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Research Article

Laboratory Sample Collection Errors at Namibia Institute of Pathology Among State Doctors and Nurses, Erongo Region, Namibia

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Abstract

Clinical laboratory is the epicenter of health care sector and because patient management depends on the laboratory services, it is significant that the quality of these services is guaranteed. However, in the laboratory setting, blood specimens may be rejected for a variety of reasons, which may have substantial clinical consequences for the patient safety. The pre-analytical phase which is outside of the laboratory and beyond the control of the laboratory professionals has been highlighted as the leading contributor of diagnostics errors rates, accounting for 70% of errors in the laboratory. This study aimed to determine the major causes of pre-analytical errors because of sample collection among clinicians in Erongo Region.

The cross-sectional quantitative study was conducted among the state doctors and nurses at district hospitals in Erongo Region with a sample size of 14 doctors and 153 Nurses. The study further assessed the data of sample rejections recorded at the four of the Namibia Institute of Pathology (NIP) laboratories within the Erongo region, in 2020 and 2021. The data was collected and analyzed using Statistical Package for Social Science (SPSS) 25.0 program.

During the two year period (2020–2021), NIP Walvis Bay had a significant improvement (38.4%) of sample rejections in 2021 as compared to 2020, however, the laboratory recorded the highest rejection rates in comparison to the other laboratories in the region. Missing specimen/ no specimen received had been the most predominant reason for sample rejections among the laboratories in the region accounting for 21.2% and 28.5% of rejected samples in 2020 and 2021 respectively. Lack of specimen collecting materials had an influence on the sample rejections.

To reduce the sample rejections, NIP need to focus on strengthening the relationship with the clinicians by constantly providing adequate training and education and ensure the availability of sufficient materials required in the collection of patients' samples by the district clinicians. It is further recommended that the clinicians engage or consult with the laboratories to seek clarity on the collection and handling of samples to avoid more sample rejections.

Keywords: Pre-Analytical Errors; Sample Rejections; Rejection Rate; Sample Collection; Specimen

Introduction and Background

Clinical laboratory is the epicenter of health care sector and because patient management depends on the laboratory services, it is significant that the quality of these services is guaranteed [1,2]. The services of a clinical laboratory play an essential role as they provide data from the analysis of human body fluids that is used in the diagnosis and treatment of patients [7]. Laboratory testing is a

highly complex process called the Total Testing Process (TTP) and is sub divided into three phases: pre- analytical phase, analytical, and the post-analytical phase [3-5]. The mistakes that occur in the TTP are therefore called laboratory errors and may be due to individual or system design flaws [4,5].

During the past years, more attention on quality methods and assessment has been paid to the analytical testing process, however, it was recently demonstrated that most errors in TTP actually occur in the pre-analytical and post-analytical phase with majority of the errors originating in the pre- analytical process [4,6]. In a study by Plebani, (2012) it was indicated that currently, pre-analytical errors account for approximately 70% of all errors that occur in the laboratory. These errors are made by physicians, nurses and phlebotomists who are outside the boundaries and control of the laboratory [5]. The frequent mistakes in the pre-analytical process occur during patient preparation and sample collection [2,8].

With the above mentioned, it is therefore, of great importance that quality in the laboratory is assured throughout all the phases and correctly performed to guarantee effective patient care. This can be achieved by using quality indicators to collect and analyze data in a systematic and consistent way and by paying the most attention to the areas that have an important impact on patient centeredness and health outcome [2]. In order to reduce errors in TTP, the pre-analytical phase should therefore be made priority [4].

Moreover, guidelines for collection of samples and evaluation of submitted specimens are crucial as acceptance of improper specimens sent to the laboratory for analysis may lead to erroneous information that can have a negative impact on patient health care. However, this can only be achieved if there is a constant monitoring of rejected specimens and by identifying the factors that are associated with the specimen rejection, can we avoid mistakes and thus, promote continuous quality improvement of laboratory services.

Measuring and improving laboratory related patient outcomes requires methods that relate to the whole quality of laboratory information to more effective patient management with the inclusion of diagnosis, treatment of disease, clinical monitoring as well as prevention of diseases [12].

