The American University in Cairo

Airline Passenger Satisfaction Analysis
Dataset #5

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I. Introduction

In the modern, highly competitive aviation industry, the realization and enhancement of passenger satisfaction is the key to business success and customer loyalty. With airlines striving for product differentiation, identifying the aspects that significantly impact passenger satisfaction has become a major issue. The goal of this project is to identify these important drivers through the use of statistical inference techniques, offering valuable insights to both practitioners and researchers.

Dataset Description

This study is based on a sample of 51 observations drawn from a broader airline passenger satisfaction dataset. The dataset includes both demographic and flight-related features, offering a comprehensive view of the passenger experience. It contains variables such as gender, customer type, age, type of travel, and flight class, alongside a variety of service quality ratings that reflect different aspects of in-flight and ground services. The primary variable of interest is satisfaction, which categorizes passengers as *Satisfied* or *Neutral or Dissatisfied*, based on their overall flight experience.

The dataset captures the following information:

- **Gender**: The gender of the passenger (Female, Male).
- **Customer Type**: Indicates whether the passenger is a loyal or disloyal customer.
- **Age**: The actual age of the passenger.
- **Type of Travel**: The purpose of the trip (Personal Travel or Business Travel).
- **Class**: The class of service booked for the flight (Business, Economy, Economy Plus).
- **Flight Distance**: The flight length in miles.
- **Service Quality Ratings** (all rated on a 1–5 scale unless otherwise noted):
  - Inflight WiFi Service (0: Not Applicable; 1–5 otherwise)
  - Departure/Arrival Time Convenience
  - Ease of Online Booking
  - Gate Location
  - Food and Drink
  - Online Boarding
  - Seat Comfort
  - In-flight Entertainment
  - On-board Service
  - Leg Room Service
  - Baggage Handling

- Check-in Service
- In-flight Service
- Cleanliness

- **Departure Delay (in minutes)**: Number of minutes the flight was delayed at departure.
- **Arrival Delay (in minutes)**: Number of minutes the flight was delayed upon arrival.
- **Satisfaction**: The overall airline satisfaction level, recorded as either Satisfied or Neutral or Dissatisfied.

Research Objectives

- To identify the most influential factors affecting passenger satisfaction.
- To determine whether results from the sample can be generalized to the wider population of airline passengers.

Methodology

The analysis follows a structured statistical framework, beginning with a descriptive overview of the dataset, followed by inferential techniques including confidence intervals and hypothesis testing. The specific steps include:

- **Descriptive Statistics**: Summarizing and visualizing dataset characteristics through numerical summaries, tables, and graphs.
- **Sampling Distributions**: Investigating the distribution of sample statistics to make valid inferences about population parameters.
- **Confidence Intervals**: Constructing 95% confidence intervals to estimate key parameters and quantify the reliability of sample findings.
- **Estimator Properties**: Evaluating the estimators used based on criteria such as unbiasedness and consistency.
- **Hypothesis Testing**: Developing and testing claims regarding differences or relationships between variables using a 0.05 significance level.

This methodical approach ensures that findings are statistically sound and practically relevant, forming a solid basis for actionable recommendations aimed at improving the airline passenger experience.

II. Descriptive Statistics

This section provides a statistical summary of the main variables in the dataset, including central tendencies, variability, and frequency distributions. Tables and percentages highlight trends and differences among subgroups, with interpretations following each set of statistics.

Age

- **Average Age:** 34 years
- **Standard Deviation:** 14 years

The dataset represents a relatively young flying demographic with moderate age variability.

Flight Distance

- **Average Flight Distance:** 1072.27 miles
- **Standard Deviation:** 772.28 miles

The wide standard deviation suggests a mix of short-haul and long-haul travelers.

Type of Travel

Type of Travel	Count	Percentage
Business	34	66.67%
Personal	17	33.33%

Type of Travel	Neutral/Dissatisfied	Satisfied
Business	17	17
Personal	15	2

Business travelers show significantly higher satisfaction than personal travelers (refer to figure 1).

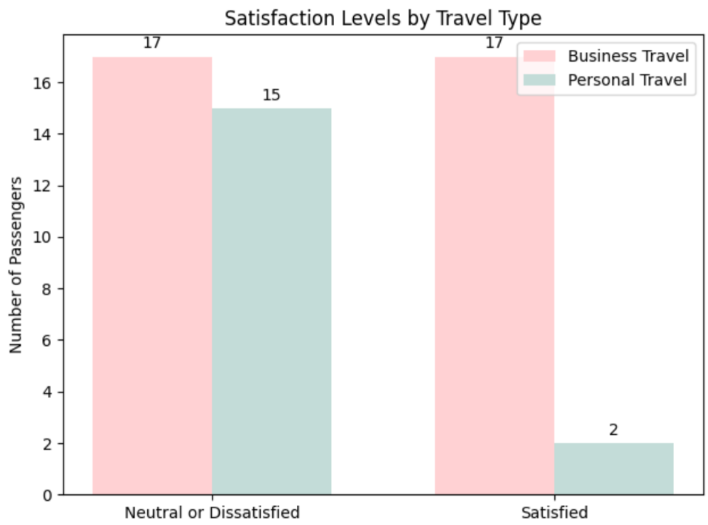

Figure 1: Satisfaction Levels by Travel Type

Gender Distribution

Gender	Count	Percentage
Female	29	56.86%
Male	22	43.14%

Gender	Neutral/Dissatisfied	Satisfied
Female	17	12
Male	15	7

Females slightly outnumber males and show marginally higher satisfaction (refer to figure 2).

Figure 2: Passenger Satisfaction by Gender

Travel Class

Class	Count	Percentage
Business	25	49.02%
Economy	22	43.14%
Eco Plus	4	7.84%

Class	Neutral/Dissatisfied	Satisfied
Business	10	15
Economy	19	3
Eco Plus	3	1

Business class passengers report the highest satisfaction levels (refer to figure 3).

