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Inter-Step Height Variation and Observations of Fall-Related Events During Stairway Negotiation

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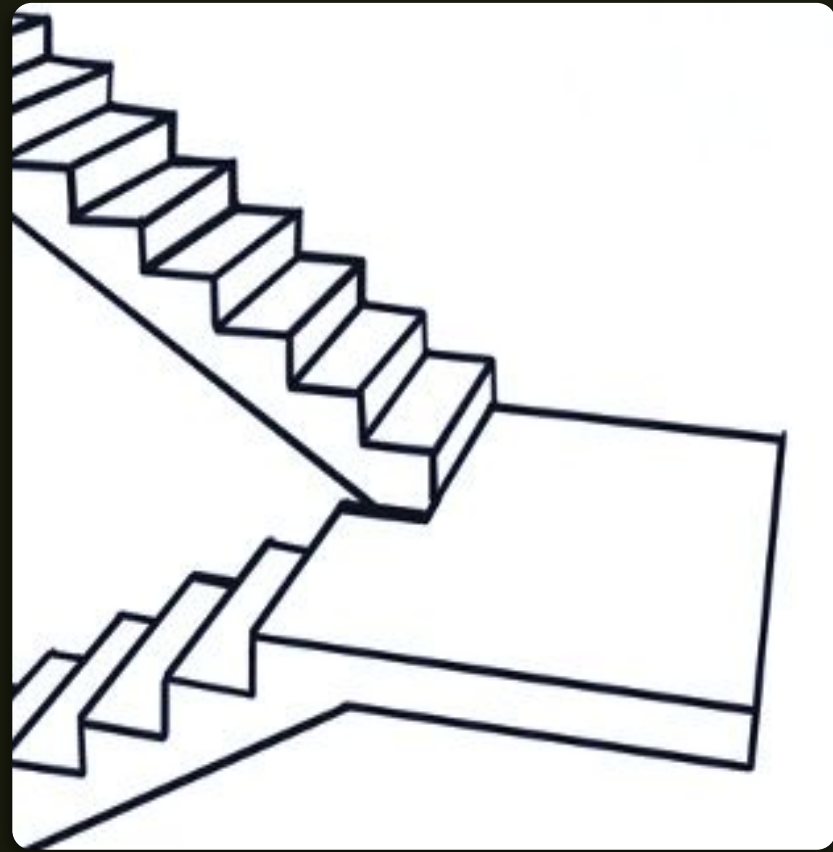
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Inter-step height variation and observations of fall-related events during stairway negotiation

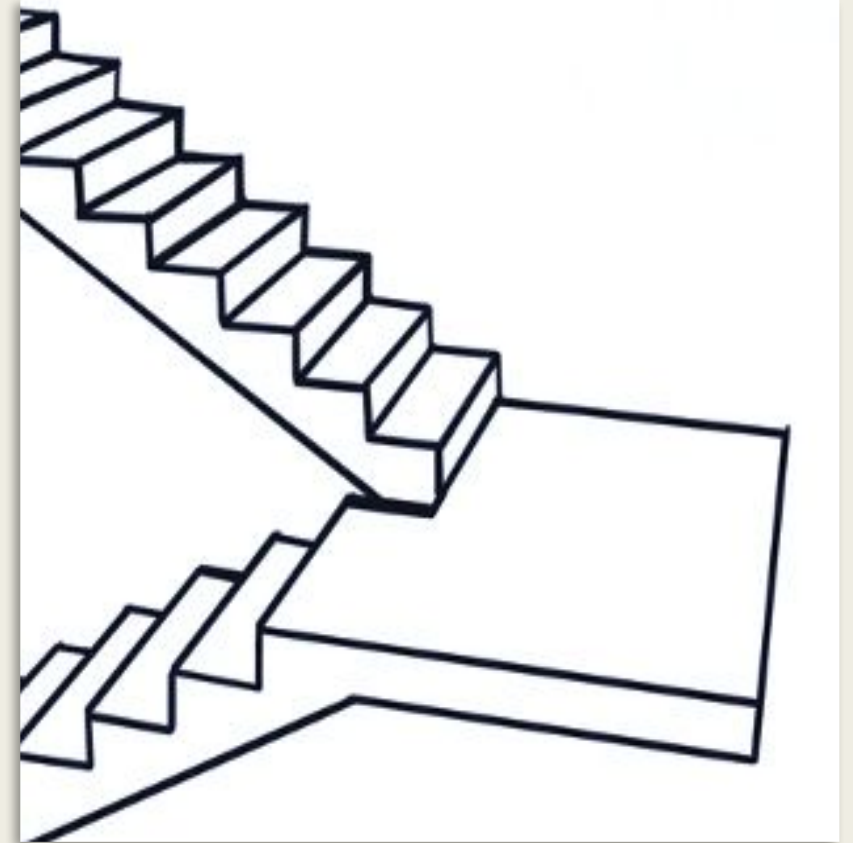
Shandon L. Poulsen, Chayston B. Brown,
Christopher J. Dakin & Sara J. Harper