Namibia Institute of Pathology (NIP) is a medical laboratory that offers laboratory services from its 39 established laboratories to state and private clients throughout the country. All NIP laboratories offer basic routine tests, certain specials tests are only done in selected and referral laboratories in Windhoek and a few of the tests not done at NIP laboratories are referred to other accredited laboratories in Namibia and South Africa. In order to ensure quality results that are highly influenced by collection and handling of specimens, NIP has developed the NIP laboratory service manual to serve as a guide for all clinical, nursing and laboratory professionals countrywide on how to correctly and adequately collect and handle specimens for laboratory testing [20].

One of the main content outlined in the NIP service manual is the rejection of specimens, which is an area of concern especially that it occurs outside the control of the laboratory. These rejections are recorded in the laboratory owing to incorrect collection methods for specimen, incomplete information filled in on the requisitions forms or specimen or the Tuberculosis (TB) testing algorithm is not followed and even when there are service interruptions due to stock outs [20].

Research methodology

The study is a cross-sectional quantitative study that was conducted among the health care workers at district hospitals in Erongo region. It is a retrospective study as the study assessed the already available data by performing gap analysis to analyze the specimen rejection statistics in Erongo region from 2020 and 2021. The study analyzed the number of pre-analytical errors as a result of improper sample collection and handling recorded at the NIP laboratories at the district hospitals in Erongo region and therefore the causes of such errors as well as determined possible intervention for these errors during the same study period. These errors were analyzed from the response provided from the checklist that contained a standard specimen rejection criterion and was utilized in the study as an assessment tool to assess the frequency of each type of error. The second part assessed the knowledge and practices of nurses and doctors of the district hospitals on the collection ad handling of samples.

Results

The total number of specimens received, the number of rejected specimen, and the number of accepted specimen, reasons for rejection in addition to their rejections rates for each component were examined over 2020 to 2021 study period. The data was entered on Microsoft Excel, cleaned, coded and edited for inconsistencies and then analyzed using SPSS version 26 to generate Frequencies and proportions. Additionally, descriptive

statistics was used to present the data as tables and charts and chi-square was used to find the relationship between demographic profiles and knowledge.

Descriptive statistics

Demography

The demographic profile of the investigated healthcare workers is shown in table 1 below. A total number of 129 health care workers (doctors and nurses) from district hospitals in Erongo participated in the study, with Walvis Bay hospital representing 41(31.8%) of the participants.

Variables	Frequency	Percent	Cumulative Percent
Districts			
Omaruru	32	24.8	24.8
Swakopmund	35	27.1	51.9
Usakos	21	16.3	68.2
Walvis Bay	41	31.8	100.0
Total	129	100.0	
Professional title			
Doctors	19	14.7	14.7
Nurses	110	85.3	100.0
Total	129	100.0	
Gender			
Female	97	75.2	75.2
Male	32	24.8	100.0
Total	129	100.0	
Age (years)			
≤ 20	1	.8	.8
21 - 30	58	45.0	45.7
31 - 40	52	40.3	86.0
41+	18	14.0	100.0
Total	129	100.0	
Work experience			
≤ 6 months	6	4.7	4.7
1 - 5 years	65	50.4	80.6
6 - 10 years	24	18.6	99.2
> 10 years	33	25.6	30.2
Not indicated	1	.8	100.0
Total	129	100.0	

Table 1: The demographic profiles of the participants.

Of these 129 participants, 85.3 % (110) were nurses and 14.7% (19) were doctors. Females accounted for 75.2 %, while the male participants accounted for 24.8%. The age groups of the participants ranged from less than or equal to 20 years to more than 41 years of age, with participants from 21-30 years and 31-40 years age group representing 45.0% and 40.8% respectively. Work experience ranged from less than or equal to 6 months to more than 10 years, and half (50.4%) of the participants have worked for 1-5 years and 4.7% of the participants worked for less than 6 months.