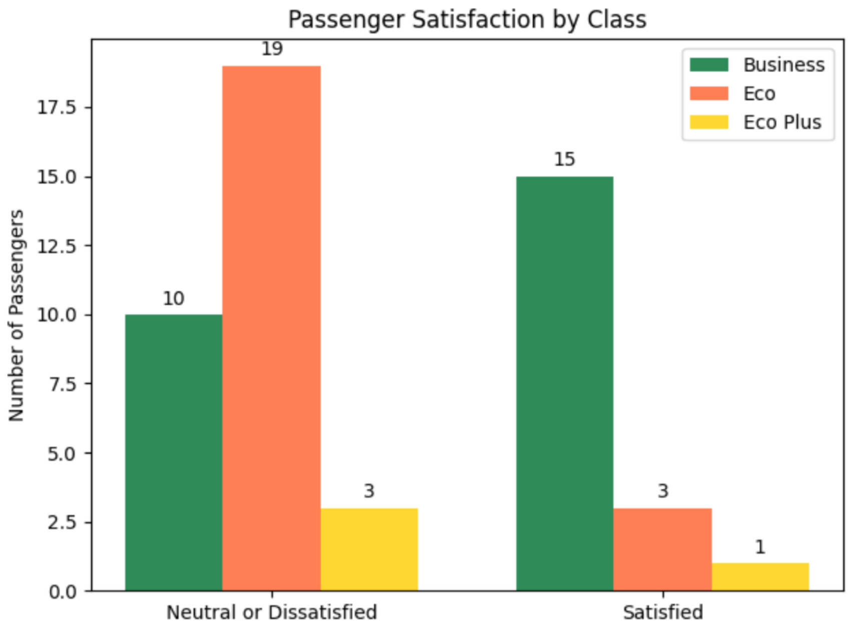

Figure 3: Passenger Satisfaction by Class

Flight Delays

- **Departure Delay:** Average = 11.49 minutes, SD = 20.11, Delayed Flights = 52.94%
- **Arrival Delay:** Average = 10.78 minutes, SD = 20.16, Delayed Flights = 47.06%

Delays are relatively common and may contribute to overall dissatisfaction.

Customer Type

Customer Type	Count	Percentage
Loyal	41	80.39%
Disloyal	10	19.61%

Customer Type	Neutral/Dissatisfied	Satisfied
Loyal	23	18
Disloyal	9	1

Loyal customers report much higher satisfaction levels than disloyal ones.

Overall Satisfaction

- **Neutral or Dissatisfied:** 32 passengers (62.75%)
- **Satisfied:** 19 passengers (37.25%)

The overall satisfaction rate is low, indicating room for service improvement.

Service Rating Summary

Service Feature	Low Rating (1–3)	High Rating (4–5)
Inflight WiFi Service	70.59%	29.41%
Ease of Online Booking	64.71%	35.29%
Gate Location	66.70%	33.33%
Online Boarding	56.86%	43.14%
Seat Comfort	52.94%	47.06%
Inflight Entertainment	49.02%	50.98%
On-board Service	50.98%	49.02%
Leg Room Service	45.10%	54.90%
Baggage Handling	37.26%	62.74%
Check-in Service	50.99%	49.01%
Inflight Service	68.62%	31.38%
Cleanliness	54.90%	45.10%

Inflight WiFi and booking systems are key pain points; baggage handling and legroom receive the highest ratings.

III. Statistical Inference

Parameter Selection and Estimators

We selected three population parameters of interest: the population mean (μ), the population proportion (P), and the population variance (σ^2). Corresponding estimators used are the sample mean ($\bar{x}$), sample proportion ($\hat{p}$), and sample variance (s^2).

1) Proof that $\bar{X}$ is a good estimator for the true mean μ:
$\bar{X}$ is a good estimator for the population mean μ because it is:

- **Unbiased:** The expected value of $\bar{X}$ equals the true mean μ, i.e., $E(\bar{X}) = \mu$.

- **Consistent:** As the sample size n increases, $\bar{X}$ converges in probability to μ.

If $X's$ are random variables that are **independent and identically distributed (i.i.d.)**, with expected value $E(X) = \mu$. Then:

$$\begin{aligned} E(\bar{X}) &= E\left(\frac{1}{n}\sum_{i=1}^{n} X_i\right) \\ &= \frac{1}{n}\left(E(X_1) + E(X_2) + \ldots + E(X_n)\right) \\ &= \frac{1}{n}\left(\mu + \mu + \ldots + \mu\right) \\ &= \frac{1}{n} \cdot n \cdot \mu \\ &= \mu \end{aligned}$$

Thus, $\bar{X}$ is an unbiased estimator of μ.

2) Proof that $\hat{p}$ is a good estimator for the true proportion p:
$\hat{p}$ is a good estimator for the population proportion p because it is:

- **Unbiased:** The expected value of $\hat{p}$ equals the true proportion p, i.e., $E(\hat{p}) = p$.
- **Consistent:** As the sample size n increases, $\hat{p}$ converges to p.

If X's are R.Vs from Bernoulli with $\mu = p$ and $\sigma^2 = pq$, for a large size n,

$$\bar{x} \overset{\text{app}}{\sim} N\left(p, \frac{pq}{n}\right), \quad \text{then} \quad \hat{p} \overset{\text{app}}{\sim} N\left(p, \frac{pq}{n}\right)$$

Since $\hat{p}$ is a variable, so it has a distribution.
The distribution of the proportion before it converges to normal is:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{\sum x}{n} = \frac{x}{n} = \hat{p}$$

3) Proof that s^2 is a good estimator for the population variance σ^2:
s^2 is a good estimator for the population variance σ^2 because it is:

- **Unbiased:** The expected value of s^2 equals the true variance σ^2, i.e., $E(s^2) = \sigma^2$.

