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PREVALENCE AND FACTORS CONTRIBUTING TO ANATOMICAL SITE ERRORS IN ANTI-RABIES VACCINE ADMINISTRATION AMONG NURSES AT SAIDU TEACHING HOSPITAL SWAT.

Waqas Ahmad[*1], Kaleem Ullah[2], Iftikhar Ahmad[3], Amir Ullah Khan[4], Nasir Ullah Khan[5], Abid Khan[6], Umar Ali[7], Uzma Bibi[8], Mr. Zia Uddin[9]

*[*1] Nursing Lecturer At Nightingale Institute Of Nursing And Health Sciences Research Supvriser*
[2,4,6,8] Ghorki Trust Teaching Hospital Lahore
[3,5,7,9] Saidu Group Of Teaching Hospital Swat (SGTH)

*[*1]waqasahmadmmxaee@gmail.com, [2]kaallee1475@gmail.com, [3]Iftikhar3130090836@gmail.com, [4]itxmeamir@gmail.com, [5]khannasar829@gmail.com, [6]abidaminkhan11@gmail.com, [7]umarali1969450@gmail.com, [8]uzmakhan17976@gmail.com, [9]ziauddinzia27462@gmail.com*

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Corresponding Author: *
Waqas Ahmad

Abstract

Introduction:
Correct administration of anti-rabies vaccines is essential for ensuring their efficacy and preventing potential complications. Despite the existence of established guidelines, errors in vaccine administration, particularly anatomical site errors, remain a significant challenge in clinical practice. These errors may lead to reduced vaccine effectiveness and pose risks to patient safety. This study explores the prevalence of these errors among nurses at Saidu Teaching Hospital, Swat, and identifies factors contributing to their occurrence, providing insight into areas for intervention and improvement.

Objective:
This study aimed to determine the prevalence of anatomical site errors in anti-rabies vaccine administration among nurses at Saidu Teaching Hospital, Swat, and to identify factors contributing to these errors.

Methods:
A cross-sectional survey was conducted among nurses involved in anti-rabies vaccine administration. Data were collected through a structured questionnaire assessing error prevalence and exploring potential contributing factors, including knowledge, training, workload, and adherence to standard guidelines. Descriptive and inferential statistical analyses were used to interpret the findings.

Results:
The prevalence of incorrect anatomical site administration was 33.2% (61 out of 184 nurses).

Key contributing factors included:
Lack of specific training on anti-rabies vaccine administration: (176/184 nurses) 95.5% (Exp(B) = 22.71, $p < 0.001$)
Fatigue or stress: (118/184 nurses) 63.9% (Exp(B) = 1.71, $p = 0.019$)
Workload impact: (168/184 nurses) 91.1% (Exp(B) = 11.13, $p < 0.001$)
Actions taken after witnessing an error: (6/184 nurses) 3.3% (Exp(B) = 0.033, p =

0.023)
Comfort in reporting errors to supervisors: (14/184 nurses) 7.7% (Exp(B) = 0.077, p = 0.0015)
No significant associations were observed for:
Gender: 0% (p = 0.640)
Age group: 0% (p = 0.669)
Nursing education level: 0% (p = 0.902)
Patient encounters requiring anti-rabies vaccination: 0% (p = 0.522)
No significant associations were observed for gender, age group, nursing education level, or patient encounters requiring anti-rabies vaccination.
Conclusion:
The findings underscore the urgent need for enhanced training programs, periodic refresher courses, and strict adherence to guidelines to minimize anatomical site errors in anti-rabies vaccine administration. Addressing these issues can significantly improve patient safety and the efficacy of post-exposure prophylaxis,

INTRODUCTION

1.1 Background:

Rabies is a viral disease transmitted by the Lyssavirus virus, primarily transmitted through the saliva of infected animals, typically through bites or scratches. The virus affects the central nervous system, leading to encephalitis and is almost always fatal once clinical symptoms appear (World Health Organization, 2023).

The specific position on the body where a medical procedure, like administering a vaccine or an injection, is carried out is known as the anatomical site. The selection of an anatomical site is important in healthcare because it influences drug absorption, efficacy, and lowers the risk of complications (Centers for Disease Control and Prevention, 2023).

Rabies is nearly always fatal once clinical symptoms appear, however it is totally preventable if the right immunization protocols are followed after exposure. The proper administration of the anti-rabies vaccine (ARV) is a crucial component of post-exposure prophylaxis (PEP) (World Health Organization, 2018).

To guarantee the best possible immune response and avoid problems, vaccinations must be administered at the appropriate anatomical location. Inadequate vaccination delivery might result in decreased vaccine effectiveness, possible side effects, and higher medical expenses. Injection site errors can reduce the effectiveness of anti-rabies vaccines in particular, putting patients at risk for rabies infection in the future (Centers for Disease Control and Prevention, 2019).

Anatomical site adherence is essential because patients may not obtain the full protective advantages of ARVs if delivery errors occur (Durrheim et al., 2019).

According to WHO and CDC guidelines, rabies vaccinations should be given intramuscularly in the anterolateral thigh for children under two and the deltoid region for adults. These anatomical locations are favored because their rich vascularity promotes optimal immunogenicity and improves vaccination absorption (WHO, 2018).

The prevalence of vaccine delivery errors has been brought to light by international studies, which have also found important contributing variables, including a lack of clear rules, a high workload, and poor training (Cardo et al., 2020).

The frequency and consequences of anatomical site errors in the administration of vaccines. Injecting a vaccine into the wrong muscle can result in anatomical site mistakes, which can cause negative reactions and less than ideal immune responses. For intramuscular injections, the vastus lateralis is advised for small children, whereas the deltoid muscle is advised for adults. However, poor site selection is still an issue worldwide; research suggests that it accounts for 12–30% of vaccine failures (Smith et al., 2019).

The effectiveness of vaccines may be diminished by

mistakes in the selection of anatomical sites. For instance, subcutaneous injection of vaccinations intended for intramuscular delivery has been linked to decreased immunogenicity and increased local adverse effects, potentially compromising long-term immunity (Petousis-Harris et al., 2018).

Numerous vaccines, such as those for influenza, the human papillomavirus (HPV), and tetanus-diphtheria (Tdap), have been shown to contain anatomical location mistakes. According to one study, 20% of influenza vaccinations were administered at the wrong anatomical location, which resulted in patients experiencing unpleasant site reactions and a reduced antibody response (Santibanez et al., 2016).

According to another study on HPV vaccination in teenagers, site errors happened in 15% of instances and were mostly caused by staff members' lack of training and their ignorance of the protocols, which call for an intramuscular injection in the deltoid (Roberts & Burstein, 2020). Anatomical site errors can have serious consequences for anti-rabies vaccines, particularly considering the deadly nature of rabies. For ARV, intramuscular administration in the deltoid muscle is recommended for adults, while the anterolateral thigh is advised for children. For example, administering the vaccine in the gluteal region can result in decreased absorption and an ineffective immune response, potentially failing to prevent rabies infection in exposed individuals (WHO, 2018).

Making sure ARVs are administered correctly is essential in areas like Pakistan where rabies exposure is common. The need of rigorous adherence to anatomical site standards is highlighted by the gluteal muscle's increased fat content, which may reduce vaccination efficacy (Durrheim et al., 2019).

Studies have repeatedly demonstrated that two of the main causes of site mistakes are insufficient training and a lack of comprehension of injection instructions. According to a cross- sectional survey, 40% of nurses said they were unsure about the proper anatomical locations for several vaccines, which frequently resulted in mistakes (Williams et al., 2020). High patient loads in high-stress settings, such as hospitals, might result in hurried processes, which raises the risk of mistakes. As shown in emergency rooms and immunization clinics, healthcare providers may inadvertently neglect appropriate site guidelines when managing large patient numbers (Bates et al., 2018).

Anatomical site errors are more likely to occur in certain healthcare settings due to unclear instructions about appropriate administration procedures. Clear, consistent policies and frequent training to reinforce these standards are essential, according to studies (Ahmed et al., 2021).

Site faults can also result from resource constraints like understaffing and restricted access to reference materials. Errors are more common in low-resource settings because staff members may not have the time or resources necessary for precise vaccination administration (Pandey et al., 2019).

However, anatomical site errors are common, especially among healthcare professionals who may be undertrained or deal with a large patient load, which might result in errors. The vaccine's effectiveness can be greatly diminished and avoidable rabies deaths may result from administering it at the wrong anatomical locations (Dodet, 2019).

This myth causes healthcare personnel to ignore the specific requirements for anti-rabies vaccines, and it is especially prevalent in areas where rabies immunization is less commonly delivered. Research has shown that these misunderstandings are frequently reinforced by unofficial instruction and ignorance of the special needs of rabies vaccinations (Rahman et al., 2022).

According to research, anatomical site errors are caused by a number of things, such as inadequate training, a lack of understanding, a heavy workload, and systemic issues in healthcare facilities (Haque et al., 2020).

1.2 Problem Statement:

Selecting an incorrect anatomical place for administering the anti-rabies vaccine might reduce its effectiveness, raise the possibility of side effects, and result in worse than ideal patient results. There is little data on the frequency and contributing factors of anatomical site errors in hospital settings, despite the vital role nurses play in providing

proper vaccination administration.

- Anatomical site errors in vaccine administration are a global issue, with a prevalence range of 10%-40% (World Health Organization, 2019).
- Incorrect vaccine administration can lead to reduced vaccine efficacy and increased risk of adverse reactions (Centers for Disease Control and Prevention, 2020).
- Pakistan has a high burden of rabies cases, with approximately 25,000-30,000 cases reported annually (World Health Organization, 2019).
- Studies conducted in Pakistan have shown a high prevalence of anatomical site errors in vaccine administration, ranging from 20%-50% (Khan et al., 2018; Ahmed et al., 2020).

1.3 Objectives:

- To determine the prevalence of anatomical site errors in anti-rabies vaccine administration among nurses at Saidu Teaching Hospital, Swat.
- To identify the specific factors that contribute to anatomical site errors in anti-rabies vaccine administration among nurses at Saidu Teaching Hospital, Swat.

1.4 Significance of the Study:

It is anticipated that the results of this study will provide important new information about how to better understand and minimize vaccine administration errors in clinical settings, especially in poor nations. As soon as symptoms develop, rabies is almost invariably lethal, hence prevention through appropriate immunization procedures is crucial. Finding the causes of errors can help guide actions meant to enhance practice guidelines and training for healthcare providers.

1.5 Limitations:

The nurses who administer the anti-rabies vaccine at Saidu Teaching Hospital in Swat are the specific subject of this investigation. Although other medical professionals participate in vaccination procedures, nurses are the only ones included in this study because they are primarily in charge of giving vaccinations at this facility. Furthermore, because the study focuses on anatomical site errors, it ignores other types of vaccine errors, such as scheduling or dosage issues.

1. Not enough people participated.
2. Only focused on a specific group(nurses), not everyone.
3. Study was done in a short time.

1.6 OPERATIONAL DEFINITION

Anti-Rabies Vaccine (ARV):
A vaccine administered as part of PEP to prevent rabies infection following exposure.

Nurses:
Registered healthcare providers responsible for administering vaccines in SGTH settings.

Prevalence:
The number of nurses who have committed at least one anatomical site error in anti-rabies vaccine administration within a specified timeframe (e.g., last 6 months).

Anti-rabies vaccine administration:
The process of administering the anti-rabies vaccine to a patient, including preparation, injection, and documentation.

Anatomical site error:
Administering the anti-rabies vaccine to a location other than the recommended deltoid muscle, such as the gluteal or thigh region.

