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Vaccine stock management in primary health care facilities in OR Tambo District, Eastern Cape, South Africa

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ABSTRACT

Background: Poor stock management has been identified as one of the causes of vaccine stock-outs in health facilities. This study assessed the occurrence of vaccine stock-outs and vaccine stock management practices in primary health care facilities in OR Tambo district of the Eastern Cape province, South Africa.
Methods: Descriptive cross-sectional study design was used in this study to assess both the stock management practices and the availability of vaccines in the facilities. The study was conducted in 64 primary health care facilities across all sub-districts in OR Tambo. Data were collected using a questionnaire administered by the researcher, record checks and through observation. The occurrence of stock-outs of six tracer vaccines on the day of the visit and in the preceding 24 months were assessed. The data were captured into REDCap tool and analysed using STATA version 14.
Results: Most standard stock management procedures were not adhered to, as these procedures were mostly handled by health care workers who either required formal training or refresher training on vaccine management. Cold chain capacity was not adequate and some vaccines were exposed to freezing. Both stock cards and the stock visibility solution (SVS) device were used in all the facilities for vaccine stock management. Less than half of the facilities visited 27 (44%) filled their stock cards regularly. Delays in receiving supplies from the pharmaceutical depot were commonly reported by facilities, which contributed to stock-outs. A total of 49 (77%) health facilities had at least one stockout for at least one vaccine on the day of the visit. Furthermore, BCG and OPV were the most affected vaccines in 37 (58%) and 28 (44%) of facilities, respectively.
Conclusion: Interventions for improving vaccine availability should be considered, especially those targeting human resources and the entire stock management system.

1. Introduction

Vaccine stock ssmanagement includes the processes undertaken to ensure that vaccines are continuously available in the right quantities and quality at any point in the vaccine supply chain, including health facilities. These processes include adequate forecasting, recording, monitoring of expiry dates, and proper storage of vaccines [1,2]. Forecasting involves calculating the right quantities to order from the supplying store based on consumption rates of a health facility and based on the target population. The accuracy of quantities ordered depends on the quality of the records of consumption and an adequate knowledge by the person doing the calculation and relevant contextual factors [2,3]. Indications are that a vast majority of primary health care (PHC) facilities in South Africa still use stock cards to manage vaccine stock, and these can be used to obtain monthly usage data [2,3]. Stock cards are paper-based tools used to capture records of transactions of a medical commodity [4]. Accurate records of all stock transactions are essential in ensuring adequate quantities of vaccines throughout the vaccine supply chain [2]. The recording and monitoring of

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expiry dates prevent vaccine wastage, while proper storage ensures that the potency of vaccines is maintained. The national department of health of South Africa published the "Cold Chain and Immunisation Operations Manual, 2015 edition" which is a guideline on standard practices for the management of the vaccines at different levels in the supply chain, including the health facilities. This is a standard national guide for every health worker who is in charge of managing and handling vaccines [2].

Poor stock management has been identified as one of the main causes of vaccine stock-outs in health facilities [2,5–7]. The complete absence of vaccines at the point of service delivery, which is referred to as vaccine stock-out [8], is one of the serious challenges that threaten the success of immunisation programmes [5–7,9–12]. Vaccine stock-outs occur more often and have more impact on populations that dwell in rural areas; the majority of which depend on the public health system for their health care needs [13–15]. Vaccine stock-outs result in repeated and costly visits to health care facilities by health care users before they can access the vaccines. These repeated visits can cause a loss of public confidence in the health system [16]. Furthermore, the children who do not receive their vaccine doses timely are prone to vaccine-preventable diseases, and their communities are also at risk of disease outbreaks [5,6,17].

Reports on vaccine availability and stock management of vaccines in South Africa are quite scarce. There are a few reports that point to significant shortages of vaccines which became more common since the introduction of new vaccines in many parts of South Africa [5,18]. There is limited information on the actual shortages of vaccines; especially in certain parts of the country such as the Eastern Cape Province. One study reported on vaccine stock management practices and stock-outs in another Province in South Africa [5]. Specifically, literature is scarce on the level of availability and stock management of vaccines in OR Tambo district of the Eastern Cape Province, one of the most rural districts in the country. A countrywide survey of vaccine stock-outs have been conducted over four years, between 2013 and 2017 [9,16,19,20]. However, the method employed is through a telephonic survey which may be subject to bias since data collection was done telephonically [21]. We conducted observations and physical counts of the stock levels in health facilities.

