My title*

My subtitle if needed

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First sentence. Second sentence. Third sentence. Fourth sentence.

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*Code and data are available at: https://github.com/YimiaoYuan09/Pet_Ownership_Impact

1 Introduction

You can and should cross-reference sections and sub-sections. We use R Core Team (2023) and Wickham et al. (2019).

The remainder of this paper is structured as follows. Section 2….

2 Data

2.1 Data Source

In this report, I use data from a cross-sectional study of pet owners and non-pet owners in Bangladesh in 2020 as the primary dataset. The dataset uses both online and offline methods to collect data. The questionnaire was divided into two main sections including socio-demographic questions and depression assessment. The first section asked participants about their place of residence, age, gender, height, weight, lifestyle habits, pet ownership and other questions. The second part used the Patient Health Questionnaire 9 (PHQ-9) depression scale to measure depression. The PHQ-9 is scored according to the Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD PHQ), and is a reliable and accurate measure of the severity and significance of depression. A total of 280 responses were recorded in the dataset, including 140 pet owners and 140 non-pet owners.

2.2 Features

The original pet owners and non-pet owners dataset, which shows in Table 1, contains 280 responses and 19 variables.

1. id: the sequential serial number.
2. Group: the group of the respondent; numeric numbers starting from 0 correspond to options “Pet Owners” and “Non-Pet Owners” respectively.

3. Agegroup: the age group of the respondent; numeric numbers starting from 0 correspond to options “Less than 15 Years”, “15-25 Years”, “26-35 Years”, “36-45 Years”, “46-55 Years”, and “Greater than 56 Years”, respectively.

4. Gender: the gender of the respondent; numeric numbers starting from 0 correspond to options “Male” and “Female” respectively.

5. Marital: the marital status of the respondent; numeric numbers starting from 0 correspond to options “Married”, “Unmarried”, “Divorced”, and “Widowed”, respectively.

6. BMIStatus: the nutritional status of the respondent based on Body Mass Index (BMI); numeric numbers starting from 0 correspond to options “Under Weight”, “Normal Weight”, “Over Weight”, and “Obese”, respectively.

7. IncomeGroup: the respondent’s average monthly family income in Bangladeshi Taka (BDT); numeric numbers starting from 0 correspond to options “Less than 60000 BDT” and “Greater than 60000 BDT” respectively.

8. Occupation: the respondent’s occupation; numeric numbers starting from 0 correspond to options “Job Holder”, “Business”, “Homemaker”, and “Others”, respectively.

9. Religion: the respondent’s religion; numeric numbers starting from 0 correspond to options “Islam” and “Others” respectively.

10. Education: the education level of the respondent; numeric numbers starting from 0 correspond to options “Greater than 12 Years Schooling” and “Less than 12 Years Schooling” respectively.

11. Tobacco: whether the respondent is a smoker; numeric numbers starting from 0 correspond to options “Yes” and “No” respectively.

12. Alcohol: whether the respondent drinks alcohol; numeric numbers starting from 0 correspond to options “Yes” and “No” respectively.

13. Disability: the physical disability status of the respondent; numeric numbers starting from 0 correspond to options “Yes” and “No” respectively.

14. phqtotal: the total PHQ-9 Score of the respondent.

15. Depressionstatus: the depression status of the respondent; numeric numbers starting from 0 correspond to options “Depressed” and “Non-depressed” respectively.

16. DifficultyofWorking: the respondent’s difficulty in working, taking care of things or getting along with people with respect to PHQ-9 responses; numeric numbers starting from 0 correspond to options “Difficult” and “Not Difficult” respectively.

17. Typeofpet: the type of pets owned by respondent; numeric numbers starting from 0 correspond to options “Dog”, “Cat”, “Bird”, “Rabbit”, “Dog and Cat”, “Dog and Bird”, “Dog, Cat, Bird and Rabbit”, “Cat and Bird”, “Cat, Bird and Rabbit”, “Bird and Rabbit”, and “Others”, respectively.