The sample variance is:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

To prove that this is an unbiased estimator of σ^2, we use the fact that:

$$\frac{(n-1)s^2}{\sigma^2} \sim \chi^2(n-1)$$

Taking the expectation of both sides:

$$E\left(\frac{(n-1)s^2}{\sigma^2}\right) = n-1 \quad \Rightarrow \quad \frac{n-1}{\sigma^2} \cdot E(s^2) = n-1 \quad \Rightarrow \quad E(s^2) = \sigma^2$$

Therefore, s^2 is an unbiased estimator for σ^2.

Estimator Applications in Data Analysis

In our data analysis, we applied the following:

- $\bar{x}$ (Sample Mean): Calculated for the mean age of respondents/passengers.
- $\hat{p}$ (Sample Proportion):
  - For satisfaction proportion (e.g., proportion of satisfied passengers).
  - For business class proportion (e.g., proportion of passengers flying in business class).
- s (Sample Standard Deviation): Calculated for the flight distance, helping to understand variability in travel lengths.

These estimators were chosen due to their desirable statistical properties (unbiasedness, consistency) and because they effectively summarize key characteristics of the population.

Furthermore, we calculated $\bar{X}$ for mean age, and $\hat{p}$ for satisfaction proportion and business class proportion, and the standard deviation of flight distance.

1. **Satisfaction Proportion:**

$$\hat{p} = 0.37, \quad Z_{0.025} = 1.96$$

$$\hat{p} \pm 1.96\sqrt{\frac{\hat{p}\hat{q}}{n}} = 0.37 \pm 0.135 \Rightarrow [0.235, 0.503]$$

   Therefore, we are 95% confident that the true proportion of satisfied passengers lies within 0.235 and 0.503. This shows that the majority aren't satisfied or are neutral, as fewer than half of the passengers in this sample report being satisfied. Even the upper bound barely crosses the halfway mark, and the midpoint estimate sits below it. While some passengers are indeed satisfied, it's clear that satisfaction is not the norm. This should raise concerns for the airline and prompt a closer look at which service areas are contributing most to this factor.

2. **Mean Age:**

   Since n is large ($n = 51$) and σ is unknown, we can use s as an estimate for σ and use the following confidence interval formula:

$$\bar{x} \pm Z_{0.025} \cdot \frac{s}{\sqrt{n}}$$

   Given:

$$\bar{x} = 34 \text{ years}, \quad Z_{0.025} = 1.96, \quad s = 14, \quad n = 51$$

$$34 \pm 1.96 \cdot \frac{14}{\sqrt{51}} = [30.16, 37.84]$$

Therefore, we are 95% confident that the true average age lies within 30 and 38 years. This points to a relatively young adult demographic making up the core of the airline's clientele. With both bounds clustering in the mid-30s range, strategies targeting this age group, whether in marketing, in-flight services, or social media engagement, are likely to support the growth of customer satisfaction. Older or much younger travelers appear less central to the current customer base.

3. **Standard Deviation of Flight Distance:**

   We are calculating a 95% confidence interval for the population variance σ^2, using the sample standard deviation $s = 772.28$ and degrees of freedom $df = 50$. The formula for the confidence interval of the variance is:

$$\left[\frac{(n-1)s^2}{\chi^2_{0.025}}, \frac{(n-1)s^2}{\chi^2_{0.975}}\right]$$

   Given:

$$s = 772.28, \quad n = 51, \quad df = 50, \quad \chi^2_{0.975} = 71.42, \quad \chi^2_{0.025} = 32.3574$$

$$\left[\frac{50 \cdot (772.28)^2}{71.42}, \frac{50 \cdot (772.28)^2}{32.3574}\right] = [417{,}541, 921{,}607]$$

   This is σ^2, so for σ the CI will be [646, 960]. Therefore, we are 95% confident that the true population standard deviation of flight distance lies between 646, 960. This confirms that the airline operates both short and long routes. The service expectations, satisfaction drivers, and operational logistics could differ substantially between them. Therefore, any analysis of passenger experience or performance metrics needs to consider the variability of flight length.

4. **Business Class Proportion:**

   We are estimating the true proportion of business class travelers with a 95% confidence interval.

$$\hat{p} = \frac{25}{51} = 0.49, \quad \hat{q} = 0.51, \quad Z_{0.025} = 1.96$$

$$\hat{p} \pm Z_{0.025} \cdot \sqrt{\frac{\hat{p}\hat{q}}{n}} = 0.49 \pm 1.96 \cdot \sqrt{\frac{0.49 \cdot 0.51}{51}} = 0.49 \pm 1.96 \cdot 0.07 = [0.35, 0.63]$$

   Therefore, we are 95% confident that the true proportion of business class travelers lies within 35% and 63%. It implies that business class travelers likely make up a substantial portion of the sample, potentially close to or even exceeding half of the flying population observed. While we can't pin down the exact percentage, the data suggests that business class is not a niche segment in this sample. It may play a significant role in shaping overall satisfaction trends. Given that nearly half the sample falls into this category, it's reasonable to assume that business class experience can heavily influence overall ratings and should be a focus area for service enhancements.

The Difference Between Means

All of the following confidence intervals will be based on a 95% confidence level.

