are deployed in 11 districts, 26 health centers, 179 health posts, 2 governmental hospitals.

## **Trial design**

A two arm, parallel group, cluster randomized controlled trial design was adopted. This design was selected in order to minimize experimental contamination between groups as the intervention is implemented at group level. The baseline data were collected from April 1 to 30, 2023. The intervention was implemented fromJuly 1, 2023 to February 29, 2024. The end-line data were collected from April 1 to 30, 2024.

## **The participants**

The source population comprised all districts, public health facilities, and health workers existing in the zone. Randomly selected health institutions and health workers constituted the study population.

## **Eligibility**

**Inclusion criteria**

All health workers, including those serving in different departments, health posts, and heads of health institutions were included in the study. Administrative district health offices and functional public health facilities, including hospitals, health centers, and health posts were included.

**Exclusion criteria**

Newly established (2 health posts), nonfunctional (4 health posts) and privately owned health facilities were not considered in this study. The health workers who were not available during baseline data collection (5 health workers); who intended to leave the institution within eight months immediately prior to the baseline data collection (6 health workers); and who did not receive the intervention or dropped out at some point (13 health workers) were also excluded.

* 1. **Sample size determination**

The study applied the assumptions of confidence level of 95%, marginal error of 5%, and intervention to control ratio of 1:1 to determine the sample size. The sample size was calculated by considering the percent of data quality in comparison group of 33% (20). Power of 90% was assumed to detect 30% difference in rates between the two groups. Since the study was a cluster design, ICC of 0.35 and average cluster size of 4.3 were utilized from previous related study (21). The design effect of 2.2 and non-response rate of 10% was considered. Therefore, a total of 309 health workers of both groups were targeted to be recruited from 72 health institutions including 6 districts, 2 hospitals, 18 health centers and 46 health posts. However, in the baseline, 5 respondents were non-respondents, and 13 were lost to follow-up in the endpoint data collection.

## **Sampling procedures and randomization**

A multistage stratified cluster sampling technique was employed to select study institutions. The zone has 11 districts (seven rural and four urban). First, the rural-urban stratification of the districts was implemented. Then, four from seven rural districts (Demba Gofa, Zalla, Gezegofa and Melokoza) and two (Sawla and Laha) from four urban districts of the zone were selected by simple random sampling technique. The districts were selected with all their respective health facilities. Based on this, 18 health centers and 2 hospitals from selected districts were considered for the study. Additionally, a total of 46 health posts were proportionally allocated from each of the corresponding health centers. Regarding the groups, two randomly selected rural districts, Geze Gofa and Demba Gofa, as well as one urban district (Sawula) with all their respective facilities were included under intervention group. Therefore, a total of 37 health institutions were included under the intervention institutions that constituted 24 health posts, 9 health centers, 1 hospital, 2 rural and 1 urban district. On the other hand, two randomly selected rural districts (Zalla and Mello Koza) and one urban district (Laha) with their respective health facilities including 22 health posts, 9 health centers and 1 hospital were the part of overall 35 control institutions. It is based on the intervention to control ratio of 1:1. Regarding the selection of health workers, the heads of the health institutions and randomly selected participants from the Outpatient Department (OPD), Maternal and Child Health (MCH), emergency, dispensary, laboratory, Health Management Information System (HMIS) departments and office management were included. Health workers were recruited at baseline, before the randomization of clusters into groups was carried out.

**Allocation sequence, concealment and blinding**

**Sequence generation**

Before the implementation of the randomization process, districts were first stratified by location type (i.e., urban or rural). Then, to reduce the risk of experimental contamination, districts were allocated using the block randomization procedure. Three (one urban and two rural) adjacent and contiguous districts were grouped into one block and the other three (one urban and two rural) districts were sorted in to the other block. Finally, the blocks were randomly selected and allocated into either intervention or control groups. The two blocks of the districts were separated geographical buffers of unselected districts, special zones and rivers. Although there is still some territorial connection between certain control and intervention districts, the risk of contamination is not significant, as there is no physical proximity between the facilities because a buffer zone with a minimum distance of ten kilometers was established.

**Allocation concealment**

In order to minimize the selection bias and ensure unpredictability, the assignment of the blocks to the either arm has been done by an independent researcher from Arbaminch University of Ethiopia, who was unaware of the study group assignments, applied sealed envelopes for the group allocation.

**Blinding**

In order to avoid any bias on study results, the outcome assessors were withheld about the interventions provided as they were deployed from unselected districts. The blinding of program implementers and study participants was not possible as they provide and receive the open-level trial. However, the control groups were kept unaware of what the intervention groups received.