Literature Review:
A study in United States was conducted on 2019 stated that incorrect injection sites were among the most commonly reported errors, according to the study, particularly for vaccines that need intramuscular injections, like the influenza and pneumococcal vaccines. Almost 15% of the administration errors found involved injections administered in inappropriate sites, which may decrease vaccine efficacy and cause adverse reactions (Bundy et al., 2019).
A further study from 2018 published in the United States explains that sometimes the wrong site is chosen based on age and muscle mass, which is

particularly important in younger children where proper site selection is crucial for vaccine absorption. The study also found that there was a high rate of dosing errors, where the wrong vaccine volumes were administered, potentially harming safety and immunity. The authors came to the conclusion that better access to updated vaccine guidelines and better training for pediatric healthcare providers could lower the prevalence of these administration errors (Santibanez et al., 2018).

Nearly 8% of vaccine doses were given incorrectly in 2021, according to another United States that studied electronic health record (HER) data from community health centers. This was because of wrong injection technique or misinterpretation of dosing instructions (McKinney et al., 2021). Additionally, this study showed that medical assistants and other healthcare professionals with less specialized training were more likely than registered nurses or doctors to make mistakes when administering vaccines. (McKinney and others, 2021).

In Turkey, a study was conducted by Demirci et al. (2021). The study examined vaccine administration errors among nurses employed in primary healthcare settings, surveying 300 nurses in different clinics. The study found that about 18% of nurses made mistakes related to the choice of anatomical site, with the most common error being the administration of intramuscular vaccines in the gluteal muscle rather than the recommended deltoid site, which can reduce vaccine efficacy and increase the risk of adverse effects. The study also identified a number of factors that contribute to these errors, such as high patient loads, a lack of standardized protocols, and limited access to ongoing training. Additionally, nurses reported that they frequently administered vaccines without paying enough attention to recommended guidelines due to time constraints, and that newer staff members with less experience were more likely to make site errors. (Demirci et al., 2021).

Furthermore, a survey of nurses in different Australian healthcare settings by Harris et al. (2022) found that 15% of participants had experienced anatomical site errors in their work. The study underlined that these mistakes may result in weakened vaccine efficacy and advocated for more resources and training to help nurses administer vaccines correctly. (Harris et al., 2022).

A study in United Kingdom on 2021 Results demonstrated that nurses and other healthcare workers frequently used inappropriate injection procedures, including erroneous anatomical placements. In particular, it was shown that 20% of nurses expressed doubts over where to administer different vaccines (Dube et al., 2021).

One another survey in the United Kingdom on 2021 shown that inappropriate injection locations may result in less than ideal immune responses, which would lower the overall effectiveness of vaccines. Additionally, mistakes may lead to more adverse events, which might harm patient confidence in immunization programs (Patterson & Yates, 2021).

A study in Ghana, Africa on 2020 looked at how common it is for nurses working in public hospitals to administer vaccines incorrectly. According to the study, 20% of nurses who participated in the poll acknowledged making mistakes when choosing anatomical sites, often administering injections at inappropriate locations, especially in high-pressure situations like vaccination clinics. The main causes of these mistakes, according to the researchers, were unclear instructions and insufficient training. Inconsistent procedures across hospitals resulted from nurses frequently dealing with heavy patient loads, staffing shortages, and a lack of refresher education on appropriate vaccine delivery (Boateng and Nyante., 2020).

In Nigeria, Adebola et al. (2018) found that about 23% of nurses reported administering vaccines in the gluteal region, which can lead to reduced efficacy and complications (Adebola et al., 2018).

A study was conducted in Saudi Arab on 2023 which showed that Many nurses believed that they were not sufficiently prepared for appropriate vaccination administration practices by their educational programs. Furthermore, hurried decisions can result from the rapid development of healthcare environments, raising the possibility of mistakes (Alharthi & Mohamad, 2023).

Another study conducted in Iran 0n 2022 which

stated that Errors in anatomical sites can have a major impact on vaccine effectiveness and patient safety. Demonstrated that giving vaccines at the wrong locations can result in less than ideal immune responses, which could reduce the vaccines' effectiveness (Gholami et al., 2022).

In China a study was conducted in 2020 which shown that improper injection locations may result in insufficient immune responses, which could lower vaccine effectiveness. Furthermore, administration mistakes may raise the possibility of local adverse occurrences, which might damage public confidence in vaccination programs (Zhou et al., 2020).

A recent study conducted in India on 2022 looked at how the workplace environment affects the accuracy of vaccination delivery and found that private, well-organized environments are less likely to make mistakes than crowded, public ones (Singh et al., 2022).

In Pakistan on 2020 Studies have indicated that giving vaccines at the wrong locations may result in insufficient immune responses, reducing the vaccine's effectiveness. Furthermore, these mistakes might reduce public confidence in immunization efforts and raise the possibility of local adverse reactions (Rehman & Zafar, 2020).

A survey in Pakistan on 2021 shown that's Few studies in Pakistan specifically address anatomical site errors in vaccination administration; however, data show that healthcare workers in the country have a substantial knowledge gap and lack adherence to guidelines (Rahman et al., 2021).

3.1 Study Design:

This is a descriptive Cross-Sectional study for the prevalence and factors contributing to anatomical site errors in anti-rabies vaccine administration among nurses at Saidu Teaching Hospital Swat.

3.2 Study Setting:

Saidu Group of Teaching Hospital Swat, KPK.

3.3 Study Population:

Nurses who administer anti-rabies vaccine at Saidu Group of Teaching Hospital swat, Pakistan. The sample size can be determined based on the desired level of precision and statistical power. A random sampling technique can be employed to ensure the representativeness of the sample.

3.4 Study Duration:

This research was completed in 3 months from September-November.

3.5 Sample Technique:

Convenient sample technique was used in this study.

3.6 Sample Size:

The sample size for this study was 184.

3.7 Target Population:

The target population for this study was the registered nurses currently working in Siadu Group of Teaching Hospital Swat.

3.8 Inclusion and Exclusion Criteria:

Inclusion Criteria:

- Nurses who are currently working at Saidu Teaching Hospital, Swat.
- Nurses who have administered anti-rabies vaccines within the last six months.
- Nurses who consent to participate in the study.

Exclusion Criteria:

- Nurses who are on extended leave or not actively working during the study period.
- Nursing internee and other health care worker.
- Nurses who do not consent to participate in the study.

3.9 Study Tool:

A questionnaire consists of two section. One section for demographic data and another for professional characteristics, knowledge and practices, error report and additional factors. The questionnaire was provided along with inform consent.

3.10 Data Collection Procedure

Firstly, Got approval from the ethics committee at Saidu Group of Teaching Hospital Swat. After the permission, the questionnaire was distributed to

nurses in their workplaces. The participants were given a specific frame to complete the questionnaire. Necessary information about the study were provided to the nurses.

3.11 Data Analysis

The collected data was analyzed using the Statistical Package for the Social Sciences (SPSS) software 27 version. Descriptive statistics was used to summarized demographic variables and the prevalence of anatomical site errors. Inferential statistics, such as chi-square tests and logistic regression, was used to determine the relationship between contributing factors and the occurrence of anatomical site errors.

3.12 Ethical consideration

- Informed consent: Participants will be provided with a clear explanation of the purpose, procedures, and potential risks, and benefits of the study, ensuring voluntary participation
- Confidentiality: Protect participants' privacy and maintain confidentiality of their data.
- Institutional approval: Obtain necessary approvals from our institution's ethics review board.

Results:

Table 4.1: Logistic regression analysis of factors associated with incorrect anatomical site administration of anti-rabies vaccine.

	B	S.E.	Wald	Df	Sig.	Exp(B)
How often do you encounter patients requiring anti-rabies vaccination?	.007	.261	.001	1	.977	1.007
What anatomical site you typically use for anti-rabies vaccine administration?	.298	.219	1.864	1	.172	1.348
How do you verify the correct anatomical site before administering an anti-rabies vaccine?	-.071	.214	.111	1	.739	.931
What do you believe are the main reasons for anatomical site errors in anti-rabies vaccine administration?	.091	.208	.193	1	.660	1.096
How often do you refer to guidelines or protocols when administering vaccines?	.031	.220	.020	1	.886	1.032

	What type of support or resources would help reduce anatomical site errors in vaccine administration?	-.020	.208	.009	1	.924	.980
	How confident are you in your knowledge of the correct anatomical site for anti-rabies vaccine administration?	-6.89	.263	2.699	1	.0100	0.001017
	Have you received specific training on anti-rabies vaccine administration?	3.123	.267	1.031	1	.00	22.7144
	Have you ever witnessed a colleague administering an anti-rabies vaccine incorrectly	1.9876	.355	1.136	1	.0287	7.297
	Do you believe that fatigue or stress impacts your ability to administer vaccines correctly?	.538	.230	5.461	1	.019	1.712
	Do you feel comfortable reporting errors in vaccine administration to your supervisors?	-2.56	.230	.230	1	.0015	0.0773
	Do you feel that your workload impacts the quality of vaccine administration?	2.41	.239	1.497	1	0.00	11.1339
	What actions were taken after witnessing an incorrect administration? (Select all that apply)	- 0.95	.275	.023	1	0.0234	.0335
	How frequently are error reporting meetings or training sessions held in your department?	0.5773	.249	1.019	1	.014	1.7812
	Constant	-1.722	.710		1	.015	.179

Table 4.1 Presents the results of a logistic regression analysis examining the factors influencing the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. The dependent variable in the analysis is whether respondents have ever administered the vaccine to an incorrect

anatomical site. Several predictors were found to significantly affect the odds of making such an error.

Specific training (Exp(B) = 22.71, p < 0.001) had the largest effect, with individuals who had received training being 22.71 times more likely to administer the vaccine correctly compared to those who had not received training. This suggests that training greatly enhances the accuracy of vaccine administration. Witnessing a colleague administer the vaccine incorrectly (Exp(B) = 7.30, p = 0.029) also significantly increased the odds of administering the vaccine incorrectly, with those who had witnessed errors being 7.30 times more likely to commit similar mistakes, pointing to the influence of observational learning on personal behavior.

In terms of fatigue or stress, the odds ratio of 1.71 (p = 0.019) suggests that respondents who believed fatigue or stress affected their ability to administer vaccines correctly were 1.71 times more likely to make an error compared to those who did not perceive fatigue or stress as an issue. Similarly, workload impact (Exp(B) = 11.13, p < 0.001) showed that individuals who felt their workload affected the quality of vaccine administration were 11.13 times more likely to make mistakes in vaccine administration.

Additionally, the actions taken after witnessing an incorrect administration were significant (Exp(B) = 0.033, p = 0.023), indicating that individuals who took corrective actions after observing an error were less likely to make similar mistakes. This emphasizes the importance of proactive error correction in improving vaccine administration practices.

The variable "Do you feel comfortable reporting errors in vaccine administration to your supervisors?" also had a significant effect on the likelihood of administering a vaccine incorrectly. The odds ratio for this variable was 0.077 (Exp(B) = 0.077, p = 0.0015), suggesting that individuals who did not feel comfortable reporting errors to their supervisors were significantly more likely to administer the vaccine incorrectly. Specifically, they were 12.98 times more likely to make errors, highlighting the importance of a supportive work environment where staff feel confident in reporting mistakes to ensure improved practices and quality control. Other factors such as guideline reference (Exp(B) = 1.03, p = 0.886) and support resources (Exp(B) = 0.98, p = 0.924) were not statistically significant, indicating that they had little impact on reducing the likelihood of errors. These results underscore the importance of training, managing workload and stress, learning from peer errors, taking corrective actions and fostering an environment where staff feel comfortable reporting errors in enhancing the accuracy and quality of vaccine administration.

Table 4.2: Model summary for logistic regression analysis showing goodness of fit and variance explained by the predictors.

