

Influential factors of days spent at the shelter

Hanfan Chen 2703334C, Zhaohao Li 2611602L, Zhenhao Qiao 2612824Q, Chao Wang 2518608W, Rachan

1 Introduction

2 Exploratory Data Analysis

```
'data.frame': 1450 obs. of 7 variables:
 $ animal_type : chr "CAT" "DOG" "DOG" "DOG" ...
 $ month : int 9 6 12 9 11 12 6 1 2 4 ...
 $ year : int 2017 2017 2016 2017 2016 2016 2017 2017 2017 2017 ...
 $ intake_type : chr "STRAY" "STRAY" "STRAY" "STRAY" ...
 $ outcome_type : chr "ADOPTION" "EUTHANIZED" "ADOPTION" "ADOPTION" ...
 $ chip_status : chr "UNABLE TO SCAN" "SCAN NO CHIP" "SCAN NO CHIP" "SCAN NO CHIP" ...
 $ time_at_shelter: int 9 4 21 4 7 4 4 5 0 15 ...
```

```
Column 1 :
[1] "BIRD" "CAT" "DOG" "WILDLIFE"
```

```
Column 2 :
[1] "1" "2" "3" "4" "5" "6" "7" "8" "9" "10" "11" "12"
```

```
Column 3 :
[1] "2016" "2017"
```

```
Column 4 :
[1] "CONFISCATED" "OWNER SURRENDER" "STRAY"
```

```
Column 5 :
[1] "ADOPTION" "DIED" "EUTHANIZED"
[4] "FOSTER" "RETURNED TO OWNER"
```

```
Column 6 :
[1] "SCAN CHIP" "SCAN NO CHIP" "UNABLE TO SCAN"
```

All the explanatory variable are categorical variable and each explanatory variable have multiple levels.

```
[1] 317
```

Over 300 zeros in raw data may cause overdispersion in Poisson regression. The hurdle model is suggested to fit.

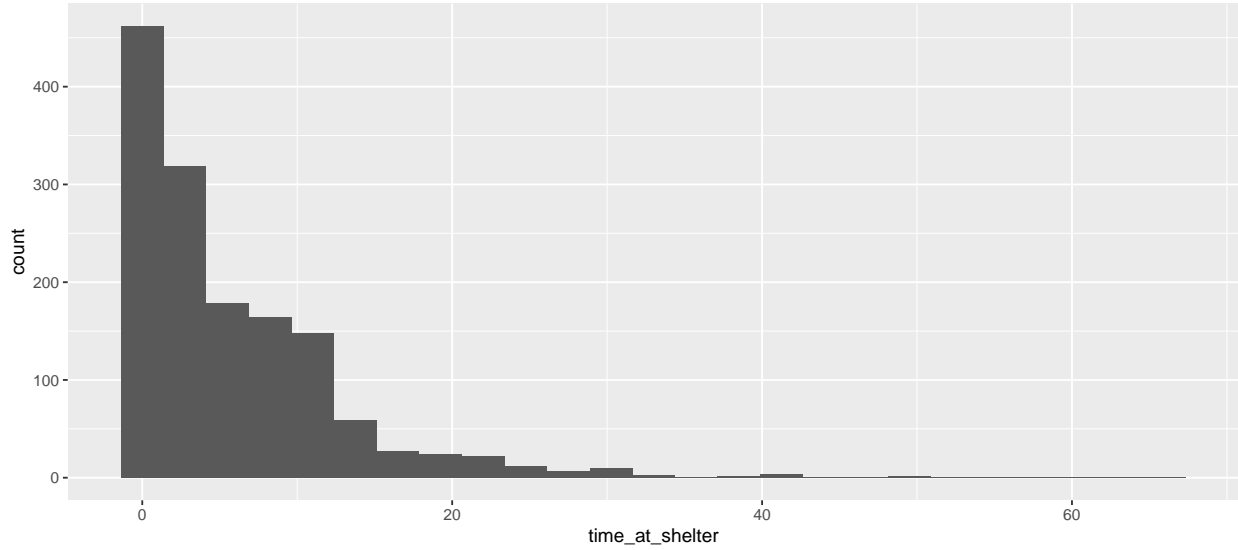


Figure 1: The histogram of day time at shelter

Figure 1 displays the histogram of the response variable, which is days time in the shelter. The histogram shows evidence of right-skewed and Poisson distribution of the response variable.



Figure 2: Pair plots of the variables

Note that year and month are strongly correlated, suggesting multicollinearity. As the data were collected over the period of a year, month and year represent the same variable, namely when the animal was admitted to the shelter. Therefore, year shall be omitted from the model.

