Evaluating the impacts of road safety treatments

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- *Aspects of road safety to evaluate*
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Road safety interventions

- *Road safety inventions may include:*
  - *Institutional reforms for better coordination among various bodies*
  - *Legal and regulatory reforms for better enforcement*
  - **Programs of physical treatments of the road network**

- *They all have a common objective:*
  - *Improve the safety performance*

Few Definitions

- *Road safety treatment –* *a measure implemented at a site for the purpose of achieving a road safety improvement.*

- *Evaluation of a road safety treatment:* *The measure of the effectiveness of a treatment in changing safety performance as a result of the treatment* ***only****. It is measured by the* ***difference*** *between:*
  - **the counterfactual scenario** *(what would have been the safety of the site in the 'after' period had treatment not been applied), and*
  - **the treatment scenario** "*what the safety of the site in the 'after' period is*".

Purpose of the evaluation

- *Improve the ex-ante appraisal: prioritization of future treatments, under budget and implementation capacity constraints:*
  - *Geographically(rural vs. urban)*
  - *Among alternative design scenarios of road sections/junctions, etc.*

- *Learning from past experience:*
  - *Continuously improve treatments effectiveness,*
  - *Taking into account changing context (driving behavior, travel pattern, driving aid technology, etc.)*

Aspects of road safety to evaluate

1. **Socio-economic evaluation of:**
   - *Programs*
   - *Specific projects*

2. **Effectiveness of treatment measures/designs**

Both evaluations require an estimation of the impacts of the treatment as the difference between the Before and the After situations.

1. Evaluation of the Socio-Economic Impacts of Road Safety Treatments

Evaluation of Socio-Economic Impacts of Road Safety Treatments

- *Cost Benefit Analysis:*
  - **Costs:** *of the initial treatment + future maintenance and future upgrades*
  - **Benefits :** *reduction in accidents, resulting in:*
    - *Reduction in Number of casualties (death, severe and minor injuries);*
    - *Reduction in damage to property; and*
    - *Reduction in costs of medical, insurance and police services*

- *Wider socio-economic benefits:*
  - *Increase in trade as a result of safer roads (reduced costs of transport and transaction)*
  - *Development of non-motorized (walking, biking) or fuel efficient (motorbikes, elec. scooters) modes of transport as a result of safer roads*

Evaluation of Socio-Economic Impacts of Road Safety Treatments

- *Estimation of costs of accidents:*

  i) direct health-care costs, including the cost of hospital care, ambulance services, autopsy and specialized health care;

  ii) direct non-health-care costs, including the cost of adapting to disability, material costs, administrative costs and the cost of police, firefighter and roadside assistance; and

  iii) indirect costs associated with the lost productivity of individuals who died and individuals who were injured and their care takers.

- *In Bulgaria the costs :*

Bulgaria	**2013**	**2018 (*)**
Casualties		
Death	*609,203*	*700,000*
Serious Injury	*83,845*	*96,341*
Minor Injury	*6,021*	*6,918*
Damage only		
Motorways	*24,368*	*28,000*
Rural	*12,184*	*14,000*
Uban	*6,092*	*7,000*
(*) estimates		

2. Evaluation of the Effectiveness of Road Safety Treatments

Causal Factors

Factors that can affect the safety performance include:

- *Treatment effect = the change in safety performance of a transportation facility caused by implementation of a specific treatment. It must be isolated from the other causal factors.*
- *Exposure effect = caused by change in traffic volume and patterns on a facility. Traffic volume and accident frequencies have a direct relationship.*
- *Trend effect = due to causal factors that are not recognized, measured or understood. For example, traffic composition (such as a higher/lower percentage of trucks or pedestrians), driver composition, enforcement level, etc. could have changed during the Before and the After period.*
- *Random effect = occurs because of a phenomenon referred to as regression-to-the-mean bias in statistics (if the site selection is made based on a short-term high prevalence of accidents, a lower accident rate would be expected in the after period, even if no intervention is made.*