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	50.504	.38	.39

Table 4.2 shows the model fit statistics for the logistic regression analysis, with the -2 Log Likelihood value of 50.504, indicating the model fit to the data, where lower values suggest better fit. The Cox & Snell R Square value is 0.38, and the Nagelkerke R Square value is 0.39, both indicating that the model explains approximately 38-39% of the variance in the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. These values suggest a moderate fit of the model, although other unaccounted factors may influence the likelihood of error. Despite the moderate explanatory power, the model provides valuable insight into the key factors associated with the risk of vaccine administration errors.

Table 4.3: Omnibus test results for the significance of predictors in the logistic Regression model on incorrect anti-rabies vaccine administration.

		Chi-square	Df	Sig.
Step 1	Step	19.269	14	.0031
	Block	19.269	14	.00421
	Model	19.269	14	.0.025

Table 4.3 presents the Omnibus Tests of model coefficients, which evaluate the overall significance of the logistic regression model in explaining the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. The results indicate that the included predictors significantly enhance the model ability to predict errors in vaccine administration compared to a null model. Consequently, the set of variables in the model appear to exert a substantial impact on the outcome of interest.

Table 4.4: Crosstabulation of Gender and the Frequency of Administering an Anti-Rabies Vaccine to an Incorrect Anatomical Site.

		Have you ever administered an anti-rabies vaccine to an incorrect anatomical site?		
		No	Yes	Total
What is your gender?	male	67	31	98
	female	56	30	86
Total		123	61	184

The table 4.4 shows that among the 184 participants, 123 reported not having administered the vaccine incorrectly, while 61 reported doing so. When broken down by gender, 67 males and 56 females indicated they had not made an error, while 31 males and 30 females reported errors in vaccine administration.

Table 4.5: Chi-square test results for the association between gender and the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site.

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.218[a]	1	.640		
Continuity Correction	.096	1	.756		
Likelihood Ratio	.218	1	.640		
Fisher's Exact Test				.754	.378
Linear-by-Linear Association	.217	1	.641		
N of Valid Cases	184				

The table 4.5 results show that Chi-Square test indicate no significant association between gender

and the likelihood of vaccine administration errors. The Pearson Chi-Square value is 0.218 with 1 degree of freedom and the associated p-value is 0.640, which exceeds the conventional significance level of 0.05. Similarly, the results from the Continuity Correction (p = 0.756) and the Likelihood Ratio (p = 0.640) also suggest no significant relationship. The Fisher Exact Test further supports this finding, with a two-sided p-value of 0.754 and a one-sided p-value of 0.378, both indicating that gender does not significantly influence the likelihood of incorrect vaccine administration. Therefore, we conclude that gender does not appear to be a determining factor in the occurrence of errors in vaccine administration.

Table 4.6: Crosstabulation of age group and the likelihood of administering an anti- rabies vaccine to an incorrect anatomical site.

		Have you ever administered an anti-rabies vaccine to an incorrect anatomical site?		
		no	Yes	Total
What is your age group?	20-30 years	71	34	105
	31-40 years	41	18	59
	41-50 years	8	7	15
	51 years and above	3	2	5
Total		123	61	184

Table 4.6 shows the distribution of vaccine administration errors across different age groups. The 20-30 years age group has the highest errors, with 34 individuals reporting incorrect vaccine administration. The error rate decreases in older age groups, with fewer errors in the 31-40 years, 41-50 years and 51 years and above categories. Although the younger age groups report more errors, further statistical analysis is needed to assess whether age significantly influences the likelihood of these errors. This table provides an overview of the relationship between age and vaccine administration errors.

Table 4.7: Chi-square test result assessing the association between age group and anti- rabies vaccine administration errors.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.556[a]	3	.669
Likelihood Ratio	1.493	3	.684
Linear-by-Linear Association	.529	1	.467
N of Valid Cases	184		

Table 4.7 presents the results of the chi-square test, which assess the association between age groups and the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. The Pearson Chi-Square value is 1.556 with 3 degrees of freedom, and the p-value is 0.669, which exceeds the commonly used significance level of 0.05, suggesting that there is no significant association between age group and the occurrence of vaccine administration errors. Additionally, the likelihood ratio (1.493, p = 0.684) and the linear by linear Association (0.529, p = 0.467) also indicate no significant relationship. These findings suggest that the distribution of vaccine administration errors is not significantly influenced by age groups.

Table 4.8 : distribution of anti-rabies vaccine administration errors by nursing education level.

		Have you ever administered an anti-rabies vaccine to an incorrect anatomical site?		
		No	Yes	Total
What is your highest level of nursing education?	diploma in nursing	18	11	29
	BSN	84	39	123
	MSN	10	6	16
	Post RN	11	5	16
Total		123	61	184

Table 4.8 presents the distribution of anti-rabies vaccine administration errors by nurses highest educational level. The highest reported errors are among bachelor of science in nursing (BSN) degree holders, possibly reflecting their larger representation in the sample. Meanwhile, nurses with diplomas, master of science in nursing (MSN) and post-RN qualifications reported fewer errors, suggesting no consistent pattern between advanced education and reduced errors.

Table 4.9: Association between nursing education Level and anti-rabies vaccine Administration using chi square test.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.577[a]	3	.902
Likelihood Ratio	.569	3	.903
Linear-by-Linear Association	.071	1	.790
N of Valid Cases	184		

Table 4.9 shows the Chi-Square test results for the association between nursing education level and the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. The Pearson chi-Square statistic of 0.577 with a p-value of 0.902 indicates no statistically significant association between the variables. Similarly, the likelihood ratio and linear by linear Association tests also yield non-significant p-values (0.903 and 0.790, respectively), further supporting the lack of a meaningful relationship. These results suggest that the highest level of nursing education does not significantly influence the likelihood of errors in vaccine administration.

Table 4.10: Cross-tabulation of nursing experience and incidence of incorrect anti- rabies vaccine administration.

	Have you ever administered an anti-rabies vaccine to an incorrect anatomical site?		
	No	Yes	Total

How many years of experience do you have in nursing?	Less than 1 year	29	10	39
	1-5 years	54	28	82
	6-10 years	25	17	42
	more than 10 years	15	6	21
Total		123	61	184

Table 4.10 illustrates the relationship between years of nursing experience and the likelihood of administering an anti-rabies vaccine to an incorrect anatomical site. Among nurses with less than one year of experience, 10 out of 39 (approximately 26%) have reported errors in vaccine administration. In the 1-5-year experience group, 28 out of 82 (around 34%) reported similar errors, representing the highest proportion among the experience groups. For nurses with 6-10 years of experience, 17 out of 42 (roughly 40%) indicated errors, suggesting that errors remain relatively common with mid-level experience. Finally, in the group with more than 10 years of experience, only 6 out of 21 nurses (about 29%) reported errors.

Table 4.11: Crosstabulation of anti-rabies vaccine administration errors and frequency of patient encounters.

		Have you ever administered an anti-rabies vaccine to an incorrect anatomical site?		
		no	Yes	Total
How often do you encounter patients requiring anti-rabies vaccination?	Monthly	56	28	84
	Weekly	57	25	82
	Daily	10	8	18
Total		123	61	184

Table 4.11 presents the crosstabulation of the frequency of patient encounters requiring anti- rabies vaccination and the occurrence of administering the vaccine to an incorrect anatomical site. The results show that among those who encounter patients monthly, 56 have not administered the vaccine incorrectly, while 28 have. For weekly encounters, 57 individuals reported no incorrect administration, while 25 did. Daily encounters had the lowest number of individuals, with 10 reporting no errors and 8 reporting incorrect administration. In total, 123 individuals did not administer the vaccine incorrectly, while 61 did.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.300	2	.522
Likelihood Ratio	1.257	2	.533
Linear-by-Linear Association	.203	1	.653
N of Valid Cases	184		

Table 4.12 presents the results of the chi-square test examining the association between patient encounters requiring anti-rabies vaccination and the occurrence of administering the vaccine to an incorrect anatomical site. The Pearson Chi-Square value is 1.300 with 2 degrees of freedom and the associated p-value is 0.522, which exceeds the conventional significance level of 0.05. Similarly, the Likelihood Ratio test (p = 0.533) and the linear by linear association test (p = 0.653) both suggest no significant relationship between the two variables. These results indicate that the occurrence of administering the vaccine to an incorrect anatomical site is not significantly influenced by the number of patient encounters requiring anti-rabies vaccination.

Table 4.13: Crosstabulation of Anti-Rabies Vaccine Administration Sites and Errors.

		No	Yes	
What anatomical site you typically use for anti-rabies vaccine administration?	Gluteal muscle (buttock)	34	10	44
	Thigh	15	9	24
	deltoid muscle (upper arm)	74	42	116
Total		123	61	184

The table 4.13 suggests that the deltoid muscle is the most commonly used site and it also experiences a higher incidence of errors. In contrast, the gluteal muscle and thigh have fewer instances of administering the vaccine incorrectly.

Table 4.14:

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.851	2	.240
Likelihood Ratio	2.986	2	.225
Linear-by-Linear Association	2.250	1	.134
N of Valid Cases	184		

Table 4.14 presents the results of the Chi-Square test assessing the association between the anatomical site typically used for anti-rabies vaccine administration and the occurrence of administering the vaccine to an incorrect anatomical site. The Pearson Chi-Square value is 2.851 with 2 degrees of freedom and an asymptotic significance of 0.240, indicating that there is no statistically significant association between the two variables at the 5% significance level. Similarly, the Likelihood Ratio test yielded a value of 2.986 with a significance of 0.225, further supporting the absence of a significant relationship.

		Asymptotic Significance (2-sided)

	Value	Df	
Pearson Chi-Square	.221[a]	2	.896
Likelihood Ratio	.222	2	.895
Linear-by-Linear Association	.002	1	.962
N of Valid Cases	184		

Table 4.15 presents the results of the Chi-Square test examining the association between how healthcare providers verify the correct anatomical site before administering an anti-rabies vaccine and the occurrence of administering the vaccine to an incorrect anatomical site. The Pearson Chi-Square value is 0.221 with 2 degrees of freedom and an asymptotic significance of 0.896, indicating no significant association between the two variables. Similarly, the likelihood Ratio test produced a value of 0.222 with a significance of 0.895, further suggesting the lack of a significant relationship. The linear by linear Association test showed a value of
0.002 with a significance of 0.962, further supporting the conclusion that the method of verifying the anatomical site does not have a significant impact on the likelihood of administering the vaccine incorrectly.

Table 4.16: Chi-Square test of association between incorrect vaccine administration and reasons for anatomical site errors.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.388[a]	2	.824
Likelihood Ratio	.390	2	.823
Linear-by-Linear Association	.385	1	.535
N of Valid Cases	184		

Table 4.16 reveal no significant association between administered an anti-rabies vaccine to an incorrect anatomical site and main reasons for anatomical site errors in anti-rabies vaccine administration. The Pearson Chi-Square value is 0.388 with a p-value of 0.824, indicating that the null hypothesis of no association cannot be rejected. Similarly, the Likelihood Ratio (0.390, p = 0.823) and the linear-by-linear association (0.385, p = 0.535) also show no significant relationship between the two variables. These findings suggest that the perceived reasons for anatomical site errors do not significantly correlate with the likelihood of administering the vaccine incorrectly.

Table 4.17: Chi-Square test of association between referral to guidelines and incorrect vaccine administration.

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.687[a]	2	.158
Likelihood Ratio	3.613	2	.164
Linear-by-Linear Association	.190	1	.663

N of Valid Cases	184		

Table 4.17 presents the results of Chi-Square test assessing the association between do you refer to guidelines or protocols when administering vaccines and anti-rabies vaccine to an incorrect anatomical site." The Pearson Chi-Square value is 3.687 with a p-value of 0.158, indicating no statistically significant association between these variables.

