Original Article

Assessing the Quality of Immunization Data from Administrative Data in Enugu State, South-East Nigeria: A Cross-Sectional Study

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Abstract

Background: Studies evaluating immunization data quality and its determinants in low- and middle-income countries are scarce. **Aim:** Therefore, this study assessed the accuracy of routine immunization data and its associated factors in Enugu State, South-East Nigeria. **Materials and Methods:** This was a descriptive cross-sectional, mixed-method study. A multi-stage sampling technique was used to select 60 out of 180 primary health facilities in six local government areas (LGAs). Routine data on Bacillus Calmette Guerin (BCG), pentavalent vaccine dose3 (Penta3), and Measles2 vaccinations in tallied registers, facility reports, and District Health Information System II (DHIS2) in 2020 were abstracted using a questionnaire. The dependent variables were the accuracy ratios of the facility and DHIS2 reports. We collected data on the independent variables including LGAs, type of location, facility type, tool availability, tool use, frequency of supervision, defaulter tracing, and vaccine tracking. Additionally, semi-structured, in-depth interviews were conducted with 35 purposively selected actors on factors affecting the data quality. The proportions of facilities with normal, under-, or over-reporting were summarized in percentages. The median accuracy ratios and interquartile range (IQR) were also reported. Differences in median accuracy ratios were tested using the independent sample median test. We tested the predictive model using a generalized linear model. Statistical significance was set at $P < 0.05$. The qualitative data were analyzed using content analysis. **Results:** The accuracy of facility reports ranged from 38% to 68% (normal), 17–30% (under-reporting), and 15–35% (over-reporting) of health facilities. In DHIS2, the accuracy ranged from 5% to 10% (normal), 37–42% (under-reporting), and 53–63% (over-reporting) of health facilities. The median (IQR) accuracy ratios of facility reports were 100.0% (98.3–103.2%), 100.0% (98.5–103.6%), and 100.0% (81.6–110.2%) for BCG, Penta3, and Measles2, respectively. The median (IQR) accuracy ratios of DHIS2 reports were 83.6% (43.3–192.7%), 88.4% (37.8–200.8%), and 46.2% (10.7–202.7%) for BCG, Penta3, and Measles2, correspondingly. No facility characteristic predicted the accuracy of routine immunization reports. Reasons for inaccurate data include untimely recording, wrong counting, delayed reporting, infrequent supervision, lack of data audits, resource constraints, and

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high workload. **Conclusions:** Routine immunization data are not always accurate in Enugu state. Continuous efforts to improve the data monitoring system, supervision, data audits, funding, and staffing are warranted.

Keywords: *Data quality, data quality audit, immunization program, Nigeria, routine immunization*

Introduction

The performance of national immunization programs is monitored and evaluated using routine immunization data.[1] However, inaccurate recording and reporting of immunization data limit the ability to monitor immunization performance in low- and middle-income countries (LMICs).[2-4] Hence, data quality, defined as data that is accurate, precise, relevant, complete, and timely enough for its intended purpose,[1] is an important barrier and necessary precursor to data use.[3,5,6] High-quality immunization data facilitate clinical decision support to immunization service providers and guide public health actions to improve immunization rates, identify populations potentially at risk for vaccine-preventable diseases, and effectively prioritize immunization program resources.[7,8]

Poor quality of routine immunization data is often characterized by the discordance between data sources (under- or over-reporting) due to data entry inaccuracies, such as incomplete and incorrect data entry, double entries, and missing values,[1,9-15] and delays in recording summarizing vaccination data after routine immunization sessions and poor review and use of routine immunization data locally.[3] Concurrence of immunization data between facility monthly report and facility vaccination tally sheets was 31% and 38% in Kenya and Ghana, respectively.[16] Tally sheets often show higher numbers of vaccines administered and are more likely to be closer to the true value of data than child health registers.[1,17]

Considerable data discrepancies have been observed in routine immunization data in Nigeria.[18-22] Discrepancies were more commonly over-reporting than under-reporting of routine immunization data.[18-21] Coverage rates of the pentavalent vaccine (3rd dose) from community surveys were discordant with national administrative coverage rates indicating over-reporting of routine immunization data.[18,20] The proportion of primary health facilities and local government areas (LGAs) with accurate data is low.[18-20,22] Likewise, the use of data for monitoring program performance and decision-making is limited by low data low.[19,20,22] Immunization data accuracy was associated with supportive supervision visits in the previous month, data collection tool availability, recent attendance to monthly LGA routine immunization review meetings, and availability of trained staff.[22] Poor quality of immunization data results from heavy workload, over-reliance on administrative coverage reports, and poor understanding of the real meaning of quality data.[18]