1. Average flight distance of satisfied vs. dissatisfied passengers

Let:

$$\begin{aligned}
\bar{X}_1 &= \text{Average flight distance for satisfied passengers} \\
\bar{X}_2 &= \text{Average flight distance for dissatisfied passengers} \\
\bar{X}_1 &= 1241.79 \text{ miles}, \quad \bar{X}_2 = 971.63 \text{ miles} \\
s_1 &= 902.65, \quad s_2 = 678.81 \\
n_1 &= 19, \quad n_2 = 32 \\
1 - \alpha &= 0.95 \Rightarrow \alpha/2 = 0.025
\end{aligned}$$

Pooled variance:

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2} = \frac{18 \times (902.65)^2 + 31 \times (678.81)^2}{49} = 590821.6307$$

Confidence interval for $\mu_1 - \mu_2$:

$$(\bar{X}_1 - \bar{X}_2) \pm t_{49,\,0.025} \cdot \sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}$$

$$= (1241.79 - 971.63) \pm 2.00958 \cdot \sqrt{\frac{590821.6307}{19} + \frac{590821.6307}{32}}$$

$$\text{CI for } \mu_1 - \mu_2 : \quad (-177.21,\ 717.53)$$

Interpretation: Since one boundry is negative and the other is positive, so we can't interpret anything about the difference between the true average flight distances of the satisfied vs dissatisfied population. Although satisfied passengers had a higher average distance, the variation in flight lengths is too large to rule out chance as the reason for this difference. This suggests that flight length alone may not be a strong predictor of satisfaction (at least not without further evidence). Hence, hypothesis testing is conducted to further analyze whether this factor affects overall passengers' ratings.

2. Average departure delay time of satisfied vs. dissatisfied passengers

Let:

$$\begin{aligned}
\bar{X}_1 &= \text{Average departure delay time for satisfied passengers}\\
\bar{X}_2 &= \text{Average departure delay time for dissatisfied passengers}\\
\bar{X}_1 &= 13.63 \text{ minutes}, \quad \bar{X}_2 = 10.22 \text{ minutes}\\
s_1 &= 28.23, \quad s_2 = 13.62\\
n_1 &= 19, \quad n_2 = 32\\
\alpha/2 &= 0.025
\end{aligned}$$

Pooled variance:

$$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} = \frac{18 \times (28.23)^2 + 31 \times (13.62)^2}{49} = 410.11$$

Confidence interval for $\mu_1 - \mu_2$:

$$(\bar{X}_1 - \bar{X}_2) \pm t_{49,\,0.025} \cdot \sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}$$

$$= (13.63 - 10.22) \pm 2.00958 \cdot \sqrt{\frac{410.11}{19} + \frac{410.11}{32}}$$

$$\text{CI for } \mu_1 - \mu_2: \quad (-8.376,\ 15.196)$$

Interpretation: Since one boundry is negative and the other is positive, so we can't interpret anything about the difference between the true average departure delay time of the satisfied vs dissatisfied population. Any observed difference in delay times might just be due to random variation. This suggests that departure delay by itself might not significantly impact passenger satisfaction.

3. Average arrival delay time of satisfied vs. dissatisfied passengers

Let:

$$\begin{aligned}
\bar{X}_1 &= \text{Average arrival delay time for satisfied passengers}\\
\bar{X}_2 &= \text{Average arrival delay time for dissatisfied passengers}\\
\bar{X}_1 &= 14.947 \text{ minutes}, \quad \bar{X}_2 = 8.312 \text{ minutes}\\
s_1 &= 29.877, \quad s_2 = 10.965\\
n_1 &= 19, \quad n_2 = 32\\
\alpha/2 &= 0.025
\end{aligned}$$

Pooled variance:

$$s_p^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} = \frac{18 \times (29.877)^2 + 31 \times (10.965)^2}{49} = 403.97$$

Confidence interval for $\mu_1 - \mu_2$:

$$(\bar{X}_1 - \bar{X}_2) \pm t_{49,\,0.025} \cdot \sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}$$

$$= (14.947 - 8.312) \pm 2.00958 \cdot \sqrt{\frac{403.97}{19} + \frac{403.97}{32}}$$

$$\text{CI for } \mu_1 - \mu_2 : \quad (-5.063,\ 18.333)$$

Interpretation: Since one boundry is negative and the other is positive, so we can't interpret anything about the difference between the true average arrival delay time of the satisfied vs dissatisfied population. This suggests that arrival delay time does not seem to be a key factor influencing passenger satisfaction, as the observed difference might just be due to random variation.

The Difference Between Proportions

1. Satisfied loyal vs disloyal passengers proportions

Let:

$$\hat{p}_1 : \text{Proportion of satisfied loyal passengers}$$

$$\hat{p}_2 : \text{Proportion of satisfied disloyal passengers}$$

$$\hat{p}_1 = 0.439, \quad \hat{p}_2 = 0.1, \quad n_1 = 41, \quad n_2 = 10, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.439 - 0.1) \pm 1.96\sqrt{\frac{0.439 \times 0.561}{41} + \frac{0.1 \times 0.9}{10}}$$

$$\text{CI for } p_1 - p_2 : \boxed{(0.099,\ 0.579)}$$

Interpretation: Since both boundaries are positive, we can conclude that the true proportion p of satisfied loyal passengers is greater than satisfied disloyal passengers. This is a strong evidence that loyalty program members are more satisfied. Which means that the customer type actually affects the passengers overall satisfaction. This also suggests that the loyalty program itself, or the preferential treatment that comes with it, is an important driver of positive passenger experience.

2. Seat comfort ratings proportions among satisfied passengers

Let:

$$\hat{p}_1 : \text{Proportion of satisfied passengers that gave 1–3 seat comfort rating}$$

$$\hat{p}_2 : \text{Proportion of satisfied passengers that gave 4–5 seat comfort rating}$$

$$\hat{p}_1 = 0.19, \quad \hat{p}_2 = 0.58, \quad n_1 = 27, \quad n_2 = 24, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.19 - 0.58) \pm 1.96\sqrt{\frac{0.19 \times 0.81}{27} + \frac{0.58 \times 0.42}{24}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.637,\ -0.143)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of satisfied passengers that gave 4-5 seat comfort rating is greater than satisfied passengers that gave 1-3 seat comfort rating. This suggests that the quality of seat comfort plays an important role in passengers' overall satisfaction, with better seat comfort being associated with higher satisfaction levels. That is, the seat comfortability has an effect on the passengers overall satisfaction.

