# Pikachu, I Choose You!
# Predicting Popularity of Pokémon in Competitive Battling

Evelyn Chen & Alexandria Guo

**ABSTRACT**

As Pokémon and e-sports become more popular in today's society, players are coming up with more unique ways of playing Pokémon competitively. The questions we explore in this paper is: what makes a Pokémon more desirable to use in competitive battle and what is their potential usage percentage? Using data acquired from Pokémon Showdown, a popular Pokémon battling site, we analyze trends in the most used Pokémon amongst the highest rated players on the site. We examined various features of Pokémon, including their quantitative stats—HP (Health), Attack, Defense, Special Attack, Special Defense, and Speed—as well as qualitative characteristics, such as their primary and secondary elemental types, if they were "Legendary," and if they could evolve into another species. Ultimately, we discovered that secondary type, HP, Attack, Special Defense, Special Attack, and Speed were significant predictors of usage in battle.

## BACKGROUND AND SIGNIFICANCE

Pokémon is a video game first launched in 1996 by Japanese gaming company Nintendo for the Game Boy, to great acclaim and popularity. The franchise has since expanded to include several cartoon series, movies, a card game, and more, gaining both nostalgic appeal and 656 new Pokémon since the original 151 were released. Most recently, the mobile game *Pokémon Go* gained attention as a global phenomenon as people everywhere caught onto the craze of augmented reality, allowing us to interact with these imaginary creatures in our physical world.

As of December 2017, the game has gathered $1.2 billion in revenue, having the honor of the most first week app downloads in the Apple App Store history.

Pokémon is short for “Pocket Monsters,” and the most core mechanism of the game entails the player collecting Pokémon to train them and battle others. All species of Pokémon have base statistics—HP, Attack, Defense, Special Attack, Special Defense, and Speed—which determine how battle proceeds. HP represents the overall health of the Pokémon, while Attack and Defense denote the Pokémon’s physical strength and durability respectively. Special Attack and Special Defense denote the Pokémon’s strength in magic-based attacks and defense. Pokémon are also assigned a primary elemental type and sometimes a secondary type too, based on various elements, such as fire, water, and grass. Each type has its own weaknesses, strengths, resistances, and immunities. For instance, fire is weak to water and fire is strong against grass. All of these factors are important things to consider in the final outcome of the battle: which player can knock out the opponent’s entire team first.

In the story mode of the Nintendo-released games, players progress through fictional lands to find progressively rarer and more powerful Pokémon, often peaking at one-of-kind ‘Legendary’ Pokémon that are significantly stronger than any previously encountered in the game. Play often consists of repeatedly battling other Pokémon to strengthen yours, until you can rise to the next tier of Pokémon ahead in the story. However, a different mode of play has also risen to popularity—competitive Pokémon, as can be seen on the website Pokémon Showdown. On this platform, training Pokémon is no longer an important part of the game, and thus time is instead spent on strategizing how to choose the ideal six Pokémon to defeat other players in battle.

The official Nintendo tournaments for Pokémon in the style described above falls under the name of ‘Video Game Championships,’ and in fact still requires players to train their Pokémon in the video game as opposed to instant creation, among other additional constraints. Over $500,000 in prize money is available in the World Championship alone, and over a million people watched the video stream of the competition in 2017. Pokémon Showdown gives players a chance to test out possible team builds without investing all the time into training the Pokémon first and gives insight into the popular battle strategies in development by top players. Thus, it is an ideal website to scrape data from and help our investigation of what makes particular Pokémon ideal for competitive battle.

## RESEARCH QUESTION

Our main research question was to see if it was possible to predict usage percentage of Pokémon in competitive battle based only on base statistic data, including quantitative stats such as HP, Attack, Defense, Special Attack (Sp. Atk), Special Defense (Sp. Def), and Speed, as well as Type, if the Pokémon is a Legendary Pokémon, and if the Pokémon can evolve. Many factors go into competitive Pokémon team building, such as team synergy between Pokémon, held items by Pokémon, and the current popular game meta (‘meta’ referring to game strategies and general opinions discussed by players, that tends to evolve over time as various Pokémon and tactics fall in and out of favor with game updates and new player discoveries).

However, we decided to focus on individual Pokémon rather than whole teams, especially since there are many different ways to choose a Pokémon team.