Nigeria envisages a health information system that provides timely, appropriate, and reliable health information services with a data quality target of 80%.[23,24] Despite policy interventions to improve immunization data quality, inaccuracies in routine immunization data persist in Nigeria.[25,26] Given the significant heterogeneity in the strength of routine immunization systems among Nigerian states, evidence from previous Nigerian studies might not be generalized.[27] Also, only one study investigated the predictors of immunization data quality in Nigeria.[22] Therefore, this study assessed the accuracy of immunization data in facility and District Health Information System II (DHIS2) reports, its association with facility characteristics, and the contextual factors affecting data accuracy in Enugu state, South-East Nigeria. This information would be useful to decision-makers and providers in tracking national and subnational progress toward universal health coverage and to inform planning and assessments of the progress and performance of routine immunization programs.

Study Methods

Study area

The study was conducted in six LGAs of Enugu state, which is one of the 36 states in Nigeria. The state has 17 LGAs with five large urban areas, whereas 12 are rural. Each LGA has a department of primary healthcare (PHC), led by a PHC coordinator. The immunization program is managed by a local immunization officer (LIO) at the LGA level. Monitoring and evaluation (M&E) officers oversee the health information system within the local government including immunization data. There is at least one PHC center in each ward. Each PHC center is headed by an officer-in-charge, who often doubles as the immunization focal person in the health facility. Most PHC centers are governed by health facility committees (HFCs) with membership from the target communities. HFCs serve as initiatives for holding providers accountable to citizens who use the facilities.

Study design

We adopted a descriptive, cross-sectional mixed-method study comprising quantitative and qualitative data collection methods. In the quantitative part, immunization

data from three vaccines (BCG, pentavalent dose 3, and Measles2) were studied from sampled health facilities. The vaccines were chosen to reflect the variation in their introduction. Whereas BCG remains since the inception of the immunization program, pentavalent and Measles2 vaccines were introduced in 2014 and 2019, respectively, with corresponding changes in data management. The qualitative part involved semi-structured in-depth interviews with actors involved in immunization data management at state, LGA, and facility levels.

Sampling and sample size

The study adopted a multi-stage sampling technique with proportional-to-size (PPS) weights in selecting the study LGAs and primary health facilities. In the first stage, the 17 LGAs were stratified into 2 groups—5 urban and 12 rural LGAs. We selected two and four LGAs from the urban and rural groups of LGAs correspondingly proportionate to their size. The total number of health facilities in the six LGAs is 180. Although a minimum sample size of $n = 37$ facilities is suitable for data quality assessment in a subnational setting,[28] using GPower 3.1.9.7, we calculated a minimum sample size of 52 based on a power of 80%, allowable errors of 0.05 and 0.5 effect size weight. Further, we increased the sample to 60 health facilities, allowing for 15% of health facilities that might refuse participation or be unavailable. We used cluster random sampling with PPS weights for selecting health facilities ($n = 6, 7, 15, 8,$ and 12 for the six LGAs correspondingly).

For the qualitative component, we purposively selected five persons from the State Immunization Working Group and in each LGA. The LGA officials comprised the PHC coordinators, LIOs, M&E officers, officers-in-charge of health facilities, and facility routine immunization (RI) focal persons. In total, we interviewed 35 actors involved in RI data management. All participants had been on their posts for at least 1 year and were willing to participate in the study.

Data collection tools

The study used a questionnaire that was adapted from health facility RI data quality and use supportive supervision (DQUSS) checklist.[29] The DQUSS questionnaire was designed as an Android-based real-time data collection checklist built using the Open Data Kit (ODK) tool. The questionnaire had two sections. The first section collected data on the facility characteristics, namely, LGA, type of location, facility type, tool availability, tool use, frequency of supervision, data use for defaulter tracing, and data use for vaccine tracking. The second section abstracted data from tally sheets, monthly summary reports, and the DHIS2 platform. The tool was piloted using the 2019 RI data from the health facilities. The tool showed high reliability with a Cronbach alpha of 0.93.

The qualitative study involved interviews using in-depth interview (IDI) guides developed by the researchers. The development of the IDI guide was guided by the research questions and literature review.[3,4] Broadly, the IDI guide explored the factors that affect data quality including the availability of tools, recording and reporting practices, supervision, data review meeting, and staffing. We focused on understanding the barriers to data quality and the best approaches to improve the quality of RI data.

