



Survival of The Rickest

Data Analysis of the Survival Rates in
“Rick and Morty”

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Goals

1

Predict how many episodes characters survive and how that varies between species

2

Compare hierarchical and non-hierarchical time-series models

3

Check the performance with a hierarchical non-time-series model



1

Data
Collection and
Preprocessing

2

Models
and
Priors

3

Posterior
Predictive
Checks

4

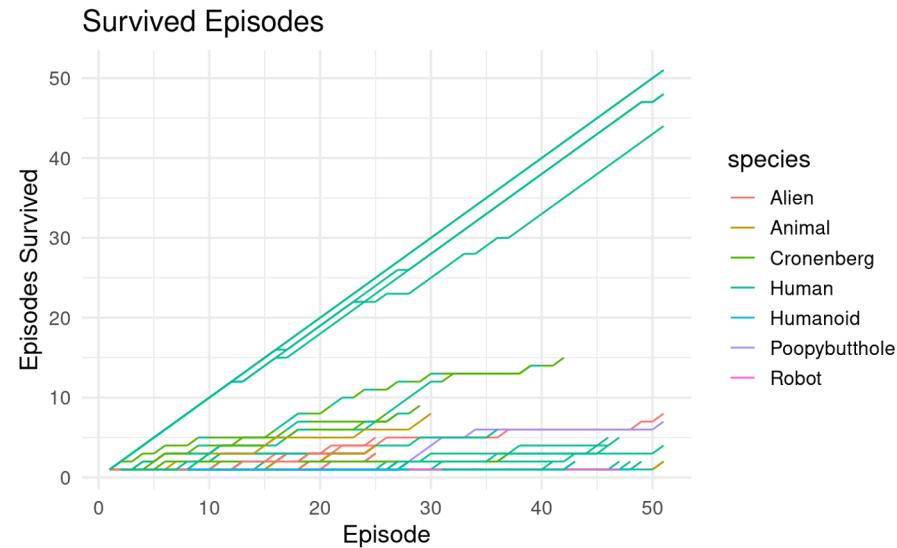
Sensitivity
Analysis

5

Model
Comparison

1. Data Collection and Preprocessing

- Dataset was built with the Rick and Morty API
- Second dataset was made without the episode number



2. Models and Priors

Time Series Non-Hierarchical

```
f1 <- brms::brm(  
  episodes_survived ~ 1 +  
    episode_number +  
    species,  
  family = "lognormal"  
)
```

Time Series Hierarchical

```
f2 <- brms::brm(  
  episodes_survived ~ 1 +  
    episode_number +  
    species +  
    (episode_number|name),  
  family = "lognormal"  
)
```

Non Time Series Hierarchical

```
f3 <- brms::brm(  
  last_episode ~ 1 +  
    species +  
    gender +  
    (1|species) +  
    (1|gender),  
  family = "lognormal"  
)
```

2. Models and Priors

Time Series

episode_number ~ **normal**(0, log(2))
human ~ **normal**(0, log(8))
animal ~ **normal**(0, log(4))
cronenberg ~ **normal**(0, log(3))
poopybutthole ~ **normal**(0, log(3))

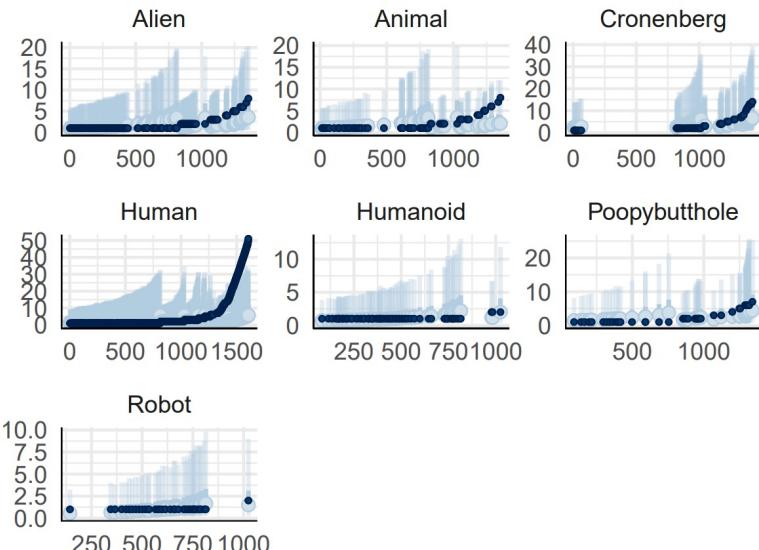
Non Time Series

human ~ **normal**(0, log(8))
animal ~ **normal**(0, log(4))
cronenberg ~ **normal**(0, log(3))
poopybutthole ~ **normal**(0, log(3))
male ~ **normal**(0, log(2))
genderless ~ **normal**(0, log(4))
unknown ~ **normal**(0, log(4))

