INTRODUCTION

The motor car - after smoking, alcohol and drugs – is society's 4th addiction. International Road Federation Statistics show that in 1990 over 500, 000 people were killed in road accidents worldwide, with about 30 per cent of these deaths occurring in developed countries. Described as a "silent epidemic", it is apt to describe the road transport system as a "non-forgiving man-made machine system that in the long run must be redesigned so that it will not generate one of the largest public health problems in society" (Tingvall, *et al*., 2000, p.61). In 1996, the World Health Organization (WHO), the World Bank and the Harvard School of Public Health published jointly a study entitled *The Global Burden of Disease* (Murray and Lopez, 1996, pp. 192 - 93) noting that road traffic accidents were the tenth leading cause of death in developing counties in 1990. By 2020 they would rank fifth as a killer behind ischaemic heart disease, cerebrovascular disease, chronic obstructive pulmonary diseases and tuberculosis (Shalizi, 2000, Table 5, p.414). The "zero vision" for roads, based on an analogy of the zero defect approach in man-machine systems of industrial production, implies a transport system without these serious health losses.

According to Tingvall (*et al*., 2000, pp.63 – 64), this alternative approach for the "zero vision" to road safety is based on the human tolerance and dose-response functions (the relationship between mechanical force and human response), assuming that human errors and mistakes will continue to occur. The general concept behind the "zero vision" is that no possible accident shall be more severe than the tolerance to mechanical forces of the human via the protective systems available. The challenge is to limit accident severity (the force that cannot be modified at the moment of impact) to a level where the road user is not exposed to a higher force level than the threshold for an injury with risk of serious consequences (Tingvall, *et al*., 2000, p.65). The responsibility for the safety of this road system is placed primarily in the hands of the system designers. The system users are supposed to adhere to the behavioural patterns within the tolerances of the system. This is in contrast to current practice where the responsibility for safety is put on the individual road users. In developing an intrinsically safe road system it is necessary to adopt, but not accept, that major misjudgements and behaviour beyond what is accepted will still occur amongst road users. It is therefore necessary to redesign a system that is tolerant to such events or eliminates them.

One prominent example of redesigning the road system (and associated land-use frontages into an activity profile) in Australia is the guidelines produced by the Roads and Traffic Authority of New South Wales and Federal Office of Road Safety (1993) entitled *Sharing the Main Street: Practitioners' Guide to Managing the Road Environment of Traffic Routes Through Commercial Centres* – recently released as a second edition (Roads and Traffic Authority of New South Wales, 2000). The conflict problem of motor vehicles, cyclists and pedestrians in the main streets of regional towns and along suburban shopping strings on sub-arterial roads on which these guidelines are based is a pervasive one and was examined in a series of inter-related research studies conducted at the University of New South Wales (Black, *et al*., 1988; Black and Westerman, 1989; Westerman, *et al*., 1989; Black, 1993). Road design and traffic management allow an appropriate speed profile to be developed for vehicles through the core of commercial and retail activities where pedestrian concentrations are the greatest that is aimed at improving road safety for all users. The behavioural aspects of pedestrian – vehicle interaction in these shopping centres, in particular, was a major research thrust by doctoral candidates (Song, 1993; El -Hazouri, 1995; and Guo, 1998) that underpinned the development of the guidelines.

The paper is organised into the following sections. First, we formulate a framework with a more concrete strategy for a zero vision where a typical research study applicable to the data collection and analysis phases of the evaluation of the health impacts of main street interventions is presented. Although we have already identified a long list of traffic and transport externalities (Black and Black, 2000) this paper focuses on road accidents as an example of a negative externality that can be reduced, if never entirely eliminated, from the main street. The next section illustrates the application of the framework with particular reference to a pedestrian accident risk model. This section includes formulating appropriate hypotheses to determine the risk factors, determining the appropriate sample size that is sufficient to conclude statistical significance in the hypotheses, outlining the data used and its collection, analysing the data to test the hypotheses, and framing our recommendations on a suitable model and showing how it may be applied to determine whether main street interventions reduce pedestrian accidents. Using a worked example of a typical kilometre of road with plausible parameters in the next section, the benefits to pedestrians, and the additional costs to motorists, are analysed and costed to show the prime importance of road safety benefits from main street redesign. An important part of the research framework is the cycle of continuous quality improvements and the final section suggests the general problem that should be investigated – namely, whether improved transport design leads to public health benefits for the community and whether a zero road toll is possible in the main street.