Data collection procedure

The data collection took place between May and June 2021 using ODK-supported DQUSS questionnaires. Eight research assistants were trained for 2 days on the tools, ODK, ethical consideration, and COVID-19 protocols. A research assistant visited one health facility at a time. In each facility, the research assistant interviewed one health worker to complete the first section of the questionnaire on facility characteristics including the location of the facility, respondent's post, facility type, availability of recording and reporting tools, monthly vaccination records for each of the tracer vaccines, data use for tracing defaulters and vaccine tracking, and frequency of supervision. Subsequently, the research assistant abstracted data from physical records in the daily tally sheets and health facility monthly summary forms into the ODK tool. Two experienced researchers supervised the facility-level data collection. In addition, BCG, Penta 3, and Measles2 data for each health facility were retrieved from the DHIS 2 platform by the researchers through the State Health Management Information System Office.

Qualitative data were collected between June and July 2021 by researchers experienced in qualitative techniques. Interviews were held at a time and place agreed by the participants. There was also a 2-day training, including a qualitative pilot exercise, for the research team on qualitative research approaches, IDI guides, research ethics, and COVID19 protocols. All interviews were conducted in the English language, audiotaped, and lasted between 30 and 60 minutes.

Data analysis

The characteristics of participating facilities were presented in numbers and percentages. The dependent variable was the accuracy of RI data for individual vaccines. The accuracy of the RI data report was summarized with median and interquartile range (IQR). The proportion of health facilities with normal, under-, or over-reporting was summarized in percentages. The

reasons for data discrepancy were summarized in a bar chart. The accuracy ratio is calculated as the number of vaccinations verified from a source at one level divided by the number of vaccinations reported by that level to a higher level all multiplied by 100.[30] An accuracy ratio less than 95% implies over-reporting, an accuracy ratio greater than 105% indicates under-reporting, whereas an accuracy ratio between 95% and 105% is deemed normal.[19,30] The independent variables included ownership (LGA), urban/rural location, facility type, availability of tools, use of tools, data use for defaulter tracking and vaccine stocking, and frequency of supervision. We described accuracy in terms of median because the data were skewed. Median accuracy was cross-tabulated with the independent variables. The median differences across the categories of independent variables were tested using the independent sample median test. We tested the predictive model with independent variables that were significant in the bivariate analysis using a generalized linear model. Statistical significance was set at a 0.05 significant level.

For the qualitative component, all transcripts were imported into NVivo 11 software and anonymized with unique identification numbers. Data were analyzed using qualitative content analysis. We read all of the transcripts to get familiar with the data. Thereafter, two transcripts were selected for detailed study and coding. We identified meaning statements within the text and assigned codes to them. Hence, key themes and sub-themes relating to immunization data quality were generated, forming the initial coding framework. We tested our initial coding framework on three additional transcripts and refined it into a final coding framework. The final framework was then applied to all of the transcripts. Two researchers reviewed and analyzed the data and reconciled differences through consensus.

Ethical considerations

Ethical approval was obtained from the Health Research Ethics Committee, Enugu state Ministry of Health, Enugu, and the University of Nigeria Teaching Hospital, Enugu, Nigeria. Written informed consent was obtained from all participants for participation.

Results

Basic characteristics of health facilities

Most of the health facilities included in this study are primary health centers [Table 1]. About 68% of the health facilities were in rural areas, whereas 60% received monthly supportive supervision. Recording and reporting tools were available in 68% of health facilities but used in 65%. Whereas 95% of health facilities reported using routine data to track vaccine stock, about 87% reported using routine data for defaulter tracking.

Table 1: Basic characteristics of health facilities (*n*=60)

Parameters	Facility type			*P*
	Health post, *n* (%)	Health clinic, *n* (%)	Primary health center, *n* (%)	
LGA				
A	0 (0.0)	0 (0.0)	6 (10.0)	0.439
B	0 (0.0)	1 (1.7)	6 (10.0)	
C	3 (5.0)	1 (1.7)	11 (18.3)	
D	0 (0.0)	0 (0.0)	8 (13.3)	
E	2 (3.3)	2 (3.3)	8 (13.3)	
F	0 (0.0)	2 (3.3)	10 (16.7)	
Location				
Rural	3 (5.0)	3 (5.0)	35 (58.3)	0.520
Urban	2 (3.3)	3 (5.0)	14 (23.3)	
Availability of tool				
Not available	2 (3.3)	1 (1.7)	16 (26.7)	0.668
Available	3 (5.0)	5 (8.3)	33 (55.0)	
Use of tool				
Low use	2 (3.3)	1 (1.7)	18 (30.0)	0.605
High use	3 (5.0)	3 (5.0)	31 (51.7)	
Supervision				
<1 month	3 (5.0)	6 (10.0)	27 (45.0)	0.194
2-4 months	2 (3.3)	0 (0.0)	12 (20.0)	
>4 months	0 (0.0)	0 (0.0)	10 (16.7)	
Data use for defaulters				
No	1 (1.7)	1 (1.7)	6 (10.0)	0.861
Yes	4 (6.7)	5 (8.3)	43 (71.7)	
Data use for vaccine tracking				
No	0 (0.0)	2 (3.3)	1 (1.7)	0.004
Yes	5 (8.3)	4 (6.7)	48 (80.0)	