This study describes the availability of vaccines and vaccine stock management practices in primary health care facilities in the OR Tambo district. It aims to add to the body of knowledge that will be relevant to inform policies around improving stock management and ultimately preventing vaccine stock-outs.

1.1. Objectives of this study

i. To assess the vaccine stock management practices in selected facilities in OR Tambo district of the Eastern Cape Province of South Africa.
ii. To establish the level and frequency of vaccine stock-outs in OR Tambo district
iii. To determine if there was a significant difference in level and frequency of stock-outs between sub-districts within OR Tambo district
iv. To determine the the causes of stock outs and the association between the presence of pharmacy personnel in the health facilities and the occurrence of vaccine stock-outs

2. Methods

2.1. Study setting

This study was conducted in the OR Tambo district of the Eastern Cape Province. The Eastern Cape is located on the east coast of South Africa and has eight districts Fig. 1. The Eastern Cape province is the second largest in South Africa and one of the poorest [22,23]. The 2016 estimates are that 20.8% of the 7, 061, 700 population of the province lives in OR Tambo District [22]. This district is comprised of four sub-districts; is rural and one of the poorest districts in the country [22]. OR Tambo district depicts a typical resource-constrained area. The district also has a poor terrain, inadequate infrastructure, and because of this, access to some health facilities is a challenge, even for the health workers. The OR Tambo district has a high neonatal and child mortality and a high burden of HIV/AIDS and Tuberculosis. Various initiatives have been implemented to improve provision and the quality of health care services in the district. Some of these initiatives include the e-health strategy, supply chain management reforms and ideal clinic realisation. It is also one of the National Health Insurance (NHI) pilot districts in South Africa.

The supply chain structure in the Eastern Cape follows the pull system, whereby facilities send requisitions or place orders to the pharmaceutical depot based on consumption rates.

2.2. Participants

The sites for data collection were mainly the primary health care facilities where immunisation services are provided. Respondents for this study were nurses, pharmacists and pharmacist assistants who are employed on a full-time basis at each selected facility and involved in the management of vaccines. Each respondent represented a facility. Student nurses and private PHC clinics and their employees were excluded from this study.

2.3. Sample size calculation

Based on the District Health Information System (DHIS), OR Tambo is comprised of 145 health facilities. The sample size was calculated using the open-source calculator, openepi.com, as described below:

Population size (N):145

Hypothesized percentage frequency of outcome factor (stock-outs) in the population (p):50% +/-10

Confidence limits as percentage of 100 (absolute +/- %) (d): 10%

Design effect (for cluster surveys-DEFF):1

Confidence level (%) = 95%

2.4. Study design

We conducted a cross-sectional study to assess both the stock management practices and the availability of vaccines in the facilities. Retrospective record review of stock cards was also used to check for stock-outs that occurred in the last two years. We used probability sampling proportional to size method. This implies that the probability of selection for a sampling unit (sub-district in this case) is directly proportional to a size measure (that is, the total number of facilities in each sub-district). A total of 64 sites proportional to the number of facilities in each sub-district were randomly selected;

The following outcomes were measured:

- The proportion of facilities that reported various stock management practices such as recording and reporting systems, storage practices, management of damaged or wasted vaccines
- The occurrence of vaccine stock-outs: This was measured as the percentage of facilities that experienced a stock-out of one or more vaccines during the study period, precisely the day of the visit to the health facility. The result was expressed as a percentage of the total number of facilities [8].

