Comments are Welcome.

# Reassessing the Relative Dangers of Walking and Motoring

Xuehao Chu

Center for Urban Transportation Research
University of South Florida
4202 East Fowler Avenue, CUT 100
Tampa, Florida 33620
Phone: (813) 974-9831
Fax: (813) 974-5168
E-mail: xchu@cutr.usf.edu

October 2004

**Abstract**

Recent evidence indicates that walking is much more dangerous than motoring (i.e., being occupants of passenger cars) in the U.S. This evidence is based on the traditional method of risk measurement that limits injury outcomes to fatalities and measures exposure with distance traveled or trips made. This paper proposes a new method of risk measurement to reassess the relative injury risks between walking and motoring (i.e., being an occupant of a passenger car) in the U.S. The proposed method measures exposure with time traveled and more importantly integrates injuries of different severity on the KABCO scale using corresponding unit costs. This method is applied to the U.S. in 2001. Walking is considerably less dangerous than motoring if only non-fatal injuries are considered, but is more dangerous when only fatal injuries are considered. When injuries of all severity levels are integrated, however, motoring is as dangerous, if not more, as walking.

**Keys-words**: walking, motoring, risk, injury severity, exposure, KABCO.

## Introduction

Is walking more dangerous than motoring (i.e., riding in a passenger car) in the U.S.? Using 1995 U.S. data, Pucher and Dijkstra (2000) estimate that walking is 36 times as likely as motoring to result in a fatal injury per unit of distance travelled, and 3 times as likely per trip made, and conclude that walking is much more dangerous than motoring in the U.S. Pucher and Dijkstra (2003) reach the same conclusion using 2001 data. Differences in risk of this magnitude take on even greater meaning in view of the national policy to encourage increased walking for both transportation and public heath purposes (FHWA, 1994a).

These risk estimates are based on the traditional method of risk measurement that has three methodological concerns. One concern is the treatment of injuries at different levels of severity. Injuries typically are limited to fatal injuries. Non-fatal injuries are either ignored or considered separately. This approach results in an incomplete and misleading picture of the relative dangers of walking versus motoring. Even when injury risks for all severity levels are considered, the multi-dimensions of different severity make a comparison difficult. Walking and motoring differ significantly in their distribution of injuries across different severity levels. The second concern is the nature of exposure used. Exposure typically is stated in terms of population, person miles travelled, or person trips made. Any of these measures of exposure can result in a biased picture of the relative dangers of walking versus motoring (Chu, 2003). The third concern is an inconsistency between injury and exposure measures. As already indicated, injuries are for a single severity. Exposure, on the other hand, reflects exposure to crashes outcomes of all severity. These methodological concerns characterize the traditional method of risk measurement.

These risk estimates are also based on an application of the traditional method that has an empirical concern. Pucher and Dijkstra (2003), for example, use the 2001 Fatality Analysis Reporting System (FARS) for data on the number of fatalities and the 2001 National Household Travel Survey (NHTS) for data on distance travelled and trips made. Two types of biases are introduced in using these data sources for measuring the risk of walking. First, the FARS includes pedestrian fatalities occurred while they were largely stationary (e.g., working on or playing in roadways or tending a broken car). At the same time, the 2001 NHTS has no data on exposure to such risks. Not excluding these pedestrian fatalities overstates the risk of walking. Second, the FARS includes fatalities occurred while they were in the process of access to or egress from another mode or while they were waiting for a bus at roadside. At the same time, the 2001 NHTS can be used to measure exposure to these types of risk. Not including such exposure also overstates the risk of walking.

This paper reassesses the relative dangers of walking and motoring by addressing these concerns. Whether walking is more dangerous than motoring has a number of behavioral and policy implications. A higher danger for walking may help understand why walking has been losing its favor for a number of years in the U.S. A good indication of the decline in walking is the journey to work data from the Census. The number of workers 16 years of age or older who usually walked to work dropped from 6,416,343 in 1960 to 3,758,982 in 2000, a decline of over 41 percent, while the total number of workers almost doubled (FHWA, 2003). Physically inactive lifestyles are seen as one of the major public health challenges of our time and reversing the trend in walking is seen as a major strategy to overcome this challenge (Sallis et al., 2004). Some believe that the higher level of danger for walking relative to motoring is a major barrier to reversing this trend (Pucher and Dijkstra, 2003).

Information on the risk of walking can also help understand the injury risks of intermodal travel (ETSC, 1999, 2003). Walking is part of almost all passenger trips, especially those involving public transit. In-vehicle travel with public transit appears to involve lower risks than motoring (ETSC, 1999). If walking is far more dangerous than either motoring or taking public transportation, accounting for the higher danger of walking as part of intermodal travel may significantly reduce the advantage of public transportation. An understanding of the injury risks for intermodal travel can influence not only traveler behavior but also policy making. Once accounting for the danger of walking for access or egress, public transportation may have higher or similar private risks with motoring but can still have a much lower social risk than motoring. The private risk is a traveller's own risk when he travels, while the social risk includes risk he imposes on all travellers.

Information on the relative dangers can help assess the modal equity in injury risk. Nationwide walking and motoring are the most used modes for local person travel in the U.S. (BTS, 2003). Some may argue against equal modal risk as a policy objective (Hakkert and Braimaister, 2002). A case may be made, however, for the desirability of equal risk between walking and motoring. Some people walk because they choose to do so. Some of these may have chosen not to own a passenger car. Others may have cars available but choose to walk for some of their travel. On the other hand, there are people who walk because they have little choice of alternative modes. These are largely captive walkers. As society as a whole has chosen to invest in providing transit services substantially subsidized for captive transit users, one might reasonably evaluate whether or not the current investment is equitable in supporting captive walkers. Transportation in this case is seen as one of the basic rights that make it possible for people to participate in society (Nash, 2001).

Safety is seen as an important issue in policies to stimulate the use of walking and other non-motorized transportation modes (Rietveld, 2001). Information on the relative dangers between walking and motoring, in fact, has been used to promote public policies for walking.

Based on their conclusion on the higher danger of walking and experiences in Germany and The Netherlands, for example, Pucher and Dijkstra (2000; 2003) propose a number of public policies that they believe will make walking safer in the U.S. Safer walking is seen as an important instrument to better public health through physical activity, an improved environment through modal shifting, and an additional travel option for those who do not drive, do not have access to a passenger car, or choose not to use a passenger car. The U.S. is not alone. The European Transport Safety Council (ETSC, 2003) recommends that the safety of walking and biking be improved because its analysis indicates that the fatality risks of walking per unit of distance travelled are 7 to 9 times higher than that for motoring.

This paper proposes a new method of measuring the risk of walking that addresses the three methodological concerns of the traditional method of risk measurement. This paper also applies the proposed method to the U.S. in 2001 in a way that addresses the empirical concern with the current estimates of the relative risks between walking and motoring. The traditional and proposed methods are presented first, covering their interpretations, characteristics, and limitations. Four data sources are then described for applying the proposed method to the U.S. in 2001. Measurement issues in using these data sources are then examined in order to address the empirical concern of the conclusion on the relative dangers of walking and motoring. This is followed by a presentation and discussion of the results, which include both a set of best estimates and many sets of alternative estimates for sensitivity analysis. The last section concludes the paper and discusses potential uncertainty in our results and future research areas.

