

Data quality of the routine health management information system at the primary healthcare facility and district levels in Tanzania

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Abstract

Background: Effective planning for disease prevention and control requires accurate, adequately-analysed, interpreted and communicated data. In recent years, efforts and investments have been put in strengthening health management information systems (HMIS) in Sub-Saharan Africa to improve data accessibility to decision-makers. This study assessed the quality of routine HMIS data at primary healthcare facility (HF) and district levels in Tanzania.

Methods: The assessment involved Outpatient, Inpatient, Antenatal care, Family Planning, Post-natal care, Labour and Delivery, and Provider-initiated Testing and Counselling service areas in primary health care facilities. Records were tracked and compared at different phases of the data journey i.e. registers, tally-sheets, HF monthly reports submitted to the district level, and electronic database. We assessed the availability and utilization of each HMIS tool and quantified completeness and accuracy levels of the collected data in each phase of the reporting system.

Results: A total of 115 HFs (including hospitals, health centres, and dispensaries) in 11 districts were assessed. Registers (availability rate=91.1%; interquartile range (IQR):66.7%-100%) and report forms (86.9%; IQR:62.2%-100%) were the most utilized HMIS tools. There was a limited use of tally-sheets (77.8%; IQR:35.6%-100%). Tools availability at the dispensary was 91.1%, health-centre 82.2% and hospital 77.8%, and was low in urban districts. The availability rate at the district level was 65% (IQR:48%-75%). Reports were highly over-represented in comparison to registers' records, with large differences observed at the HF phase of the data journey and more profound in hospitals. Tool availability and data quality in the reproductive health service area outperformed the general services (outpatient and inpatient) areas. Indicators with large number of clients, multiple variables, disease categorization, or those linked with dispensing of medicine performed poorly.

Conclusion: There are high variations in the tool utilisation and data accuracy at facility and district levels. A significant improvement on patient registration and use of tally-sheets was observed over the years. The routine HMIS is weak and data at district level inaccurately reflects what is available at the source (HFs). These results highlight the need to design tailored and inter-service strategies for improving data quality.

Background

Disease prevention and control requires prompt and adequate actions towards reduction or elimination of existing conditions, and preventing new occurrences. Efficient decisions to such actions should be based on correctly collected, analysed, interpreted and timely data. In low- and middle-income countries, data for decision-making are generated by the health information systems, mostly through the routine Health Management Information System (HMIS) [1]. HMIS integrates data collection, processing, reporting and facilitates use at all levels to improve health service effectiveness and efficiency in response [1,2]. HMIS collects data at health facilities (HFs), which contains statistics on health services, disease epidemiology, and administration [3]. Quality information is essential to monitor, evaluate, prioritize, and improve the delivery of health care services [1,2,4].

Studies in Sub-Saharan Africa (SSA) have reported challenges with data quality, including poor utilization of HMIS tools, incomplete recording, inconsistency, inaccuracy and untimely reporting [1,5–13]. The concerns about the quality of routine information have undermined data utilization for decision-making in the health sector [9,10,14,15]. Challenges in data quality in SSA are compounded by human, health system and infrastructure factors [1,2,16]. Healthcare workers face a poor understanding of HMIS tools and the variables/indicators, inadequate skills, workload, and lack of incentives [9,11,13]. Excessive data demand, large number of reports, frequent changes in HMIS tools, changes in organisation structures or of human resources, lack of effective systems to monitor quality and absence of standards guidance to measure data quality contribute to poor quality [16,17]. Limited infrastructure and means to transmit reports from one level to another add more complexity [5,14,17–19]. Data quality assessments need to address these attributes and processes to establish valid conclusions that foster solution-focused thinking [15,16].

Weak health information systems in SSA are critical challenges to reaching the global and national health goals because the health system performance cannot be adequately monitored where data are of poor quality [2,10]. It is evident that increased investment in health is dependent on an efficient and reliable HMIS. With the current increased investment in disease control, availability of quality information is critical. Significant efforts have been made to strengthen health information systems and improve the quality of data used for decision-making at different levels of the health system. We hypothesize that, despite improvement on attributes such as reporting completeness and timeliness, as reported by many countries [16], the accuracy level of the data reported is not adequate. Available evidences suggest a lack of HMIS data quality in the Tanzania [9,20–22]; and that of recently, no robust assessment and analysis at primary health care and district levels has been done. This study, therefore, assessed data quality of the routine HMIS at primary health care facility and district levels in Tanzania to determine attribute-based differentiation of quality levels and propose strategies for improvement.

Methods

Study design

This cross-sectional study was carried out from October-November 2017 and involved 11 districts and all levels of primary health care facilities (i.e. dispensary, health centre, and hospital) in Tanzania. A multistage sampling technique was used to randomly select 1-2 regions from each geographical zone [23] and one district from each region. District hospitals were conveniently included. However, where there was no district hospital, a regional hospital was included. At least 50% of the health centres (HC) with a minimum-maximum criterion of 2-4, and 20% of dispensaries (min-max of 5-8) were randomly selected (Additional File- Figures S1.1 and S1.2).

Data sources

The study involved reviews of documents, systems and databases and collection of primary data at facility and district levels. The source of data included facility-level registers, tally sheets and monthly summary reports (paper and electronic). Seven service areas namely Outpatient department (OPD), Inpatient department (IPD), Antenatal care (ANC), Family Planning (FP), Post-natal care (PNC), Labour and Delivery (LnD) and Provider-Initiated Testing and Counselling (PITC) were included in the assessment. A total of 34 indicators selected from each of the service area (OPD=5; IPD=4; ANC=8; PNC=6; LnD=2; FP=6; PITC=3) were assessed. The selected indicators included those that were easy to collect, difficult to understand, difficult to compile, and takes time to compile. The list of indicators and details on the selection procedure is provided in **Additional File-Table S2.2**.

The research team for each district comprised of four trained research assistants under the supervision of two senior researchers. Training was done before actual data collection and involved pilot exercise to ensure clarity on the HMIS tools (registers, tally sheets and reporting forms) and how they are supposed to be used, the type of data to be collected, as well as ethical issues when dealing with patient information.

Data collection procedures

The assessment considered and tracked data based on the order of events in the existing HMIS (referred to in this context as “data journey”). Primarily, patient data are recorded in registers at the time a client is been attended. The records are compiled at the end of each month to make a report, done in duplicate and separately for each service area. Tally sheets, designed for each service area with the same structure as the reported indicators, are used daily to track each record. The original monthly report is submitted to the district office. Used registers, tally sheets and carbon copies of all reports are kept at the facility for their use and future reference. The reports submitted to the district office are expected to be filed and organized and the data is later entered in an electronic system for further analysis and use. (**Additional File- Figure S2.1**).

At the facility, records of each indicator were tracked across all sources, i.e. physical counts from registers, records marked in tally-sheets and compiled totals in report forms. At the district health office, original copies of monthly report forms submitted by facilities were reviewed. The filled records were compared to those observed in the carbon copies of reports (found at the facility), and to what has been entered in the electronic system, known as District Health Information System-2 (DHIS2). The period of data assessment covered 4 years, January 2014 to September 2017 (45 months) with a detailed review covering 12 months. To select months for the detailed review, we fixed the last quarter of 2014 (October-December) and the first quarter of 2017 (January-March) (providing maximum time to resolve existing data issues). Then we

conveniently assigned April-June 2016 and July-September 2015 to get an equal time interval (6 months) between the quarters. (**Additional File-Figure S2.2**).

