



The effectiveness of avalanche airbags

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ICAR 2015



Starting position

- Grade of burial is strongest factor of survival if caught in an avalanche.
- Avalanche airbags can reduce mortality by reducing this factor.
- Airbags are the only avalanche safety device to directly prevent critical burial.



Functionality of avalanche airbags

- Physical process called **inverse segregation**:

“Larger particles are sorted toward the surface, thus reducing the user’s chance of becoming critically buried.”



Picture: beaconreviews.com

Aims of the study

- To provide an updated perspective on the effectiveness of avalanche airbags
 - Known study by *Brugger et al. (2007)* only with limited number of analysed cases.



International study

Authors Paper Resuscitation

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Marek Biskupič, Hermann Brugger

Data



canadianavalancheassociation



Røde Kors
Hindrer og lindrer nød



**Slovakian Avalanche
Prevention Center**



Question to answer

If 100 persons are caught in avalanches, how many of them would have survived the accident by wearing an avalanche airbag?

$$\text{Mortality difference} = \text{Mortality}_{\text{User}} - \text{Mortality}_{\text{Non-User}}$$



The dataset

Well-documented avalanche accidents with airbags, where ...

- the **destructive avalanche size** was ≥ 2.0

| <i>Size</i> | <i>Destruction potential</i> | <i>Volume</i> | <i>Runout</i> |
|-------------|--|------------------------|----------------|
| 1 | Relatively harmless to people | 100m ³ | 10-30m |
| 2 | Could bury, injure or kill a person | 1.000m ³ | 50-200m |
| 3 | Could bury and destroy cars, damage trucks, destroy small buildings and break a few trees | 10.000m ³ | several 100m |
| 4 | Could bury and destroy trucks and railway cars, and destroy fairly large buildings and small areas of forest | 100.000m ³ | 1.000-2.000m |
| 5 | Could devastate the landscape, has catastrophic destructive potential | >100.000m ³ | approx. 3.000m |

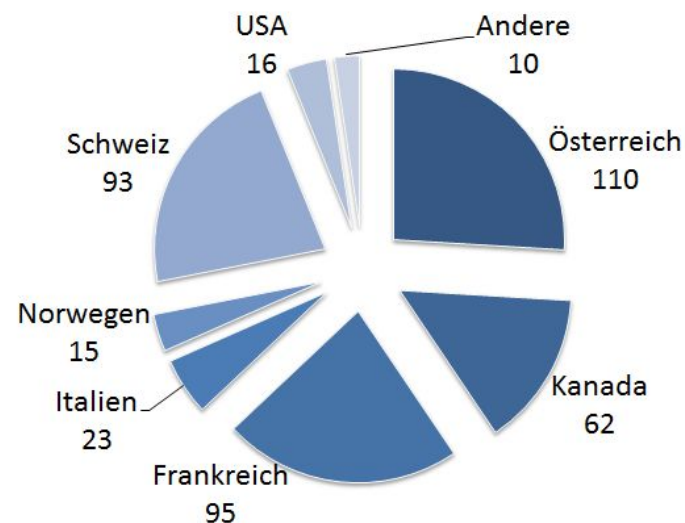
The dataset

Well-documented avalanche accidents with airbags, where ...

- the **destructive avalanche size** was ≥ 2.0
- avalanche involvements had **potential for critical burial**

