Institutionalized Data Quality Assessments: A Critical Pathway to Improving the Accuracy of Integrated Disease Surveillance Data in Sierra Leone

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Abstract

Background Public health agencies require valid, timely and complete health information for early detection of outbreaks. Towards the end of the Ebola Virus Disease (EVD) outbreak in 2015, the Ministry of Health and Sanitation (MoHS), Sierra Leone revitalized the Integrated Disease Surveillance and Response System (IDSR). Data quality assessments were conducted to monitor the accuracy of data generated through the IDSR system.

Methods Starting 2016, regular data quality assessments (DQA) were conducted in randomly selected health facilities. A structured electronic checklist was used to interview district health management team (DHMT) members and health facility staff. We used malaria data to assess data accuracy as malaria was endemic in Sierra Leone. Verification factors (VF) calculated as the ratio of verified malaria cases in the health facility register to the number of malaria cases recorded in the national health information database, were used to assess data accuracy. Allowing a 5% margin of error, VF < 95% were considered over reporting while a VF > 105 was underreporting. Differences in the proportion of accurate reports in the first and fourth assessments were compared using Z-test for two proportions.

Results Between 2016 -2018, four DQA were conducted in 444 health facilities where 1,729 IDSR reports were reviewed. Registers and IDSR technical guidelines were widely available in health facilities and health care workers were conversant with reporting requirements. Overall data accuracy improved from VF of 95.3% in 2016 to 100.2% in 2018. Compared to the baseline in 2016, the proportion of accurate IDSR reports in 2018 increased by 19.5% (CI 12.5% -26.5%). Over reporting was more common in private clinics and not for profit facilities while
under-reporting was more common in lower level government health facilities. Leading reasons for data discrepancies included counting errors in 358 (80.6%) health facilities, and missing source documents in 47 (10.6%) health facilities.

Conclusion This is the first attempt to institutionalize routine monitoring of IDSR data quality in Sierra Leone. Regular data quality assessments may have contributed to improved data accuracy over time. Data compilation errors accounted for most discrepancies and should be minimized to improve accuracy of IDSR data.

introduction

Public health surveillance data is used to monitor disease trends, detect outbreaks and trigger response activities. It also guides in allocation of resources, evaluation of public health interventions, policies and strategies [1]. Policy makers and public health agencies rely on good quality data to make decisions. In infectious disease surveillance and response, reliable, valid, timely, complete and accurate health information is essential for early detection and control of outbreaks [2]. The revised International Health Regulations (2005), require state parties to build public health capacity to detect, report, and respond to public health threats [3, 4]. This can only be achieved through robust public health surveillance systems that generate high quality data. Emphasis on improved accountability of donor funding in the health sector has also driven the need for accurate data to track progress of key indicators [5]. Demand for high quality data has led to an increase in the number of data quality assessments worldwide [6].

Data quality refers to those features and characteristics that ensure data are accurate and complete and that they convey the intended meaning. Data quality is
measured both directly and indirectly [7]. Simple checks on the number of empty variables in medical records provide an idea of how complete and accurate the data are. Accuracy is measured by comparing summary reports to recounted values verified through formal data quality assessments [1, 8-10]. The validity of laboratory tests, training of persons who record information in the surveillance system, frequency of supervision and data management practices are indirect measures of data quality [7]. More comprehensive definitions of data quality have been described, such as breaking down data quality into dimensions of data, data use and data collection process. Each dimension is then assessed using attributes [6].

Good data quality still remains a challenge especially in low resource settings. Assessments of implementation of IDSR in African countries have identified data quality issues such as late reporting [11], incomplete reporting [12] and data inconsistencies across reporting levels [13]. However, repeated assessments, feedback, data management trainings appear to improve data quality over time. Sierra Leone had the highest number of cases during the Ebola outbreak in West Africa, 2014-2016 [14]. The outbreak led to a breakdown of the public health system including surveillance. Efforts to revitalize surveillance started with a rapid assessment of IDSR capacity in 2015. The assessment identified potential threats to data quality such as low reporting rates, unavailability of data collection and reporting tools and difficulties in data transmission. Starting January 2015, the Ministry of Health and Sanitation, with technical support from WHO and other partners, supported the country to restructure and operationalize the IDSR system. Technical guidelines were adapted and aligned to Africa regional IDSR guidelines (2010) and the international health regulations (2005). Also, health care workers
were trained, data collection tools distributed, and necessary infrastructure provided [15]. At first, the IDSR system was paper based, where health facility IDSR focal persons would send weekly IDSR reports to the district health office through hand delivery, phone calls or short text messages. Officials in the district health office would then collate reports in an MS excel database and forward to national surveillance officials at the national level. The migration to electronic IDSR data transmission (e-IDSR) started in July 2016 at the district level, whereby weekly IDSR data received from health facilities were entered into the District Health Information Software (DHIS) platform, and were thereafter accessible to officials at the national level including partners.