## Traditional Method

The traditional method defines risk as a ratio of crash outcomes in the numerator and exposure to these crash outcomes in the denominator. The numerator is stated in the number of crashes or injuries of a particular severity level. More recently, the numerator sometimes is stated in the number of conflicts (Garder, 1989; and Silcock et al., 1998), particularly for assessing risks at the micro level such as at intersections. In contrast with methods of induced exposure (Lyles and Stamatiadis, 1991; Stamatiadis and Deacon, 1997), the traditional method measures exposure from data sources outside crash databases. A variety of measures have appeared in the literature for the denominator. Wolfe (1982) provides an early review. At the micro level, examples include pedestrian volume (Davis et al., 1988), the product of pedestrian and vehicle volumes at intersections (Cameron, 1982) or roadway segments (Knoblauch et al., 1984), and the square root of that product (TRL, 2001). At the macro level, examples from the U.S. include distance travelled (Pucher and Dijkstra, 2000, 2003) and trips made (Pucher and Dijkstra, 2000, 2003). The number of streets crossed has also been used as exposure at the macro level elsewhere (Roberts et al., 1996). Frequently non-travel-based measures of exposure are used at the macro level, including population (NHTSA, 2004) and population divided by the percent of workers walking to work (STPP, 2002a).

**Interpretation**

It has been hypothesized that the numerator and the denominator under the traditional method are linked through a "safety performance function." This function reflects the safety level of an entity (the road system or one of its components) at a particular time point. The components could be roadway segments, intersections, sub-systems like walking, etc. A safety performance function passes the origin and is hypothesized to be convex. There is a particular level of exposure for any given entity during a particular time period. The injury risk for this entity during that time period is measured by the slope of the ray between the origin and the point on its safety performance function at that level of exposure (Hauer, 1995). Leden (2002) and Jacobsen (2003) provide evidence on the non-linear nature of safety performance functions for walking. Kononov and Allery (2002) demonstrate how safety performance functions can provide a framework for the planned Highway Safety Manual. Arkekani et al. (1997) review previous efforts on empirical estimations of safety performance functions for roadway sections and intersections for both walking and motoring.

**Characteristics**

The validity of a risk measure imposes certain requirements on how the numerator and denominator should be measured. First, they should reflect the intended usage of the measure (Hakamies-Blomqvist, 1998). If it is used to compare risks across modes, for example, the denominator has to be comparable across modes. Population is not a comparable measure of exposure because it does not capture variations in the amount of travel per person across modes. Distance travelled improves upon population as a measure of exposure but is not a comparable measure either because it does not capture variations in speed across modes. Second, they should reflect the intended concept of risk (Hakkert and Braimaister, 2002). One may distinguish, for example, between the private risk on a traveller himself when he travels and the social risk on all travellers when he travels (Jorgensen, 1996). Third, they must be consistent (Hauer, 2001). If the denominator measures the amount of exposure by pedestrians, for example, the numerator must count the number of pedestrians rather than the number of accidents involving pedestrians. Without this consistency, it is possible that the risk of walking appears to be higher than the risk of motoring while in reality they are equal. Fourth, the denominator must reflect the exposure to the crash outcomes in the numerator. The current estimates of the relative risks of walking and motoring for the U.S. fail to meet this requirement. As already indicated earlier, one example is the exclusion of exposure due to access to or egress from another mode in the denominator while injuries due to access or egress are included in the numerator.

## Limitations

In addition to the methodological concerns raised in the introduction, the traditional method is biased when the degree of under-reporting of injuries differs across walking and motoring. It is a common practice to use the traditional method for assessing whether a particular entity is over-represented in certain class of crashes or injuries. Suppose we want to know whether walking is over-represented in non-fatal injuries. Mathematically, this is equivalent to comparing the share of exposure for walking and the share of non-fatal injuries for walking. This assessment is also equivalent to determine whether the risk of non-fatal injuries for walking is higher than the average risk for both walking and motoring. The result of this assessment is biased downward (upward) if non-fatal injuries are more (less) likely to be un-reported for walking than for motoring (Hauer, 2001). Hauer demonstrates this limitation in two simple steps. Under the condition that the number of non-fatal injuries is proportional to exposure, the risk for walking should be equal to the average. Under the same condition but allowing underreporting of injuries for walking, on the other hand, the traditional method would understate the risk of walking.

# Proposed Method

We want a risk measure at the macro level for comparing the average private risks between walking and motoring. Consider a road system within a particular geography and during a particular time period where people travel on one of two modes indexed by $i$ (= $w$ (walking), $m$ (motoring)). Suppose that all personal injuries resulting from traveling fall into $S$ categories indexed by $s$. Let $O_s^i$ be the number of injuries of severity $s$ on mode $i$. Let $c_s$ be the unit cost of an injury of severity $s$. Finally let $T^i$ be the amount of exposure in time to injuries of all severity on mode $i$. We define a time-based and integrated measure of injury risk for mode $i, r^i$, as follows:

$$r^i \equiv \frac{\sum_{s=1}^{S} c_s O_s^i}{T^i}. \tag{1}$$

**Interpretation**

The proposed method has three interpretations. The first interpretation relates the proposed method to time-based risk measures from the traditional method. These time-based risk measures under our framework are simply $O_s^i / T^i$ for each combination of mode *i* and severity *s*. Let us re-write equation (1) as follows:

$$r^i = \sum_{s=1}^{S} c_s \left( \frac{O_s^i}{T^i} \right). \tag{2}$$

We can see that the integrated risk for a given mode is the cost-weighted sum of its non-integrated risks across all severity levels.

The second interpretation relates the proposed method to risk as expectation in the literature. Suppose someone walks for an hour in the road system. He is most likely to come back without any injuries. The probability of having a safe trip, $P_n^w$, is close to 1. At the same time, however, there is a small probability, $P_s^w$, of being injured at severity level *s*, with $P_n^w + \sum_{s=1}^{S} P_s^w = 1$. Since the unit injury cost of a safe trip is zero, the expected injury cost of that one-hour walk would be $0 \cdot P_n^w + \sum_{s=1}^{S} c_s P_s^w = \sum_{s=1}^{S} c_s P_s^w$. Haight (1986) suggests that this expected cost be used as a measure of injury risk per unit of exposure. $P_s^w$ would be defined as $O_s^w / T^w$ (*s* = 1,..,*S*) and $P_n^w$ as $1 - \sum_{s=1}^{S} P_s^w$ in the proposed method.

The third interpretation relates the proposed method to the concept of safety performance functions. Let the number of injures for mode *i* and severity level *s* be a function of exposure and some vector of shifting parameters *v*: $O_s^i\left(T^i, v\right)$. The vector of shifting parameters is added to allow for the possibility of other forces that may change the safety level of an entity. In the case of walking, for example, one shifting parameter would be the amount of vehicle miles traveled. Holding other components of the vector constant, an increase in the amount of vehicle miles traveled would shift the function upward. In addition, these functions for walking all take a zero value if no vehicle miles are traveled. As discussed above, these functions all pass the origin and all are convex.

Now define a new safety performance function for each mode *i*: $C^i\left(T^i, v\right) \equiv \sum_{s=1}^{S} c_i O_s^i\left(T^i, v\right)$. This function has all the properties of the component safety performance functions. Figure 1 shows two examples of this function for mode *i* with two different vectors of shifting parameters. The lower curve ($v = v_2$) represents a higher level of safety for mode i than the top curve ($v = v_1$). Just like the traditional method, risk using the proposed method can be interpreted as the slope of the ray between the origin and a point on the curve. Figure 1 also shows three examples of risk measures: $r_1^i$, $r_2^i$, and $r_3^i$. Two of them, $r_1^i$ and $r_3^i$, are measured in relation to the top safety performance function, and the other to the bottom function. Also, $r_1^i$ and $r_2^i$ are measured at exposure level $T_0^i$ while the other at $T_1^i$. One important point of this figure is that risk can be reduced in one of two ways. Risk is reduced from $r_1^i$ to $r_2^i$ at the same exposure level by improving the level of safety from the top curve to the bottom curve. On the other hand, risk is reduced from $r_1^i$ to $r_3^i$ exposure is increased from $T_0^i$ to $T_1^i$ along the top curve without any improvement in the level of safety.