Administrative

Laboratory requisition form accompanies the collected clinical specimen and therefore, a fully completed requisition form is crucial for proper patient identification. The data of the investigated Health Care Workers (HCWs) on who completes the NIP requisition forms at the district hospitals in Erongo region are shown in figure 1 below.

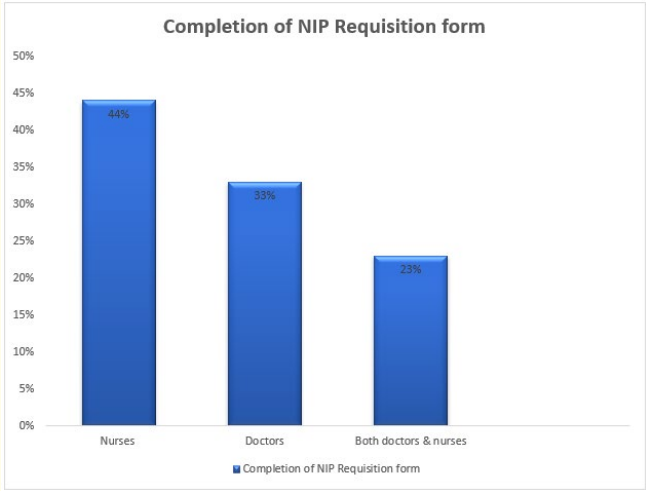

Figure 1: Frequency of participants who complete NIP requisition forms.

The data collected from the 129 participants in the region, indicated that the Nurses (87/129) are more involved than Doctor (72/129) in completing the NIP requisition forms in Erongo region. Out of these 129 health care workers, 57 (44.2%) of the HWS indicated that nurses complete the requisitions forms at

the district's hospitals in Erongo. Of these health care workers, 42 (32.6%) of the participants indicated that the doctors are the ones that complete the NIP requisition forms, while 30 (23.3%) indicated that both nurses and doctors complete the requisition forms together as shown in figure 1.

An easy to understand requisition form, enables users (HCWs) to optimally fill in all the required information that is necessarily for patient management. On the question regarding how user-friendly the NIP requisition form currently in use is, the responses of the HCWs at the district hospitals in Erongo region are shown in figure 2 below.

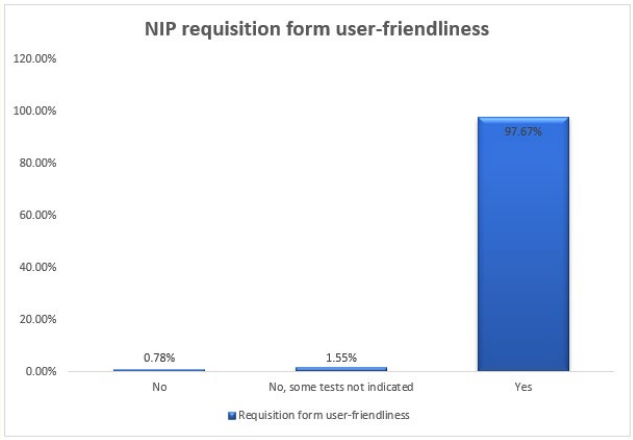

Figure 2: Frequency distribution of participants by requisition form user-friendliness.

The participation in Erongo region shows that 97.7% of the participants indicates that the requisition form in use is user-friendly and 2.4% indicated that the form is not user-friendly as per figure 2 above. Out of the 2.4% that have indicated that the requisition form in use is not user-friendly, 1.55% of these participants said that the form is not user-friendly due to that some of the tests that are requested by the doctors are missing on the form.

Specimen collection, storage and transportation

Specimen collection

The collection of patients' samples in Erongo region is done by the HCWs outside the laboratory. The investigation results of the HCWs regarding the collection of the specimens from patients at these district hospitals for the NIP laboratories in Erongo region is depicted by the figure 3 below.