Table 1: Preview of the raw pet owners and non-pet owners dataset

(a)

id	Group	Agegroup	Gender	Marital	BMIStatus	IncomeGroup	Occupation
141	1	2	1	1	1	0	3
142	1	1	0	1	2	0	0
143	1	4	0	1	1	0	3
144	1	2	1	0	3	0	2
145	1	1	0	1	2	0	0

(b)

Religion	Education	Tobacco	Alcohol	Disability	phqtotal	Depressionstatus
0	0	1	1	1	1	1
0	0	1	1	1	2	1
0	0	0	1	0	13	0
0	0	1	1	1	9	1
0	0	1	1	1	0	1

(c)

DifficultyofWorking	Typeofpet	MonthGroupofhavingPets	Purposeofpets
0		NA	
0		NA	
1		NA	
1		NA	
1		NA	

18. MonthGroupofhavingPets: the amount of time pet owners spend living with their pets; numeric numbers starting from 0 correspond to options "Less than 75 Months" and "Greater than 75 Months" respectively.

19. Purposeofpets: the purpose of pet owners living with their pets; numeric numbers starting from 0 correspond to options "Companion/Friend" and "Others" respectively.

2.3 Data Measurement

…….Todo…….

2.4 Methodology

Since it is difficult to observe through many variables, this report will only explore and analyze through specific aspects. The original dataset contains demographic information about the respondents as well as health level and depression status. This report will only model and

Table 2: Preview of the cleaned pet owners and non-pet owners dataset

pet_group	age_group	gender	bmi_status	depression_status	pet_type
non-pet owners	26-35 years	female	normal weight	non-depressed	NA
non-pet owners	15-25 years	male	over weight	non-depressed	NA
non-pet owners	46-55 years	male	normal weight	depressed	NA
non-pet owners	26-35 years	female	obese	non-depressed	NA
non-pet owners	15-25 years	male	over weight	non-depressed	NA

Table 3: Statistics summary of the cleaned pet owners and non-pet owners dataset

	pet_group	age_group	gender	bmi_status	depression_status	pet_type
	non-pet owners:140	less than 15 years : 0	male :117	under weight : 28	depressed : 89	cat : 93
	pet owners :140	15-25 years :126	female:163	normal weight:149	non-depressed:191	dog : 13
	NA	26-35 years :142	NA	over weight : 75	NA	dog, cat : 12
	NA	36-45 years : 7	NA	obese : 28	NA	cat, bird: 9
	NA	46-55 years : 3	NA	NA	NA	bird : 5
	NA	greater than 56 years: 2	NA	NA	NA	(Other) : 8
	NA	NA	NA	NA	NA	NA's :140

discuss the relationship between depression status and pet ownership, respondent's age, and respondent's BMI status. Other columns such as gender and pet type will also be kept in this report to explore some interesting relationships between the variables.

The dataset is cleaned by renaming the column names, selecting target columns, specifying the class of the columns, and changing the numbers in the table to corresponding description in the codebook to improve the redability. After the cleaning process, 280 rows and 6 variables remain. Table 2 shows a preview of the cleaned dataset.

Table 3 is a summary of the cleaned data, showing detailed statistics about the dataset. According to this table, we can see that the majority of the respondents are young adults, aged between 15 to 35 years. In this dataset, a higher percentage of these respondents are female. Furthermore, within the subset of respondents who reported pet ownership, a significant majority expressed a preference for owning cats.

2.5 Data Analysis

Figure 1 illustrates the distribution of different types of pets among respondents who identify as pet owners. From this graph, we can see that most of the respondents preferred to keep cats, with nearly 100 people, and only a small amount of people had more than two pets in their homes. In addition to cats, most people would choose to keep dogs or keep dogs and cats together to add some energy or enthusiasm to their homes.