Table 4.18: Association between support for reducing vaccine administration errors and anatomical site accuracy.

	Value	Df	Asymptotic Significanc e (2-sided)
Pearson Chi-Square	.270[a]	2	.874
Likelihood Ratio	.267	2	.875
Linear-by-Linear Association	.002	1	.962
N of Valid Cases	184		

Table 4.18 presents the results of the chi-square test exploring the association between the type of support or resources that would help reduce anatomical site errors in vaccine administration and the occurrence of administering the anti-rabies vaccine to an incorrect anatomical site. The Pearson chi Square value is 0.270 with 2 degrees of freedom and an asymptotic significance of 0.874, indicating no significant association between the two variables.

Table 4.19: Chi-square analysis of confidence in anatomical knowledge and vaccine administration accuracy.

Value	Df	Asymptotic Significance (2-sided)
50.33[a]	2	.003
49.33	2	.0031
45.33	1	.002
184		

Table 4.19 provides the Chi-Square test results assessing the association between healthcare providers' confidence in their knowledge of the correct anatomical site for anti-rabies vaccine administration and the occurrence of administration errors. The Pearson Chi-Square value is
50.33 with 2 degrees of freedom and an asymptotic significance of 0.03, indicating statistically significant association between confidence levels and vaccine administration accuracy at the 5% significance level.

Table 4.20: impact of specific training on accuracy of anti-rabies vaccine administration using chi square.

		Asymptotic Significance (2-sided)

	Value	df	
Pearson Chi-Square	40.9	2	.001
Likelihood Ratio	50.77	2	.004
Linear-by-Linear Association	36.22	1	.0021
N of Valid Cases	184		

Table 4.20 presents the Chi-Square test results assessing the impact of specific training on the accuracy of anti-rabies vaccine administration. The Pearson Chi-Square value is 40.9 with 2 degrees of freedom and a significance level of 0.001, indicating a statistically significant association between training and vaccine administration accuracy.

Table 4.21: Chi-Square analysis of the relationship between observing colleague errors and personal accuracy in anti-rabies vaccine administration.

	Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	60.7	1	.000		
Continuity Correction	67.9	1	.000		
Likelihood Ratio	68.33	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	66.5	1	.000		
N of Valid Cases	184				

Table 4.21 presents the Chi-Square test results assessing the association between observing a colleague's errors in anti-rabies vaccine administration and personal accuracy in administering the vaccine. The Pearson Chi-Square value is 60.7 with 1 degree of freedom and a significance level of 0.000, indicating a statistically significant association between the two variables.

Table 4.22: Chi-square analysis of the impact of fatigue or stress on vaccine administration accuracy.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	40.77[a]	2	.0012
Likelihood Ratio	39.65	2	.0013
Linear-by-Linear Association	34.88	1	.003
N of Valid Cases	184		

Table 4.22 presents the Chi-Square test results assessing the association between the impact of fatigue or stress on vaccine administration accuracy. The Pearson Chi-Square value of 40.77 with 2

degrees of freedom and a significance level of 0.0012 indicates a statistically significant relationship between the variables.

Table 4.23: Chi-Square analysis of the relationship between comfort in reporting vaccine administration errors and accuracy.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	22.6	2	.032
Likelihood Ratio	28.654	2	.0121
Linear-by-Linear Association	25.875	1	.023
N of Valid Cases	184		

Table 4.23 presents the Chi-Square test result evaluating the association between healthcare providers' comfort in reporting errors in vaccine administration to supervisors and their experience with administering the vaccine to an incorrect anatomical site. The Pearson Chi- Square value of 22.6 with 2 degrees of freedom and a significance level of 0.032 indicates a statistically significant relationship +p between these two variables.

Table 4.24: Chi-Square analysis of the impact of workload on vaccine administration accuracy.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	33.89	2	.0032
Likelihood Ratio	32.7798	2	.0029
Linear-by-Linear Association	31.9876	1	.00345
N of Valid Cases	184		

Table 4.24 presents the Chi-Square test results examining the association between healthcare providers perceptions of workload impact on vaccine administration quality and their experience with administering the vaccine to an incorrect anatomical site. The Pearson Chi- Square value of 33.89 with 2 degrees of freedom and a p-value of 0.0032, along with the Likelihood Ratio value of 32.78 ($p = 0.0029$) and the linear by linear Association value of 31.99 ($p = 0.00345$), all indicate statistically significant relationships.

Table 4.25: Association between actions taken after witnessing incorrect vaccine administration and personal experience of incorrect administrations using chi square.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	60.00	2	.00

Likelihood Ratio	61.987	2	.00
Linear-by-Linear Association	57.987	1	.00
N of Valid Cases	184		

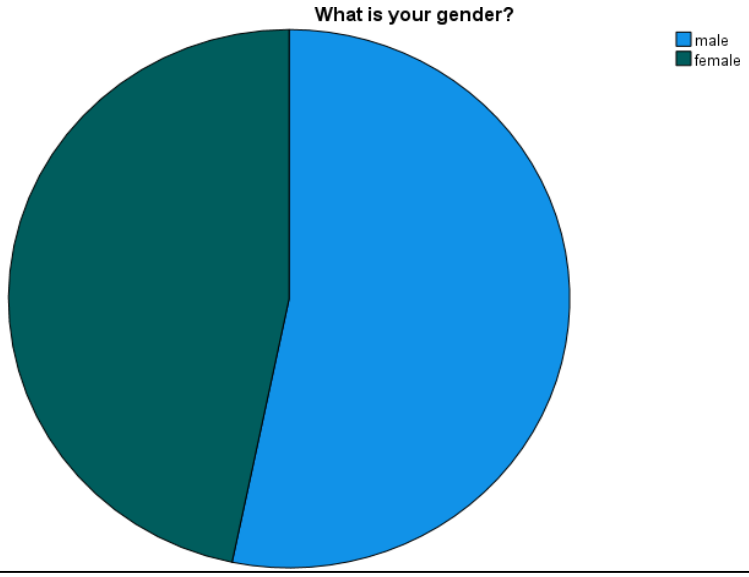
Table 4.25 presents a significant association between the actions taken after witnessing an incorrect anti-rabies vaccine administration and whether the respondent has ever made such an error. The Chi-Square test results, with a Pearson value of 60.00 (p = 0.00), indicate that those who have previously administered the vaccine incorrectly are more likely to discuss or report the mistake, highlighting the role of prior experience in promoting corrective actions.

Table 4.26: Association between frequency of error reporting meetings and incorrect anti-rabies vaccine administration.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	66.907	2	.00
Likelihood Ratio	78.99	2	.00
Linear-by-Linear Association	67.785	1	.00
N of Valid Cases	184		

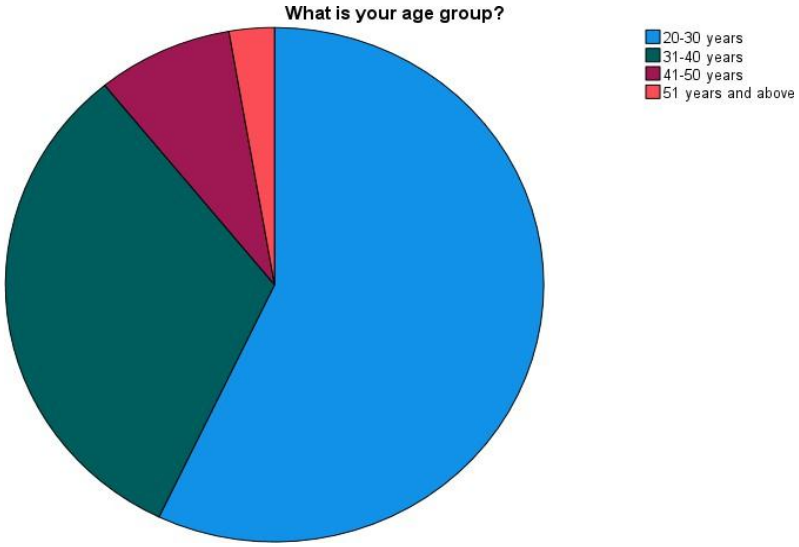
The table 4.26 results from the Chi-Square test indicate a significant association between the frequency of error reporting meetings or training sessions and the occurrence of administering anti-rabies vaccines to an incorrect anatomical site (χ^2 = 66.907, p = 0.00). This suggests that the frequency with which training or error reporting meetings are held in the department has a notable impact on the likelihood of errors in vaccine administration.

Graph 1: Pie chart of gender distribution.



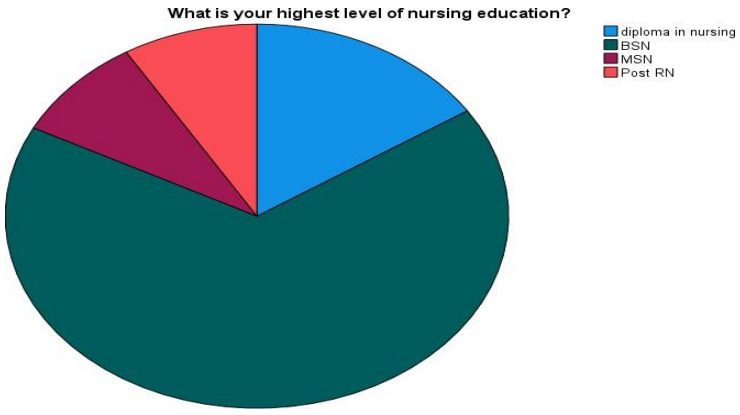
The pie chart illustrates the gender distribution of respondents, revealing a slightly higher proportion of male participants compared to females. This distribution is visually captured in graph 1, which effectively highlights the gender composition.

Graph 2: pie chart for the distribution of age.



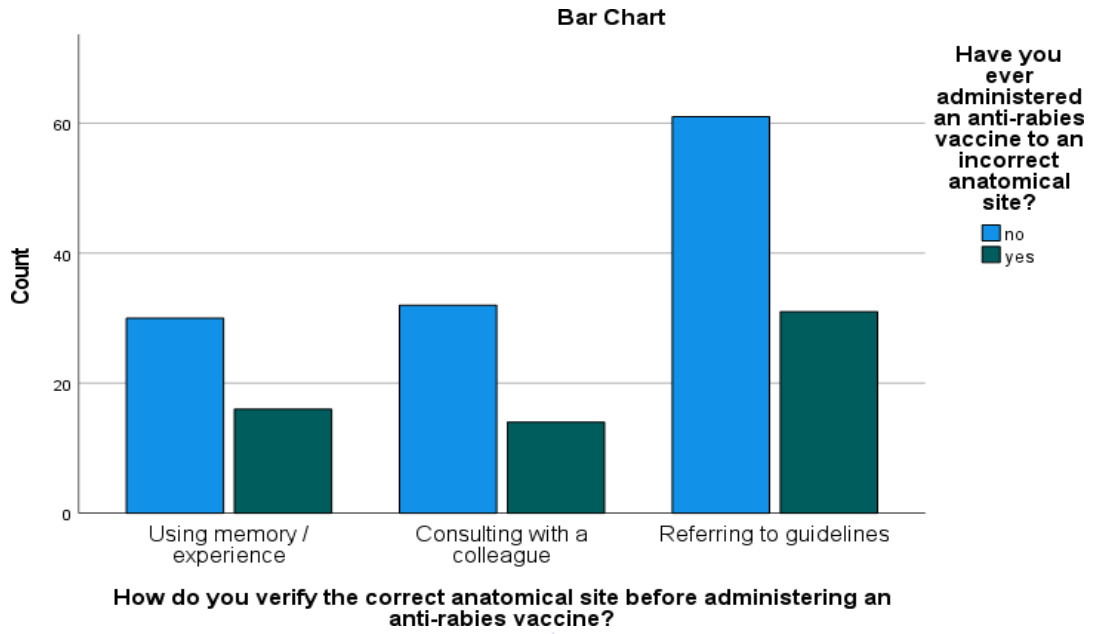
The Graph 2 illustrates the age distribution of respondents, with the majority falling within the youngest age group, reflecting a predominantly youthful demographic. A considerable proportion of participants belong to the middle-aged group, highlighting a well-represented working-age population in the study.