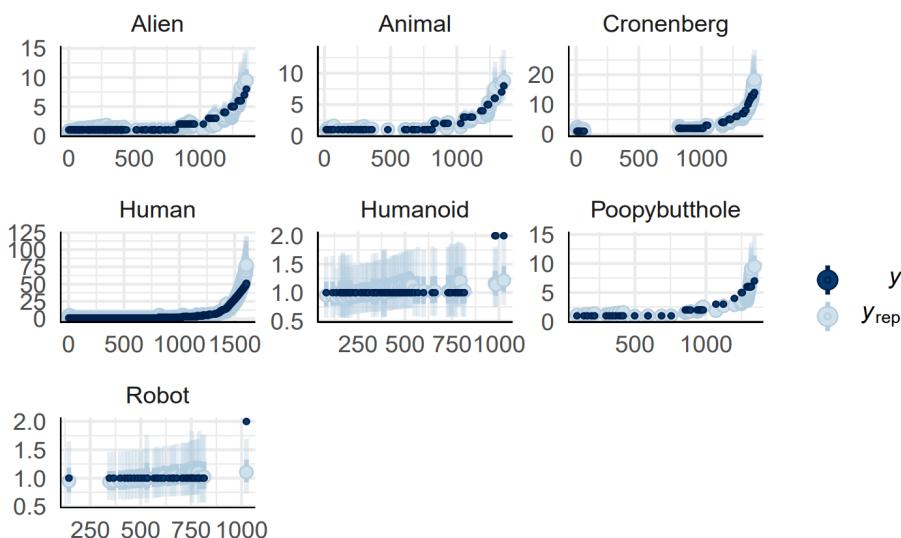
- Convergence diagnostics give good values with the priors and models

3. Posterior Predictive Checks

Non-Hierarchical Model



Hierarchical Model



4. Sensitivity Analysis

- Checked different, uninformative prior with the same three models
- No big differences could be observed for the convergence and posterior predictive checks

Time Series Priors

episode_number ~ **normal**(0, log(2))
human ~ **normal**(0, log(2))
animal ~ **normal**(0, log(2))
cronenberg ~ **normal**(0, log(2))
poopybutthole ~ **normal**(0, log(2))

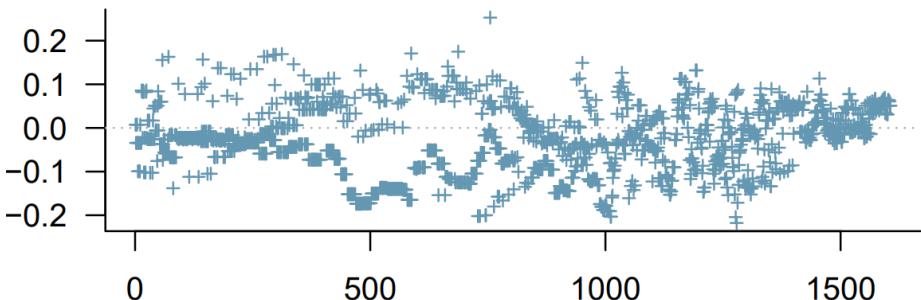
Non Time Series Priors

human ~ **normal**(0, log(2))
animal ~ **normal**(0, log(2))
cronenberg ~ **normal**(0, log(2))
poopybutthole ~ **normal**(0, log(2))
male ~ **normal**(0, log(2))
genderless ~ **normal**(0, log(2))
unknown ~ **normal**(0, log(2))