Findings on the accuracy of RI data

Table 2 shows the proportion of health facilities (in) accurately reporting RI data, the median accuracy with IQR, and the test of normality. The data were not normally distributed (*P*-value for W >0.05). Health facility reports were accurate in about 62%, 68%, and 38% of health facilities regarding BCG, Penta 3, and Measles2 data, respectively. Data from just 5% and 10% of health facilities were accurately reported in DHIS2 for BCG and Penta 3, respectively. Measles 2 data was not accurately reported in DHI2.

About 22%, 17%, and 30% of health facilities under-reported BCG, Penta 3, and Measles2 in their health facility report in that order. Data from about 42%, 37%, and 37% of health facilities were under-reported in DHIS2 for BCG, Penta 3, and Measles 2, correspondingly. Almost 18%, 15%, and 35% of health

Table 2: Descriptive statistics of data accuracy of selected health facilities in Enugu state, 2020

Vaccine report	Under-reporting		Normal		Over-reporting		Median (IQR)	Shapiro Wilk test (W)	*P*-value for W*
	Number of facilities (*n*)	Percent (%)	Number of facilities (*n*)	Percent (%)	Number of facilities (*n*)	Percent (%)			
BCG facility report	13	21.7	37	61.7	10	16.7	100.0 (98.3-103.2)	0.625	<0.001
BCG DHIS2 report	25	41.7	3	5.0	32	53.3	83.6 (43.3-192.7)	0.667	<0.001
Penta 3 facility report	10	16.7	41	68.3	9	15.0	100.0 (98.5-103.6)	0.582	<0.001
Penta 3 DHIS2 report	22	36.7	6	10.0	32	53.3	88.4 (37.8-200.8)	0.702	<0.001
Measles 2 facility report	18	30.0	21	35.0	21	35.0	100.0 (81.6-110.2)	0.807	<0.001
Measles 2 DHIS2 report	22	36.7	0	0.0	38	63.3	46.2 (10.7-202.7)	0.315	<0.001

IQR=Interquartile range; *Significant for Shapiro Wilk test (W): *P*>0.05

Table 3: Median (IQR) accuracy of BCG data disaggregated by facility characteristics in Enugu state, 2020

Facility characteristics	Median (IQR)	*P*	Median (IQR)	*P*
LGA				
A	102.4 (98.0-109.6)	0.118	68.010.2-193.9)	0.595
B	98.8 (98.2-111.1)		170.4 (77.8-345.0)	
C	100.5 (96.9-108.3)		85.3 (48.5-1792)	
D	100.3 (99.3-101.1)		86.2 (5.5-138.2)	
E	100.0 (94.7-100.0)		53.5 (31.9-122.2)	
F	100.0 (100.0-103.2)		113.3 (57.0-388.0)	
Location				
Rural	100.5 (99.5-103.6)	0.020*	85.3 (45.5-192.6)	1.000
Urban	99.3 (96.9-100.0)		77.8 (38.6-203.3)	
Facility type				
Health post	100.5 (94.4-133.5)	0.739	71.5 (21.8-223.8)	0.591
Health clinic	105.5 (89.7-117.8)		55.2 (36.3-288.6)	
Primary health center	100.0 (98.7-101.8)		89.0 (47.3-192.6)	
Tool availability				
Not available	100.3 (10.0-108.3)	0.596	85.3 (54.3-179.2)	1.000
Available	100.0 (96.5-101.8)		81.8 (36.2-196.3)	
Tool use				
Low use	100.0 (99.7-105.8)	0.978	85.3 (50.2-172.9)	1.000
High use	100.0 (96.1-102.1)		81.8 (38.6-197.)	
Frequency of supervision				
Less than one month	100.0 (98.6-102.8)	0.285	60.3 (26.5-120.8)	0.021*
2-4 months	100.0 (95.1-102.9)		193.9 (80.9-433.1)	
Greater than 4 months	101.4 (97.9-124.5)		152.8 (44.9-262.3)	
Data use for Defaulters				
No	100.6 (95.3-112.7)	0.939	71.2 (19.2-200.6)	0.704
Yes	100.0 (98.3-102.9)		87.2 (46-189.4)	
Data use for vaccine tracking				
No	104.1 (94.0−)$^{+}$	0.858	38.6 (12.3−)$^{+}$	1.000
Yes	100.0 (98.4-102.7)		85.3 (47.3-192.6)	