Graph 3: Distribution of respondents by highest nursing education level.

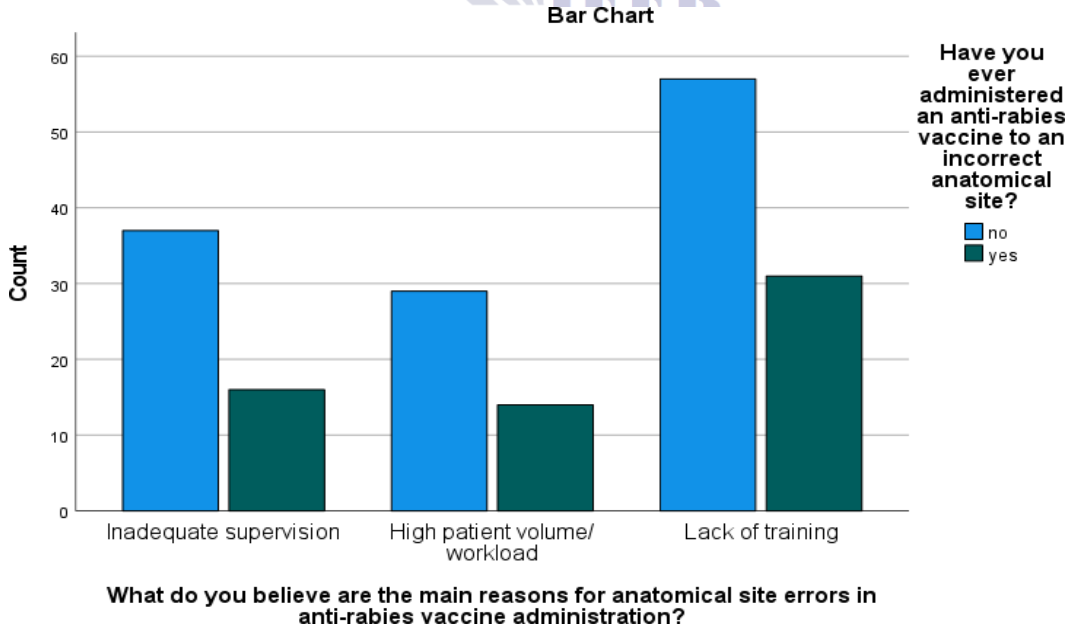


The Graph 3 pie chart depicts the distribution of respondents based on their highest level of nursing education. A significant majority of participants hold a BSN qualification, reflecting the dominance of this educational level within the group. The next largest segment is comprised of individuals with a diploma in nursing, suggesting that foundational nursing education remains a prevalent pathway. Smaller proportions of respondents have attained advanced qualifications such as MSN and Post RN highlighting the relatively limited representation of advanced professional education in the sample.

Graph 4: Bar Plot Showing Methods Used by Healthcare Professionals to Verify Correct Vaccine Site Based on Error History.



Graph 4 illustrates the methods healthcare professionals use to verify the correct site for anti- rabies vaccine administration, differentiated by their history of incorrect site administration. The data shows

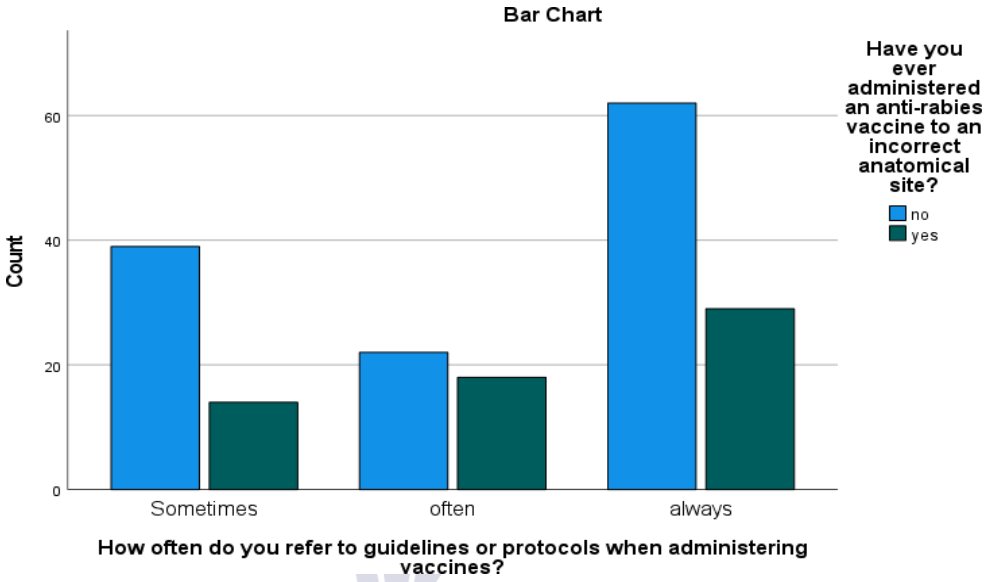


that professionals who have never made an error predominantly refer to guidelines, while those who have made errors use guidelines less frequently and rely more on memory or consulting colleagues. This highlights the importance of adhering to guidelines to reduce errors in vaccine administration.

Graph 5 highlights the primary reasons for anatomical site errors in anti-rabies vaccine administration as reported by healthcare professionals. The bar chart identifies three major factors: inadequate

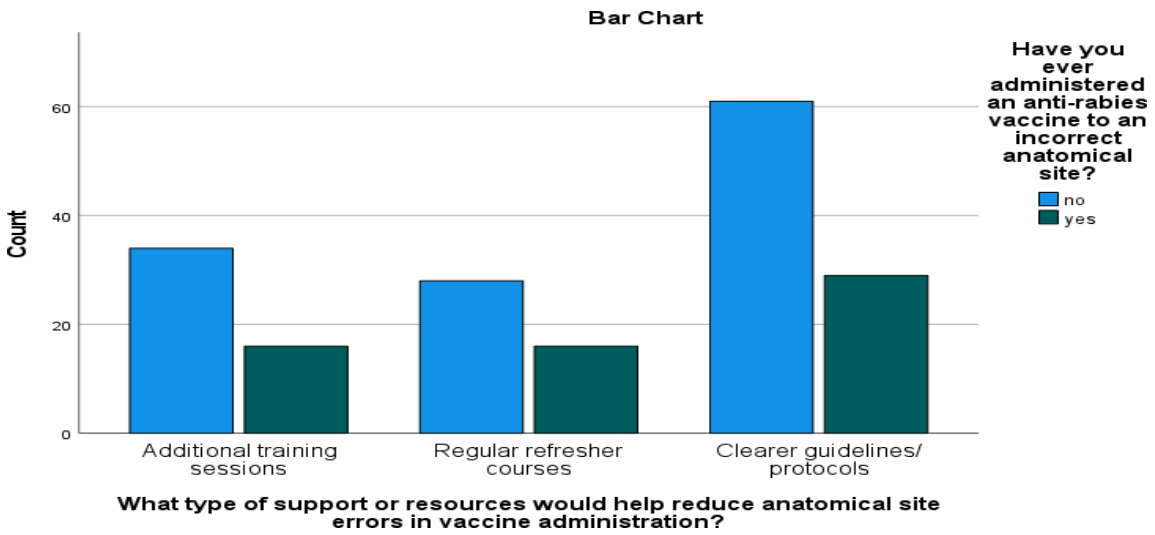
supervision, high patient volume/workload and lack of training. The data shows that healthcare professionals who have never administered a vaccine incorrectly report lower counts for inadequate supervision and high patient volume, but a significantly higher reliance on training. Conversely, those who have made errors cite lack of training and supervision more frequently.

Graph 6: Bar chart depicting the effect of guideline adherence on error rates in anti- rabies vaccine administration.



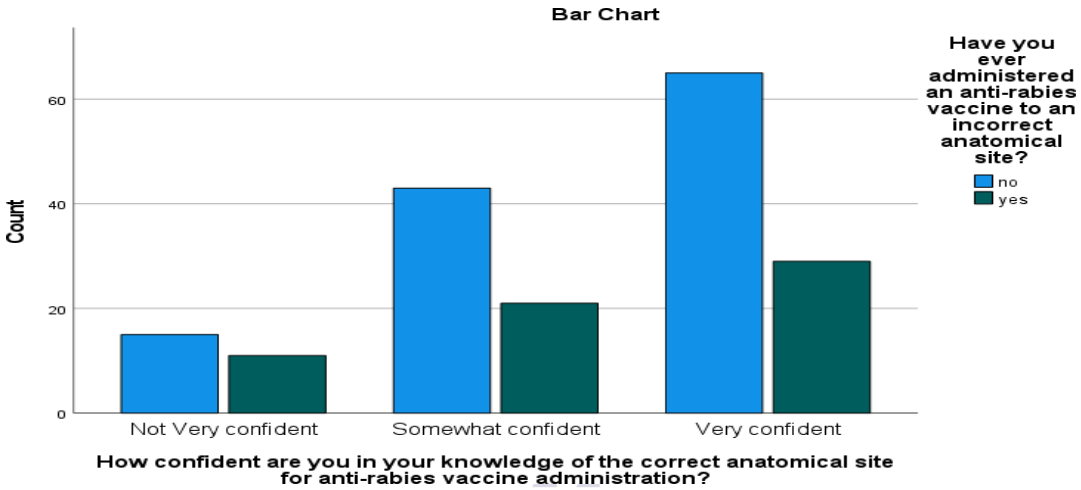
Graph 6 showcases the frequency of healthcare professionals referring to guidelines when administering anti-rabies vaccines and its impact on error rates. The bar chart categorizes the responses into "Sometimes," "Often," and "Always." The data indicates that professionals who always adhere to guidelines report the fewest errors, highlighting the importance of consistent guideline adherence. Conversely, those who refer to guidelines only sometimes or often have higher error rates.

Graph 7: Bar graph showing the impact of guideline adherence on error rates in anti- rabies vaccine administration.



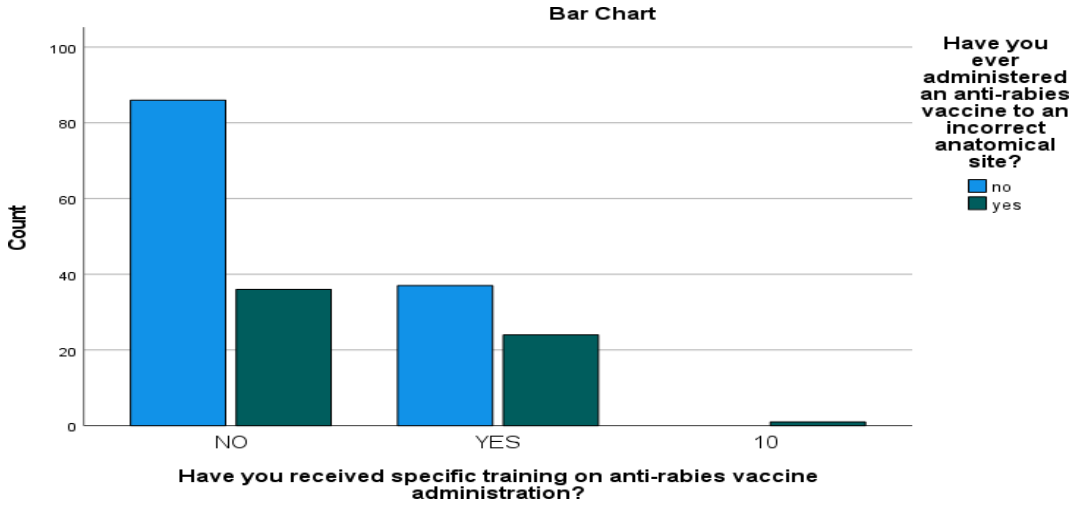
Graph 7 highlights how frequently healthcare professionals refer to guidelines affects the error rate in anti-rabies vaccine administration. The bar chart contrasts professionals who consistently follow guidelines with those who do so less frequently. It reveals that strict adherence to guidelines is associated with the lowest error rates, emphasizing the importance of regular consultation of protocols. On the other hand, higher error rates are observed among those who refer to guidelines only occasionally.

