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Short communication

An update on the association between setting quantified road safety targets and road fatality reduction

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ABSTRACT

This note is intended to rectify estimates provided in a previous paper (Wong et al., 2006) of the short-term effectiveness in terms of road fatality reduction of the setting of quantified road safety targets using data from 14 OECD countries during the period 1980–1999. This work is important in measuring the association between target setting and road safety improvement, because such targets are intended to serve as a useful tool to motivate timely road safety measures by the road authorities and others. The estimates to be rectified were based on before-and-after analysis using a comparison group of countries for each country that had set a target. This note first provides a correction to the qualification test for the inclusion of a country in any particular comparison group. It then presents the numerical effects of this correction on the estimates of the effectiveness of setting quantified road safety targets, both in individual countries and across the whole group of countries that set targets in the relevant period. Finally, impacts on the findings of the previous paper are discussed, with the conclusion that the changes in those of the numerical estimates that are affected do not alter the main message of the paper.
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1. Introduction

A quantified road safety target is a number or index that is set by a national or local government as a goal for reducing the numbers of people who are killed or injured in road traffic collisions. Setting a quantified road safety target serves as an effective catalyst that motivates decision making to support the formulation of comprehensive road safety strategy, as a framework for the development and implementation of objective-related, cost-effective and practical measure to meet the target (Elvik, 2008; OECD Scientific Expert Group, 2008; Wegman et al., 2008). Since the 1980s, a number of Organization for Economic Co-operation and Development (OECD) countries have established quantified road safety targets to motivate and monitor actions to reduce road accidents, injuries, and fatalities (OECD Scientific Expert Group, 1994). However, measuring the association between target setting and fatality reduction has been challenging. A few studies have attempted to measure the degree to which a quantified road safety target has been realized, and estimated the effectiveness of national road safety targets in reducing road fatalities (Elvik, 1993, 2001; Wong et al., 2006; Wong and Sze, 2010). Elvik (2001) made an early attempt with a treatment-comparison group approach to evaluating the effectiveness of target setting, in which the effects of confounding factors were to some extent controlled.

Wong et al. (2006) enhanced this approach by adopting a systematic approach to the selection of a comparison group of countries, based primarily on odds ratios calculated from historical road fatality data, for use in evaluating target setting in any one country. Recently, the authors have been led to investigate the validity of the formulation developed for the odds ratio qualification test for selecting the comparison group, which is an important step in estimating the effectiveness of setting quantified road safety targets in reducing road fatalities. This note first provides a correction to the formulation of the odds ratio qualification test for the selection of the comparison group and then reports consequential changes in the numerical estimates of effectiveness of setting quantified targets in reducing fatalities in the short run in a few of the countries studied, and thus in all the countries taken together, compared with those presented in the original paper (Wong et al., 2006). Finally, a brief discussion is provided.

2. Rectification of qualification test

The main question that the previous study addressed was whether countries with quantified road safety targets were more successful in reducing road fatalities than countries without such targets in the first 3 years after the setting of such a target, based on

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before-and-after analysis using a comparison group of countries. A rigorous qualification test was conducted for careful selection of an appropriate comparison group by the use of historical fatality data of both treatment and comparison countries (Wong et al., 2006).

On pp. 999–1000 of the original paper (Wong et al., 2006), for each treatment country and its corresponding group of candidate comparison countries, the following notation was used, except that heading of the last column has been clarified here.

Period	Number of fatalities in the treatment country	Number of fatalities in a candidate comparison country
1	K_1	M_1
2	K_2	M_2
...		
p	K_p	M_p
...		
P	K_P	M_P

Thus K_p and M_p are the observed number of fatalities in the treatment country and the candidate comparison country in period p, respectively, and P is the number of periods for which data are available before the implementation of the road safety target in the treatment country. Each period is 1 year in length. The odds ratio between period p and period $p+1$ is defined as $(M_{p+1}K_p)/(K_{p+1}M_p)$. The logarithm transformation of the odds ratio is taken, and for the transition from period p to period $p+1$ an unbiased estimate of the logarithm of the odds ratio from the four observed numbers is

$$\begin{aligned}\hat{Y}_p = {} & (\ln M_{p+1})\left(1-\frac{1}{2M_{p+1}\ln M_{p+1}}\right)^{-1} \\ & +(\ln K_p)\left(1-\frac{1}{2K_p\ln K_p}\right)^{-1} \\ & -(\ln K_{p+1})\left(1-\frac{1}{2K_{p+1}\ln K_{p+1}}\right)^{-1} \\ & -(\ln M_p)\left(1-\frac{1}{2M_p\ln M_p}\right)^{-1} \end{aligned} \tag{1}$$

The mean of the logarithm of the odds ratio over the $P-1$ transitions can then be estimated by

$$\bar{Y} = \frac{1}{P-1}\sum_{p=1}^{P-1}\hat{Y}_p \tag{2}$$

If the changes over the years in the number of fatalities in the candidate comparison country were similar to those in the treatment country, then the long-term expectation of this odds ratio would be unity. Assuming that the sample mean is then normally distributed around $\ln(1)=0$ and the variance of $\bar{Y}$ is estimated by $s_{\bar{Y}}^2$, the limits for rejection of this null hypothesis at the significance level of 5% are $\pm 1.96 s_{\bar{Y}}$. A candidate is rejected if $\bar{Y} < -1.96 s_{\bar{Y}}$ or $\bar{Y} > 1.96 s_{\bar{Y}}$. In this way, a suitable group of one or more comparison countries is established for each treatment country, which will, in turn, form the basis for the evaluation of the road safety performance of the treatment country (Hauer, 1997; Allsop, 1995).