245 accidents
424 victims

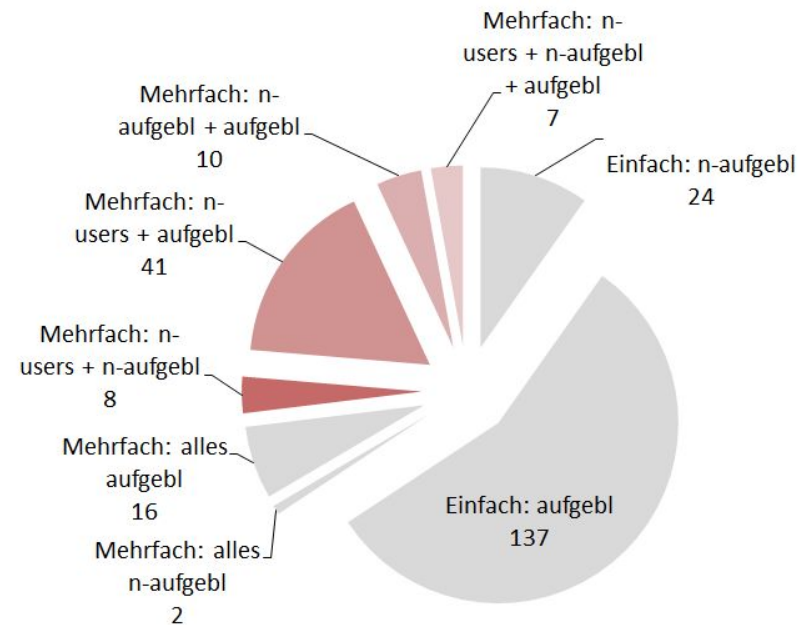
(1994-2012)



Control group

- Only avalanches accidents that involved **both users and non-users of avalanche airbags** were considered.