The other explanatory variables are all categorical and their box plots are shown. The median time at shelter appears to be low for all the explanatory variables, which is due to the median time at shelter being 4.

Since the response variable is right-skewed, a median of the response variable is calculated. The figures below display the median of each category of the different explanatory variables.

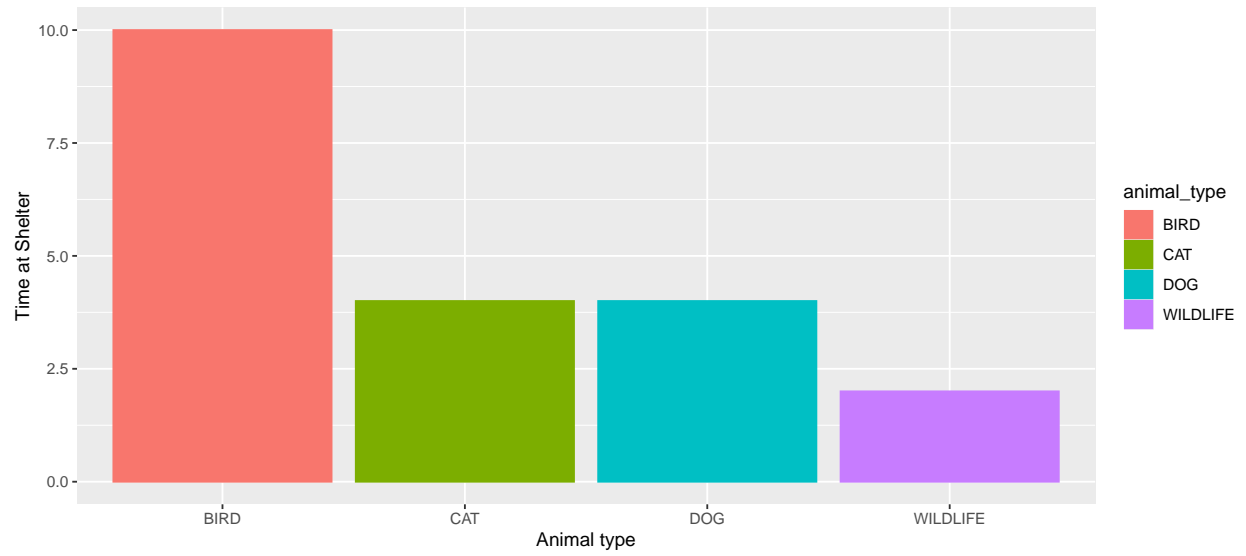


Figure 3: Bar plot of animal type vs time at shelter