STRATEGIC FRAMEWORK FOR HEALTH IMPACT ANALYSIS

A strategy for the "zero vision" for roads involves the recognition that traffic accidents are but one of the externalities of transport, and that a sustainable system requires mobility to be a function of public health, not *vice versa* (Tingvall *et al*., 2000, p. 68). Similarly, the World Bank (1996) report on sustainable transport identifies the need to develop a strategic approach to motorisation – specifically, how to meet mobility needs associated with economic and population growth but with fewer transport negative externalities. In the formulation of a more concrete strategy, it is important to define transport externalities, identify the full social costs of transport, and justify why decision makers must include externalities when considering the costs and benefits of any road safety program.

Transformation of external elements into economic cost concepts has the advantage of offering comparability with other direct market costs that have a bearing on decision making, such as local government's decision whether or not to implement contemporary street design given its relatively high capital and maintenance costs to produce a quality environment. There remains little research into the health impacts of these types of intervention. Therefore, what follows is little more than a preliminary conceptualisation of the kinds of health impact assessments that could be studied from a properly conceived research design. There are a number of externalities associated with the main street in its wider land use and transport context (Black and Black, 2000) and these should be quantified in a full social cost – benefit framework, using unit cost values for each externality (see, Poldy, 1993). Having identified these social impacts, the practical implications are to investigate two important, and interconnected, issues. The first question is: what is the magnitude of the externalities of vehicular road traffic in any particular main street (both with and without the main street interventions)? The second question is: what are the changes to the public health (such as road safety) of those in the main street that follow from the interventions?

We would expect that public health (broadly defined and measured) does improve following the redesign of the main street, but, as in any field of public policy, there must be a comprehensive analysis of policies, programs and projects to see whether they achieve their intended outcomes. New health paradigms can guide the way in such an analysis:

> "Patient health outcome usually refers to a final health status measurement after the passage of time and the application of treatment. In the future, patient outcome will be increasingly described by a cumulative series of health status measurements" (Wilken, *et al.*, 1993).

Statistical methods and appropriate techniques for the analysis of the health impacts of main street interventions are important to outline in a multi-disciplinary field of study. The history of medicine, science and technology is full of ideas whose concepts have been borrowed from other disciplines. Transport engineers may well benefit in their continuing professional education by reading from the medical statistics literature. In medicine and health, the statistical and epidemiological tools that are often used measure risk factors for diseases and the success of interventions are based on dichotomous outcome variables such as disease is present and disease is absent, or the patient is dead or alive. Univariate measures such as odds ratios, relative risk and other risk measures are commonly used in analyses. Multivariate analyses often include logistic regression where the dependent variable is the dichotomous outcome variable. For example, a good starting point for statistical methods is the British Medical Journal *Statistics at Square One* (http://www.bmj.com/collections/statsbk/index.shtml). Armitage and Berry (1994) provide good examples in their textbook. Additional explanations of statistical methods, and whether interventions work, can be found in Black (2000) and Black and Irvine (2000), respectively.

What follows is merely a short summary of the 10 steps in a typical research study applicable to the data collection and analysis phases of the evaluation of the health impacts of main street interventions:

1. Define the research question;
2. Conduct focus groups with, for example, users of the main street to determine the issues and possible measures;

3. Set up appropriate hypotheses to determine the risk factors and/or set up hypotheses that test the effectiveness of the interventions;
4. Design an instrument to collect relevant data to quantify the outcome measure and the variables that are hypothesised to explain changes in the outcome;
5. Pilot the instrument with a sub group of users and further refine the instrument;
6. Determine the appropriate sample size that is sufficient to conclude statistical significance in the hypotheses;
7. Collect the data;
8. Analyse the data to test the hypotheses;
9. Form recommendations and conclusions; and
10. Continue to monitor outcomes in a cycle of continuous quality improvements.

