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http://jept.ir
doi:10.34172/jept.2025.20

Journal of Emergency Practice and Trauma
Volume 10, Issue 2, 2024, p. 142-148

Original Article

Prehospital Delay and Its Associated Complications Among Patients with Snake Envenomation : A Cross-Sectional Analytical Study

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Received: July 31, 2025
Accepted: October 6, 2025
ePublished: October 27, 2025

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Citation: Dey D, Ramamoorthy L, Lalthanthuami HT, Ayyan SM. Prehospital delay and its associated complications among patients with snake envenomation : a cross-sectional analytical study. Journal of Emergency Practice and Trauma 2024;10(2):142-148. doi:10.34172/jept.2025.20

Abstract

Objective: Snakebite envenoming is a significant public health problem in rural tropical regions, often resulting in disability and death. Timely hospitalization and prompt administration of antivenom are crucial for survival. However, factors such as limited awareness, poor access to healthcare, antivenom therapy, and reliance on traditional healers contribute to delays in seeking medical care, thereby increasing complications and adverse outcomes.

Methods: This cross-sectional analytical study aimed to evaluate pre-hospital delay, its associated factors, and related complications among patients with snake envenomation presenting to the emergency department of a tertiary care public center in South India, from August 2023 to May 2024. This study included 100 adult participants with confirmed snakebite characteristics. Participants were selected through consecutive sampling, and data collection focused on details of the snakebite incident, time of hospital presentation, causes of delay, and complications. The data were analysed using mean ± standard deviation, median (interquartile range), and associations were tested using the Chi-square test, Fisher's exact test, and the Mann-Whitney U test.

Results: In our study, 18% of participants arrived at the hospital more than 4 hours after envenomation, with a median arrival time of 90 minutes. Among the study participants, prehospital practices included washing the bite site with soap and water (n = 19, 19%) and application of native concoctions (n = 17, 17%). Lack of awareness and knowledge regarding snakebite contributed to delayed hospital arrival. On the first day of admission, the most common complications were leukocytosis (83%), dyselectrolytemia (n = 70, 70%) hepatic dysfunction (n = 56, 56%) renal dysfunction (n = 57, 57%), haematuria (n = 48, 48%), and metabolic acidosis (n = 45, 45%). Delayed presentation was significantly associated with higher rates of complications like hematuria ($P = 0.003$), renal dysfunction ($P = 0.008$), metabolic acidosis ($P = 0.047$).

Conclusion: The current study revealed that traditional practices, combined with a lack of awareness about bites, socioeconomic constraints, and the absence of a guardian, often lead to delayed medical care. These delays result in longer hospital stays, increased morbidity, and higher mortality. Early hospitalization can significantly reduce complications, disability, and mortality in patients with snake envenomation.

Keywords: Bite, Snake, Snake bite, Snakebites, Snakebite envenoming, Snakebite envenomings, Time-to-treatment, First aid / adverse effects

Introduction

Snakebite is a serious public health concern, leading to significant illness and death worldwide, especially in tropical areas (1). This venom can have various toxins that cause a wide range of symptoms and complications, including local tissue damage, bleeding problems, kidney failure, paralysis, and even death if not treated. The World Health Organization (WHO) estimates that about 5.4 million people are bitten by snakes each year, resulting in 1.8 to 2.7 million cases of envenomation. Annually, approximately 81,410 to 137,880 people die from these bites, and roughly three times as many, around 400,000 survivors, suffer amputations and other permanent disabilities (2). The situation of snake envenomation varies worldwide, with some regions experiencing a higher burden than others. In tropical and subtropical areas, especially in Africa, Asia, and Latin America-snakebite envenomation is a major public health issue due to venomous snakes and limited access to medical care and antivenom (3).

The Southeast Asia region is known for its diverse range of venomous snakes and is home to some of the world's

most densely populated agricultural communities. Snakebites in this area account for about 70% of the estimated global deaths from snakebite envenoming. Research from India shows that there are between 58,000 and 1.24 million cases of snakebite envenoming each year, resulting in deaths (4). India has roughly 236 snake species, most of which are non-poisonous and only cause minor panic reactions and local injuries when bitten. However, 13 of these species are venomous, with the common cobra, saw-scaled viper, Russell's viper, and common krait being especially dangerous (5).