The New York Stairway

Inter-step height variations

- Variations of **6.35 mm (about 1/4 inch)** may cause more falls
- Variations **greater than 9.525 mm (3/8 inch)** related to 60% of falls on stairs.



OVERVIEW

Why research falls?

How can we reduce falls on stairs?

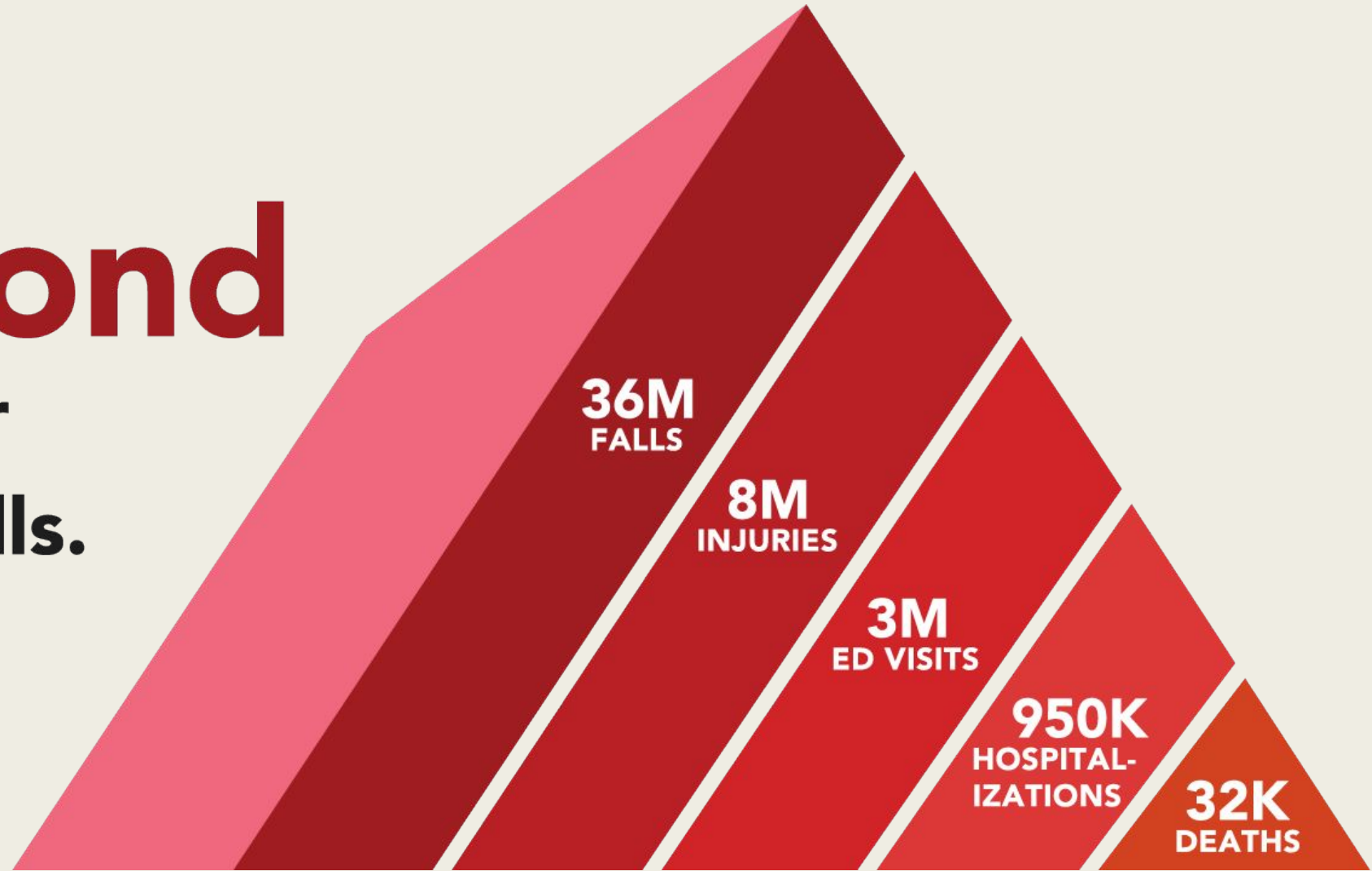
A possible solution