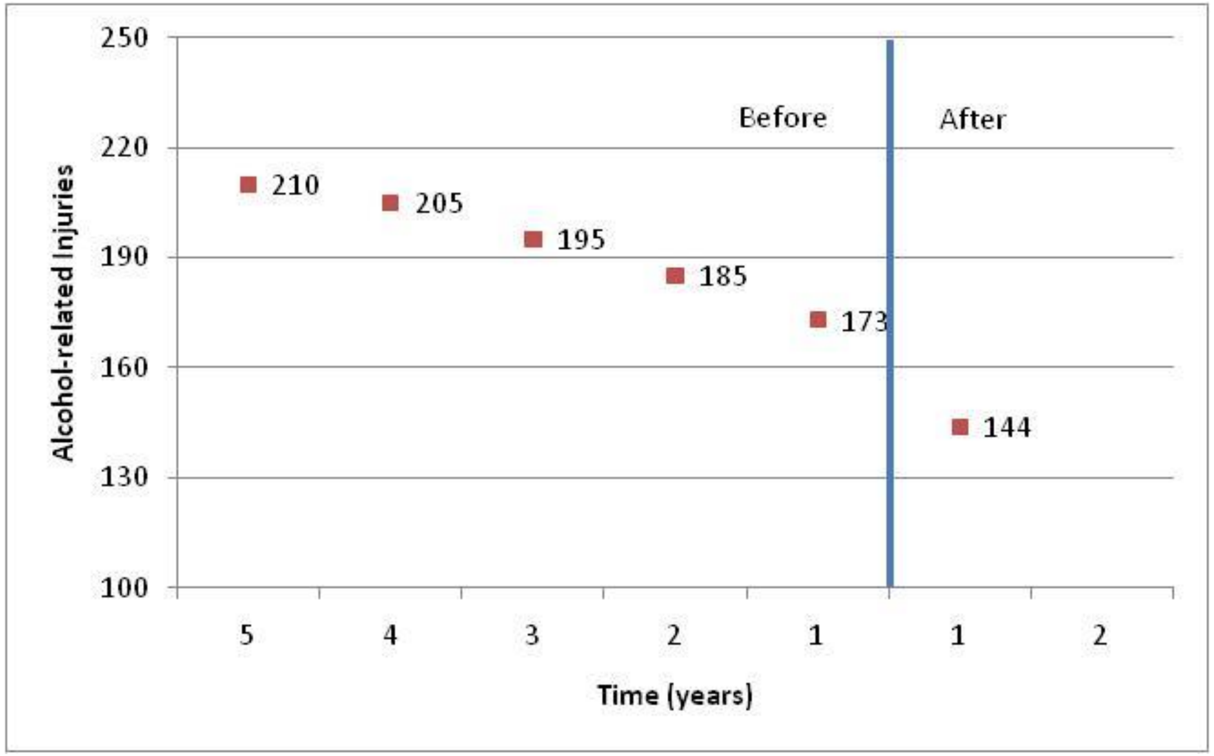
Methods of evaluating the impacts of Road Safety treatments

- *Cross-Section studies : the safety effects of one group of facilities are compared with another group. These two groups of facilities have some common features, and the safety impacts of those features that are not in common must be evaluated.*
- *Before-After studies: used when it is desired to study the safety implications of a certain improvement or operational change.*

Several commonly used methods for the evaluations of the impacts of the treatment as the difference between the Before and the After situations:

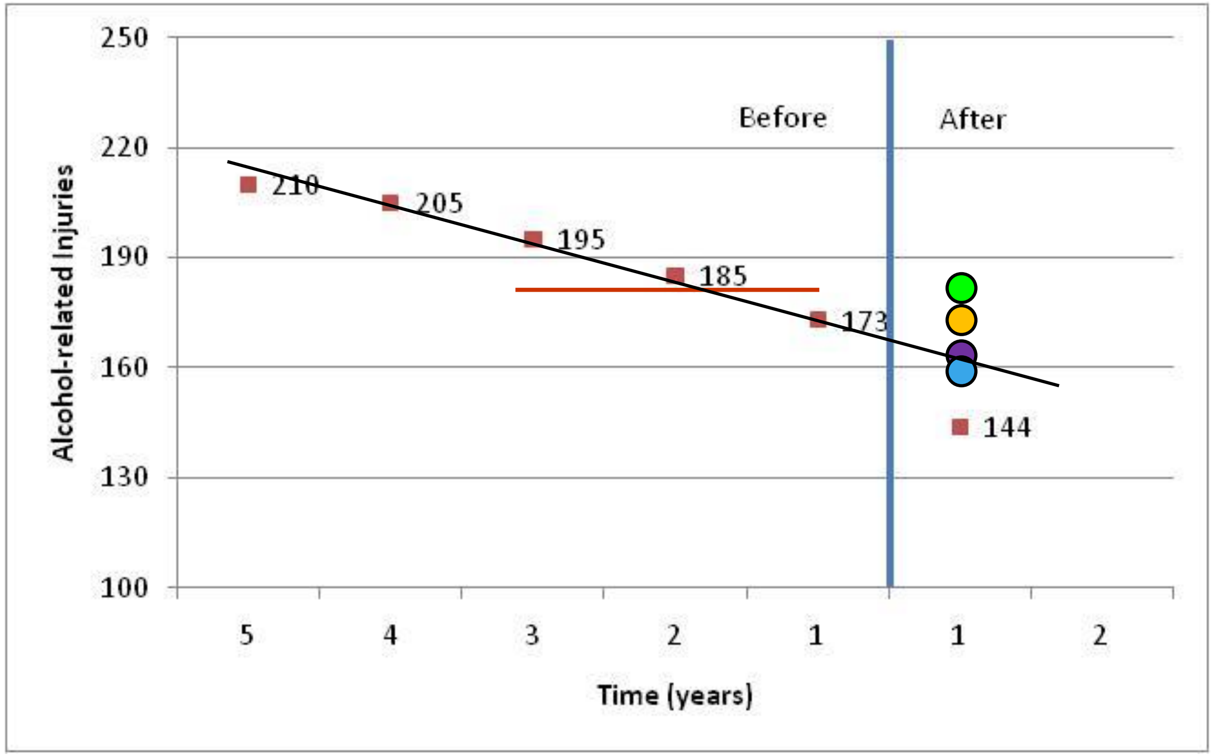
- *Simple comparison of Before-and-After situations,*
- *Before-and-After study with yoked comparison,*
- *Before-and-After with comparison group and,*
- *Before-and-After study with Empirical Bayes approach.*