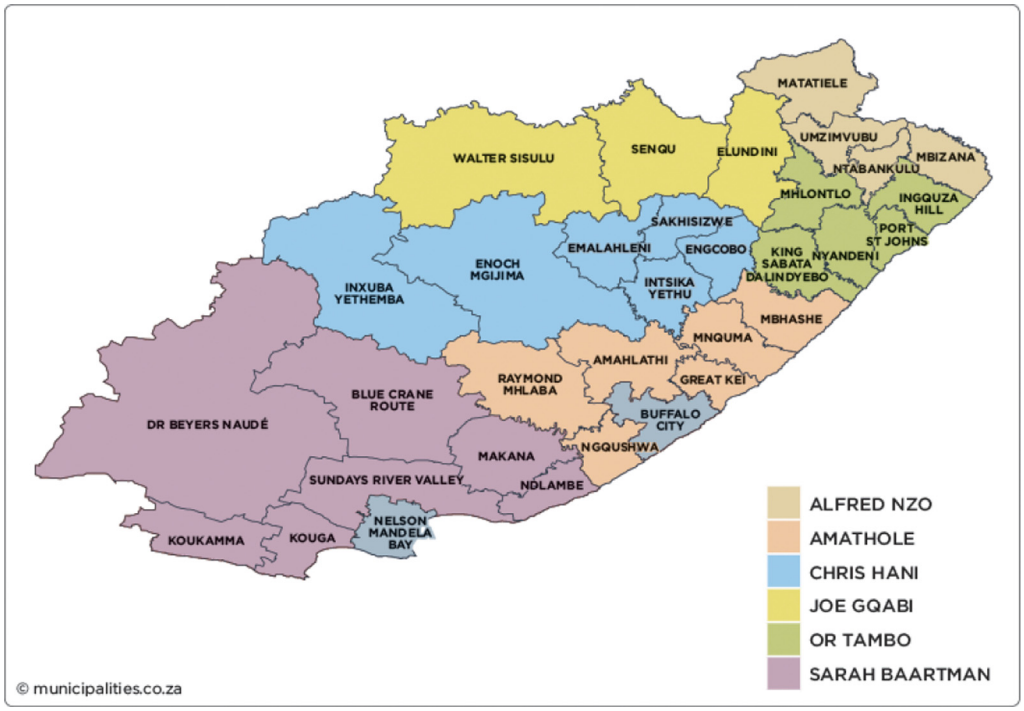

Fig. 1. Map of the Eastern Cape Province showing districts and sub-districts (https://municipalities.co.za/provinces/view/1/eastern-cape).

- Duration (in days) of vaccine stock-outs over two years: 1st February 2017 – 1st February 2019. Duration of stock-outs was calculated from the day the vaccine was not available until the day the new vaccine stock was obtained or the day of our visit.

2.5. Data collection and logistics

Before data collection, ethics approvals from the Research Ethics Committee of the Faculty of Medicine and Health Sciences, Stellenbosch University (S18/08/154), the Eastern Cape Province Department of Health (EC_201810_009) and OR Tambo district. In each facility visited, we sought the consent of participants before collecting data. Data was collected between 25th February to 15th March 2019. Data on vaccine stock management procedures in the facilities were collected using a questionnaire and physical observation of vaccine stock management procedures in the participating clinics. The questionnaire was adapted from the WHO effective vaccine management (EVM) assessment tool [24] (Appendix 2). The questions on stock management procedures focused on following areas; procedures used for stock recording, vaccine ordering and stock delivery, managing and recording of damaged and expired stock, the frequency of inventory, storage arrangements and availability of vaccines. We also checked the vaccine stock records, stock at hand and records of vaccine orders. We verified if the stock cards were consistently used for stock management. The stock cards were also checked to see if they reflected the following: minimum or re-order levels, maximum and current stock levels and vaccines received and issued. Vaccine stock-outs data were collected through physical counts of the six tracer vaccines in the fridges. The vaccines were Bacillus Calmette Guerin (BCG), measles, rotavirus (RV), Pneumococcal Conjugate Vaccine (PCV), Oral Polio Vaccine (OPV) and hexavalent vaccine, a combination of Diphtheria, Tetanus, Acellular Pertussis, Inactivated Polio Vaccine, Haemophilus influenzae type b, and Hepatitis B (DTaP-IPV-Hib-HBV). We assessed the availability of vaccines on the day of visit to the facilities. We also assessed the duration of stock-outs in the last two years (Feb 2017 – Feb 2019). The initial plan was to assess the occurrence of stock-outs and duration for at least three years before and after the introduction of the SVS in order to determine the effects of the SVS on vaccine availability. Unfortunately, we could not find most of the previous years' stock cards. Since most facilities had at most two years records, we collected those data which were available.

Data sets from questionnaires were stripped off all personal information upon completion of data collection. Study data collected on the questionnaire was managed using Research Electronic Data Capture (REDCap) tool hosted at the South African Medical Research Council. REDCap is a "secure, web-based application designed to support data capture for research studies [25].