## **Variables**

**Outcome variables**

Data quality is a multidimensional construct expressed in terms of timeliness, accuracy, and completeness. **Data accuracy rate** was determined by comparing the data recorded in the summary forms (HMIS report) with the data in the registers from health facilities. For the districts, the results of aggregated reports were compared with recounted reports of indicators from each reporting facilities (22). A sample of 13 indicators including ANC first, pentavalent third dose, postnatal care, contraceptive acceptance rate and malaria testing rate were used for assessing data accuracy. If the value of the verified data exceeds 100%, which is considered as under-reporting whereas less than 100% will be over-reporting (23). A margin of error will be considered acceptable at 5% (95% to 105%), fair at 10% (90% to 110%), unacceptable at greater than 10% (below 90% and above 110%) (24)

Completeness was explained by report completeness and completeness of indicator data**.** **Report completeness** was measured by the number of institutions reported against total institutions expected for a specified period (13). Report completeness is computed only for districts and health centers, but not for health posts and hospitals, as the latter do not have independent reporting facilities under them. C**ompleteness of indicator data** was examined by all the relevant data elements in a reports were filled and measured by calculating the proportion of data cells filled for all cases from the total expected in the reports (25). To identify data completeness, the aforementioned 13 data elements were computed (26).

Timelinessof reporting was determined by analyzing health institution summary reports that were remitted to the next level within a predetermined reporting period based on the Ethiopian national reporting schedule (27). Report timeliness was also calculated only for districts and health centers. **Data quality practice**

Data quality practice is the primary outcome in this study. It is a composite construct measured by the level of agreement on 11 items using a Likert scale format, where a score of 5 represents 'Strongly Agree,' 4 represents 'Agree,' 3 represents 'Neutral,' 2 represents 'Disagree,' and 1 represents 'Strongly Disagree.' In this case, the perception of respondents about how their institution performs in terms of data quality is assessed.

The items used to measure this construct include: provision of quality healthcare and generation of sufficient data, quality of documentation, accuracy in data compilation, effectiveness of data communication; efficiency of data collection, sharing, and reporting systems; appropriateness and accuracy of data for quality decision-making, timeliness of reporting, assurance of completeness of information in records and reports, conducting data quality reviews before reporting, and promotion of integrity in data management.

The 11 item scores for each respondent are averaged to produce a single value, and finally, the mean of these scores is computed, treating the variable as continuous.

Predictors like perceived ease of data management, level of information utilization, supervision quality and perceived level of job satisfaction were also computed using the same procedure as data quality practice.

**The Intervention**

The study implemented the ACDI packagesthat were targeted to improve data quality in RHIS among selected health institutions. The following interventions were implemented to improve the knowledge, practice, and skill of the experts and the system to produce quality data.

**Training**

Training process was led by intervention team members, who had received initial master training and were assigned to deliver the intervention. The training of the intervention community members, selected staff from different departments, comprising HMIS officers, managers, Performance Monitoring Members (PMT) members, and health extension workers was carried out. The training was organized in their respective institutions. At the beginning of the intervention process, a four-day initial training for the intervention community was organized on six relevant modules. Then assessment-based on-the-job training workshops were conducted in every two months by the intervention team.

**Supportive supervision and feedback**

In this study, checklist based supervisory assessment and action oriented written feedback system on data management process were implemented for one day per every two month period. A total of four supportive supervision visits were delivered for each intervention institution during the eight month implementation period.

**Mentorship**

The mentorship program was organized in every three months each for two days. Trained experts, from the members of the intervention team, were the mentors and the intervention communities were the mentees. Close observation, guidance and spot assistance based on initial and subsequent assessment findings were addressed and forwarded for discussion.

**Monitoring and Evaluation**

In this project, every two-month review meetings and learning workshops based supervision findings were organized following the second day of the supervisory assessments. Monitoring was implemented in an ongoing process by the institution representatives for the correction and implementation of supervision feedbacks as part of self-assessment.

**Recognition**

This project involved individual and organizational certification of outstanding performance, appreciating the workers, departments and institutions by using verbal communication, encouraging the workers to share their successful experience for other institutions, promoting and scaling up their effective intervention approaches. The recognition process was practiced along with learning workshops.

We state that the intervention is augmented, as substantial modifications were made to conventional routine practices. Overall**,** the intervention institutions have received all the stated interventions while the control institutions were given the training modules at the end of the study period. Different Standard Operating Procedures (SOPs) were established for the implementation of each intervention packages and corresponding activities.

* 1. **Data collection procedures**

A total of eight data collectors and three supervisors were deployed for data collection after three-day intensive training. The questionnaire was designed in English version and translated to the Amharic language for better understanding of respondents. The data were collected with a structured, pre-tested, and standardized questionnaire customized from Performance of Routine Information System Management (PRISM) assessment tools (28). The data were collected using face to face interview questionnaires, document review templates, physical observation checklist that were also used for organizing surveys, reviewing documents and conducting observations. An electronic data collection process has been implemented using the Kobo Toolbox.