5. Model Comparison – Time Series Models

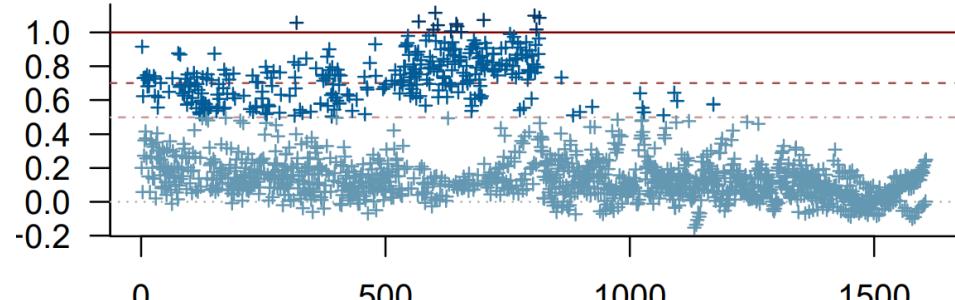
Non-hierarchical Model

- ELPD Difference: -2114.7
- SE Difference: 63.0



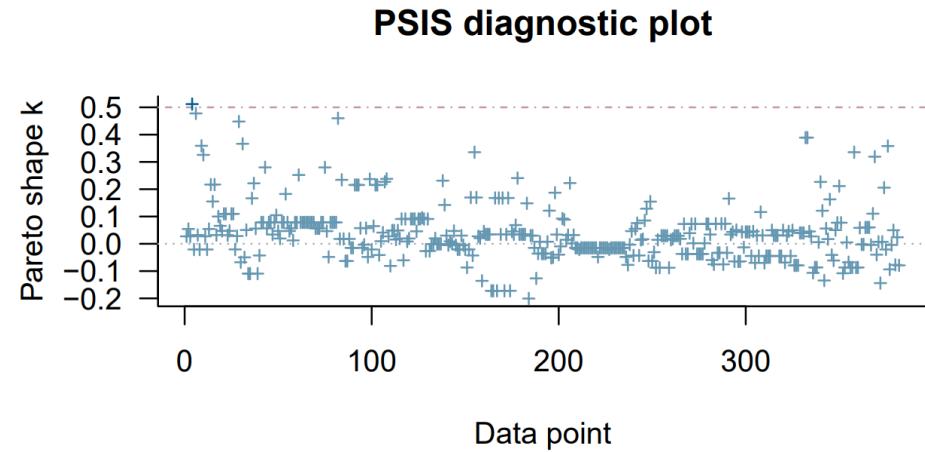
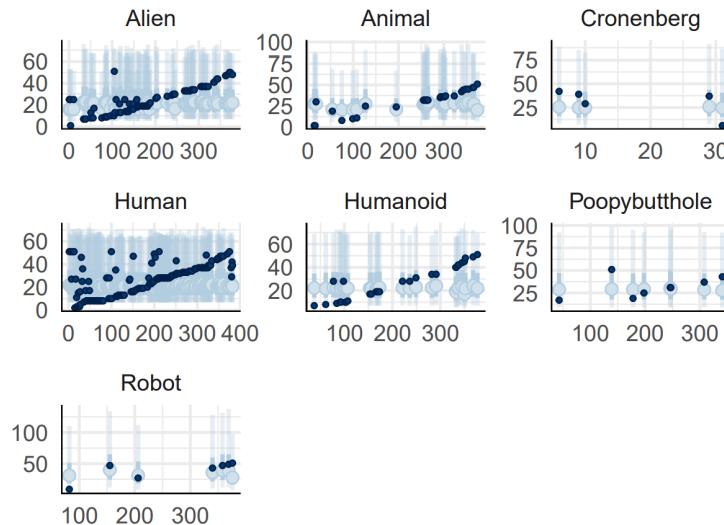
Hierarchical Model

- ELPD Difference: 0
- SE Difference: 0



5. Model Comparison – Non-Time Series Model

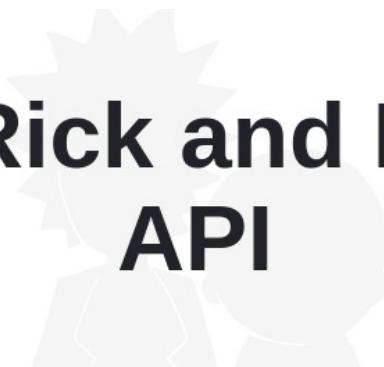
- Compared to time series models it does not perform as good
- It does give better \hat{k} values compared to hierarchical time-series model



Possible Improvements and Future Work

- PSIS ($k\text{-hat}$) for time-series hierarchical model needs improvement
- More complex datasets should be tested (and created)