These steps informed the overall research structure for the Guidelines on *Sharing the Main Street* (see, for example, Roads and Traffic Authority of New South Wales, 1989, Figure 3, p. 8). In this paper, we elaborate only on steps 3 and 6 to 9 when describing the development of a pedestrian accident risk model that can be applied to simulate the possible reductions in accident risk following main street redesign, and help address the conference theme as to whether a zero road toll is a dream or a realistic vision. We later emphasise the need to initiate research into a cycle of continuous quality improvement for main road interventions (step 10).

PEDESTRIAN ACCIDENT RISK ANALYSIS

Human behaviour is such that in the main street of towns, or along suburban shopping strings, pedestrians cross the road away from designated pedestrian crossing facilities. Our surveys suggest that jaywalkers may account for up to 80 per cent of all crossers during times of heavy pedestrian activity, often around lunch time (Lukovich, 1989, p. 3-5). Even at traffic signals with a pedestrian crossing phase about one third of crossers will do so against the red light. Given the importance of this topic of vehicle and pedestrian conflict, Song (1993) studied the behaviour of pedestrians crossing the road at “mid-block” – away from designated facilities for pedestrians. The pedestrian accident risk models are published in Song (1993a, b). Consistent with the strategic framework developed above, we formulate appropriate hypotheses to determine the risk factors, determine the appropriate sample size that is sufficient to conclude statistical significance in the hypotheses, outline the data used and its collection, analyse the data to test the hypotheses, then form our recommendations on a suitable model.

(a) Appropriate hypotheses

A probabilistic risk model based on Bayes’ law is applied to the accident risk to pedestrians crossing the road. There are three important events. Event A is defined as a headway in the vehicular traffic stream presented to an intending crossing pedestrian that is less than the pedestrian's acceptance of a critical gap. For a pedestrian crossing a traffic stream the critical gap is the minimum time necessary to walk safely across that stream between successive inter-vehicular headways. Event *B* is the event that the pedestrian crosses regardless of whether the available headway is greater or smaller than the critical gap. *B/A* is the conditional event that a pedestrian crosses when the headway chosen is actually smaller than the critical gap. Categories of human error may include: slips (correct intention, incorrect action); lapses (correct knowledge, wrong application); mistakes (incorrect knowledge, interpretation or action); and violations. When pedestrians select a crossing time in their minds at the pre-crossing stage error may be caused by mistakes, in observations, perception, judgement and decision-making (Chapman, *et al*., 1982). Event *C* is the event of a vehicle – pedestrian collision.

Hypotheses are required on vehicular traffic flow and on pedestrian crossing behaviour given the traffic flow conditions. In order to estimate the distribution of time headways between successive vehicles in the road traffic stream, a traffic flow model must be specified. We can hypothesise the appropriateness of one of five headway distributions: negative exponential; shifted negative exponential; double displaced negative exponential; gamma; and a composite function. Given the availability of data to calculate the probability of the conditional event *(B/A)* it is necessary to investigate the impact of various traffic variables on these probabilities. From an extensive literature review (Song, 1993, p.146) we hypothesise that the conditional event that a pedestrian crosses when the headway chosen is actually smaller than the critical gap is influenced by vehicular traffic flow, vehicular traffic speeds and the exposure time for pedestrians to cross the street, either individually or in combination.

(b) Sample size and data collection

We have analysed a census of vehicles but only over a three-hour period at one location on one day. Headway data on sub-arterial roads in Sydney were extracted from video-camera observations recorded between 11 am and 2 pm when pedestrian-vehicle interactions are at their highest. About 3000 (n = 3118) headways in shopping streets were collected at 8 sites along Marrickville Road, Beamish Street, Botany Street, and Anzac Parade) to allow data to be analysed for single traffic streams and for combined, two-way, flows. The combined traffic flows ranged from 1250 to 1460 veh/h; single-lane flows ranged from 850 to 990 veh/h.

