Survivor(al) Analysis: Impacts of Demographics on Game Show Contestant Survival

Introduction

Motivation:

In this report, we utilize survival analysis to explore the implications of self-identified race, gender, and personality type to game show survival. In particular, we focus on the American classic TV series *Survivor*, which is currently on its 43rd season. In this show, each season 16 to 18 contestants are divided into tribes and navigate challenges within these social alliances in order to promote their own survival.[1] Throughout each season, contestants are progressively eliminated by vote of their peers until there is a sole survivor. Given that aspects of identity heavily influence how people are perceived in a social context, we hypothesize that contestant outcomes may differ on the measures related to retention or screen time.

Related Work:

While survival analysis is a statistical methodology typically used in health fields to understand the time to an event of interest (such as death, myocardial infarction, or cancer recurrence)[2], we are able to utilize the number of days survived on *Survivor* as our main outcome of interest. Our inspiration for this project came from a small scale paper studying the effects of demographics in *Masterchef Junior* contestant survival rates.[3] This research looked at race and gender to determine the outcome of percent of season survived, with the additional analysis to look at the impact of a female judge on these survival rates. While the TV series *Survivor* and *Masterchef Junior* differ in their elimination processes, both our studies explore the intricacies of societal bias and how that plays into game show success.

Initial Questions:

Our initial goal was to investigate the extent to which gender, race, and personality have led to differences in days survived on *Survivor*. Based on cultural norms in the U.S., we hypothesized that contestants who are white, male, or extroverts would have the longest survival time. In determining a lack of results on these measures, we decided to integrate geographic comparisons as well for survival time. More additional questions arose throughout the course of our research. We determined that another component of entertainment culture was not only how long the contestants stayed on the show, but how much individualized screen time they received while there. Thus, we decided to explore the frequency of confessionals as supplementary analyses. Finally, in more recent years (in alignment with the Black Lives Matter movement in the U.S.), *Survivor* has made the effort to encourage more diversity within their casts. To this end, we also wanted to visually see if contestants had representation that evolved over the 42 seasons. In this paper, we consider all these aspects as part of a comprehensive investigation of demographics on game show survival.

[1] https://www.cbs.com/shows/survivor/about/

[2] https://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_survival/BS704_Survival_print.html

[3] https://www.katiejolly.io/pdf/survival_analysis_paper.pdf

Data Sources & Cleaning:

In order to analyze the show *Survivor*, we used data sources from the castaway_details and castaways datasets[4], as well as others, from the survivoR package.[5] This fan-made package contains data from all seasons of the U.S. TV show *Survivor*. According to the authors of the package, "the data was sourced from Wikipedia and the Survivor Wiki. Other data, such as the tribe colours, was manually recorded and entered by myself and contributors." As each dataset contained distinct information on the contestants for each season, it was necessary to use joins to combine datasets to produce a final dataset to be analyzed. This was performed using a full join on the contestants' full names. It should be noted that a few contestants appear in multiple seasons, however we treated them as separate throughout most of our analysis for the purposes of getting an accurate picture of each season. Additionally, in order to standardize our results for the survival analysis and exploratory data analysis, we removed seasons 2, 41, 42, and 43 as the seasons contained data for a different number of days from the standard 39 days. As the original data contains information from several versions around the globe, it was integral to filter and only analyze data from the U.S. edition. In order to best model our covariates of interest, we then created a new personality type variable (extracting whether a person is an introvert or extrovert) and a POC indicator variable instead of individual races. We also used contestants' home states to code contestants into a region based on census regions and divisions of the United States.[6] Furthermore, we determined that missing data was not an issue, as it occurred in low frequency and was not patterned in nature. The final dataset used in the analysis contains unique information for each castaway for each season, including the following key variables:

- version_season: version and season number
- full_name: contestant full name
- age_during_show : age, in years
- poc : POC indicator, if known. Else, marked as White.
- gender: 2 levels: Female, Male.
- personality_type_binary : Extracted from the Myer-Briggs personality type of the castaway. 2 levels: Extrovert, Introvert.
- days_survived: Number of days survived in the show until elimination
- region: region in the U.S. where the contestant is from. We created this variable based on the state variable available in the dataset. 4 levels: West, Midwest, Northeast, South. Indicator variables for each of the 4 regions have also been created for analyses.

As a supplemental analysis, we also used the confessionals data from the same survivoR package to visualize the number of confessionals each contestant received. This data looked at all seasons as it was unrelated to the survival analysis and consistency in the datasets was not necessary. Nevertheless, this data also only looked at the U.S. edition of the show.