The Rick and Morty API

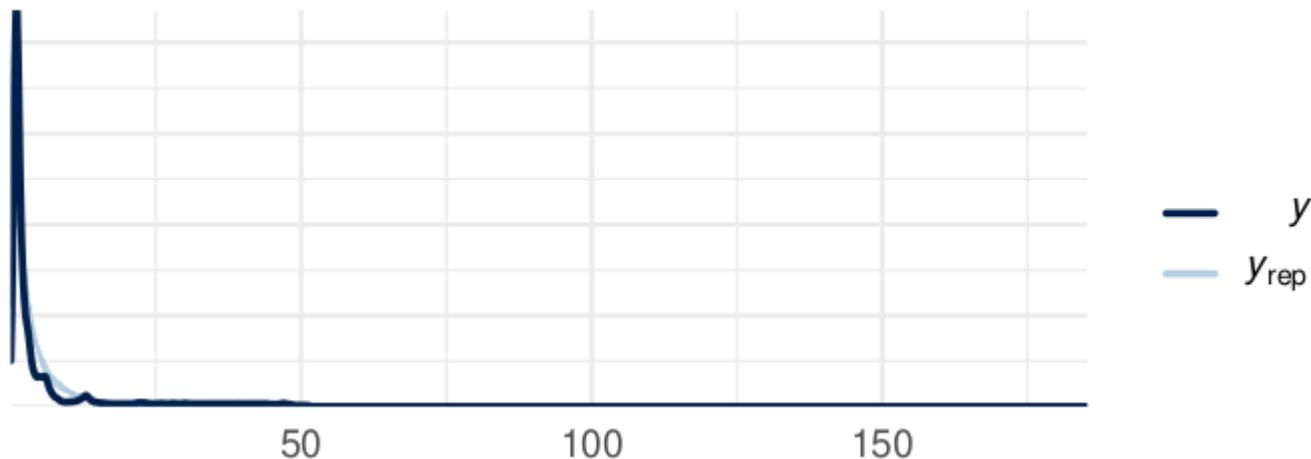




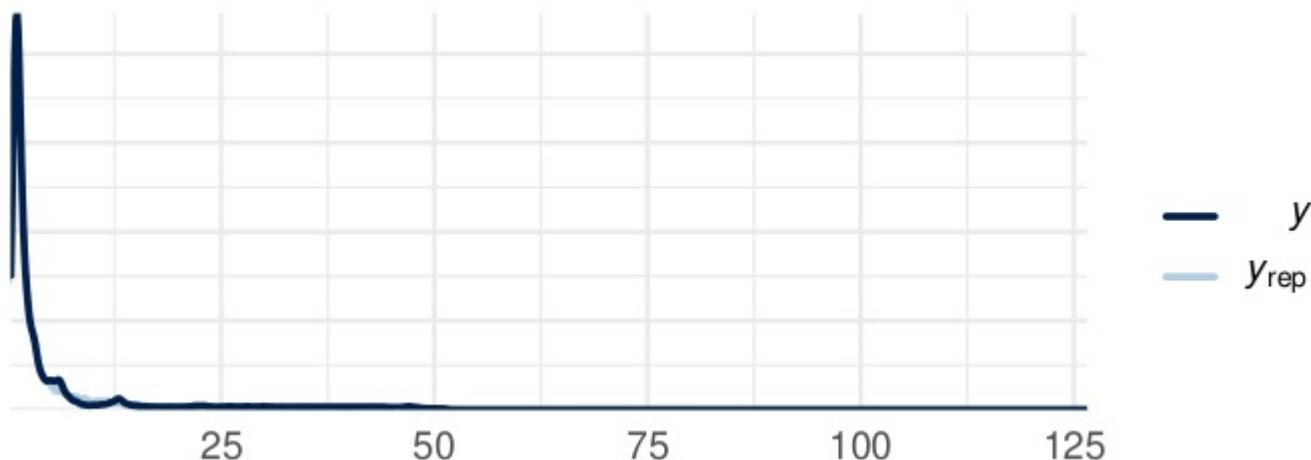
- Prediction of unclear and complex survival rates of Rick and Morty characters
- Best overall predictive results with time-series hierarchical model
- Future improvement especially for PSIS ($k\text{-hat}$) values required



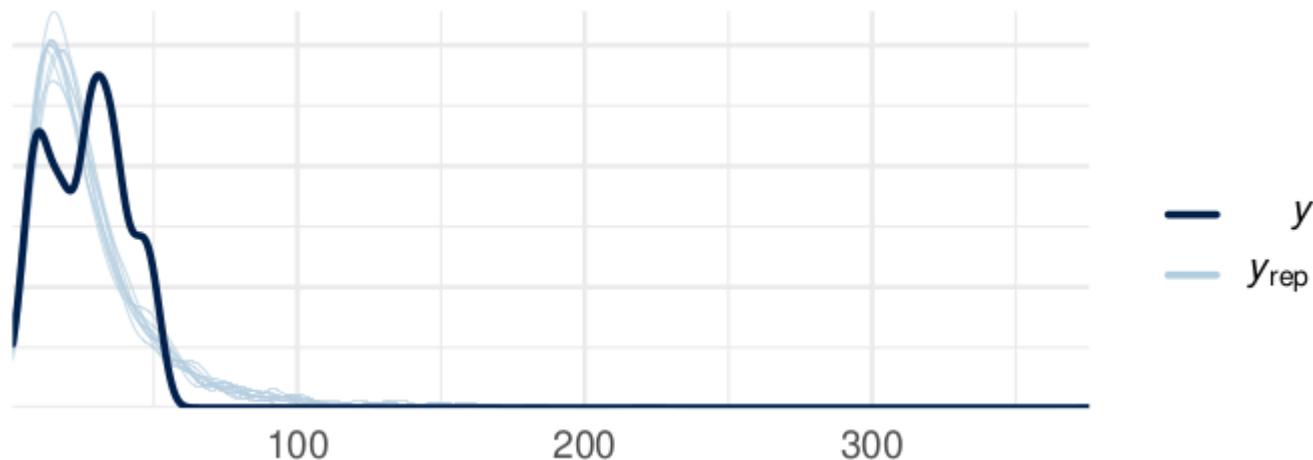
PPC of Model 1



PPC of Model 2



PPC of Model 3



Summary of Model 1

```
Family: lognormal  
Links: mu = identity; sigma = identity  
Formula: episodes_survived ~ 1 + episode_number + species  
Data: rickmorty (Number of observations: 1606)  
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;  
      total post-warmup draws = 4000
```