2.6. Data analysis

Data from REDCap was exported to STATA statistical software, version 14, for analysis. Data were analysed using descriptive analysis. The categorical variables were summarised using frequencies. Association between variables was determined using Fischer's exact test. The continuous variables such as duration of stock-outs were summarised using the median as they were not normally distributed.

3. Results

3.1. Response rate

The calculated sample size for 95% confidence level was 59. However, we visited a total of 64 facilities to increase the significance level of our findings. Of the 64 facilities we set out to visit, two facilities declined, making the overall response rate for this study to be 97% (62/64). These two facilities were replaced with nearby facilities.

3.2. Characteristics of facilities visited in OR Tambo district

All four sub-districts in OR Tambo which have a total of 145 facilities participated in the study. Table 1 shows the number of facilities visited in each sub-district in the OR Tambo district. Table 2 shows the characteristics of the facilities visited; the position of respondents, pharmacy personnel and the type of storage equipment used. There was a total of 28 (44%) pharmacist's assistants in all the facilities visited, 2 (3%) pharmacists and 34 (53%) nurses who were vaccinators or facility managers. Districts with more facilities had more pharmacy assistants. For example, 23 facilities were visited in Nyandeni, and this district had 11 pharmacist's assistants.

3.3. Recording and reporting systems and practices

Both stock cards and the stock visibility solution (SVS) devices were used in all facilities for capturing vaccine stock levels. The stock cards were used to record vaccines movement and utilisation. In contrast, the SVS mobile device was used to report stock levels to the managers at the district, provincial, up to the national levels. Only one facility was found to be using a desktop computer to capture vaccine stock.

The stock cards had sections for the following information: name of the vaccine, dosage form, and strength, quantity ordered, requisition number, to/from where orders were received or transferred to, quantity received, quantity issued, stock balance, unit price and remarks. They also had sections for re-order level, and total monthly issues and consumption levels. However, the stock cards did not have fields for recording batch number, expiry date and Vaccine Vial Monitor (VVM) status of vaccines, in keeping with the standard set in the Cold Chain Manual. Less than half of the facilities visited, 27 (44%) filled their stock cards regularly, at least up to one week before the study. Only nine (14%) facilities had physical stock closely matching with stock on the stock cards. Approximately half (49%) of the facilities had separate stock cards for measles vaccine and its diluent.

Twenty six (43.3%) facilities recorded expiry dates and 32 (50%) facilities recorded batch numbers of vaccines. Even though there were no fields for the batch number of vaccine vials on the stock cards, some facilities made use of the 'remarks section' for this purpose. No facility had records of the VVM status of vaccines on their stock cards because the provision was not made for this information on the stock-cards. There was no other record that indicated the VVM status of vaccines.

The health care workers (HCWs) gave reasons for poor recording practices. Staff shortages were a major contributory factor as this was linked to the inability to fill stock cards and keep them up to date. The use of SVS was another reason why the cards were not filled, as they felt that there was no need to have double entries of vaccine stock levels. This may have also been linked to staff shortages. Thirdly, high staff turnover and institutional memory loss could have contributed to poor recording practices. For example, when a HCW was transferred out of a facility, he/she failed to transfer cards/records to the new staff who takes over. Lastly, many facilities had undergone renovations or moved to new facilities and many of these cards were lost in the process. Lack of training of the HCW on stock management practices contributed to their inability to calculate the minimum and maximum stock levels.

Table 1
Number of facilities visited in OR Tambo district.

Sub-district	Number of facilities visited
KSD	21 (32.8%),
Nyandeni	23 (35.9%)
Quakeni	7 (10.9%)
Mthlontlo	13 (20.3%)

3.4. Knowledge and record of maximum and minimum stock levels on the stock cards

Among facilities visited, 31(49%) of respondents understood the concept of maximum and minimum stock levels. Furthermore, it was observed that 24(39%) and 25(40%) of facilities, recorded minimum and maximum stock levels on stock cards, respectively.