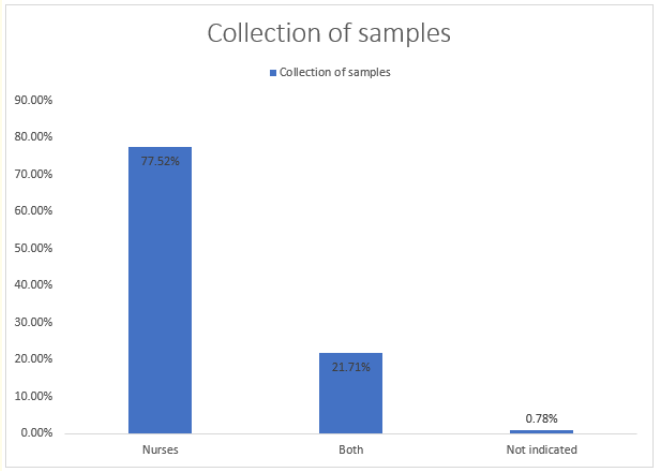

Figure 3: Frequency distribution of participants by collection of specimens.

In Erongo region, 77.52 % of the participants indicated that it is mostly nurses that collect samples from patients. These are the samples that are sent to the laboratories for analysis. Among the 129 HCWs that were recruited in the study, 21.71% of the participants in the region stated that both the doctors and the nurses collect the samples from the patients for analysis. 0.78% of the participants had no response on who collects the samples from the patients.

The data of HCWs in Erongo district hospitals regarding their knowledge of the NIP rejection criteria are shown in the figure 4 below. The investigation was done to establish the number of HCWs who have knowledge and those without knowledge on the conditions under which the samples are deemed unacceptable for analysis.

Nearly half (46.51%) of the 129 participants in the region who took part in the sudy are not aware of the NIP rejection criteria which is a list of all possible conditions that can used to justify the nullification of a sample. The remaining participants which represents 53.49% of the 129 participants who were recruited in the study have indicated a positive response towards knowing about the NIP rejection criteria (Figure 4).

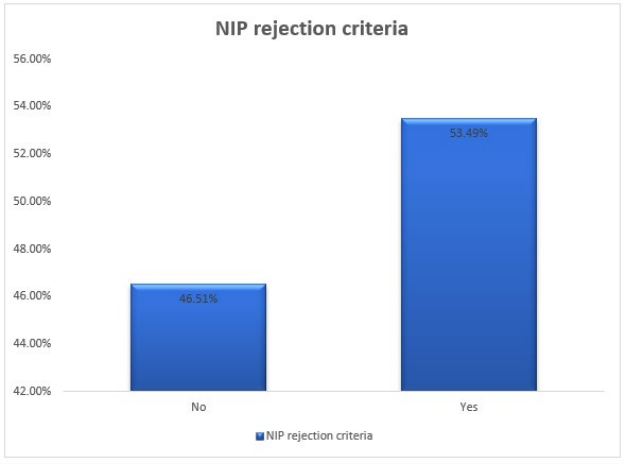

Figure 4: Health Care Workers awareness of NIP rejection criteria response.

The awareness of healthcare professionals in the region on the NIP service handbook is presented in the figure 5 below. A service handbook is a guideline for sample collection and handling requirements that NIP has put in place to guide the HWCs in proper sample collection and handling to avoid sample rejections.

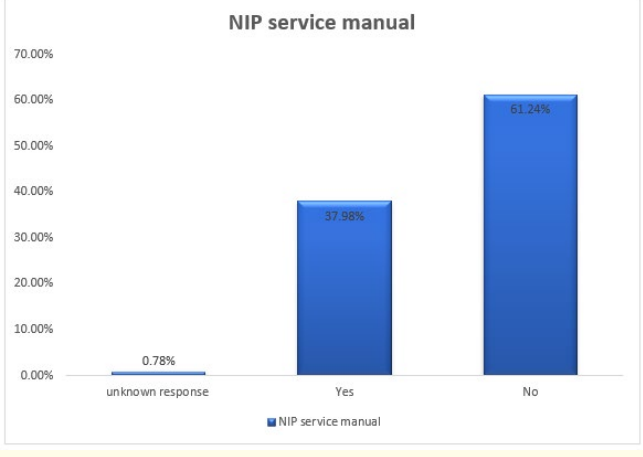

Figure 5: Distribution of participants by awareness of NIP service manual.