* 1. **Quality control**

Data collectors and supervisors have received an intensive training on data collection protocol. We have adapted a standard Performance of Routine Information System Management (PRISM) assessment tools (28) in designing the questionnaire for the study. During the manuscript writing process, we have thoroughly followed the guideline of the Consolidated Standards of Reporting Trials (CONSORT) with Extension to Cluster Randomized Trials to assure a standard reporting process of the trial.

* 1. **Statistical analysis**

Data were exported to Stata 17 for analysis. Descriptive statistics including frequencies, proportions, mean, and standard deviation were computed. The 95% confidence interval was used.

Repeated measures analysis was conducted using a General Linear Mixed Effects Model regression. Variables with a p-value of less than 0.25 in the bi-variable analysis were entered into the multivariable regression analysis. A p-value of less than 0.05 in the multivariable regression analysis were reported to identify predictor variables significantly associated with the outcome variable (29). We applied the intention-to-treat (ITT) approach to account for missing values from 13 participants lost to follow-up, in order to preserve the benefit of randomization and prevent bias caused by dropouts.

**Results**

**Participant flow**

During the baseline data collection, a total of 304 participants (154 intervention and 150 control) were surveyed from 71 health institutions (37 intervention and 35 control). However, for the end-line data collection, a total of 291 health workers participated, resulting in a loss to follow-up of 13 (4.2%) participants. On the other hand, 70 health institutions were included in the final data collection, as two health extension workers from two health posts were lost to follow-up (Figure 1).

**Characteristics of the study participants**

About half (50.5%) of the participants who completed the follow up were from the intervention institutions. Among the 291 study participants, 184 (63.2%) were males and 227 (78.0%) were from rural health institutions. The average age of the participants was 30.05 years (SD = 3.81), while the median work experience was 6.16 years (SD = 3.70) (Table 1).

**Randomization**

**Analysis**

**Gofa Zone**

* Consists of 11 districts: 7 urban and 4 rural

**Three Control districts (2 rural, 1 urban)**

* One hospital, 9 health centers, 22 health posts
* 150 health workers

**Three Intervention districts (2 rural, 1 urban)**

* One hospital, 9 health centers, 24 health posts
* 154 health workers
* One health post was excluded as the HEW was absent at the end-line (left for the academic training).
* Two health workers were excluded due to relocation, two for annual leave, and one for maternity leave
* One health post was excluded because the HEW was unavailable at the endpoint due to maternity leave
* Five health workers were not considered in the final data due to relocation, and one promoted for academic training
* A total of 70 health institutions (6 districts, 2 hospitals, 18 health centers, and 44 Health posts)
  + - In total, 291 health workers were surveyed at the end-line
* Three intervention districts with 1 hospital, 9 health centers, 21 health posts
* 144 health workers
* Three intervention districts with 1 hospital, 9 health centers, 23 health posts
* 147 health workers

Figure 1. Flow diagram illustrating the selection procedure for health workers in public health institutions of Gofa Zone, Southern Ethiopia, 2024.