Exploratory Analysis:

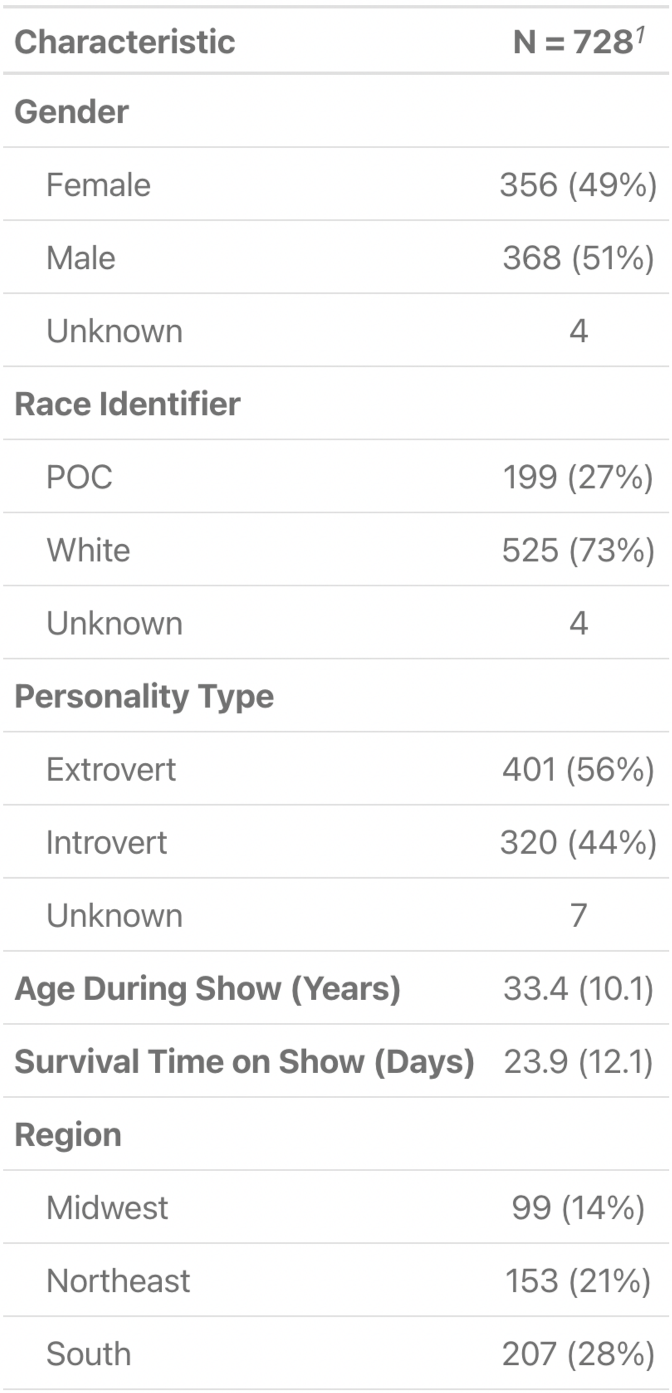
We performed exploratory data analysis to visualize the distributions of our variables of interest, including POC, gender, personality type, age, and geographic location. In order to best depict the true nature of our data, we used a combination of tables and plots, depending on which method we believed to be most effective. In our summary demographic table*, we decided to only count contestants once, regardless of if they appeared in multiple seasons (in contrast to the rest of our analysis).

Table 1: Summary Statistics

[4] https://github.com/doehm/survivoR

[5] https://cran.r-project.org/web//packages/survivoR/survivoR.pdf

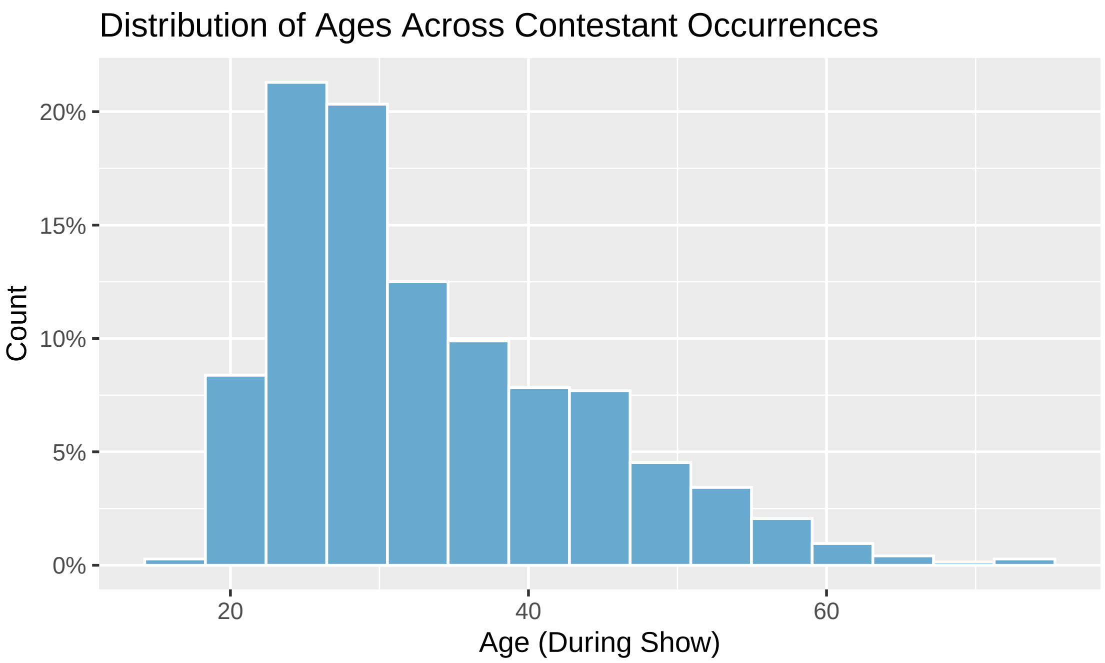
[6] https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf



Characteristic	N = 728[1]
Gender	
Female	356 (49%)
Male	368 (51%)
Unknown	4
Race Identifier	
POC	199 (27%)
White	525 (73%)
Unknown	4
Personality Type	
Extrovert	401 (56%)
Introvert	320 (44%)
Unknown	7
Age During Show (Years)	33.4 (10.1)
Survival Time on Show (Days)	23.9 (12.1)
Region	
Midwest	99 (14%)
Northeast	153 (21%)
South	207 (28%)

Note: N = 728 refers to the total count of records (i.e. contestant occurrences) in `survivor_data_final`*; distinct persons may be listed in multiple records, across seasons and/or within seasons.*

Figure 1: Distribution of Age



Note: Since contestants can re-appear across seasons at different ages, we rely on discrete records from `survivor_data_final` (i.e. contestant occurrences) as the unit of analysis for this plot in order to ensure comprehensiveness of age data.

We also included tables showing the mean days survived based on these demographic measures of interest.

Personality Type	Distinct Persons	Contestant Occurrences	Mean Days Survived
Extrovert	309	401	24.0
Introvert	271	320	23.6

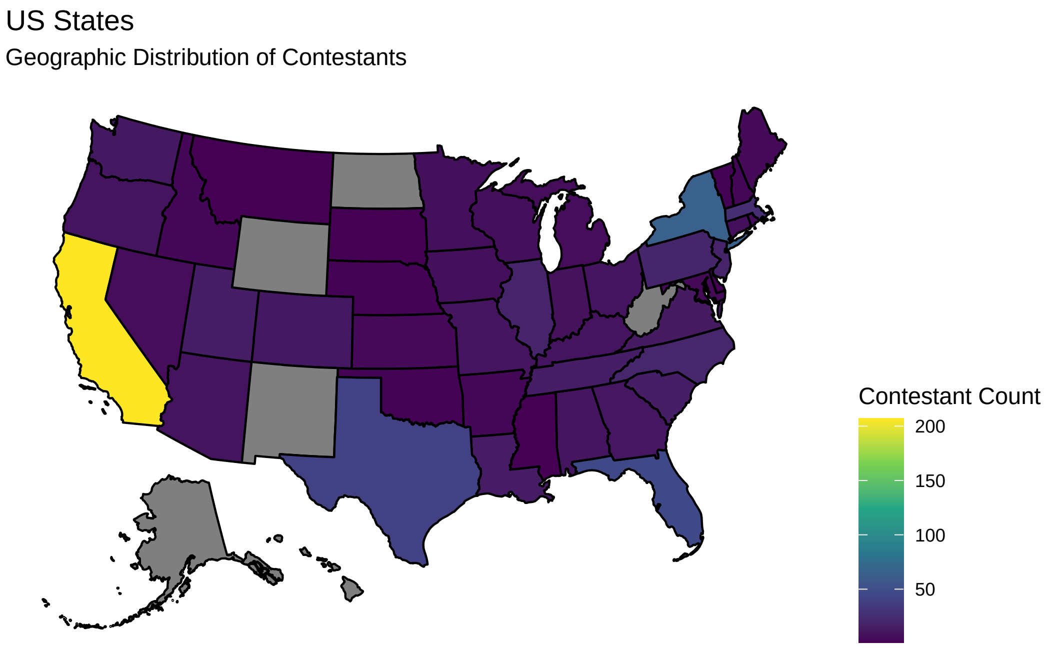
POC Status	Distinct Persons	Contestant Occurrences	Mean Days Survived
POC	164	199	22.6
White	418	525	24.3

Gender	Distinct Persons	Contestant Occurrences	Mean Days Survived
Female	292	356	23.1
Male	290	368	24.5

Region	Distinct Persons	Contestant Occurrences	Mean Days Survived
Midwest	84	99	24.4
Northeast	122	153	25.0
South	178	207	22.7
West	218	269	23.8

Next, to visualize the geographic origins of *Survivor* contestants, we created a map to chart the number of contestants coming from each state. This map indicates that California was the most popular state of origin for contestants.