Most of the participants (61.24%) in Erongo region have no knowledge of the NIP Service manual. Among the 129 participants, only 37.96% of the participants are aware of the NIP service manual in the districts within Erongo region. 0.78% of the participants have not indicated their awareness of the NIP service manual as presented in figure 5.

The data from the participants on their knowledge regarding the requirements of mixing techniques, test tubes, sample volume, and sample rejection are shown in the figure 6 below. The analysis will establish which identified criterion HCWs has more knowledge on and the one with the least knowledge.

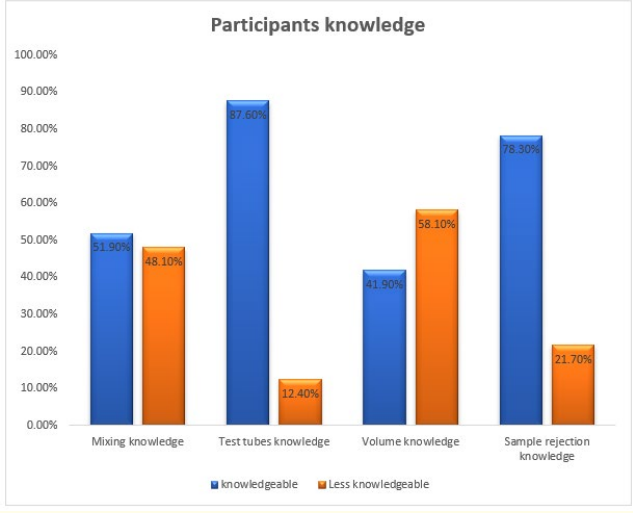

Figure 6: Distribution of health care workers by knowledge of mixing techniques, test tubes, sample volume and sample rejection.

The participants are significantly knowledgeable on the test tubes, with 87.60% of the participants knowing which tubes to use for specific tests and only 12.40 % of the participants are not knowledgeable on the test tubes as shown in figure 6. 78.30% of the participants are knowledgeable on the sample rejections while 21.70% are less knowledgeable. Nearly half (51.90%) of the participants know the mixing technique of the tubes when collecting blood, while the remaining 48.10% do not have knowledge on how to mix the tubes during blood collection. The category with the least understanding was seen with the test volume knowledge where more than half 58.10% do not have knowledge on the volumes required for testing and only 41. 90% of the participants know the volumes needed for the test tubes.

Storage and transportation of specimen

In order to preserve the integrity of the specimen and guarantee that analysis yields high-quality results, samples must be stored properly. Participants were asked how they preserve the samples while waiting to be transferred to the laboratory. The information on clinical specimen storage at the district hospitals in the Erongo region is shown in table 2 below.

	Frequency	Percent	Valid Percent	Cumulative Percent
Box	2	1.6	1.6	1.6
Cool dry area	1	.8	.8	2.3
Freezer	1	.8	.8	3.1
Fridge	27	20.9	20.9	24.0
Fridge, hamper	2	1.6	1.6	25.6
Hamper	75	58.1	58.1	83.7
Fridge/room temp	1	.8	.8	84.5
Hamper, Room temp	1	.8	.8	85.3
In specimen bag	3	2.3	2.3	87.6
Not known	13	10.1	10.1	97.7
Room temp	2	1.6	1.6	99.2
Wooden box	1	.8	.8	100.0
Total	129	100.0	100.0	

Table 2: Storage profile of samples in Erongo region.

The frequent way of storing samples while waiting for transportation to the laboratories within the district hospitals in the region were indicated to be in a specimen hamper, accounting for 58.1 % of the participants indicating as such. It was only 20.9% of the HCWs in this study indicated that they store the samples in the fridge, while 1.6% of the participants indicated that a box was used, and another 1.6% indicated that both the fridge and hamper were used to store samples, while another 1.6% indicated that the samples are kept at room temperature. There was also one participant which representing 0.8%, who indicated that both fridge and room temperature, hamper and room temperature, cool dry area, Freezer, and wooden box are used for sample storage while waiting for the samples to be taken to the laboratory. It was also shown that 13% of participants have indicated that they do not know how the samples are stored before being delivered to the laboratory (Table 2).