Definition of indicators

At the facility level, tools availability was defined as the presence of filled/used HMIS tools (registers/tally-sheets/report forms by service area). At the district office, we tracked report forms from the health facilities for the selected 12 months. This tracking aimed to establish the fact that patient records were filled, tally-sheets were utilized, reports were compiled and submitted to the district office each month. The availability rate at the facility level was calculated as the percentage of observed registers/tally-sheets/report out of those expected in a specified period. The availability rate at the district level was used to measure reporting completeness (percentage of reports received from HFs in a specified period). Completeness focused on recording by reviewing the filling practices of registers compared to the provided instructions. Accuracy measured the numerical correspondence between data reported in one tool (subsequent) and that appearing in the source.

Data management and analysis

Data entry was done in EpiData 3.1 (EpiData Association, Odense M, Denmark), then migrated to STATA 13 (STATA, College Station, TX) for analysis. We assessed data quality by year, service area, indicators, tool, facility level, ownership and district. Based on the total expected register-months, tally sheet-months and monthly reports, we calculated the median availability rates and the interquartile range (IQR). For the IQR we presented the 25th and 75th percentiles, and range (p75-p25) to assess variability in performance.

For accuracy, we calculated a difference ratio (an index measure that quantifies the difference between data sources) [8,15,24]. Six difference ratio (DR) indices, *Diff1-6*, were calculated, assessed, and grouped considering the three phases of the *data journey*, i.e. from the point a record is entered in a register at the facility to the point it reaches the DHIS2. The “health facility phase” focused on data activities occurring at the healthcare facility (recording to report compilation). The “transmission phase”, focused on report processing and communication (facility-district, district files-DHIS2) accounting for the revisions/corrections happening during this process. The “robust phase” compared data recounted from registers with totals entered in the DHIS2. With this phase, we present an *ideal situation* where all quality issues at the facility or during transmission are masked and data of the two extreme ends of the *data journey* is compared. This categorization facilitates systematic understanding, tagging quality issues and explore mechanisms to design practical-oriented data quality interventions stage wise.

DR<1 indicates fewer data in the subsequent source, implying under-representation. DR>1 means more data in the subsequent source, implying over-representation, while DR≈1 implying consistency between sources. Matching levels were categorized into 5 groups (depending on the increase/decrease from DR=1) and presented using colour-coded tables by different attributes. These were: (i) matched: $0.95 \leq DR \leq 1.05$, i.e. acceptable difference $\pm 5\%$; (ii) moderately matched: $0.75 \leq DR < 0.95$ or $1.05 < DR \leq 1.25$; (iii) moderately under-represented: $0.5 < DR \leq 0.75$ or moderately over-represented: $1.25 < DR \leq 1.5$; (iv) highly under-represented: $DR < 0.5$ or highly over-represented: $1.5 < DR \leq 2$; and, (v) extremely over-represented: $DR > 2$. Statistical significance was tested using t-tests and proportional tests, significance considered at p-value <0.05.

Results

Tools availability

A total of 115 healthcare facilities in 11 districts were assessed. Both urban and rural districts were included in the study. The urban districts were Dodoma, Igunga, Kahama, Kinondoni and Njombe. The rural districts were Hai, Kibaha, Mbinga, Mbulu, Nkasi and Tandahimba. Dodoma had no district hospitals, therefore, the respective regional hospital was included. Of the 115 HFs, 58.3% (n=67) were dispensaries, 31.3% (n=36) health centres and 10.4% (n=12) hospitals. Of all the HFs, 114 had OPD, IPD (43), ANC (108), PNC (105), PITC (94), LnD (93) and FP (88) service-areas.

The overall median availability rate for registers was 91.1% (IQR:66.7%,100%) compared to 77.8% (IQR:35.6%, 100%) and 86.9% (IQR: 62.2%,100%) for the tally-sheets and report forms, respectively (Table 1). HMIS tools were mostly available at the dispensaries 91.1% (IQR:60%, 100%) than health centres 82.2% (IQR: 55.6%, 100%) and hospitals 77.8% (IQR:30%, 97.8%) (p-value<0.0001). Faith-based owned facilities had a significantly higher amount of tools available than the government and private-owned facilities (p-value<0.0001). The service-areas with high tool availability rates were ANC 95.6% (IQR:73.3%,100%), FP 93.3% (IQR:66.7%,100%) and LnD 91.1% (IQR:73.3%,100%). PITC had the lowest rate 53.3% (IQR:20%,88.9%). Hai, Kibaha, Mbinga, Mbulu (rural districts) had the highest availability rates while Kinondoni and Dodoma (urban districts) had the lowest levels (Table 1). A high variation in the range value was observed in the tally-sheet indicating a significant difference in its utilisation between facilities. A remarkable increasing trend in the availability of tools with lesser variation between HFs was observed from 2014 (median=83.3%; range=100%) to 2017 (median=100%; range=22%) (Table 1; Figure 1).

In terms of availability of tools, we categorised HFs into 4 groups: (i) >75%-100% (very high); (ii) 50%-75% (high); (iii) 25%-50% (average); and (iv) <25% (low). In all service-areas, with exception of PITC, over 50% of the facilities were able to locate up to >75% of the required registers (Figure 2), with high percentages observed in the ANC (82.4%), OPD (74.6%), LnD (73.1%) and FP (72.7%) service areas. PITC registers were

rarely available with only 45% of the facilities been able to locate >75%. Over 15% of the facilities presented less than 25% of the expected PITC registers followed by PNC service-area (11.4%). Tally-sheets for ANC, LnD, and FP were available in larger proportions than those for IPD, OPD, and PNC (Figure 3). Report forms were highly available in all service-areas except for PITC which had 42.1% of facilities providing $\leq 25\%$ of expected report forms (**Additional File-Figure S3.1**). Urban districts of Igunga, Kibaha, Njombe, Kinondoni, and Tandahimba fell into average or low categories of availability particularly on tally-sheets (**Additional File- Figures S3.2, S3.3 and S3.4**).

At the district office, the overall median availability of submitted HF reports was 65% (IQR:48%,75%) indicating that a third of expected report forms were not found. The district-specific performance indicated that less than half of the expected reports were found in the urban districts of Dodoma (median=45%, IQR:25%,51%) and Kinondoni (median=46%, IQR: 41%-50%) (Figure 4). Rural districts had higher rates: Hai (75%, IQR:67%,82%), Igunga (74%, IQR:56%,81%), Mbinga (73%, IQR:67%,76%), Nkasi (72%, IQR:66%,81%), and Mbulu (71%, IQR:71%,86%). Overall, higher matching availability rates at HF and district levels were observed at HF than at the district level with variations between service areas and HFs (**Additional File-Figure S3.5**). In most districts, there was an increase in the availability of report forms over the years. However, the availability rate in the urban districts of Dodoma, Kibaha, Kinondoni and Njombe remained low during the period under review (Figure 5).

Completeness

Wrongly filled or empty cells in HF registers were common. Diagnoses were either not recorded or recorded without indicating disease severity (as instructed) or without laboratory results when available. This was common for malaria and anaemia. In OPD registers, it was a common practice for patient' height and weight variables to be left blank, and occasionally sex and age were not filled.

Poor adherence to the coding procedures was frequent. For instance, instead of using "*N-Ndiyo*" and "*H-Hapana*" (Kiswahili words for "Yes" and "No", respectively), several records were in the English version of the words "*Y-Yes*" and "*N-No*". In other situations, instead of using a "tick" mark as instructed when the service was provided, a recorder would use "N" or "X", or leave the entries blank or use a different code that meant a different thing altogether. Consequently, this resulted in changing the meaning of that particular record. In some cases, health workers couldn't remember the meanings of some of the codes they used. Such practices were reported to complicate compilation of the report, especially if a different person (from the one who did the recording) is compiling the report.

Improper use of carbon papers was observed in HFs. In some instances, it was hard to identify the value recorded in the report form. The use of worn-out carbon papers was common and resulted into a blank or very faint report copies. Such poor recording practices led to differences between recounted and reported data hence low accuracy performance (**Additional File-Figure S3.6**).