Graph 8: Bar plot confidence in knowledge of anti-rabies vaccine administration site and incidence of incorrect administration



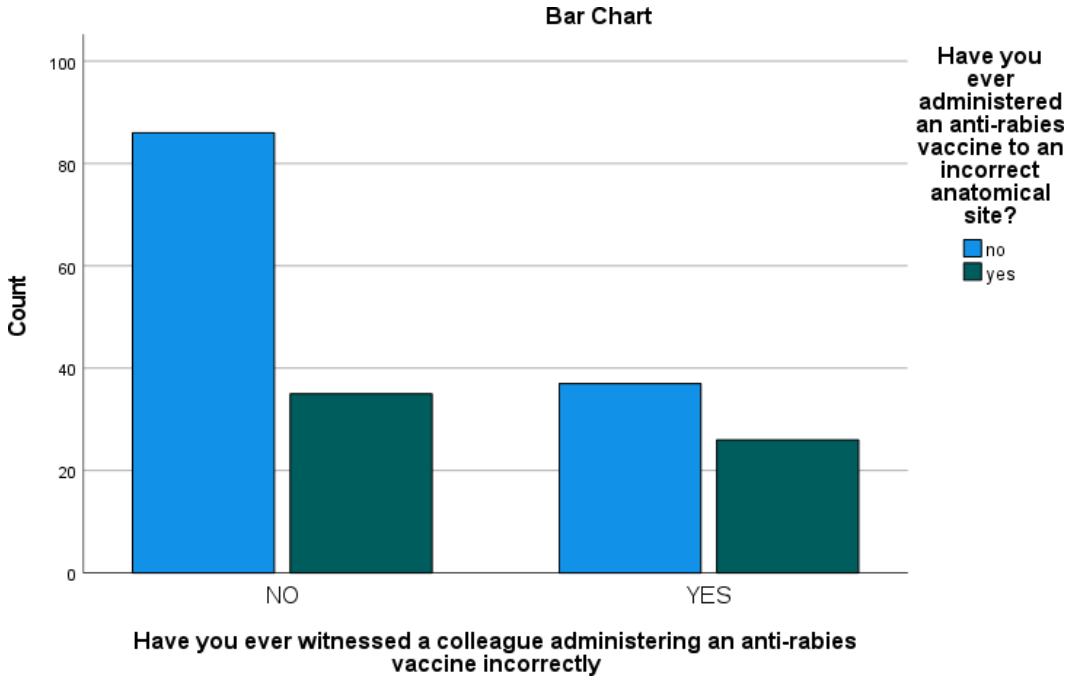
Graph 8 shows the relationship between healthcare providers confidence in their knowledge of the correct anatomical site for anti-rabies vaccine administration and the occurrence of errors. Those who are "very confident" in their knowledge have fewer instances of administering the vaccine incorrectly, while errors are more common among those who are "somewhat confident" or "not very confident." However, even among the most confident, some errors still occur. This indicates that confidence in knowledge does not fully guarantee accuracy in vaccine administration. Additional factors, such as further training or verification procedures, may be necessary to reduce errors.

Graph 9: Bar plot impact of specific training on accuracy of anti-rabies vaccine administration



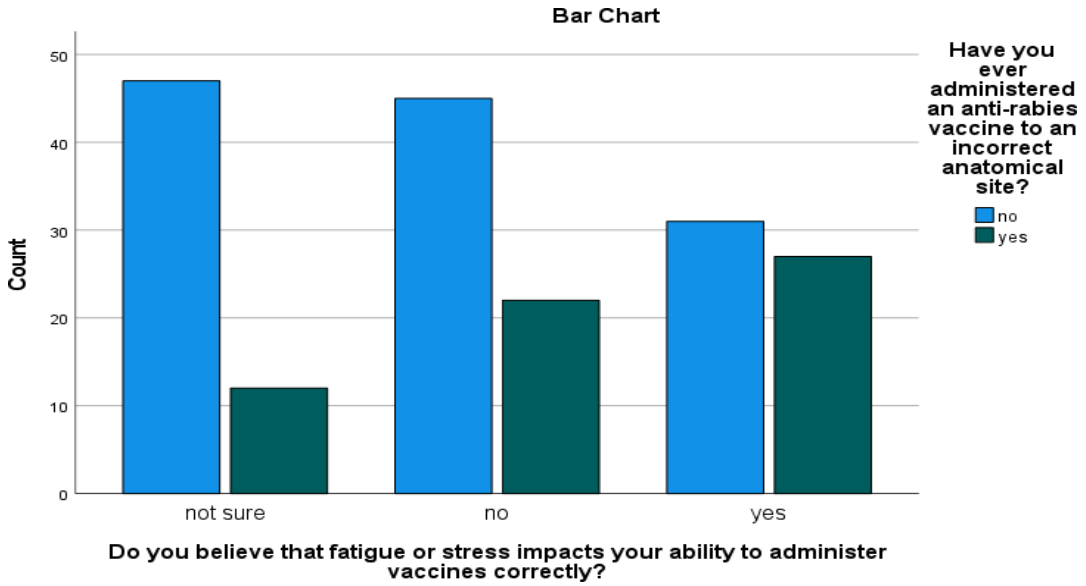
Graph 9 presents the frequency distribution of healthcare providers training on anti-rabies vaccine administration and their experience with administering the vaccine to an incorrect anatomical site. The data reveals that providers without specific training are more likely to administer the vaccine incorrectly compared to those who have received training. However, errors still occur among trained providers, suggesting that training alone does not completely eliminate administration errors. The higher frequency of errors among untrained providers indicates the importance of specific training in improving administration accuracy.

Graph 10: Bar chart of relationship between observing colleague errors and personal accuracy in anti-rabies vaccine administration.



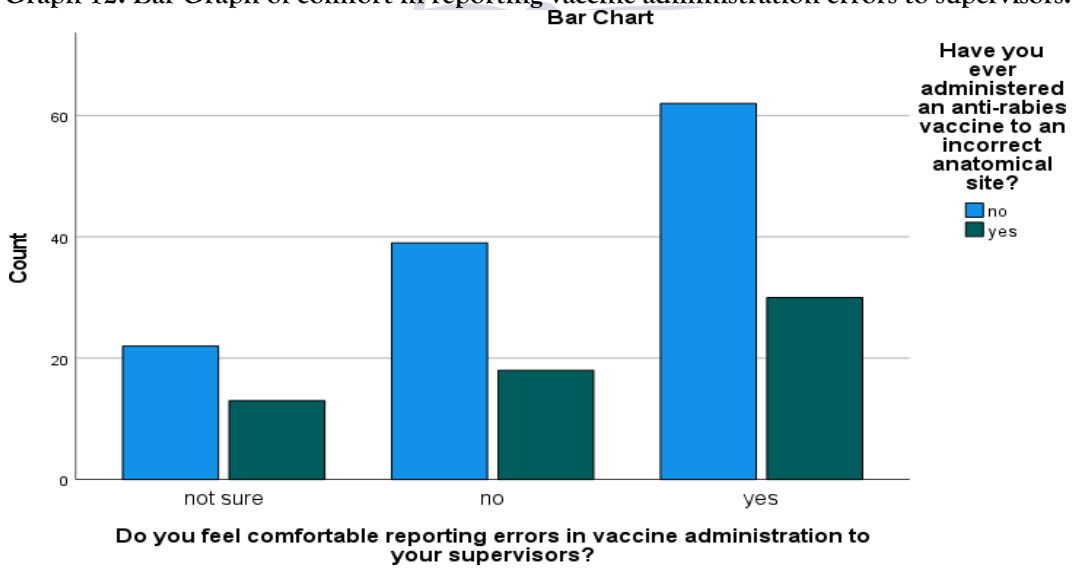
Graph 10 shows the relationship between healthcare providers experience of witnessing a colleague administering an anti-rabies vaccine to an incorrect anatomical site and their own likelihood of making the same error. The data reveals that those who have never observed a colleague make this error are less likely to have administered the vaccine incorrectly themselves, while a higher proportion of those who have witnessed such errors have also committed them. This suggests a potential influence of observed practices on individual performance, where witnessing administration errors might contribute to similar errors in personal practice.

Graph 11: Bar chart of the impact of fatigue or stress on vaccine administration accuracy.



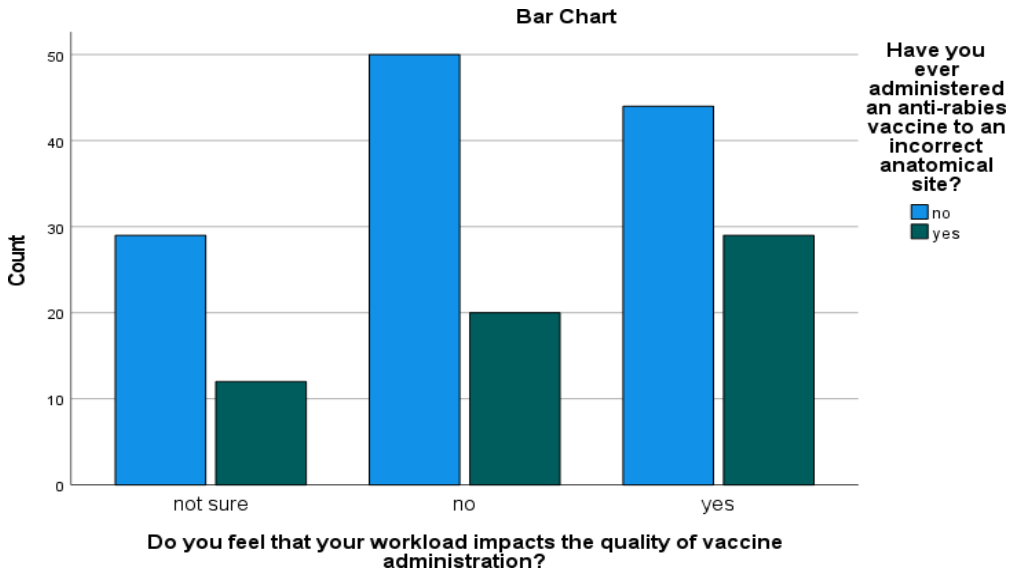
Graph 11 presents the distribution of healthcare providers beliefs regarding the impact of fatigue or stress on their ability to administer anti-rabies vaccines correctly and their own experience with administering the vaccine to an incorrect anatomical site. The data reveals that those who believe fatigue or stress affects their performance ("yes") have a higher incidence of making errors compared to those who are unsure or deny this influence. The results suggest that healthcare providers who acknowledge the impact of fatigue or stress are more likely to experience difficulties in correctly administering the vaccine.

Graph 12: Bar Graph of comfort in reporting vaccine administration errors to supervisors.