The level of pedestrian activity along the footpaths and pedestrian street crossing was determined by field observations of pedestrians at 83 different retail locations in Sydney over a 100 m length in each shopping street. The survey duration was also from 11 am to 2 pm. Annual flow rates had to be extrapolated from these data, and, in the absence of a full daily survey repeated over different times of the year, we assumed expansion factors from the literature as the hourly rate multiplied by 10 to give the mean daily estimate.

The unit length of road used by the Roads and Traffic Authority of New South Wales for pedestrian accident surveys is 500 m. Accidents at intersections were eliminated because of our focus on "mid-block" crossings. Of all vehicle-pedestrian accidents in the data base (Road User Movement 00 to 07) it is only those classified as RUM 00 to 05 that are relate to this study. Further analysis of the accident data for the streets included in this research suggested that 90 per cent of all pedestrian accidents fell into one of these five categories, so an adjustment was made for other streets using the same proportion of all pedestrian accidents.

(c) Data analysis

Event *A* may be estimated in the following way. Histograms of the observed headway data grouped into one-second time intervals were produced at the eight sites then aggregated into pooled single-stream and two-way flows. The five headway distributions were fitted to these observations with the chi-square value and P-value allowing the best distribution to be selected. The negative exponential was found to best represent the combined traffic flow whereas the shifted exponential distribution best fitted the single traffic lane flow (Song, 1993, Table 6-2, p.143). From the selected headway distribution, the probability of a headway being less than the pedestrian's critical gap (say, 5 seconds) can be calculated. For example, using data for Bondi Road with a critical gap of 5 seconds and an exposure distance of 7.2 m the probability of a pedestrian who wants to cross the road at "mid-block" finding a headway less than five-seconds is 0.74.

Event *C* is calculated from the Roads and Traffic Authority of New South Wales data base using the number of pedestrian accidents recorded per unit length of road per year divided by the number of pedestrians crossing that road each year. For example, on Bondi Road this is 5 accidents per year (multiplied by 0.9 as noted above). The estimated number of pedestrians crossing each year over a 500m length of road is 511, 000. Here, the probability of event *C* is 8.8×10^{-6}. The conditional event *(B/A)* equals the probability of event *C* divided by the probability of event *A* – here, 1.2×10^{-5}. Altogether, probabilities of a pedestrian accident (potential accident risk) were calculated for 48 main streets and 31 local streets in Sydney.

Multivariate analyses were undertaken based on the product of the three variables – traffic flow, speed and crossing exposure distance. The correlations amongst independent variables both in linear and logarithmic form were carefully examined. No statistically significant correlations were identified other than that of traffic flow and road width (for main roads) and vehicle speed and road width on local streets. Step-wise regression was employed. One model fitted to the data contained a product of the three variables; the other also had the same three variables but squared vehicle velocity to represent an "energy" measurement based on studies that show a correlation between accident severity and fatalities and the energy of the collision (see, also, Tingvall, *et al*., 2000). The coefficients of determination for both models and for main roads and local streets were found to be 0.89, 0.83, 0.92 and 0.81, respectively.

(d) Recommendations on a suitable model

Risk assessment in road traffic risk management is concerned with quantifying risks to populations. The impact of an intervention (a countermeasure or a new regulation for road safety) can only be evaluated by examining the distribution of effects in the affected population as a whole. Our research has identified several different tactics (risk-takers, elderly) for crossing roads based on traffic flow and geometrical conditions. Therefore, a general probability formula is more useful in traffic risk management when considering the different groups of investigated subjects and probabilities of type-specific risk to persons in a population. Research at UNSW investigated accident risk to pedestrians with a behavioural probabilistic model based on Bayes' law (Song *et al* 1993a, b) and we are able to recommend a suitable model for the purposes of addressing the conference theme of whether a zero road toll is possible in the main street.