Example One



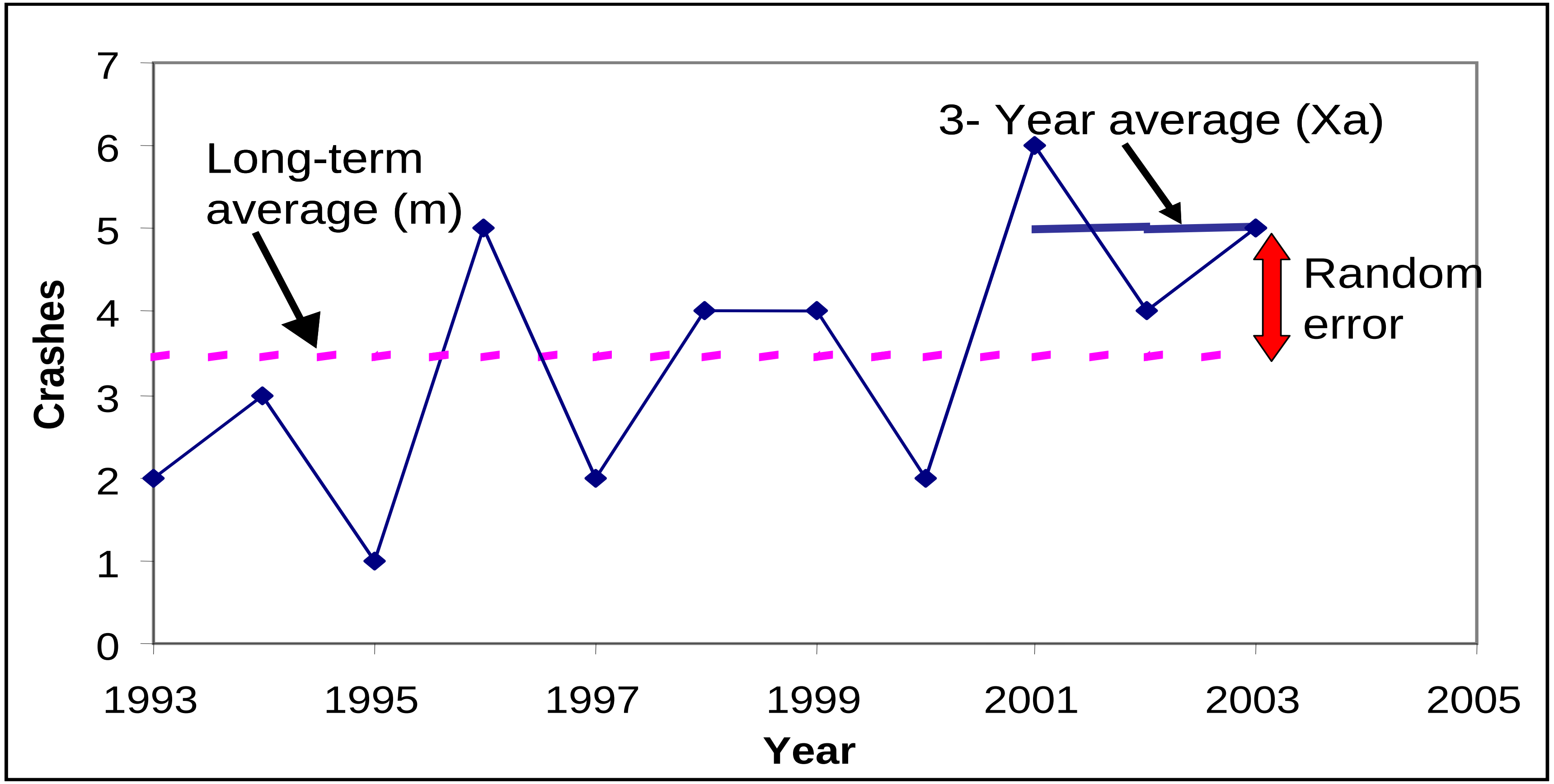
250
220
190
160
130
100
Alcohol-related Injuries
Before
After
210
205
195
185
173
144
5
4
3
2
1
1
2
Time (years)