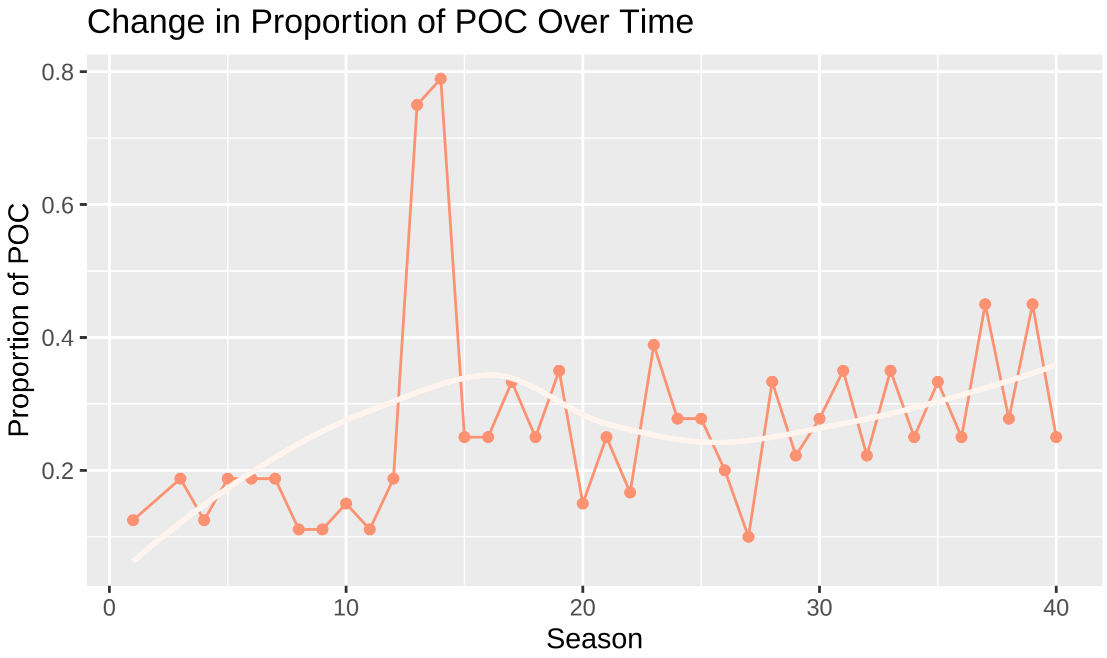
Figure 2: Map of Geographic Origins



Notes: i) Seasons 2, 41, 42, and 43 have been removed from the exploratory analysis due to inconsistent number of days. ii) Since contestants can re-appear across seasons with different states of residence, we similarly rely on discrete records from `survivor_data_final` (i.e. contestant occurrences) as the unit of analysis for this plot in order to ensure comprehensiveness of location data.

Additionally, we used a line plot* to visualize the change in diversity (looking at both POC status and gender) to view how the proportion of POC and women has changed over the show's many seasons.

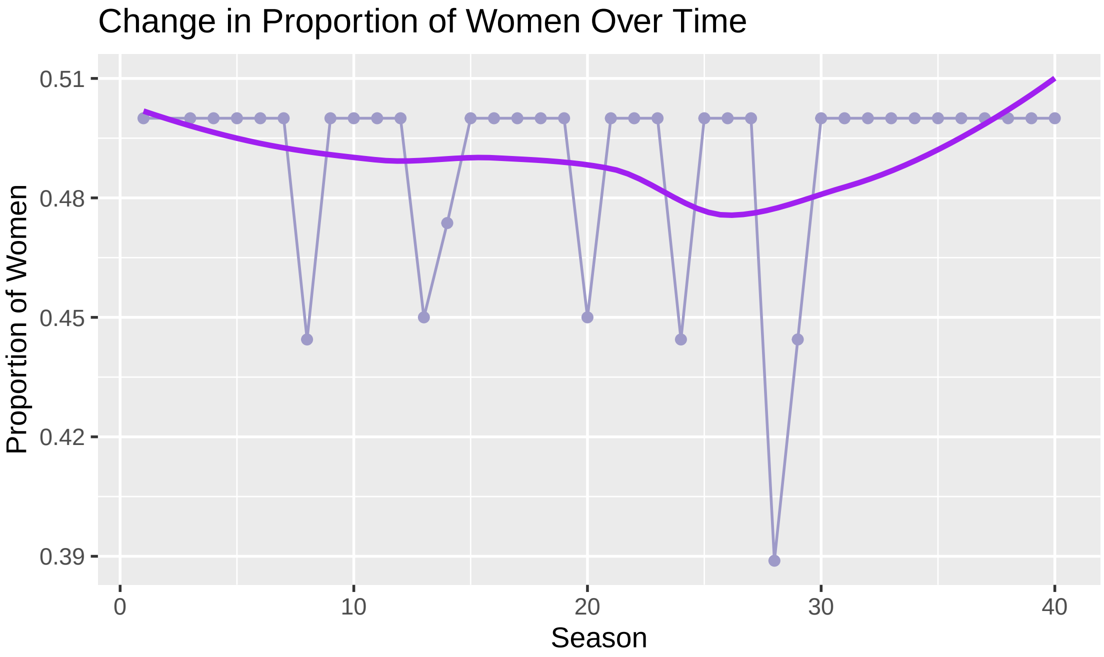
Figure 2: Contestant POC over Time



Note: Distinct person counts by POC status.