Starting May 2017, electronic reporting was piloted in health facilities in one district and by June 2019, IDSR reporting was done electronically in all health facilities. One year after the revitalized IDSR system was operationalized, we undertook periodic DQA of data generated through the IDSR system. We also explored reasons for discrepancies in recounted data and data available in DHIS. Data on positive malaria cases were used for the exercise as malaria is endemic in all districts of Sierra Leone [16].

methods

Design and study setting

Four retrospective assessments were conducted in selected health facilities in all districts of Sierra Leone. IDSR data collected in July 2016, May 2017, November 2017 and October 2018 was reviewed. Health facilities were selected based on the health service level, whereby at least one hospital, two Community Health Centers (CHC), two Community Health Posts (CHP), and two Maternal Child Health Posts
(MCHP) were included per district. The number of facilities increased in the third and fourth assessments. The DHMT would list all health facilities included in the IDSR reporting system, stratifying them by service level and ownership. For each type of facility, selection would be done using randomly generated computer numbers.

**Interviews and Data Validation**

An electronic checklist was developed and uploaded onto tablets using the Open Data Kit (ODK) platform. In preparation for the visit, the office of the directorate of prevention and control (DPC) would send a notification of the DQA exercise to the district health management team (DHMT). This was to allow the team prepare a list of health facilities and avail two DHMT officials to join the national team. On the first day of the assessment, the national team would meet the members of the DHMT, give an overview of the DQA process and interview key informants in the DHMT. The team would record the number of positive malaria cases for each of the selected health facilities, as recorded in the district database. During the first assessment, IDSR data was stored in an MS Excel database at the district health office and DPC. From January 2017, the country shifted to electronic data transmission from district level whereby all IDSR data was uploaded directly to district health information system platform (DHIS). During the second, third and fourth assessments the team would log onto the DHIS2 platform and retrieve the information for each selected health facility.

**Variables**

The checklist was organized into seven sections. The first section was on availability and consistent use of registers at health facilities. Section two assessed the
processes and tools that facilitated reporting in the IDSR. This included observations on availability of reporting tools, IDSR weekly reports and questions on the compiling of IDSR reports. The third section was on data analysis and interpretation and the fourth section had questions on feedback mechanisms used by the DHMTs. The remaining sections were on data validation, logistics management and reasons for discrepancies in data.

**Statistical analysis**

Malaria positive cases reported on epidemiologic weeks 27-30 in 2016 and epidemiologic weeks 18-21 in 2017, 44-47 in 2017 and 40-43 in 2018 were used in the exercise. For each of the four weeks, the number of cases recorded in the health facility registers were counted and recorded in the assessment tool. Records of confirmed malaria cases in outpatient registers were used in facilities without laboratories. In hospitals with laboratories, malaria positive tests as recorded in the laboratory register were used. If rapid diagnostic tests were used in the outpatient department to test malaria, the data would be added to that recorded in the laboratory register. Next, the assessment team obtained the four weekly reports from the health facility and abstracted the number of confirmed malaria cases recorded. The last step involved abstracting the number of confirmed malaria cases for each health facility as recorded in the MS Excel database in district office or from the DHIS website.

**Calculation of Accuracy**

Data accuracy was determined by calculating a verification factor (VF) that was the ratio of the recounted (verified) value of positive malaria cases recorded in the health facility registers divided by value of positive malaria cases in the district
office database in 2016 or DHIS database in 2017 and 2018. Verification factors (VF) were calculated to compare concurrency between the verified counts of total malaria cases for each epidemiologic week in the registers with the number recorded in the health facility reports and the district database or DHIS. We adopted this method from the World Health Organization (WHO) guidelines for data quality assessment [8].