-----------------

Figure 1 Here

-----------------

**Characteristics**

In addition to meeting the basic requirements of a valid risk measure as discussed earlier, the proposed method improves the validity of comparing injury risks between walking and motoring over the traditional method in three important ways. It uses a time-based measure of exposure; it integrates injury outcomes of all severity; and it makes the numerator and denominator consistent.

Measuring risk by time-based exposure has long been used in a comparative approach in many countries outside the U.S. Jonah and Engel (1983) measure the risk of crash involvement for walking by time traveled along with several other exposure measures. Data for exposure are based on self-reporting surveys in Canada. Anderson et al. (1989) compare time-based fatality risks between walking, riding as a passenger, and driving for Australia during 1984-1985. Chipman et al. (1993) explains the role of driving speed and the roadway environment in differences of crash involvement rates among driver groups in Ontario, using various exposure measures including time-based. Keall (1995) measures the risk of injuries for walking by time traveled for age and gender groups, using the 1989-1990 New Zealand Travel Survey. Jensen (1999) compares time-based injury risks between walking, biking, and motoring in Denmark for 1993-1995. The U.K. Department of Environment Transport and the Regions (DETR, 1998) and the European Transport Safety Council (2003) use a time-based measure to compare risk levels between walking and motoring. Chu (2003) appears to be the only recent effort to estimate time-based risks for the U.S.

The literature has some integration efforts as well, typically in the form of a simple sum of injuries of different severity levels. TRL (2001), for example, compares the combined number of fatally and seriously injured persons per unit of travel (including trips made, distance traveled, and time traveled) between walking and motoring for the U.K. in 1998. Jensen (1999) makes a similar comparison for Denmark during 1993-1995 using the total number of injuries of all severity levels as the outcome measure. These efforts also make the numerator and the denominator consistent in the sense that both include injuries of all severity. One downside of these efforts is that they treat injuries of all severity as equal.

**Limitations**

The proposed method shares one limitation of the traditional method discussed earlier. That is, differential degrees of under-reporting of injuries between walking and motoring lead to biases in the relative injury risks between the two modes. In the case of the proposed method, one can easily show that both steps of demonstrating this limitation hold. As a result, our proposed method is subject to this limitation. To demonstrate the first step, assume that the number of non-fatal injuries is proportional to exposure for each severity level *i*, i.e., $O_s^w / \left(O_s^w + O_s^m\right) = T^w / \left(T^w + T^m\right)$. This is equivalent to: $O_s^w \left(T^w + T^m\right) = T^w \left(O_s^w + O_s^m\right)$. Multiplying both sides by $c_s$, summing across *s*, dividing both sides by $\left(T^w + T^m\right) \sum_{s=1}^{S} c_s O_s^m$ , multiplying both sides by $T^m / T^w$, and re-arranging gives us

$$\frac{\sum_{s=1}^{S} c_s O_s^w}{\sum_{s=1}^{S} c_s O_s^m} \frac{T^m}{T^w} = \frac{T^m}{T^w + T^m} \left( 1 + \frac{\sum_{s=1}^{S} c_s O_s^w}{\sum_{s=1}^{S} c_s O_s^m} \right) = \frac{T^m}{T^w + T^m} \left[ 1 + \left( \frac{T^w}{T^m} \right) \frac{\sum_{s=1}^{S} c_s O_s^w}{\sum_{s=1}^{S} c_s O_s^m} \frac{T^m}{T^w} \right]. \quad (3)$$

Solving equation (3) for the overall term on the left side and simplifying gives the result that the overall term on the left side is equal to 1.

## Data

We use four data sources to apply the proposed method to the U.S. in 2001. These are the Fatal Analysis Reporting System (FARS), the General Estimate System (GES), the 2001 National Household Travel Survey (NHTS), and established unit costs of injuries by severity.

### FARS

We use the 2001 FARS data to measure the number of fatal injuries. The FARS contains the annual census of all fatal crashes on public roads in the U.S. (NHTSA, 2004). Fatal injuries occurred at the scene of a crash or within 30 days of the crash are included. Crashes are identified with, among others, whether they occurred on interstates through a variable on functional classification. Persons involved, including those who died, are identified, among others, with whether they were on foot or occupants of a motor vehicle. Occupants of a motor vehicle are further identified with the type of motor vehicles they were riding in. To better match person travel by motor vehicles for exposure measurement, we only include cars (1-11), vans (20-22, 28-29), sports utility vehicles (14-19), and pickup trucks (30-39, 67), where the numbers are the codes for body type used in the FARS (Tessmer, 2002). These motor vehicles combined are referred to as passenger cars in this paper.

### GES

Data on non-fatal injuries are estimated from the 2001 GES, which contains a nationally representative sample of all police-reported motor vehicle crashes of all severity. To be eligible for the GES sample, a police accident report must be completed for the crash, and the crash must involve at least one motor vehicle traveling on a traffic-way and result in property damage, injury, or death. GES data collectors make weekly visits to approximately 410 police jurisdictions in 60 sites across the U.S., where they randomly sample about 57,000 police accident reports per year (NHTSA, 2004).

The severity of injuries is rated on a five point scale known as KABCO, which consists of categories designated fatal (K), incapacitating (A), non-incapacitating (B), possible (C), and none (O). Different descriptions are used in some cases for the non-fatal injuries. North Carolina, for example, describes ratings A, B, and C as serious, moderate, and minor, respectively (Popkin et al., 1991). Regardless of the descriptions used, these ratings are determined by investigating officers of crashes based on the definitions provided in the National Safety Council (NSC, 1996). Just like the FARS, the GES also identifies persons involved in crashes with whether they were on foot or an occupant of motor vehicles, which are further identified with body type. Again, only occupants of passenger cars are considered for measuring injuries from motoring.

**NHTS**

We measure exposure with hours of travel, using data on self-reported trip duration from the 2001 NHTS. The 2001 NHTS collected data about one-way trips taken during a designated travel day by a national random sample of 26,028 households (USDOT, 2003). A one-way trip is defined as any time a subject went from one address to another for purposes other than changing the mode. The information about these one-way trips includes duration of the trip and modes of transportation among other things. If more than one mode is used on a one-way trip, the mode that covered the most distance is designated as the main mode for that trip. Data collected include travel by persons of all ages. The travel days were assigned to all days of the week and all seasons from April 2001 through April 2002. The travel day started at 4:00 am of the day assigned and continued until 3:59 am of the following day. Travel data were collected through telephone interviews to get information on pre-mailed travel diaries. The survey has also developed weights to expand the sample to national annual totals.

Previous efforts in the U.S. have not used time-based exposure partly because of data problems, as BTS (1998) states: "Analyses of safety trends for non-motorized modes—bicycling and walking—suffer from the absence of exposure measures (such as hours of exposure to traffic). Moreover, bicyclists and walkers often take trips too short in length to be counted in national travel surveys. Furthermore, trips that begin and end at a residence, without an intermediate stop, are typically not counted, thus excluding much recreational bicycling and walking." To avoid these problems, the 2001 NHTS included in the questionnaire multiple prompts on including walk/bike trips and trips that started and ended in the same place. These reminders have significantly increased the completeness of walk-trip reporting, as indicated by a 73.8 percent jump from 1995 in the number of reported trips with walking as the main mode (Chu, 2003).