Data accuracy

Antenatal care service (ANC). At the HF phase, Diff1 indicates over 50% representation of data in tally-sheets while Diff2 shows extreme over-representation (of close to 3-folds) in the reports compared to registers' records. A similar pattern was observed for Diff6 when registers counts were compared to the DHIS2 records. The transmission phase indicated consistency. The slight difference between Diff2 and Diff6 (with stable Diff3-Diff5) suggests that the reports transmitted to the district were manipulated (corrected/revised) before entered in the DHIS2, yet the changes were not documented. The over-representation levels decreased slightly over the years (Table 2).

The indicators for the provision of tetanus vaccine (TT2) and malaria intermittent preventive treatment (IPT2) performed badly with lower registration than what had been tallied (>2-folds), compiled, and reported (>3-folds). This implies that there was intensive marking of clients in tally-sheets without registration. Indicators on gestation age and HIV testing for pregnant women were moderately matched in the tally-sheets and reports (**Additional File-Table S3.1**). The indicator for HIV testing among pregnant women <25 years old was highly under-represented in all phases (Diff1=0.31, Diff4=0.14; Diff5=0.16 and Diff6 =0.03). Data were found in registers but not reflected in the tally-sheets or report forms or DHIS2 (**Additional File-Table S3.1**). There was variation in the ANC performance by districts in Diff1, Diff2, and Diff6 with much higher over-representation observed in Mbulu, Kinondoni, Kahama, and Nkasi districts (**Additional File-Figure S3.11**).

Labour and Delivery service (LnD). At the HF level there was over-representation of data in the tally-sheets and reports as compared to what was recorded in the registers. In 2016, at the transmission phase, there was an over-representation of data in the district report as compared to the copy available at the facilities indicating that the reports were not comparable. There was no significant difference between Diff2 and Diff6. The Diff6 values decreased over time indicating an improvement in the data accuracy (Table 3). The first indicator had good matching levels at the HF phase. However, it was found to be revised at the transmission phase, thus more records were observed in the district copy than in HF copies (source), DR=1.31. For the 2nd LnD indicator, few data were observed in the registers than tally-sheets or reports. Although a large number of clients were indicated to deliver at the HF as marked in the tally sheet, almost

none were marked of who assisted in the delivery. The values in a report for this period (for the 2nd indicator) matched those of who delivered at the HF. There was a little variation on the data quality performance by district on LnD.

Post-natal (PNC) service. For the PNC, the quality of data, especially in the filling of tally-sheets and compilation, improved significantly over the years. However, the results indicated that sometimes the data journey was not followed hence resulting in larger DR at report/register (Diff2) than tally sheet/register (Diff1). Diff2 and Diff6 were very similar indicating that data management at the transmission phase does not influence the quality of PNC data (Table 4). Although about half of postnatal indicators performed well in Diff1, there were variations in Diff2. The first indicator (attendance within 48 hours), had moderate over-representation, indicating that tally-sheets captured more attendees than those recorded in the registers (Diff1=1.30). However, data were extremely over-represented in report forms compared to data entered in the registers. The Diff2 of 3.09 implied that registers had less data compared to what was included in summary reports. This indicates that reports were not compiled using data from the tally-sheets and cases were not recorded in the registers but somehow summed up in the reports. District performance in PNC differed highly in Diff2 and Diff6. Health workers reported some of the PNC registers and indicators to be difficult to understand (**Additional File- Figure S3.5**).

Family planning (FP) service. For the FP service area more data were found in the registers than in the tally-sheets (DR less than 1). Comparing earlier years (2014 and 2015) against recent ones (2016 and 2017), a high improvement was observed at the transmission phase (Table 5). However, the under-representation of data in tally-sheets did not improve. Overall, half of the indicators in FP services performed quite well with data presenting good matching between tally-sheets, registers and report-forms. An indicator on cervical cancer screening presented a DR less than 1 for Diff1 indicating more data were recorded in the registers than tally-sheets. The screening for breast cancer had a DR of 1.34 for Diff2 indicating data were compiled in report forms but not indicated in registers. Most of the variations between district performance in FP were observed in Diff1.

Outpatient (OPD) service. This service area indicated the highest levels of mismatch in the HF and robust phases. Diff1 showed moderate over-representation in tally-sheets versus registers, which improved significantly over time suggesting adoption on the use of tally-sheets. Extremely large Diff2 and Diff6 values were observed in 2014-2015. It was observed that records in the reports could be up to over 5-7-times higher than register records, but was better in 2017 suggesting an improvement in client registration. The transmission phase performed well suggesting moderate manipulation of HF reports before been entered in DHSI2. The variation in this manipulation between indicator, HFs, and districts is captured by the slight differences observed between Diff2 and Diff6 (Table 6). Individual OPD indicators did not

perform well. Data obtained from registers were much less than in the report forms. The indicator of mild/severe anaemia performed worse with DR value indicating a difference of over 6-times between the register records and the report form. Blood smear positive records were corrected in the report forms by inflating values in the copy at the district, with a plus that the changes were documented ($\text{Diff3}/\text{Diff4} > 1.25$). The performance varied between districts, with Kinondoni and Kahama having high levels of data over-representation (**Additional File-Table S3.1**).

Inpatient (IPD) service. IPD was among the service areas that indicated a high level of mismatch between data source, more particularly over-representation of data in the reports versus records in tally-sheets or registers. This was presented at the HF phase with Diff1 values of >2 in 2014 and 2016, and Diff2 reporting extreme representation from 2014 to 2017 indicating fewer records in registers versus reported values. Diff1 improved slightly in 2015 and then significantly during 2017 which indicates a better use of tally-sheets. For Diff2 there was no indication of improvement observed during the 4-year period under review (Table 7). At transmission phase, an improvement was observed as the data matched better for the 2016 and 2017. Most of the IPD indicators presented difference between data sources of at least over 50% (**Additional File-Table S3.1**). Data on severe anaemia was extremely over-represented in the tally-sheets and report forms compared to register records ($\text{Diff1} = 2.38$ and $\text{Diff2} = 3.81$). This implies that data were not found in registers but were marked in tally-sheets and recorded in the report forms. High difference between registers and reports were observed. There was high variation between district performance in IPD data accuracy mainly in Diff1 and Diff2 with Kinondoni and Dodoma under-utilizing tally-sheets and Mbulu over-representing data in the reports.

Provider-Initiated Testing and Counselling (PITC) service. In this service-area, Diff2 went from moderate (in 2014) to extremes (in 2017) report over-representation indicating weakness in the registration process. PITC reports were highly manipulated during transmission phase before data was entered in DHIS2, marked by large Diff3/Diff4. There were significant variations between HFs and districts for Diff2 and Diff6 (Table 8). Little improvements were observed over the years. Indicator on 'number of new clients' was 2-fold over-represented between the register counts and the reported records and its data was corrected before been entered in DHIS2. Kinondoni, Kibaha and Nkasi showed high levels of data over-representation. Mbulu had matched data for Diff2 but high Diff6 indicating the submitted reports were revised before data were entered in the DHIS2 though, the changes were not documented. Nkasi had the highest Diff4 and Diff5 indicating corrections made during the transmission phase (**Additional File-Figure S3.11**).

An overall annual pattern indicated a slight improvement on Diff1 (from 1.37 in 2014 to 1.26 in 2017), but a high improvement on Diff2 (from 2.61 in 2014 to 1.70 in 2017). This indicates that although tally-sheets

were not fully utilized, the reports were better prepared in 2017 than in 2014. Similarly, there was a marked improvement in values for Diff6 from 2.72 in 2014 to 1.76 in 2017, indicating less variation between register' records and DHIS2 entries over the years. Data accuracy by HF levels categorized by service areas indicates high Diff2 and Diff6 for hospitals, and in OPD, IPD, ANC, and PNC (Table 9). Data accuracy was observed to vary between HFs even within districts (**Additional File-Table S3.2**).