3.5. Vaccine ordering and lead/response time

The requisition booklets were used in all the facilities for placing orders to the pharmaceutical depot. We sought their responses regarding the response time, that is, how long it took for the facilities to receive supplies from the pharmaceutical depot once an order is placed. Facilities reported they experienced delays: 45 (77.6%) facilities reported that lead time took between one to three months; 10 (17%) reported that their lead times ranged between two to three weeks. All facilities reported that they placed an emergency ('special') orders while waiting for their main supplies from the depot. Special orders are generally for a maximum of five items, and these are usually made whenever there is an urgent need for items while waiting for bulk orders to be supplied by the depot. The working norm is that a person from the facility placing a special order goes to the depot to pick and collect the special order. As a result, special orders were received on the same day. Also, some facilities had to send their pharmacist's assistants to pick their bulk orders. If this did not happen, the lead time was longer than two or three months. It was also observed that most facilities placed special orders weekly and, in many facilities, the understanding and the standard was that special orders are routine and are placed weekly.

Twenty-six (42%) facilities reported that the depot reduced the amounts they ordered. The vaccines mostly reduced were BCG and OPV. Other vaccines were reduced depending on the availability at the depot. Also, in most instances, the facilities did not receive matching quantities of measles vaccine and its diluent. A few facilities did not know that they had to order measles diluent separately.

3.6. Reasons for long response times from the pharmaceutical depot

On the issue of long response time from the depot, we had a conversation with the staff of the depot. They highlighted the following reasons why facilities experienced delays with their orders; the primary reason being the backlog of orders at the depot. Staffing issues caused these backlogs. The discussion elicited the fact that the depot was experiencing staffing challenges coupled with the ongoing renovations, which made working conditions a problem.

Another concern expressed by the depot officials was the 'erratic' orders from the facilities. The facilities made inconsistent orders, sometimes very high and sometimes low, which could be attributed to their inability to calculate their maximum and minimum stock levels. Also, some facilities tend to order in excess from the depot when there are issues of undersupply to the depot. As a result, the stock levels at the depot may not be enough to serve other facilities. Delays were also caused by shortages from the suppliers. Other reasons reported were delays in procurement on their part, which relates to the staffing issues. Furthermore, the electronic stock management system malfunction sometimes occurs, causing delays in procurement by the depot and eventually resulting in longer response time for the facilities. The depot staff high-

Table 2
Characteristics of facilities visited in OR Tambo district.

	Pharmacy personnel				Position of respondents				Type of storage equipment			
Sub-district (number of facilities visited)	Pharmacist	Pharmacy assistant	Both	None	Pharmacist's assistant	Pharmacist	Vaccinator	Facility manager	Vaccine fridges (chest like)	Vaccine fridges (upright)	Glassdoor	Ordinary domestic
KSD (n = 21)	0	7	1	13	6	1	12	2	5	4	0	11
Nyandeni (n = 23)	0	11	0	12	9	0	8	6	6	2	0	9
Quakeni (n = 7)	0	4	0	3	4	0	1	2	3	1	1	3
Mthlontlo (n = 13)	1	6	0	6	5	1	4	3	3	8	0	3
Total N (% of 64)	**1 (2%)**	**28 (44%)**	**1 (2%)**	**34 (53%)**	**24(3%)**	**2 (3%)**	**25 (39%)**	**13 (20%)**	**17(27%)**	**15 (23%)**	**1 (2%)**	**36 (56%)**

lighted a gap in communication between the depot and the facilities as one of the contributing factors for delays and inefficiencies in supplying the facilities with their needs.

3.7. Assessment of storage practices in the facilities

The policy of the department of Health, as stated in cold chain manual [2] and the good pharmacy practice in South Africa [3] manual, advises that every facility should have standard vaccine storage equipment. However, where domestic fridges are used, the temperature must be kept between 2 °C and 8 °C and monitored regularly with a thermometer. In addition, temperature readings should be taken twice daily; first thing in the morning and last thing in the afternoon on a working day [2]. It also stipulates the level of ice in the freezer compartment when the fridge should be defrosted [3].

Upon observation, 36(56%) of the facilities had domestic fridges in the facilities, either used alone or in combination with the standard ones. The first to expire first out (FEFO) principle was practiced in 41(73%) facilities. Of the 36 facilities that use domestic fridges, 8(22%) store vaccines in the vegetable drawer. There were expired vaccines in 6 (11%) of facilities, although these had just expired upon our visit. The expired vaccines were mostly the hexavalent vaccine. Eleven (20%) facilities had frozen vaccines whereas 9 (15%) facilities had vaccines that had reached the VVM discard point. Most of the frozen vaccines occured in the domestic fridges. The quantities of measles vaccines and their corresponding diluents matched in 16 (29%) facilities.