**Unit Costs**

Our unit costs come from FHWA (1994b). The unit cost for fatal injuries originally comes from the Urban Institute (1991), while the unit costs for non-fatal injuries come from Miller et al. (1988). These particular unit costs are used for several reasons. First, they correspond to the KABCO scale. The non-fatal injuries estimated from the GES are based on the same scale. Second, these unit costs reflect the willingness-to-pay to avoid injuries rather than the discounted sum of future earnings. The willingness-to-pay approach values small changes in risk that people actually face in real life. In contrast, using discounted future earnings values the full transition between no-injury to injuries. Haight (1994) and Small (1999) briefly review these approaches to valuing injuries. Third, unit costs for all levels of injury severity are available from a single source.

## Measurement Issues

This section addresses four specific issues related to the empirical concern with the recent evidence in the literature on the relative dangers of walking and motoring. In addition, this section identifies five other measurement issues in applying the proposed method to the U.S. in 2001 using the data sources described earlier. Table 1 lists all nine issues numbered from 1 through 9. Also shown in Table 1 are the expected effects of these issues on the absolute risks of walking and motoring and the relative risk of walking to motoring, and the strategy taken to deal with each issue.

The first issue is whether time spent on access to or egress from another mode should be considered exposure for walking. Access and egress walking may have a rather negligible consequence in terms of distances traveled but can be rather significant in terms of travel time (Rietveld, 2001). While accounting for the risk of walking during access or egress portions of an intermodal trip has been done before (ETSC, 1999), previous studies have never taken into account access and egress in assessing the risk of walking. Excluding access or egress walking overstates the absolute and relative risks of walking because injuries resulting from access or egress walking are included in the injury estimates from the FARS and the GES.

Our strategy is to include access or egress exposure for our best estimate of the risk of walking. The 2001 NHTS includes several pieces of information on access to and egress from the main mode of a trip. There are up to five modes for access and egress, respectively. In addition, the total amount of time taken for all access modes combined is also collected. Similarly, there is information on the total amount of time taken for egress. Access or egress occurs not just for trips whose main mode is public transportation but also other modes such as carpooling. We choose to limit to those trips that used walking as the sole access or egress mode.

These trips represent about 85 percent of all trips that involved some access modes and 81 percent of all trips that involved some egress modes. There are no trips that involved more than three access or egress modes. We believe that this approach leaves out little access and egress walking. At the same time, our strategy also tests the sensitivity of our best estimate by excluding access or egress exposure.

This second issue is whether time spent waiting for transit vehicles should be considered as exposure for walking. Goodwin and Hutchinson (1977) suggest that the amount of time that people spend waiting for a bus be part of exposure for walking in measuring the injury risk of walking. In generally time spent waiting for transit is certainly not walking, and probably should not be treated as exposure for walking. If data on pedestrian injuries include those occurred while waiting for a transit vehicle, on the other hand, excluding time spent waiting for a transit vehicle would overstate the risk of walking.

Our strategy is to include time spent on waiting for a local transit bus as exposure of walking for our best estimate of the risk of walking. In addition to duration data on access and egress modes, the 2001 NHTS also collected duration data on waiting for the first bus. Thus, the amount of waiting time measured here excludes transfer waiting as well as waiting for rail modes.

The third issue relates to pedestrian exposure on limited-access highways. Our exposure data for walking include little, if any, time spent on limited-access highways, which include interstates as well as other expressways. But our injury data for walking include injuries that resulted from crashes on limited-access highways. Not adjusting either exposure or injury data would overstate the absolute and relative risk of walking. Our strategy is to exclude pedestrian injuries on interstates for our best estimate of the risk of walking. While the FARS identifies fatal crashes by a full range of functional classes, the GES only identifies crashes of all levels with whether they occurred on interstates.

The fourth issue relates to stationary exposure by pedestrians in roadways. Just like the issue with limited-access highways, the NHTS does not have information on time that people spend on foot while stationary in roadways. That is reasonable because the NHTS is designed to collect information on travel. This time spent while stationary in roadways, on the other hand, represents exposure to vehicular traffic. Again not adjusting either exposure or injury data would overstate the risk of walking.

Our strategy is to exclude pedestrian injuries that occurred while working on or playing in roadways for our best estimate of the risk of walking. The GES identifies pedestrian actions just before being involved in a crash, but the FARS does not do so in the same details. As a result, the GES is used to estimate the number of non-fatal injuries and the proportion of fatal injuries related to these two activity types. This proportion is then applied to the total number of fatal injuries from the FARS to estimate the number of fatal injuries related to these two activity types.

The fifth issue is the argument that some walking does not represent real exposure to vehicular traffic and should be excluded in measuring the risk of walking (Julien and Carre, 2002). Walking may be done, for example, along off-road trails. In addition, only a portion of time spent on on-road walking may represent real exposure to vehicular traffic. Our strategy is to not exclude this type of walking. Though the NHTS does not allow the separation of walking in terms of its nature of exposure to vehicular traffic, this type of walking should be included when the risk of walking is measured at the macro level. When improvements allow people to shift their walking away from an environment exposed to vehicular traffic to off-road trails or other well-protected roadside environments, walking becomes less risky to these people. This reduction in the risk of walking would not be captured if walking in the new environments is excluded from the exposure measure.

Rather than directly dealing with the sixth issue (i.e., potential uncertainty in the unit costs), we test the sensitivity of our best estimate to an alternative set of unit costs. The last three issues are left to future research and discussed in the conclusion section.

## Results

We present our results in several components: injuries, unit costs, exposure, and risks. Our best estimate and alternative estimates of the risk of walking are presented separately. The best estimate results from using our best estimates of injuries, unit costs, and exposure. The alternative estimates result from different combinations of alternative estimates of injuries, unit costs, and exposure.

### Injuries

Table 2 summarizes the injury data by severity for walking and motoring separately. One set of estimates is included for motoring. Specifically, 31,785 people died, an estimated 306,537 suffered incapacitating injuries, an estimated 679,152 suffered non-incapacitating injuries, and an estimated 1,679,128 had possible injuries.

-----------------

Table 2 Here

-----------------

On the other hand, Table 2 includes four sets of estimates for walking coded as I1 through I4. I1 represents our best estimate, which excludes injuries occurred on interstates or while working on or playing in roadways. I2 adds injuries occurred on interstates to the best estimate. I3 adds injuries occurred while working on or playing in roadways to the best estimate.

I4 adds both injuries on interstates and injuries occurred while working on or playing in roadways to the best estimate, and represents all pedestrian injuries from the FARS and the GES.

**Unit Costs**

Table 3 shows two sets of unit costs coded as C1 and C2. C1 are from FHWA (1994b) and represent our best estimate. C2 are from the National Safety Council (NSC, 2002) and is our alternative estimate for sensitivity analysis. For ease of comparison with the C2 unit costs, the C1 unit costs from the FHWA have been adjusted to 2002 dollars using the GDP implicit price inflator, which increased by 15.17 percent from 1994 to 2002 (NBER, undated).

-----------------

Table 3 Here

-----------------

**Exposure**

Table 4 summarizes the exposure data for both walking and motoring. There is just one estimate for motoring. Americans spent an estimated 111,910 million hours riding in a passenger car in 2001. There are four estimates, coded as E1 through E4, for walking. E1 represents our best estimate, which includes walking for utilitarian purposes, for exercise, for walking a dog, for access to or egress from another mode, and for waiting for the first bus of a door-to-door trip. E2, representing 92.9 percent of E1, excludes waiting for buses from our best estimate. E3, representing 86.9 percent of E1, excludes walking for access or egress purposes. E4, representing 79.7 percent of E1, excludes both walking for access or egress purposes and waiting for buses.