**METHODS**

*Data collection*: Our datasets were a compilation of base Pokémon statistics up to Generation 6 (downloaded from Kaggle) and a sample of usage statistics of Pokémon on the battling website Pokémon Showdown from February 2018, restricted to the 'Anything Goes' battle tier and players with a Glicko rating of 1760 or higher (downloaded from Smogon). In 'Anything Goes,' players can use any Pokémon they want and as many of the same Pokémon species as they want.The two datasets were combined using a Python script, which we wrote to a comma-separated values file. Additionally, the dataset was expanded to include Generation 7 Pokémon, which were not included in the Kaggle dataset. Another predictor was created to account for whether a Pokémon could still evolve or not, due to exploratory analysis of possible outliers hinting that final evolved Pokémon tended to be more popular.

*Variable Creation*: After combining the two datasets together, we first created a new variable called *Calc.Usage*, which is the raw usage value of a single Pokémon divided by the total usage value for all Pokémon for all battles held in February 2018. The Smogon dataset includes a *Usage.Per* value, but it is weighted based on the player's skill level. This weighting system caused around 80 Pokémon to have a usage percentage of 0 to six significant digits, so we decided to recalculate the percentage in terms of the total number of Pokémon used rather than the total number of battles.

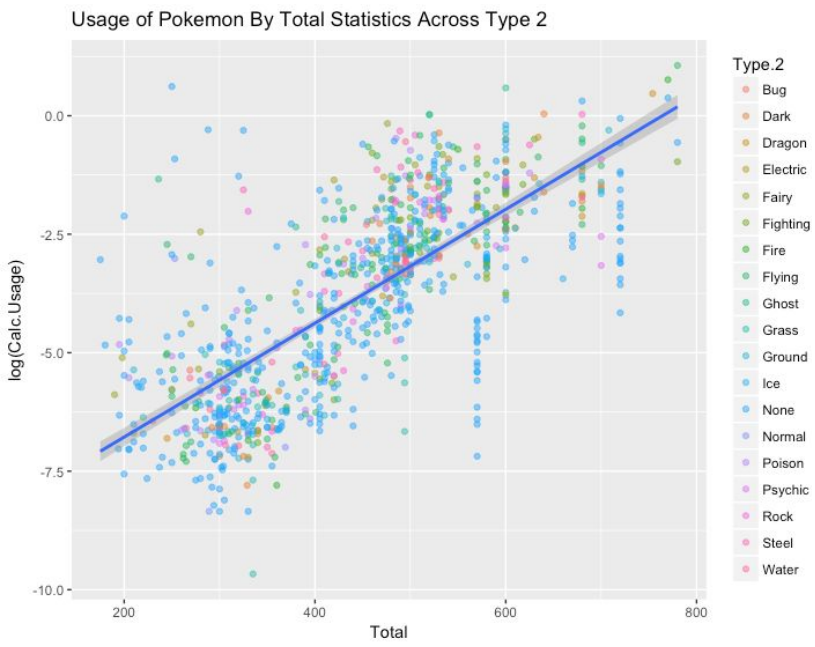
*Model Refinement*: The number of times a single Pokémon was used in all the battles in February 2018 was divided by the sum of all Pokémon used in all battles of that tier (total *Raw* count). Based on the VIF criterion with a threshold of 10, we removed *Total*, which is the summation of *HP*, *Attack*, *Defense*, *Sp.Atk*, *Sp.Def*, and *Speed*. After removing multicollinear variables, we used the AIC criterion to reduce the number of variables from 10 to 6 variables, removing *Type.1*, *Defense*, *Legendary,* and *Can_Evolve*. We also decided to add interaction terms as well to make the model stronger. Using the AIC criterion, we added three new terms: *Attack:Sp.Atk*, *Type.2:Attack*, and *Type.2:Speed*. Despite adding interaction terms, the residual plot of the model had a distinct cone-like pattern. Thus, we did a Box-cox transformation on the model with a lambda of 0, resulting in the following model: log(*Calc.Usage*) ~ *Type.2* + *HP* + *Attack* + *Sp.Def* + *Sp.Atk* + *Speed* + *Attack:Sp.Atk* + *Type.2:Attack* + *Type.2:Speed*). Before we finalized our model, we wanted to check if any of our predictors were insignificant. We ran a partial F-test on the model, and the resulting ANOVA table suggested that we remove the three interaction terms we had previously added. Finally, we also checked for any influential outliers using Cook's distance, but there were none that were significantly influential enough, so no data points were removed.