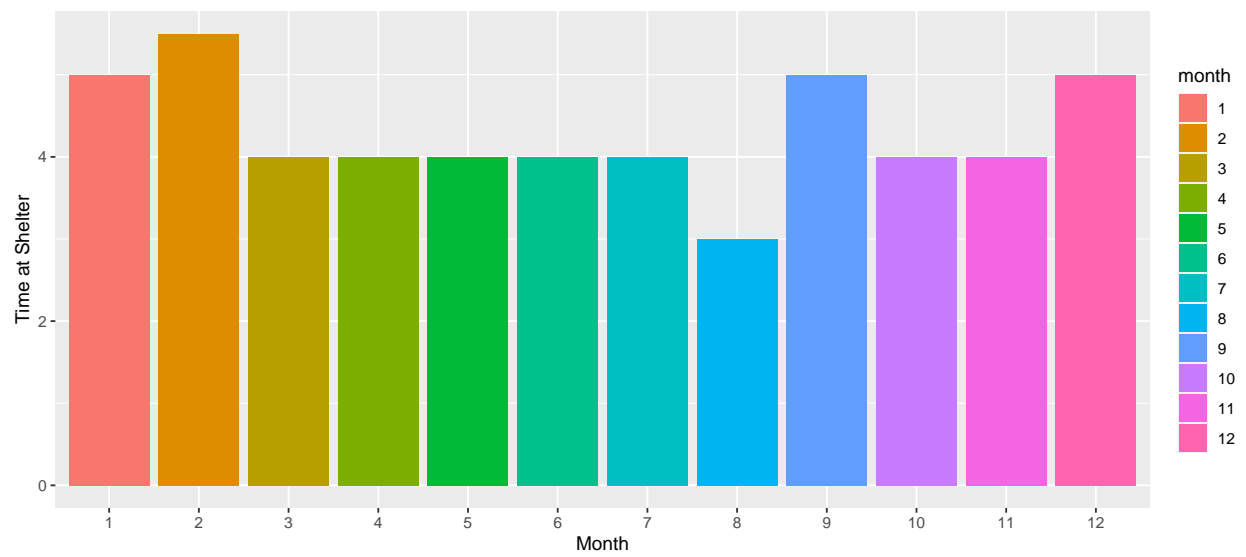


Figure 4: Bar plot of month vs time at shelter

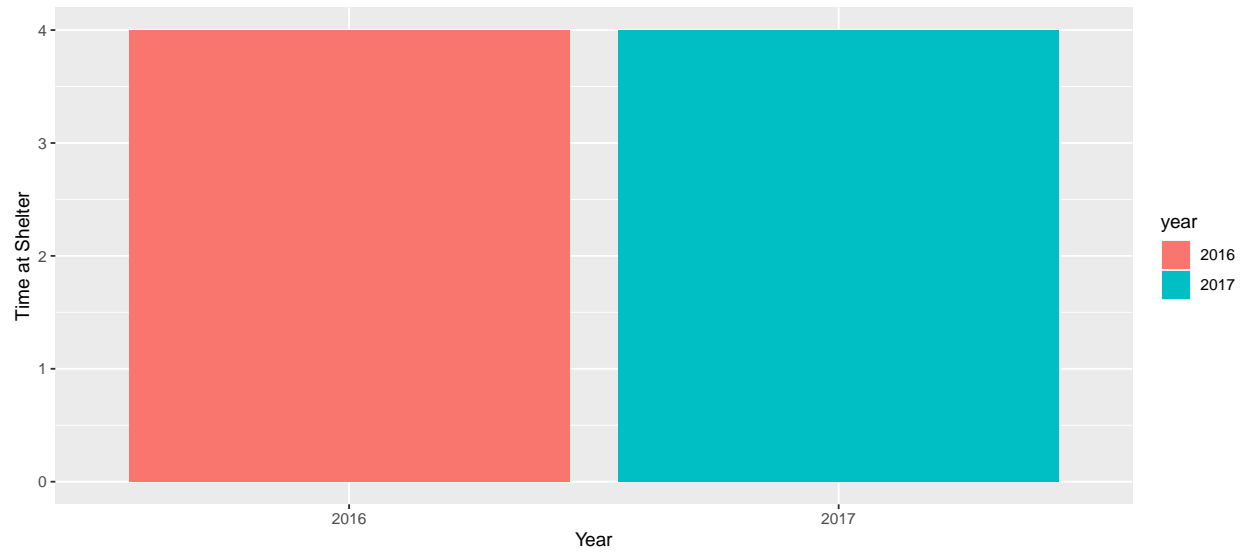


Figure 5: Bar plot of year vs time at shelter

```
[1] FALSE FALSE FALSE
```

No overlap between the months and years, according to the bar plot5, no obvious difference between two years and the relationship between the response variable and month variable is similar to that relationship between the response variable and the year variable. Therefore, the year variable is removed.