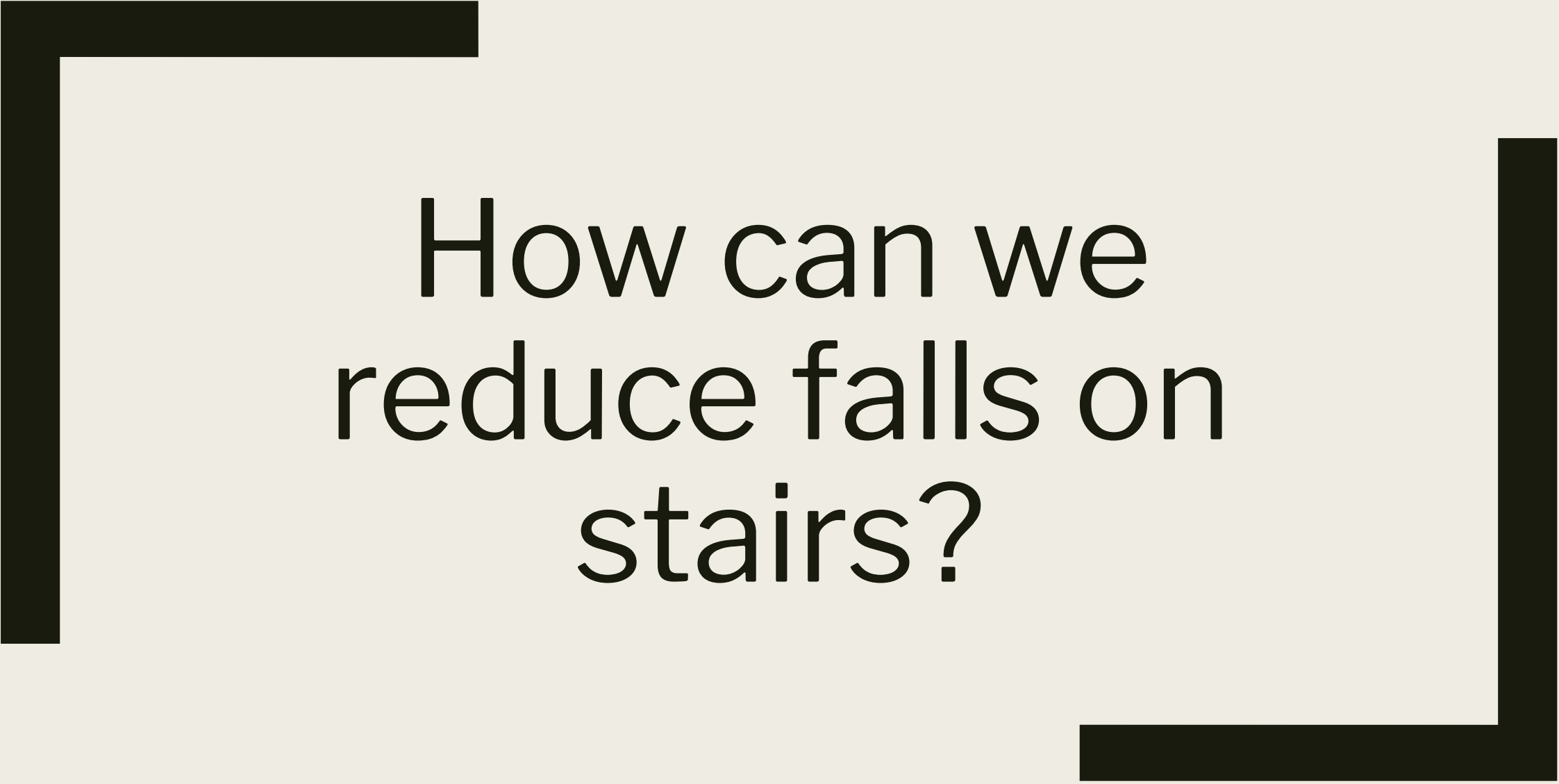
The image features two thick, black L-shaped brackets. One is positioned on the left side, with its horizontal bar at the top and its vertical bar extending downwards. The other is on the right side, with its horizontal bar at the bottom and its vertical bar extending upwards. These brackets frame the central text.