*Significant at *P*<0.05; $^{+}$ 75th percentile could not be computed. IQR=Interquartile range

facilities over-reported BCG, Penta 3, and Measles 2 in their health facility report, respectively. Data from about 53%, 53%, and 63% of health facilities were over-reported in DHIS2 for BCG, Penta 3, and Measles 2, correspondingly.

Common errors affecting data quality

Summation, transcription, missing data, and unavailability of data tools were the most common data quality errors in this study [Figure 1].

Factors affecting the quality of BCG data

As shown in Table 3, significant median (IQR) differences in accuracy ratios of facility BCG reports were associated with the location of the health facility (*P* = 0.02): rural areas (100.5%, IQR: 99.5–103.6%) and urban areas (99.3%, IQR: 96.9–100.0). The frequency of supervision (*P* = 0.021) was significantly associated with median (IQR) differences in BCG data reported in DHIS2: less than 1 month (100.0%, IQR:

Table 4: Median (IQR) accuracy of Penta3 data disaggregated by facility characteristics in Enugu state, 2020

Parameters	Facility report	*P*	DHIS2	*P*
LGA				
A	102.8 (99.1-107.0)	0.854	73.3 (9.8-104.2)	0.748
B	98.4 (93.3-100.3)		103.3 (67.4-377.1)	
C	100.0 (97.7-103.8)		87.8 (51.6-237.0)	
D	101.0 (94.0-105.2)		68.5 (9.7-217.7)	
E	100.0 (97.5-100.8)		58.8 (23.8-216.2)	
F	100.0 (100.0-100.4)		95.3 (9.3-210.4)	
Location				
Rural	100.0 (99.5-104.7)	0.588	87.8 (37.5-192.0)	1.000
Urban	100.0 (97.0-100.6)		97.6 (37.7-247.1)	
Facility type				
Health post	102.4 (100.1-112.2)	0.110	80.2 (17.6-308.3)	0.896
Health clinic	96.7 (79.9-105.6)		85.0 (48.3-305.9)	
Primary health center	100.0 (98.6-103.5)		89.0 (34.6-192.0)	
Tool availability				
Not available	100.2 (100.0-103.8)	0.596	101.5 (68.6-237.0)	0.267
Available	100.0 (97.4-102.8)		80.2 (28.2-192.0)	
Tool use				
Low use	100.2 (99.8-103.8)	0.568	101.5 (56.1-220.2)	0.279
High use	100.0 (97.0-103.2)		80.2 (27.4-193.1)	
Frequency of supervision				
Less than 1 month	100.0 (97.2-102.3)	0.451	70.1 (23.4-100.7)	0.021*
2-4 months	100.4 (100.0-104.8)		170.5 (86.0-398.6)	
Greater than 4 months	101.4 (98.7-118.1)		198.2 (49.4-272.7)	
Data use for Defaulters				
No	99.9 (85.3-103.6)	0.939	53.9 (24.5-192.6)	0.704
Yes	100.0 (98.9-103.5)		91.2 (39.8-217)	
Data use for vaccine tracking				
No	93.3 (81.4−)$^{+}$	0.858	38.2 (9.9−)$^{+}$	1.000
Yes	100.0 (99.0-103.5)		89.0 (38.1-198.2)	

*Significant at $P<0.05$; $^{+}$ 75th percentile could not be computed. IQR=Interquartile range

98.6–102.8%), between 2 and 4 months (100.0%, IQR: 95.1–102.9), and greater than 4 months (101.4%, IQR: 97.9–124.5%).

Factors affecting the quality of pentavalent vaccine (3rd dose) data

Tables 4 shows that no facility characteristics were significantly associated with the median accuracy of the facility report of Penta 3 data. Furthermore, the frequency of supervision (P = 0.021) was significantly associated with median (IQR) differences in BCG data reported in DHIS2: less than 1 month (70.0%, IQR: 23.4–100.7%), between 2 and 4 months (170.5%, IQR: 86.0–398.6%), and greater than 4 months (198.2%, IQR: 49.4–272.7%).