Verification factor (VF) of > 100% was interpreted as underreporting while a verification factor of <100% indicated over reporting. A 5% margin of error was considered acceptable (95% to 105%). We examined the difference in proportion of accurate reports in the first and fourth assessments using the z-test for two proportions.

**Results**

Four data quality assessments were conducted in 444 health facilities of which 390 (87.8%) were lower level facilities (CHC, CHP, MCHP) (Table 1). The number of health facilities included in the assessment increased from 79 in 2016 to 138 in 2018, thus improving the representativeness of the data. We reviewed 1,729 weekly IDSR reports that is, 299 in the first assessment, 377 in the second assessment, 501 in the third assessment and 552 in the fourth assessment.

**Data collection, collation, analysis and reporting**

Although patient registers and IDSR reporting tools were available in most lower level health facilities they were less available in hospitals and laboratories. Hospital outpatient registers were used in 42 (85.7%) out of 49 hospitals. Registers
used to record data for children aged < 5 years were used in 383 (98.2%) lower level health facilities while general clinic registers were used in 384 (98.5%) health facilities. Out of 144 health facilities with laboratories, 109 (75.7%) used laboratory registers to record patient information (Table 2). IDSR weekly reporting forms were available in 130 (94.2%), case based forms in 116 (84.1%) and technical IDSR guidelines in 122 (88.4%) health facilities (Table 3). There was a high level of awareness of IDSR reporting requirements as 401 (90.3%) of respondents correctly defined an epidemiologic week and 418 (94.1%) defined zero reporting correctly. Regular data analysis was conducted in 242 (54.5%) of the health facilities.

**Accuracy of IDSR Data by level of health care facility**

The proportion of accurate reports was similar across all health facility types and was highest (52.5%) for data received from CHPs. Out of 49 reports received from clinics and health facilities owned by not-for-profit organizations 19 (38.8%) were over-reported. Under-reporting was more common in reports from CHPs (29%) and MCHPs (28.5%) (Table 4).

**Improvements in Data Accuracy Over with Repeated Assessments**

Overall data accuracy improved from VF of 95.3% in the first assessment to VF of 100.2% in the fourth assessment (Table 4). There was a significant improvement in the proportion of accurate weekly reports from 36.8% in the first assessment to 56.3% in the fourth assessment (confidence interval, 12.5%, 26.5%) (Figure 1). The number of districts with accurate data increased from six (46.2%) out of thirteen in the first assessment to nine out of fourteen (64.3%) in the fourth assessment. The largest discrepancies between recounted register data and DHIS data were 40.6% over reporting in Pujehun district in the first assessment and 25.7% underreporting in Tonkolili district in the fourth assessment (Table 5). The proportion of reports
with over-reporting >20% reduced from 20.4% in 2016 to 8.9% in 2018. Reports with underreporting > 20% also reduced from 20.4% to 12.3% in 2018 (Figure 1). Weekly reports from Kailahun district were accurate during all assessments. Over reporting was more common in the first assessment (5/13 districts) and second assessments (4/14 districts) compared to the fourth assessment where underreporting was more common (3/14 districts) (Table 5).

**Reasons for data discrepancies**

Data compilation errors, made when generating monthly summaries of malaria cases, were the most common cause of discrepancies between recounted data and data in DHIS. This was observed in 358 (80.6%) of all the health facilities and remained constant during all assessments. Other reasons for discrepancies were missing registers in 47 (10.6%) health facilities, failure to submit health facility IDSR weekly reports to the district office in 25 (5.6%) and failure to enter data into the DHIS2 database in 24 (5.4% health facilities (Table 6).

discussion

This is among the first attempts to institutionalize routine monitoring of public health surveillance data quality in Sierra Leone and in the African region. By the fourth assessment, more than half of the weekly IDSR reports were within allowable accuracy limits and there was a reduction in the magnitude of the discrepancies between recounted data and data in the DHIS. This improvement implies that the regular data quality assessments had a positive effect on data accuracy and is consistent with findings from repeated data quality audits conducted elsewhere [17–19].
Other contributors to improved data accuracy could be regular supportive supervision and shift to electronic reporting that were introduced simultaneously with the DQA. Availability of registers to record patient information in standard manner may also have had a positive impact on data accuracy. If patient data is captured in different tools with different formats, then aggregation may be erroneous. Also, if registers are not available, patient information may not be recorded at all or may be recorded in informal registers and not transferred to the new register when it is available.