-----------------

Table 4 Here

-----------------

**Risks**

Three sets of absolute and relative risks are estimated. Two sets represent our best estimates, using the traditional and the proposed methods, respectively. These estimates are based on the best estimates of injuries (I1), unit costs (C1), and exposure (E1) in Tables 2-4. The other set of risks is used to assess the sensitivity of our best estimates using the proposed method to alternative estimates of injuries, unit costs, and exposure in the same tables.

*Best Estimates*

Table 5 shows our best estimates of the absolute and relative risks. Walking is considerably less risky than motoring if only non-fatal injuries are considered under the traditional method. The relative injury risk ranges from 0.19 for possible injuries to 0.58 for incapacitating injuries. Walking is considerably more risky, on the other hand, when only fatal injuries are considered. The relative injury risk is 1.41, indicating that the absolute fatality risk is about 41 percent higher for walking than for motoring. It is difficult, however, to determine whether walking is more dangerous than motoring overall with these four dimensions of injury risks when the different severity levels are considered separately under the traditional method.

-----------------

Table 5 Here

-----------------

The proposed method gives a clear picture of the relative dangers of walking and motoring. When injuries are integrated under the proposed method, the injury risk of walking is lower than that of motoring. The absolute injury risks are $1.69 per hour for walking and $2.00 per hour for motoring. That is, the relative risk is only 0.85, which is considerably lower than the relative risk for fatal injuries. The differences are even more dramatic with previous estimates that are based on distance traveled or trips made from the 2001 NHTS (Pucher and

Dijkstra, 2003).

Figure 2 illustrates the case where the injury risk of walking is lower than that of motoring in the framework of safety performance functions. The horizontal axis measures exposure in hours traveled for both walking and motoring, and the vertical axis measures cost-weighted injury outcomes for both modes. The top curve represents the safety performance function for motoring: $C^m\left(T^m, v_m\right)$. The bottom curve represents the function for walking: $C^w\left(T^w, v_w\right)$. The amount of exposure ($T^i$, $i = w, m$) and the corresponding ray (indicated by its implied injury risk $r^i$ ($i = w, m$)) are both shown for each mode.

-----------------

Figure 2 Here

-----------------

*Alternative Estimates*

Table 6 shows estimates of the absolute and relative risks for walking and motoring under the proposed method for 32 scenarios. These scenarios represent not only the combinations from alternative estimates of injuries and exposure but also the two estimates of unit costs in Table 3.

One purpose of Table 6 is to show the sensitivity of our results in Table 5 to variations in estimates of injuries, unit costs, and exposure. Variations in all three components (i.e., injuries, unit costs, and exposure) influence the absolute risk of walking, but only variations in unit costs affect the absolute risk of motoring. The absolute risk of walking varies from a low of \$1.69 per hour of exposure to a high of \$2.58 per hour of exposure, while that of motoring varies between \$2.00 and \$2.04 per hour of exposure. The resulting relative risk varies from a low of 0.85 to a high of 1.26. The estimates of the relative risk toward the high end of this range result from understating exposure and overstating injuries for walking. A more reasonable range to follow would that for the 10 scenarios where two best estimates are used among the three components: injuries, unit costs, and exposure. This range is from 0.91 under scenario I1-C1-E2 to 1.06 under scenario I1-C1-E4.

Another purpose of Table 6 is for the readers to focus on the scenario that is the most reasonable to them. To some, for example, the most reasonable scenario might be I1-C1-E3 because they believe that time spent on waiting for buses should not be considered exposure for walking. In this case, the absolute risk is $1.95 per hour for walking and $2.00 per hour for motoring. The corresponding relative risk is 1.95. To others, as another example, the most reasonable scenario might be given by the average of all 32 scenarios. In this case, the absolute risk would be $2.09 per hour for walking, $2.02 per hour for motoring, and the corresponding relative risk is 1.04.

## Conclusion

This paper has proposed a time-based and integrated method to measure and compare the injury risks of walking and motoring and applied it to the U.S. in 2001. The results show that walking is considerably less risky than motoring if only non-fatal injuries are considered, and is more risky when only fatal injuries are considered. However, the risk of walking is somewhat lower or similar to that of motoring when injuries of all severity levels are integrated. In fact, the average risk is about $2.00 of expected injury costs per hour of exposure for motoring but only $1.69 per hour for walking. We conclude that motoring on average is just as dangerous, if not more dangerous, as walking in the U.S. in 2001.

Previous efforts have concluded that walking is far more dangerous than motoring. We attribute the overstatement by previous efforts to two sets of factors. One set of factors is methodological: the use of exposure measures that are based on distance traveled or trips made and the separate consideration of injuries of different severity levels. The other set of factors is empirical: the failure to exclude injuries occurred on interstates or while people were working on or playing in roadways, and the failure to include exposure related to access to or egress from another mode, and the failure to include exposure related to waiting for local transit bus services.

The reader is cautioned about how our results may be used. Just as from the traditional method, the meaningfulness of a risk measure from the proposed method also depends on how it is used and the nature of the relationship between the numerator and the denominator of a risk measure (Hauer, 1995). If a risk measure is used to indicate the injury risk facing by a road user, it is meaningful: The lower the value, the lesser the chance of the user to be injured per unit of exposure. This is true regardless of how the numerator and the denominator are related to each other. On the other hand, such risk measures should not be used to draw conclusions about the safety effect of interventions. Such conclusions become invalid if the numerator relates to the denominator in a non-linear fashion.

While the validity of our results is significantly improved over that of previous estimates using the traditional method, uncertainty still exists in our estimates due to at least three factors. These are listed in Table 1 as measurement issues 7 through 9. One source of uncertainty results from differential under-reporting of injuries between walking and motoring (Hauer, 2001). Another source of uncertainty results from errors in the estimated number of injuries. In addition to sampling errors, the data on severity ratings for non-fatal injuries may also contain non-sampling errors. In a retrospective study to compare the ratings assigned by investigating officers and physicians who participated in the study, Popkin et al. (1991) find a number of discrepancies. An injured person with multiple superficial injuries that are not incapacitating, for example, may lead the investigating officer to assign the incapacitating level to that person. However, there is no evidence to indicate that the pattern of discrepancies differ between walking and motoring. The third source of uncertainty results from our measure of exposure. Our exposure data cover both public and private roads, but our injury data only cover public roads. This incomparability between exposure and injury data would overstate the absolute risks for both walking and motoring.

However, we do not know how these sources of uncertainty may have affected our estimates. That is, it is possible that the uncertainty from each source may have caused our results to understate the danger of walking relative to motoring. But it is also possible that the danger of walking in this paper is overstated for the U.S. in 2001.

## Acknowledgments

The author wish to thank Achilleas Kourtellis and Naved Siddiqui for editorial reviews, and Steve Polzin for comments on an earlier version. The author is fully responsible for any remaining errors.

## References

Anderson, P.R., H.J. Montesin, and M.A. Adena (1989). *Road Fatality Rates in Australia 1984-1985*. Canberra, Australia: Federal Office of Road Safety.

Arkekani, Sia, Ezra Hauer, and Bahram Jamei (1997). Traffic Impact Models, Chapter 7 of *Monograph on Traffic Flow Theory*, ed. by Nathan H. Gartner, Carroll J. Messer and Ajay K. Rathi. Washington, D.C.: Transportation Research Board. http://www.tfhrc.gov/its/tft/tft.htm, assessed on September 7, 2004.

Bureau of Transportation Statistics (BTS) (1998). *Transportation Statistics beyond ISTEA: Critical Gaps and Strategic Responses*. Washington, D.C.: U.S. Department of Transportation.

BTS (2003). *Highlights of the 2001 National Household Travel Survey*. Washington, D.C.: U.S.

Department of Transportation.