Figure 2 shows the relationship between BMI status, pet ownership, and gender among respondents. As we can see from the graph, most respondents have normal weight, some are over

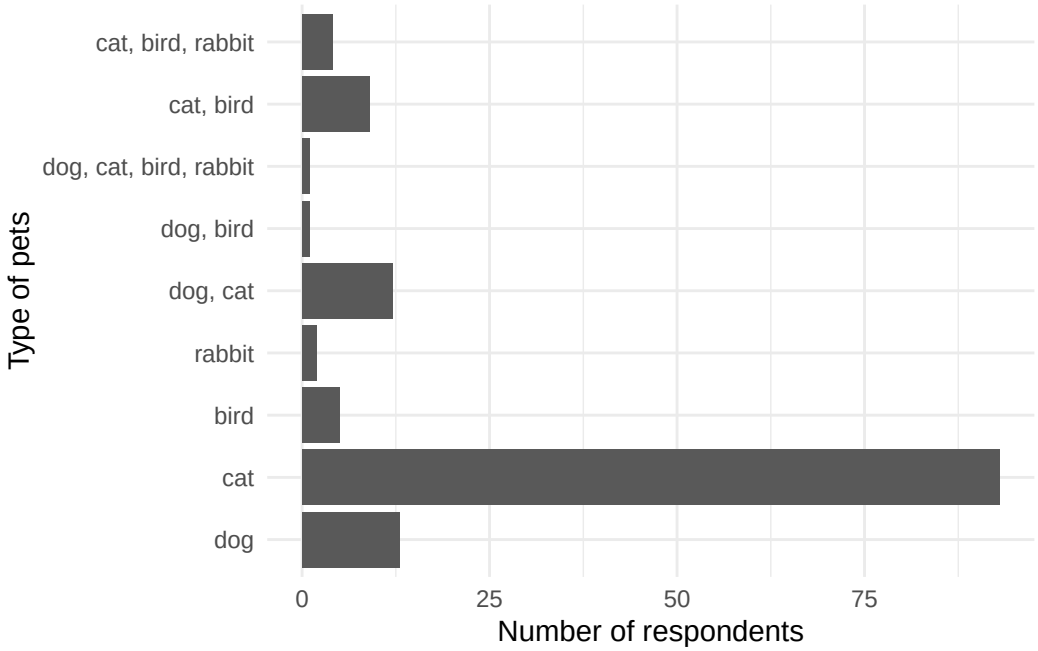


Figure 1: The distribution of pet species

weight, and only a small amount of people are falling into extreme categories, either under weight or obese. It is interesting to see that for women, there are more pet owners with normal weight than non-pet owners. However, the situation is different for men, as there are more normal weight non-pet owners than pet owners. Overall, pet owners tend to have a healthier weight compared to non-pet owners.

Figure 3 shows the relationship between depression status, pet ownership and age. As can be seen from the graph, the majority of respondents are between the ages of 15 and 35. Among respondents over the age of 36, the presence or absence of a pet have no significant effect on depression. However, for young people, pets seem to have a greater impact, especially in the 15 to 25 age group. The presence and companionship of pets reduces the number of depressed people.

3 Model

3.1 Model set-up

In this report, we use the Bayesian logistic regression model to analysis and examine the relationship between depression status and pet ownership, along with various demographic factors. The model is formulated as follows:

