# Introduction

# Methods

We followed the STROBE guideline for better observational cross-sectional study reporting in epidemiology.

## Population and study sites

## Data collection

## Outcome variables

The CDC recommends that rabies patients receive a dose of rabies vaccine and human rabies immune globulin (HRIG) on the day of exposure, and then again on days 3, 7, and 14. To construct our outcome variable, we categorized each patient as "1" or "Yes" if they Maintained the recommended vaccine schedule appropriately. Otherwise, they were recorded as not maintained by "0" or "No".

**Possible factors**

To find out potential risk factors associated with not maintaining the recommended vaccine schedule, we examined a range of socioeconomic factors and the medical history of the patients as independent variables. These included the patient's age, gender, profession, income category, highest education, location, distance residence to IDH, heard about rabies hospital before, animal bite, exposure type, number of bites/scratches, type of animal, site of bite, status of biting animals, reason of bite, category of wound, measures taken, and reason for coming late to take the vaccine.

## Statistical analysis

We conducted descriptive statistics by crosstabs, presenting counts and percentages to summarize categorical variables. Chi-square tests and Fisher's exact test were employed to investigate factors associated with the status of the vaccine schedule. Binary and multivariable logistic regression was utilized to identify associated risk factors. Initially, bivariable analysis assessed the relationship between the status of the vaccine schedule and other factors. Univariable (unadjusted) and multivariable (adjusted) logistic regression analyses were then conducted to compare associated risk factors. In the univariable analyses, variables were individually added to the logistic regression model, while in the adjusted model, all possible variables were included simultaneously. Results were reported as unadjusted/crude odds ratios (COR) and adjusted odds ratios (AOR) with their respective 95% confidence intervals and 5% level of significance. All analyses were performed using R software.

**Variable selection**

Variables were chosen through a two-stage process. Initially, bivariable analysis (chi-square test) was performed individually for each independent variable. A significance threshold of p-value ≤ 0.20 was applied arbitrarily to determine the inclusion of covariates in the multivariable models (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0242864). In the second stage, a comprehensive multivariable model was constructed using the selected predictor variables. Additionally, we assessed multicollinearity in the final model using a cut-off value of 4.00 for the variance inflation factor (VIF) analysis (https://link.springer.com/article/10.1186/s12889-023-15617-8). At this stage, all variables were incorporated into the model since the VIF values for each variable were below 4.00.

**Model performance**

We utilized the Area under the Receiver Operating Characteristic (AUROC) curve, sensitivity, specificity, and the Hosmer–Lemeshow goodness-of-fit test to assess the accuracy of the best model. Higher AUROC values indicated superior model performance. In the ROC curve, a lower p-value suggests that the model effectively discriminates between two categories, with an area under the curve exceeding 0.50 (https://link.springer.com/article/10.1186/s12981-022-00495-8). The Hosmer–Lemeshow goodness-of-fit test evaluates the similarity between model-estimated probabilities and observed outcomes, typically through a goodness-of-fit test. A Hosmer–Lemeshow goodness-of-fit test with a p-value greater than 0.05 indicates the model's ability to accurately classify observations into outcome categories (https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.985445/full).

# Results

## *Study population*

In our research, we systematically examined various numerical variables, including age, family income, distance from residence to the Infectious Disease Hospital (IDH), travel costs to the hospital and IDH, time taken to reach the hospital, time gap for wound washing, medicine costs, and time gap for hospital visits. For each variable, we computed key descriptive statistics such as the minimum, maximum, mean, standard deviation, and coefficient of variation. The findings indicate that the mean age of participants was 25.83 years, with a standard deviation of 14.99 years. Family income had a mean of 34564.38 Taka, with a standard deviation of 45119.19 Taka. The average distance from participants' residences to the IDH was 14.05 kilometers, with a standard deviation of 10.78 kilometers. Travel expenses to the hospital and IDH averaged 141.70 Taka and 11.49 Taka, respectively, with standard deviations of 108.00 Taka and 81.92 Taka. The mean time taken to reach the hospital was 87.93 hours, with a standard deviation of 56.06 hours. Participants typically waited for an average of 3.23 hours before washing their wounds, with a standard deviation of 3.09 hours. The average medicine cost was 344.08 Taka, with a standard deviation of 49.61 Taka. Finally, the meantime gap between the bite incident and hospital visit was 90.77 hours, with a notable standard deviation of 395.39 hours, indicating significant variability in this aspect among participants (Table 1).