66 accidents
~~245 accidents~~
~~424 victims~~
223 victims

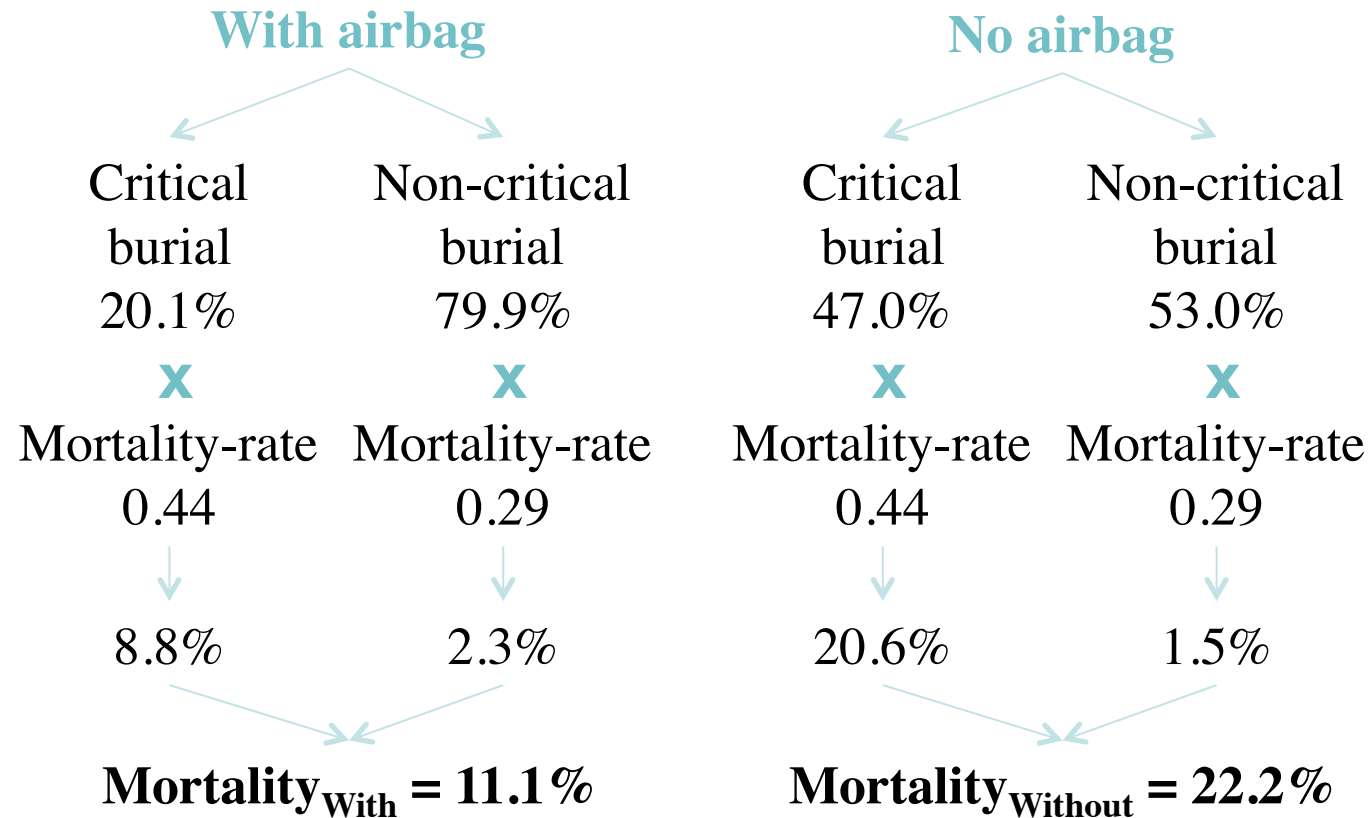


Binomial logistic regression

- **Airbags** can only influence mortality **indirectly** (grade of burial).
- Other factors: **Avalanche size** and the question, whether the victim suffered **severe traumatic injuries**.



Multidimensional perspective

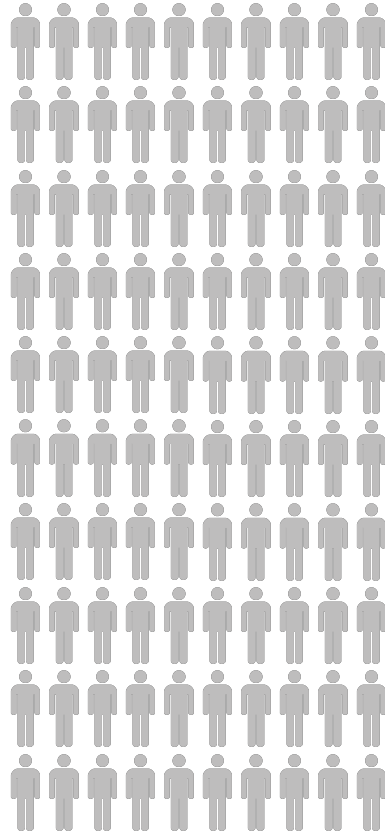


Mortality difference for inflated airbags: 11.1%



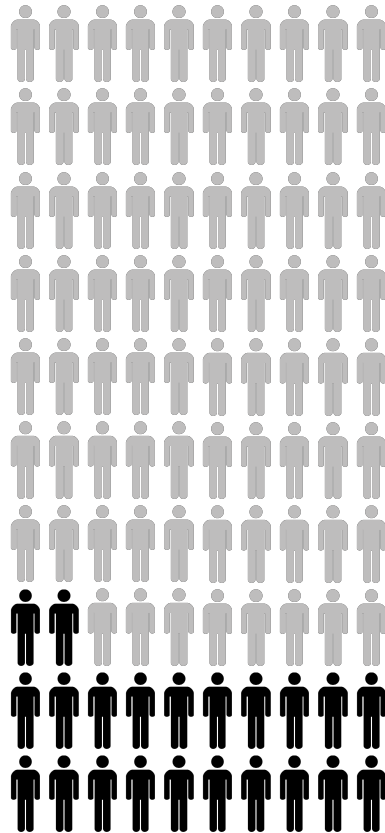
Effect on mortality

Without airbag (control group)



Effect on mortality

Without airbag (control group)