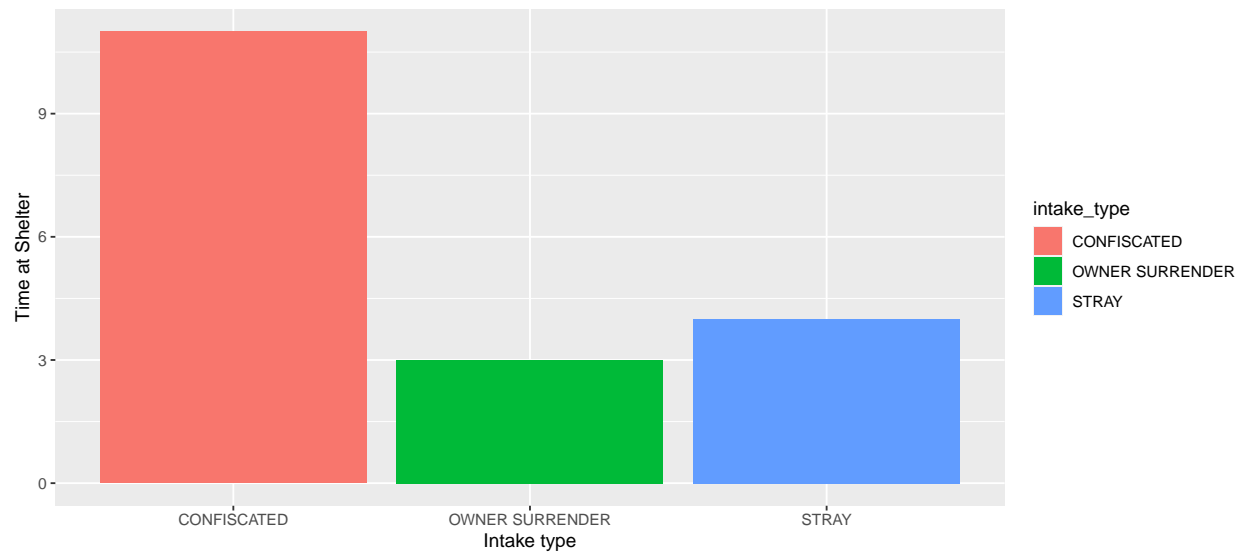


Figure 6: Bar plot of intake type vs time at shelter

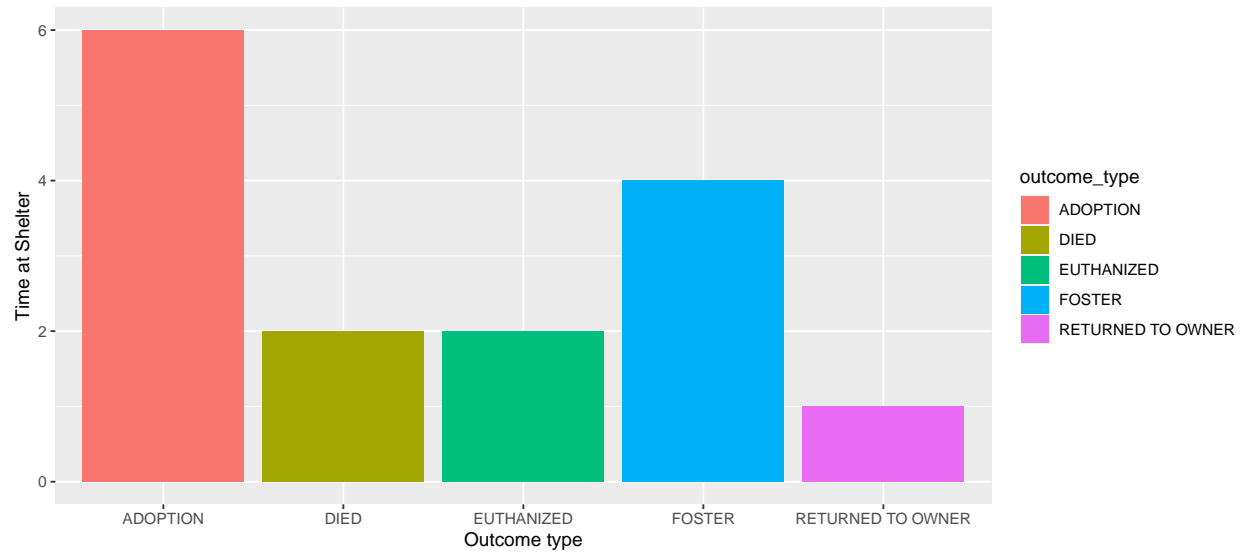


Figure 7: Bar plot of outcome type vs time at shelter

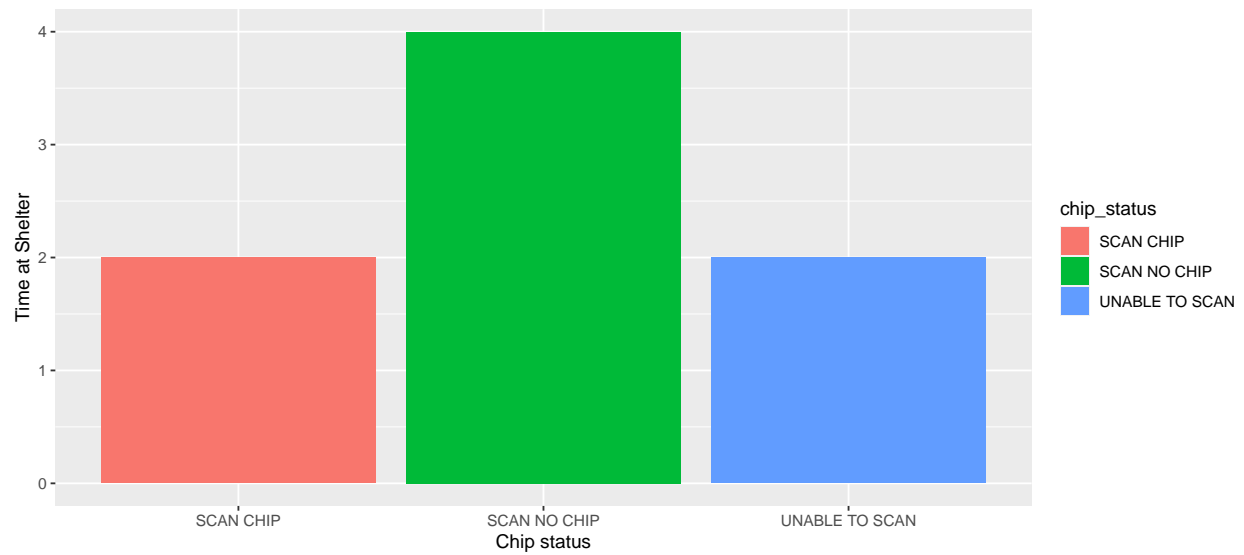


Figure 8: Bar plot of chip status vs time at shelter

3 Formal Data Analysis

3.1 Fitting a Poisson model

Call:

```
glm(formula = time_at_shelter ~ ., family = "poisson", data = data10)
```