Among the 365 individuals participating in the study, the largest segment, comprising 75.1%, fell within the age range of 15 years and older. The majority of participants were male, accounting for 71.2% of the total. A significant portion, 52.6%, identified as either students or housewives, while a notable 52.9% belonged to the higher income category (earning >=30000). In terms of education, a considerable 32.1% of participants had a primary educational background. Dhaka North City Corporation housed the highest number of residents among the patients, constituting 54.8% of the total. Interestingly, the majority of participants, approximately 86.6%, hailed from a distance greater than 10 km from the Infectious Disease Hospital (Figure 1 and Table 2). More than half of the participants learned about rabies hospitals from their neighbors. The characteristics of animal exposure, detailed in Table 2, reveal that a plurality (49.3%) of patients reported incidents involving cats, followed closely by dogs (48.8%), with a small minority involving other animals (1.9%). A majority (57.0%) of patients experienced bites, with the majority of incidents (72.3%) involving single bites. Stray animals were responsible for the majority of bites/scratches (53.4%), with the lower limb being the most common site of injury (53.4%). The majority of animals involved were healthy (82.2%), and most bites were provoked by patients themselves. Notably, the majority of wounds were classified as cat-III (42.7%). Following a bite, the most common immediate action taken by participants was washing the wound with water only (71.2%). Delays in seeking vaccine treatment were attributed primarily to other commitments (40.3%), followed by distance from residence (27.4%), lack of awareness regarding vaccine schedules (17.5%), and the suffering caused by the bite (14.8%).

Figure 2 illustrates the highest and average durations of delay among the participants. The longest delay was observed in individuals who experienced suffering due to the bite (4320 hours), followed by those occupied with other tasks (720 hours), individuals residing at a distance from treatment facilities (600 hours), and those unaware of the vaccine schedule (408 hours). On average, the longest delay was also noted among individuals experiencing bite-induced suffering (331 hours), followed by those occupied with other tasks (52.31 hours), individuals residing at a distance (52.11 hours), and those unaware of the vaccine schedule (36.68 hours).

Table 2 presents the prevalence and risk factors linked to vaccine schedule status, analyzed through crosstabs and chi-square tests. Notably, among the assessed risk factors, including age category, patient education level, distance from residence to IDH, type of animal bite, biting animal's health status, reason for the bite, and reason for delayed vaccine administration, significant associations with vaccine schedule status were identified. Patients experiencing delays in their vaccine schedule status exhibited higher prevalence rates among those in older age categories (91.2%), having completed higher secondary education (95.7%), residing more than 10 kilometers away from the IDH (88.0%), being bitten or scratched by a cat (88.9%), encountering healthy biting animals (88.3%), being provoked by animals as the reason for the bite (94.2%), and citing distance as the reason for delayed vaccine uptake (92.0%), compared to those without delays.

# Moreover, our adjusted logistic regression modeling provided further insights into the factors associated with vaccine delay. Findings revealed that individuals with a higher secondary education level exhibited 8 times higher odds of vaccine delay (Adjusted Odds Ratio [AOR]: 8.38, 95% Confidence Interval [CI]: 1.70-11.22). Similarly, participants residing farther from the IDH demonstrated 6.78 times higher odds of experiencing vaccine delay (AOR: 6.78, 95% CI: 2.50-8.49). Additionally, patients with Cat-II wounds displayed 4.94 times higher odds of vaccine delay (AOR: 4.94, 95% CI: 3.13-7.21), while those attributing delayed vaccine uptake to residence distance exhibited 8.78 times higher odds of experiencing vaccine delay (AOR: 8.78, 95% CI: 1.76-10.71) (See Table 3). The adjusted model utilized in our study demonstrated a satisfactory fit as evidenced by the Hosmer and Lemeshow goodness-of-fit test, with a p-value exceeding 0.05, indicating goodness of fit (P>0.05). Furthermore, the classification accuracy of the model was deemed acceptable, with an area under the curve (AUC) value of 71.10% (See Tables 4 and Figure 3).