**RESULTS**

Our final model considers the effects of *Type.2*, *HP*, *Attack*, *Sp.Atk*, *Sp.Def*, and *Speed* statistics on the ratio between the frequency of a single Pokémon being picked and the total number of Pokémon chosen to participate in battle. The final model can be found in the Appendix, due to its large size. The adjusted $R^2$ of the final model is 0.561, a large improvement compared to the original full model's adjusted $R^2$ of 0.2227.

**DISCUSSION**

*Model Interpretation*: In the graph below, we find that the log-transformed response variable varies relatively linearly by the total sum of base statistics, which is captured in the *HP*, *Attack*,




*Sp.Def*, *Sp.Atk*, and *Speed* in our model (see Appendix for additional figures). There also is fairly random distribution of types in Type 2, although many Pokémon do not have a secondary type. After examining the final model's coefficients, it appears that if a Pokémon has Bug or Grass as a secondary type, it is less likely to be picked, which is not surprising since Bug and Grass Pokémon tend to have more weaknesses and weaker abilities. Additionally, it appears that Pokémon with secondary types that are Fairy, Rock, or Steel are two times more likely to be picked. For instance, Fairy Pokémon are known for their relatively high Special Defense stats as well as their immunity to Dragon-type moves, making them popular. On the other hand, Rock Pokémon, although having the most number of type weaknesses and relatively low speed, tend to have high Attack values and are one of three Pokémon types who have resistance against Normal-type moves. Steel Pokémon tend to have high defenses, since they have the second greatest amount of resistances against all types and are completely immune to Poison-type attacks, while also sporting relatively good Attack stats. Unsurprisingly, an increase in the Pokémon's quantitative stats, *HP*, *Attack*, *Sp.Def*, *Sp.Atk*, and *Speed* has a positive effect on its pick rate. This is due to the fact that higher values in all of these stats results in a stronger Pokémon. What was interesting was that predictors for Legendary Pokémon and Pokémon who could not evolve into stronger Pokémon did not appear in our final model, since Legendary Pokémon and Pokémon that did not evolve into another Pokémon seemed to have higher pick rates. However, the quantitative stat variables—*HP*, *Attack*, *Sp.Def*, *Sp.Atk*, and *Speed*—already describe the effects of the Legendary and Can Evolve predictors, since Legendary Pokémon and Pokémon who cannot evolve into stronger forms tend to have higher quantitative stats, which may be why there is no need for them.

*Limitations of Analysis*: The Smogon website releases new usage statistics from Pokémon Showdown every month. Thus, our selection of a particular month to download from was based on the most recently available one, at the start of our project. However, downloading data from additional months and performing a time-series analysis may reveal more insights into the world of competitive Pokémon, particularly with trends in the meta. We also selected the 'Anything Goes' tier to maximize the number of data points we had, given other more popular and restrictive tiers only allow a certain subset of the 807 Pokémon to be selected. This is not the most accurate reflection of how most Pokémon competitions are held though, and it may be possible to incorporate usage percentages across different battle-type tiers.

Additionally, we fit the data once before the addition of the *Can_Evolve* predictor and recalculation of *Calc.Usage*, which yielded a slightly different model with *Type.1* and *Sp.Def* instead of *Type.2* and *Defense*, and three interaction terms. This indicates our model may not be entirely robust, and may be too dependent on the data.

## APPENDIX

Our code for this project can be found here: https://github.com/echen4/stat318

### Final Model

$$\log(Calc.Usage) = \exp(\text{-}9.254859 - 0.076716*Type.2Bug + 0.342487*Type.2Dark + 0.487192*Type.2Dragon + 0.261327*Type.2Electric + 1.169910*Type.2Fairy + 0.342497*Type.2Fighting + 0.343992*Type.2Fire + 0.455790*Type.2Flying + 1.470654*Type.2Ghost - 0.510445*Type.2Grass + 0.554030*Type.2Ground + 0.087589*Type.2Ice + 0.033639*Type.2None + 0.572496*Type.2Poison + 0.251262*Type.2Psychic + 1.067608*Type.2Rock + 1.303036*Type.2Steel + 0.499578*\text{Type.2Water} + 0.011962*HP + 0.015208*Attack + 0.020778*Sp.Def + 0.005269*Sp.Atk + 0.016191*Speed)$$