According to the trends of the proportion of POC, the initial seasons had a very low proportion of POC contestants and the overall data shows an increasing trend in the proportion of POC. It was interesting to note that some "early" seasons such as seasons 13 and 14 had very high proportions of POC (over 0.5).

Figure 3: Contestant Gender over Time



Note: Distinct person counts by gender.

The graph for the proportion of women per season shows a relatively steady trend around 0.5, indicating a generally even distribution of men and women in the data. There are some seasons with a proportion less than 0.5 and greater than 0.5, but a majority of seasons had an exact proportion of 0.5.
In addition to the aforementioned exploratory data analysis, we were curious to see which contestants were receiving the most confessionals. As a result, we created a Shiny app that allows users to select which season they would like to view. Users can then examine the number of confessionals each contestant received, as well as the total number of confessionals they received over the season, and the mean number of confessionals per episode they received while on the show.

Survival Analysis:

Methodology:

For our statistical analysis, we used survival analysis to understand the time to elimination for *Survivor* contestants. In this method, we suppose that there is a true survival time, T, as well as a true censoring time, C. The survival time represents the time at which the event of interest occurs: in this dataset, the time (in days) at which participant is voted out. The censoring time is the time at which the participant drop out of the game show or survived until the last day of the show.

We observed the Survival Time T and Censoring Time C. Suppose there is a random variable Y

$$Y = min(T, C)$$

In other words, if the event occurs before the censoring such that T < C, then we observed the true survival time T. If censoring occurs before the event such as T > C, then we observe the censoring time. The status indicator as,

$$\delta = \begin{cases} 1 & T \leq C \\ 0 & T > C \end{cases}$$

Thus, $\delta = 1$ if we observe the true survival time, and $\delta = 0$ if we observe the censoring.

We use the Cox-propositional hazard model to evaluate the effect of several factors on survival time in Survivor Show. It allows us to examine how specified factors influence the rate of the event that we interested at a particular point in time. This rate is the hazard rate. Covariates are age, gender, personality type, and region in this model. The Cox model is expressed by the hazard function denoted by h(t). Briefly, the hazard function can be interpreted as the risk of voted out at time t. It can be estimated as follow:

$$h(t) = h_0(t) \exp(x_1\beta_1 + x_2\beta_2 + x_3\beta_3 + x_4\beta_4 + x_4\beta_5)$$

where,

- t represents the survival time
- $h(t)$ is the hazard function determined by a set of participants' covariates $(x_1, x_2, x_3, x_4, x_5)$: x_1 is gender, x_2 is POC, x_3 is age during the show, x_4 is personality type, and x_5 is region
- the coefficients $(\beta 1, \beta 2, \beta 3, \beta 4, \beta 5)$ measures the impact of covariates
- $h_0(t) \geq 0$ is the baseline hazard function. It is the hazard function for an individual if all $(x_1, x_2, x_3, x_4, x_5)$ are equal to zero.

Cox Proportional-Hazards Model

To investigate the number of days survived on *Survivor*, we built a Cox Proportional-Hazards Model adjusting for the variables of age, gender, personality type (introvert versus extrovert) and POC (White vs POC). The Cox Proportional-Hazards model was chosen since it allows us to examine multiple factors that could be influencing the rate at which contestants are eliminated. An assumption of the Cox Proportional-Hazards model is that each covariate has a multiplicative effect in the hazards function that is constant over time. After fitting the Cox model, we tested the assumption and none of the covariates in our model are in violation.

Results:

Kaplan-Meier Curves

To investigate each of the covariates individually, we created Kaplan-Meier curves to look at survival time with respect to:

Figure 4: Personality Type (Introvert vs Extrovert)