# Discussion

# References

Fig 1:



Table 1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Minimum | Maximum | Mean | SD | CV |
| Age | 1.00 | 65.00 | 25.83 | 14.99 | 0.58 |
| Family income | 10000 | 450000 | 34564.38 | 45119.19 | 1.31 |
| Residence to IDH | 2.00 | 110.00 | 14.05 | 10.78 | 0.77 |
| Travel costs to the hospital | 10.00 | 1000.00 | 141.70 | 108.00 | 0.76 |
| Travel costs to the IDH | 0.00 | 1000.00 | 11.49 | 81.92 | 7.13 |
| Time to reach | 10.00 | 600.00 | 87.93 | 56.06 | 0.64 |
| Time gap to wash | 1.00 | 15.00 | 3.23 | 3.09 | 0.96 |
| Medicine cost | 150.00 | 800.00 | 344.08 | 49.61 | 0.14 |
| Time gap hospital visit | 0.00 | 4320.00 | 90.77 | 395.39 | 4.36 |

Figure 2



Table 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Maintained the recommended vaccine schedule appropriately | | |  |
|  | Yes  n (%) | No  n (%) | Total  n (%) | P-value |
| **Demographic characteristics** |  |  |  |  |
| **Age category** |  |  |  |  |
| <15 | 15 (16.5) | 76 (83.5) | 91 (24.9) | 0.039 |
| >=15 | 24 (8.8) | 250 (91.2) | 274 (75.1) |  |
| **Gender** |  |  |  |  |
| Female | 12 (11.4) | 93 (88.6) | 105 (28.8) | 0.770 |
| Male | 27 (10.4) | 233 (89.6) | 260 (71.2) |  |
| **Profession** |  |  |  |  |
| Student/Housewife | 21 (10.9) | 171 (89.1) | 192 (52.6) | 0.075 |
| Job/Business | 12 (8.2) | 135 (91.8) | 147 (40.3) |  |
| Others | 6 (23.1) | 20 (76.9) | 26 (7.1) |  |
| **Income Category** |  |  |  |  |
| <30000 | 13 (7.6) | 159 (7.6) | 172 (47.1) | 0.068 |
| >= 30000 | 26 (13.5) | 167 (86.5) | 193 (52.9) |  |
| **Highest Education** |  |  |  |  |
| No education or below the primary | 9 (17.3) | 43 (82.7) | 52 (14.2) | 0.047 |
| Primary | 14 (12.0) | 103 (88.0) | 117 (32.1) |  |
| Secondary | 6 (6.7) | 84 (93.3) | 90 (24.7) |  |
| Higher Secondary | 3 (4.3) | 66 (95.7) | 69 (18.9) |  |
| Above higher secondary | 7 (18.9) | 30 (81.1) | 37 (10.1) |  |
| **Location** |  |  |  |  |
| Dhaka North | 22 (11.0) | 178 (89.0) | 200 (54.8) | 0.651 |
| Dhaka South | 11 (9.0) | 111 (91.0) | 122 (33.4) |  |
| Outside Dhaka | 6 (14.0) | 37 (86.0) | 43 (11.8) |  |
| **Distance residence** **to IDH** |  |  |  |  |
| <10 | 12 (24.5) | 37 (75.5) | 49 (13.4) | 0.018 |
| >=10 | 38 (12.0) | 278 (88.0) | 316 (86.6) |  |
| **Hear about Rabies hospital** |  |  |  |  |
| Doctor | 7 (21.9) | 25 (78.1) | 32 (8.8) | 0.362 |
| Neighbor | 24 (12.3) | 171 (87.7) | 195 (53.4) |  |
| Relative | 7 (10.6) | 59 (89.4) | 66 (18.1) |  |
| Others | 12 (16.7) | 60 (83.3) | 72 (19.7) |  |
| **Know about rabies hospital before** |  |  |  |  |
| Yes | 19 (17.6) | 89 (82.4) | 108 (29.6) | 0.161 |
| No | 31 (12.1) | 226 (87.9) | 257 (70.4) |  |
| **Characteristics of animals’ exposure** |  |  |  |  |
| **Animal Bite/scratch** |  |  |  |  |
| Dog | 27 (15.2) | 151 (84.8) | 178 (48.8) | 0.041 |
| Cat | 20 (11.1) | 160 (88.9) | 180 (49.3) |  |
| Others | 3 (42.9) | 4 (57.1) | 7 (1.9) |  |
| **Exposure type** |  |  |  |  |
| Bite | 34 (16.3) | 174 (83.7) | 208 (57.0) | 0.090 |
| Scratch | 16 (10.2) | 141 (89.8) | 157 (43.0) |  |
| **Number of bites/scratches** |  |  |  |  |