We assume that the change in potential accident risk (R) for a pedestrian crossing the main street follows the "energy" model calibrated for data on main roads in Sydney (n = 48), as described above. The potential accident risk (1×10^{-6}) for the existing street is:

$$R = 3.8(qs^2t)^{0.64}.\ 10^{-7}$$

where, the term in brackets is vehicle-metres per second squared (energy) and,

q = vehicle traffic flow, veh/s;
s = mean vehicle speed, m/sec;
t = critical gap for pedestrians to cross a vehicular traffic stream, sec.

Main street treatments narrow the road carriageway and slow vehicle speeds. We will assume the appropriate model now for the redesigned street is the pedestrian accident risk model in a functional form as calibrated for local streets in the Randwick municipality (n = 31):

$$R = 3.4(q.s^2.t)^{0.59}.\ 10^{-7}$$

(e) Application of Model to Main Street Treatments

Appropriate data may be substituted into these equations to simulate design changes implicit in *Sharing the Main Street*. Clearly, a reduction of speed and less traffic together with shorter crossing distances of the road carriageway will reduce the pedestrian accident risk. However, without resorting to such sensitivity testing, we can suggest approximate results holding the values of all variables the same using a graph based on Song (*et al.*, 1993a, Figure 6, p.54) where it can be readily seen that the potential risk of an accident for a pedestrian to cross the road (accident risk per million person-years) halves from about 8 to 4 with the redesigned road. To provide some perspective on these numbers, the following *fatal* accident risks are noted; 39 - pedestrians crossing the road in NSW (1990); 50 - a frequent flying professor in the USA; and 2 - travel by train as a passenger in NSW (1986).

EXTERNALITY COSTING – WORKED EXAMPLE

The objective here is to expand on the framework presented earlier to show how some other externalities of main street redesign may be included and in doing so place the pedestrian accident problem into a wider context. Let us assume a road with the following parameters amenable for further analysis. The system characteristics of a main street without interventions are: one kilometre in length; vehicular traffic flow of 550 veh/h. If mobility by road transport is the main goal of society motorists will feel frustrated in urban areas if they are unable to drive at their desired (high) speeds. Other road traffic imposes externalities on all road users. Costs of congestion are the most widely known to transport engineers of the Pigouvian externalities and they provide a useful reference of costs commonly used in transport project appraisal and to justify road proposals.

Assume a regulatory speed limit of 40 km/h is imposed along the main street. A single vehicle travelling at the legal speed limit (the base from which our later estimates of externalities and health costs are derived) takes one and a half minutes to cover the one-kilometre-long main street. The observed mean speed of 32 km/h at a flow of 550 veh/h suggests annual congestion will amount to an additional $274 000 per annum (with no traffic growth) based on an assumption of the monetary value of travel time at $15 per hour. If the main street interventions achieve their policy targets of 25 km/h then travel time will of course increase with an additional 0.52 minutes adding on another $383 000 per year in road user delays. Thus, we can say that speed control, achieved through main street engineering and traffic management designs, adds around two-thirds of a million dollars each kilometre to perceived road user costs over and above the travel time costs inherent in a driver obeying the regulatory speed limit of 40 km/h.

Although empirical research (Black, 1989) shows that a proportion of pedestrians crossing the road do sometimes slow down or stop vehicles this externality of pedestrians on vehicles is ignored here. More importantly, the externalities imposed by road vehicles on pedestrian crossing delay, on the other hand, are rarely costed in project appraisal. We can speculate that the situation before any main street intervention is represented by platoons of vehicles and that street redesign causes the traffic to arrive with headways in a more random distribution. Research at UNSW has derived a pedestrian delay model for bunched traffic and has compared this with Tanner's model (a negative exponential distribution of vehicular headways) that is widely used in transport engineering practice. Pedestrian delay models developed by Guo (*et al*, in press) allow mean pedestrian delay to be estimated for both cases – before and after. Based on the assumption of a change in headway distributions a main street redesign is expected to reduce the mean delay for pedestrians arriving at the kerbside at random from 6 to 4 seconds given the vehicular traffic flow levels (550 veh/h) in this worked example. Congestion costs are calculated by aggregating small increments of time over all road users. Thus, the total delay to all pedestrians in this example obviously depends on the number of people crossing the road. We will assume as being representative that along the one-kilometre length of road pedestrian activity is such that 3000 cross per hour (a figure based on surveys along Burwood Road, Sydney). The difference in before and after delay attributed to the main street intervention is therefore only 100 minutes per hour. Assuming such flows over 10 hours each day, say 17 hours delay, and for 365 days a year, the total annual pedestrian delay (costed at $15 per hour, as for motorists) amounts to about $93 000 per annum.