Why research
falls?



Every
second
an older
adult falls.



The image features two thick, black L-shaped corner brackets. One is positioned in the top-left corner, and the other is in the bottom-right corner, framing the central text.

How can we
reduce falls on
stairs?

The simple answer:

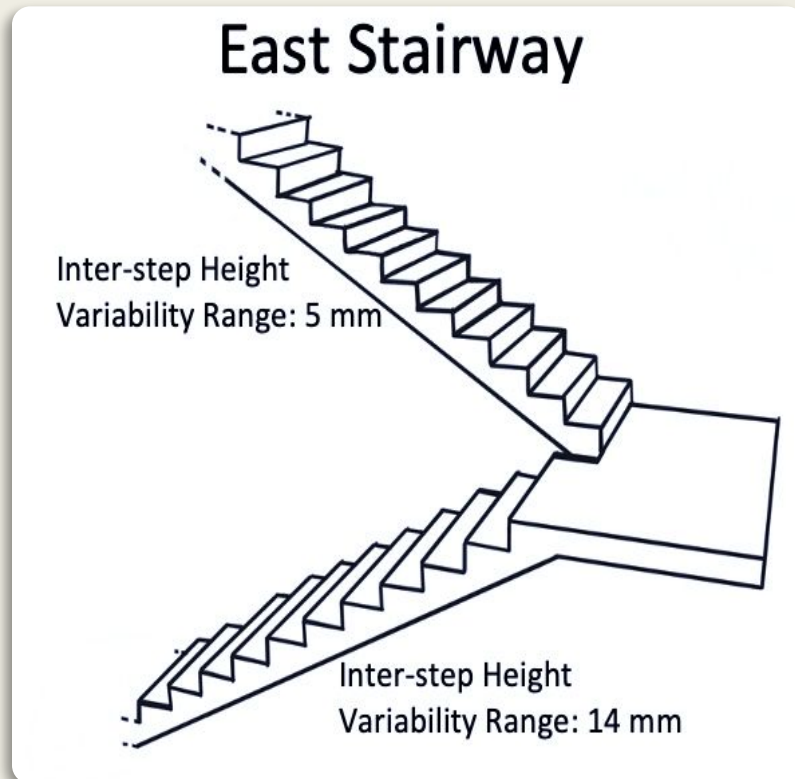
The simple answer:

Build better stairs.