Cameron, M.H. (1982). A Method of Measuring Exposure to Pedestrian Accident Risk. *Accident Analysis and Prevention*, Vol. 14, pp 397-405.

Chipman, M.L., C.G. Macgregor, A.M. Smiley, and M Leegosselin (1993). *The Role of Exposure in Comparisons of Crash Risk among Different Drivers and Driving Environments*. Accident Analysis and Prevention, Vol. 25, pp 207-211.

Chu, Xuehao (2003). *A Time-Based Comparative Approach to Understanding the Danger of Walking in the United States*. Tampa, FL: Center for Urban Transportation Research, University of South Florida.

Davis, S.E., L.E. King, and H.D. Robertson (1988). Predicting Pedestrian Crosswalk Volumes. *Transportation Research Record*, Vol. 1168, pp 25-30.

Department of Environment Transport and the Regions (DETR) (1998). *Walking in Great Britain*. London: Stationary Office.

Dewey, James F., David Denslow, David Lenze, Lynne Holt, and Babak Lotfinia (2003). *Transportation Issues: Pedestrian Safety*. Gainesville, FL: University of Florida.

European Transport Safety Council (ETSC) (1999). *Exposure Data for Travel Risk Assessment: Current Practice and Future Needs in the EU*. Brussels.

ETSC (2003). Transport Safety Performance in the EU—A Statistical Overview. Brussels.

Federal Highway Administration (FHWA) (1994a). *The National Bicycling and Walking Study: Transportation Choices for a Changing America*—Final Report. FHWA-PD-94-023. Washington, D.C.: U.S. Department of Transportation.

FHWA (1994b). *Motor Vehicle Accident Costs*, Technical Advisory, T 7570.2. Washington, D.C.: U.S Department of Transportation. http://www.fhwa.dot.gov/legsregs/directives/techadvs/t75702.htm, accessed on September 7, 2004.

FHWA (2003). *Journey to Work Trends in the United States and its Major Metropolitan Areas 1960-2000*. FHWA-EP-03-058. Washington, D.C.: U.S. Department of Transportation. Exhibit 1.1.

Garder, Per (1989). Pedestrian Safety at Traffic Signals: A Study Carried out with the Help of a Traffic

Conflicts Technique. *Accident Analysis and Prevention*, Vol. 21, pp 435-444.

Goodwin, P.B., and T.P. Hutchinson (1977). The Risk of Walking. *Transportation*, Vol. 6, pp 217-230.

Haight, Frank A. (1986). Risk, Especially Risk of Traffic Accident. *Accident Analysis and Prevention*, Vol. 18, pp 359-366.

Haight, Frank A. (1994). Problems in Estimating Comparative Costs of Safety and Mobility. *Journal of Transport Economics and Policy*, Vol. 28, pp 7-30.

Hakamies-Blomqvist, Liisa (1998). Older Drivers' Accident Risk: Conceptual and Methodological Issues. *Accident Analysis and Prevention*, Vol. 30, pp 293-297.

Hakkert, A.S., and Braimaister, L. (2002). *The Uses of Exposure and Risk in Road Safety Studies*. Leidschendam, the Netherlands: SWOV Institute for Road Safety Research. R-2002-12.

Hauer, Ezra (1995). On Exposure and Accident Rate. *Traffic Engineering and Control*, Vol. 36, pp 134-138.

Hauer, Ezra (2001). Computing and Interpreting Accident Rates for Vehicle Types or Driver Groups. *Transportation Research Record*, Vol. 1746, pp 69-73.

Jacobsen, P.L. (2003). Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling. *Injury Prevention*, Vol. 9, pp 205-209.

Jensen, Soren Underlien (1999). Pedestrian Safety in Denmark. *Transportation Research Record*, Vol. 1674, pp 61-69.

Jonah, B.A., and Engel, G.R. (1983). Measuring the Relative Risk of Pedestrian Accidents. *Accident Analysis and Prevention*, Vol. 5, pp 193-206.

Julien, A., and Carre, J.R. (2002). Recherche Transports Sécurité, Vol. 76, pp 173-189.

Knoblauch, R.L., H.N. Tobey, and E.M. Shunaman (1984). Pedestrian Characteristics and Exposure Measures. *Transportation Research Record*, Vol. 959, pp 35-41.

Keall, Michael D. (1995). Pedestrian Exposure to Risk of Road Accident in New Zealand. *Accident Analysis and Prevention*, Vol. 27, pp 729-740.

Kononov, Jake, and Bryan Allery (2002). *Highway Capacity Manual: A Conceptual Blueprint and the*

*Analytical Framework*. TRB 2003 Annual Meeting CD-ROM. http://www.ltrc.lsu.edu/TRB_82/TRB2003-000112.pdf, accessed on September 7, 2004.

Jorgensen, N.O. (1996). The Risk of Injury and Accident by Different Travel Modes. *Proceedings of the International Conference on Passenger Safety in European Public Transport*. Brussels: European Transport Safety Council. pp 17-25.

Leden, Lars (2002). Pedestrian Risk Decrease with Pedestrian Flow—A Case Study Based on Data from Signalized Intersections in Hamilton, Ontario. *Accident Analysis and Prevention*, Vol. 24, pp 457-464.

Lyles, Richard W., and Polichronis Stamatiadis (1991). Quasi-Induced Exposure Revisited. *Accident Analysis and Prevention*, Vol. 23, pp 275-285.

Miller, Ted R., C. Philip Brinkman, and Stephen Luchter (1988). Crash Costs and Safety Investment, in *Proceedings of the 32nd Annual Conference*, Association of the Advancement of Automotive Medicine, Des Plaines, IL.

Nash, Chris (2001). Equity versus Efficiency in Transport Systems, Chapter 4 of *Handbook of Transport Systems and Traffic Control*, ed. by Kenneth J. Button and David A. Hensher (Amsterdam: Pergamon), pp 33-45.

National Bureau of Economic Research (NBER) (undated). *GDP and Related Price Measures: Indexes and Percent Changes*, http://www.nber.org/palmdata/indicators/price.html, accessed on September 7, 2004.

National Highway Traffic Safety Administration (NHTSA) (2004). *Traffic Safety Facts 2002.* Washington, D.C.: U.S. Department of Transportation.

National Safety Council (NSC) (1996). *Manual on Classification of Motor Vehicle Traffic Accidents*, 6th ed. Washington, D.C.

NSC (2002). *Estimating the Costs of Unintentional Injuries, 2002*. www.nsc.org/lrs/statinfo/estcost.htm, accessed on September 7, 2004.

Popkin, Carol L., B.J. Campbell, Alfred R. Hansen, and J. Richard Stewart (1991). *Analysis of the*

*Accuracy of the Existing KABCO Injury Scale*. Chapel Hill, NC: Highway Safety Research Center, University of North Carolina.

Pucher, John, and Lewis Dijkstra (2000). Making Walking and Cycling Safer: Lessons from Europe. *Transportation Quarterly*, Vol. 54, pp 25-50.

Pucher, John, and Lewis Dijkstra (2003). Promoting Safe Walking and Cycling to Improve Public Health: Lessons from the Netherlands and Germany. *American Journal of Public Health*, Vol. 93, pp 1509-1516.

Rietveld, Piet (2001). Biking and Walking: The Position of Non-Motorized Transport Modes in Transport Systems, Chapter 15 of *Handbook of Transport Systems and Traffic Contro*l, ed. by Kenneth J. Button and David A. Hensher (Amsterdam: Pergamon), pp 299-319.

Roberts, I, R Norton, and B Taura (1996). Child Pedestrian Exposure Rates: The Importance of Exposure to Risk Relating to Socioeconomic and Ethnic Differences in Auckland, New Zealand. *Journal of Epidemiology and Community Health*, Vol. 50, pp 162-165.