Table 1. Characteristics of study participants among health institutions of Gofa Zone, South Ethiopia Region, 2024.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Baseline** | | | | **End-line** | | | |
| **Characteristic** | **Intervention Group (n=154)** | **Control Group (n=150)** | **p-value (adjusted)** | **Intervention Group (n=147)** | | **Control Group (n=144)** | **p-value (adjusted)** |
| Age (years), Mean ± SD | 29.25±3.57 | 30.91±3.80 | 0.168 | 29.17±3.58 | | 30.96± 3.85 | 0.151 |
| Sex, n (%) |  |  |  |  | |  |  |
| Male | 99 (64.3) | 95 (63.3) | 0.988 | 93 (63.3) | | 91 (63.2) | 0.964 |
| Female | 55 (35.7) | 55 (36.7) |  | 54 (36.7) | | 53 (36.8) |  |
| Educational status, n (%) |  |  |  |  | |  |  |
| Certificate and lower | 3 (1.9) | 0 (0.0) | 0.994 | 3 (2.7) | | 0 (0.0) | 0.994 |
| Diploma | 88 (57.1) | 110 (73.3) | 0.801 | 85 (57.8) | | 105 (72.9) | 0.794 |
| Degree | 59 (38.3) | 38 (25.3) | 0.933 | 55 (37.4) | | 37 (25.7) | 0.920 |
| Masters and above | 4 (2.6) | 2 (1.3) |  | 4 (2.7) | | 2 (1.4) |  |
| Department of the participant, n (%) |  |  |  |  | |  |  |
| Office management | 26 (16.9) | 28 (18.7) | 0.882 | 24(16.3) | | 26 (18.1) | 0.877 |
| MCH | 39 (25.3) | 47 (31.3) | 0.824 | 36 (24.3) | | 45 (31.3) | 0.807 |
| HMIS unit | 11 (7.1) | 12 (8.0) | 0.906 | 12 (8.2) | | 12 (8.3) | 0.931 |
| OPD | 18 (11.7) | 15 (10.0) | 0.992 | 17 (11.6) | | 15 (10.4) | 0.962 |
| Emergency | 15 (9.7) | 7 (4.7) | 0.937 | 15 (10.2) | | 7 (4.9) | 0.831 |
| Laboratory | 11 (7.1) | 7 (4.7) | 0.944 | 11 (7.2) | | 6 (4.2) | 0.896 |
| Dispensary | 10 (6.5) | 12 (8.0) | 0.880 | 9 (6.1) | | 12 (8.3) | 0.844 |
| Health post | 24 (15.6) | 22 (14.7) |  | 23 (15.6) | | 21 (14.6) |  |
| Work experience (years), Median ± SD | 6.16±3.59 | 6.33±3.80 | 0.853 | 6.16±3.56 | | 6.33±3.84 | 0.801 |
| Conducting DQA, n (%) |  |  |  |  | |  |  |
| Yes | 72 (46.8) | 23 (15.3) | 0.067 | 128 (87.1) | | 85 (59.0) | 0.087 |
| No | 82 (53.2) | 127 (84.7) |  | 19 (26.8) | | 59 (41.0) |  |
| Written guideline, n (%) |  |  |  |  | |  |  |
| Yes | 53 (34.4) | 49 (32.7) | 0.925 | 129 (87.8) | | 45 (31.3) | 0.001 |
| No | 101 (65.6) | 101 (67.3) |  | 18 (22.2) | | 99 (68.7) |  |
| Strategic plans, n (%) |  |  |  | 130 (88.4) | | 50(34.7) | <0.001 |
| Yes | 89 (57.8) | 49 (32.7) | 0.291 | 17 (11.6) | | 94(65.3) |  |
| No | 65 (42.2) | 101 (67.3) |  |  | |  |  |
| PMT availability, n (%) |  |  |  |  | |  |  |
| Yes | 125 (81.2) | 122 (81.3) | 0.836 | 137 (93.2) | | 121 (84.0) | 0.204 |
| No | 29 (18.8) | 28 (18.7) |  | 10 (6.8) | | 23 (16.0) |  |
| Training on RHIS, n (%) | |  |  |  | |  |  |
| Yes | 39 (25.3) | 35 (23.3) | 0.873 | 128 (87.1) | | 101 (70.1) | 0.385 |
| No | 115 (74.7) | 115 (76.7) |  | 19 (12.9) | | 43 (29.9) |  |
| Receive feedback on RHIS, n (%) |  |  |  |  | |  |  |
| Yes | 60 (39.0) | 59 (39.3) | 0.567 | 136 (92.5) | | 108 (75.0) | 0.365 |
| No | 94 (61.0) | 91 (60.7) |  | 11 (7.5) | | 36 (25.0) |  |
| Receive supportive supervision on RHIS, n (%) |  |  |  |  | |  |  |
| Yes | 26 (16.9) | 16 (10.7) | 0.845 | 136 (92.5) | | 107 (74.3) | 0.244 |
| No | 128 (83.1) | 134 (89.3) |  | 11 (7.5) | | 37 (15.7) |  |
| Consistently use standard tools, n (%) |  |  |  |  | |  |  |
| Yes | 67 (43.5) | 81 (54.0 | 0.353 | 137 (93.2) | | 93 (64.6) | 0.031 |
| No | 87 (56.5) | 69 (46.0) |  | 10 (6.8) | | 51 (35.4) |  |
| Supervision quality, Mean ± SD | 2.35±0.28 | 2.42±0.18 | 0.510 | 3.82±0.59 | | 2.33±0.43 | <0.001 |
| Availability of rewarding system, n (%) |  |  |  |  | |  |  |
| Yes | 14 (9.1) | 20 (13.3) | 0.925 | 130 (88.4) | | 19 (13.2) | <0.001 |
| No | 140 (90.9) | 130 (86.7) |  | 17 (11.6) | | 125 (86.8) |  |
| Encouraging system for good performance, n (%) |  |  |  |  | |  |  |
| Yes | 9 (5.8) | 8 (5.3) | 0.953 | 142 (96.6) | | 8 (5.6) | <0.001 |
| No | 145 (94.2) | 142 (94.7) |  | 5 (3.4) | | 136 (94.4) |  |
| Perceived level of your job satisfaction on RHIS, Mean ± SD | 2.42±0.25 | 2.46±0.17 | 0.484 | 3.84 ±0.58 | | 2.41±0.58 | <0.001 |
| Ease of data management, Mean ± SD | 2.29±0.32 | 2.31±0.32 | 0.529 | 2.95±0.78 | | 2.33±0.73 | 0.01 |
| Information utilization, Mean ± SD | 2.319±0.171 | 2.275±0.126 | 0.319 | 3.023±0.908 | | 2.263±0.606 | 0.011 |