3.8. Disposal ***of damaged or expired stock***

According to the cold chain manual, all facilities are required to report expired and damaged stock as avoidable wastage. Stock damaged by heat or freezing must also be reported as avoidable wastage [2]. The responsible staff is expected to notify the supervisor immediately. Standard Operating Procedures should then be followed to ensure that all damaged vaccines are identified and that none of this damaged vaccine is distributed or used. When the respondents were asked if they knew the procedure to follow for managing vaccine wastage, half 32(51%) reported that they knew how it is done. Thirty-seven facilities (59%) reported that they had records of wastages. However, upon verification, no facility had a comprehensive report of vaccine wastages in the previous year.

When the respondents were asked to explain the procedure for managing damaged vaccines, the responses varied among respondents. Most of them reported that they filled the 'incident form' firstly before disposing the expired or damaged vaccines into the waste bucket which were picked up by a private waste disposal company. Other respondents said they would phone the district pharmacist who would pick damaged items up, after filling the waste indicator forms. Most of them reported that they hardly experienced wastage; they experienced stock-outs more than wastages. We also asked if they knew how to calculate vaccine wastage, 30(49%) said they did. Also, 38(67%) facilities reported that they did not know that they were supposed to report wastages to managers.

Table 3
Percentage of facilities reporting stock-outs per sub-district on the day of visit.

Sub-district Total number of facilities (N)	n (%)	95% CI
KSD (N = 21)	18(86)	63–96
Nyandeni (N = 23)	19(83)	61–94
Sub-district 3 (N = 7)	2(29)	6–70
Sub-district 4 (N = 13)	10(77)	46–93
Overall stock out n (%)	**49 (77)**	**64 – 86**

Table 4
Occurrence of vaccine stock-outs in the facilities on the day of visit.

Vaccine	Number of facilities with stock-outs	Percentage of facilities (95% CI)
BCG	37	58% (45–70)
Measles vaccine	8	13% (6–23)
Rotavirus vaccine (RV)	9	14% (7–25)
Pneumococcal conjugate vaccine (PCV)	3	5% (1–13)
Hexavalent	3	5% (1–13)
Oral Polio vaccine (OPV)	28	44% (32–56)

Table 5
Duration of stock-outs of vaccines in the primary health facilities in OR Tambo in the last two years (Feb 2017 – Feb 2019).

Vaccine	Median days	Interquartile range, Q1-Q3
BCG	167	71–299
Measles	44	1–74
Rotavirus	61	21–80
Hexavalent	72	27–151
PCV	85	33–140
OPV	103	60–210

3.9. Availability ***of vaccines in the facilities in OR Tambo district***

A total of 49 (77%) health facilities had a stockout of at least one vaccine on the day of the visit (Table 3). Table 3 shows the occurrence of vaccine stock-outs on the day of the visit across each sub-district. KSD had the highest occurrence of stock-outs at 86%, while Quakeni sub-district had the lowest occurrence, at 29%. The Pearson's chi-squared test for the difference in the occurrence of stock-outs across the sub-districts yielded a p-value of 0.02. implying a significant difference in the occurrence of vaccine stock-outs across the sub-districts. The differences observed could be attributed to the different sample sizes for each sub-district. The sub-districts with high number of facilities visited experienced more stock-outs.

BCG and OPV were the most affected vaccines with 37 (58%) and 28 (44%) facilities experienced the stockouts of these vaccines, respectively, on the day of the visit. Amongst the newer vaccines, nine (14%) facilities had stock-out of Rotavirus vaccine, similar to eight (13%) facilities with stock-outs of Measles vaccines on the day of the visit (Table 4). However, in the last two years (February 2018-February 2019), apart from BCG and OPV having the longest median duration of 167 and 103 days, respectively; amongst the newer vaccines PCV experienced the longest duration of stock-outs, at 85 days. Table 5 shows the median duration of vaccine stock-outs in the affected facilities.