Information from the participants on the method used to transport specimens from the local hospital in the region to the local laboratory is shown in table 3 below. It is imperative to note that specimen from the hospital to the laboratory is transported under well controlled environment.

A total of 115 participants stated that the specimens that are collected at the hospital are transported to the laboratory packed in a hamper as depicted in the table 3 above. This represents 89.1% of the participants as presented in table 3. 13 participants giving a percent of 10.1% have shown that the do not have knowledge of how the specimens are transported from the hospital to the laboratory. 0.8% (1) participant showed that a vehicle is used to transport the specimen to the laboratory but have not indicated how the cold chain is maintained during transportation.

	Frequency	Percent	Cumulative Percent
In hamper	115	89.1	89.1
Not known	13	10.1	99.2
Vehicle	1	.8	100.0
Total	129	100	

Table 3: Frequency distribution of specimen transportation in Erongo region.

Discussion, Conclusion and Recommendations

Discussion

Prevalence of pre-analytical errors during sample collection by clinicians

The study evaluated the sample rejections using the NIP rejection criteria, which is broken down into two categories: mistakes relating to request form completeness and errors relating

to samples. NIP set a monthly quality indication of 5% rejection rate. In the two years covered by our analysis, there was an overall rejection rate of 1.32%. This was higher than the 0.23% that was recorded in a study by Musa, (2020), 0.5% in study by Shiferaw., *et al*. 2018 and in a study by Chavan., *et al*. 2019 throughout their study period from 2012 to 2016.

Even though a general sample rejection rate from 2020 to 2021 is below the recommended limit of 5% sample rejections at NIP, and the sample rejection should not considerable or negligible to warrant interventions, there were however, some rejection criteria that showed a large increase from 2020 to 2021, raising serious concerns. While this was not found to be for all rejection criteria, there is a greater likelihood that the rejection rate may rise in the years to come if no action is taken on the areas of concern that significantly rose over the study period. Among the criteria with significant increase from 2020 to 2021, of more than 5% rejection rate are; no sample received (6.47%), clotted sample (6.03%). The study found that the problems related to form completion have however drastically reduced by almost half from 2020 to 2021.

If samples are not received or are rejected due to various reasons by laboratory, means that there will be no results for the patients, and for the patients who travels long distances to the hospital, will have to wait longer as the samples will be re-collected and submitted to the laboratory again. The longer the patients wait for the results, the more diagnosis and treatment is delayed and for the diseases of public concern, means the diseases will be spreading even further and more communities will be at risk. Hence there is a need for targeted intervention to reduce the rejection rate significantly. The intervention will see an improved quality health care.

Problems relating to completion of request forms

The study discovered that incomplete requisition forms were the most common errors made in the laboratories across the two years that were evaluated when it came to request form completion errors. This mistake was also identified as a common one in studies conducted by Gupta., *et al*. 2015 who found nearly 50% of the rejections to be due to incomplete forms and by Tapper *et al*. 2017 at the University Hospital of the West Indies. However, compared to Tapper., *et al*. 2017 at 124 (25%) and Gupta., *et al*. 2015, our study's rejection rate was lower (10.57% in 2020 and 7.45% in 2021), averaging 8.94% over two years. Since more than 98% of the participant's demonstrated proficiency in completing the requisition forms, it is possible that the healthcare workers neglected to thoroughly review the forms to ensure that all necessary details had been entered before the samples were delivered to the laboratory.

In the area of issues with request form completion, name dispute or misidentification was found to be the fourth reason for sample rejection in the Erongo region. Over the course of the two years, the rejection rate for misidentification was 5.38% overall. A study from 2015 found that the misidentification ratio was 0.3%, which is lower than the rate in our study [25]. Misidentification of patient specimen has been linked to poor diagnostic and treatment outcomes, according to a number of studies [25,31].