Factors affecting the quality of measles 2 data

Table 5 shows that no facility characteristics were significantly associated with the median accuracy of the facility report of Measles 2 data. In the DHIS2 report, significant median (IQR) differences were associated with LGAs (P = 0.002) and frequency of supervision (P = 0.021). Regarding the frequency of supervision, the median (IQR) accuracy ratios were less than 1 month (36.1%, IQR: 3.7–84.3%), between 2 and 4 months (40.0%, IQR: 12.1–282.3%), and greater than 4 months (205.3%, IQR: 91.7–672.8%).

Predictors of the accuracy of RI data

As shown in Table 6, none of the independent variables significantly predicted the accuracy of related RI data.

Qualitative findings

The factors that affect data quality from our findings were the availability of recording and reporting tools, recording errors, reporting errors, data review meetings, supervision, and staffing.

Recording and reporting tools

The recording and reporting tools were available in most facilities despite shortfalls across the state in the preceding year. During the period of lack, service providers improvised the recording and reporting tools. Lack of training when new tools were introduced and

Table 5: Median (IQR) accuracy of Measles 2 data disaggregated by facility characteristics in Enugu state, 2020

Facility characteristics	Facility report	*P*	DHIS2	*P*
LGA				
A	116.2 (103.9-144.8)		21.3 (0.3-59.0)	
B	100.0 (85.7-101.4)		170.5 (72.5-255.3)	
C	100.0 (67.4-120.0)	0.112	185.2 (17.5-257.5)	0.002*
D	100.0 (92.0-117.0)		45.7 (10.5-384.9)	
E	91.2 (18.5-101.7)		39.6 (9.4-161.1)	
F	99.4 (77.1-100.0)		2.5 (23.4-42.1)	
Location				
Rural	100.0 (83.9-116.5)	0.655	38.8 (4.6-202.6)	0.267
Urban	95.2 (74-101.4)		72.4 (26.5-240.0)	
Facility type				
Health post	120.0 (100.9-135.9)		36.6 (7.8-171.8)	
Health clinic	100.0 (50.6-118.4)	0.135	30.4 (0.0-544.3)	0.896
Primary health center	100.0 (78.0-108.2)		49.2 (15.1-212.8)	
Tool availability				
Not available	100.5 (98.7-111.4)	0.206	49.2 (33.1-202.7)	1.000
Available	98.2 (70.7-108.0)		43.3 (1.6-228.9)	
Tool use				
Low use	100.0 (91.2-110.9)	0.420	60.5 (33.2-212.8)	0.508
High use	100.0 (67.4-109.3)		43.2 (0.4-202.5)	
Frequency of supervision				
Less than 1 month	100.0 (81.6-102.4)		36.1 (3.7-84.3)	
2-4 months	100.0 (94.4-126.1)	0.583	40.0 (12.1-282.3)	0.021*
Greater than 4 months	93.1 (37.5-136.0)		205.2 (91.7-672.8)	
Data use for Defaulters				
No	99.6 (18.5-139.0)	0.735	38.0 (6.5-154.3)	0.704
Yes	100.0 (83.7-108.7)		51.3 (10.7-217.8)	
Data use for vaccine tracking				
No	84.3 (0.0−)$^{+}$	0.428	6.2 (0.0−)$^{+}$	1.000
Yes	100.0 (82.2-110.9)		49.2 (14.2-212.8)	

*Significant at $P<0.05$; $^{+}$ 75th percentile could not be computed. IQR=Interquartile range

concomitant use of paper and electronic tools were identified as challenging. "*The problem with that version is that they (service providers) are using the tools they are not trained to use"* (EN2LG2MEO2). **"***We are doing both types of recording; the manual recording, and the electronic recording"* (EN2SPM5). Additionally, the LGA units lack functional laptops and funds to procure data for internet connectivity to support data management.

Recording errors

Missing data, summation errors, illegibility of duplicate copies, and falsification of figures were common occurrences in the facility and DHIS2 reports. The errors were due to the failure of immunization service providers to record immediately after vaccination, counting of vaccines instead of vaccinations, or outright falsification to enhance the image of the facility or claim better performance. "*We have areas where they do the work but fail to capture the data completely* (EN2LG2PHCC2).