The Fisher's exact test for association between the presence of pharmacy personnel (pharmacy assistant or pharmacist or both) and the occurrence of stock-outs yielded a p-value of p = 0.2. Therefore, there was no association between the occurrence of vaccine stock-outs and the presence of any pharmacy personnel. In other words, stock-outs occurred regardless of the presence of the pharmacist's assistants and pharmacists.

4. Discussion

This study describes the stock management practices in primary health care facilities in OR Tambo district, Eastern Cape, as well as the occurrence of vaccine stock-outs. The response rate achieved in this study (97%) is in line with the 2014 Stop Stockout Project (SSP) survey conducted in South Africa, where 98% responded to the survey [16]. This high response rate increases the validity and generalizability of the findings to the entire district [26]. Our findings on the status of vaccine availability in the primary health facilities in the study area indicate that a high proportion of facilities experience vaccine stock-outs. The level of stock-outs in this study (77%) is much higher than that of another study conducted in another province in South Africa, where 29% of facilities experienced vaccine stock-outs [5]. Other countries have also reported a much lower proportion, such as 8% in Ethiopia; 51% in Kenya [27] and 6.7% in Tanzania [28]. Similarly, our findings indicate much higher levels of vaccine shortages than those of the stop stockout project (SSP) in the Eastern Cape, where the authors used a phone in method. According to the SSP 2016 reports, 14% of facilities in the Eastern Cape reported stock-outs of vaccines on the day the telephonic survey [18]. The proportion of facilities that reported stock-outs of hexavalent vaccine in this study (5%) is almost similar to that of the 2017 report by the SSP [20]. However, the occurrence of stock-outs of rotavirus (4%) and measles vaccines (2%) as reported by the SSP in 2017 are much lower than in this study where we found 14% and 13% respectively. The stock-out data from this study was based on physical counts, while the SSP was based on a telephonic survey. The most affected vaccines were BCG and OPV, and other studies have reported the same [29]. The stock-out of BCG could be related to global shortages that have been ongoing since 2012 due to problems with procurement combined with high demand [30,31].

Most of the facilities visited seemed reluctant to fill stock cards. A vast majority of stock cards were not updated; minimum and maximum stock levels were neither recorded on the cards nor used as a basis for ordering of vaccines. Most of the participants lacked adequate knowledge of the standard procedure for ordering vaccines. Although not explicitly asked in many facilities, there was an indication that few pharmacist's assistants had special training on vaccine management. According to the national department of health cold chain manual, the minimum levels and maximum levels of vaccines need to be set for every vaccine in order to adequately quantify needs and aid in determining quantities to order [2]. The minimum stock level is the level below which vaccine stocks should never drop without having placed an order. It is the amount of stock that will be used in the time between placing and receiving an order plus the reserve or safety stock that is kept for emergencies and unanticipated demand or delivery delays [2,32]. Setting the minimum stock levels for every vaccine guards against experiencing shortages or stock-outs in the facilities. The maximum stock level, on the other hand, is set to guard against oversupply, which results in the avoidable wastage of vaccines when they expire before use. The maximum stock level is the amount needed to meet demand until the next order is received, considering factors that play out between placing of orders and receiving them. For example, lead time, delays etc. [2]. Both maximum levels and minimum stock levels are calculated from historical stock data, which is usually obtained from the stock cards.

When stock cards are not regularly updated, historical data needed for decision making is not available, and the facility runs the risk of stock-outs or overstocking. Lak of accurate data results in ordering chaos, wasted trips to the depot, and probably avoidable wastage, suggesting serious deficiencies in staff training and supervision. There is a need to urgently resolve these deficiencies. There are also other similar reports where health facilities are not able to quantify their needs and keep updated stock records [15,33–36]. It is, therefore, as a matter of urgency for policymakers to consider replacing the stock cards with electronic stock management systems, a necessity in the 21st century. For example, the Rx solution, a software which is mostly used in hospitals should be adapted in the primary health care facilities. The Rx solution has advantages over the paper-based system of stock management, because there is better tracking of stock movement, including batch numbers and expiry dates of medicines. Also, there is auto-

mated ordering of vaccines; the Rx solution can automatically recommend quantities of items to be ordered based on historical data [37–39], which is not easily obtainable with the stock cards. This can solve the challenges of improper forecasting. It will be essential to harmonise the functions of both the Rx solution with the SVS to avoid duplication of efforts for health workers; by designing a single system for stock management in the facilities and reporting of stock levels to the managers.