Speed control is a major intervention in road safety, and the concept of a speed profile slowing to about 25 km/h in the core pedestrian activity centre, is a vital part of

Sharing the Main Street. Ideally, pedestrian accident risk models should be applied but our research has not distinguished amongst fatalities, sever and minor injuries. Therefore the costs presented here are based on a simple analysis. The pedestrian accident rate for five years along the one-kilometre shopping street in our example is assumed to be 20 (based on the number of accidents reported in Sydney over a five-year period in the Traffic Authority of NSW data base that was analysed by Black, *et al*., 1988). If we assume that the reduction in the mean speed of vehicles falls from 40 km/h to 25 km/h (with main street interventions) *and* that the relationship between speed and injury and fatality rates follows the pattern identified by Seifried (1990; cited by Whitelegg 1993, Figure 5.5, p. 86) then the following results for the number of pedestrians involved in accidents on the road are assumed to be as follows:

Fatalities (before)	5	Fatalities (after)	2
Serious injuries	5	Serious (after)	7
Slight injuries	10	Slight (after)	11

Using the Bureau of Transport Economics (2000, Table 15) estimates for the average cost (1996 prices) of a fatality on a road at $1.5 million and the average cost of a serious injury as $325 000 the main street intervention saves about $3.85 million in accident externality costs each *year*. As we have shown, earlier the main street redesign may possibly half the number total number of pedestrians in addition to the reduction in severity that arises as a result of slower impact speeds. If this is correct then the numbers in the after situation might look something like: fatalities - 1; serious – 4; and slight – 5. The trend towards a zero road toll in this hypothetical example benefits the community by $6 325 000 per year per kilometre of treatment.

Main street treatments in Australia to produce quality environments are expensive, but have been received favourably by stakeholders. To justify the expenditure of costs a full social cost accounting approach is needed. This worked example, based on a one-kilometre length of urban road with plausible data, indicates that pedestrians will be the prime beneficiaries in the redesign of roads. When externalities are included in the evaluation, and costed annually, savings in pedestrian accident trauma are about $6.33 million. Additionally, it is slightly easier to cross the road and the savings in pedestrian delay is almost $100 000. The mobility of drivers is constrained by the speed profile along the main street intervention and motorists are worse off in terms of increased travel time. Additional road user delays are estimated at $ 650 000 per year. The net social benefits on these three externalities as costed is about $5.8 million per annum for each kilometre of main street redesign.

RESEARCH - A CYCLE OF CONTINUOUS QUALITY IMPROVEMENT

National guidelines for practitioners on managing road environments entitled *Sharing the Main Street* were issued in 1993 and have recently been revised based on implementation experience (Roads and Traffic Authority of New South Wales, 2000). The NSW Parliamentary Stay Safe Committee, Australian Institute of Traffic Planning and Management and the Institute of Public Works Engineers Australia convened a conference in 2000 on practical experience gained in implementing schemes and data from those proceedings would be an initial starting point for a comprehensive evaluation. Designs aimed at meeting the needs of the people who use the "main street" have goals of increased road safety for pedestrians and vehicles and better environmental quality. Innovations implemented in Australian "main streets" provide real-world laboratories to study, collect data and analyse statistically environmental health outcomes (physical and mental) in a cycle of continuous quality improvement. What is needed to apply the framework in this paper is to compare and contrast selected road environments where interventions ("Main Street" design) have been implemented with those "control" main streets (with comparable levels of people and vehicular traffic activity) without any interventions.