Difficulties in generating quality public health data in Africa are well documented. In Malawi, an undercount of 5.4% of the number of patients receiving antiretroviral treatment was found [10] which is within the range found in our study. More extreme deviations of 75.2% have been reported in Prevention of Mother to Child infection of HIV program sites in South Africa [9].

In our assessment, further analysis of health facility data revealed discrepancies in data that could have been masked if only the overall accuracy was considered. Disaggregation of data enabled us to calculate accuracy for each district and also check if accuracy varied by health facility type. We found that accuracy levels in several districts improved over time, probably as a result of feedback given to DHMTs during quarterly IDSR review meetings. Constant feedback on performance is a common approach used in many data quality improvement interventions and is part of the quality improvement process [18, 20]. While the type of health facility did not appear to influence data accuracy, we did observe that underreporting was more common in lower level peripheral health units and over reporting was more common in private clinics and not for profit owned facilities. Possible reasons for over-reporting of malaria cases may be the need to account for malaria
commodities [21], duplication, or poor record keeping that leads to estimation of the actual cases when reporting.

Errors made by health care workers when counting and compiling reports were observed in all assessments and were the most important reason for discrepancies in data uploaded onto the DHIS. Starting 2016, the MoHS, Sierra Leone, with support from WHO and other partners, undertook phased migration from paper based reporting to electronic reporting of IDSR data up to the health facility level. Currently, health facility IDSR data is uploaded directly onto DHIS platform, thus reducing discrepancies arising from transmission of reports to the district health office. Improvements in IDSR data quality will be dependent on the thoroughness of health care workers who compile and upload IDSR reports.

Our assessment had a few limitations. First, most of the health facilities included in the assessments were government owned health facilities that benefited from capacity building on IDSR and also from routine supervision. Data quality in such health facilities may be better compared to data quality in private health facilities. We are not able to examine possible differences in these two types of facilities owing to the small number of private health facilities included in this assessment. Secondly, the assessment focused on one attribute of data quality and cannot be used assess validity of the data, as this requires more rigorous techniques.

conclusion

These assessments are the first attempt to institutionalize monitoring of IDSR data quality in Sierra Leone post EVD outbreak. Regular DQA contributed to gradual improvements in data accuracy and also enabled us identify data quality issues that
need to be addressed. The shift to electronic surveillance system is likely to reduce transcription errors, thus focus should be on proper documentation, storage of patient information and accurate compilation of data at the health facility level. The MoHS should build the capacity of district health management team members to conduct DQA using the electronic checklist as this is more sustainable and can increase coverage to all health facilities.

### Abbreviations

| CHC       | Child Health Center          |
|-----------|------------------------------|
| CHP       | Child Health Post            |
| DHIS      | District Health Information Software |
| DHMT      | District Health Management Team |
| DQA       | Data Quality Assessment      |
| EVD       | Ebola Virus Disease          |
| IDSR      | Integrated Disease Surveillance and Response |
| MCHP      | Maternal Child Health Post   |
| MoHS      | Ministry of Health and Sanitation |
| ODK       | Open Data Kit                |
| VF        | Verification Factor          |
| WHO       | World Health Organization    |

### Declarations

**Ethics approval and consent to participate**

Consent to publish this work was obtained from the Ministry of Health and Sanitation, Sierra Leone. Ethical approval was not sought or obtained from an ethical review board as it is not required for routine assessments undertaken by the Ministry of Health and Sanitation (MoHS). Formal consent to participate was not deemed necessary also, as the information sought from the assessment was necessary for MoHS programmatic improvement.

**Consent for publication**

This manuscript does not contain any images, videos or personal data that requires consent from individuals.
Availability of data and material

The data that support the findings of this study are available from the

Corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Only authors affiliated with World Health Organization were involved in

Conceptualization of this work, and subsequent development and publication.