Example One: Prediction



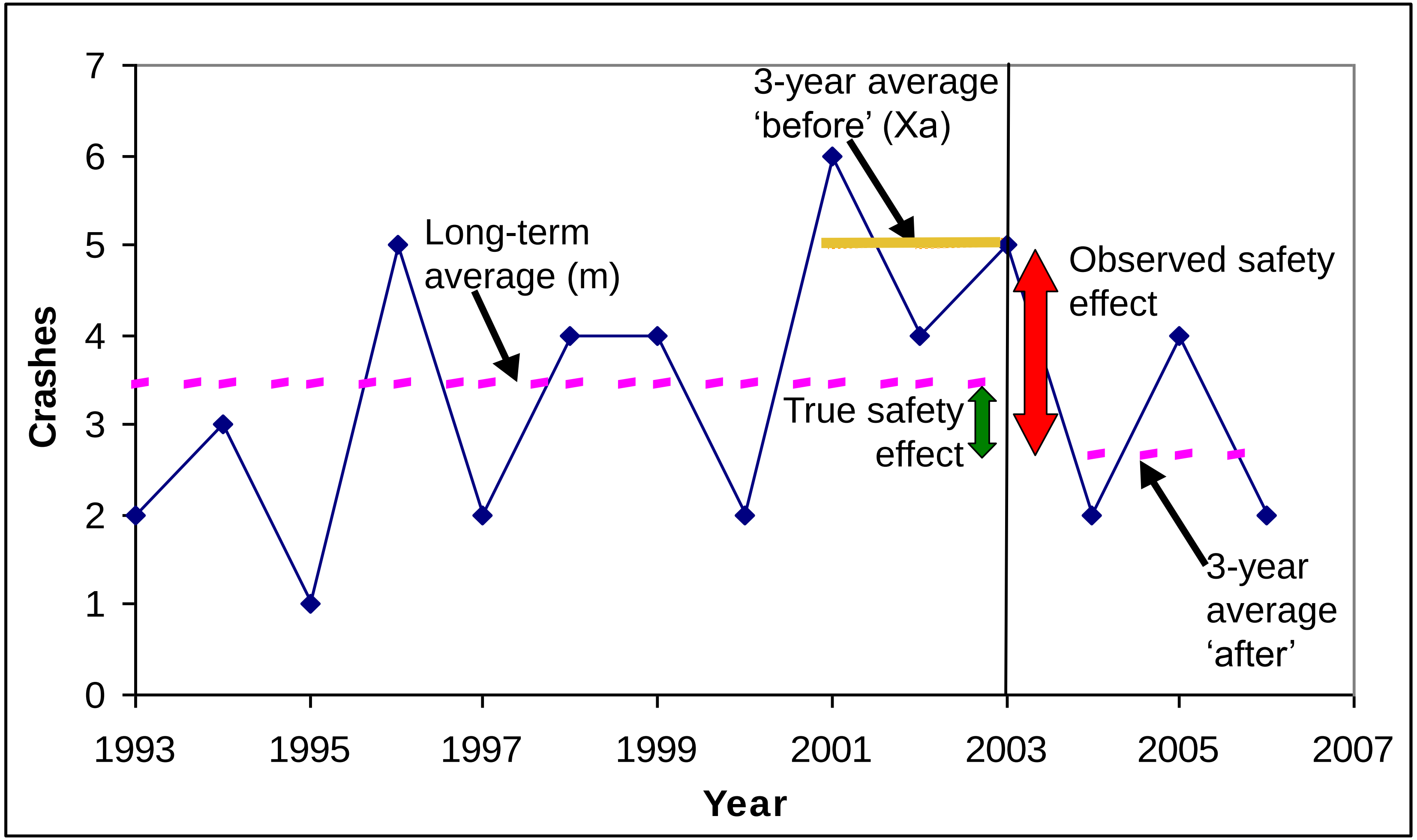
- Three-year before average (184)
- One-year before (173)
- Regression (165)
- Comparison group (160)

Example Two



Long-term average (m)
3- Year average (Xa)
Random error
Crashes
Year
0
1
2
3
4
5
6
7
1993
1995
1997
1999
2001
2003
2005

Example Two: True Safety Impact



Before and After Study with Simple Comparison Method

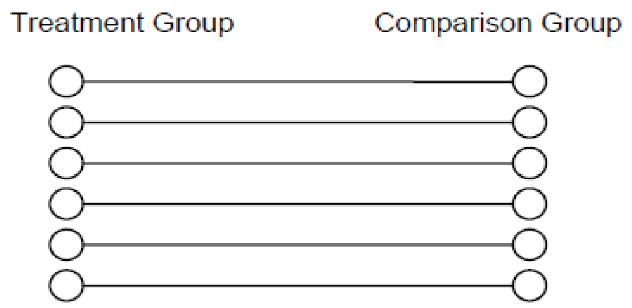
- *In this approach, accident counts in the before period are used to predict the expected accident rate and, consequently, expected accident counts if the safety treatment had not been implemented.*

- *The entire change in accident counts between the BA conditions is considered the impact of the treatment.*

- *The effect of the passage of time on the safety of a facility is ignored; this technique is unable to separate the treatment effect from the other effects described in Causal Factors Section.*

Before-and-After Study with Yoked Comparison

- *In this approach, the treated facility and untreated facility are referred to as the treatment site and comparison site, respectively.*



Source: Harwood, D.W. et al. “Safety Effectiveness of Intersection Left- and Right-Turn Lanes.” *Transportation Research Record*, No. 1840 (2003): 131–139.