*MCH = Maternal and Child Health, HMIS unit = Health Management Information System unit, OPD = Outpatient Department, PMT = Performance Monitoring Team, SD = Standard Deviation, DQA = Data Quality Assessment, RHIS = Routine Health Information System*

**Data quality dimensions**

**Report completeness and report timeliness**

At the beginning of the study, the average report completeness of the health institutions was 96.20% (95% CI: 93.40, 97.50; p = 0.065), with the intervention institutions at 98.70% and the control institutions at 93.60%. However, by the end of the study, no significant change was observed, with the report completeness slightly dropping to 92.70% (95% CI: 85.20, 100.20; p = 0.146), with the intervention institutions at 98.10% and the control institutions at 87.3%. The overall average report completeness rate was 95.80% (95% CI: 93.02, 98.62; p = 0.054).

Regarding report timeliness, the result improved from 53.30% (95% CI: 34.10, 72.60; p = 0.627) at baseline to 76.50% (95% CI: 63.20, 89.50; p = 0.003) at end-line, with an overall average timeliness score of 78.20% (95% CI: 64.90, 91.50; p = 0.001) (Figure 2).

Figure 2. Report completeness and timeliness among health institutions in Gofa Zone, Southern Ethiopia, 2024 (n = 24).

**Data accuracy and data completeness**

Data completeness in the health institutions showed a significant change from a baseline score of 93.51% (95% CI: 90.12, 96.88; p = 0.936) to an end-line score of 93.44% (95% CI: 90.54, 96.33; p < 0.001). The overall data completeness score was 93.36% (95% CI: 91.02, 95.70; p < 0.001). Within this context, the intervention institutions had an average score of 99.13%, while the control institutions scored 87.59%.

On the other hand, the data accuracy score increased from 89.40% (95% CI: 85.32, 93.46; p = 0.895) at baseline to 95.63% (95% CI: 92.82, 98.45; p < 0.001) at the end point of the study, indicating a significant change over time. However, there was no statistically significant difference between the groups, with an overall average data accuracy rate of 94.65% (95% CI: 92.30, 97.00; p = 0.087). In this case, the average data accuracy score in the intervention institutions was 99.69%, compared to 92.60% in the control group (Figure 3).

Figure 3. Data completeness and accuracy among treatment groups in health institutions of Gofa Zone, Southern Ethiopia, 2024 (n = 72).

**Data quality practice score**

At baseline, the mean score for data quality perception was 2.32 (95% CI: 2.25, 2.35; SE = 0.02), with a total of 59% respondents scoring at or above the average, and thus categorized as having a “good” perception of data quality practice. At end-line, a total of 77.3% of respondents had a good perception of data quality, with a mean data quality perception score of 3.13 (95% CI: 3.05, 3.21; p < 0.001). Overall, 68.7% of respondents had a good perception of data quality, having a mean score of 2.57 (95% CI: 2.52, 2.62; p = 0.001), with intervention institutions scoring significantly higher (mean = 2.77; 95% CI: 2.70, 2.83; SE = 0.02) than control institutions (mean = 2.38; 95% CI: 2.31, 2.44; SE = 0.02) (Figure 4).

Figure 4. The average change in data quality score from baseline to end-line among health workers in public health institutions of Gofa zone, Southern Ethiopia, (n= 304).

**Data quality and associated factors**

In the bi-variable analysis, treatment group, time, encouraging system for good performance, ease of data management, level of information use, availability of written guideline on RHIS, receive supportive supervision on RHIS, training on RHIS, the combined effects of encouraging system for good performance and Training on RHIS, availability PMT system, receive feedback on RHIS, consistently use standard tools, and availability of rewarding system were significantly predicted the change in the data quality practice. However, in multivariable analysis predictors like treatment group, time, encouraging system for good performance, ease of data management, level of information use, availability of written guideline on RHIS, consistently use standard tools and the combined effects of encouraging system for good performance and training on RHIS, were significantly predicted the change in the data quality practice among the treatment groups (**Table 2**)

**The overall effect of intervention**. On average, health workers in the treatment group scored 0.17 points higher in data quality practice than those in the control group, after adjusting for other predictors (95% CI: 0.05, 0.30; p = 0.007). Similarly, a unit increases in time increases data quality score by 0.29 units (95% CI: 0.17, 0.41, p < 0.001).

**Training and encouragement practice:** A unit increase in the encouragement system for good performance in RHIS significantly increases the data quality score by 0.53 units (95% CI: 0.29, 0.76; p < 0.001). The combined intervention of training on RHIS and an encouragement system for good performance improved data quality by 0.44 units (95% CI: 0.23, 0.65; p = 0.010).

**Ease of data management skill:** it is a technical factor that evaluated the individual perception of how they feel about simplicity of operating data management process. In this regard, having data management skill significantly improves the data quality by 0.14 (95% CI=0.07, 0.22, p < 0.001).