Population-Level Effects:

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS
Intercept	-0.06	0.08	-0.20	0.10	1.00	3255
episode_number	0.03	0.00	0.02	0.03	1.00	5427
speciesAnimal	-0.01	0.13	-0.26	0.24	1.00	3988
speciesCronenberg	0.91	0.12	0.68	1.13	1.00	3634
speciesHuman	0.48	0.07	0.34	0.62	1.00	2861
speciesHumanoid	-0.51	0.14	-0.78	-0.23	1.00	3841
speciesPoopybutthole	0.22	0.16	-0.08	0.52	1.00	4462
speciesRobot	-0.79	0.18	-1.14	-0.42	1.00	4392
	Tail_ESS					
Intercept	3204					
episode_number	3171					
speciesAnimal	3477					
speciesCronenberg	2979					
speciesHuman	2960					
speciesHumanoid	2994					
speciesPoopybutthole	2773					
speciesRobot	3366					

Family Specific Parameters:

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sigma	1.05	0.02	1.02	1.09	1.00	5753	3144

Summary of Model 1

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	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
Intercept	-0.06	0.08	-0.20	0.10	1.00	3255	
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speciesAnimal	-0.01	0.13	-0.26	0.24	1.00	3988	
speciesCronenberg	0.91	0.12	0.68	1.13	1.00	3634	
speciesHuman	0.48	0.07	0.34	0.62	1.00	2861	
speciesHumanoid	-0.51	0.14	-0.78	-0.23	1.00	3841	
speciesPoopybutthole	0.22	0.16	-0.08	0.52	1.00	4462	
speciesRobot	-0.79	0.18	-1.14	-0.42	1.00	4392	
Intercept		3204					
episode_number		3171					
speciesAnimal		3477					
speciesCronenberg		2979					
speciesHuman		2960					
speciesHumanoid		2994					
speciesPoopybutthole		2773					
speciesRobot		3366					

Family Specific Parameters:

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sigma	1.05	0.02	1.02	1.09	1.00	5753	3144

Summary of Model 2

```

Family: lognormal
Links: mu = identity; sigma = identity
Formula: episodes_survived ~ 1 + episode_number + species + (episode_number | name)
Data: rickmorty (Number of observations: 1606)
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
      total post-warmup draws = 4000
  
```

Group-Level Effects:

`~name` (Number of levels: 377)

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat
sd(Intercept)	0.40	0.03	0.35		0.46		1.01
sd(episode_number)	0.02	0.00	0.02		0.02		1.01
cor(Intercept,episode_number)	-0.28	0.10	-0.46		-0.06		1.02
			Bulk_ESS	Tail_ESS			
sd(Intercept)			508	1102			
sd(episode_number)			266	488			
cor(Intercept,episode_number)			216	479			

Population-Level Effects:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS
Intercept	-0.20	0.07	-0.34		-0.07	1.00		1035
episode_number	0.01	0.00	0.01		0.02	1.01		736
speciesAnimal	-0.09	0.12	-0.33		0.15	1.00		1651
speciesCronenberg	0.00	0.08	-0.17		0.17	1.00		2071
speciesHuman	0.10	0.07	-0.03		0.23	1.00		1725
speciesHumanoid	-0.06	0.11	-0.27		0.16	1.00		2324
speciesPoopybutthole	-0.13	0.20	-0.51		0.27	1.00		1880
speciesRobot	-0.12	0.25	-0.61		0.37	1.00		2288
			Tail_ESS					
Intercept			1864					
episode_number			1845					
speciesAnimal			2193					
speciesCronenberg			2746					
speciesHuman			2090					
speciesHumanoid			2562					
speciesPoopybutthole			2782					
speciesRobot			2748					

Family Specific Parameters:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS	Tail_ESS
sigma	0.25	0.01	0.24		0.26	1.00		3802	3155

Summary of Model 3

```
Family: lognormal  
Links: mu = identity; sigma = identity  
Formula: last_episode ~ 1 + species + gender + (1 | species) + (1 | gender)  
Data: rickmorty_cat (Number of observations: 382)  
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;  
       total post-warmup draws = 4000
```

Group-Level Effects:

~gender (Number of levels: 4)

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	0.53	0.48	0.02	1.87	1.00	1187	1763

~species (Number of levels: 7)

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	0.53	0.45	0.02	1.72	1.01	924	1105

Population-Level Effects:

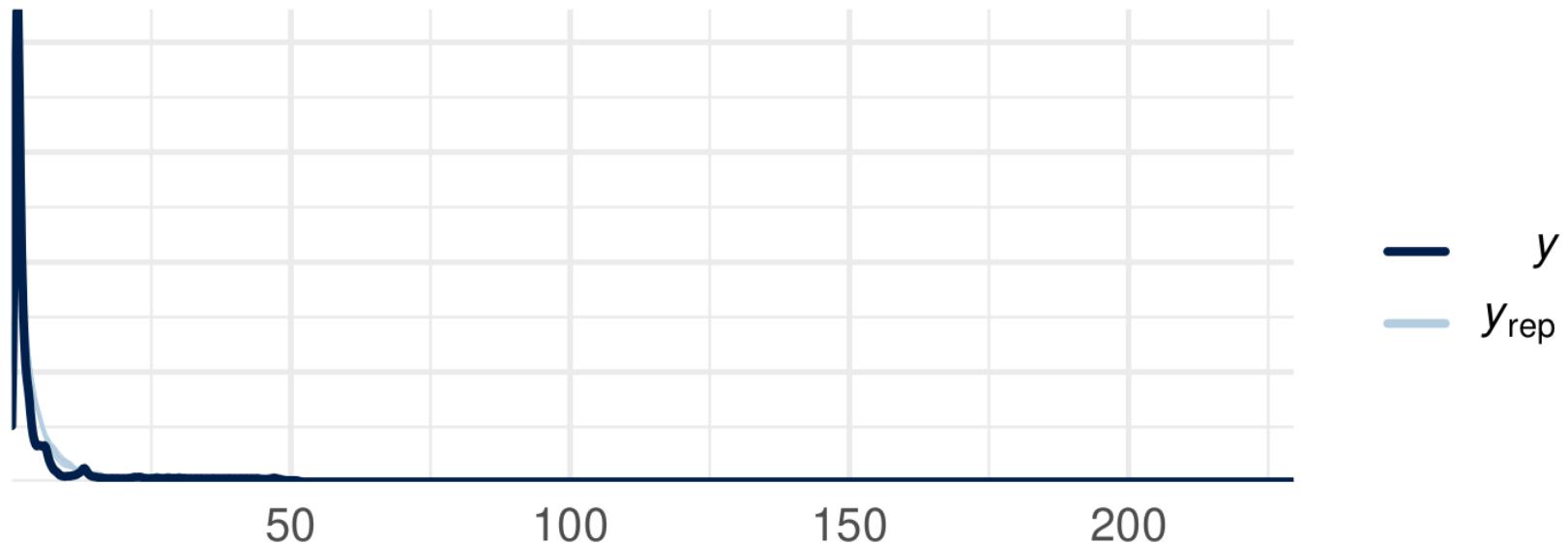
Estimate Est.Error 1-95% CI u-95% CI Rhat Bulk_ESS

Intercept	3.16	0.58	1.98	4.38	1.00	1516
speciesAnimal	0.18	0.59	-1.15	1.41	1.01	1427
speciesCronenberg	0.06	0.63	-1.26	1.40	1.00	1697
speciesHuman	-0.05	0.64	-1.48	1.43	1.00	1474
speciesHumanoid	-0.05	0.82	-1.88	1.61	1.00	1040
speciesPoopybutthole	0.19	0.59	-1.11	1.38	1.00	2137
speciesRobot	0.49	0.83	-1.30	2.35	1.00	1681
genderGenderless	-0.18	0.68	-1.58	1.35	1.00	1440
genderMale	-0.02	0.44	-0.92	0.93	1.00	1653
genderunknown	-0.27	0.62	-1.52	1.24	1.00	1700