The ratio of missed test requests was determined to be 0.1% in a study by Dikmen., *et al*. (2015), which is substantially lower than the ratio of 4.22% obtained in this study.

Problems relating to sample

In our investigation, missing samples or samples that were never delivered to the laboratory accounted for 24.55% of all sample rejections, making them the most frequent reasons for rejection. Our study's sample rejection rate is higher than that of Kichner., *et al*. (2007), which was 1.7%, and Chiku., *et al.* (2017), which was 6%.

The second most frequent cause of sample rejections in the area during our analysis was clotted samples. This is consistent with research from Chavan., *et al*. 2019 and Musa (2020), who identified clotted samples as the second reason for sample rejection. The most frequent reason for sample rejection, according to 2015 studies [25,29] was clotted samples. Musa (2020) study concurred with ours that these rejections are the second cause of rejection, but their rejection rate was greater at 30%, while the clotted sample rate reported by Kichner in 2007 was 14%, our study's rate was 10.68%. Most likely, poor mixing after blood collection and leaving the tubes lying horizontally rather than upright position are the main causes of clotted samples [25,34]. This is seen from the participants' insufficient understanding of tube mixing in the Erongo region.

The study's third most common rejection was haemolysed sample at 8.49%, which is comparable with a study conducted by Musa (2020) but in contrast with Chavan., *et al*. 2019, Noordin and Isa, 2021 who found haemolysed samples to be the most reason for rejection. According to reports, a primary cause of hemolysis is vigorous blood mixing [22,28]. The participants' lack of understanding of mixing tubes may be the cause of haemolysed samples.

Insufficient sample was the fourth reason for sample rejections in this study, accounting for 7.04% of sample rejections over the previous two years (2020–2021). In contrast to the study conducted by Noordin and Isa, 2021 it indicated that insufficient sample was the third-leading cause of rejection, accounting for 6.1% of rejections. Blood collection from patients, particularly neonates, is reportedly difficult causing samples to be insufficient; this necessitates special training and abilities [25]. Additionally, insufficient samples affect laboratory test findings because of an improper blood to anticoagulant ratio, which has a greater impact on coagulation tests like Prothrombin time and APTT according to a study by Atay., *et al*. 2014.

Causes of pre-analytical errors during sample collection among the state doctors and nurses

Lack of training and knowledge

The majority of participants (68.99%) have indicated that they have not received any training. The study emphasizes that inadequate training has a significant impact on healthcare personnel' expertise and is a contributing factor in sample rejections. This is supported by a study by Chiku., *et al*. 2019, which demonstrated that sharing information on sample collection, handling, and request form completion with healthcare professionals decreased the pre-analytical mistakes from 19.05% to 6.76%.

The clinicians' lack of understanding is one of the reasons why certain samples are rejected. This is clear from the study's findings, which also revealed that there is a knowledge gap on the number of tubes needed for particular tests (12.40%), mixing methods (48.10%), sample rejections (21.70%), and volume needed for particular tests (58.10%).

According to the study, mixing tube knowledge and training for p-value 0.06 have a strong link. The major reasons of sample rejection in this study, clotted samples and hemolysis, have both been shown to be influenced by improper tube mixing, in line with a research by Shoaib., *et al*. 2020 that stated poor mixing related to phlebotomy training is the cause of clotted samples. The high rates of incomplete and missing samples, which are also the main causes of sample ejections in the Erongo Region, are further attributed to a lack of understanding regarding the volume and test-tube requirements.

Additionally, 1.6% of participants said that a high number of students or new employees who are untrained and have less knowledge and expertise as a result of their faults in the pre-analytical phase are the reason for rejections in their environment. A small percentage (0.8%) of interviewees also mentioned that trained or experienced nurses may change shifts, which may contribute to certain errors.