Sallis, James F., Lawrence D. Frank, Brian E. Saelens, and M. Katherine Kraft (2004). Active Transportation and Physical Activity: Opportunities for Collaboration on Transportation and Public Health Research. *Transportation Research Part A*, Vol. 38, pp 249-268.

Silcock, David, Tim Selby, Richard Walker, and Derek Packham (1998). Measurement of Pedestrians' Exposure to Risk, *Proceedings of the Conference—Traffic Safety on Two Continents*, Malmo, Sweden, September 22-24, 1997, Vol. 9a, pp 27-40.

Small, Kenneth A. (1999). Project Evaluation, Chapter 5 of Essays in *Transportation Economics and Policy: A Handbook in Honor of John R. Meyer*, ed. by José A. Gómez-Ibáñez, William B. Tye, and Clifford Winston (Washington, D.C.: Brookings Institution), pp 137-177.

Stamatiadis, Nikiforos, and John A. Deacon (1997). Quasi-Induced Exposure: Methodology and Insight. *Accident Analysis and Prevention*, Vol. 29, pp 37-52.

Surface Transportation Policy Project (STPP) (2002a). *Mean Streets*. Washington, D.C.

STPP (2002b). *Pedestrian Safety in California: Five Years of Progress and Pitfalls*. California Walks.

Tessmer, Joseph M. (2002). *FARS Analytic Reference Guide 1975 to 2002*. Washington, D.C.: National Highway Traffic Safety Administration, U.S. Department of Transportation.

The Urban Institute (1991). *The Costs of Highway Crashes*. Washington, D.C.: Federal Highway Administration Research Report Number FHWA-RD-91-055.

Transport Research Laboratory (TRL) (2001). *Cost-Benefit Analysis of Measures for Vulnerable Road Users*. Deliverable 5 for European Research Project PROMISING. The Netherlands: SWOV Institute for Road Safety Research.

US Department of Transportation (USDOT) (2003). *2001 National Household Travel Survey*. http://nhts.ornl.gov/2001/index.shtml, accessed on September 7, 2004.

Wittink, Roelof (2001). *Promotion of Mobility and Safety of Vulnerable Road Users*, Final report of the European Research Project PROMISING. SWOV Institute for Road Safety Research, The Netherlands.

Wolfe, Authur C. (1982). The Concept of Exposure to the Risk of a Road Traffic Accident and an Overview of Exposure Data Collection Methods. *Accident Analysis and Prevention*, Vol. 14, pp 337-340.

Figure 1 : Safety Performance Function and Injury Risks for Mode $i$

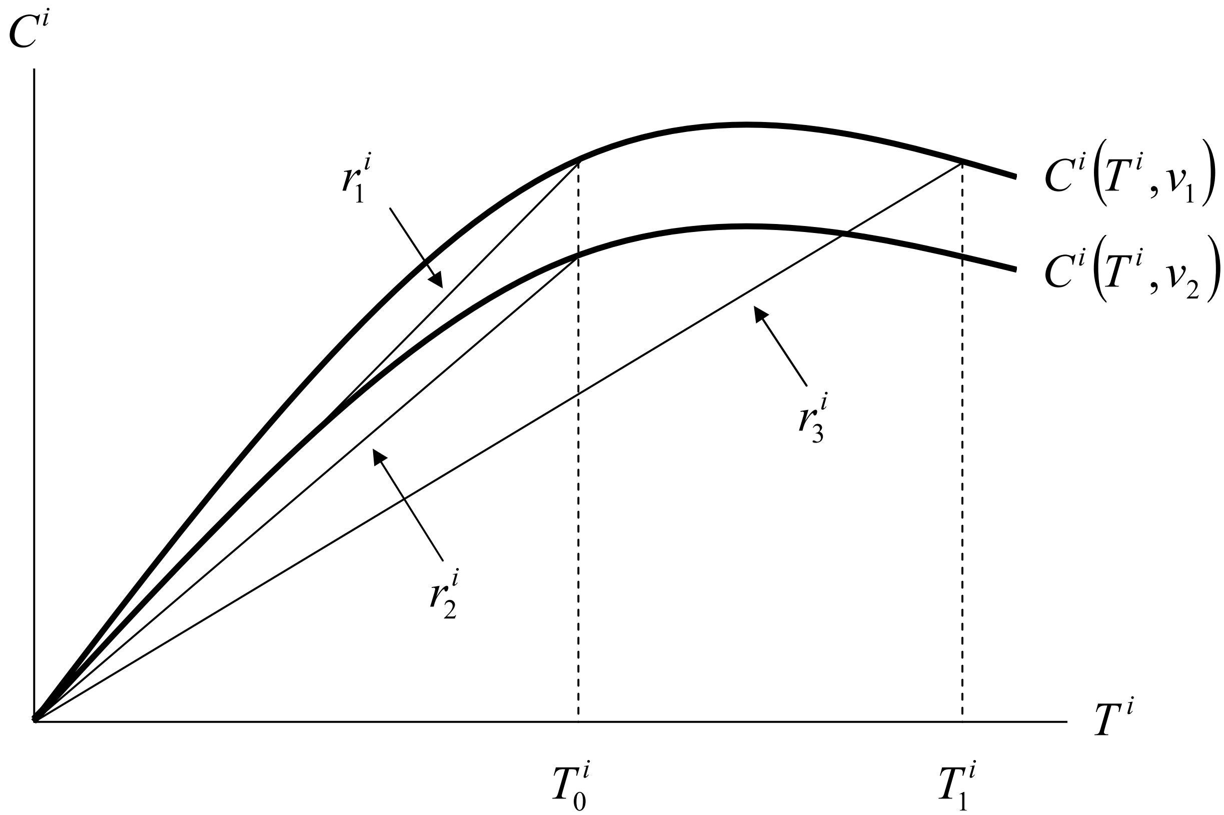

Figure 2 : Case of Lower Injury Risk of Walking (*w*) Than Motoring (*m*)