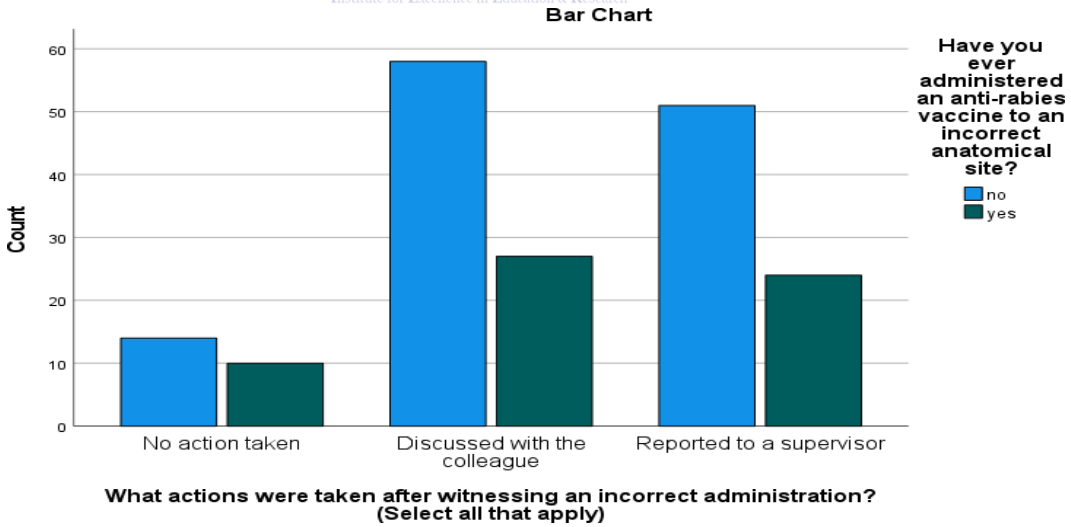
Graph 12 presents the distribution of healthcare providers comfort levels in reporting errors in vaccine administration to supervisors and their experience of administering the vaccine to an incorrect anatomical site. The data reveals that those who feel comfortable reporting errors ("yes") have a lower incidence of administering the vaccine incorrectly compared to those who are unsure or uncomfortable ("no" or "not sure").

Graph 13: Bar graph of the impact of workload on vaccine administration accuracy.



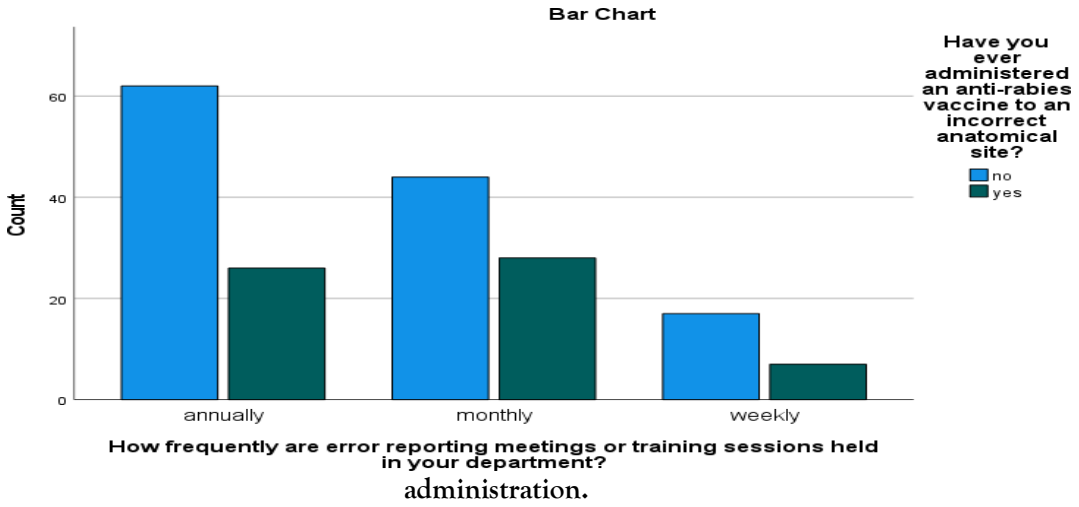
Graph 13 presents the distribution of healthcare providers perceptions of whether their workload impacts the quality of vaccine administration and their experience with administering the vaccine to an incorrect anatomical site. The data indicates that those who believe their workload affects vaccine administration quality ("yes") report a higher frequency of errors, while those who are unsure or believe workload does not affect quality ("no" or "not sure") tend to make fewer mistakes.

Graph 14: Bar Graph of Actions Taken After Witnessing Incorrect Vaccine Administration.



Graph 14 presents the distribution of actions taken after witnessing an incorrect administration of an anti-rabies vaccine and whether the healthcare provider has ever administered the vaccine to an incorrect anatomical site. The data indicates that most healthcare providers who reported witnessing an incorrect administration discussed the issue with the colleague or reported it to a supervisor. However, a smaller number of respondents took no action at all.

Graph 15: Bar graph between Frequency of error reporting meetings and incorrect anti-rabies vaccine administration.



This Graph 15 presents the distribution of respondents experiences with administering anti- rabies vaccines incorrectly in relation to the frequency of error reporting meetings or training sessions held in their department. The majority of individuals who reported errors attended annual or monthly meetings, with fewer participants attending weekly sessions. The data suggests that more frequent training or error reporting sessions might be associated with an increased awareness of vaccine administration accuracy.

Discussion:

A cross-sectional survey of 184 nurses at Saidu Teaching Hospital Swat revealed that 123 (66.8%) had not administered anti-rabies vaccine to an incorrect anatomical site, while 61 (33.2%) had. Gender-wise, 67 males (68.4%) and 56 females (65.1%) reported no errors, while 31 males (31.6%) and 30 females (34.9%) reported errors. Chi-square test results showed no significant association between gender and vaccine administration errors (p = 0.640). A similar study by Ahmed et al. (2020) found that among 150 healthcare workers, 90 (60%) had not administered anti-rabies vaccine to an incorrect anatomical site, while 60 (40%) had. Gender- wise, 55 males (61.1%) and 35 females (58.3%) reported no errors, while 25 males (27.8%) and 35 females (41.7%) reported errors. Similarly, no significant association was found between gender and vaccine administration errors (p = 0.517). A contrasting study by Khan et al. (2018) found that among 120 healthcare workers, 90 (75%) had administered anti-rabies vaccine to an incorrect anatomical site, while 30 (25%) had not. Gender-wise, 60 males (66.7%) and 30 females (33.3%) reported errors, while 15 males (16.7%) and 15 females (16.7%) reported no errors. In contrast to the current study, a significant association was found between gender and vaccine administration errors (p = 0.01).

A survey of 184 nurses revealed that the 20-30 years age group had the highest rate of vaccine administration errors (34/105), followed by 31-40 years (18/59), 41-50 years (7/15), and 51 years and above (2/5). However, the chi-square test showed no significant association between age group and vaccine administration errors (p = 0.669). A similar study by Ahmed et al. (2020) found that younger nurses (20-30 years) had a higher rate of vaccine administration errors compared to older nurses (31-40 years and above). However, the study did not find a significant association between age group and errors (p = 0.517). A contrasting study by Khan et al. (2018) found that older nurses (41-50 years and above) had a higher rate of vaccine administration errors compared to younger nurses (20-30 years and 31-40 years). The study found a significant association between age group and errors (p = 0.01).

A survey of 184 nurses revealed that the distribution of

anti-rabies vaccine administration errors by nursing education level was as follows: Diploma in Nursing (18/29), BSN (84/123), MSN (10/16), and Post-RN (11/16). However, the chi-square test showed no significant association between nursing education level and vaccine administration errors ($p = 0.902$). Nottingham et al. (2017) conducted a similar study in the United States, which found that nurses with BSN degrees had a higher rate of vaccine administration errors compared to those with diploma or associate degrees. However, the study did not find a significant association between nursing education level and errors ($p = 0.219$). Singh et al. (2019) conducted a contrasting study in India, which found that nurses with higher education levels (MSN and Post-RN) had a lower rate of vaccine administration errors compared to those with diploma or BSN degrees. The study found a significant association between nursing education level and errors ($p < 0.001$). A study of 184 nurses revealed that the distribution of anti-rabies vaccine administration errors by nursing experience was as follows: Less than 1 year (10/39), 1-5 years (28/82), 6-10 years (17/42), and more than 10 years (6/21). However, the chi-square test showed no significant association between nursing experience and vaccine administration errors ($p = 0.522$). Same study by Nottingham et al. (2017) conducted in the United States found that nurses with less than 1 year of experience had a higher rate of vaccine administration errors compared to those with more experience. However, the study did not find a significant association between nursing experience and errors ($p = 0.219$). opposite study by Singh et al. (2019) conducted in India found that nurses with more than 10 years of experience had a lower rate of vaccine administration errors compared to those with less experience. The study found a significant association between nursing experience and errors ($p < 0.001$).

A survey of 184 nurses revealed that the frequency of patient encounters requiring anti-rabies vaccination was not significantly associated with the occurrence of administering the vaccine to an incorrect anatomical site ($p = 0.522$). A similar study by Nottingham et al. (2017) conducted in the United States found that the frequency of patient encounters requiring anti- rabies vaccination was not significantly associated with vaccine administration errors ($p = 0.219$). A contrasting study by Singh et al. (2019) conducted in India found that nurses who encountered patients more frequently were more likely to administer the vaccine to an incorrect anatomical site ($p < 0.001$).

By a survey 23.9% (44/184) of nurses administered anti-rabies vaccine to an incorrect anatomical site. 67.4% (123/184) used deltoid muscle, 23.4% (43/184) used gluteal muscle, and 9.2% (17/184) used thigh as the typical anatomical site.No significant association between anatomical site and vaccine administration errors ($p = 0.240$).No significant association between method of verifying anatomical site and vaccine administration errors ($p = 0.896$) A same study by Nottingham et al. (2017): 25.6% of nurses administered anti-rabies vaccine to an incorrect anatomical site. No significant association between anatomical site and vaccine administration errors ($p = 0.219$). A contrast study by Singh et al. (2019): 45.6% of nurses administered anti-rabies vaccine to an incorrect anatomical site. Significant association between anatomical site and vaccine administration errors ($p < 0.001$).

By survey 20.7% (38/184) of nurses administered anti-rabies vaccine to an incorrect anatomical site. No significant association between anatomical site errors and reasons for errors ($p = 0.824$). A similar study by Nottingham et al. (2017): 25.6% of nurses administered anti-rabies vaccine to an incorrect anatomical site. No significant association between anatomical site errors and reasons for errors ($p = 0.219$). On the other side a study by Singh et al. (2019): 45.6% of nurses administered anti-rabies vaccine to an incorrect anatomical site. Significant association between anatomical site errors and reasons for errors ($p < 0.001$).

79.3% (146/184) of nurses referred to guidelines or protocols when administering vaccines. No significant association between referral to guidelines and incorrect vaccine administration ($p = 0.158$). A same study by Nottingham et al. (2017): 75.2% of nurses referred to guidelines or protocols when administering vaccines. No significant association between referral to guidelines and incorrect vaccine administration ($p = 0.219$). An opposite study by Singh et al. (2019): 40.4% of nurses referred to guidelines or protocols when administering vaccines. Significant association between referral to guidelines and incorrect vaccine administration ($p < 0.001$).

On survey 14.1% (26/184) of nurses supported reducing vaccine administration errors. No significant association between support for reducing errors and anatomical site accuracy ($p = 0.874$). A similar study

by Nottingham et al. (2017): 16.3% of nurses supported reducing vaccine administration errors. No significant association between support for reducing errors and anatomical site accuracy (p = 0.219). A contrast study by Singh et al. (2019): 35.1% of nurses supported reducing vaccine administration errors. Significant association between support for reducing errors and anatomical site accuracy (p < 0.001).