3. Inflight entertainment ratings proportions among satisfied passengers

Let:

$\hat{p}_1$: Proportion of satisfied passengers that gave 1–3 inflight entertainment rating

$\hat{p}_2$: Proportion of satisfied passengers that gave 4–5 inflight entertainment rating

$$\hat{p}_1 = 0.16, \quad \hat{p}_2 = 0.58, \quad n_1 = 25, \quad n_2 = 26, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.16 - 0.58) \pm 1.96\sqrt{\frac{0.16 \times 0.84}{25} + \frac{0.58 \times 0.42}{26}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.658,\ -0.182)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of satisfied passengers that gave 4-5 inflight entertainment rating is greater than satisfied passengers that gave 1-3 inflight entertainment rating. This indicates that the quality of inflight entertainment has a significant impact on passengers' overall satisfaction, with better entertainment correlating with higher satisfaction levels.

4. Onboard service ratings proportions among satisfied passengers

Let:

$\hat{p}_1$: Proportion of satisfied passengers that gave 1–3 onboard service rating

$\hat{p}_2$: Proportion of satisfied passengers that gave 4–5 onboard service rating

$$\hat{p}_1 = 0.12, \quad \hat{p}_2 = 0.64, \quad n_1 = 26, \quad n_2 = 25, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.12 - 0.64) \pm 1.96\sqrt{\frac{0.12 \times 0.88}{26} + \frac{0.64 \times 0.36}{25}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.746,\ -0.294)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of satisfied passengers that gave 4-5 onboard service rating is greater than satisfied passengers that gave 1-3 onboard service rating. This suggests that the quality of onboard service significantly influences passengers' overall satisfaction, with higher service ratings strongly correlating with better satisfaction levels.

5. Leg room service ratings proportions among satisfied passengers

Let:

$$\hat{p}_1 : \text{Proportion of satisfied passengers that gave 1–3 leg room service rating}$$

$$\hat{p}_2 : \text{Proportion of satisfied passengers that gave 4–5 leg room service rating}$$

$$\hat{p}_1 = 0.17, \quad \hat{p}_2 = 0.54, \quad n_1 = 23, \quad n_2 = 28, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.17 - 0.54) \pm 1.96\sqrt{\frac{0.17 \times 0.83}{23} + \frac{0.54 \times 0.46}{28}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.510,\ -0.0081)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of satisfied passengers that gave 4-5 leg room service rating is greater than satisfied passengers that gave 1-3 leg room service rating. This result suggests that leg room service plays a critical role in shaping passengers' overall satisfaction. The closer the rating to 4-5, the more satisfied the passengers are, and this is strongly reflected in their overall satisfaction with the flight. So improving leg room service could be a key factor in enhancing the passenger experience, especially for those who currently rate it poorly.

6. Check-in service ratings proportions among satisfied passengers

Let:

$$\hat{p}_1 : \textit{Proportion of satisfied passengers that gave 1–3 check-in service rating}$$

$$\hat{p}_2 : \textit{Proportion of satisfied passengers that gave 4–5 check-in service rating}$$

$$\hat{p}_1 = 0.31, \quad \hat{p}_2 = 0.44, \quad n_1 = 26, \quad n_2 = 25, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$*:*

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.31 - 0.44) \pm 1.96\sqrt{\frac{0.31 \times 0.69}{26} + \frac{0.44 \times 0.56}{25}}$$

C.I for $p_1 - p_2$*:* $\boxed{(-0.394,\ 0.1336)}$

Interpretation: Since one boundry is negative and the other is positive, so we can't interpret anything about the difference between the true proportion of passengers who have 1-3 and 4-5 checkin service ratings. This indicates that check-in service may not be a strong driver of overall passenger satisfaction, as there is a possibility that the true difference in satisfaction between these two groups is small. In other words, while there might be some variation in individual ratings, the overall impact of check-in service on satisfaction doesn't appear to be significant based on this data. Therefore, improving check-in service may not have a major impact on overall passenger satisfaction compared to other service areas.

7. Inflight service ratings proportions among satisfied passengers

Let:

$\hat{p}_1$: *Proportion of satisfied passengers that gave 1–3 inflight service rating*

$\hat{p}_2$: *Proportion of satisfied passengers that gave 4–5 inflight service rating*

$$\hat{p}_1 = 0.25, \quad \hat{p}_2 = 0.43, \quad n_1 = 16, \quad n_2 = 35, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$*:*

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.25 - 0.43) \pm 1.96\sqrt{\frac{0.25 \times 0.75}{16} + \frac{0.43 \times 0.57}{35}}$$

C.I for $p_1 - p_2$*:* $\boxed{(-0.448,\ 0.088)}$

Interpretation: Since one boundry is negative and the other is positive, so we can't interpret anything about the difference between the true proportion of passengers who have 1-3 and 4-5 inflight service ratings. This suggests that inflight service may not be a major contributor to the overall satisfaction levels of passengers. The variation in ratings could be relatively minor, meaning that improvements to inflight service may not drastically affect the passengers' overall satisfaction. As a result, it might be worth considering focusing on other aspects of the passenger experience for improvement, as inflight service alone may not be a strong determining factor in satisfaction.