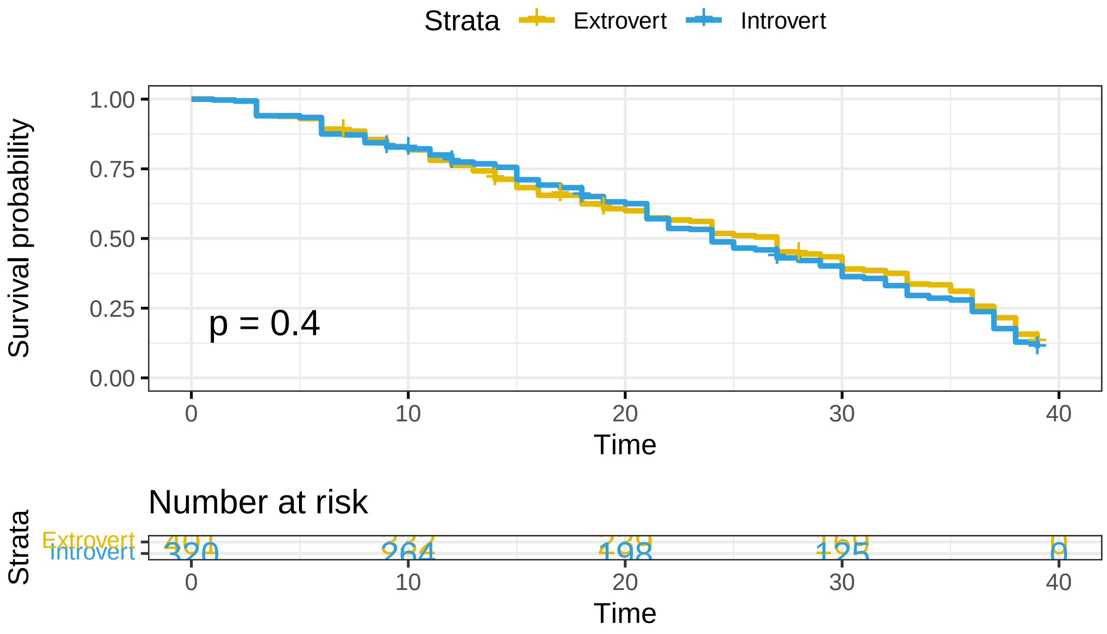


Figure 5: POC (White vs Non-White)

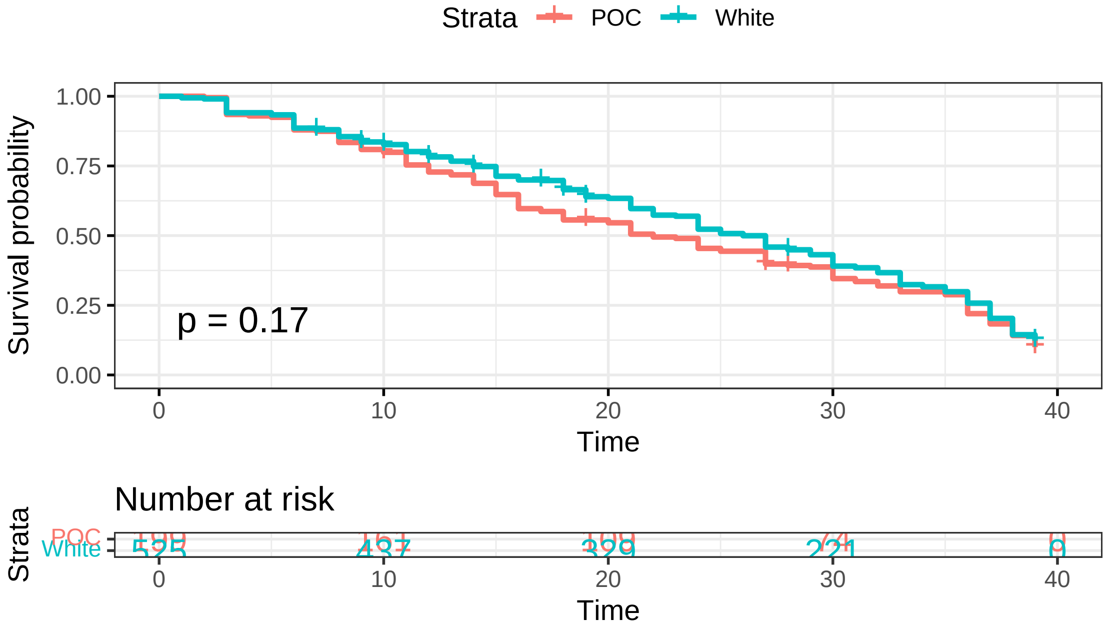


Figure 5: Gender (Female vs Male)