| Single | 33 (12.5) | 231 (87.5) | 264 (72.3) | 0.559 |
| Double | 10 (16.7) | 50 (83.3) | 60 (16.4) |  |
| >=triple | 7 (17.1) | 34 (82.9) | 41 (11.2) |  |
| **Type of animal** |  |  |  |  |
| Stray | 26 (13.3) | 169 (86.7) | 195 (53.4) | 0.538 |
| Community own | 12 (17.6) | 56 (82.4) | 68 (18.6) |  |
| Own pet | 12 (11.8) | 90 (88.2) | 1O2 (27.9) |  |
| **Site of bite** |  |  |  |  |
| Upper limb | 18 (12.8) | 123 (87.2) | 141 (38.6) | 0.516 |
| Lower limb | 26 (13.3) | 169 (86.7) | 195 (53.4) |  |
| Others | 6 (20.7) | 23 (79.3) | 29 (7.9) |  |
| **Status of biting animals** |  |  |  |  |
| Healthy | 35 (11.7) | 265 (88.3) | 300 (82.2) | 0.029 |
| Sick but no rabies | 12 (26.1) | 34 (73.9) | 46 (12.6) |  |
| Suspected rabid | 3 (15.8) | 16 (84.2) | 19 (5.2) |  |
| **Reason of bite** |  |  |  |  |
| Provoked by patient | 16 (10.0) | 144 (90.0) | 160 (43.8) | 0.006 |
| Provoked by animals | 3 (5.8) | 49 (94.2) | 52 (14.2) |  |
| Unprovoked | 31 (20.3) | 122 (79.7) | 153 (41.9) |  |
| **Category of wound** |  |  |  |  |
| Cat-I | 3 (5.5) | 52 (94.5) | 55 (15.1) | 0.055 |
| Cat-II | 19 (12.3) | 135 (87.7) | 154 (42.2) |  |
| Cat-III | 28 (17.9) | 128 (82.1) | 156 (42.7) |  |
| **Measures taken** |  |  |  |  |
| Wash with water and soap | 4 (8.0) | 46 (92.0) | 50 (13.7) | 0.553 |
| Wash with water only | 38 (14.6) | 222 (85.4) | 260 (71.2) |  |
| Others | 1 (8.3) | 11 (91.7) | 12 (3.3) |  |
| Did nothing | 7 (16.3) | 36 (83.7) | 43 (11.8) |  |
| **Reason for coming late to take the vaccine** |  |  |  |  |
| Don’t know about the vaccine schedule | 11 (17.2) | 53 (82.8) | 64 (17.5) | 0.013 |
| Busy with other works | 17 (11.6) | 130 (88.4) | 147 (40.3) |  |
| Bite induced suffering | 14 (25.9) | 40 (74.1) | 54 (14.8) |  |
| Distance | 8 (8.0) | 92 (92.0) | 100 (27.4) |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Maintained the recommended vaccine schedule appropriately | | |  |
|  | COR (95% CI) | P-value | AOR (95% CI) | P-value |
| **Demographic characteristics** |  |  |  |  |
| **Age category** |  |  |  |  |
| <15 | 2.06 (1.03 – 4.12) | 0.042 | 1.26 (0.45 – 3.50) | 0.660 |
| >=15 | Reference |  | Reference |  |
| **Gender** |  |  |  |  |
| Female | 0.90 (0.44 – 1.85) | 0.770 |  |  |
| Male | Reference |  |  |  |
| **Profession** |  |  |  |  |
| Student/Housewife | 0.73 (0.34 – 1.52) | 0.395 | 0.69 (0.28 – 1.69) | 0.421 |
| Job/Business | 2.44 (0.88 – 6.77) | 0.086 | 2.59 (0.41 – 6.39) | 0.312 |
| Others | Reference |  | Reference |  |
| **Income Category** |  |  |  |  |
| <30000 | 1.90 (0.95 – 3.84) | 0.071 | 0.52 (0.24 – 1.12) | 0.096 |
| >= 30000 | Reference |  | Reference |  |
| **Highest Education** |  |  |  |  |
| No education or below the primary | 4.61 (1.18 – 17.98) | 0.028 | 6.39 (1.10 – 7.08) | 0.039 |
| Primary | 2.99 (0.83 – 10.81) | 0.095 | 5.88 (1.51 – 12.93) | 0.011 |
| Secondary | 1.57 (0.38 – 6.52) | 0.534 | 2.94 (0.68 – 8.74) | 0.149 |
| Higher Secondary | 5.13 (1.24 – 21.23) | 0.024 | 8.38 (1.70 – 11.22) | 0.009 |
| Above higher secondary | Reference |  | Reference |  |
| **Location** |  |  |  |  |