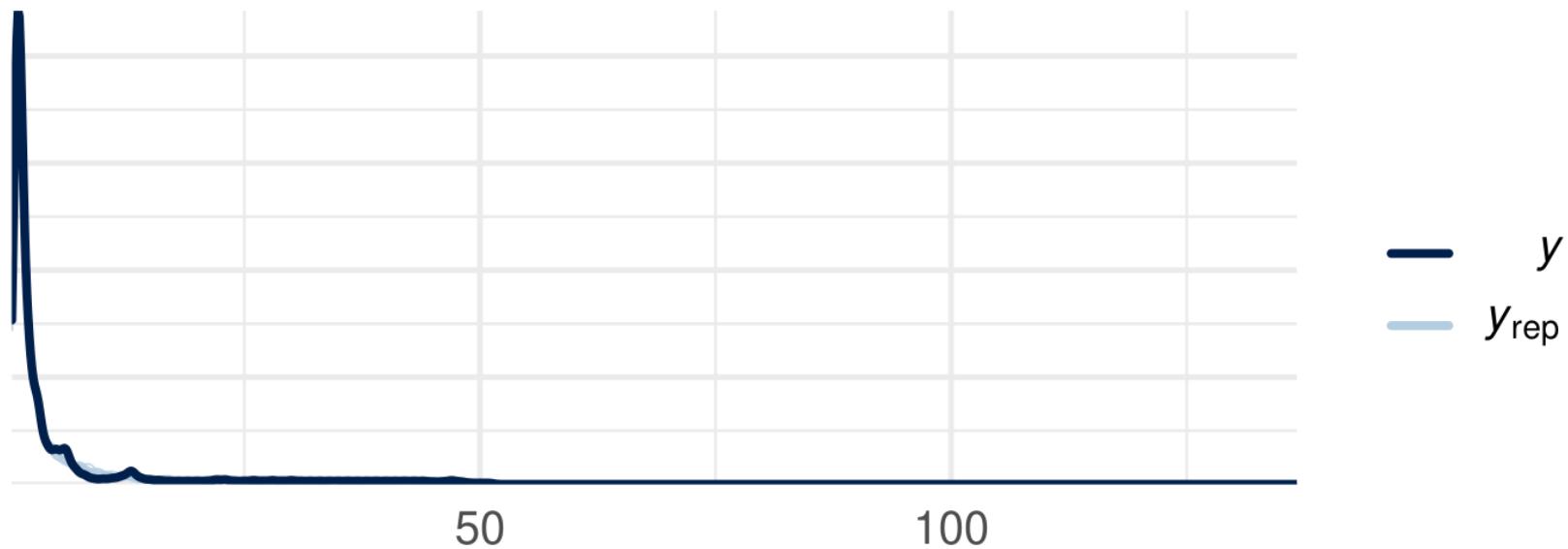
Tail_ESS

Intercept	1357
speciesAnimal	1065
speciesCronenberg	1310
speciesHuman	882
speciesHumanoid	912
speciesPoopybutthole	1990
speciesRobot	1115
genderGenderless	1263
genderMale	1324
genderunknown	1304

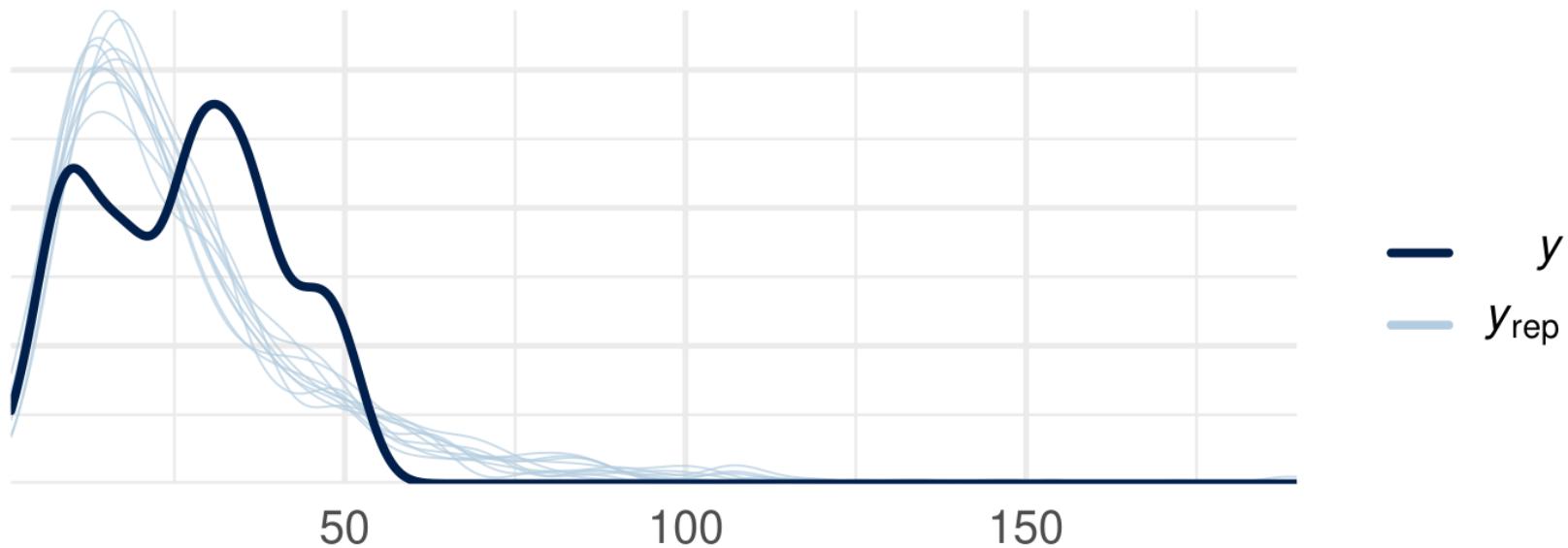
Sensitivity Analysis – PPC of Model 1



Sensitivity Analysis – PPC of Model 2



Sensitivity Analysis – PPC of Model 3



Sensitivity Analysis - Summary of Model 1

```
Family: lognormal  
Links: mu = identity; sigma = identity  
Formula: episodes_survived ~ 1 + episode_number + species  
Data: rickmorty (Number of observations: 1606)  
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;  
total post-warmup draws = 4000
```