Deviance Residuals:

| | | | | |
|---------|---------|---------|--------|---------|
| Min | 1Q | Median | 3Q | Max |
| -6.9146 | -1.9976 | -0.8903 | 0.6306 | 12.7550 |

Coefficients:

| | Estimate | Std. Error | z value | Pr(> z) | |
|-------------------------------|-----------|------------|---------|----------|-----|
| (Intercept) | 2.997158 | 0.197263 | 15.194 | < 2e-16 | *** |
| animal_typeCAT | 0.441668 | 0.195885 | 2.255 | 0.024150 | * |
| animal_typeDOG | 0.485824 | 0.194425 | 2.499 | 0.012462 | * |
| animal_typeWILDLIFE | 0.225305 | 0.231453 | 0.973 | 0.330336 | |
| month2 | 0.075718 | 0.055370 | 1.367 | 0.171470 | |
| month3 | -0.132108 | 0.057115 | -2.313 | 0.020721 | * |
| month4 | -0.193819 | 0.056691 | -3.419 | 0.000629 | *** |
| month5 | -0.005919 | 0.052007 | -0.114 | 0.909386 | |
| month6 | -0.035721 | 0.050097 | -0.713 | 0.475818 | |
| month7 | -0.057427 | 0.050613 | -1.135 | 0.256526 | |
| month8 | -0.413755 | 0.058842 | -7.032 | 2.04e-12 | *** |
| month9 | -0.082308 | 0.056140 | -1.466 | 0.142617 | |
| month10 | 0.101852 | 0.051801 | 1.966 | 0.049273 | * |
| month11 | -0.055580 | 0.054389 | -1.022 | 0.306833 | |
| month12 | 0.114138 | 0.051633 | 2.211 | 0.027065 | * |
| intake_typeOWNER SURRENDER | -1.451530 | 0.043649 | -33.254 | < 2e-16 | *** |
| intake_typeSTRAY | -1.031365 | 0.039395 | -26.180 | < 2e-16 | *** |
| outcome_typeDIED | -0.649881 | 0.097578 | -6.660 | 2.74e-11 | *** |
| outcome_typeEUTHANIZED | -0.592552 | 0.025262 | -23.456 | < 2e-16 | *** |
| outcome_typeFOSTER | -0.279520 | 0.076201 | -3.668 | 0.000244 | *** |
| outcome_typeRETURNED TO OWNER | -1.531722 | 0.042358 | -36.161 | < 2e-16 | *** |
| chip_statusSCAN NO CHIP | -0.171716 | 0.028935 | -5.934 | 2.95e-09 | *** |
| chip_statusUNABLE TO SCAN | -0.247414 | 0.068726 | -3.600 | 0.000318 | *** |