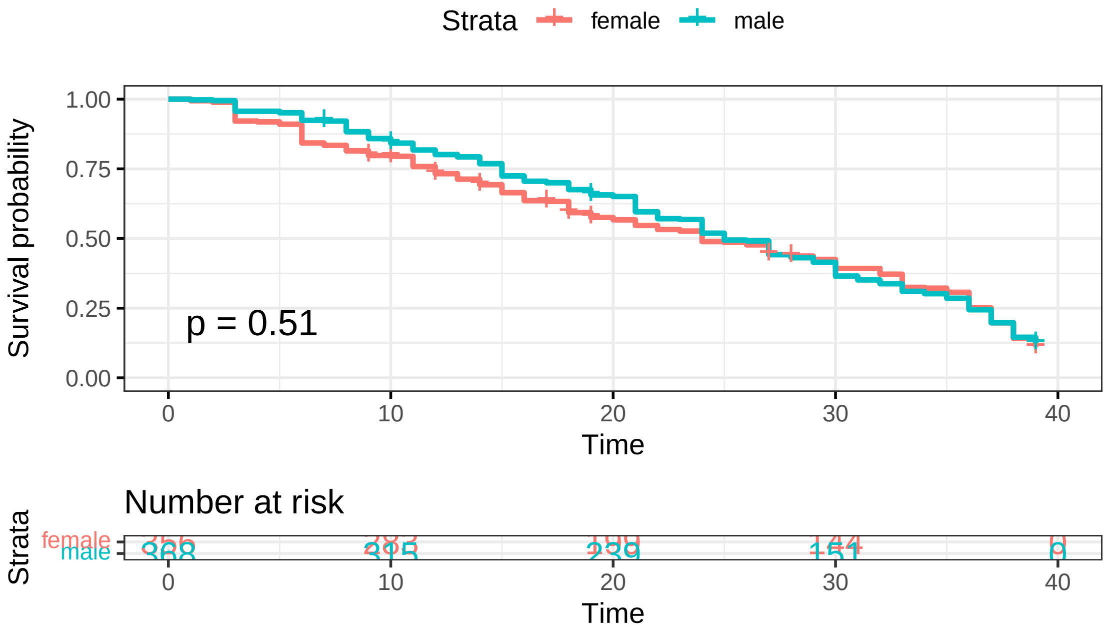


Figure 6: Region

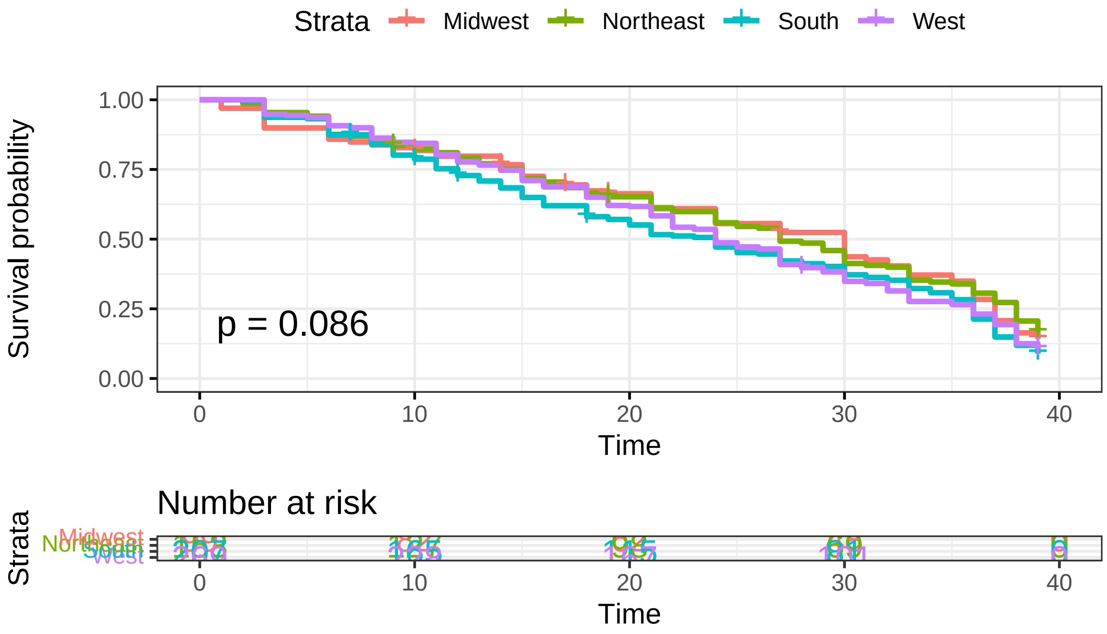
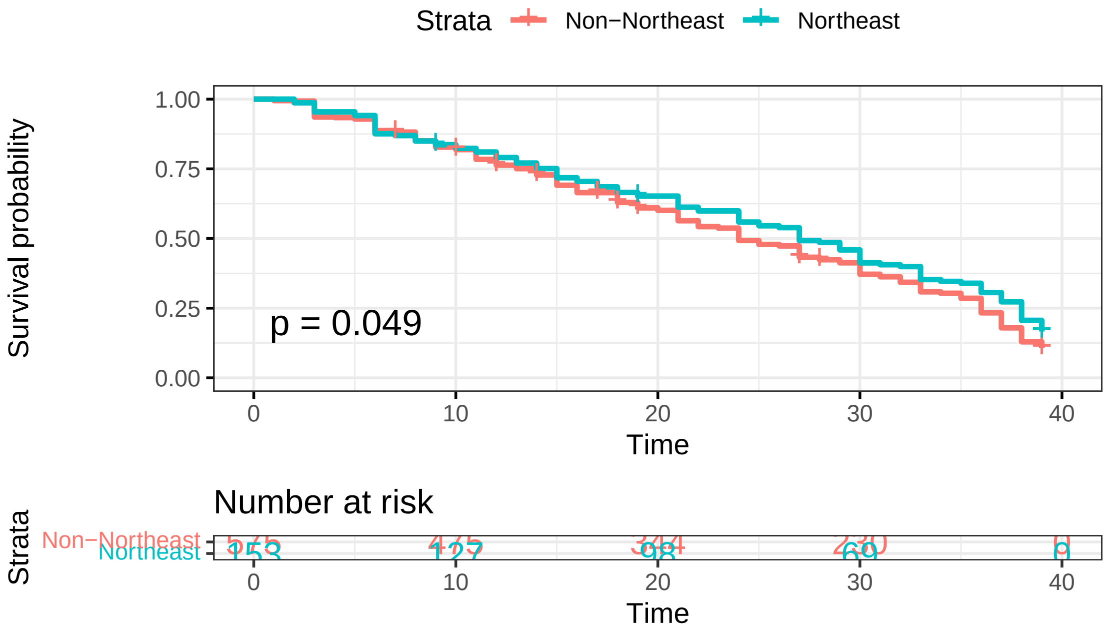


Figure 7: Northeast vs Non-Northeast Region



The results of our Cox Proportional-Hazards model are displayed below.