- *For instance, if the treated facility is an intersection, the comparison site should be a similar intersection with respect to area type (commercial business district, urban, rural), intersection type (three-legged or four-legged), traffic control (signalized, two-way stop-controlled, etc.), geometric design and traffic volume.*

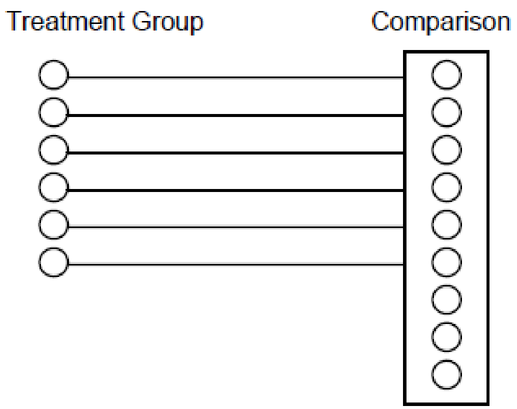
Before-and-After Study with Yoked Comparison

It still suffers three main issues:

- *It makes use of only one comparison site, and it is conceivable to have different estimates when other comparison sites are used. Consequently, the findings based on the evaluation of the facility will be variable with relatively wide confidence limits.*
- *It is unable to address the issue known as regression-to-the-mean bias. If the treatment site is chosen based on the fact that the agency has observed high accident counts in a short term, the accident frequency will likely be lower in the after period even if no treatment is applied. However, this method cannot identify whether the lower accident frequency is due to the treatment or the intrinsic randomness of accidents.*
- *It is unable to deal with cases where the comparison site has no history of accident occurrences.*

Before-and-After Study with Comparison Group

- *The rationale behind the before-and-after study with comparison group is the same as the yoked comparison technique; however, in this approach there is no need for a one-to-one matching between members of the comparison group and the treatment group.*



Source: Harwood, D.W. et al. "Safety Effectiveness of Intersection Left- and Right-Turn Lanes." *Transportation Research Record*, No. 1840 (2003): 131–139.

Before-and-After Study with the Empirical Bayes Approach

- *The EB method is a statistical approach to determine the appropriate weighting to place on each relevant factor to estimate accident outcomes for a treatment group.*

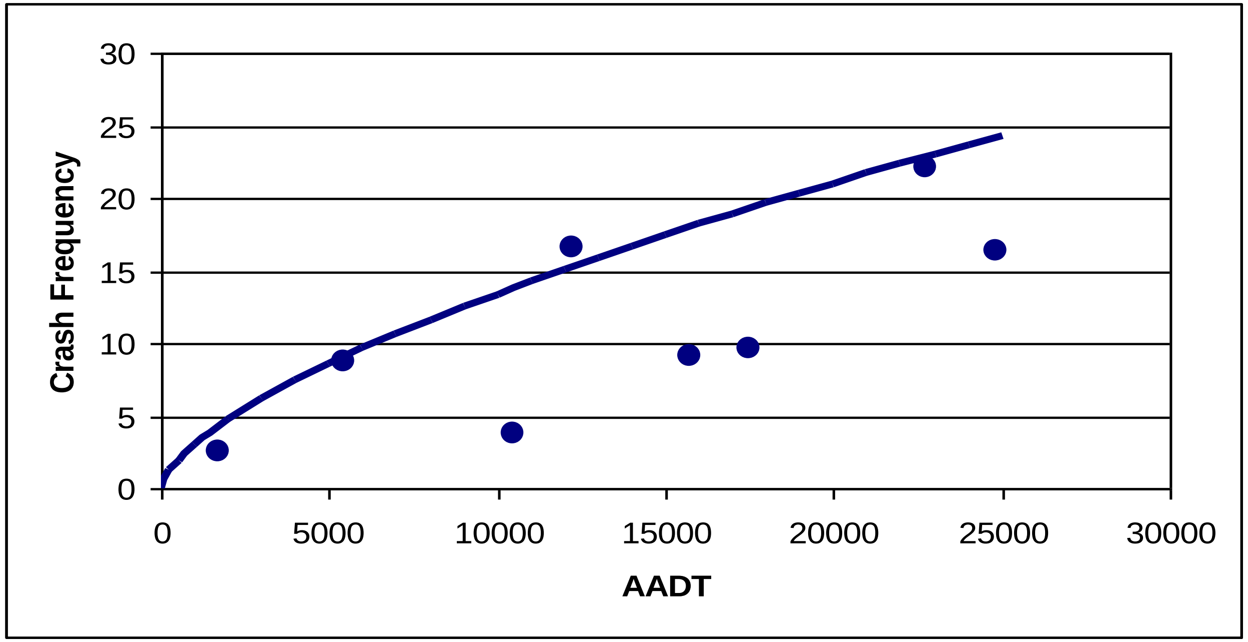
- *It determines a smoothed value for expected accidents and eliminates the randomness element of accidents.*

