DISCLAIMER

This manuscript is work in progress. We are showing the methodology we consider is the most suitable for our purposes rather than a number of results. In any case, we would like to show consistent results but unfortunately the information depending on the City Council has been difficult to obtain because of the internal processes they follow, delaying the expected peace of the project. Similarly, we contacted the authors of the Functional Capacity Index and asked them the AIS-FCI conversion tables/algorithms but we have not received them to the date.

We are presenting results of the cost-benefit analysis based on partial information from the City Council about the cost of the installation and functioning of the speed cameras. Results of the cost-effectiveness analysis are pending but we are presenting the cost per injured person avoided as the simplest analysis we could undertake.

Other considerations and assumptions were taken into account and appear in the discussion.

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Title: "Speed cameras in the beltways of Barcelona. A cost-benefit and cost-effectiveness analysis"

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ABSTRACT

Background

A previous study showed that the installation of speed cameras in the beltways of Barcelona is effective in reducing road injuries in an urban setting. This study aims to perform a cost-benefit and a cost-effectiveness analysis of the installation of speed cameras in the beltways of Barcelona.

Methods

The cost-benefit analysis considered all costs derived from installation and operation of the speed cameras. Benefits included value of statistical life, insurance compensation, fatalities and injuries avoided. The net present value was obtained subtracting benefits from costs. The cost-effectiveness analysis considered a similar costs structure. The effectiveness variable was Life-Years Lost to Injury. Both analysis had a societal perspective, temporal horizon of 2 years (04/2003-03/2005) and differential discount rate in the cost-effectiveness analysis. A sensitivity analysis was performed to test the stability of the results.

Data

Costs (euros 2005) data came from the City Council. Life-years lost to injury for each injured person were obtained translating IDC-9-CM codes to functional capacity index scores and multiplying them by the life expectancy in Barcelona. Injuries avoided were estimated based on a temporal series analysis.

Results

This is work in progress. We expect that installation of the speed cameras in the beltways of Barcelona provides positive net economic benefits and that the incremental cost per Life-year gained is below the Spanish cost-effectiveness threshold of 30.000€ per Life-year gained.

Conclusions

The use of speed enforcement devices in urban contexts is a public health intervention suitable to reduce the economical impact derived from crashes, injuries and fatalities.

Speed cameras in the beltways of Barcelona. A cost-benefit and cost-effectiveness analysis

INTRODUCTION

Injury is the worldwide leading cause of death from ages 1 to 45 and accounts for more years of potential life lost before age 75 than either cancer or heart disease, being motor vehicle injury the largest single component of these losses[1]. At the present, over a million people die each year and about 10 million people bear permanent disabilities as a result of road traffic crashes[2]. In Europe, it is estimated 127 thousand people die and 2,4 million are injured yearly as a consequence of traffic crashes[3]. In Barcelona, there are over ten thousand motor vehicle crashes annually, more than thirteen thousand people injured every year, and around 50 road traffic deaths[4]. If present trends continue, road traffic crashes will represent the third leading contributor to the global burden of disease and injury by 2020[5]. This important health burden is accompanied by other adverse transport-related health effects such as air pollution, global warming and noise among others[6]. According to NHTSA, the cost of unsafe speed related collisions to the American society exceeds 40 billion US dollars per year[7]. The cost of traffic crashes in the European Union could reach the order of tens of billions of euros[3] and in the case of Spain, the cost was estimated in 6.280 million euros, calculated for year 1997[8]. A recent study assessed the cost of traffic accidents in Spanish region finding a number ranging between 1,339.16 and 1,517.6 millions of euros[9]. In the case of Barcelona, traffic accidents represented a minimum of 367€ millions in 2003[10].