Reporting issues

Too many recording and reporting tools to fill, delayed reporting, and non-adherence to reporting timelines were identified by almost all participants as key reporting challenges. *"The challenges we have is that the record books are too many"* (EN2LG1HW1), and "*even after 2 months, 3 months facilities will still be submitting their data. Still, after 3 months, the DHIS2 database will be closed*" (EN2LG2MEO2). Still, delays in data entry into the DHIS2 at the LGA level limited reporting.

Supervision

Supervision of service providers is supportive but irregular and infrequent at both the facility and district levels. Supervisors often cashed in on other funded programs to supervise immunization staff. "*It is only when there is an intervention. Under the normal routine immunization, they (supervisors) do not usually come*" (EN2LG1HW1). "*Though integrated quarterly supportive supervision is supposed to be routine,*

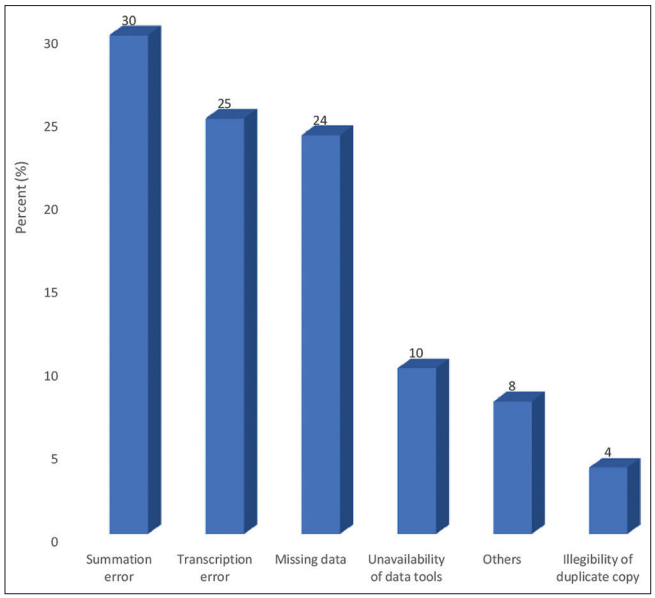

Figure 1: Common immunization data quality errors in Enugu State, Nigeria, 2021

Table 6: Predictors of the accuracy of RI data in Enugu state, Nigeria, 2020

Parameter	Accuracy of BCG Health facility report		Accuracy of Penta 3 DHIS2 report		Accuracy of Measles 2 DHIS report	
	B	Sig.	B	Sig.	B	Sig.
(Intercept)	98.4	0.000	187.92	0.003	753.9	0.135
LGA						
A					−251.2	0.648
B					−168.2	0.756
C					−179.7	0.675
D					749.3	0.129
E					175.0	0.691
F					0[a]	
Location						
Rural	0.8	0.913				
Urban	0[a]					
Frequency of supervision						
<1 month			−76.5	0.288	−511.1	0.209
2-4 months			75.2	0.367	−600.6	0.210
>4 months			0[a]		0[a]	
(Scale)	730.6[b]		40624.9[b]		1151308.4[b]	

because of lack of fund, it can happen once per year" (EN2SPM2).

Data review meeting

Monthly data review meetings, which are opportunities for data validation and feedback, have ceased due to the lack of funds. The transport and refreshment of the meeting participants are not supported. *When we have any issue with data, we call the facility focal persons or the officer-in-charge and ask questions over the phone" (*EN2LG4LIO4*).*

Staffing

Most participants noted that inadequate staffing, uneven staff distribution, absenteeism, and multiple roles of immunization service providers hinder data recording and reporting. Truant staff were reported to be in "*their businesses in the urban areas or living outside the state*" (EN2LG1ME01). Furthermore, immunization service providers participated in all other service delivery activities. The resultant high workload among remnant staff was blamed for the recording and reporting errors. Yet, the lack of financial incentives discouraged health workers from dedicating additional time to data management.

Discussion

The purpose of this study was to investigate the accuracy of RI data and its associated factors at the facility and DHIS2 levels. A double burden of under-reporting and over-reporting in both the facility and DHIS2 reports and the factors responsible for this variability needs further exploration.