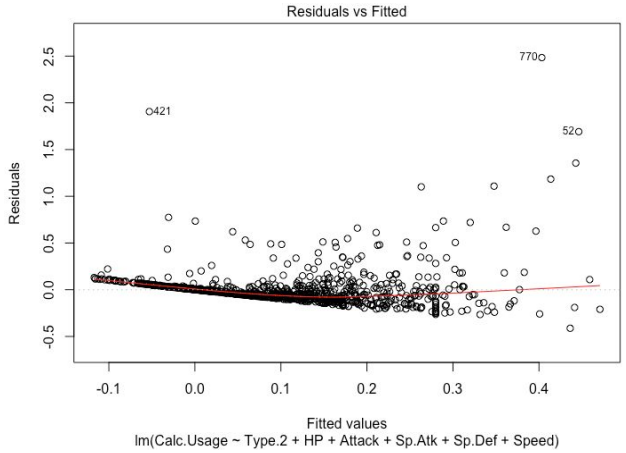
### Classification/Handling of Special Case Pokémon

SS = (Same Stats), purely cosmetic
DT = same stats (Different Type)
CF = different stats (maybe type), stays in a single form for battle (Constant Form)
SF = different stats (maybe type), switches between forms in a single battle (Switches Forms)

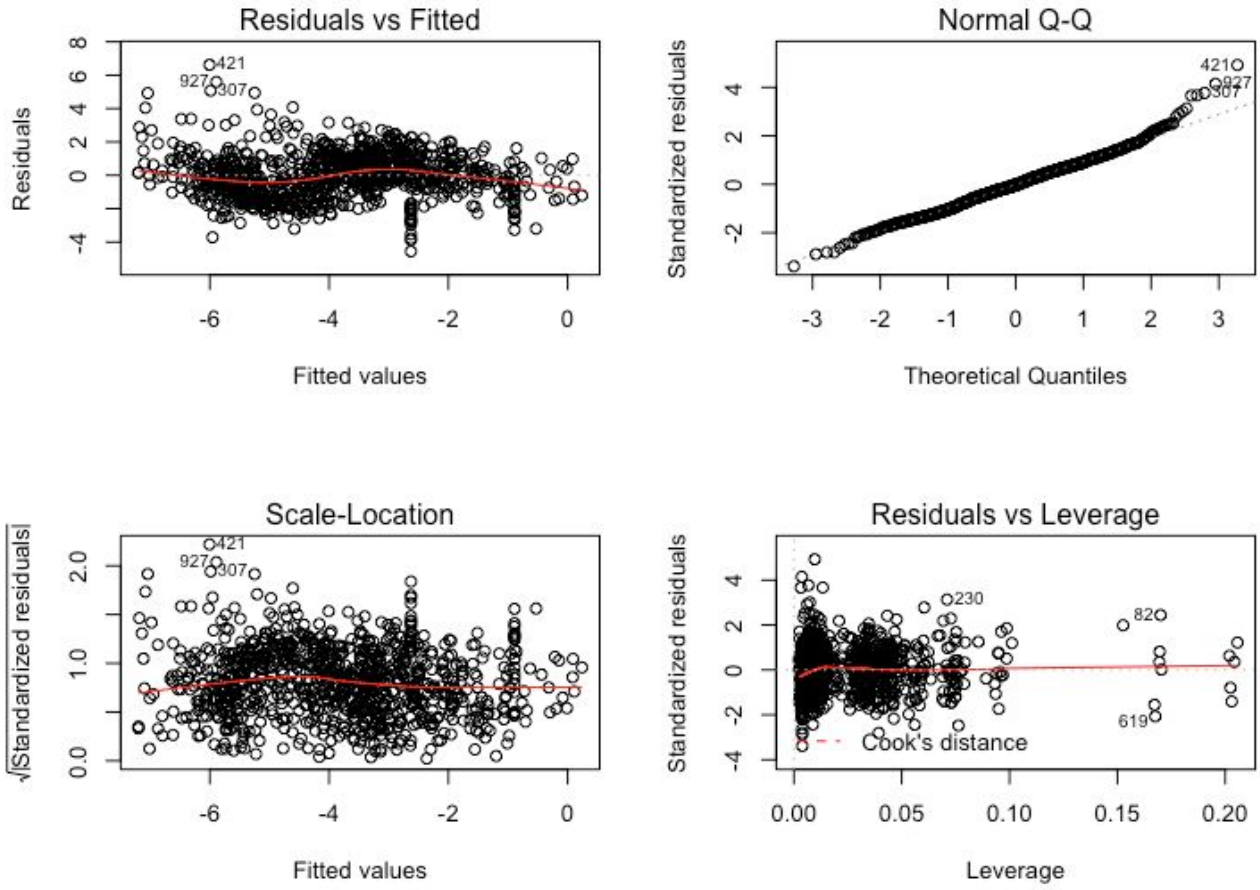
(CF) all Mega (X/Y), Primal: list separately
(SS) Pikachu: COSMETIC, combine listings
(SF) Castform: OMITTED, not usual gameplay to go through all forms
(CF) Deoxys: list separately
(SS) Burmy: COSMETIC
(DT) Wormadam: list separately
(DT) Rotom: list separately
(CF) Giratina: list separately
(CF) Shaymin: list separately
(DT) Arceus: list separately
(SF) Darmanitan: list separately
(CF) Tornadus: list separately
(CF) Thundurus: list separately
(CF) Landorus: list separately
(CF) Kyurem: list separately
(SF) Meloetta: list separately
(SF) Aegislash: list separately
(CF) Pumpkaboo sizes: list separately
(CF) Gourgeist sizes: list separately
(CF/SF) Zygarde: list 50% and 10% separately, create a Complete Zygarde listing with 10% and 50% usages added
(CF) Hoopa: list separately
(DT) Oricorio list separately
(CF) Lycanroc: list separately
(SF) Wishiwashi: list separately
(DT) Silvally: list separately
(SF) Minior: list separately
(CF/SF) Necrozma: list base form (and Dusk and Dawn Wing forms) separately, create a Ultra Necrozma listing with only Dusk and Dawn Wing Necrozma usages added