Authors' contributions

All the listed Authors made significant contributions in the conceptualization and

revision of the manuscript. CN conceptualized the assessments, developed the

Initial draft and revised the manuscript based on feedback from co-authors. MV

Conceptualized the assessments, monitored implementation and reviewed and

Approved draft manuscript. MM, AC, VC, SS and WG were involved in

Conceptualization and conduct of all the assessments and review of the draft

Manuscript; JK participated in the assessments and review of the draft manuscript,

EL contributed to writing and reviewing of the draft manuscript, JG participated in

data analysis, conceptualization and review of draft manuscript, ZY, AY, AT and ISF

Were involved in conceptualization of the data quality assessments reviewed and

Approved the draft manuscript.
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Table 1: Type of Health Facilities included in the data quality assessment, Sierra Leone, 2016-2018

| Facility type                                      | July 2016 | May 2017 | November 2017 | October 2018 | Total |
|---------------------------------------------------|-----------|----------|---------------|--------------|-------|
| Community Health Centre (CHC)                     | 27        | 28       | 40            | 41           | 136(30.6) |
| Community health post (CHP)                       | 23        | 27       | 40            | 44           | 134(30.2) |
| Maternal and child health post (MCHP)             | 24        | 26       | 36            | 34           | 120(27.0) |
| Hospital                                          | 5         | 14       | 14            | 16           | 49(11) |
| Others (including clinics and not for profit organizations) | 0       | 2        | 0             | 3            | 5(1) |
| **Total**                                         | **79**    | **97**   | **130**       | **138**      | **444** |

Table 2: Availability of Standard inpatient and outpatient Registers in Health Facilities, Sierra Leone, 2016-2018

| Type of register                  | Recommended use/Description                                                                 | No. of facilities required to use register |
|-----------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------|
| Hospital outpatient register     | Used in hospitals to record information for all outpatient visits                           | 49                                      |
| Hospital in-patient register     | Used in hospitals to record information on all admissions                                    | 49                                      |
| Under Five years register        | Used in CHC, CHP and MCHP to record information on outpatient visits for children aged less than five years | 390                                     |
| General clinic register          | Used in CHC, CHP and MCHP to record information on outpatient visits for persons aged >5 years | 390                                     |
| Mother and neonate register      | Used in all health facilities to record information on antenatal visits and child immunization | 444                                     |
| Maternity and delivery register  | Used in all health facilities to record information on deliveries, maternal deaths          | 444                                     |
| Laboratory register              | Used only in health facilities (some CHCs and all hospitals) that have laboratories, to record information for all laboratory tests conducted in the laboratory, including malaria diagnostic tests | 144                                     |
### Table 3: Availability of IDSR technical guidelines and reporting tools, Sierra Leone, 2016-2018

| IDSR tool                  | July 2016 Frequency (%) | May 2017 Frequency (%) | November 2017 Frequency (%) |
|----------------------------|-------------------------|------------------------|-----------------------------|
| Case based form            | 67 (84.8)               | 77 (79.3)              | 121 (93.1)                  |
| Line listing form          | 65 (82.3)               | 77 (79.3)              | 110 (84.6)                  |
| Weekly reporting form      | 75 (94.9)               | 94 (96.9)              | 124 (95.4)                  |
| Rumor log                  | 41 (51.9)               | 54 (55.7)              | 84 (64.6)                   |
| Technical IDSR Guidelines  | 71 (89.9)               | 90 (92.8)              | 113 (86.9)                  |

### Table 4: Comparing Accuracy of IDSR weekly reports among Different Types of Health Facilities in Sierra

| Type of Health Facility | No. of health facilities | No. (%) of health facilities with Accurate Reports | No. (%) of health facilities with over-reporting VF 95%-105% | No. (%) of health facilities with under-reporting VF <95% |
|-------------------------|--------------------------|---------------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------|
| Community Health Center | 528                      | 276 (52.3)                                        | 129 (24.4)                                                  |
| Community Health Post   | 507                      | 266 (52.5)                                        | 94 (18.5)                                                   |
| Maternal, Child Health Post | 461                | 226 (49)                                          | 102 (22.1)                                                  |
| Hospital                | 184                      | 86 (46.7)                                         | 57 (31)                                                     |
| Clinics and not for profit organizations | 49       | 24 (49)                                           | 19 (38.8)                                                   |
### Table 5: Comparing Accuracy of Malaria Data by district and time, Sierra Leone, 2016-2018