Height Variations

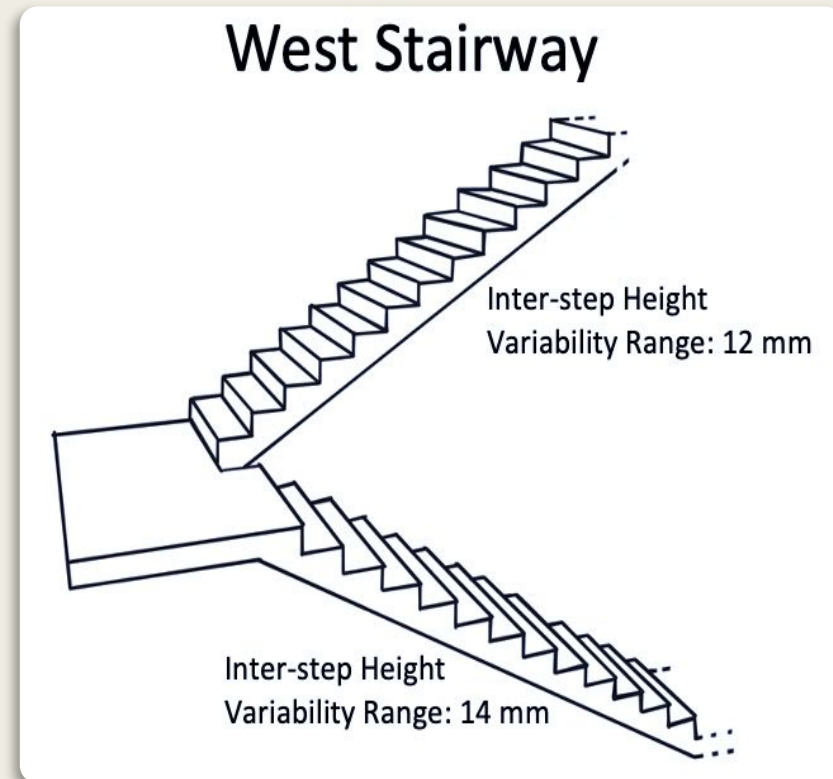
East Stairway

- Upper – 5 mm
- Lower – 14 mm



West Stairway

- Upper – 12 mm
- Lower – 14 mm



Question #1

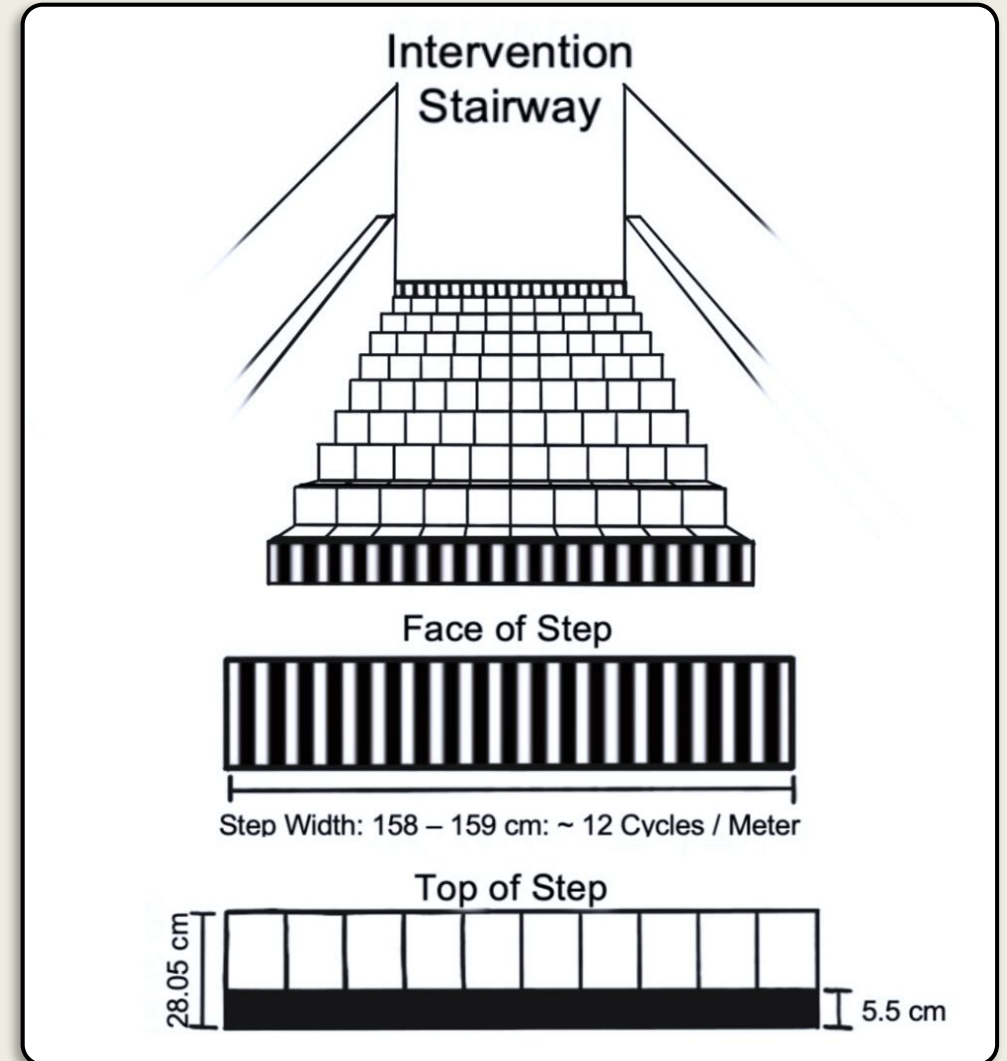
- Are falls associated with greater step height variations?
- Prediction
 - **More falls** on flights with **greater variation**
 - Possible mechanisms: Assumptions of uniformity or lack of attention



A Possible
Solution

Basis of intervention: Striping

- Step edge striping **5.5 cm wide**
- Vertical Striping on **first and last stair faces**