Envenomation by venomous snakes can cause urgent medical emergencies such as shock, paralysis, hemorrhage, and severe tissue damage at the bite site, potentially leading to permanent disability if not treated promptly (6). Delays in seeking modern medical care worsen symptoms, increase the risk of complications, and raise the chances of unfavorable outcomes. These delays can be caused by various factors, including pre-hospital procedures, limited awareness about snakebites, long distances to hospitals, lack of efficient transportation, absence of guardians, difficulty accurately identifying the snake species, misconceptions among the public, and patients' inability to recognize snakebites as a serious health issue (7,8). Pre-hospital delay is particularly critical because timely medical intervention, including administration of antivenom and supportive care, can significantly reduce morbidity and mortality. Understanding the specific causes and patterns of these delays in local settings is essential for designing effective strategies to ensure prompt medical care and reduce adverse outcomes.

Research indicates that the longer the delay before hospital arrival, the greater the risk of complications, mortality, and more extended hospital stays for snakebite victims. The risk of complications depends on factors such as the snake species, bite location, the victim's age and gender, existing health issues, time before hospitalization, pre-hospital interventions, and presence of other medical conditions (9,10). While previous studies have described the general clinical profile of snakebite victims, there is limited data specifically examining the relationship between pre-hospital delays and clinical outcomes in tertiary care settings in India. Therefore, we aimed to quantify these delays, identify their determinants, and evaluate their association with complications and clinical severity. By understanding the key factors contributing to pre-hospital delays, the findings are expected to inform targeted interventions, such as community awareness programs, improved emergency response protocols, and hospital preparedness strategies, ultimately helping to mitigate delays and improve patient outcomes.

Methods

A cross-sectional analytical study was conducted at the Emergency Department of a tertiary care center in Pondicherry, South India, between August 2023 and May 2024. The study included 100 adult participants, all aged 18 years or older, who presented with a history of snakebite and clinical signs of envenomation. Participants were recruited using consecutive sampling, enrolling all eligible patients meeting the inclusion criteria during the study period, except those with dry bites, who were discharged early after only 6 hours of observation and could not be followed up further. The initial sample-size calculation was based on estimating a single mean with an absolute precision of 0.5 h and a 5% level of significance ($\alpha = 0.05$). An assumed variance of 9 hrs produced a required sample size of 138 participants, which was rounded to 150 to allow for 10% attrition (11,12). However, other studies in comparable settings reported shorter pre-hospital delays with lower variability. One study reported a median time to hospital of 1.2 hrs (IQR 0.67–2.3 h, approximated SD $\approx$ 1.21 h), while another reported a median delay of 150 min (IQR 90–195 min, approximated SD $\approx$ 1.30 h) (7,13). Given these lower variances, the enrolled sample of 100 participants provides adequate precision and statistical power to estimate the pre-hospital delay.

The study received approval from the institute's Research Monitoring Committee (CON/NRMC/M.Sc/2022/MSN/5) and the Ethical Committee for Human Studies (CON/IEC/M.Sc./2022/MSN/5) and adhered to the ethical standards established by the institution and the Declaration of Helsinki (2013 revision). Participants were enrolled only after obtaining informed consent from their legally authorized representatives. Before data collection, participants were informed about data confidentiality, anonymity, and their right to withdraw from the study.

Data were collected in three sections. Section I recorded participants' demographic details, including age, gender, domicile, and personal habits. Section II covered prehospital practices and other information related to snakebites, such as the type of snake, the presence of any fang marks, whether any antivenom was received, and participants' comorbidities. Section III documented clinical variables at admission, including the time between the snakebite and hospital arrival, reasons for delayed presentation, initial treatments, and snakebite severity using the Snakebite Severity Score (SSS), a standardized, open-access tool widely used in prior research (7), in which each body system is scored based on clinical manifestations. Section III also included vital signs, physical and neurological assessments (including the Glasgow Coma Scale), laboratory investigations, and any biochemical or hematological complications. The data collection tool (questionnaire/proforma) was validated by experts, achieving a Content Validity Index (CVI) of 0.8, ensuring content accuracy and relevance. Eligible patients were identified, and informed consent was obtained from them or their legally authorized representatives as

soon as possible after admission. Baseline characteristics, including demographic details and specifics of the snakebite, were documented. A detailed history and physical examination were conducted to assess the severity of the snakebite, vital signs, and other clinical parameters. Hematological and biochemical tests were conducted upon admission and as indicated. Clinical manifestations and complications were monitored through laboratory reports, with daily follow-ups lasting approximately 30 minutes until discharge. For analytical purposes, early presentation was defined as hospital arrival ≤ 4 hours after the bite, and late presentation as > 4 hours, consistent with previous studies (14).