The survey also revealed that participants were unaware of NIP documents, which were put in place to provide information on the right way to collect, handle, and transport samples and which are meant to give participants additional information and direction in order to prevent sample rejections. Similar circumstances were noted in a research by Mosha and Kabanyana in 2021, which stated that despite the existence of sample handling guidelines, improvement was still necessary for the samples brought to the laboratory. Participants said that they were unaware of the NIP rejection criteria in 46.51% of cases and the NIP service manual in 61.24% of cases. Noordin and Isa, 2021 indicated in the study that it is preferable to reduce pre-analytical errors by having the standard instructions for pre-analytical sample collection and handling available.

Hospital infrastructural factors

Inadequate sample collection materials

The failure to obtain sufficient or adequate materials for sample collection has resulted in the rejection of samples. It was challenging for the physicians to gather all of the samples that were needed for testing because of the lack of collection tubes, requisition forms, vacutainer needles, and vacutainer holders. Since a form was marked for a specific test but no materials were available for that particular test request, samples were not taken. As a result, the tests indicated on the form and the tubes that were received at the laboratories did not match, leading to a higher number of missing samples being recorded at the laboratories.

Lack of/inadequate Transportation

The delivery of samples to the laboratory is delayed due to a lack of transportation. Because the samples can be too old for testing, this jeopardizes their integrity and causes them to be rejected. 3.1% of the participants have this as their situation. According to Atay., *et al*. 2014, improper sample transportation can result in rejection.

Other challenges related to patient factors

Difficulties in finding veins

75.6% of the participants said that having trouble locating veins during blood collection is their biggest challenge during the pre-analytical phase. This is particularly challenging for infants and the elderly, and often leads to inadequate blood collection or even partial blood non-collection. According to reports, the challenges with blood collection are strongly linked to insufficient samples, which lead to sample rejections in the laboratory. Blood collection errors could occur due to inexperienced or untrained employees having trouble locating veins during sample collection 31).

Uncooperative patients and Communication barriers

Difficult patients who refuse to be collected samples have resulted in pre-analytical errors. It was also noted that communication breakdown among the clinicians and patient has also been noted to cause pre-analytical errors. Communication barrier was also highlighted to be the cause of pre-analytical errors in a study by (Atay *et al*., 2014).

Conclusion

According to the report, incomplete forms, missing test requests, missing samples, clotted samples, haemolysed samples, and inadequate samples are the main reasons for sample rejections in the Erongo region. The study went on to find that inadequate training and knowledge, a hard workload, and a lack of suitable materials needed for sample collection are the main causes of these pre-analytical errors in the region.

Recommendations

The study recommends improved communication between local NIP laboratories and healthcare personnel and allow clinicians to freely seek clarity on sample collection and handling protocols. Additionally, in order to target locations with high sample rejection rates, NIP should frequently be sending monthly sample rejections reports to healthcare professionals to assess the concern at hand in their areas.

As per the findings of our study that highlights an increased need for training of healthcare workers, the study recommends that medical staff participating in specimen collection should be continually refresh training by the NIP laboratories on quality sample collections and sample rejection criteria.

Most important and sustainable solution recommended by this study, is the inclusion of proper laboratory and sample collection in the formal curriculum of the healthcare professionals (doctors and nurses).

All pertinent documentation that detail the NIP sample collection and transportation requirements standard procedures should be discussed and clearly explained and made available to the health workers. It is recommended that it would be advantageous if the laboratory could provide visual aids and making the collection process simpler for doctors and nurses for example, it would be helpful if the laboratory could prepare a set of tubes to be used in the collection of Cerebrospinal Fluid sample.

To ensure uninterrupted services, the study recommends that NIP should procure adequate materials to ensure that the stock for sample collection materials are available at all times and in continuous supply to meet the demands of healthcare facilities. Moreover, the study recommends that healthcare facilities should determine their consumption rate of the sample collection materials on an annual basis in order to determine their minimum and maximum stock to ensure stock availability based on the number of patients received.

The study recommends for more clinical laboratory-based research on sample collection techniques, handling techniques, transportation safety as well as sample receiving procedures in the laboratory and the potential effects on patient treatment outcomes and general public health. This will contribute to a decrease in sample rejections and an improvement in the caliber of the outcomes, leading to higher patient satisfaction and health care.

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