**Perceived level of information use**: On average, when health workers have better perception on information utilization, their data quality practice significantly improve by 0.15 unit (95% CI: 0.08, 0.23), p < 0.001).

**Availability of written guideline on RHIS**: when there were written guidelines on RHIS in the department of the health workers, their perceived level of data quality practice increases (β = 0.14; 95% CI: 0.04, 0.24, p = 0.005).

**Consistently using standard tools**: a unit increase in consistence in use for standard tools increase data quality practice by 0.11 units (95% CI: 0.02, 0.21; p = 0.023).

Table 2. General Linear Mixed Effect model estimation of data quality practice score with predictors among health workers in health institutions of Gofa zone, South Ethiopia region, 2024 (n= 304).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Bivariate Model** | | | **Multivariate Model** | | |
| β (95% CI) | **SE** | **P** | **β(95% CI)** | **SE** | **p** |
| Constant | 2.69 (2.59, 2.79) | 0.05 | <0.001 | 1.50(1.27, 1.73) | 0.12 | <0.001 |
| Treatment group | 0.71 (0.61, 0.81) | 0.05 | <0.001 | 0.171 (0.05, 0.29) | 0.06 | 0.007 |
| Time | 0.82 (0.70, 0.94) | 0.06 | <0.001 | 0.293 (0.17, 0.41) | 0.06 | <0.001 |
| Encouraging system for good performance | 1.35 (1.25, 1.45) | 0.05 | <0.001 | 0.530 (0.29, 0 .77) | 0.12 | <0.001 |
| Ease of data management | 0.39 (0.29, 0.47) | 0.05 | <0.001 | 0.142 (0.07, 0.22) | 0.04 | <0.001 |
| Level of information use | 0.41 (0.32, 0.50) | 0.05 | <0.001 | 0.152 (0.08, 0.23) | 0.04 | <0.001 |
| Availability of written guideline on RHIS | 0.47 (0.35, 0.58) | 0.06 | <0.001 | 0.144 (0.04, 0.24) | 0.05 | 0.005 |
| Receive supportive supervision on RHIS | 0.51 (0.40, 0.62) | 0.06 | <0.001 | -0.045 (-0.14, 0.09) | 0.07 | 0.520 |
| Training on RHIS | 0.40 (0.30, 0.50) | 0.05 | <0.001 | -0.042 (-0.15, 0.07) | 0.06 | 0.460 |
| Encouraging system for good performance x Training on RHIS | 0.46 (0.23, 0.68) | 0.11 | <0.001 | 0.437 (0.23, 0 .65) | 0.11 | <0.001 |
| Availability PMT system | 0.17 (0.02, 0.31) | 0.07 | 0.026 | -0.072 (-0.19, 0.05) | 0.06 | 0.229 |
| Receive feedback on RHIS | 0.28 (0.16, 0.39) | 0.06 | <0.001 | -0.024 (-0.14, 0.09) | 0.06 | 0.684 |
| Consistently use standard tools | 0.31 (0.19, 0.42) | 0.06 | <0.001 | 0.112 (0.02, 0 .21) | 0.05 | 0.023 |
| Availability of rewarding system | 0.94 (0.82, 1.05) | 0.06 | <0.001 | -0.004 (-0.16, 0.15) | 0.08 | 0.962 |

**Model fitness**

Comparing Akaike's Information Criterion (AIC) and Bayesian Criterion (BIC) between the null and final models provides an indication of model fit. Lower values of the information criteria from the null to the final model suggest better-fitting models. On the other hand, the ICC measures the proportion of the total variance explained by the grouping factor. A higher ICC value (> 5%) indicates that the grouping factor has a significant impact on the outcome variable (**Table 3**).

**Table 3**. Indicating the model fitness in the mixed linear effect model analysis among health workers in public health institutions of the Gofa zone, Southern Ethiopia, 2024 (n = 304).

|  |  |  |
| --- | --- | --- |
| **Information Criteria** | **Null model** | **Final model** |
| ICC (%) | 14.55 | 8.20 |
| AIC | 1397.28 | 824.62 |
| BIC | 1414.84 | 903.61 |

Akaike's Information Criterion (AIC), Bayesian Criterion (BIC), Intraclass Correlation Coefficient (ICC)

**Discussion**

The aim of this study was to evaluate the effect of capacity development interventions on the performance of data quality in the RHIS among public health institutions. In a simple descriptive analysis, the components of data quality dimensions, report timeliness and data completeness improved over time from baseline to end-line within the intervention groups. The overall data quality score changed from baseline to end-line and demonstrated a significant difference among the groups. The intervention groups, time, encouragement for good performance, availability of written guidelines on RHIS, combined effects of training and supportive supervision or the encouragement system, as well as perceptions of the ease of data management and information utilization practices, were significant predictors and changed from baseline to end-line or between the intervention and control groups.