Statistical analysis was performed using IBM SPSS 25.0. Descriptive statistics (mean, standard deviation, frequencies, and percentages) were used to summarize baseline characteristics. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test, while continuous variables were compared using the Independent t-test or Mann–Whitney U test, depending on the distribution. A *P* value < 0.05 was considered statistically significant. Odds ratios (ORs) for complications with early (≤ 4 h) versus late (> 4 h) hospital presentation were calculated using 2 × 2 contingency tables. Chi-square or Fisher's exact tests were applied in SPSS 25.0, which provided the ORs and 95% confidence intervals. The choice between mean ± SD and median (IQR) depended on data distribution, with normally distributed variables summarized using means and standard deviations, and skewed variables summarized using medians and interquartile ranges.

Results

Among the hundred participants, there was a male predominance (71%), and most individuals came from rural areas (94%). The average age of the participants was 45.5 ± 15.6 years. The highest incidence of snakebites was observed in the 31-45 age group (33%), followed by the 45-60 age group (29%) and the 18-30 age group (21%). The majority of cases involved a Russell viper bite (30%), followed by bites from common krait and water snakes (15% each). 31% of the participants failed to identify the species of the snake. The mortality rate was 6%.

The median time from the bite to hospital arrival was 90 minutes (interquartile range, 45-180 minutes). Of 100 patients, 82 arrived early, and 18 came more than 4 hours late. The most common reasons for delay were lack of awareness of the type of bite (8%), lack of a guardian (4%), and unavailability of transport (3%). Additionally, six patients arrived late for unspecified reasons. Those who arrived late also had longer hospital stays (6 vs. 13 days, $P = 0.001$). Engagement in pre-hospital care was associated with a threefold increase in the likelihood of delayed hospital presentation (Table 1).

There was no clinical significance with gender ($P = 0.203$), domicile ($P = 0.237$), season ($P = 0.471$), presence of fang marks ($P = 0.849$), history of visiting health centre ($P = 0.156$), or time of presentation to the hospital. Snakebite severity score was lower among patients who presented early (3 vs 4; $P = 0.004$); similarly, full GCS score was higher among patients who presented early (15 vs 14.5; $P = 0.006$). (Table 2)

The complications observed among the study participants included leukocytosis (83%), which occurred on the first day of hospitalization, along with other common issues such as anemia (75%) and electrolyte imbalance (70%). Renal dysfunction (57%) and hepatic dysfunction (56%) were also notable. These complications

Table 1. Presentation time and prehospital delay N = 100

Time of hospital presentation			Frequency(%)
Time from bite to hospital in minutes (median + IQR)[a]			90 (45-180)
Time of presentation	Early (< 4 hours)		82
	Delayed (≥ 4 hours)		18
Reason for delayed presentation (multiple response)	Financial issue		1
	Mode of transport (bicycle, on foot)		2
	Unavailability of transport		3
	Absence of a guardian		4
	Thought of applying home remedies		1
	Distance from the location of the bite to the hospital		2
	Felt not so important		3
	Not aware of the type of bite		8
	Any others (Not aware of the bite itself for some period, poor road conditions, and traffic)		6
Duration of Hospitalization in days, based on time of hospital presentation [b]	Early	6 (4, 8)	*P*-value < 0.001
	Delayed	13 (10, 15.8)	

IQR- Interquartile range
[a] Median with interquartile range
[b] Mann-Whitney U-test; $P < 0.05$.

