Airline Safety: A Whole New World?

Arnold Barnett

MIT

The Earth is Flat?

In 2017, four billion passengers flew on scheduled commercial flights worldwide. The number killed in aviation accidents was seven.

Does that outcome mean that **historical differences** across nations in air-passenger death risk have **all but disappeared**?

Well, let's not jump to conclusions.

Question:

Based on data for the decade 2008-17, to what extent (if any) does passenger safety in scheduled commercial aviation vary across the world?

How should we measure aviation safety?

We focus here on passenger deaths, because “death is different.”

(US Supreme Court)

Deaths per 100 million passenger miles is a troubled statistic, but why not use the simple ratio of passengers killed to passengers carried?

There might be a reason.

When a Boeing 737 hits a mountain killing all passengers, the implications about safety are the same whether it is full or only 1/3 full. Yet the number of passengers killed is 150 in one case and only 50 in the other. Thus, the "passengers killed" statistic treats the two events very differently, for no good reason.

A crash that kills 28 passengers out of 28 has a very different survival rate than another that kills 28 out of 280. Yet the statistic "number killed" treats the two events the same way, which is unfortunate.

Another Measure of Safety Performance Over a Past Period:

Death Risk Per Randomly Chosen Flight

Question:

If a person chose a flight at random from among those of interest (e.g. Brazilian domestic flights over the period 1990-99), what is the probability that he would not survive it?

This death risk per flight statistic has some conceptual advantages compared to other statistics about passenger mortality risk.

What Conceptual Advantages?

- Ignores length and duration of flight, which are virtually unrelated to mortality risk
- Weights each crash by the percentage of passengers killed
- Easy to calculate and understand

But, like the ratio passengers killed/passengers carried, the death risk per flight statistic has a flaw.

It proceeds as if passengers choose flights at random, but:

- **Passengers do not choose flights completely at random: the average A-380 carries far more passengers than the average Embraer-120.**
- **If there is any correlation between size of aircraft and risk of crashing, then death risk per flight might offer a biased estimate of the risk for a passenger selected at random.**

In short, both passengers killed/passengers carried and death risk per flight are imperfect measures of passenger mortality risk.

That being the case, it is prudent to calculate both risk metrics and postpone any assessment about which is preferable. That is what we will do.

The statistic passengers killed divided by passengers carried answers the question:

If we choose one boarding pass at random from all those used by the passengers of interest (e.g. Brazilian domestic air travelers over 1990-99), what is the probability that its owner did not survive her flight?

We'll focus on the last decade 2008-17, but will start with a partition of the world's nations that has worked well in prior decades in characterizing the mortality risk of passenger air travel.

Historically, we could summarize passenger mortality risk in various nations by dividing the world into **three homogeneous subgroups**:

Traditional First World

Advancing Nations

Less Developed

The subgroup-specific risk statistics for 2008-17 were:

	Death Risk	
Subgroup	**Per Flight**	**Per Boarding**
First World	1 in 21.6 M	1 in 28.8 M
Advancing	1 in 7.5 M	1 in 10.9 M
Less Dev.	1 in 800 K	1 in 1. 3M

K = thousand M = million

Note that the death risk per **flight** statistics in the table **were all smaller** than those for death risk per **boarding**.

Why is that?

Well, the planes that suffered fatalities had an average of 62 passengers on board, while all scheduled flights over 2008-17 averaged 102 passengers apiece.

In other words, death risk per flight has an upward bias in terms of the risk to actual passengers, unlike death risk per boarding.

Thus, **death risk per boarding** seems the preferable risk metric.

Why did it take me 40 years to recognize that? Sad!

The cross-group differences in passenger death risk over 2008-17 are of immense statistical significance.

But are the individual groups homogeneous?

In formulating statistical tests for homogeneity, we need note that:

- Because a few crashes with many fatalities have a **wildly-disproportionate impact** on overall death tolls, tests based on **numbers of deaths** are all but useless.

- Tests based on percentages killed in individual crashes can be conducted, but they **necessarily deviate from standard procedures**

To put it briefly:

- **Traditional First-World nations pass the homogeneity test with "flying colors." The p-value of the key test exceeds 50%, meaning that the cross-national variations are less than would be expected by sheer chance.**

- **The Advancing Nations and the Less Developed Nations both fail the homogeneity tests.**

Among Advancing Nations, China sharply outperformed the rest of the group:

Entity	Death Risk Per Flight	Per Boarding
China	1 in 65.2 M	1 in 79.6 M
Other Advancing Nations	1 in 4.8 M	1 in 7.4 M

M = million

Among Less Developed Nations, Eastern Europe Was Conspicuously Different:

Entity	Death Risk Per Flight	Death Risk Per Boarding
Eastern Europe	0	0
Other Less Developed	1 in 800,000	1 in 1.2 M

A Reformulation of the Subgroups:

- Both China and Eastern Europe are "promoted" to the lowest-risk subgroup
- China leaves the Advancing Nations, as do the Eastern European countries that were part of that group
- The Eastern European countries contained in the "Less Developed" group all leave it for greener pastures

With these revised groupings, the mortality-risk table becomes:

Subgroup	Death Risk Per Flight	Death Risk Per Boarding
Lowest Risk	1 in 24.3 M	1 in 33.2 M
Intermediate Risk	1 in 4.8 M	1 in 7.4 M
Higher Risk	1 in 800 K	1 in 1. 2 M

K = thousand M = million

In the safest subgroup—of which the US is a founding member--death risk per boarding was 1 in 33.2 million

At that level of risk, an American kid at DCA or DFW or SJC is far more likely to grow up to be President than to perish on the forthcoming flight.

The time-trend in worldwide passenger death risk is a joy to behold:

Worldwide Death Risk per Boarding for Five Decades from 1968 to 2017

Decade	Death Risk per Boarding
1968-77	1 in 350,000
1978-87	1 in 750,000
1988-97	1 in 1.3 million
1998-2007	1 in 2.7 million
2008-17	1 in 7.9 million

Overall Conclusions

- Not exactly "a whole new world" in aviation safety
- In general that is good news: the strong downward pattern of past decades continued in full force over 2008-17
- Yet the least developed nations (minus Eastern Europe)have if anything lost ground relative to other nations, despite having considerably more room for improvement.
- But the achievements of the Lowest Risk group continue to constitute the eighth wonder of the world.

Congratulations!