Table 2: Modeling Survival Time by Age, Gender, POC, Personality Type, Region

Risk Factor	Parameter Estimate (Standard Error)	Hazard Ratio (HR) (95% CI)	P-Value
Age during show (years)	-0.00 (0.00)	1.00 (0.99, 1.01)	0.9538
Gender			
Female	Ref		
Male	-0.05 (0.08)	0.95 (0.81, 1.11)	0.5003
POC (person of color)			
POC	Ref		
White	-0.11 (0.09)	0.89 (0.75, 1.07)	0.2104
Personality Type			
Extrovert	Ref	Ref	
Introvert	0.06 (0.08)	1.07 (0.91, 1.25)	0.4242
Region			
Midwest	Ref		
Northeast	-0.00 (0.15)	1.00 (0.75, 1.33)	0.9880
South	0.26 (0.14)	1.30 (1.00, 1.70)	0.0528
West	0.17 (0.13)	1.18 (0.91, 1.53)	0.1989

Notes: N = 721, number of events = 626

As age increases in years, there is no difference in survival since the hazard ratio is 1. We are 95% confident that the HR falls between 0.99 to 1.01. However, the HR is not statistically significant.
- For gender, the HR value of 0.96 suggests that the survival time for male contestants is longer compared to female contestants (the reference category). We are 95% confident that the HR falls between 0.82 and 1.12. However, the HR is not statistically significant.
- For POC, the HR value of 0.89 would suggest that the survival time for White contestants is longer

compared to POC contestants (the reference category). We are 95% confident that the HR falls between 0.75 and 1.06. However, the HR is not statistically significant.
- For personality type, the HR value of 1.07 would suggest that the survival time for introvert contestants is shorter compared to extrovert contestants (the reference category). We are 95% confident that the HR falls between 0.91 - 1.25. However, the HR is not statistically significant.
- For region, Midwest is the reference category. However, all of these hazard ratios are not statistically significant, p-value > 0.05.

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* The HR value of 0.99 for Northeast suggests that the survival time for contestants from the NE is nea
* The HR value of 1.29 for the South suggests that the survival time for contestants from the South is s
* The HR value of 1.18 for the West suggests that the survival time for contestants from the West is sh
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Discussion:

From conducting survival analyses, we did not observe any statistically significant covariates in the Cox-Proportional-Hazards model. This stands in contrast with our initial hypotheses that race, gender, and personality type would impact days survived. The hazard ratio values for gender (males surviving longer than female contestants), POC (White contestants surviving longer than POC), personality type (extrovert surviving longer than introverts) follow our general expectations. We also included region as a covariate in our final model without expecting that it would impact survival time. The indicator for South was nearly statistically significant (at alpha = 0.05), which could warrant further investigation. However, since none of the hazard ratios are statistically significant based on the current data, we cannot make any conclusions. Upon conducting analysis on the Kaplan-Meier curves to investigate each covariate individually, we discovered a marginally statistically significant (at alpha = 0.05) curve comparing contestants from the Northeast to those not from the Northeast. This indicates that it can be estimated that contestants from the Northeast tend to have overall better survival trajectories on the show than contestants not from the Northeast.

It is integral to note that these results do not necessarily reflect societal biases and difficulties individuals face on the show, as there are several limitations to the data. For example, individuals were only categorized as "POC" if there were known references to their racial backgrounds and categorized as "White" otherwise. This could potentially cause a bias towards the null as some individuals who are actually POC might have erroneously been categorized. Additionally, each season was relatively limited in the number of contestants with many seasons having around 20 contestants. In order to conduct the analysis, we removed some of the seasons from the show, which means that this analysis does not necessarily represent the show's full cast. Finally, there are several "behind the scenes" factors that could affect how long contestants stay on the show, such as producer influence, that potentially influence the narratives on the show. Nevertheless, the show has taken several necessary steps to promote diversity on the show, such as including a higher proportion of POC in recent seasons compared to the original seasons as visualized in the exploratory data analysis. As of 2020, CBS (the show's network) announced that reality TV shows must have 50% non-White casts and increased writing room diversity.[7] Several years in the future, it would be interesting to expand this project to analyze survival times of POC before and after this change was implemented to see if survival times have improved. Another potential future analysis could involve determining if the number of confessionals (and length of screen time on the show) varies by race, gender, and age.

[7] https://www.cnbc.com/2020/11/09/cbs-reality-shows-must-now-have-50percent-non-white-casts-network-says.html