Table 2. Relationship between hospital presentation time and participants' characteristics (N = 100)

Participants' characteristics		Early presentation (n = 82) n (%)	Delayed presentation (n = 18) n (%)	*P*-value
Gender[a]	Male	56 (78.9)	15 (21.1)	0.203
	Female	26 (89.7)	3 (10.3)	
Domicile	Rural	76 (80.9)	18 (19.1)	0.237
	Urban	6 (100)	0	
Type of snake	Common krait	14 (93.3)	1 (6.7)	0.011
	Russel viper	24 (80.0)	6 (20.0)	
	Indian cobra	9 (100)	0	
	Water snake	15 (100)	0	
	Not known	20 (64.5)	11 (35.5)	
Season	Summer	25 (86.2)	4 (13.8)	0.471
	Monsoon	18 (85.7)	3 (14.3)	
	Autumn	14 (87.5)	2 (12.5)	
	Winter	25 (73.5)	9 (26.5)	
Time of bite	Morning	17 (94.4)	1 (5.6)	0.024
	Day-time	32 (84.2)	6 (15.8)	
	Evening	24 (85.7)	4 (14.3)	
	Night	9 (56.3)	7 (43.8)	
Presence of fang marks	Yes	61 (82.4)	13 (17.6)	0.849
	No	21 (80.8)	5 (19.2)	
Visited the healthcare center[a]	Yes	67 (84.8)	12 (15.2)	0.156
	No	15 (71.4)	6 (28.6)	
Age (years) [b]		44.7 ± 15.5	49.3 ± 16.0	0.261
Antivenom received[c]	Yes	79 (82.3)	17 (17.7)	0.719
	No	3 (75.0)	1 (25.0)	
Snakebite Severity Score[d]		3 (2, 4)	4 (3, 5)	0.004
Glasgow Coma Score on arrival[d]		15 (15, 15)	14.5 (13, 15)	0.006

[a]Chi-square test; [b]Mean ± standard deviation with Independent student t-test; [c]Fisher's exact test; [d]Median (Interquartile range) with Mann Whitney U-test; $P < 0.05$

typically developed within 1 to 5 days, with most occurring within the first 2 days of presentation. (Table 3)

Notably, delayed presentation was significantly associated with higher rates of anaemia ($P = 0.133$, OR = 3.12), metabolic acidosis ($P = 0.041$, OR = 2.97), hypoalbuminaemia ($P = 0.028$, OR = 3.14), haematuria ($P = 0.001$, OR = 7.42), dyselectrolytemia ($P = 0.053$, OR = 4.15), hypotension ($P = 0.002$, OR = 6.33), renal dysfunction ($P = 0.003$, OR = 8.00). Mortality was 4.9% (4/82) in the early presentation group compared with 11.1% (2/18) in the delayed presentation group, with an odds ratio of 2.44 (95% CI: 0.41-14.46), indicating a higher odds of death with delayed presentation. (Table 4)

Discussion

This study shows that delayed hospital presentation after snakebite is associated with a higher burden of complications, specifically metabolic acidosis, hypoalbuminaemia, haematuria, hypotension, and renal dysfunction, and with more extended hospital stay, whereas mortality (6%) did not demonstrate a statistical significance with late presentation in our cohort, however there was twice the risk of increased mortality among the participants with delayed presentation as odds ratio was 2.44. Patients who presented early had lower snakebite severity scores and a higher proportion of full GCS than those who presented late, underscoring the clinical value of timely care. In our setting, 82% of participants sought care within 4 hours, whereas 18% arrived more than 4 hours after seeking care. The median time from bite to hospital was 90 minutes, and the median time from bite to ASV administration was 170 minutes.

India is among the countries most affected by snakebite envenomation, mainly due to the presence of highly venomous species such as the Indian cobra and Russell's viper (10). Prompt administration of effective antivenom is crucial, yet many bites occur in remote rural areas where timely access is challenging (11). Shorter times to antivenom are repeatedly linked to better outcomes (7). In our cohort, the principal contributors to late presentation were unawareness of the bite (8%), absence of a guardian (4%), and prehospital practices such as topical application of native remedies, washing the site with soap and water, and use of pressure immobilization. Thirty-one percent reported an unspecified bite, reflecting a lack of knowledge about the specific species involved, and all of these were associated with delayed arrival. Additionally, six participants presented late for unspecified reasons, such as not being aware of the bite for some period, poor road conditions, and traffic. These patterns align with prior work of Michael GC et al, who linked the use of concoctions and homemade remedies with delayed presentation (12, 13), and Silva A et al reported that 105 (14%) patients delayed while waiting for symptoms to