Question #2

- Where there is greater height variation, do more falls occur on an unaltered or striped (intervention) stairway?
- Prediction
 - **More falls** will occur on the **unaltered stairway** on flights with **greater variation**

The Questions:

- Are falls associated with greater step height variations?
- Where there is greater height variation, do more falls occur on an unaltered or striped (intervention) stairway?

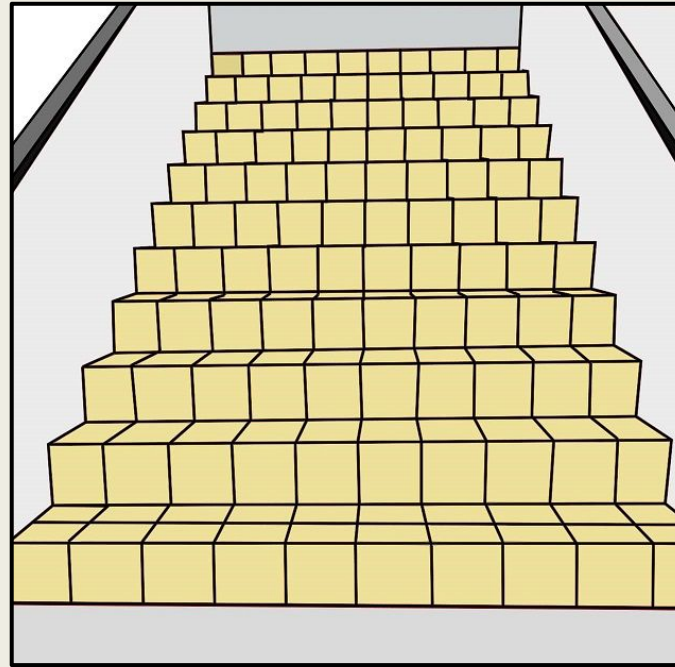


How did we go
about testing this?