It was stated in the previous paper that $s_{\bar{Y}}^2$ was estimated by

$$s_{\bar{Y}}^2 = \frac{1}{(P-1)}\left\{\frac{1}{(P-2)}\left(\sum_{p=1}^{P-1}\hat{Y}_p^2-(P-1)\bar{Y}^2\right)\right\} \tag{3}$$

However, there are two problems with this estimate.

First, the expression given in Eq. (3) for the estimated variance of $\bar{Y}$ assumes that

$$\mathrm{var}\left(\sum_{p=1}^{P-1}\hat{Y}_p\right) = \sum_{p=1}^{P-1}\mathrm{var}(\hat{Y}_p) \tag{4}$$

but this is true only if $\mathrm{cov}(\hat{Y}_p, \hat{Y}_q) = 0$ for all $q \neq p$. In this case the covariance can be assumed to be zero for values of q other than $p+1$, but $\hat{Y}_p$ and $\hat{Y}_{p+1}$ must have a negative covariance because, to first order, $\hat{Y}_p$ contains the term $(\ln M_{p+1} - \ln K_{p+1})$ and $\hat{Y}_{p+1}$ contains the term $(\ln K_{p+1} - \ln M_{p+1})$.

In fact, expanding $\mathrm{cov}(\hat{Y}_p, \hat{Y}_{p+1})$ including only the first order terms gives, if the numbers of fatalities are assumed to be approximately Poisson-distributed:

$$\mathrm{cov}(\hat{Y}_p, \hat{Y}_{p+1}) \approx -\mathrm{var}(\ln K_{p+1}) - \mathrm{var}(\ln M_{p+1}) \approx -\frac{1}{K_{p+1}} - \frac{1}{M_{p+1}} \tag{5}$$

Secondly, the $\mathrm{var}(\hat{Y}_p)$ estimated in Eq. (3) by $(\sum_{p=1}^{P-1}\hat{Y}_p^2 - (P-1)\bar{Y}^2)/(P-2)$ refers to the total variance that is due to the variability of the odds ratio and the variability of the observed counts (Hauer, 1997, pp. 133–138), neither of which can be negative. On the assumption that the numbers of fatalities are approximately Poisson-distributed it is possible to estimate the latter component by

$$\frac{1}{(P-1)}\sum_{p=1}^{P-1}\left(\frac{1}{K_p}+\frac{1}{M_p}+\frac{1}{K_{p+1}}+\frac{1}{M_{p+1}}\right) \tag{5}$$

Hence, the right hand side of Eq. (3) cannot be less than

$$\frac{1}{(P-1)^2}\sum_{p=1}^{P-1}\left(\frac{1}{K_p}+\frac{1}{M_p}+\frac{1}{K_{p+1}}+\frac{1}{M_{p+1}}\right) \tag{6}$$

These two problems are addressed by taking the sample variance $s_{\bar{Y}}^2$ of $\bar{Y}$ to be given by

$$\begin{aligned}\mathrm{Max}\Bigg\{ & \frac{1}{(P-1)(P-2)}\left(\sum_{p=1}^{P-1}\hat{Y}_p^2-(P-1)\bar{Y}^2\right), \\ & \times\frac{1}{(P-1)^2}\sum_{p=1}^{P-1}\left(\frac{1}{K_p}+\frac{1}{M_p}+\frac{1}{K_{p+1}}+\frac{1}{M_{p+1}}\right)\Bigg\} \\ & -\frac{2}{(P-1)^2}\sum_{p=2}^{P-1}\left(\frac{1}{K_p}+\frac{1}{M_p}\right)\end{aligned} \tag{7}$$

Table 1 presents the results of odds ratio qualification test, with the original variance estimates given by Eq. (3) and the modified estimates given by Eq. (7), respectively. Among the nine treatment countries under investigation, no change in the set of comparison countries passing the odds ratio qualification test was found for six of the countries, namely Netherlands (number of comparison countries selected equal to 7), Sweden (3), New Zealand (3), Australia (3), Hungary (3), and Spain (1).

Among the other three treatment countries for which the results of the odds ratio qualification test were changed, the number of comparison countries that were selected increased from three to four (Iceland has been added) for Norway, and decreased from two to one (Spain has been dropped) for Finland. For Denmark, the selected comparison group now comprises Australia and Hungary instead of Australia and Spain. There was no change in the results of pooled odds ratio qualification test (illustrated in the right-most

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