Discussion

Registers and report forms were the most commonly available and used HMIS tools in healthcare facilities with high variation between levels of the health system. The urban districts indicated low utilization of HMIS tools than rural ones. The lower-level HFs and faith-based owned facilities performed better than higher level and government facilities. The service area under reproductive and child health performed better than other service areas. The availability rates of report forms submitted to the district offices indicate weakness in the transmission or storage of reports at the district level. Data accuracy varied by district, facility, service area and indicators. The volume of data and complexity in the process of getting indicator data affected the accuracy significantly. Both tool utilisation and data accuracy improved from 2014 to 2017. We observed a reduction in variation on performance within the health system level over time. This is likely to imply improvement and homogeneity in the functioning, resulting in equality on resource allocation and capacity-strengthening programmes. Our methodology assessed the quality while paying attention to health system levels and processes behind routine HMIS data generation to allow systematic thinking along the concerns identified. The approach has facilitated our understanding on the factors related to data quality for each step of the data journey, which is key in designing relevant interventions.

The variations and inadequate utilization of HMIS tools by facility characteristics have been reported previously in Tanzania and elsewhere [11,21,24]. Private-owned facilities, hospitals and healthcare facilities with high client volume are known to significantly affect the quality of HMIS data due to poor adherence in recording procedures, incompleteness and late reporting [3,5,6,9,13,25–27]. The performance of urban districts on HMIS tool utilization and data quality has been reported by other studies with inconclusive results [12,15,26]. Healthcare facilities in urban areas are assumed to have the infrastructure, sufficient workforce, frequent supervision hence expected to perform better. However, these settings have high workloads due to large catchment population, targeted by multiple programmes and frequent change of human resources resulting in insufficient supervision despite proximity to district offices. These factors are frequently ignored though do highly compromise data quality [2].

There was a high level of mismatch between the register records and those in tally-sheets or report forms, which were highly over-represented. This was common in service areas and healthcare facilities receiving a relatively larger number of clients [26]. These findings highlight difficulties in the utilization of registers

when a large number of clients need to be simultaneously attended by the same healthcare provider. Due to the over-burden, inadequate staffing, and the fact that recording is paper-based, it could seem practical and sufficient to tally records in pre-populated sheets than to write patient details in registers, yet not adherence to recording guidelines but be able to produce a report [11,12]. This phenomenon could explain a significant variation on quality observed between indicators when register counts were compared to subsequent sources [11,12]. Indicators dealing with a large amount of data and direct client contact, and those associated with dispensing medication/vaccination performed worse [24]. Complex indicators which include a subset of the population served (ANC-5c), time or day specification (PNC-1a and 2), categorization of disease severity had substantial quality issues (**Additional File-Figures S3.6 - S3.9**).

Over-reported routine HMIS data is a challenge in many countries in SSA [24,28]. Our results indicate a clear reduction in the variation of the mismatch, especially for OPD and IPD service areas from 2014 to 2017. However, a high difference between DHIS2 data and registers' records still existed particularly for hospital data. The robust phase presented large DR values for many HFs, implying transmitted data are not of good quality. Since the errors originate from the primary source it is difficult to correct them at later stages. A number of studies in other countries have reported similar findings [11,12,24,26]. Our findings indicate that HF reports were manipulated before the data are entered in DHIS2. Some studies attribute report manipulation with pressure received from superiors to hide poor service provision, enhance the image of the facility, meet targets or justify the use of medicine [11,24]. Moreover, it could also be due to inadequacy in supervision and data audits [5,25]. The variations in data and report management practises within districts, healthcare facilities, and disease programmes have also been documented in other countries [8,11,24,26]. Future research works that document health workers' opinions on the workload on recording and reporting, and perception on HMIS tools and indicators are necessary to inform and guide intervention in these areas.

The poor quality of the HMIS data and underperformance found in this study and other studies in SSA is likely to be attributed to the combination of multiple factors. These include insufficient human resource with core competence on data management, low motivation and lack of incentives, poor infrastructure, inadequate resources to conduct comprehensive supportive supervision and, lack of standard operating procedures [3,6, 22, 27,29]. In Tanzania, the majority of the district HMIS focal persons and those dealing with data at the facility level are the same healthcare providers, as a result, they are overburdened, thus key operational problems are not readily identified and remedied timely [11,26]. For many years, the HMIS in low-income countries have remained paper-based, which is cumbersome, and of uncertain reliability [10]. The DHIS2, recently introduced as a tool to aggregate and process routine facility-based data is expected to facilitate availability, standardization, quality, timely usage, and evidence-based decisions at different levels of the health system [2,24, 30]. However, DHIS2 is not the magic bullet and will not solve underlying quality problems currently facing HMIS [24,31]. Quality assurance and audit should be

emphasized at each stage of the *data journey* to detect and fix process-loopholes that compromise quality.

Poor data quality has both direct and indirect impact on the effectiveness and efficiency of the healthcare system. The HMIS aims to produce data that are used to document disease epidemiological patterns and progress towards national goals to improve health programmes. The findings from this study and others [2,9,10,21], indicate that HMIS in low-and-middle income countries are characterized by poor data quality, thus compromising its use in decision making and planning. There is evidence that improved use of routine health data improves the quality of the data as more attention is paid to its demand and usability [10, 32-33]. This means, inadequate data use creates a vicious cycle of inadequate data demands and production of good quality information. It is our expectation that, findings from this study will stimulate strategic thinking, which consider health system capacity while defining routine HMIS indicators and developing appropriate tools to ensure quality of data generated. Similarly, it is important to strengthen the capacities of the facility and district level routine data management and analysis, the through introduction of relevant professional cadres.

This assessment has some limitations. First, the study lacked the qualitative component which could address health workers' perspectives on the causes of the quality issues observed. Second, the data collected from health facility registers and tally sheets were assumed to be correct and no direct observations were done to assess the quality of clinical practice at the health facilities. Lastly, data accuracy metrics were established based on the recording or reporting guidelines as provided by the government. The study did not consider any practice modification improvised by the health worker to facilitate their work.

Conclusions

In conclusion, investing in HMIS in Tanzania has resulted in improvement in tool utilization and data accessibility in recent years. However, the quality of the routine data is still weak. The DHIS2 at the district level inaccurately reflects what exists at the primary facility level (data source). These challenges make HMIS an ineffective tool for monitoring health service performance and as a source of data for planning and decision-making. Findings from this study emphasize the importance of having continuous data quality auditing exercises and innovating strategies that consider the underlying data management processes, indicator types and human resource challenges.

Abbreviations

ANC: Antenatal Care; DHIS2: District Health Information System-2; DR: Difference Ratio; FP: Family Planning; HF: Health facility; HMIS: Health Management Information System; IPD: Inpatient Department;

IQR: Interquartile Range; LnD: Labour and Delivery; OPD: Outpatient Department; PITC: Provider Initiated Testing and Counselling.

Declarations

Ethics approval and consent to participate

This study received ethical approval from the Medical Research Coordinating Committee of the National Institute for Medical Research Ref. No. NIMR/HQ/R.8a/Vol. IX/2230. Permissions to access hospital registers and reporting documents were sought from the Ministry of Health, Community Development, Gender, Elderly and Children and the respective Regional Administrative Secretaries and Hospital Authorities. No identifiable variables such as names of individuals were collected for this work. Names of health facilities involved in the study were not used for reporting.

Consent for publication

Not applicable

Availability of data and materials

The data used are available upon request.

Competing interests

The authors declare that they have no competing interests

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Authors' contribution

LEGM, SFR, CJ conceived the original idea and planned the study. SFR contributed to the design, implementation of the research, did the analysis with contributions from LEGM. SFR, EPL, IRM, PKT, DM,

SM supervised the project. All authors participated in data collection. LEGM wrote the first version of the manuscript. All authors proofread and approved the final version of the manuscript.