Table 3. Distribution of complications among participants with snake envenomation N = 100

Complications	Frequency	Time of presentation (Median days)(IQR)
Anaemia	75	2 (1,3)
Leukocytosis	83	1 (1,1)
Thrombocytopenia	39	1 (1,2)
Metabolic acidosis	45	1 (1,2)
Hypoalbuminemia	38	1 (1,3)
Oliguria	17	1 (1,2)
Haematuria	48	1 (1,1)
Dyselectrolytemia	70	1 (1,2)
Disseminated intravascular coagulation	32	1 (1,2)
Hypotension	12	1 (1,5)
Renal dysfunction	57	1 (1,1)
Hepatic dysfunction	56	1 (1,1)

IQR- Interquartile range
*Median with interquartile range

Table 4. Association between time of hospital presentation and development of complications and mortality among patients with snake envenomation (N = 100)

Complications		Hospital presentation		*P*-value*	Odds Ratio	
		Early	Delayed		OR (95% CI)	*P*-value
Anaemia	Yes	59 (78.7)	16 (21.3)	0.133	3.12 (0.66, 14.65)	0.150
	No	23 (92.0)	2 (8.0)			
Leukocytosis	Yes	67 (80.7)	16 (19.3)	0.463	1.79 (0.37, 8.63)	0.468
	No	15 (88.2)	2 (11.8)			
Thrombocytopenia	Yes	29 (74.4)	10 (25.6)	0.112	2.284 (0.81, 6.43)	0.117
	No	53 (86.9)	8 (13.1)			
Metabolic acidosis	Yes	33 (73.3)	12 (26.7)	0.041	2.97 1.01, 8.70	0.047
	No	49 (89.1)	6 (10.9)			
Hypoalbuminaemia	Yes	27 (71.0)	11 (29.0)	0.028	3.14 (1.10, 9.02)	0.033
	No	55 (88.7)	7 (11.3)			
Oliguria	Yes	12 (70.6)	5 (29.4)	0.179	2.24 (0.68, 7.45)	0.187
	No	70 (84.3)	13 (15.7)			
Haematuria	Yes	33 (68.8)	15 (31.2)	0.001	7.42 (1.99, 27.68)	0.003
	No	49 (94.2)	3 (5.8)			
Dyselectrolytemia	Yes	54 (77.1)	16 (22.9)	0.053	4.15 (0.89, 19.33)	0.070
	No	28 (93.3)	2 (6.7)			
Disseminated intravascular coagulation	Yes	25 (78.1)	7 (29.1)	0.489	1.45 (0.51, 4.18)	0.490
	No	57 (83.8)	11 (16.2)			
Hypotension	Yes	6 (50.0)	6 (50.0)	0.002	6.33 (1.75, 22.89)	0.005
	No	76 (86.4)	12 (13.6)			
Renal dysfunction	Yes	41 (71.9)	16 (28.1)	0.003	8.00 (1.73, 37.03)	0.008
	No	41 (95.3)	2 (4.7)			
Hepatic dysfunction	Yes	45 (80.4)	11 (19.6)	0.630	1.29 (0.46, 3.67)	0.630
	No	37 (84.1)	7(15.9)			
Survived	Yes	78(83.0)	16 (17.6)	0.294	2.44 (0.41, 14.46)	0.327
	No	4(66.7)	2)33.3)			

*Chi-square test; $P < 0.05$

appear, followed by catching the snake (7).

Consistent with our observations that earlier presentation corresponds to milder illness, prior research supports the Snakebite Severity Score as a valid and reliable tool for grading envenomation and predicting outcomes; notably, all patients in the poor-outcome group had an SSS > 8 (5). Our cohort's lower SSS among early presenters reinforces the importance of reducing prehospital delay.

Snake venom can produce life-threatening neurotoxicity, hematotoxicity, cardiotoxicity, and myotoxicity (14). In our study, the most frequent complications were leukocytosis (83%), anemia (75%), dyselectrolytemia (70%), renal dysfunction (57%), hepatic dysfunction (56%), and hematuria (48%). These typically evolved over a median of 1–5 days, with most appearing within the first two days of hospitalization. Complications were more frequent in the delayed presentation group, with higher odds. Although the mortality rate was only 6 per 100 participants, the odds ratio for delayed presentation was 2.44. Consistent with these results, similar complications have been reported in the literature (1, 15, 16).