The depot faces some challenges which complicate the challenges faced by the facilities and the weakness of the system, resulting in delays in delivery of the supplies to facilities. The facilities reported that there are frequently delays of up to 3 months in the delivery of supplies from the depot. It appeared that facilities that had transport and had a pharmacist's assistant to go to the depot to pick their orders were in a better position to ensure the adequacy of stock.

The depot confirmed the reduction of orders sent by the facilities and the reason is that they perceive that the facilities order more than their needs, in anticipation of stock-outs. The depot reduces orders in order to conserve stocks and ensure that the available stock is enough for other facilities. Excess ordering could occur when there is a sudden increase in demand from the facilities, in cases of outbreaks, for example, where the facilities will need to perform immunisation campaigns. All the issues highlighted above, including staff shortages, adjustments of quantities ordered by facilities (which was also reported in a previous study conducted in this same depot in 2013), imply that these challenges have been persistent [40]. A qualitative study conducted in one of the provinces of South Africa highlighted a gap in communication as one of the factors that influence stock management in the health facilities [41]. The communication between the depot and the facilities must be strengthened in order to solve these challenges.

Human resource constraints have been identified to be one of the significant causes of supply chain-related problems [42], including poor stock management [5,43–45]. This is probably one of the reasons for poor stock management noted in this study. Vaccine stock management was handled by nurses in facilities where there were no pharmacy assistants. As with other studies, there were more facilities with nurses responsible for pharmaceuticals, and fewer had pharmacy assistants in the facilities visited [5,41,46]. Generally, nurses were not trained in vaccine stock management; they might have been merely orientated.

The issue of nurses taking up the responsibility of managing pharmaceuticals is a challenge because it interferes with their primary clinical duties in the facilities. Nurses feel overwhelmed by the excess workload that comes with management of pharmaceuticals [5]. It is therefore essential to recruit more pharmacist assistants who will be dedicated to the stock management of vaccines and other medicines. On the other hand, the policymakers may consider proper training and refresher training for the nurses on the management of pharmaceutical. Such training should have specific focus on management of vaccines since these have specific qualities and requirements. One option could be to include management of pharmaceuticals as part of the compulsory professional development for nurses [41].

Vaccines are meant to be administered well before their expiry date is reached. The vaccines and diluents must be arranged in such a way as to maintain the FEFO stock management system [2,32]. Most facilities understood and adhered to this principle as compared to another study where none of the facilities was adherent [47]. There were more domestic fridges than the vaccine fridges in the facilities visited, as it is the case in most facilities in South Africa [2]. The number of domestic fridges in the facilities was more than what was reported in another study [47]. The use of the domestic fridges may partly explain why some facilities had frozen vaccines. Ideally all facilities should use the standard vaccine refrigerators, but when domestic fridges are used, it is expected that the temperatures are monitored regularly [2]. The use of domestic fridges is because of resource constraints. Still, policymakers must invest in proper storage equipment to avoid accidental and not so infrequent freezing of vaccines in health facilities.

5. Conclusion

Significant stock-outs occurred in the primary health care settings in the OR Tambo district. These stock-outs were linked to poor vaccine stock management, particularly in the area of record-keeping and quantification of needs. Stock-outs were also associated with and aggravated by long lead times experienced by the facilities and a gap in communication between the supplying depot and the facilities. There is a need to explore multipronged and context-specific interventions that could be used to improve vaccine stock management in primary health care facilities, and ultimately reduce stock-outs. These interventions should target the entire supply chain system, human resources and tools used for stock management in the facilities. There is therefore a need for an urgent recruitment drive to fill staff vacancies at the facilities with qualified people and at the medical depot, should it be necessary. Also, there is a need for the urgent establishment of an integrated electronic stock management system for vaccines, medicines and medical devices at depot and health facilities. There should be extensive retraining of depot and facility staff in all aspects of stock management, especially to reduce vaccine stock-outs by ensuring that all required vaccines are available consistently in all health facilities throughout the year. Finally, it will be useful if a reliable system of periodic supervision, mentoring and support to maintain appropriate knowledge and practices among depot and facility staff is established.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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