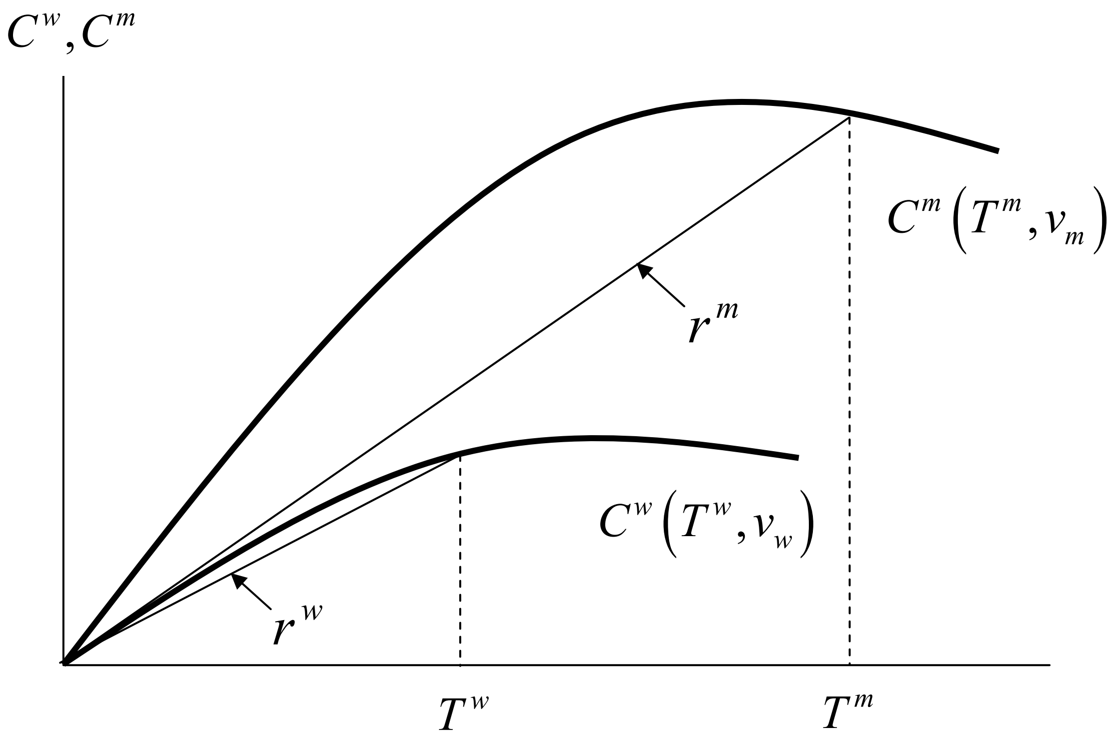

Table 1. Measurement Issues, Effects, and Strategies

| ID | Issues | Effects | | Strategy |
|---|---|---|---|---|
| | | Absolute Risk | Relative Risk | |
| 1 | Exclusion of access/egress travel for w | Higher for w | Higher | Include |
| 2 | Exclusion of waiting for buses for w | Higher for w | Higher | Include |
| 3 | No data on freeway exposure for w | Higher for w | Higher | Exclude injuries on interstates |
| 4 | No data on stationary exposure for w | Higher for w | Higher | Exclude injuries from working on or playing in roadways |
| 5 | Inclusion of no-risk exposure | None | None | Leave it alone |
| 6 | Errors in unit costs | Uncertain for w & m | Uncertain | Test alternative |
| 7 | Under-reporting of injuries | Lower for w & m | Uncertain | Future research |
| 8 | Errors in non-fatal injuries | Uncertain for w & m | Uncertain | Future research |
| 9 | Exposure covers private roads | Lower for w & m | Uncertain | Future research |

Table 2 : Number of Injuries by Severity and Mode, 2001 U.S.

| Severity | Walking | | | | Motoring |
|---|---|---|---|---|---|
| | I1. Best Estimate | I2. Add Interstates | I3. Add Working on or Playing in Roadway | I4. Add Both | |
| Fatal | 4,273 | 4,789 | 4,366 | 4,882 | 31,785 |
| Incapacitating | 17,060 | 17,477 | 17,728 | 18,145 | 306,537 |
| Non-incapacitating | 25,415 | 25,725 | 26,266 | 26,533 | 679,152 |
| Possible | 30,364 | 30,392 | 31,210 | 31,229 | 1,679,128 |

Table 3 :  Unit Costs of Injuries by Severity (2002 $)

| Severity | C1. Best Estimate (FHWA) | C2. Alternative (NSC) |
|---|---|---|
| **Possible** | $22,000 | $21,000 |
| **Non-incapacitating** | $44,000 | $44,000 |
| **Incapacitating** | $207,000 | $172,000 |
| **Fatal** | $2,994,000 | $3,472,000 |

Table 4 :  Total Annual Exposure by Mode, 2001 U.S.

| Severity | Walking | | | | Motoring |
|---|---|---|---|---|---|
| | E1. Best Estimate | E2. Exclude Waiting for Bus | E3. Exclude Access or Egress | E4. Exclude Both | |
| Million Hours | 10,658 | 9,901 | 9,252 | 8,495 | 1,679,128 |
| Percent | 100 | 92.9 | 86.9 | 79.7 | 100 |

Table 5. Best Estimates of Absolute and Relative Risks by Method, 2001 U.S.

| Method | Severity | Absolute Risk | | Relative Risk |
|---|---|---|---|---|
| | | Walking | Motoring | Walking/Motoring |
| Traditional Method (Injuries per 10 million hours) | K (Fatal) | 4.0 | 2.8 | 1.41 |
| | A (Incapacitating) | 16.0 | 27.4 | 0.58 |
| | B (Non-incapacitating) | 23.8 | 60.7 | 0.39 |
| | C (Possible) | 28.5 | 150.0 | 0.19 |
| Proposed Method (2002 $ per Hour) | Integrated | $1.69 | $2.00 | 0.85 |

Table 6 : Alternative Estimates of Injury Risks Using Proposed Method, 2001 U.S.

| Scenario | | | Absolute Risk (2002 $/Hour) | | Relative Risk (Walking/ Motoring) |
|---|---|---|---|---|---|
| Injury | Unit Costs | Exposure | Walking | Motoring | |
| **I1. Best Estimate** | **C1. Best Estimate** | **E1. Best Estimate** | **$1.69** | **$2.00** | **0.85** |
| | | E2. Exclude Waiting for Bus | $1.82 | $2.00 | 0.91 |
| | | E3. Exclude Access/Egress | $1.95 | $2.00 | 0.98 |
| | | E4. Exclude Both | $2.12 | $2.00 | 1.06 |
| | C2. Alternative | E1. Best Estimate | $1.83 | $2.04 | 0.90 |
| | | E2. Exclude Waiting for Bus | $1.97 | $2.04 | 0.97 |
| | | E3. Exclude Access/Egress | $2.11 | $2.04 | 1.03 |
| | | E4. Exclude Both | $2.30 | $2.04 | 1.13 |
| I2. Add Interstates | C1. Best Estimate | E1. Best Estimate | $1.74 | $2.00 | 0.87 |
| | | E2. Exclude Waiting for Bus | $1.87 | $2.00 | 0.94 |
| | | E3. Exclude Access/Egress | $2.00 | $2.00 | 1.00 |
| | | E4. Exclude Both | $2.18 | $2.00 | 1.09 |
| | C2. Alternative | E1. Best Estimate | $1.88 | $2.04 | 0.92 |
| | | E2. Exclude Waiting for Bus | $2.02 | $2.04 | 0.99 |
| | | E3. Exclude Access/Egress | $2.16 | $2.04 | 1.06 |
| | | E4. Exclude Both | $2.36 | $2.04 | 1.16 |
| I3. Add Working on or Playing in Roadways | C1. Best Estimate | E1. Best Estimate | $1.85 | $2.00 | 0.92 |
| | | E2. Exclude Waiting for Bus | $1.99 | $2.00 | 1.00 |
| | | E3. Exclude Access/Egress | $2.13 | $2.00 | 1.07 |
| | | E4. Exclude Both | $2.32 | $2.00 | 1.16 |
| | C2. Alternative | E1. Best Estimate | $2.01 | $2.04 | 0.98 |
| | | E2. Exclude Waiting for Bus | $2.16 | $2.04 | 1.06 |
| | | E3. Exclude Access/Egress | $2.31 | $2.04 | 1.13 |
| | | E4. Exclude Both | $2.52 | $2.04 | 1.24 |
| I4. Add Both | C1. Best Estimate | E1. Best Estimate | $1.89 | $2.00 | 0.95 |
| | | E2. Exclude Waiting for Bus | $2.03 | $2.00 | 1.02 |
| | | E3. Exclude Access/Egress | $2.18 | $2.00 | 1.09 |
| | | E4. Exclude Both | $2.37 | $2.00 | 1.19 |
| | C2. Alternative | E1. Best Estimate | $2.05 | $2.04 | 1.01 |
| | | E2. Exclude Waiting for Bus | $2.21 | $2.04 | 1.08 |
| | | E3. Exclude Access/Egress | $2.37 | $2.04 | 1.16 |
| | | E4. Exclude Both | $2.58 | $2.04 | 1.26 |
| Average | | | $2.09 | $2.02 | 1.04 |