For a comprehensive evaluation, the health indicators requiring field measurements at all sample sites include road traffic noise (and community annoyance), ambient air quality from vehicle emissions, and traffic accidents involving injuries or death. Focus group discussions and social surveys of pedestrians and businesses fronting on to the "main street" should be conducted to establish qualitative information on noise annoyance, and stress, on emissions and health, and on perceptions of road safety and road crossability. By quantifying the magnitude of health benefits (or costs) to the community through *Sharing the Main Street* programs in Australia the full social worth of the projects in terms of better community health (broadly defined) over and above the traditional traffic benefits that have previously been widely studied can be established. *Sharing the Main Streets* is a practical guide to the development of quality environments for people and this significant national innovation would be further enhanced in the eyes of the community and elected representatives by establishing and demonstrating its health benefits, including road safety. Furthermore, such a study would be consistent with the NHMRC recommendations that health impact assessment be a formal part of infrastructure investment in Australia.

CONCLUSIONS

As in medicine, there are confounders. The openness of the problem in studying the main street is a non-trivial one. Despite the inherent complexity of the general problem of vehicular and pedestrian traffic in the main street, and the high variability involved over time and space, models can be very useful in providing insights into system behaviour and interactions and how they may change with controlled interventions. This paper has provided a framework and a typical research study applicable to the data collection and analysis phases of the evaluation of the health impacts of main street interventions. This approach was illustrated by using a probabilistic accident risk model where the explanatory variables on main roads and on local streets are vehicular speed, traffic flow and pedestrian critical gap. The reductions in pedestrian accidents following main street interventions have been simulated with this model. Costing of these accident reductions and other externalities such as motorist delay and pedestrian delay have been attempted using a hypothetical example.

The profession of public health rose to respectability riding on the coat tails of sanitary engineering. Today, in road safety, there are no simple equivalents to drains and sewers. Some answers may come from trends in health funding: curative medicine accounts now for about 97 per cent of the health budget, but some argue that it would be better if preventative medicine was reallocated more resources. The transport parallel to the reduction of accidents and their severities is obvious: travel demand management and promoting public transport, walking and cycling. The foremost health policies for transport should be to give the highest priority to walking, cycling and public transport - forms of travel that are health promoting, of low risk to health, and fulfil sustainable transport objectives. Promotions of these are notoriously difficult. Broad motivational and behavioural changes (such as health promotion campaigns) have been of limited success (British Medical Association 1997; McCarthy, n.d., p.146). However, a degree of support for walking and cycling policies has been developing in Europe, and this is possible too in Australian cities. These interventions cover widening footpaths, narrowing road carriageways and ensuring good street lighting to encourage the “greening of towns”. Interventions achieved in the main street of Australian towns and along the suburban sub-arterial roads of cities during the last several years can also be described as “greening” yet with more of an underpinning rationale with speed profiles and frontage land-use activity adaptation. The design and control measures in *Sharing the Main Street* represent a more comprehensive vision for a “greener” future for our society and one that is seriously challenging the zero road toll vision in these particular environments.

Some answers to assist meeting the challenge of a zero road toll may also come from a whole of government approach by coordinating the health impact of housing, transport, urban planning, pollution control, food and water, safety and waste disposal (Palmer 1998). This will require evidence that - from engineering experience and from statistical analyses - the costs of main street interventions are to the overall public benefit. Berwick (1996, p. 877) states: “journal reviewers demand evidence (for) proper control and statistical analyses”. They ignore the role of what he describes as “real-time science” – the routine collection of data and the analyses of those results in terms of patient outcomes. In such a “science”, this paper adds weight to the argument that rigorous statistical techniques are a fundamental key to successfully unlocking the paradigm that routinely collected data can be used effectively in a cycle of continuous quality to improve health outcomes. This “science” is equally applicable in the broader study of the health impacts of main street interventions.

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