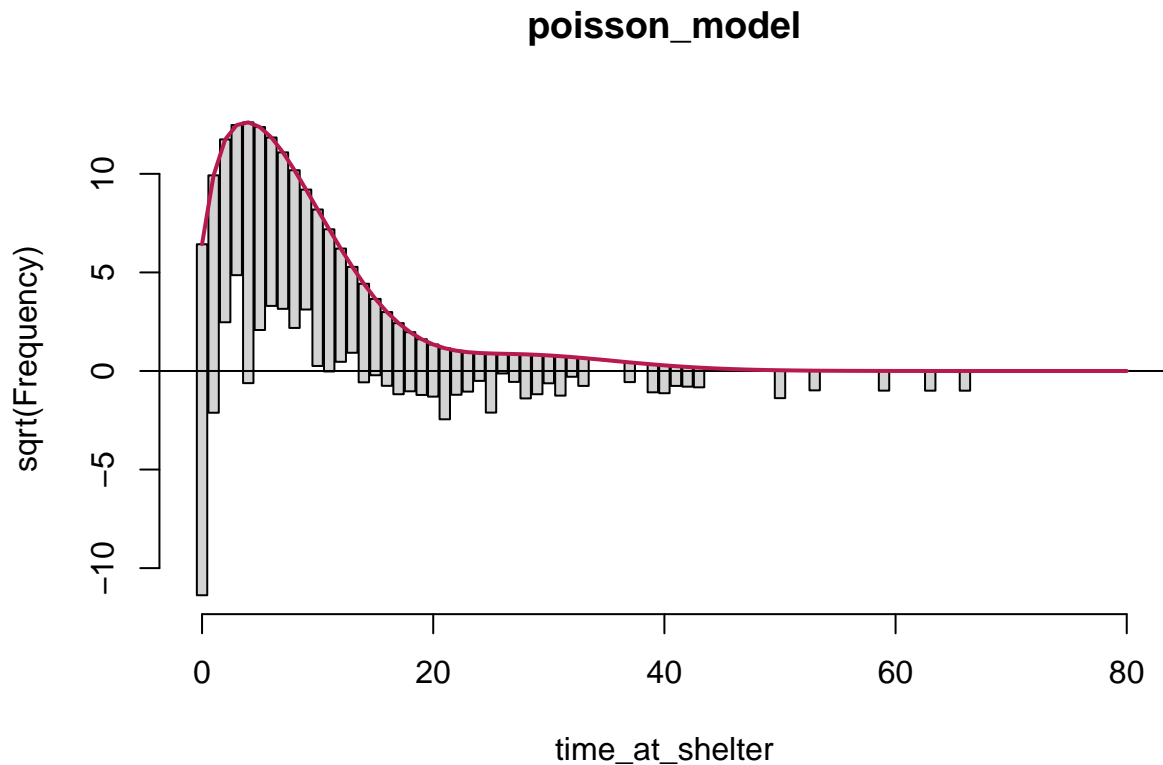
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

Null deviance: 10551.2 on 1449 degrees of freedom
 Residual deviance: 8079.3 on 1427 degrees of freedom
 AIC: 12147

Number of Fisher Scoring iterations: 6

[1] 41



The Poisson model is severely under-fitting zero counts. There were 317 zero counts observed in the data set but the model only fitted 41. It is also over-fitting the lower positive counts and under-fitting the higher counts, suggesting there is over-dispersion in the model. Hence a hurdle model will be fitted to provide a better fit.

3.2 Fitting a Hurdle model

Call:

```
hurdle(formula = time_at_shelter ~ ., data = data10, dist = "poisson",
       zero.dist = "binomial")
```

Pearson residuals:

| | Min | 1Q | Median | 3Q | Max |
|--|---------|---------|---------|--------|---------|
| | -4.3608 | -1.0287 | -0.5823 | 0.4795 | 14.9926 |

Count model coefficients (truncated poisson with log link):

| | Estimate | Std. Error | z value | Pr(> z) |
|---------------------|------------|------------|---------|--------------|
| (Intercept) | 2.9579923 | 0.1983275 | 14.915 | < 2e-16 *** |
| animal_typeCAT | 0.3743137 | 0.1965591 | 1.904 | 0.056867 . |
| animal_typeDOG | 0.3213099 | 0.1951832 | 1.646 | 0.099723 . |
| animal_typeWILDLIFE | 0.4412799 | 0.2325810 | 1.897 | 0.057786 . |
| month2 | -0.0007866 | 0.0555725 | -0.014 | 0.988706 |
| month3 | -0.1913094 | 0.0574189 | -3.332 | 0.000863 *** |
| month4 | -0.2968745 | 0.0570389 | -5.205 | 1.94e-07 *** |
| month5 | -0.0358694 | 0.0522504 | -0.686 | 0.492405 |

| | | | | | |
|-------------------------------|------------|-----------|---------|----------|-----|
| month6 | -0.1290100 | 0.0505296 | -2.553 | 0.010675 | * |
| month7 | -0.0908291 | 0.0508464 | -1.786 | 0.074043 | . |
| month8 | -0.3531232 | 0.0594007 | -5.945 | 2.77e-09 | *** |
| month9 | -0.1700644 | 0.0563869 | -3.016 | 0.002561 | ** |
| month10 | 0.0425144 | 0.0518410 | 0.820 | 0.412164 | |
| month11 | -0.0777278 | 0.0545280 | -1.425 | 0.154023 | |
| month12 | 0.0460268 | 0.0517740 | 0.889 | 0.374006 | |
| intake_typeOWNER SURRENDER | -1.1067328 | 0.0453104 | -24.426 | < 2e-16 | *** |
| intake_typeSTRAY | -0.7609702 | 0.0407405 | -18.678 | < 2e-16 | *** |
| outcome_typeDIED | -0.6233442 | 0.0998502 | -6.243 | 4.30e-10 | *** |
| outcome_typeEUTHANIZED | -0.2197569 | 0.0254704 | -8.628 | < 2e-16 | *** |
| outcome_typeFOSTER | -0.1110361 | 0.0769153 | -1.444 | 0.148847 | |
| outcome_typeRETURNED TO OWNER | -0.9857031 | 0.0450846 | -21.863 | < 2e-16 | *** |
| chip_statusSCAN NO CHIP | -0.2019465 | 0.0290236 | -6.958 | 3.45e-12 | *** |
| chip_statusUNABLE TO SCAN | -0.2152199 | 0.0686741 | -3.134 | 0.001725 | ** |