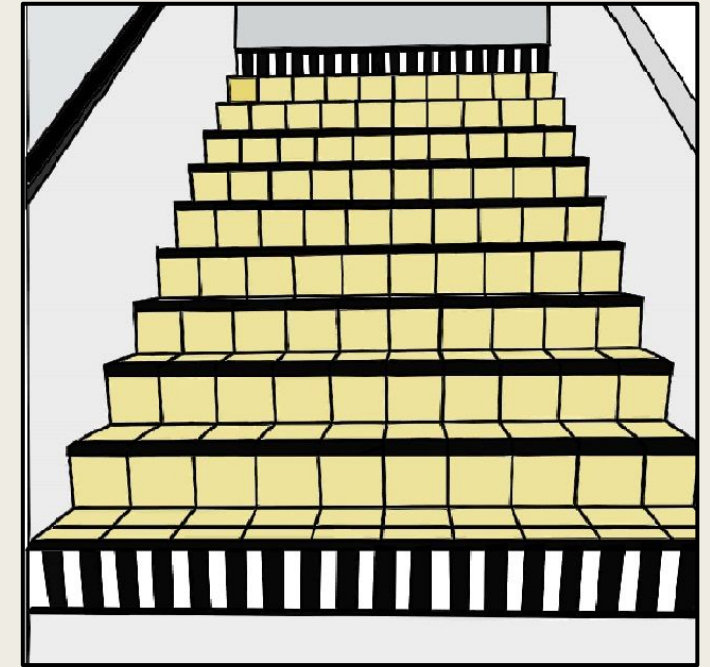


Methods

- Primarily college-aged adults
- Security cameras
- Fall events were recorded by flight and stairway condition



Control



Intervention

Results

- Question #1: More falls on flights with greater variation?
 - **Yes!**
 - 16 of 20 observed falls
- Question #2: Were there more falls on the control stairway with greater variation?
 - **Yes!**
 - 13 of 16 observed falls

	Control	Stripe/Intervention
Low Variance	2 Fall-related Events LC	2 Fall-related Events LS
High Variance	13 Fall-related Events HC	3 Fall-related Events HS

Monte Carlo Simulation ($P = 0.0358$)

Discussion

- Striping, a simple, vision-based strategy, may reduce fall risk
- If a primarily young, healthy population benefits from striping, what about those who could benefit the most?

Future work

- Apply the intervention to high-risk populations
 - Older adults
 - Those with visual impairment