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Tables

Table 1: Status of overall HMIS tool availability rates at HF by different attributes

Variable	Categories	Median	IQR (p25,p75)	Range	P-value
All years	Registers	91.1%	(66.7,100)	33%	<0.001
	Report forms	86.7%	(62.2,100)	38%	
	Tally-sheets	77.8%	(35.6,100)	64%	
2014	Overall	83.3%	(0,100)	100%	
	Registers	91.7%	(16.7,100)	83%	
	Report forms	75.0%	(0,100)	100%	
	Tally-sheets	41.7%	(0,100)	100%	
2015	Overall	100.0%	(50,100)	50%	
	Registers	100.0%	(75,100)	25%	
	Report forms	100.0%	(75,100)	25%	
	Tally-sheets	100.0%	(16.7,100)	83%	
2016	Overall	100.0%	(83.3,100)	17%	
	Registers	100.0%	(91.7,100)	8%	
	Report forms	100.0%	(91.7,100)	8%	
	Tally-sheets	100.0%	(33.3,100)	67%	
2017	Overall	100.0%	(77.8,100)	22%	
	Registers	100.0%	(88.9,100)	11%	
	Report forms	100.0%	(77.8,100)	22%	
	Tally-sheets	100.0%	(55.6,100)	44%	
Facility level	Dispensary	91.1%	(60,100)	40%	<0.001
	Health Centre	82.2%	(55.6,100)	44%	
	Hospital	77.8%	(30,97.8)	68%	
Facility Ownership	Faith-based Organization	91.1%	(68.9,100)	31%	<0.001
	Government	86.7%	(60,100)	40%	
	Private	68.9%	(20,95.6)	76%	
Service area	Antenatal care	95.6%	(73.3,100)	27%	<0.001
	Family planning	93.3%	(66.7,100)	33%	
	Inpatient	77.8%	(44.4,100)	56%	
	Labour and Delivery	91.1%	(73.3,100)	27%	
	Outpatient	83.3%	(57.8,100)	42%	
	PITC	53.3%	(20,88.9)	69%	
	Post-natal care	77.8%	(46.7,97.8)	51%	
District	Dodoma	60.0%	(24.4,88.9)	64%	<0.001
	Hai	97.8%	(71.1,100)	29%	
	Igunga	87.8%	(66.7,100)	33%	
	Kahama	80.0%	(55.6,100)	44%	
	Kibaha	93.3%	(77.8,91.1)	13%	
	Kinondoni	46.7%	(22.2,80)	58%	
	Mbinga	95.6%	(75.6,100)	24%	
	Mbulu	100.0%	(91.1,100)	9%	
	Njombe	88.9%	(71.1,100)	29%	
	Nkasi	78.9%	(66.7,97.8)	31%	
	Tandahimba	88.9%	(60,100)	40%	

Key: PITC= Provider-Initiated Testing and Counselling

Table 2: Data accuracy as indicated by difference ratio for the antenatal care service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	1.11	1.74	1.07	1.04	0.98	1.84
	Nov	1.58	2.70	0.99	0.96	0.94	2.12
	Dec	1.80	2.98	1.01	0.96	0.98	2.25
2015	July	1.36	1.53	1.02	1.00	1.01	1.33
	Aug	1.75	2.50	1.03	1.14	1.13	2.22
	Sept	1.37	1.66	1.00	1.00	1.01	1.50
2016	Apr	1.47	1.81	1.05	1.08	1.08	1.57
	May	1.36	2.03	0.98	1.13	1.11	1.97
	Jun	1.29	1.53	1.03	1.02	0.99	1.31
2017	Jan	1.66	1.83	1.06	1.04	0.98	1.57
	Feb	1.82	2.13	1.03	1.03	1.03	1.86
	March	1.33	1.53	1.02	1.02	1.00	1.33

Key

$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 3: Data accuracy as indicated by difference ratio for the labour and delivery service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	2.06	2.71	1.25	1.21	0.98	2.41
	Nov	1.13	1.62	0.97	0.99	1.00	1.57
	Dec	1.28	1.68	0.98	1.02	1.01	1.73
2015	July	1.19	1.39	0.97	1.05	1.06	1.37
	Aug	1.20	1.25	1.02	1.12	1.09	1.32
	Sept	1.10	1.21	1.00	1.19	1.10	1.35
2016	Apr	1.28	1.38	1.00	0.98	0.98	1.40
	May	1.14	1.19	1.27	1.25	0.99	1.22
	Jun	1.08	1.16	2.62	1.80	0.99	1.18
2017	Jan	1.28	1.29	1.26	0.99	0.98	1.31
	Feb	1.28	1.25	0.99	0.97	1.05	1.20
	March	1.28	1.31	1.09	1.09	1.00	1.26

Key

$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 4: Data accuracy as indicated by difference ratio for the post-natal care service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	1.35	1.51	0.99	0.91	0.90	1.37
	Nov	1.87	6.48	1.11	0.97	0.98	5.30
	Dec	1.25	1.37	0.95	1.13	0.92	1.38
2015	July	1.24	1.85	0.93	1.19	0.96	2.17
	Aug	0.95	1.70	1.00	1.11	1.09	1.87
	Sept	1.42	1.35	1.02	0.98	0.91	1.31
2016	Apr	1.23	1.46	1.06	1.03	0.95	1.43
	May	1.31	2.43	1.00	1.26	1.28	1.88
	Jun	1.01	1.57	0.97	0.95	1.00	1.56
2017	Jan	1.04	1.32	1.05	0.98	1.07	1.20
	Feb	1.00	1.27	0.94	0.98	1.04	1.11
	March	1.01	1.79	0.97	0.95	0.97	1.64

Key			
$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 5: Data accuracy as indicated by difference ratio for the family planning service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	0.57	1.14	1.06	1.11	1.09	1.33
	Nov	0.75	0.95	1.04	1.20	1.13	1.19
	Dec	0.60	1.15	1.00	1.28	1.21	0.99
2015	July	1.18	1.33	0.99	1.03	0.99	1.37
	Aug	1.38	1.39	1.00	1.09	1.19	1.58
	Sept	0.81	1.15	0.95	0.98	0.98	1.00
2016	Apr	0.76	1.08	0.94	0.93	0.97	1.03
	May	0.84	1.06	0.95	0.95	0.95	1.07
	Jun	0.80	1.09	0.95	0.94	1.00	1.12
2017	Jan	0.76	0.93	0.94	0.98	1.05	0.85
	Feb	0.67	0.79	0.97	0.96	0.99	0.80
	March	0.83	0.87	1.00	0.98	0.96	0.93

Key			
$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 6: Data accuracy as indicated by difference ratio for the outpatient service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	1.76	6.94	1.72	1.19	1.00	7.10
	Nov	1.71	3.33	1.58	1.34	0.99	5.55
	Dec	1.50	7.63	1.11	0.99	0.88	6.56
2015	July	1.47	5.35	1.05	1.01	0.99	6.25
	Aug	1.04	3.70	1.03	0.96	0.97	3.43
	Sept	1.61	2.41	1.11	0.88	0.86	3.44
2016	Apr	1.07	2.87	1.13	1.12	1.07	3.19
	May	1.57	4.23	0.95	1.00	1.02	4.82
	Jun	0.74	5.66	1.06	0.90	1.32	4.66
2017	Jan	1.06	2.92	0.95	1.18	1.13	3.60
	Feb	1.31	2.10	0.95	0.93	0.92	3.05
	March	1.24	2.27	1.02	1.10	0.94	3.26

Key

$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 7: Data accuracy as indicated by difference ratio for the Inpatient service area