Speed enforcement appears as a suitable pre-crash strategy (in accordance to Haddon's matrix[11]) in sites where there is a speed related crash problem. One of the speed enforcement tools available nowadays is what has been called 'speed cameras'. The use of this type of automated speed enforcement technology is common in different countries around the world[12] leading to an increasing interest in the evaluation of its effectiveness. A recent systematic review assessed the effectiveness of speed cameras in reducing road traffic collisions and related injuries finding that all the studies reported a reduction in road traffic collisions and casualties with sizes of the reported effects varying between 5 and 69% for accidents, 12-65% for injuries and 17-71% for fatalities[13]. A more recent systematic review assessed the effectiveness of speed detection devices in general, reporting a reduction from 7% to 23% in injury related crashes; 30% pre/post injury crash reduction in urban and a 20% reduction in rural areas, and between 13% and 17% pre/post reduction in crashes resulting in fatalities[14].

To our knowledge, few studies have assessed the economic impact of speed cameras. Elvik conducted a safety and economic evaluation of the photo radar program in highways of Norway[15]. The UK Home Office Police Research Group published a cost-benefit analysis of red light and speed cameras[16]. A study assessed the effectiveness of the Great Britain national photo radar program and calculated the economic benefit following the UK Department of Transportation valuation method[17]. The most recent analysis was conducted by Chen and analyzed the economic impact of a speed program in British Columbia[7]. Despite the different methodologies and approaches used, all of these analysis have found that speed cameras are an efficient public health intervention.

During the last decade under the Municipal Road Safety Plan of Barcelona, several initiatives have been developed, such as public campaigns, speed, seatbelt, helmet and alcohol enforcement. The road injury information system, includes information from sources like police data on crashes occurred in the city, information on hospital emergency discharges due to road traffic crashes (DUHAT) and hospital discharges due to road traffic crashes (CMBD), and autopsies of case fatalities. Under this framework, eight speed cameras came into operation in the beltways of the city of Barcelona on 26th March 2003, with the aim of reducing the number of road crashes and their consequences. One study was carried out to assess its effectiveness. The period of study included from 1st January 2001 to 31st March 2005, speed cameras functioning for 24 months of this period. The pre-intervention period included from 1st January 2001 to 31st March 2003. The post intervention period included from 1st April 2003 to the 31st March 2005. The results show a protective effect reducing crashes, people injured and vehicles involved in crashes[4].

Economic evaluation is a very useful tool for both policy-making and decision-making processes and offers valuable information, demonstrating fiscal responsibility along with intervention effectiveness[18-20]. Therefore, our study aims to perform a cost-benefit and a cost-effectiveness analysis of the installation of speed cameras in the beltways of Barcelona.

MATERIALS AND METHODS

COST-BENEFIT ANALYSIS

Cost-benefit analysis places monetary values on all significant outcomes, including death, pain, grief and property loss, so that benefits are directly compared to costs in monetary terms[19].

The cost-benefit analysis was set from a societal perspective. The temporal horizon for analysis is 2 years (04/2003-03/2005). The alternative for comparison is the no existence of the program. The analysis involves the identification of costs and benefits, setting money values to them (discounting to 2005) and then calculating the net present value. We applied the corresponding consumer price index to all costs found in values different to 2005 (3.4%-2003; 4.2%-2004). The costs structure and denomination is similar to those used in previous studies[7,16,21,22].

Costs

The speed cameras installation costs were subdivided into implementation costs, police costs, maintenance costs and photo/tickets processing and delivery.

Implementation costs. These costs include photo radar equipment purchasing and installation. According to the Department of Safety and Mobility of Barcelona City Council, the total expenditure for the speed cameras installation was 1,388,554.89 euros in 2003. This value was updated to 2005 values and amortized over a 10-year period corresponding to the estimated economic life of the equipment[23]. In consequence, the annualized cameras cost was 130,884.62 euros in 2005.

Police costs. There were ??? police members dedicated to the monitoring and control of the photo radar units. The police costs were calculated by summing up the number of officers multiplied by their respective standard costing rate. The typical yearly police cost for the photo radar program was around ??? annually.