Population-Level Effects:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS	Tail_ESS
Intercept	-0.04	0.08	-0.19	0.10	1.00		3476		
episode_number	0.03	0.00	0.02	0.03	1.00		5837		
speciesAnimal	-0.02	0.13	-0.28	0.22	1.00		3720		
speciesCronenberg	0.89	0.12	0.66	1.11	1.00		3429		
speciesHuman	0.47	0.07	0.33	0.61	1.00		2516		
speciesHumanoid	-0.52	0.14	-0.79	-0.24	1.00		4217		
speciesPoopybutthole	0.21	0.15	-0.10	0.50	1.00		4346		
speciesRobot	-0.80	0.18	-1.15	-0.44	1.00		4385		
Intercept			3724						
episode_number			3482						
speciesAnimal			2619						
speciesCronenberg			2957						
speciesHuman			2845						
speciesHumanoid			3023						
speciesPoopybutthole			3083						
speciesRobot			2867						

Family Specific Parameters:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS	Tail_ESS
sigma	1.05	0.02	1.02	1.09	1.00		6249		2921

Sensitivity Analysis - Summary of Model 2

Family: lognormal
 Links: mu = identity; sigma = identity
 Formula: episodes_survived ~ 1 + episode_number + species + (episode_number | name)
 Data: rickmortality (Number of observations: 1606)
 Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;
 total post-warmup draws = 4000

Group-Level Effects:
 ~name (Number of levels: 377)

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat
sd(Intercept)	0.40	0.03	0.35		0.46	1.01	

sd(episode_number)	0.02	0.00	0.02	0.02	1.03
cor(Intercept,episode_number)	-0.28	0.10	-0.46	-0.09	1.04
Bulk_ESS Tail_ESS					
sd(Intercept)	591	1514			
sd(episode_number)	208	525			
cor(Intercept,episode_number)	150	484			

Population-Level Effects:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS
Intercept	-0.20	0.07	-0.33		-0.07	1.00		821
episode_number	0.01	0.00	0.01		0.02	1.01		652
speciesAnimal	-0.08	0.12	-0.31		0.16	1.00		1672
speciesCronenberg	0.01	0.08	-0.15		0.16	1.00		2215
speciesHuman	0.10	0.06	-0.03		0.22	1.00		1835
speciesHumanoid	-0.06	0.11	-0.28		0.16	1.00		1893
speciesPoopybutthole	-0.11	0.20	-0.51		0.26	1.00		2255
speciesRobot	-0.12	0.24	-0.60		0.34	1.00		1994

	Tail_ESS
Intercept	1851
episode_number	862
speciesAnimal	2226
speciesCronenberg	2640
speciesHuman	2583
speciesHumanoid	2785
speciesPoopybutthole	2920
speciesRobot	1764

Family Specific Parameters:

	Estimate	Est.Error	l-95%	CI	u-95%	CI	Rhat	Bulk_ESS	Tail_ESS
sigma	0.25	0.01	0.24		0.26	1.00		3725	3152

Sensitivity Analysis - Summary of Model 3

```
Family: lognormal  
Links: mu = identity; sigma = identity  
Formula: last_episode ~ 1 + species + gender + (1 | species) + (1 | gender)  
Data: rickmorty_cat (Number of observations: 382)  
Draws: 4 chains, each with iter = 2000; warmup = 1000; thin = 1;  
total post-warmup draws = 4000
```

Group-Level Effects:

-gender (Number of levels: 4)

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	0.37	0.33	0.01	1.26	1.01	1095	1880

-species (Number of levels: 7)

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sd(Intercept)	0.34	0.32	0.01	1.19	1.01	511	526

Population-Level Effects:

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS
Intercept	3.14	0.42	2.23	3.97	1.00	1071
speciesAnimal	0.16	0.37	-0.82	0.85	1.01	664
speciesCronenberg	0.06	0.43	-0.82	0.86	1.00	1180
speciesHuman	-0.03	0.36	-0.75	0.90	1.01	675
speciesHumanoid	-0.04	0.55	-1.16	1.20	1.00	736
speciesPoopybutthole	0.19	0.39	-0.66	0.92	1.01	799
speciesRobot	0.48	0.59	-0.67	1.66	1.00	969
genderGenderless	-0.13	0.44	-0.94	0.79	1.01	2323
genderMale	-0.03	0.36	-0.74	0.82	1.00	1767
genderunknown	-0.22	0.40	-0.96	0.73	1.00	1487

Tail_ESS

Intercept	1071
speciesAnimal	195
speciesCronenberg	826
speciesHuman	167
speciesHumanoid	225
speciesPoopybutthole	340
speciesRobot	714
genderGenderless	1951
genderMale	1780
genderunknown	1362

Family Specific Parameters:

	Estimate	Est.Error	1-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
sigma	0.69	0.03	0.64	0.74	1.00	1833	1164