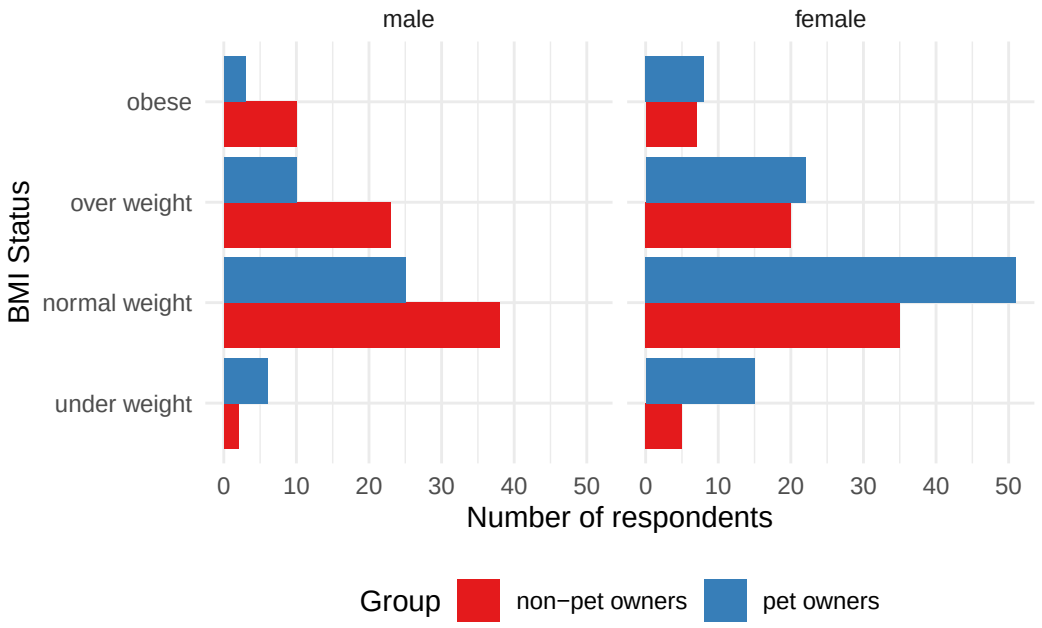


Figure 2: The relationship between BMI status and pet ownership by gender

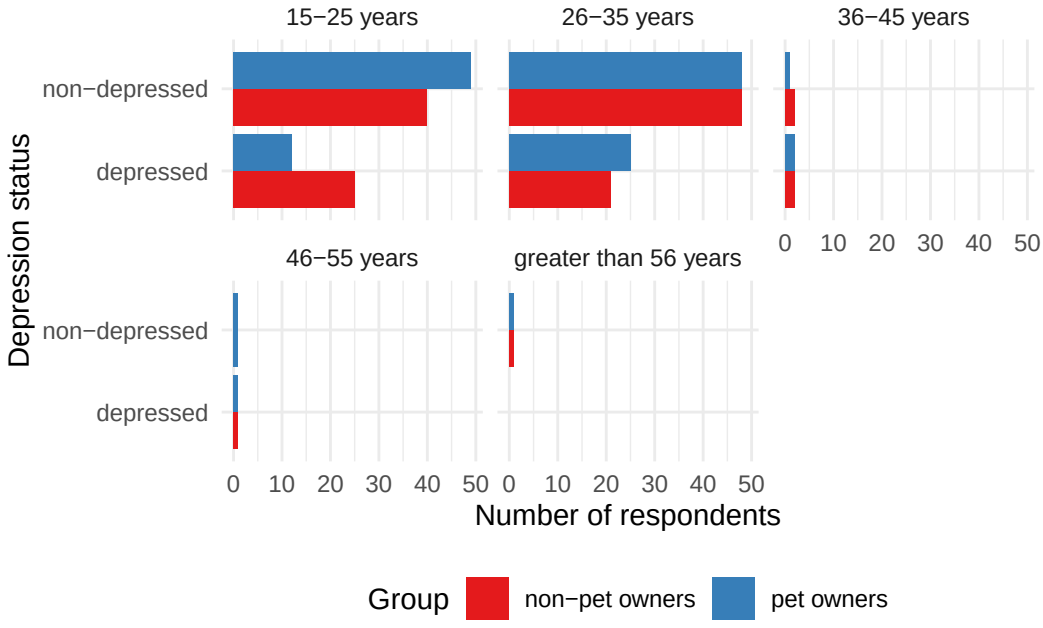


Figure 3: The relationship between depression status and pet ownership by age group

$$y_i|\pi_i \sim \text{Bern}(\pi_i) \tag{1}$$
$$\text{logit}(\pi_i) = \alpha + \beta_1 \times \text{pet ownership}_i + \beta_2 \times \text{age}_i + \beta_3 \times \text{BMI status}_i \tag{2}$$
$$\alpha \sim \text{Normal}(0, 2.5) \tag{3}$$
$$\beta_1 \sim \text{Normal}(0, 2.5) \tag{4}$$
$$\beta_2 \sim \text{Normal}(0, 2.5) \tag{5}$$