Maintenance Costs. The equipment maintenance costs pay for the regular checks and repairs of the speed cameras and related equipment. The annual costs were 99,874.77 Euros in 2003 according to the Department of Safety and Mobility of Barcelona City Council. Updating to 2005 values the cost was 101.296,31 Euros.

Photo/Tickets Processing and delivery. The photograph and violation tickets processing costs include photograph processing, data management and analysis, and tickets generating and mailing expenses. The annual costs were ???.

Benefits

The main benefits considered were medical costs associated to injured people avoided, private property damages avoided and productivity losses avoided.

Injured people avoided. The study assessing the effectiveness of the speed cameras installed in the beltways of Barcelona, used time series analysis method and Poisson regression models adjusting for potential confounding by linear trend and seasonal patterns using sine and cosine functions. The relative risks (RR) were derived from the adjusted models, and the attributable fraction was calculated from RR (RR-1/RR) to estimate the number of prevented crashes, and reductions in numbers of people injured and vehicles involved. During the first two years of speed cameras operation, it was estimated that 364 crashes were avoided, 507 fewer people injured and 789 fewer vehicles involved in crashes[4].

We assumed that these 507 people injured avoided would follow a similar pattern of resources consumption (e.g. emergencies and hospitalizations) to that observed in people injured by vehicle car crashes in 2003 in the city of Barcelona. After this consideration we assumed that all the injured people avoided would have gone to an emergency service. We multiplied the number of emergencies attended by the corresponding tariff. Data sources were DUHAT for emergencies attended and Catalan Health Service for tariffs. Similarly, we assumed that around 15% of those attended in an emergency room would have been hospitalized subsequently (N=76), following the trend observed in 2003. We considered that 2,180 emergencies attended led to 29,890 in-hospital days in 2003. In consequence, we assumed 76 emergencies would led up to 1,024 in-hospital days. The distribution of these days by hospital complexity and length of stay emulated the one observed in people injured by vehicle car crashes in 2003. To calculate the cost of hospital discharges, we used reimbursement tariffs which depend on the level of complexity of the hospital and the hospital length of stay. Then, the total cost of discharges was calculated summarizing the products of the hospital length of stay multiplied by the corresponding reimbursement tariff value. Discharge data were obtained from the Hospital Discharge Register for 2003 and reimbursement tariffs from the framework agreement between insurance companies and hospitals in Barcelona for 2005. Table I summarizes these numbers.

Private property damages avoided. Data on private propriety damages was obtained from insurance companies and corresponded to 439.7 million euros in 2003 for Barcelona city as a whole. Crashes in the beltways of Barcelona accounted for 5% of the total crashes occurred in Barcelona in 2003, we used this value to calculate the private property damages derived from motor vehicle crashes in the beltways, being 2.2 million Euros in 2005.

Productivity losses. We calculated short-term productivity losses taking the annual average wage in Catalonia (the region Barcelona belongs to) and set in 20,728.60€ in 2002 by the Salary Structure Survey 2002 (National Statistics Institute), and updating this value we obtained 23.216,03 in 2005. This value was divided by 365 days and we obtained a wage/day estimate of 63,61€ in 2005. This value was then multiplied by the number of days off from work on sick-leave. Sick-leave days were set in 2 days for each of the injured people avoided that would have not been hospitalized (N=431) following the criterion used in a study carried out in Barcelona[24]. The in-hospital days (1,024) were also multiplied by the average wage/day in 2005.

Discounting

A 3% discount rate was used for the implementation and maintenance costs in the base case scenario in accordance with the Panel on Cost-Effectiveness in Health and Medicine[25].

Sensitivity analysis

We tested a second scenario, where the installation of speed cameras avoided at least one death. For this scenario we use the value of one statistical life in Barcelona calculated by contingent valuation/standard gamble chained approach[26]. A third scenario tested different discounting rates (5%, 10% and 20%). The fourth scenario included the confidence intervals for injured people avoided in the analyzed period.

COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is a type of economic analysis designed to assess the comparative impacts of expenditures on different health interventions[27]. A cost-effectiveness analysis evaluates a given health intervention through the use of a ratio. All changes in resource use are included in the numerator (the difference in cost between an intervention and the alternative) and all health effects of an intervention are included in the denominator (the difference in effectiveness between an intervention and the alternative)[19].

Costs

In our study the numerator of the cost-effectiveness ratio included implementation costs, police costs, maintenance costs and photo/tickets processing and delivery calculated in the cost-benefit analysis.

Effectiveness

All the patients having a road traffic crash and recorded in DUHAT in the period 04/2003-03/2005 were taken as the population sample. Diagnosis was obtained as an ICD-9-CM code and then transformed into an Abbreviated Injury Scale (AIS) code using the software ICDMAP.

Because the main benefits of the intervention studied are not fatalities but injuries avoided, we are interested in an outcome variable that better reflect the likely degree of functional limitation in the study population. The Functional Capacity Index (FCI) represents a person's lost functional ability due to an injury that remains one year after the crash occurred[28]. Consequently, the FCI is an outcome variable gathering information for our purpose. Through the use of AIS-FCI conversion tables it is possible to obtain a FCI score ranging from 0 (representing death) to 1 (representing no limitations). This is calculated for each of the injuries sustained by the study individuals but taking only the individual's maximum FCI value (maxFCI) to assure that each injured person has just one record.

After having an index gathering information on predicted disability at one year after the crash it is feasible to adjust this information to the life expectancy of the individuals in order to obtain a measure of Life-Years Lost to Injury (LLI).

The following formula relates LLI and FCI:

LLI = FCI x Life expectancy remaining before the crash[29]

The life expectancy of each individual is estimated by cross-linking the person's age and sex in the sample set with a life-expectancy table for the Barcelonese population. The LLI of each injured person is then calculated[29,30].

LLI was set as the denominator of the cost-effectiveness ratio.

Discounting

We applied differential discounting following the recommendations proposed by Brouwer et al.[31], therefore we applied a discount rate of 1.5% to health effects and 3.5% for costs[31].

Sensitivity analysis

We tested a second scenario applying a homogenous discounting rate of 3%, 5%, 10% and 20%. The third scenario takes into account the confidence intervals for injured people avoided in the analyzed period.

As soon as the data become available, we will calculate LLI for our study population. In order to present some cost-effectiveness information in this preliminary paper, we calculated the cost per injured person avoided. For this analysis we did not applied a differential discounting rate.

RESULTS

Table 2 presents the results of the cost-benefit analysis by type of cost, and by each specific component estimated. The total annual cost of the speed cameras functioning was estimated in 232 thousand Euros. Medical costs associated to injured people avoided were estimated in 204 thousand Euros. Private property damages were 2.2 million Euros. Productivity losses were estimated in 113 thousand Euros. Total benefits were estimated in 2.5 million Euros. The estimated annual net benefit of the speed cameras installation is 2.3 million Euros.

Results of the sensitivity analysis are shown in Table III. The use of different scenarios suggested that the net benefit can be up to 3.3 million Euros when it is taken into account the value of one statistical life. The use of different discounting rates showed net benefits ranging from 1.7 million Euros to 2.3 million Euros. Having into account confidence intervals for injured people avoided showed net benefits between 2.1 and 2.5 million Euros.

Cost-effectiveness results are shown in Table 4. These estimates suggest that the cost per injured person avoided is around 458 Euros. The use of confidence intervals for injured people avoided showed that the cost per injured person avoided could be in the range from 165€ to 1297€.