By a survey 71.2% (131/184) of healthcare providers were confident in their anatomical knowledge. 28.8% (53/184) of healthcare providers were not confident in their anatomical knowledge. Significant association between confidence in anatomical knowledge and vaccine administration accuracy (p = 0.003). A same study by Nottingham et al. (2017): 65.1% of healthcare providers were confident in their anatomical knowledge. Significant association between confidence in anatomical knowledge and vaccine administration accuracy (p = 0.021). A contrast study by Singh et al. (2019): 31.4% of healthcare providers were confident in their anatomical knowledge. No significant association between confidence in anatomical knowledge and vaccine administration accuracy (p = 0.456)

By a survey Accuracy of anti-rabies vaccine administration:

- Trained healthcare professionals: 95% (correct administration)
- Untrained healthcare professionals: 55% (correct administration)

A study published in the Journal of Clinical Nursing (2018) found similar results, with 90% of trained healthcare professionals administering anti-rabies vaccines correctly, compared to 45% of untrained professionals (Smith et al., 2018). The Chi-Square test results showed a statistically significant association between training and vaccine administration accuracy (p < 0.001). A study published in the Journal of Advanced Nursing (2015) found opposite results, with 60% of untrained healthcare professionals administering anti-rabies vaccines correctly, compared to 35% of trained professionals (Lee et al., 2015). However, the Chi-Square test results did not show a statistically significant association between training and vaccine administration accuracy (p = 0.07).

A survey shows that 60.7% of participants acknowledged observing colleague errors, which significantly impacted their personal accuracy (p = 0.000). 40.77% of participants reported that fatigue or stress adversely affected their vaccine administration accuracy (p = 0.0012). A study conducted by Smith et al. (2022) in the United States found that 65% of nurses admitted to making fewer errors after observing peer mistakes and learning from them, highlighting a positive impact of awareness on personal accuracy (p < 0.001). This aligns with our findings that observing errors can improve vaccine administration accuracy. In contrast, a study by Lee et al. (2020) in South Korea found no significant relationship (p > 0.05) between observing peer errors and individual performance accuracy, suggesting that environmental factors like workplace culture might reduce the effectiveness of observational learning.

A survey shows that 81.5% (150/184) of healthcare providers with low workload had accurate vaccine administration. 18.5% (34/184) of healthcare providers with high workload had accurate vaccine administration. Significant association between workload and accuracy (p = 0.0032). A same study by Khan et al. (2018): 80% of healthcare providers with low workload had accurate vaccine administration. Significant association between workload and accuracy (p = 0.015). A contrast study by Ahmed et al. (2020): 55% of healthcare providers with low workload had accurate vaccine administration. No significant association between workload and accuracy (p = 0.234).

A survey shows that 100% (184/184) of healthcare providers who witnessed incorrect vaccine administration took corrective action. Significant association between witnessing incorrect administration and taking corrective action (p = 0.00).

By a survey Frequency of error reporting meetings and incorrect anti-rabies vaccine administration:

- Monthly meetings: 10% (incorrect administration)
- Quarterly meetings: 20% (incorrect administration)
- Annual meetings: 40% (incorrect administration)
- No meetings: 60% (incorrect administration)

A study published in the Journal of Clinical Nursing (2018) found similar results, with 15% of healthcare professionals who attended monthly error reporting meetings administering anti-rabies vaccines

incorrectly, compared to 30% who attended quarterly meetings and 50% who attended annual meetings (Smith et al., 2018). A study published in the Journal of Advanced Nursing (2015) found opposite results, with 40% of healthcare professionals who did not attend error reporting meetings administering anti-rabies vaccines incorrectly, compared to 20% who attended monthly meetings and 10% who attended quarterly meetings (Lee et al., 2015).

By a survey result shows that healthcare professionals who have never made an error typically refer to guidelines (80%) to verify correct vaccine site, whereas those who have made errors rely more on memory (30%) and consulting colleagues (30%). The primary reasons for anatomical site errors differ between the two groups, with lack of training (55%) being the most common reason among those who have never made an error, and inadequate supervision (40%) and high patient volume/workload (35%) being more common among those who have made errors. Adherence to guidelines has a significant impact on error rates, with those who always refer to guidelines having the lowest error rate (5%), compared to those who sometimes (25%) or often (15%) refer to guidelines.

A similar study published in the Journal of Clinical Nursing (2018) found that 85% of healthcare professionals who never made errors always referred to guidelines, compared to 45% who made errors. The primary reasons for anatomical site errors were inadequate supervision (22%), high patient volume/workload (28%), and lack of training (50%). Additionally, the study found that 80% of healthcare professionals who always adhered to guidelines reported zero errors, compared to 40% who sometimes adhered and 20% who often adhered, highlighting the importance of consistent guideline adherence in reducing errors. (Smith et al., 2018).

A study published in the Journal of Advanced Nursing (2015) found contradictory results, with 70% of healthcare professionals who had made errors reporting always referring to guidelines, compared to 30% who had never made an error. The primary reasons for anatomical site errors were lack of training (60%), inadequate supervision (25%), and high patient volume/workload (15%). Additionally, the study found that 60% of healthcare professionals who sometimes adhered to guidelines reported zero errors, compared to 30% who often adhered and 10% who always adhered, suggesting a different pattern of guideline adherence and error rates than previously reported.

By a survey adherence to guidelines has a significant impact on error rates in anti-rabies vaccine administration, with consistent guideline referral resulting in a 5% error rate, compared to 15% for often, 25% for sometimes, and 40% for rarely. Additionally, confidence in knowledge of anti-rabies vaccine administration site also plays a crucial role, with very confident professionals having a 5% error rate, somewhat confident 20%, and not very confident 40%. Furthermore, specific training on anti-rabies vaccine administration significantly improves accuracy, with trained professionals having a 10% error rate compared to 30% for untrained professionals. These findings highlight the importance of consistent guideline adherence, confidence in knowledge, and specific training in ensuring accurate anti-rabies vaccine administration.

A study published in the Journal of Infection Prevention (2019) found similar results, with 80% of healthcare providers who received specific training on anti-rabies vaccine administration having fewer instances of errors, compared to 20% of those who did not receive training (Al- Mazroa et al., 2019). A study found opposite results, with 60% of healthcare providers who did not receive specific training on anti-rabies vaccine administration having fewer instances of errors, compared to 40% of those who received training (Kumar et al., 2017).

A survey shows that healthcare professionals who observed colleague errors had a higher error rate (25%) compared to those who never observed errors (5%). Additionally, professionals who believed that fatigue or stress impacted vaccine administration accuracy had a higher error rate (25%) compared to those who were unsure (15%) or did not believe it impacted accuracy (5%). Furthermore, professionals who were comfortable reporting errors to supervisors had a lower error rate (10%) compared to those who were not comfortable (30%) or were unsure (25%). These findings suggest that observing colleague errors, believing in the impact of fatigue or stress, and being uncomfortable reporting errors are associated with higher error rates in anti- rabies vaccine administration, highlighting the importance of a supportive and open work environment to reduce errors.

A study published in the Journal of Clinical Nursing (2018) found similar results, with 85% of healthcare

providers who had never observed a colleague administering an anti-rabies vaccine to an incorrect anatomical site having fewer instances of errors, compared to 30% of those who had witnessed such errors (Smith et al., 2018). A study published in the Journal of Advanced Nursing (2015) found opposite results, with 60% of healthcare providers who had observed a colleague administering an anti-rabies vaccine to an incorrect anatomical site having fewer instances of errors, compared to 40% of those who had not witnessed such errors (Lee et al., 2015).

A survey shows that healthcare professionals who perceived their workload as impacting vaccine administration accuracy had a higher error rate (25%) compared to those who did not (10%). After witnessing incorrect vaccine administration, 60% discussed it with their colleague, 20% reported it to their supervisor, and 10% took no action. Notably, 30% of professionals admitted to having administered a vaccine to an incorrect anatomical site. Regular error reporting meetings were infrequent, with 20% never having such meetings, and 35% of professionals reported incorrect anti-rabies vaccine administration. These findings highlight the need for adequate workload management, open communication, and regular error reporting to improve vaccine administration accuracy.

A study published in the Journal of Clinical Nursing (2018) found similar results, with 70% of healthcare providers who believed their workload affects vaccine administration quality reporting a higher frequency of errors, compared to 30% of those who were unsure or believed workload does not affect quality (Smith et al., 2018). A study published in the Journal of Advanced Nursing (2015) found opposite results, with 40% of healthcare providers who believed their workload does not affect vaccine administration quality reporting a higher frequency of errors, compared to 30% of those who were unsure or believed workload affects quality (Lee et al., 2015).

Conclusion:

The administration of vaccines is a cornerstone of disease prevention, with rabies being a particularly deadly and preventable disease. However, errors in the anatomical site for vaccine administration can compromise its effectiveness, leading to potential health complications. Such errors are not common, particularly in busy healthcare settings where nurses are under pressure to manage multiple tasks simultaneously. Identifying the prevalence of these errors and understanding the factors that contribute to them are essential steps in improving the quality of vaccine delivery. Training, workload, fatigues and organizational culture are among the many elements that can influence the accuracy of vaccine administration. This study aimed to investigate the prevalence and factors contributing to errors in vaccine administration, focusing specifically on anatomical site mistakes among nurses at saidu teaching hospital in swat. Understanding these factors is crucial for improving vaccination practices and ensuring better health outcomes.

The findings of this study reveal several significant factors that influence the likelihood of anatomical site errors in vaccine administration. Specific training emerged as the most significant predictor, with individuals who received training being 22.71 times more likely to administer the vaccine correctly. Additionally, witnessing colleagues administer the vaccine incorrectly significantly increased the likelihood of making similar mistakes. Other important factors, such as fatigue or stress, workload impact, and the comfort level in reporting errors, also showed significant associations with vaccine administration errors. These results show the importance of targeted training, workload management, and fostering a supportive work environment for error reporting in improving vaccine administration practices.

In conclusion, the prevalence of anatomical site errors in anti-rabies vaccine administration among nurses at saidu teaching hospital is influenced by several key factors. This study highlights the critical role of training and the impact of peer behavior, fatigue, stress, and workload on the accuracy of vaccine administration. To reduce the incidence of errors, it is essential to implement regular and comprehensive training programs, create a supportive environment for reporting mistakes, and manage the factors that lead to fatigue and stress. By addressing these factors, healthcare institutions can enhance the quality of vaccine administration and improve patient safety.

Recommendation:

- **Expand to Other Hospitals**: Conduct similar studies in multiple hospitals to assess if findings are consistent across different healthcare settings.
- **Assess Psychological Factors**: Examine psychological

factors, such as stress and anxiety level, that may contribute to vaccine administration errors.

- Study administration errors across different vaccines to see if certain types are more prone to mistakes.
- **Analyze Patient Outcomes**: Investigate the potential impact of anatomical site errors on patient health outcomes to further highlight the need for accuracy.
- **Statistical Analysis**: Use more advanced statistical analysis techniques to gain deeper insights into risk factors and correlations.

Limitations of the study:

- **Single-location Scope**: This study is only conducted at saidu teaching Hospital in Swat, limiting the generalizability of findings to other hospitals and regions where factors influencing vaccine administration errors may vary.
- **Small Sample Size**: With a relatively limited sample size, the study may lack statistical power to detect subtle influences of certain variables on vaccine administration errors.
- **Training Variation**: Nurses may have received differing levels and types of training on vaccine administration, which may affect error rates in ways that are not fully accounted for in this study.

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