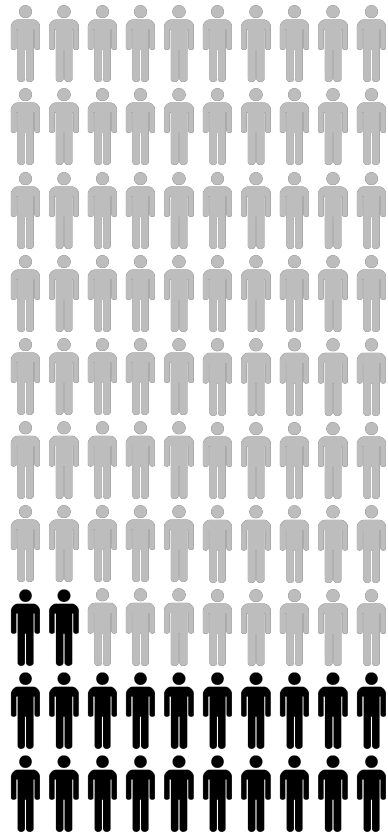
Survived



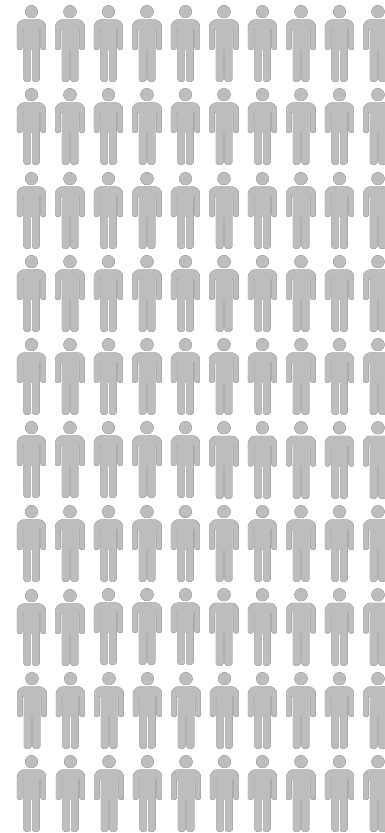
Killed

Effect on mortality

Without airbag (control group)



With airbag (treatment group)



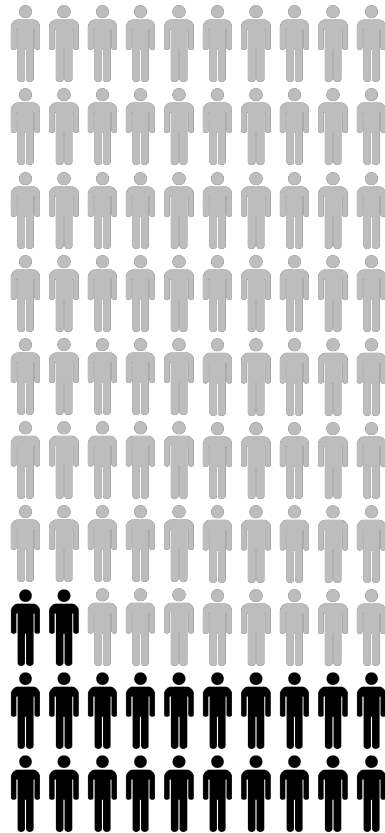
Survived



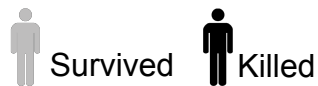
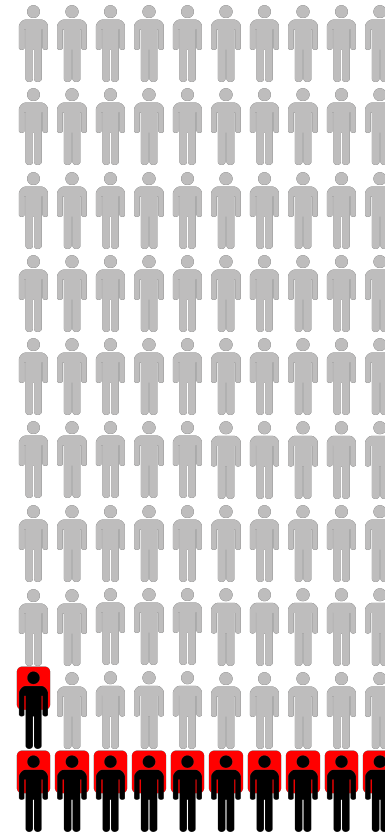
Killed

Effect on mortality

Without airbag (control group)