In this model, y_i represents the binary outcome variable indicating whether an individual is experiencing depression. The likelihood of depression (π_i) is captured through a logistic link function ($\text{logit}(\pi_i)$), which comprises a linear combination of the intercept (α) and the coefficients (β_1, β_2, β_3)) corresponding to the predictor variables such as pet ownership, age, and BMI status. These predictor variables are denoted as race_i, region_i, and employ_i, where i indexes the individuals in the dataset.

Informative prior distributions are assigned to the intercept (α) and coefficients (β_1, β_2, β_3) to regularize the model. More specifically, we use a normal distribution with a mean of 0 and a standard deviation of 2.5 for each parameter. Additionally, enabling parameter autoscaling is employed to enhance the model's performance.

There are several reasons for choosing this model. Firstly, logistic regression is suited for binary outcome variables, hence it can be used to analyze depression status. Additionally, the utilization of Bayesian methods allows us to integrate prior knowledge and uncertainty into our analysis, resulting in more resilient estimations of the model parameters. Furthermore, by assigning prior distributions, Bayesian models can subtly tune the estimation procedure to reduce the risk of overfitting and improve the performance.

We also considered other modeling methods, such as linear regression model. However, we chose the Bayesian logistic regression model since the depression status is a binary variable.

We run the model in R (R Core Team 2023) using the `rstanarm` package of Goodrich et al. (2022). We use the default priors from `rstanarm`. Rstanarm uses Markov chain Monte Carlo (MCMC) methods to estimate the posterior distribution of the parameters. Supplementary materials, such as convergence assessments and posterior summaries, can be found in Appendix Section B.

3.2 Model Justification

We expect a positive relationship between the size of the wings and time spent aloft. In particular…

We can use maths by including latex between dollar signs, for instance θ.

……..todo…….

3.3 Model Implication

…….todo……..

4 Results

Our results are summarized in Table 4.

5 Discussion

5.1 Influence of Pet Ownership on Mental Health

In Bangladesh, the levels of depression, anxiety, and stress has been reported to be as high as 54.3%, 64.8%, and 59.0%, respectively (**cite-depression?**). Depression is not an unfamiliar word in today's society. On the contrary, more and more people are suffering from depression, while the age of the sufferers is starting to get progressively younger. According to statistics, in Bangladesh, 14% of young people aged 15 to 24 often feel depressed or have little interest in doing things (**cite-young?**).

As people gain a deeper understanding of depression, more and more individuals are starting to pay attention to mental health, and extensive research is also beginning to explore methods for treating and preventing depression. In our analysis, the model supports that people who own pets are less likely to suffer from depression than those who do not own pets. There are also studies that show an association between pet ownership and lower levels of depression.

Pets can reduce stress, anxiety and depression, ease loneliness, encourage exercise and play, and even improve cardiovascular health. For example, birds can encourage social interaction and help keep your mind sharp. Even watching fish in an aquarium can help people reduce muscle tension and lower pulse rate.

In a U.S. research study, approximately 86% of pet owners reported that their pets had a positive impact on their mental health (**cite-us-survey?**). For pet-owning families, pets are not just animals. They are more like family members, an integral part of the household. Their presence can bring joy to your life and provide companionship during times of sadness and despair. While pets may only be a small part of your life, for them, you are their entire world. They are your concern and worry when you contemplate ending your life, and they also give you the courage to keep going.