**Regression Assumptions**

Residuals for our model suggested by the AIC Criterion, lm.aic:



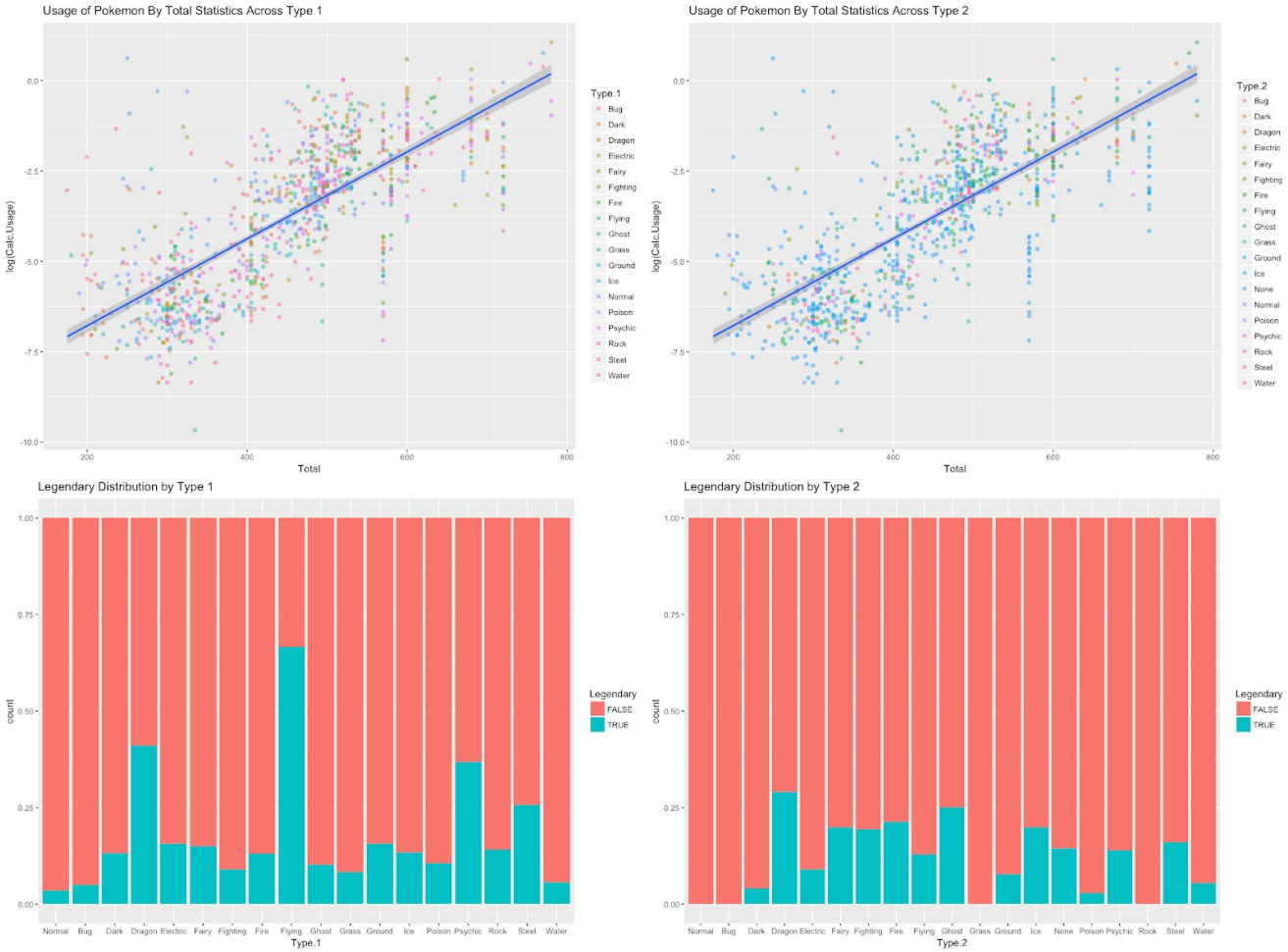

Residuals and other diagnostics for our final model, lm.transY:




In performing a multivariable linear regression analysis, we assume independence, identical distribution, mean of zero, and normal distribution for errors. Although we did not perform a time-sequence analysis of our data, given that we drew from a single month, there should not

be correlation between different Pokémon with different statistics. Given the lack of a significant pattern in the residual plot and smooth line along the x-axis, we can also say the errors should have largely identical distribution and a mean of zero. The QQ-plot indicates that our data is slightly non-normal, but the deviation is not large, and the assumption of normality is not strict. You can also see a distinct improvement between the residual plots of the untransformed (lm.aic) and final (lm.transY, log-transformed response variable) models.

### Additional Plots of Interest




Numbering the graphs clockwise from the top left, we first consider figure (1), in which the log of Calc.Usage is plotted against the Total stats across all primary types. Figure (2) was included in the body of the paper. From these two plots, we can see the relatively even distribution of types across stat totals, and the relatively linear fit between total statistics and popularity. Figure (3) graphs the number of Legendary Pokémon across