THE AMERICAN JOURNAL *of* MEDICINE®

Fatality Risks on the Road and in Space

On February 1, 2013, millions of Americans commemorated the 10-year anniversary of the loss of Space Shuttle *Columbia* and its 7-member crew. Much less visible, however, was the 10-year anniversary of the 122 automobile crash deaths that also occurred in the United States on February 1, 2003.[1] Space travel and road travel do not pose competing risks and are rarely considered together in any context. However, the 2 anniversaries offered a time to reflect on the deaths associated with these 2 disparate modes of travel and an opportunity to consider why these events produce such discordant public responses.

Funding: None.
Conflict of Interest: None.
Authorship: Both authors had access to the data and a role in preparing the manuscript.

The United States has more automobiles than any other country on Earth, and about 87% of adult Americans are licensed to drive.[2] In 2009, Americans collectively accumulated about 4.8 trillion kilometers of automobile travel (a distance equal to 16,000 round trips between the Earth and the Sun).[3,4] Most trips did not result in a crash, creating the impression that automobile travel is uneventful, innocuous, and far safer than spaceflight. To examine the validity of this perception, we compared the fatality risk associated with American automobile travel to the fatality risk associated with American spaceflight.

We determined the American spaceflight fatality risk by analyzing all crewed missions launched by the United States with a planned maximum altitude exceeding 100 kilometers (in accordance with the Fédération Aéronautique Internationale definition of spaceflight). Deaths during training

Table Comparing Space Travel and Automobile Travel*

	US Space Travel (50 years)	US Automobile Travel (1 year)†
Basic data		
Average trip distance (km‡)	6,264,294	16
Average trip duration (hours)	237.1	0.3
Average trip velocity (km/h)	25,646	50
Average vehicle occupancy (persons)	5.3	1.7
Exposure indices		
Total number of trips (count)	168	233,849,000,000
Total distance traveled (100 million vehicle-kilometers)	11	48,280
Total person-distance traveled (100 million person-kilometers)	60	80,627
Travel fatalities		
Fatal incidents (count)	2	30,196
Travel-related fatalities (persons)	14	32,885
Demographics		
Average age at death (years)	42	42
Proportion male among fatalities (%)	71	70
Proportion white among fatalities (%)	71	74
Analytic comparisons		
Lifetime risk of travel-related death (%)	3.6 (2.0-6.0)	0.86 (0.81 - 0.92)
Risk of fatal incident (per vehicle-trip)	1.2×10^{-2} ($0.2 \times 10^{-2} - 4.6 \times 10^{-2}$)	1.3×10^{-7} ($1.3 \times 10^{-7} - 1.3 \times 10^{-7}$)
Risk of death (per 100,000 person-hours)	6.3 (3.6-10.8)	0.028 (0.027-0.028)
Risk of death (per 100 million vehicle-kilometers)	1.3 (0.76-2.3)	0.68 (0.67-0.69)
Risk of death (per 100 million person-kilometers)	0.23 (0.13-0.40)	0.41 (0.40-0.41)

*Values in parentheses represent 95% confidence intervals. See **Supplemental Appendix** for assumptions, calculations, and references.
†"1 year" denotes 2010 where possible and 2009 otherwise.
‡1.000000 kilometer = 0.6213712 statute miles.

http://dx.doi.org/10.1016/j.amjmed.2014.01.027

were excluded (eg, fatal crashes during flights planned for lower altitudes, the fatalities resulting from the Apollo 1 training launch pad fire), as was distance accumulated by crew residing on a space station between spaceflight missions. The fatality risk associated with modern automobile travel in the United States was determined using the National Highway Traffic Safety Administration database (drawing on data from 2010, the safest year on record at the time of the final Space Shuttle mission) and the most recent US Department of Transportation National Household Travel Survey.[3,4]

Between 1961 and 2011, the National Aeronautics and Space Administration (NASA) launched 168 crewed spaceflight missions, encompassing the Mercury, X-15, Gemini, Apollo, Skylab, Apollo-Soyuz, and Space Shuttle programs (Appendix: **Supplementary Tables 1-3**, online). The average spaceflight carried about 5 crew members and traveled about 6 million kilometers over 10 days for an average velocity of about 26,000 kilometers per hour (**Table**). In contrast, Americans made about 234 billion automobile trips in 2009. The average automobile trip carried about 2 vehicle occupants and traveled about 16 kilometers over 19 minutes, for an average velocity of about 50 kilometers per hour.[1]

Evaluating total fatalities and transportation distances confirms that the risk of death during spaceflight is substantial. Approximately 1.2% of all missions had fatal outcomes, and 3.6% of US spaceflight crew (astronauts, cosmonauts, mission specialists, and others) died while on a space mission. These risks are a testament to the bravery of individuals who travel to outer space in the name of patriotism, scientific discovery, and human progress.

One striking feature of the results is that the risk of death during automobile travel is, by some measures, similar to that of spaceflight. In both settings, those who died had an average age of about 42 years, about two thirds were male, and about two thirds were white. Moreover, the per-passenger-kilometer risk for automobile travel (0.41 deaths per 100 million passenger-kilometers; 95% confidence interval [CI], 0.40-0.41) was higher than the per-passenger-kilometer risk for spaceflight (0.23 deaths per 100 million passenger-kilometers; 95% CI, 0.13-0.40). The comparative rarity of spaceflight and frequency of automobile travel also make the aggregate lifetime fatality risk arising from these 2 activities similar in magnitude.

Contrasting automobile travel and space travel helps to illustrate 3 issues pertinent to contemporary road safety policy. First, deaths during spaceflight have been entirely related to launch and landing, so dividing the number of fatalities by the enormous distances traveled by spacecraft in orbit yields a somewhat misleading expression of risk. Similarly, the risks of automobile travel vary substantially according to setting, such that an urban trip replete with merges and turns may be more dangerous than a highway trip of equal distance. Current statistics express road risks on the basis of travel distance, yet the public health implications of transportation policy decisions might be made clearer if such risks were expressed per trip, per population, or by some other metric.

Second, the psychology of risk perception helps explain why popular sentiment appears to devote more attention to one fatal spacecraft incident than to over 100 fatal automobile crashes.[5] From the perspective of the average American, spaceflight is exotic, with a history remarkable for the deaths of celebrated individuals in catastrophes beyond their control. Compared with spaceflight disasters, automobile crashes are smaller in scale, less uniformly fatal, less likely to be filmed, and less commonly iconized. These same features (familiarity, personal control, catastrophic potential, dread, victim identifiability, and media attention, among others) also may explain why some health issues receive much more policy attention than others.[6]

Third, the comparison between space travel and automobile travel may help highlight the modifiable risks associated with automobile travel in America. As drivers, we may wish to reflect on how unthinkable it would be for an astronaut to operate a spacecraft under the influence of alcohol or without a safety restraint. As citizens, we may want to reconsider our current policies on speed limits, speed cameras, mandatory helmet laws, and physician warnings for medically unfit drivers. As a society, we may pause to consider how the apparent safety of our daily drive distracts us from the riskier aspects of automobile travel.

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