Regarding data quality dimensions, report timeliness improved from baseline to end-line among the treatment groups, even though it did not meet the national MOH standard of 90%. This result aligns with a study conducted at Metema Primary Hospital in Northwest Ethiopia, where report timeliness increased following the implementation of intervention packages such as training, supportive supervision, and feedback (19) and Philippines (30). The interventions we applied; such as training, supervision, mentorship, motivation, and monitoring and evaluation on RHIS, might have helped build the capacity and knowledge of health workers, motivate staff, and enhance data flow and submission processes.

Similarly, data completeness also showed significant improvement following the implementation of the interventions. A similar finding was reported in the Oromia region of Ethiopia, where data completeness increased from about 42% before the intervention to 100% post-intervention. The intervention included here were discussions and action plan preparation with the management team at district level, on-the-job training, supportive supervision, data audits, and performance review meetings (2). Another study in Nigeria also reported improvement in changes in data completeness (10). A possible explanation for the association could be the strategies we implemented, such as standardizing data collection and reporting tools, training staff, validating data, conducting regular supportive supervision, offering timely feedback, and closely monitoring performance, all of which may have impacted overall performance. Together, these actions could also have strengthened the data management process, leading to more complete and reliable health data in source documents and reporting formats, which may have contributed to improvements in data completeness and overall data quality.

In this study, the overall ACDI intervention recorded a significant difference among the treatment groups, with greater improvement observed in the treatment groups compared to the control groups. Similarly, the intervention was found to be effective from baseline to end-line. Studies in the Oromia region of Ethiopia (2), Amhara region of Northwest Ethiopia (19), low- and middle income countries (31) showed improvement in the performance following the implementation of a combination of interventions, rather than single interventions. These packages of interventions included preparing an action plan of activities, on-the-job training, supportive supervision, provision of feedback, data audits, and performance review meetings (32). The combination of interventions greatly impacts helping to address multiple dimensions of data quality (33). Training provides the essential knowledge and skills necessary for accurate data collection and reporting (14,20). Supportive supervision ensures consistent, on-the-ground guidance to address challenges and reinforce correct practices (7). Feedback highlights errors or weaknesses, offering opportunities to correct and improve data practices in real time (5). Review meetings serve as platforms for teams to assess performance, share lessons learned, and engage in collaborative problem-solving. Motivation creates a culture of accountability and encourages individuals to take ownership of the quality of the data they produce (34).

Encouragement for good performance in RHIS was among the predictors that significantly improved after application of the implementation in this study. Studies in Ethiopia and other parts of the globe have indicated that data quality practice is highly associated with institutional management support and encouragement (25,35). Our intervention has involved the heads of institutions and departments, whose encouragement and support could have made staff more effective and dedicated by addressing resource limitations and creating a supportive work environment in which staff feel safe to try new approaches and perform better through boosted morale.

As indicated in this study, when training is combined with encouragement and support from managing bodies, there is a statistically significant improvement in the perceived quality of routine data. Some descriptive studies have revealed the association of training and data quality practice (20,36). A study in Ghana has revealed that a combination of interventions is necessary to achieve the intended outcome of data quality (37). Giving training to the healthcare workforce, especially to the heads of health institutions and leaders of departments, help them gain a deeper understanding of the importance of data quality in healthcare decision-making (38). This awareness encourages a culture of prioritizing accurate, reliable, and consistent data at all levels of the institution.

The perceived ease of data management skills and processes is a significant predictor of data quality practices that improved from before to after the intervention in the study. A study in in Oromia Special Zone, Amhara region of Ethiopia indicated a relationship between competency and data quality in RHIS (39). Another study in Massaguet district of Chad also indicated an association between the presence of a health technician and staff dedicated to data management and data quality in the HMIS (40). The perceived ease of data management skills and processes influences user engagement and motivation (41). When health workers and managers perceive data management processes as easy to understand and perform, they are more likely to engage consistently in proper data recording and reporting, feel confident in handling data, be motivated to ensure accuracy and completeness, and complete records on time while avoiding errors (42).

The perceived level of information utilization is one of the predictors of data quality that showed improvement from baseline to end-line among the groups. A PRISM framework analysis revealed that organizational and behavioral determinants, such as data use, are key factors influencing data quality (43). The likely explanation for this association is that using data in decision-making fosters accountability and ownership among health workers by reinforcing their responsibility for producing quality data. Regular data reviews help identify and correct errors, thereby strengthening validation practices. This promotes a culture of continuous data quality improvement, motivates accurate reporting, and drives ongoing improvement through targeted actions based on identified gaps (44).

Using written guidelines in RHIS is an independent predictor of improved data quality practice in the study. As indicated by the Health Metrics Network, written guidelines promote standardization of data collection and reporting by ensuring uniform methods, definitions, and indicators, thereby minimizing errors and inconsistencies (3).