Our finding of over-reporting in some facility reports is consistent with over-reporting of BCG,[10] pentavalent (Penta3) vaccine dose 3,[10,12,15,18,19,31] and Measles 2 in prior studies.[12,14,19,21,31] Similarly, other previous studies found under-reporting of BCG,[12] Penta3,[14] and Measles 2[18] in facility reports comparable to our findings. Nonetheless, the median accuracy of the facility reports was within the normal range, indicating that facility reports are reasonably reliable for decision-making and planning of immunization programs.[12,31] Over- and under-reporting in facility reports in this study resulted from missing data, summation, transcription errors, and data manipulation in the health facilities. From our qualitative findings, many health workers have not been trained on the updated recording and reporting tools. Facility service providers did not also consistently record vaccinations on the tally sheets. Equally, some facility service providers counted the vials of vaccines instead of the number of children vaccinated. Yet, the duplicate copies of the tools were not always legible. Furthermore, some facility service providers intentionally falsified data to rectify missing data, enhance the image of the facility, or claim better performance, which have also been reported elsewhere.[12,19,32] Similar to the findings of previous studies,[3] facility service providers in the current study seemed overworked and under-motivated from multiple responsibilities, uneven staff distribution, and absenteeism and saw data recording duties as time-consuming additions to their service delivery responsibilities. Moreover, facility service providers

received infrequent supervision, poor feedback, and missed the opportunities of validating their data at review meetings as were also reported in preceding studies.[3,18,32] To improve the quality of facility reports, there is a need to address the causes of data inaccuracies identified in this study.

Data inaccuracies in DHIS2 were also characterized by under- and over-reporting with extreme outliers. Our finding of under-reporting in DHIS2 is consistent with evidence from previous studies,[3,25,33] whereas the over-reporting is comparable to the findings of earlier studies.[34-36] Nevertheless, our findings differ from a high degree of accuracy in electronic immunization registers reported from high-income settings.[37,38] In the current study, the large discrepancies indicate that the DHIS data cannot be relied upon to plan immunization programs.[22,31] From our qualitative findings, under-reporting in the DHIS2 was due to missing data arising from the non- or delayed submission of facility reports, weak management capacity, and resource constraints. Facility service providers did not always adhere to reporting timelines in the current study as was also found in previous studies.[26,32] Yet, the LGA officials lacked the opportunities to fill the data gaps through supervision and data review meetings. Furthermore, multiple (non-immunization) responsibilities of LGA immunization officers and the lack of digital facilities such as functional laptops and reliable internet connectivity hindered effective data management. Lack of computers and poor internet connectivity have also been identified as key barriers to DHIS2 management at the LGA level.[25,32] However, over-reporting in DHIS2 resulted from a lack of validation of facility reports due to infrequent supervision of facility staff, lack of data review meetings, and irregular supervision of LGA officials. Consequently, LGA officials manipulate data to rectify missing data and or to claim better program performance as was reported in other studies.[34,36] There is a need to address these contextual factors that affect DHIS2 management at the LGA level.

This study adds to the growing scholarship on the quality and usefulness of routine immunization data in LMICs by highlighting the contextual factors needed to improve the accuracy of RI data in Enugu state. However, the findings of this study should be interpreted vis-à-vis some limitations. First, large variations of accuracy ratios as seen in this study imply low precision of accuracy ratios in validating RI data. Second, vaccine doses administered but not recorded cannot be verified and, as such, may have affected the accuracy ratios. Third, lockdown due to the COVID-19 pandemic might have constrained immunization data management during the year of the study. Furthermore, limited archived paper records at the LGA level meant that we could not analyze the accuracy of the LGA routine reports. Moreover, we did not assess the quality of the immunization monitoring system. Future research into the monitoring system would provide useful insights that complement the findings of the current study.

Conclusions

This study has provided evidence that RI data in Enugu state, Nigeria, are not always accurate and might limit data use for decision-making. The facility and DHIS2 reports have a double burden of over- and under-reporting. To improve the quality of data at the facility level, health workers need to be trained on the tools, tally as they vaccinate, count the number of vaccinations, keep legible records, and timely submit their reports. At the LGA level, immunization service providers need to be equipped with functional laptops and a stable internet facility. At both facility and LGA levels, immunization service providers need to desist from data manipulation, limit non-immunization roles, be regularly supervised, and hold regular data review meetings. Finally, the government needs to increase the funding of data-focused supervision and data review meetings, as well as staffing of the primary health care system to improve RI data quality.

Ethical approval and consent to participate

Ethical approval was received from the Health Research Ethics Committee, Enugu State Ministry of Health, Enugu, Nigeria (protocol code: MH/MSD/REC21/182).

Authors contributions

All authors (ODC, GN, OU, NN, EU, and OO) contributed to the conceptualization of the study; ODC, GN, OU, and NN collected the data/carried out the study; ODC and GN analyzed the data. ODC drafted the first manuscript. All authors reviewed and approved the final manuscript for publication.

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Conflicts of interest

There are no conflicts of interest.

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