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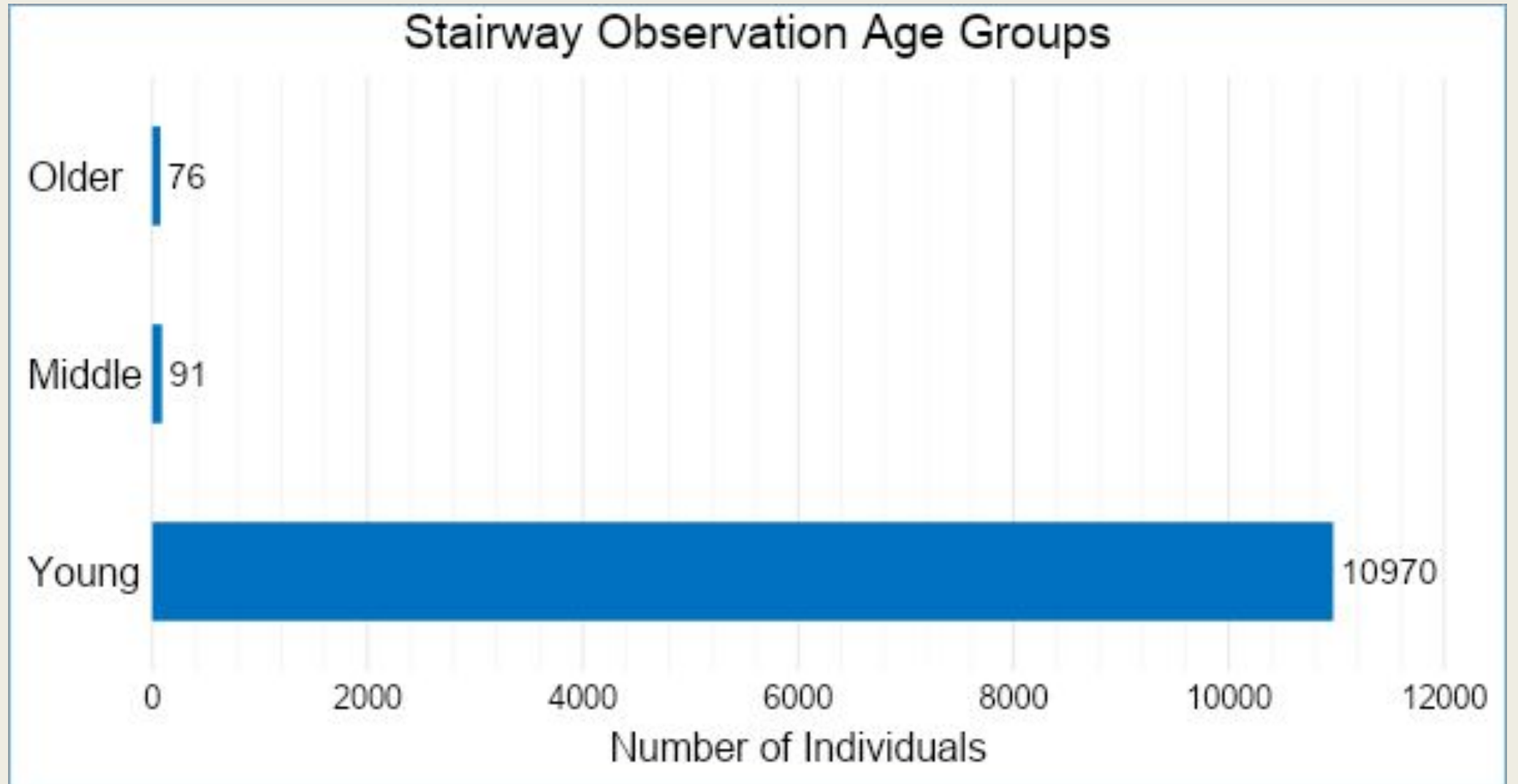
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Observations and age groups



Monte-Carlo Simulation

- Four assumptions were used to code our hypotheses for the total number of falls observed (n=20):
 - (1) Falls in HC > falls in LC
 - (2) Difference between LS and LC < 2 falls
 - (3) Number of falls in HC will be \geq two times of HS
 - (4) Difference between LC and HC > the difference between LS and HS
- Probability of a distribution meeting these assumptions occurring by chance is $P=0.0358$

	Control	Stripe/Intervention
Low Variance	2 Fall-related Events LC	2 Fall-related Events LS
High Variance	13 Fall-related Events HC	3 Fall-related Events HS

Occupational Safety and Health Administration (OSHA)

- 1910.25(b)(3) – Stairs should have **uniform riser heights and tread depths** between landings
- 1926.1052(a)(3) – **Variations** in riser height or tread depth **shall not be over 1/4 in (0.635 cm)** in any stairway system
 - Last amended FR 68795, Dec. 17, 2019.

Tread depth

Tread depth ranges (cm)			
West upper	0.6	East upper	0.4
West lower	3.8	East lower	3.8

At a glance

- Why
 - Falls present a health and financial burden
- How
 - Step edge and face striping may reduce fall risk on stairs
- Further work
 - High-risk populations (i.e., older adults)