8. Cleanliness ratings proportions among satisfied passengers

Let:

$\hat{p}_1$: *Proportion of satisfied passengers that gave 1–3 cleanliness rating*

$\hat{p}_2$: *Proportion of satisfied passengers that gave 4–5 cleanliness rating*

$$\hat{p}_1 = 0.25, \quad \hat{p}_2 = 0.52, \quad n_1 = 28, \quad n_2 = 23, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.25 - 0.52) \pm 1.96\sqrt{\frac{0.25 \times 0.75}{28} + \frac{0.52 \times 0.48}{23}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.5296,\ -0.0104)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of satisfied passengers that gave 4-5 cleanliness rating is greater than satisfied passengers that gave 1-3 cleanliness rating. This suggests that cleanliness plays a significant role in determining passengers' overall satisfaction. The results indicate that passengers who rated cleanliness highly (4-5) are more satisfied compared to those who gave lower ratings (1-3). This insight emphasizes the importance of maintaining a high level of cleanliness on board, as it strongly contributes to the overall positive passenger experience.

9. Satisfied Business Class vs Economy Class Passengers Proportions

Let:

$$\hat{p}_1 : \textit{Proportion of satisfied Business Class passengers}$$

$$\hat{p}_2 : \textit{Proportion of satisfied Economy Class passengers}$$

$$\hat{p}_1 = 0.6, \quad \hat{p}_2 = 0.136, \quad n_1 = 25, \quad n_2 = 22, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.6 - 0.136) \pm 1.96\sqrt{\frac{0.6 \times 0.4}{25} + \frac{0.136 \times 0.864}{22}}$$

C.I for $p_1 - p_2$: $\boxed{(0.224,\ 0.703)}$

Interpretation: Since both boundaries are positive, we can conclude that the true proportion of satisfied Business Class passengers is more than the satisfied Economy Class passengers. This finding highlights that passengers in Business Class are far more satisfied than those in Economy Class. The difference in satisfaction likely stems from the superior amenities, more spacious seating, better service, and overall enhanced experience offered in Business Class. This underscores the importance of offering upgraded services and amenities for premium passengers to ensure higher levels of satisfaction.

10. Dissatisfied Inflight Service (rated 1-3) vs Satisfied Inflight Service (rated 4-5) in terms of overall Satisfaction

Let:

$\hat{p}_1$: *Proportion of passengers satisfied overall given that they rated 1–3 for inflight service*

$\hat{p}_2$: *Proportion of passengers satisfied overall given that they rated 4–5 for inflight service*

$$\hat{p}_1 = 0.25, \quad \hat{p}_2 = 0.67, \quad n_1 = 36, \quad n_2 = 15, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.25 - 0.67) \pm 1.96\sqrt{\frac{0.25 \times 0.75}{36} + \frac{0.67 \times 0.33}{15}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.69, \ -0.14)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of passengers satisfied overall given that they rated 4-5 for inflight service is greater than the true proportion of passengers satisfied overall given that they rated 1-3 for inflight service. So, even within the group that ultimately said they were satisfied, those who gave in-flight service a low mark were significantly less likely to report overall satisfaction than those who rated service highly. The negative interval confirms this. Good in-flight service roughly triples the odds of overall satisfaction. This highlights that in-flight service quality remains a critical component, even among passengers predisposed to be happy with their trip.

11. Departure/ Arrival convenience ratings proportions among satisfied passengers

Let:

$\hat{p}_1$: *Proportion of satisfied passengers that gave 1–3 departure/ arrival convenience rating*

$\hat{p}_2$: *Proportion of satisfied passengers that gave 4–5 departure/ arrival convenience rating*

$$\hat{p}_1 = 0.428, \quad \hat{p}_2 = 0.304, \quad n_1 = 28, \quad n_2 = 23, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$:

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.428 - 0.304) \pm 1.96\sqrt{\frac{0.428 \times 0.572}{28} + \frac{0.304 \times 0.696}{23}}$$

C.I for $p_1 - p_2$: $\boxed{(-0.1385, \ 0.386)}$

Interpretation: Since one boundary is negative and the other is positive, we can't interpret anything about the difference between the true proportion of passengers who gave 1-3 and 4-5 departure/arrival convenience ratings. The lack of clarity in the confidence interval suggests that factors influencing convenience ratings might be more complex or less impactful on overall satisfaction in this case.

12. Dissatisfied ease of online booking (rated 1-3) vs Satisfied ease of online booking (rated 4-5) in terms of overall Satisfaction
Let:

$$\hat{p}_1 : \textit{Proportion of passengers satisfied overall given that they rated 1–3 for ease of online booking}$$

$$\hat{p}_2 : \textit{Proportion of passengers satisfied overall given that they rated 4–5 for ease of online booking}$$

$$\hat{p}_1 = 0.435, \quad \hat{p}_2 = 0.5, \quad n_1 = 33, \quad n_2 = 18, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$*:*

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.435 - 0.5) \pm 1.96\sqrt{\frac{0.435 \times 0.565}{33} + \frac{0.5 \times 0.5}{18}}$$

C.I for $p_1 - p_2$*:* $\boxed{(-0.35,\ 0.22)}$

Interpretation: Since one boundary is negative and the other is positive, we cannot conclude anything about the true proportion of passengers satisfied overall, given that they rated 4-5 for ease of online booking versus those who rated 1-3 for ease of online booking, given that they gave an overall satisfied rating. Therefore, we can use hypothesis testing in the next section to further analyze whether the ease of online booking has an effect or not.