Zero hurdle model coefficients (binomial with logit link):

| | Estimate | Std. Error | z value | Pr(> z) | |
|-------------------------------|------------|------------|---------|----------|-----|
| (Intercept) | 1.905e+01 | 6.099e+02 | 0.031 | 0.975 | |
| animal_typeCAT | -1.328e+01 | 6.099e+02 | -0.022 | 0.983 | |
| animal_typeDOG | -1.266e+01 | 6.099e+02 | -0.021 | 0.983 | |
| animal_typeWILDLIFE | -1.454e+01 | 6.099e+02 | -0.024 | 0.981 | |
| month2 | 7.990e-01 | 4.898e-01 | 1.631 | 0.103 | |
| month3 | 3.817e-01 | 4.040e-01 | 0.945 | 0.345 | |
| month4 | 3.724e-01 | 4.020e-01 | 0.926 | 0.354 | |
| month5 | -9.406e-04 | 3.735e-01 | -0.003 | 0.998 | |
| month6 | 4.541e-01 | 3.702e-01 | 1.227 | 0.220 | |
| month7 | 1.809e-01 | 3.643e-01 | 0.497 | 0.620 | |
| month8 | -2.548e-01 | 3.782e-01 | -0.674 | 0.500 | |
| month9 | 3.331e-01 | 3.984e-01 | 0.836 | 0.403 | |
| month10 | 3.409e-01 | 3.981e-01 | 0.856 | 0.392 | |
| month11 | 5.129e-02 | 4.062e-01 | 0.126 | 0.900 | |
| month12 | 4.482e-01 | 4.345e-01 | 1.032 | 0.302 | |
| intake_typeOWNER SURRENDER | -3.171e+00 | 5.161e-01 | -6.143 | 8.07e-10 | *** |
| intake_typeSTRAY | -2.406e+00 | 4.857e-01 | -4.955 | 7.25e-07 | *** |
| outcome_typeDIED | -8.929e-01 | 8.223e-01 | -1.086 | 0.278 | |
| outcome_typeEUTHANIZED | -2.999e+00 | 2.661e-01 | -11.273 | < 2e-16 | *** |
| outcome_typeFOSTER | -2.137e+00 | 5.383e-01 | -3.969 | 7.21e-05 | *** |
| outcome_typeRETURNED TO OWNER | -4.203e+00 | 3.115e-01 | -13.491 | < 2e-16 | *** |
| chip_statusSCAN NO CHIP | -1.024e-01 | 1.978e-01 | -0.518 | 0.605 | |
| chip_statusUNABLE TO SCAN | -6.084e-01 | 3.793e-01 | -1.604 | 0.109 | |

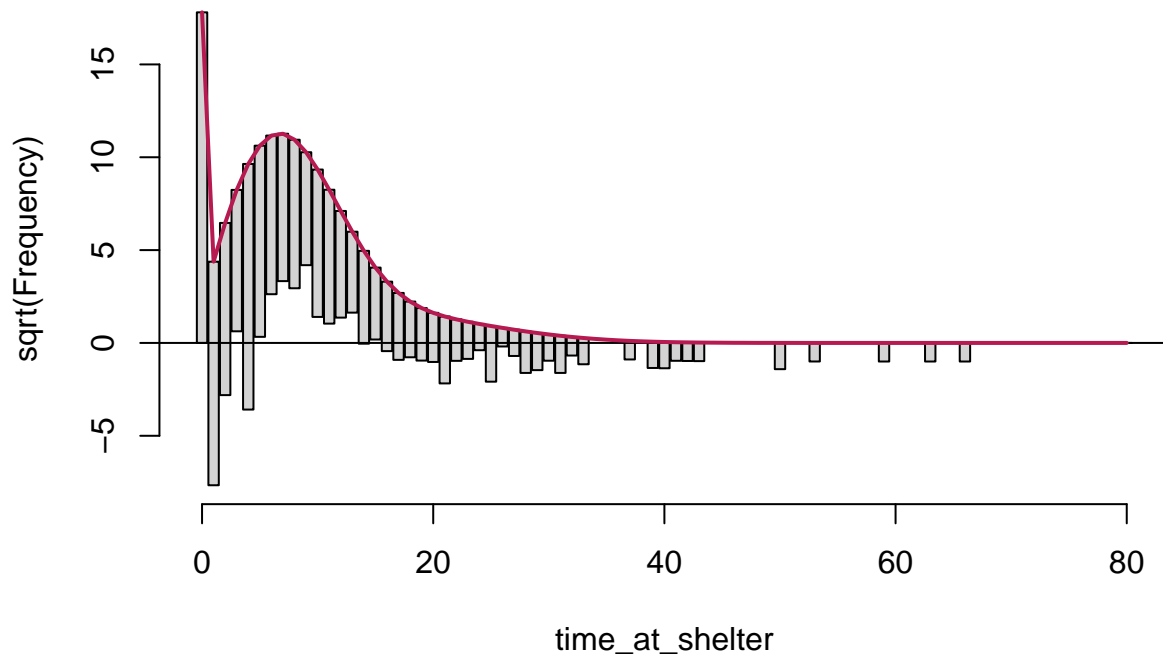
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Number of iterations in BFGS optimization: 30