Some studies indicate that delays worsen mortality or coagulopathy. Al Masroori S et al linked delayed presentation and delayed ASV to coagulopathy (17), Silva A et al associated early presentation with lower mortality (7), and Mahendra et al reported that delayed (>6 hours) presentation correlated with cellulitis, bleeding, AKI, respiratory failure, and mortality (18). In contrast, Michael GC et al found no link between late presentation and primary outcomes (death or disability), suggesting antivenom can remain effective even when given later (13). These discrepancies are plausibly driven by differences in healthcare access and transport, antivenom availability and timing, snake species and venom phenotypes, prehospital behaviors, and case-mix/severity at presentation across settings.

This study was conducted in a single hospital in South India, so the results may not be generalizable to other settings where healthcare, transportation, or snake species differ. Still, the link we saw between delay and more complications makes sense medically and is similar to

what other studies have found

The data support focused community education to discourage harmful first-aid practices, such as native remedies, washing and incisions, and pressure immobilization, and to promote immediate transport to healthcare facilities (18,19). Health-system measures, such as strengthening primary-level readiness with ASV, streamlined referral and transport, and early triage protocols, may further shorten bite-to-needle times (20, 21). Given that a notable fraction of patients do not recognize delay, education should also target risk recognition and urgency cues.

The limitations of this study include the exclusion of patients with dry bites and those discharged early, which may have skewed the results toward more severe cases and reduced the overall sample size. As the study was conducted at a single tertiary care center, the findings may not be generalizable to other settings, particularly primary or secondary healthcare facilities. Follow-up was limited to the period of hospitalization; hence, long-term complications and post-discharge disabilities were not captured. Data collection was also restricted to a defined period due to academic commitments related to thesis submission, with no enrollment during June and July, which may have introduced seasonal bias. Furthermore, recall bias may have affected the accuracy of reported pre-hospital delays, and selection bias may be present, as patients with more severe envenomation are more likely to present to tertiary care centers than those with milder symptoms.

Future research should focus on larger multi-center studies and community-based surveys to validate these findings across diverse settings. Incorporating longer follow-up would also help in understanding long-term complications and disabilities, thereby providing a more comprehensive picture of the burden of snakebite.

Conclusion

Promoting early visits to primary healthcare centers is crucial for improving outcomes in snakebite globally. Despite this, delays in seeking medical care remain a significant challenge, particularly in regions such as South Asia, where only a small proportion of patients reach hospitals within a few hours of being bitten. This delay is problematic as it hinders timely intervention, which is vital for effective treatment. Furthermore, there is a critical need to enhance early diagnosis of systemic envenoming. Rapid and accurate diagnosis is essential to ensure prompt administration of antivenom, thereby significantly improving patient outcomes. Delays in presenting to healthcare facilities can lead to severe complications, prolonged hospital stays, and long-term morbidity. Moreover, while some studies indicate that disability and mortality are not directly associated with delayed presentation, they suggest that patients who present later may require higher doses of antivenom. This highlights the importance of early intervention not only to prevent complications but also to reduce the overall need for more intensive treatment, potentially. Our findings underscore the need for targeted public health strategies, including strengthening community awareness programs on the risks of delayed treatment, engaging traditional healers to encourage prompt hospital referral, and improving access to emergency transport services in rural areas. Such measures can significantly reduce pre-hospital delays and improve outcomes.

Acknowledgements

We acknowledge the Nursing Staff and Senior Resident medical officers of the Emergency and Trauma department, as well as other medical wards.

Authors' Contribution

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Data Availability Statement

The dataset used in the current study is available from the College of Nursing, JIPMER, upon request, through the corresponding author.

Ethical Approval

The institutional Ethics Committee (JIP/CON/IEC/M.Sc./2022/MSN/5) for human studies and the Research Monitoring Committee (JIP/CON/NRMC/M.Sc./2022/MSN/5) approved the study. The procedures followed were in accordance with the institution's ethical standards.

Funding

Recieved Intramural Grant fo INR.7700(for xeroxing and printing of Informed Consent forms and thesis binding) by JIPMER,Oct-Dec-2023-24_14.

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