Year	Month	Health facility phase		Transmission phase			Robust
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
2014	Oct	1.31	2.84	1.53	1.23	0.94	3.20
	Nov	2.11	3.67	1.29	0.97	0.91	4.07
	Dec	2.28	2.45	1.61	1.79	1.05	2.58
2015	July	1.07	2.73	1.47	1.28	0.93	2.42
	Aug	1.29	3.00	1.82	1.59	1.04	3.13
	Sept	1.35	2.98	1.01	1.03	2.16	2.22
2016	Apr	2.50	2.84	1.14	1.02	0.99	2.68
	May	1.89	2.89	1.12	0.92	0.91	2.22
	Jun	2.33	2.78	1.17	1.16	0.93	3.48
2017	Jan	1.70	2.50	1.44	1.39	1.02	3.47
	Feb	1.15	2.86	1.03	0.91	0.95	2.64
	March	1.24	2.66	0.97	0.91	0.95	2.62

Key			
$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 8: Data accuracy as indicated by difference ratio for the PITC service area

Year	Month	Health facility phase		Transmission phase		Robust	
		<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers	
2014	Oct	2.39	0.88	1.11	0.76	2.21	
	Nov	1.09	1.00	1.76	0.99	1.99	
	Dec	1.39	1.01	0.89	0.93	2.16	
2015	July	1.82	1.00	0.94	0.91	2.07	
	Aug	1.59	0.90	1.44	1.10	2.39	
	Sept	1.92	0.85	1.58	1.14	2.95	
2016	Apr	1.56	1.47	1.45	0.90	3.52	
	May	1.76	1.57	1.56	1.08	3.04	
	Jun	2.84	1.09	0.98	0.96	2.51	
2017	Jan	1.80	1.38	1.07	1.11	2.26	
	Feb	2.11	1.15	1.02	1.06	2.20	
	March	1.48	1.01	1.30	1.56	1.69	

Key			
$\geq 0.95-1.05$	Matched	$> 1.05-1.25$	Moderately matched
$< 0.95-0.75$	Moderately matched	$> 1.25-1.5$	Moderately over-represented
$< 0.75-0.5$	Moderately under-represented	$> 1.5-2$	Highly over-represented
< 0.5	Highly under-represented	> 2	Extremely over-represented

Table 9: Data accuracy as indicated by difference ratio by HF levels and service area

Service area	Facility level	Health facility Transmission phase					Robust phase
		<i>Diff1</i> Tally vs. Registers	<i>Diff2</i> Report (Facility) vs. Registers	<i>Diff3</i> Report (District) vs. Report (Facility)	<i>Diff4</i> DHIS2 vs. Report (Facility)	<i>Diff5</i> DHIS2 vs. Report (District)	<i>Diff6</i> DHIS2 vs. Registers
ANC	Dispensary	1.28	1.53	1.02	1.01	1.00	1.31
	Health Centre	1.64	2.25	1.03	1.06	1.06	1.92
	Hospital	2.51	3.93	1.05	1.15	1.07	3.71
FP	Dispensary	0.75	0.97	0.98	1.05	1.05	0.97
	Health Centre	0.92	1.03	0.98	0.99	1.04	1.10
	Hospital	1.06	1.63	0.98	1.03	1.01	1.65
IPD	Dispensary	0.50	1.60	1.00	0.67	0.70	0.40
	Health Centre	1.53	1.76	1.03	0.89	0.94	1.48
	Hospital	1.95	4.25	1.66	1.61	1.26	4.76
LnD	Dispensary	1.06	1.15	1.10	1.04	1.04	1.19
	Health Centre	1.49	1.56	1.08	1.01	0.99	1.53
	Hospital	1.31	1.84	2.00	1.87	1.03	1.79
OPD	Dispensary	1.26	2.67	1.16	1.07	1.02	2.42
	Health Centre	1.38	3.48	1.04	0.97	1.01	4.37
	Hospital	1.37	9.08	1.06	1.05	0.97	12.27
PITC	Dispensary		1.36	1.37	1.29	0.97	1.83
	Health Centre		2.35	1.13	1.08	1.02	3.20
	Hospital		1.95	0.96	1.59	1.53	2.43
PNC	Dispensary	1.01	1.18	0.98	0.96	0.99	1.10
	Health Centre	1.26	1.59	0.98	1.07	1.00	1.70
	Hospital	1.67	4.11	1.08	1.24	1.17	3.62
All Services	Dispensary	1.11	1.49	1.06	1.05	1.01	1.43
	Health Centre	1.42	2.07	1.03	1.03	1.02	2.24
	Hospital	1.73	3.94	1.21	1.30	1.13	4.48

Key	
≥0.95-1.05	Matched
<0.95-0.75	Moderately matched
<0.75-0.5	Moderately under-represented
<0.5	Highly under-represented
>1.05-1.25	Moderately matched
>1.25-1.5	Moderately over-represented
>1.5-2	Highly over-represented
>2	Extremely over-represented