Log-likelihood: -5193 on 46 Df

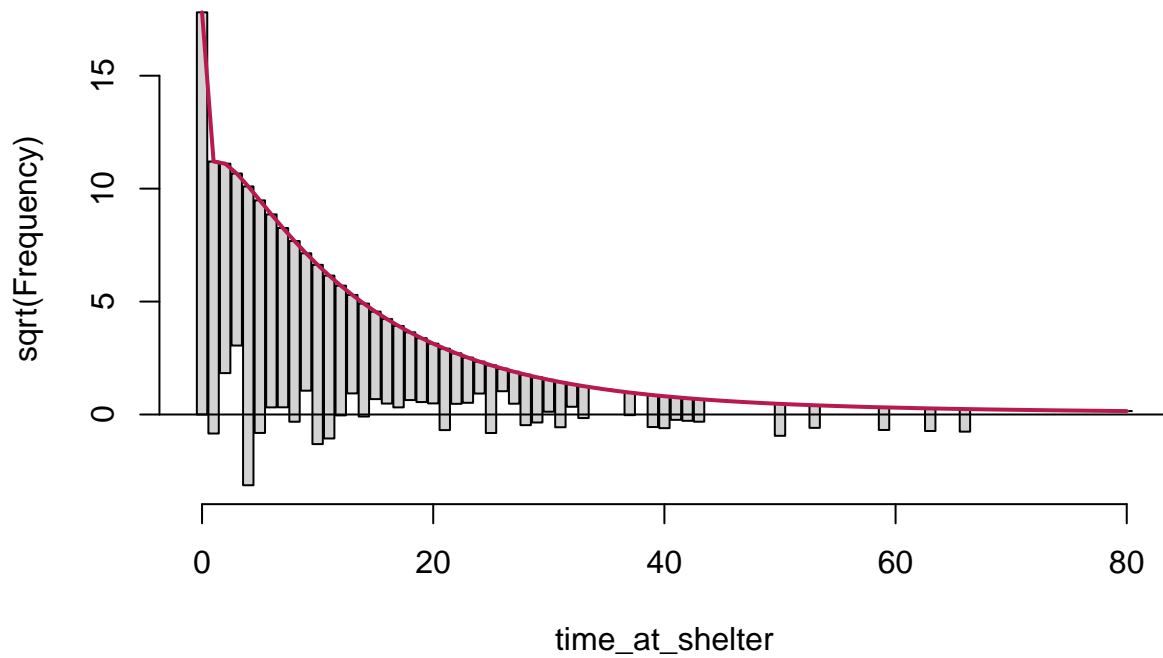
[1] 317

hurdle_model



The model is fitting the zero counts perfectly. However, counts 1,2 and 4 are being severely under-fitted, while 6-9 are being over-fitted. There is also under-fitting at the higher counts which suggests over-dispersion. Therefore, a negative binomial hurdle model shall be fitted to address this.

hurdle_model_nb



This shows a much better fit to the data. However, some values are still being under-fitted.

3.3 Variable Selection

```
Global model call: hurdle(formula = time_at_shelter ~ ., data = data10, dist = "negbin")
---
Model selection table
  cnt_(Int) cnt_anm_typ cnt_chp_stt cnt_int_typ cnt_otc_typ zer_(Int)
760      2.496          +          +          +          +      19.15
  zer_anm_typ zer_chp_stt zer_int_typ zer_otc_typ df    logLik  AICc delta
760          +          +          +          + 25 -3858.628 7768.2    0
  weight
760      1
Models ranked by AICc(x)
```

4 Conclusions