Before-and-After Study with the Empirical Bayes Approach

- *We know the short-term crash history for the site*
- *The long-term average crash history for that site would be even better, BUT…*
  - *Long-term crash records may not available*
  - *If the average crash frequency is low, even the long-term average crash frequency may be imprecise*
  - *Geometrics, traffic control, lane use, and other site conditions change over time*
- *We can get the crash history for other similar sites, referred to as a REFERENCE GROUP*

Before-and-After Study with the Empirical Bayes Approach

Safety Performance Function = Mathematical relationship between crash frequency per unit of time (and road length) and traffic volumes (AADT)



Before-and-After Study with the Empirical Bayes Approach

How Are SPFs Derived?

- *SPFs are developed using negative binomial regression analysis (a generalized Poisson where the variance is larger than the mean)*
- *SPFs are based on several years of crash data*
- *SPFs are specific to a given reference group of sites and severity level*
  - *Different road types = different SPFs*
  - *Different severity levels = different SPFs*

Before-and-After Study with the Empirical Bayes Approach

SPF Example: Regression model for total crashes at rural 4-leg intersections with minor-road STOP control

$$N_p = \exp(-8.69 + 0.65 \ln ADT_1 + 0.47 \ln ADT_2)$$

where:

N_p = *Predicted number of intersection-related crashes per year within 250 ft of intersection*

ADT_1 = *Major-road traffic flow (veh/day)*

ADT_2 = *Minor-road traffic flow (veh/day)*

Calculating the Long-Term Average Expected Crash Frequency

The estimate of expected crash frequency:

$$N_e \quad = \quad w\,(N_p) \quad + \quad (1 - w)\,(N_o)$$

Expected Accident Frequency

Predicted Accident Frequency

Observed Accident Frequency

Weight (w; 0<w<1) is calculated from the over dispersion parameter

Weight (w) Used in EB Computations

$$w = 1 / (1 + k N_p)$$

w = weight

k = overdispersion parameter for the SPF

N_p = predicted accident frequency for site

Summary

Table 3. Summary of Before-and-After Study Application.

Methodology	Ability to determine or account for:			
	Treatment Effect	Exposure Effect	Trend Effect	Random Effect
Before-and-After with Empirical Bayes	Yes	Yes	Yes	Yes
Before-and-After with Comparison Group	Yes	Yes	Yes	No
Before-and-After with Yoked Comparison	Yes	Yes	Potential	No
Naïve Before-and-After Study	Yes	Potential	No	No

Summary

Technique	Data Requirements	Strengths	Weaknesses
Before-and-After with Empirical Bayes	Accident counts in the before and the after periods Safety performance functions that suit the facility and the type of target accidents	Has a concrete theoretical background and is the preferred approach by researchers Addresses the issue of regression-to-the-mean bias	Safety performance functions do not exist for all facilities being analyzed
Before-and-After with Comparison Group	Accident counts in the before and the after periods for the treatment and comparison sites A comparison group that is in conformity with the treatment group in the before period	The treatment sites and comparison group sites need to be similar, but a one-to-one pairing is not required	Does not address regression-to-the-mean bias Conformity check between treatment group and comparison group is required in the before period
Before-and-After with Yoked Comparison	Accident counts in the before and the after periods A comparison group that has a one-to-one similarity with the treatment group	Simple to carry out Fewer data requirements	Has to be a one-to-one match between treatment and comparison sites; therefore different estimates are obtained when other comparison sites are used Does not address regression-to-the-mean bias
Naïve Before-and-After	Accident counts in the before and the after periods	Simple to carry out Few data requirements	Does not address regression-to-the-mean bias Does not account for exposure and trend effects over time

Thank You!

Благодаря!