13. Food and drink ratings proportions among satisfied passengers
Let:

$$\hat{p}_1 : \textit{Proportion of satisfied passengers that gave 1–3 food and drink rating}$$

$$\hat{p}_2 : \textit{Proportion of satisfied passengers that gave 4–5 food and drink rating}$$

$$\hat{p}_1 = 0.31, \quad \hat{p}_2 = 0.495, \quad n_1 = 29, \quad n_2 = 22, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$*:*

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.31 - 0.495) \pm 1.96\sqrt{\frac{0.31 \times 0.69}{29} + \frac{0.495 \times 0.505}{22}}$$

C.I for $p_1 - p_2$*:* $\boxed{(-0.18,\ -0.108)}$

Interpretation: Since both boundaries are negative, we can conclude that the true proportion of passengers satisfied overall given that they rated 4-5 for food and drink is greater than the true proportion of passengers satisfied overall given that they rated 1-3 for food and drink, given that they gave an overall satisfied rating. This suggests that food *and drink quality plays a significant role in overall passenger satisfaction, with higher food and drink ratings being strongly associated with greater overall satisfaction. Therefore, improving food and drink offerings could potentially lead to higher levels of satisfaction among passengers.*

14. Dissatisfied online boarding (rated 1-3) vs Satisfied online boarding (rated 4-5) in terms of overall Satisfaction

Let:

$\hat{p}_1$: *Proportion of passengers satisfied overall given that they rated 1–3 for online boarding*

$\hat{p}_2$: *Proportion of passengers satisfied overall given that they rated 4–5 for online boarding*

$$\hat{p}_1 = 0.103, \quad \hat{p}_2 = 0.73, \quad n_1 = 29, \quad n_2 = 22, \quad \frac{\alpha}{2} = 0.025$$

CI for $\hat{p}_1 - \hat{p}_2$*:*

$$(\hat{p}_1 - \hat{p}_2) \pm z_{\alpha/2}\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{n_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{n_2}}$$

$$(0.103 - 0.73) \pm 1.96\sqrt{\frac{0.103 \times 0.897}{29} + \frac{0.73 \times 0.27}{22}}$$

C.I for $p_1 - p_2$*:* $\boxed{(-0.843,\ -0.41)}$

Interpretation: The estimated proportion of overall satisfaction among passengers who rated online boarding poorly (1–3) was 10.3%, compared to 73% for those who rated it highly (4–5). The 95% confidence interval for the difference in proportions is (–0.843, –0.41). Since this interval is entirely negative, it strongly suggests that passengers who had a better online boarding experience were substantially more likely to report being satisfied overall. This implies that improving the boarding process could have a real impact on customer satisfaction levels.

Hypothesis Testing

1. Claim: *50% or more of the passengers are satisfied*

$$H_0 : p \geq 0.5 \quad \textit{(Null Hypothesis)}$$
$$H_1 : p < 0.5 \quad \textit{(Alternative Hypothesis)}$$

$\hat{p}$***:*** *proportion of satisfied passengers*

$$\hat{p} = 0.3725, \quad n = 19$$

Test statistic:

Pivotal quantity under H_0*:*

$$Z_c = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0 q_0}{n}}}$$

$$Z_c = \frac{0.3725 - 0.5}{\sqrt{\frac{0.5\times0.5}{19}}} = -1.1115$$

Acceptance/Rejection region:

$$1 - \alpha = 0.95 \Rightarrow \alpha = 0.05$$

$$Z_t = -Z(0.05) = -1.645$$

Since $Z_c > Z_t$ (i.e., Z_c doesn't lie in the rejection region), then we ***fail to reject*** *the null hypothesis H_0 at $\alpha = 0.05$. Therefore, there isn't enough evidence to support the claim that less than 50% of passengers are satisfied with the service.*

2. Claim: *When the average flight distance is high (greater than or equal 1600 miles), then the overall passengers satisfaction level is satisfied.*

$$H_0 : \mu \geq 1600 \quad \textit{(Null Hypothesis)}$$

$$H_1 : \mu < 1600 \quad \textit{(Alternative Hypothesis)}$$

μ***:*** *average flight distance in miles*

$$\bar{x} = 1241.79, \quad n = 19$$

Test statistic:

Pivotal quantity under H_0:

$$Z_c = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$$

$$Z_c = \frac{1241.79 - 1600}{902.65/\sqrt{19}} = -1.729$$

Acceptance/Rejection region:

$$1 - \alpha = 0.95 \Rightarrow \alpha = 0.05$$

$$Z_t = -Z(0.05) = -1.645$$

Since $Z_c < Z_t$ (i.e., Z_c lies in the rejection region), then we ***reject*** *the null hypothesis H_0 at $\alpha = 0.05$ Therefore, there's enough statistical evidence to conclude that the average flight distance among satisfied passengers is actually less than 1600 miles, which challenges the claim that higher flight distances are linked to overall satisfaction.*

3. Claim: *When the average departure delay time is low (less than or equal to 10 minutes), then the overall passenger satisfaction level is satisfied.*

$$H_0 : \mu \leq 10 \quad \textit{(Null Hypothesis)}$$

$$H_1 : \mu > 10 \quad \textit{(Alternative Hypothesis)}$$

μ***:*** *average departure delay time in minutes*

$$\bar{x} = 13.63, \quad n = 19$$

Test statistic:
Pivotal quantity under H_0:

$$Z_c = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}}$$

$$Z_c = \frac{13.63 - 10}{28.23/\sqrt{19}} = 0.56$$

Acceptance/Rejection region:

$$1 - \alpha = 0.95 \Rightarrow \alpha = 0.05$$

$$Z_t = Z(0.05) = 1.645$$

Since $Z_c < Z_t$ (i.e., Z_c doesn't lie in the rejection region), then we ***fail to reject*** *the null hypothesis H_0 at $\alpha = 0.05$. This means there's not enough evidence to dispute the claim that low average departure delays (10 minutes or less) are associated with satisfied passengers.*