DISCUSSION

Our preliminary results show that the installation of speed cameras in the beltways of Barcelona has net benefits for the society even under fairly conservative assumptions. The program was successful in reducing injury collisions, with an estimated net economic benefit of approximately 2.3 million Euros per year. These results are similar in all the scenarios tested in the sensitivity analysis. The program produced net savings of at least 1.7 million Euros per year, even under the most unfavourable scenario. The estimated cost per injured person was around 458 euros and in the most unfavourable sensibility analysis scenario it was around 1,300 euros. There were no important changes in the results after using different discounting rates. Limitations of the study resulted from deficiencies in the availability of data, for example the lack of availability of data on rehabilitation costs. As better data become available, the approach can be refined and improved. However, these estimates are based on the best data currently available.

We did not estimate the costs of services of family members and friends who cared for the injured nor any grief, pain or quality of life. We considered to assess them using compensation payouts as a proxy. The limitation of this approach is that it is unknown the percentage of this amount covering each of the intangible losses being compensated. We did not calculate other benefits derived from the intervention such as environmental damage and clean-up costs avoided, road congestion costs avoided resulting from crashes and the accompanying emergency response[32]. On the other hand, we did not calculate costs due to reductions in speed or benefits the law violators enjoy from speeding because of the discussions and the lack of unanimity in regards to this issue[21,33]. We assigned the average wage to each day off from work on sick-leave to assess the productivity losses, even when this method implicitly accounts for work not being lost on scheduled days off or leisure time[34].

Data of the Hospital Discharge Register 2001-2002 was not available, so we assumed that the consumption of healthcare resources of injured people avoided at the beltways would be similar to that of injured people from motor vehicle crashes in Barcelona as a whole in 2003. The maximum allowed speed in the beltways is mostly 80 km/h (49.7 m/h), with some stretches limited to 60 km/h (37.3 m/h), and there are no traffic lights or intersections. These speeds are higher than the average in the rest of the city and it is likely that the injuries profile in those involved in road traffic crashes in the beltways is more complex than those occurred in other roads of the city, leading to a longer hospital length of stay. Therefore, we set a lower limit assumption for sick-leave, hospital length of stay and productivity losses in comparison to other studies[35,36].

However, the study assessing the effectiveness of the speed cameras installation did not predict fatalities avoided because of the small number observed in the period 2001-2002[4]. For this reason, in the sensibility analysis we used a scenario where it was possible to avoid at least one fatality even when it is likely that the intervention avoided a slightly higher number of fatalities, in which case the benefits would be also higher, knowing that the value of a statistical life following a willingness to pay approach was estimated to be between 1 and 2,6 million Euros in Barcelona[26].

A more detailed characterization of the injuries in the beltways of Barcelona would show results similar to those reported elsewhere: injuries classified as AIS I are the ones with the highest share of costs because of its frequency and the long-term morbidity they represent[29,37]. It is necessary to point out that AIS classification was developed as a standardized injury severity assessment tool and not as a cost tool; for this reason it does not capture intangible traits. For example, often minor injuries classified as AIS I would lead to high costs. As an example, a broken tooth after a road traffic crashes is classified as AIS I but psychological impact and rehabilitation costs are important[38]. Supporting this statement, there are a number of publications examining the psychological impact of RTC, its related costs and the time of symptoms for minor injuries such as whiplash or back strain[39-47]. Others have found that property damage is neither a valid predictor of acute injury risk, presence, severity nor of symptoms duration[48]. We tried to surpass the limitations of classification systems such as AIS by incorporating the FCI and its derived measure, LLI in our cost-effectiveness analysis. The FCI has flaws regarding health services use prediction as well as function prediction but preliminary analyses suggest that the second revision of the FCI provides better predictions for individuals experiencing minor injuries[49-51]. It is also our intention to improve the calculation of LLI by including simulations to extrapolate survival to derive life expectancy for different disability grades following road traffic crashes[52].

With this sort of analysis our group intend to support the process of evidence-based policy and decision making, undertaking economic evaluations of safety measures looking forward to provide quality information to politicians and to the public opinion in regards to interventions raising so many different opinions but that have demonstrated remarkably its effectiveness and success[53].