Table 4: Explanatory models of flight time based on wing width and wing length

	Not Depressed
(Intercept)	0.70
	(0.27)
pet_grouppet owners	0.42
	(0.27)
age_group26-35 years	−0.16
	(0.27)
age_group36-45 years	−1.30
	(0.83)
age_group46-55 years	−1.65
	(1.34)
age_groupgreater than 56 years	18.80
	(16.50)
bmi_statusobese	0.45
	(0.49)
bmi_statusover weight	0.08
	(0.31)
bmi_statusunder weight	−0.72
	(0.45)
Num.Obs.	280
R2	0.059
Log.Lik.	−169.659
ELPD	−179.8
ELPD s.e.	7.3
LOOIC	359.7
LOOIC s.e.	14.6
WAIC	358.0
RMSE	0.46

5.2 Second discussion point

5.3 Third discussion point

5.4 Weaknesses and future steps

Weaknesses and next steps should also be included.

Appendix

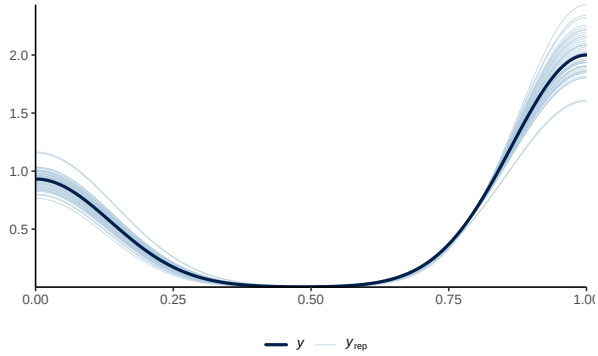
A Additional data details

B Model details

B.1 Posterior predictive check

In **?@fig-ppcheckandposteriorvsprior-1** we implement a posterior predictive check. This shows...

In **?@fig-ppcheckandposteriorvsprior-2** we compare the posterior with the prior. This shows...



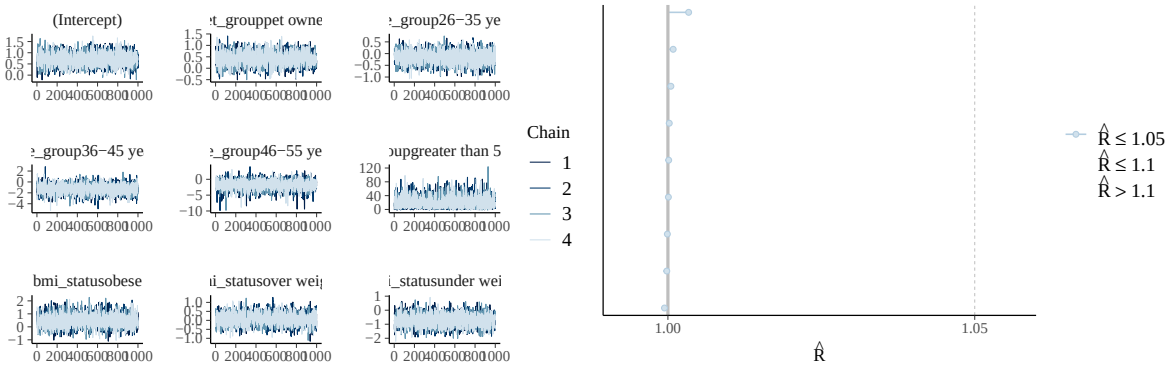
(a) Posterior prediction check

Figure 4: Examining how the model fits, and is affected by, the data

B.2 Diagnostics

Figure 5a is a trace plot. It shows... This suggests...

Figure 5b is a Rhat plot. It shows... This suggests...



(a) Trace plot (b) Rhat plot

Figure 5: Checking the convergence of the MCMC algorithm

References

Goodrich, Ben, Jonah Gabry, Imad Ali, and Sam Brilleman. 2022. "Rstanarm: Bayesian Applied Regression Modeling via Stan." https://mc-stan.org/rstanarm/.

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