| Dhaka North | 0.80 (0.37 – 1.72) | 0.570 |  |  |
| Dhaka South | 1.31 (0.50 – 3.46) | 0.583 |  |  |
| Outside Dhaka | Reference |  |  |  |
| **Distance residence** **to IDH** |  |  |  |  |
| >=10 | 2.37 (1.14 – 4.94) | 0.021 | 6.78 (2.50 – 8.49) | <0.001 |
| <10 | Reference |  | Reference |  |
| **Hear about Rabies hospital** |  |  |  |  |
| Doctor | 1.40 (0.49 – 3.97) | 0.527 |  |  |
| Neighbor | 0.70 (0.33 – 1.49) | 0.356 |  |  |
| Relative | 0.59 (0.22 – 1.61) | 0.306 |  |  |
| Others | Reference |  |  |  |
| **Know about rabies hospital before** |  |  |  |  |
| Yes | 1.56 (0.84 – 2.90) | 0.306 |  |  |
| No | Reference |  |  |  |
| **Characteristics of animals’ exposure** |  |  |  |  |
| **Animal Bite** |  |  |  |  |
| Dog | 0.70 (0.38 – 1.30) | 0.257 | 0.85 (0.36 – 2.02) | 0.718 |
| Cat | 4.19 (0.89 – 19.80) | 0.070 | 2.41 (0.40 – 4.62) | 0.338 |
| Others | Reference |  | Reference |  |
| **Exposure type** |  |  |  |  |
| Bite | 1.72 (0.91 – 3.25) | 0.093 | 1.36 (0.56 – 3.30) | 0.500 |
| Scratch | Reference |  | Reference |  |
| **Number of bites/scratches** |  |  |  |  |
| Single | 1.40 (0.65 – 3.03) | 0.392 |  |  |
| Double | 1.44 (0.59 – 3.52) | 0.422 |  |  |
| >=triple | Reference |  |  |  |
| **Type of animal** |  |  |  |  |
| Stray | 1.15 (0.56 – 2.40) | 0.701 |  |  |
| Community own | 1.61 (0.68 – 3.82) | 0.283 |  |  |
| Own pet | Reference |  |  |  |
| **Site of bite** |  |  |  |  |
| Upper limb | 1.05 (0.55 – 2.00) | 0.879 |  |  |
| Lower limb | 1.78 (0.64 – 4.97) | 0.269 |  |  |
| Others | Reference |  |  |  |
| **Status of biting animals** |  |  |  |  |
| Healthy | 2.67 (1.27 – 5.64) | 0.010 | 2.11 (0.79 – 5.62) | 0.137 |
| Sick but no rabies | 1.42 (0.39 – 5.12) | 0.592 | 0.75 (0.14 – 3.98) | 0.738 |
| Suspected rabid | Reference |  | Reference |  |
| **Reason of bite** |  |  |  |  |
| Provoked by patient | 0.55 (0.15 – 1.97) | 0.360 | 0.41 (0.08 – 2.04) | 0.278 |
| Provoked by animals | 2.29 (1.19 – 4.38) | 0.013 | 10.34 (3.25 – 12.87) | <0.001 |
| Unprovoked | Reference |  | Reference |  |
| **Category of wound** |  |  |  |  |
| Cat-I | 2.44 (0.69 – 8.59) | 0.165 | 1.46 (0.36 – 5.88) | 0.591 |
| Cat-II | 3.79 (1.10 – 13.02) | 0.013 | 4.94 (3.13 – 7.21) | <0.001 |
| Cat-III | Reference |  | Reference |  |
| **Measures taken** |  |  |  |  |
| Wash with water and soap | 1.97 (0.67 – 5.79) | 0.218 |  |  |
| Wash with water only | 1.05 (0.11 – 10.30) | 0.970 |  |  |
| Others | 2.24 (0.61 – 8.24) | 0.227 |  |  |
| Did nothing | Reference |  |  |  |
| **Reason for coming late to take the vaccine** |  |  |  |  |
| Distance | 2.39 (0.90 – 6.31) | 0.079 | 8.78 (1.76 – 10.71) | 0.015 |
| Busy with other works | 1.50 (0.62 – 3.63) | 0.364 | 5.58 (1.95 – 14.55) | 0.010 |
| Bite induced suffering | 4.03 (1.57 – 10.35) | 0.004 | 3.51 (1.03 – 8.98) | 0.045 |
| Don’t know about the vaccine schedule | Reference |  | Reference |  |

Table 4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Hosmer and Lemeshow Test** | | | **Area Under the Curve** | |
| Chi-square | df | P-value | Area | 95% CI |
| 12.709 | 8 | 0.122 | 71.10% | 71.00%-71.20% |

Figure 3