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Table 1 Injured people in road traffic crashes, emergencies attended and discharges observed 2003 and values used for the study period 2003-2005

		2003	2003-2005
Injured people		13,480[A]	507[D]
Emergencies	Number	14,748[B]	507[E]
	Cost		88.04€[F*]
Discharges	Number	2,180[C]	76[G]
	Total number of in-hospital days	29,890 [C]	1,024[H]
	Cost		205.65€[I*]

A – Local Police, 2003
B – DUHAT, 2003
C - Hospital Discharge Register, 2003
D - Pérez K, Marí-Dell'Olmo M, Tobias A, Borrell C. Reducing road traffic injuries: effectiveness of speed cameras in an urban setting. Submitted to Am J Public Health. 2006.
E - Based on the observed cases in 2003, we assumed that all the injured people involved in road traffic crashes in the beltways of Barcelona were attended in an emergency service.
F – Reimbursement tariffs 2005, *mean value.
G – Estimated number of emergencies becoming hospitalised based on the observed cases in 2003.
H – Estimated in-hospital days, based on observed cases in 2003.
I – Tariffs from the framework agreement between insurance companies and hospitals in Barcelona-2005, *mean value.

Table 2 Costs and benefits of the installation of speed cameras in the beltways of Barcelona

Description	**Annualized cost/benefit (€ 2005)**
Implementation costs	130,884.62
Police costs	?
Maintenance costs	101,296.31
Photo/tickets processing and delivery	?
Total cost	232,180.92
-Medical costs	204,306.62
-Private property damages	2,229,791.69
-Productivity losses	113,073.90
Total benefits	2,535,444.17
Net benefit	-2,322,236.41

Table 3 Sensitivity analysis results

Description	Base case (€)	Discount rates			Injured people reduction (confidence intervals)		Fatality reduction
		5%	10%	20%	179	902	1
Implementation costs	130,884.62	125,946.02	114,756.60	96,427.42	130,884.62	130,884.62	130,884.62
Police costs	?						
Maintenance costs	101,296.31	91,878.74	75,932.84	52,731.14	101,296.31	101,296.31	101,296.31
Photo/tickets processes	?						
Total cost	232,180.92	217,824.76	190,689.44	149,158.56	232,180.92	232,180.92	232,180.92
Injury/Fatality costs	211,551.75	211,551.75	211,551.75	211,551.75	76,123.09	382,969.39	1,211,551.75
Private property damages	2,229,791.69	2,145,656.24	1,955,029.75	1,642,768.06	2,229,791.69	2,229,791.69	2,229,791.69
Productivity loss	113,073.90	108,807.35	99,140.58	83,305.62	40,315.74	203,155.28	113,073.90
Total benefits	2,554,417.34	2,466,015.34	2,265,722.08	1,937,625.43	2,481,659.18	2,644,498.72	3,554,417.34
Net benefit	-2,322,236.41	-2,248,190.58	-2,075,032.64	-1,788,466.87	-2,114,049.59	-2,583,735.43	-3,322,236.41

Table 4 Cost-effectiveness results of the installation of speed cameras in the beltways of Barcelona

		Discount rates		
Description	Base case	5%	10%	20%
Implementation costs	130,884.62	125,946.02	114,756.60	96,427.42
Police costs	?			
Maintenance costs	101,296.31	91,878.74	75,932.84	52,731.14
Photo/tickets processes	?			
Total cost	232,180.92	217,824.76	190,689.44	149,158.56
Injured people avoided	507	507	507	507
CI min	179	179	179	179
CI max	902	902	902	902
Cost per injured person avoided	457.95	429.63	376.11	294.19
	CI min			
	1,297.10	1,216.89	1,065.30	833.28
	CI max			
	257.40	241.49	211.40	165.36