| District       | July 2016 No. of malaria cases recounted HF register | July 2016 No. of malaria cases recorded in District database /DHIS | VF Recounted data in HF register / District database | May 2017 No. of malaria cases recounted HF register | May 2017 No. of malaria cases recorded in District database /DHIS | VF Recounted data in HF register / District database | No. of malaria cases recounted HF register |
|----------------|------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------|-----------------------------------------------|-----------------------------------------------|--------------------------------------------------|-----------------------------------------------|
| Bo             | 661                                                  | 528                                                             | **125.2**                                        | 918                                           | 1027                                           | **89.4**                                         | 1143                                           |
| Bombali        | 849                                                  | 860                                                             | 98.7                                             | 1088                                          | 1315                                          | **82.7**                                         | 1134                                           |
| Bonthe         | 538                                                  | 705                                                             | **76.3**                                         | 657                                           | 675                                           | 97.3                                            | 781                                            |
| Kailahun       | 1047                                                 | 1033                                                            | 101.4                                            | 1235                                          | 1235                                          | 100.0                                           | 749                                            |
| Kambia         | 868                                                  | 847                                                             | 102.5                                            | 636                                           | 580                                           | **109.7**                                       | 887                                            |
| Kenema         | 932                                                  | 898                                                             | 103.8                                            | 699                                           | 711                                           | 98.3                                            | 1100                                           |
| Koinadugu      | 987                                                  | 1092                                                            | **90.4**                                         | 854                                           | 868                                           | 98.4                                            | 1185                                           |
| Kono           | 1092                                                 | 1221                                                            | **89.4**                                         | 1218                                          | 1153                                          | **105.6**                                       | 986                                            |
| Moyamba        | 740                                                  | 788                                                             | **93.9**                                         | 876                                           | 865                                           | 101.3                                           | 656                                            |
| Port Loko      | 1023                                                 | 1005                                                            | 101.8                                            | 855                                           | 992                                           | **86.2**                                        | 1243                                           |
| Pujehun        | 646                                                  | 1087                                                            | **59.4**                                         | 764                                           | 746                                           | 102.4                                           | 588                                            |
| Tonkolili      | 778                                                  | 775                                                             | 100.4                                            | 1223                                          | 1220                                          | 100.2                                           | 1199                                           |
| Western Area   | -                                                    | -                                                               | -                                                | 731                                           | 778                                           | **93.9**                                        | 1487                                           |
| Rural          |                                                      |                                                                  |                                                  |                                                |                                                |                                                 |                                                |
| Western Area   | 996*                                                 | 863*                                                            | **115.4**[1]                                     | 1116                                          | 1106                                          | 100.9                                           | 1865                                           |
| Urban          |                                                      |                                                                  |                                                  |                                                |                                                |                                                 |                                                |
| **Total**      | **11157**                                            | **11702**                                                       | **95.3**                                         | **12870**                                     | **13271**                                     | **97**                                          | **15007**                                      |
| Data Quality Error                                      | Number (%) of health facilities where error was identified | July 2016 N=79 | May 2017 N=97 | November 2017 N=130 | October 2018 N=138 |
|--------------------------------------------------------|-----------------------------------------------------------|----------------|---------------|---------------------|-------------------|
| Counting Errors                                        |                                                           | 58 (73.4)      | 70 (72.2)     | 111 (85.4)          | 119 (86.2)        |
| Missing Source Documents (Registers)                   |                                                           | 7 (8.9)        | 13 (13.4)     | 14 (10.8)           | 13 (9.4)          |
| Reports not submitted to the district                  |                                                           | 7 (8.9)        | 2 (2.1)       | 10 (7.7)            | 6 (4.3)           |
| Health facility reports not entered into district database |                                                           | 8 (10.1)       | 0 (0)         | 9 (6.9)             | 7 (5.1)           |

[1] In 2016, Western Area was one district. In 2017, Western Area Rural District was formed.

Figures
Figure 1: Comparing Accuracy of IDR weekly Reports Over time, Sierra Leone, 2016-2018

Comparing Accuracy of IDR weekly Reports, Sierra Leone, 2016-2018