Consistency in using standard tools was a significant predictor of data quality practice in the study. A qualitative study conducted in Eastern Ethiopia revealed that the lack of standard forms was one of the barriers to data quality (34). According to a report in South Africa, the standardization of routine data collection and reporting tools strengthens the system, supports a nationwide common platform, and reduces fragmentation in the health information data management system (45). A possible explanation for the association of standardization tool utilization and data quality is that consistency in using documentation tools in RHIS is an important process that supports the regular, standardized, and systematic use of approved tools. These tools include registers, tally sheets, reporting forms, and electronic health records by health workers during service delivery, data recording, and reporting (46,47).

**Strengths and weaknesses of the study**

Strength of the study is the use of a cluster RCT, which helps minimize contamination by randomizing entire groups rather than individuals, reducing bias from cross-group interactions. Cluster RCTs reflect real-world implementation, are practical for group interventions, and improve statistical power. They are cost-effective, ethically sound, control for group-level confounders, and allow for long-term impact measurement. Combining general linear mixed models with ITT enhances statistical power, minimizes bias, handles missing data, improves generalizability, ensures ethical transparency, addresses confounding, and provides accurate, real-world effect estimates.

A limitation of the study is that there is a geographical proximity between some districts, with limited buffer zones, which may compromise the risk of contamination, even though there is no contact between institution to institution. During sample size calculations, the assumption of equal cluster size was considered, but in practice, the number of health workers selected varied among health institutions.

**Conclusion**

The ACDIs implemented in this study were found to be highly effective in influencing and bringing about the desired changes in data quality improvement. An encouraging system for good performance in RHIS, ease of data management, perceived level of information use, availability of written guidelines on RHIS, the synergetic effects of receiving supportive supervision on RHIS and training on RHIS, as well as the joint effects of an encouraging system for good performance and RHIS training, were significant predictors of data quality practices. Providing training for large groups of managers and health workers, and integrating RHIS training with supportive supervision are recommended strategies to improve data quality in health. Enhancing the data management skills of health workers and cultivating a culture of information use are also recommended interventions. Therefore, these approaches can be scaled and utilized in similar settings to improve data quality practices.

### **List of abbreviations**

ACDI = Augmented Capacity Development Interventions

ANC = Antenatal Care

CONSORT = Consolidated Standards of Reporting Trials

DHIS2 = District Health Information Software, version 2

DQA = Data Quality Assessment

HMIS = Health Management Information System

MCH = Maternal and Child Health,

OPD = Outpatient Department

PMT = Performance Monitoring Team

PRISM = Performance of Routine Information System Management

RHIS = Routine Health Information System

WHO = World Health Organization

**Declarations**

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**Authors’ contributions**

BK involved in designing the study, data collection, data analysis, data interpretation, and manuscript write up. DK, AG, and KG were participated in the design of the study, critically reviewed and revised the manuscript. All authors have approved the final version of the manuscript.

**Statements and declarations**

**Ethical considerations**

Ethical approval of the protocol for this study was received from the institutional Review Board of the College of Medicine and Health Sciences, Hawassa University with the Reference No. of IRB/183/14 and date 08/06/2022. Approval letter was received from former Southern Nations, Nationalities and Peoples Region (SNNPR) Health Bureau. Permission letter was also obtained from the Gofa Zone Health Department, District Health Offices and each of respective health facilities. All procedures were conducted based on the voluntary participation of the study participants in compliance with the Helsinki Declaration of ethical principles. The study protocol was registered on 14 December 2022 at the Pan African Clinical Trial registry with ID number of PACTR202212472091194. The control institutions have received ACDI manuals after endpoint data collection.

**Consent to participate**

Written informed consent to participate in this study was obtained from all participants after providing full information about the purpose, procedures, potential risks, and benefits of the study. Participation was voluntary, and confidentiality was assured.

**Consent for publication**

Not applicable

**Declaration of conflicting interests**

The Authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**Data availability**

The data sets utilized in this study are available from the corresponding author and provided on reasonable request of authorized personnel.

**ORCID iDs**

Bedilu Kucho Doka, MPH https://libapps.s3.amazonaws.com/accounts/136240/images/iD_icon.gif <https://orcid.org/0009-0003-0334-2305>

Dejene Hailu, PhD https://libapps.s3.amazonaws.com/accounts/136240/images/iD_icon.gif <https://orcid.org/0000-0001-7870-1753>

Abebaw Gebeyehu, PhD https://libapps.s3.amazonaws.com/accounts/136240/images/iD_icon.gif <https://orcid.org/0000-0003-2954-7379>

Keneni Gutema, PhD https://libapps.s3.amazonaws.com/accounts/136240/images/iD_icon.gifhttps://orcid.org/0000-0003-2697-7242

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