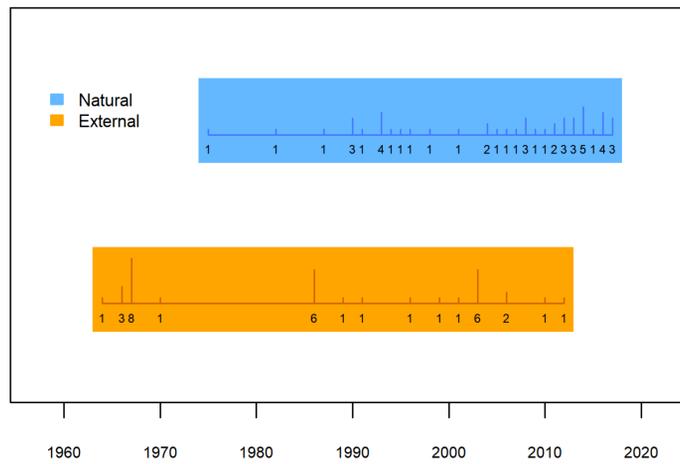


# Competing Risks Survival Bias Among U.S. Astronauts

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> Could deaths from external causes at young ages bias estimates of natural-cause survival for the US astronaut cohort?



> Early deaths might create bias

1. The pattern of mortality from the two causal groups is different in timing and frequency.
2. Externally-caused deaths happen soon after selection; naturally-caused deaths happen many years later.
3. If external cause mortality depends on factors that influence natural-cause mortality, bias may result.

## The Astronaut Cohort

360 total astronauts:

- 338 NASA (selected 1959-2013)
- 22 USAF (selected 1959-1967)
- Follow-up: 04/15/1959 to 12/31/2017

81 total deaths:

- 34 external causes
- 47 natural causes

> No evidence of imbalance between outcome groups at baseline:

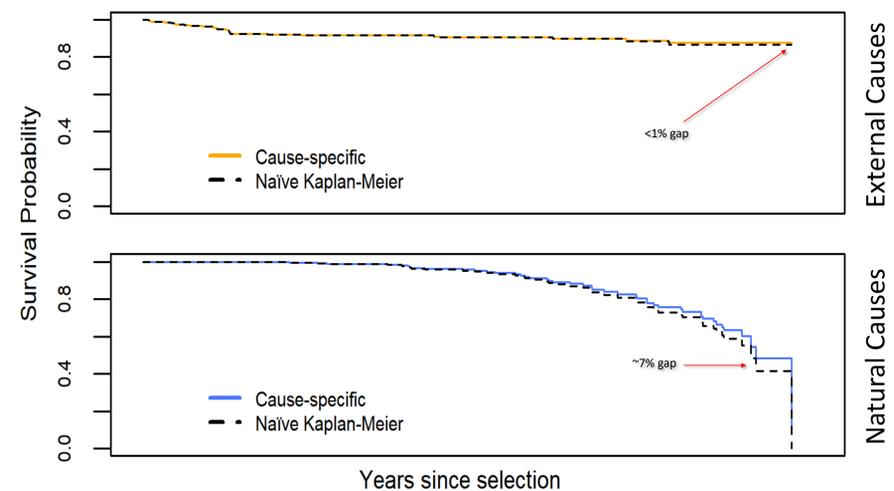
Characteristic	External (N=34)	Natural (N=47)	Test Statistic <sup>1</sup>	p-value
Male n (%)	30 (88.2)	45 (95.7)	0.712	0.3988
White n (%)	30 (88.2)	45 (95.7)	0.712	0.3988
Highest education n (%)				
High school	0 (0.0)	2 (4.3)	2.000	0.1573
Bachelor	12 (35.2)	18 (38.3)	1.200	0.2733
Master	12 (35.2)	18 (38.3)	1.200	0.2733
Doctorate	10 (29.4)	9 (19.1)	0.053	0.8185
Military service n (%)	29 (85.3)	40 (84.8)	0.000	1.0000

<sup>1</sup> Categorical variables assessed with Chi-square test; continuous variables assessed with t-test with equal variances.

<sup>2</sup> Meaningful difference according to value of standard difference of  $\geq 0.1$ .

<sup>3</sup> Statistically significant difference according to value of test statistic.

> Competing risk survival curves: No appreciable differences with naïve Kaplan-Meier



> Evidence weighs against bias

1. Externally-caused deaths appear to be unrelated to baseline covariates other than time since selection
2. External causes show <1% difference in survival (naïve vs competing risk) after 55 years
3. Naïve survival curves for natural causes show only ~7% pessimism after 55 years, but data are thin at this point

> Conclusion: No competing risks survival bias

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