Figures

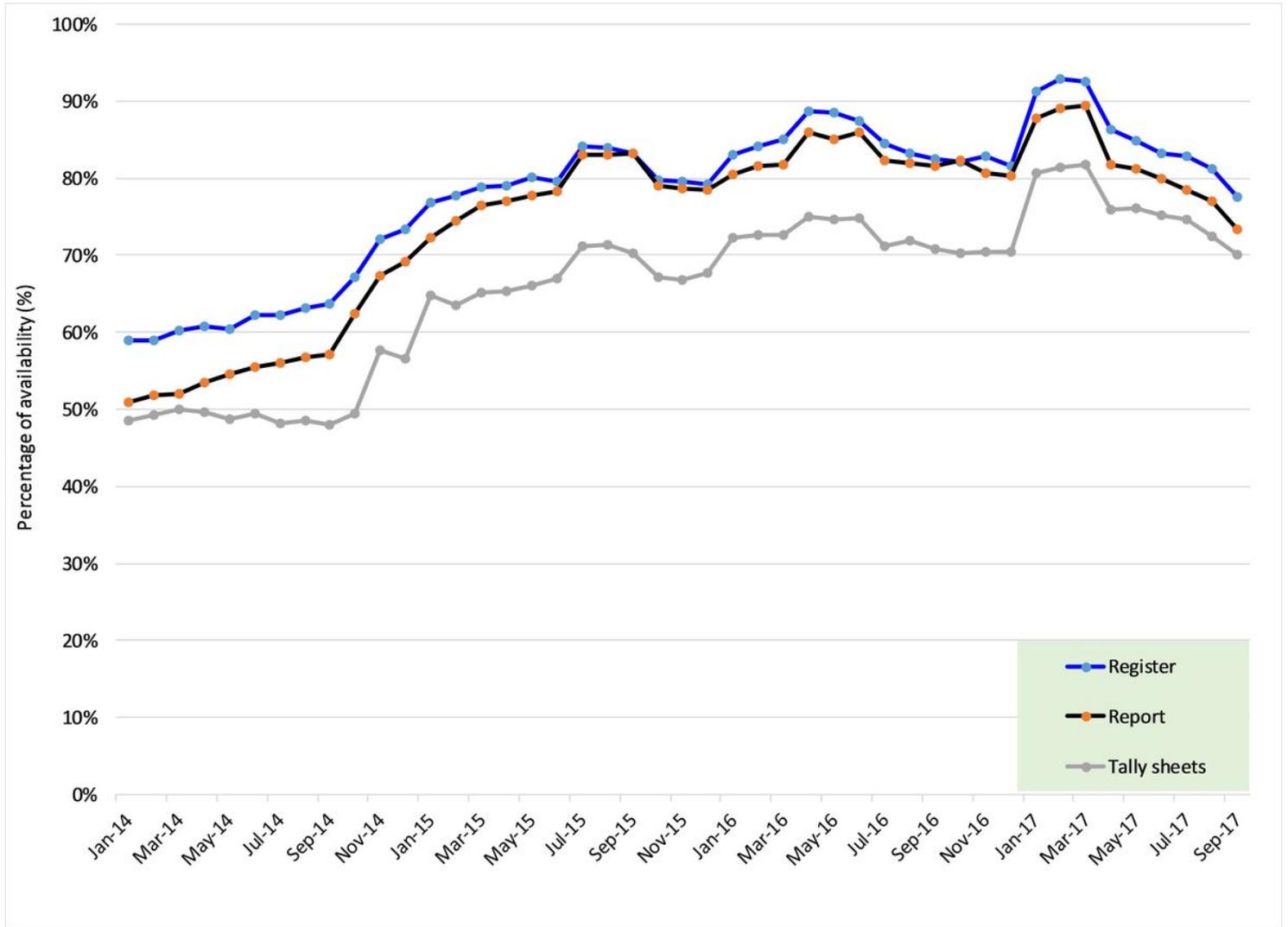


Figure 1

Figure 1

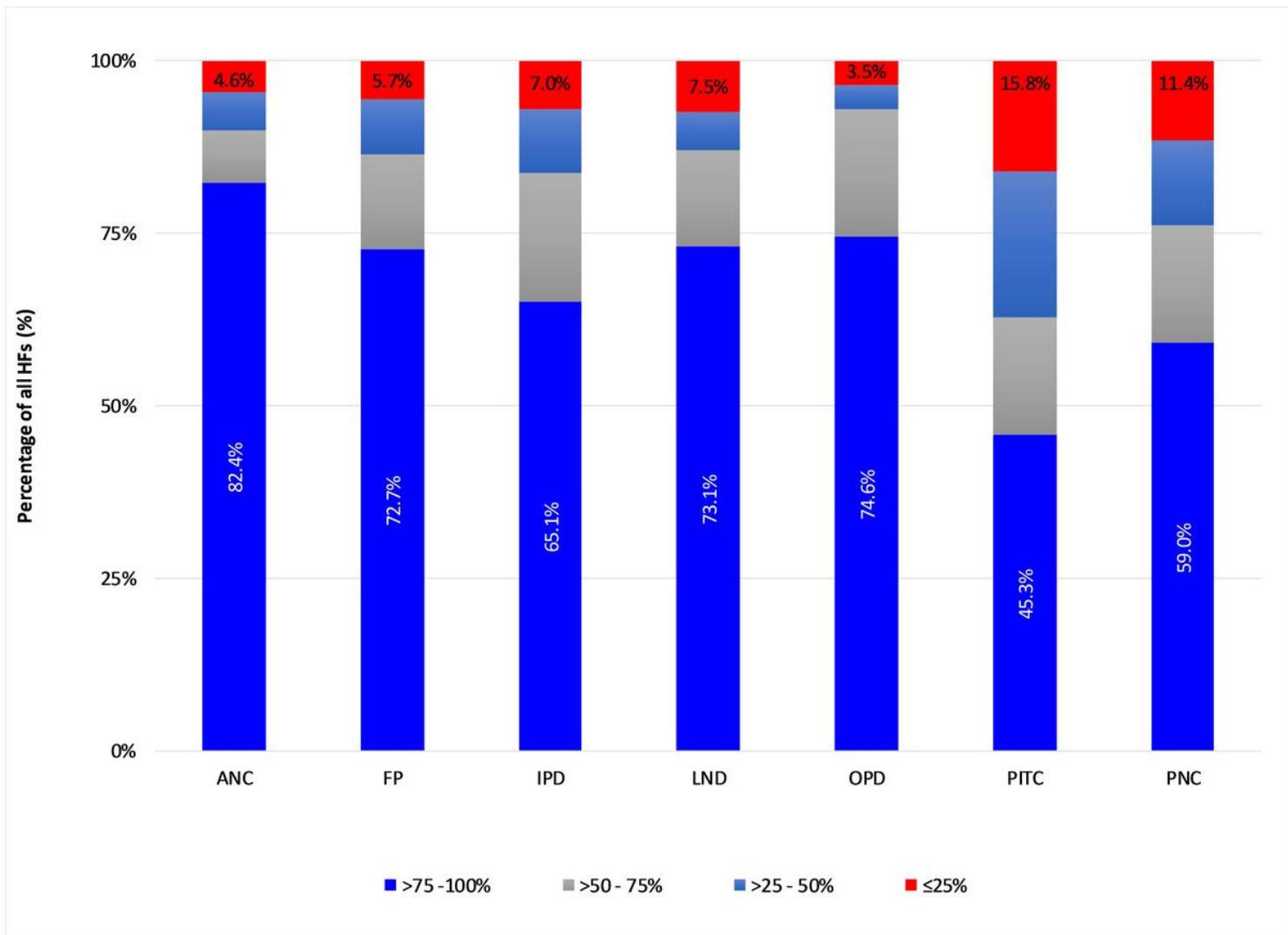


Figure 2

Figure 2

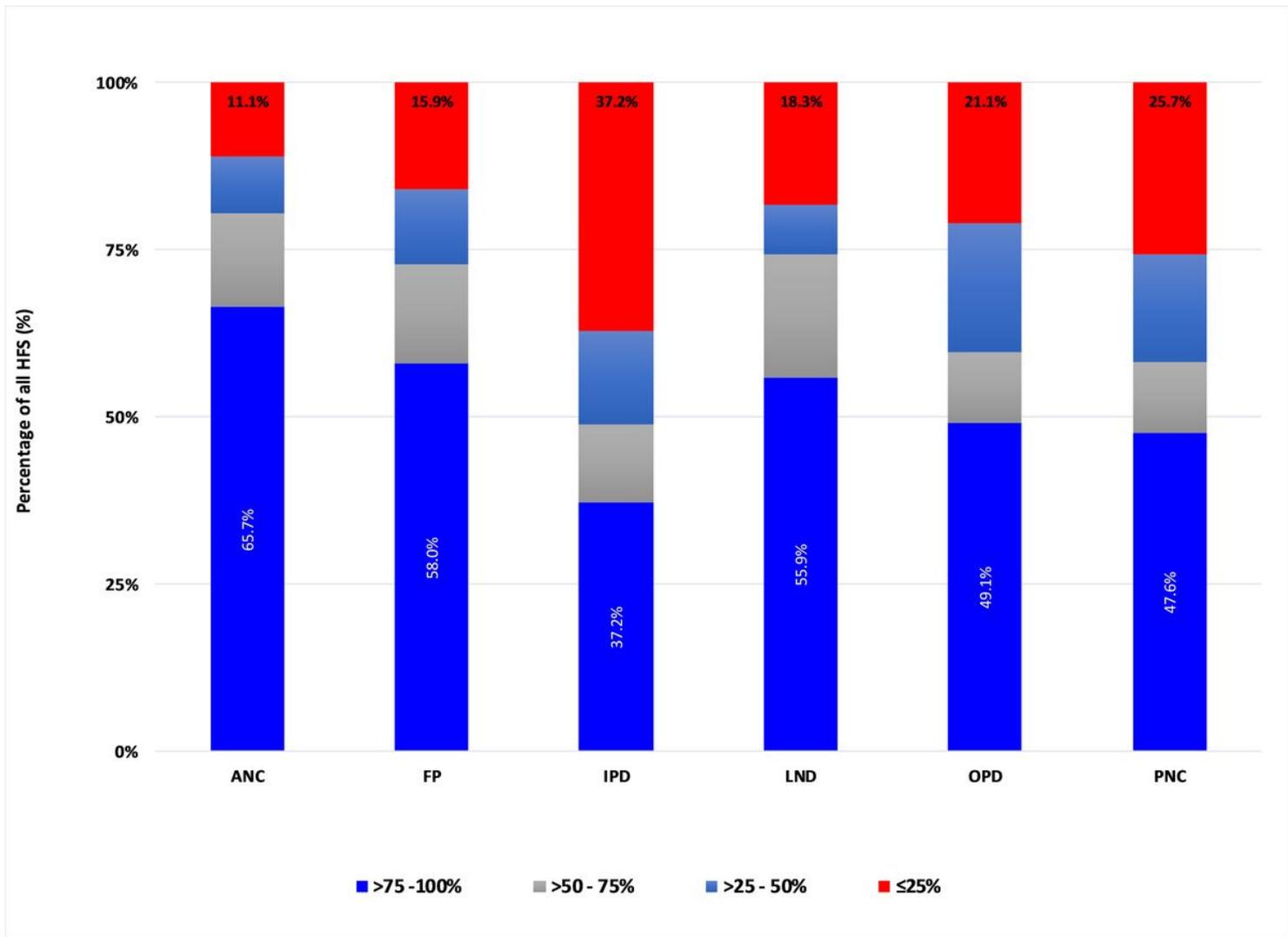


Figure 3

Figure 3