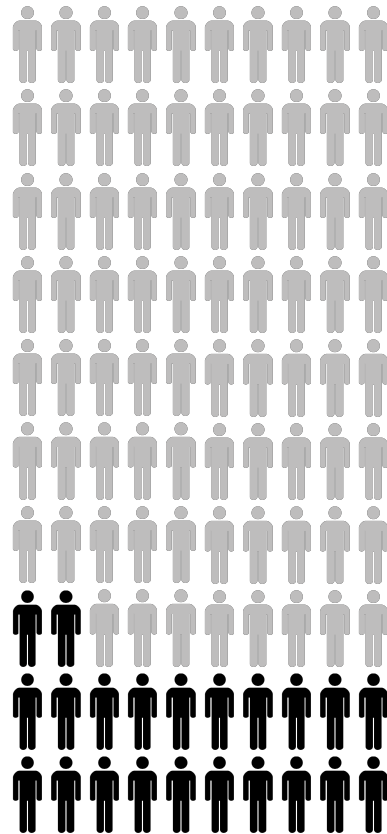


With airbag (treatment group)

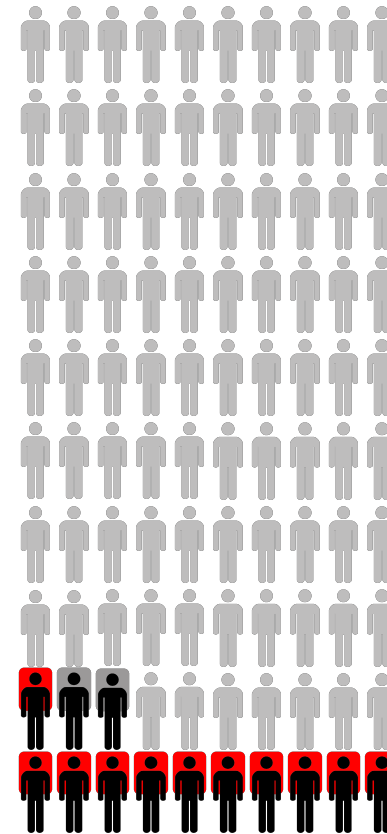


Effect on mortality

Without airbag (control group)



With airbag (treatment group)



Survived



Killed



Survived



Killed



Killed (non-inflated)

Non-inflated airbags

- Complete dataset **rate of non-inflated airbags 20%** (61/307).
- **Mortality difference is reduced to 9%.**
- **Non-inflated airbags** are a **considerable threat** to the performance of avalanche airbags.
- Reasons:
 - 60% deployment failure (training!¹)
 - 12% maintenance errors
 - 17% device failures
 - 12% destruction of the airbag during involvement



¹ Non-inflation rate professionals: 5%
Non-inflation rate non-professionals: 14%



Val Acletta, Disentis: handle not attached (Pictures: KaPo GR)



Felsental, Andermatt: Airbag destruction (Pictures: Rescue station)

Risk compensation

- Binomial logistic regression shows that **risk reduction** by **wearing an airbag** is achieved. Furthermore, this reduction is **almost equal** to the **risk increase** by being caught in an **avalanche** that is **one size bigger**.
- The **potential for a risk compensation effect** among airbag users **clearly exists**. The safety benefit can easily be undone when riding in more delicate terrain where bigger avalanches can occur.



Conclusions

- **Airbags** are a **valuable avalanche safety device**, but the impact on mortality is lower than previously reported and they do not guarantee survival.
- The **mortality** of **victims with an inflated airbag** which are caught in an avalanche size ≥ 2 is **reduced** from **22%** to **11%**.
- If **non-inflated airbags** are **included**, the **mortality** is reduced **only** from **22%** to **13%**.
- The observed overall non-inflation rate of 20% clearly highlights that **non-inflations** still pose a **considerable threat to the performance of avalanche airbags**.



Conclusions

- 60 % of cases with non-inflated airbags: deployment failure!
Familiarity with release procedure and correct maintenance are of paramount importance.
- Personal safety benefits from airbags are quickly nullified if used to justify increased exposure to avalanche hazard.





Questions?