all secondary types, while figure (4) graphs the number of Legendary Pokémon across all primary types. As one can see in figure (4), there are no Legendary Pokémon with Bug or Grass as a secondary type, indicated by the completely orange bars, which may contribute to why they have scaling factors on the popularity of less than one. Additionally, the Flying type seems to have a particularly high percentage of Legendary Pokémon—further investigation though, reveals that there are only 5 primary Flying type Pokémon, of which 3 are Legendary. Thus, the impact of the Flying type Legendary distribution is overall not large.

**REFERENCES**


*Data:*

Antar. “Data - Official Smogon University Usage Statistics Discussion Thread, Mk.2.” *Smogon University - Competitive Pokémon Community*, 22 Dec. 2016, www.smogon.com/forums/threads/official-smogon-university-usage-statistics-discussion-thread-mk-2.3508502/.

Barradas, Alberto. “Pokemon with Stats | Kaggle.” *Kaggle*, 29 Aug. 2016, www.kaggle.com/abcsds/pokemon.

“Index of /Stats/.” *Smogon University - Competitive Pokémon Community*, www.smogon.com/stats/.

*Pokémon Mechanics:*

“Main Page.” *Bulbapedia, the Community-Driven Pokémon Encyclopedia*, bulbapedia.bulbagarden.net/wiki/Main_Page.

*Other:*

“Pokémon World Championships 2017 Detailed Stats.” *Esports Charts*, esc.watch/tournaments/pokemon/pokemon-world-championships-2017.

Smith, Craig. “80 Amazing Pokemon Go Statistics.” *DMR*, 6 May 2018, expandedramblings.com/index.php/pokemon-go-statistics/.