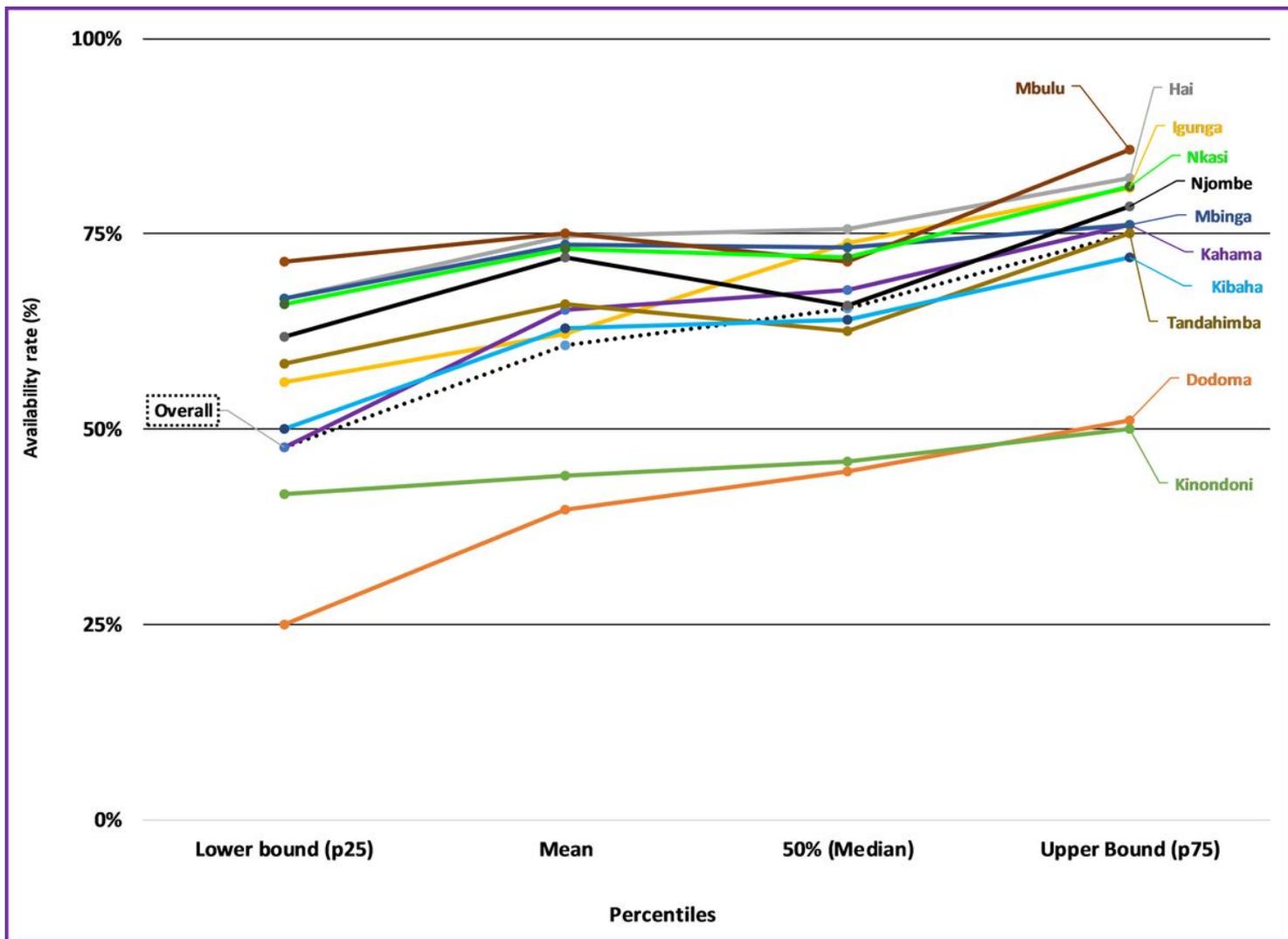


Figure 4

Figure 4

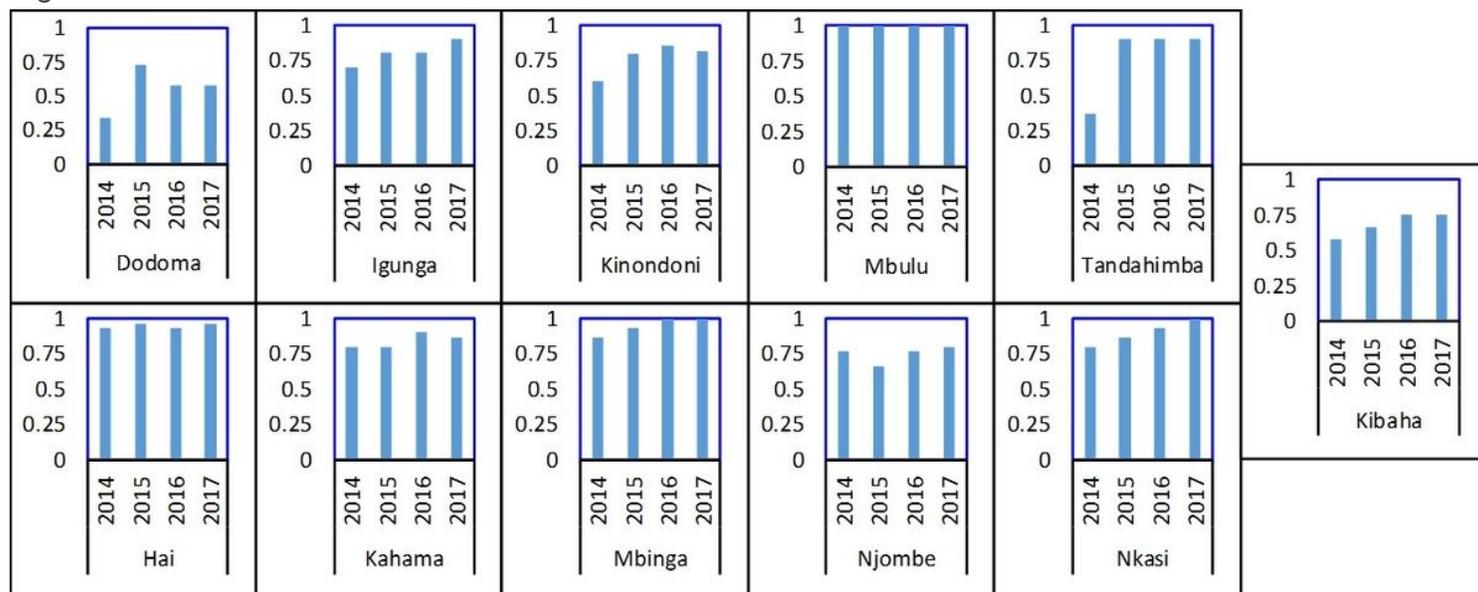


Figure 5

Figure 5

Supplementary Files

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