4. Claim: *80% or more of the satisfied passengers found that online booking doesn't affect their overall satisfaction level.*

$$H_0 : p \geq 0.8 \quad \textit{(Null Hypothesis)}$$

$$H_1 : p < 0.8 \quad \textit{(Alternative Hypothesis)}$$

$\hat{p}$: *Proportion of passengers who gave a 1–3 online booking rating given that they are overall satisfied.*

$$\hat{p} = 0.526, \quad n = 19$$

Test statistic:
Pivotal quantity under H_0:

$$Z_c = \frac{\hat{p} - p_0}{\sqrt{\frac{p_0 q_0}{n}}}$$

$$Z_c = \frac{0.526 - 0.8}{\sqrt{\frac{0.8 \times 0.2}{19}}} = -2.39$$

Acceptance/Rejection region:

$$1 - \alpha = 0.95 \Rightarrow \alpha = 0.05$$

$$Z_t = -Z(0.05) = -1.645$$

Since $Z_c < Z_t$ (i.e., Z_c lies in the rejection region), we ***reject*** *the null hypothesis H_0 at $\alpha = 0.05$. This suggests that fewer than 80% of satisfied passengers rated online booking neutrally or poorly, meaning online booking may actually influence their overall satisfaction more than initially claimed. This result challenges the assumption that online booking doesn't impact satisfaction, and implies that better online booking experiences might contribute more significantly to satisfaction than previously believed. So, improving the online booking process could be a strategic area for boosting overall passenger satisfaction.*

IV. Conclusion

Conclusion

Overall, a few important findings were pulled from the dataset about what affects overall passenger satisfaction. We didn't find enough evidence to support the idea that 50

We also saw that small delays, like an average of 13 minutes, don't seem to make a big impact on how satisfied passengers feel. That suggests that people are okay with some delay, as long as it's not too much. On the other hand, the online booking process looks like it might be more of a problem than expected. Even some passengers who were satisfied overall gave low ratings to the booking experience, which means it's probably worth looking into improving that part of the service.

For service-related factors, the confidence intervals told us that cleanliness and food drink ratings stood out; passengers who rated those higher were more likely to be satisfied overall. Business class passengers also showed much higher satisfaction levels compared to economy, which really shows how much amenities and comfort can matter.

Implications and Areas for Improvement

These findings point out some clear factors airlines should focus on. The online booking system seems to need work, as it's the first thing passengers deal with, and if it's frustrating, that's a bad start. Improving food and drinks, and making sure everything is clean, also seems to make a big difference. Business class is doing well, but airlines might want to find ways to bring some of that comfort and quality into economy, even if just a bit.

As a result, it seems like airlines should start focusing on certain factors, like booking, meals, and the condition of the cabin, which might do a better job at making passengers actually feel more satisfied instead of assuming the factors of 'how far or how long a passenger flies' is the only/main thing that determines overall satisfaction.

1. ***Improve Digital Booking Experiences***
   Our findings show that even among passengers who are satisfied, quite a few gave poor ratings to the online booking system. This points to the fact that the digital interfaces are just not cutting it. It'd be a good idea to focus on making the booking system more user-friendly, faster, and clearer, especially for mobile users. Fixing this could take out a major roadblock in the customer journey.

2. ***Focus on Service Touchpoints That Drive Satisfaction***
   Confidence intervals pointed out that passengers who gave higher ratings to food & drink and cleanliness had better overall satisfaction. Airlines should think about improving the quality, presentation, and consistency of in-flight meals, while also making sure cleanliness is top-notch across all cabins. These are the areas that really seem to have an impact on passenger experience.

3. ***Address Economy Class Gaps***
   Business class passengers are way more satisfied than economy class passengers. While it's normal for there to be some differences, airlines should still look for affordable ways to improve the economy experience. Things like better seat comfort, a nicer cabin vibe, or more attentive service could help close the gap.

4. ***Reconsider Delay Mitigation Priorities***
   Our analysis showed that short delays (around 13 minutes) didn't really impact passenger satisfaction. Sure, reducing delays is still important, but this data suggests

that small delays are not as big of an issue as some other factors. Maybe it's worth focusing on improving other areas that have more influence on how passengers feel.

Limitations:

Data Constraints: *One of the main limitations of this study is the relatively small sample sizes in certain subgroups (for instance, n = 1932 for delay-related studies), which made the results less reliable and harder to generalize. We also didn't have data on post-flight experiences, like baggage collection or overall airport services, which made it harder to fully capture the factors influencing passenger satisfaction. Missing out on these data points might've caused us to overlook some important elements that could affect satisfaction. A larger sample would've helped to get more precise and generalizable findings, improving the robustness of the analysis.*

Methodological Gaps: *There were a few methodological challenges too. For example, assumptions about normality weren't always met, and in cases where variance wasn't pooled correctly, the results might've been biased, especially when calculating confidence intervals. The analysis also didn't factor in things like airline brand or weather conditions, which could've influenced passenger satisfaction and potentially distorted the findings.*

Scope for Future Research: *To get a deeper understanding of passenger sentiment, future studies could combine quantitative data with qualitative insights, like open-ended responses, to capture more nuances that numbers alone can't reveal. This study had a limited scope and its findings can't easily be generalized to the wider population of passengers. The small sample sizes in some groups (e.g., n = 1932 for delay-related analysis) reduced the statistical power, and not having post-flight data like baggage handling or the quality of services on the ground restricted our understanding of the whole passenger experience.*

The analysis also showed there's no solid evidence that 50

To fix these issues, airlines should prioritize services that'll have the biggest impact, like improving seat comfort, ensuring reliable in-flight WiFi, and making digital check-in processes smoother. They could also focus on offering targeted incentives to disloyal passengers and use predictive analytics to reduce delays, which could help boost satisfaction. For future studies, increasing sample sizes, including longitudinal data, and exploring cultural differences in passenger expectations could help make the findings more comprehensive. A mix of solid data and operational flexibility could help airlines turn a decent experience into long-lasting loyalty, especially as competition grows.

Contributions

We would like to acknowledge the contributions of each team member to this project:

Planning: *Entire team*

Introduction: *Samer Romany*

Descriptive Statistics: *Mariam Hassan (statistics), Shahd Eldanasory (graphs and analysis)*

Inferential Statistics: *Shahd Eldanasory & Mariam Hassan*

Analysis: *Mariam Nousseir, Shahd Eldanasory, & Mariam Hassan*

Conclusion: *Samer Romany and Shahd Eldanasory*