EVALUATION OF THE QUASI-INDUCED EXPOSURE

FINAL REPORT

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EXECUTIVE SUMMARY

Even though crash databases can provide sufficiently accurate estimates of the frequencies of crashes, accurate estimates of crash exposure are often difficult or impossible to make. This problem is even greater when crash rates are needed for data disaggregated by time of crash, driver age and so forth. To overcome some of the problems and limitations in estimating exposure by driver and situation type from exogenous values such as travel distance, drivers licensed, and vehicles registered, methods have been developed that derive exposure estimates from the crash database itself. Despite their promise, however, these induced-exposure techniques have not been widely used. The objective of this research effort is to develop estimates of travel using a trip diary approach and compare these estimates to one of the more promising induced-exposure techniques, that which derives exposure from the innocent victim, the non-responsible driver in two-vehicle crashes.

The basic tool for the data collection was a trip diary that allows for the development of exposure estimates for the various age groups of drivers. The objective of the diary was to collect trip and driver information. Driver information collected included the driver age, gender, and household structure. Trip information provided data for the specific trip taken such as time of day, day of the week and trip purpose. Also important in this information was the type of roadways on which the individual driver selected for their designated route. This information would then allow for the development of travel patterns on each roadway classification, which could then be compared to the exposure information based on the quasi-induced exposure methods. After evaluating three different trip diary designs, a map based trip diary was selected that required participants to trace on the map all their trips for a ten-day period.

Approximately 65 diaries were distributed but only 26 were returned that prohibited the team from a robust statistical analysis of the data. A qualitative analysis however was performed that indicated some trends between the two exposure methods. The first trend noted was for the 35-64 age group which showed similar exposure levels based on both the quasi-induced exposure and the vehicle-miles of travel (VMT) exposure derived from the trip diaries. The second trend observed was that for the over 64 age group which showed a VMT exposure consistently 2 to 3 times higher than the exposure given by the quasi-induced method. The first trend is possible due to larger sample size both in participants and in number of routes.
completed. The second trend could be explained by the fact that the participants were recruited from a senior citizens meeting forum. Members in these forums are in general more active members of the community, in better health since they are able to attend the forum multiple times a week, and generally in the lower age range of the 65 and over category.

This study, attempting to validate exposure metrics given by the quasi-induced method, has produced some promising results. There were cases that exposure estimated by each method produced similar results. This demonstrates that with adequate statistical strength of both trips logged in trip diaries and available crash records from the crash database the quasi-induced exposure method can be validated. Even though the results indicate that there was a difference in the exposure estimated by the two methods, there is adequate evidence that there are indeed significance differences among the various age groups of drivers in the time and place that they drive that requires further investigation on this area. It is believed that further research with the benefit of greater numbers will then be able produce the same results and validate the method in more disaggregated conditions. However, of possibly even more importance than the lack of significant findings form this study are the lessons learned. By streamlining the requirements of the trip diaries it is possible to increase the number of respondents, attaining a greater number of trips from a more representative sample of the population. Following the recommendations of this study it is possible to collect the required data that would allow for ultimately validating the quasi-induced exposure method.
INTRODUCTION

Crash rates are useful metrics for establishing the relative safety of various driver classes, vehicle types, roadway components, and so on. Such rates assist in establishing policies and practices aimed at improving highway safety. Although computerized databases now yield sufficiently accurate estimates of the frequencies of crashes to support investigations sub-divided by many roadway, driver, and environment characteristics, the corresponding accurate estimates of crash exposure for these categories are often difficult or impossible to make. Moreover, investigators sometimes disagree about which exposure measure is most appropriate for each specific application.

The traditional methods are based on estimating the amount of vehicle-kilometers traveled by simply multiplying the average daily traffic of the roadway by the length of the roadway. However, the use of vehicle-kilometers traveled calculated in this manner prohibits the development of exposure metrics for specific driver and situation combinations, as often needed in various studies. To overcome some of the problems and limitations in estimating exposure by driver and situation type from exogenous values such as travel distance, licensed drivers, and registered vehicles, methods have been developed that derive exposure estimates from the crash database itself (1,2). Despite their promise, however, these induced-exposure techniques have not been widely used. Safety researchers have been somewhat reluctant to embrace them perhaps because these techniques have not been adequately compared to more conventional ones and perhaps because underlying assumptions have not been convincingly validated.

The main goal of this research effort was to develop a methodology for comparing exposure metrics based on travel estimates and the quasi-induced exposure. Trip diaries were utilized to develop travel estimates to be used as an indicator of crash exposure. These estimates were then compared to equivalent estimates based on the quasi-induced exposure technique, an induced exposure method that derives exposure from the non-responsible driver in two-vehicle crashes. The crash rates given by both methods were then used to determine exposure by different times of the day, on different roadway types, and by age and gender of the driver. The findings of this research would allow for the development of a procedure that could evaluate this
induced exposure technique and thus, improve the ability to develop crash rates for specific groups of drivers and other variables of interest.

**BACKGROUND**

Induced exposure analysis was first presented by Thorpe who developed formulas that determine the relative likelihood of driver involvement in a crash as the ratio of the number of involvements to the exposure (3). The exposure to a crash was based on both single and multiple vehicle crashes, even though no distinction of the at-fault driver in multiple vehicle crashes was made. The next advancement was made by Carr, who introduced the notion of identifying the responsible driver for the crash occurrence in multiple vehicle crashes based on the report completed by the investigating officer (4). Both Thorpe and Carr measured the relative involvement to exposure ratio using as the numerator the percentage of crashes for a given driver/vehicle group and as the denominator the exposure as calculated by their models. In Thorpe’s model, the exposure is the difference in percentages of multiple and single vehicle crashes, while in Carr’s model it is the percentage of non-responsible drivers for the corresponding driver/vehicle group.

Quasi-induced exposure, as developed by Carr and coined by Haight, has been used more frequently than any other induced exposure method (5). This approach has been applied in several studies that examined driver characteristics and assessed the effects of possible causal factors on crashes (1,6,7,8). Even though there has been a resurgence of interest in this method lately, a number of issues have been raised concerning the basic assumptions of this method and thus, the reliability of the ratios obtained using this exposure metric. The basic requirement to determine the driver mostly at fault in the quasi-induced exposure method has been the focus of concern. However, past research indicated that this should not be the principle argument for rejecting this approach and that validation of this method is no more difficult than validating any other exposure estimates (9).

A significant advantage of the quasi-induced exposure method is its ability to develop exposure estimates for specific driver and vehicle groups for which estimates in other methods, such as vehicle-kilometers of travel, are less readily available. More specifically the quasi-
induced exposure technique derives these estimates from the distribution of not-responsible
drivers/vehicles in the set of two-vehicle crashes for which fault can be reasonably attributed to
one driver/vehicle. The key assumption is that the distribution of not-responsible
drivers/vehicles closely mirrors the distribution of all drivers/vehicles exposed to a crash hazard
(1,9).

An important issue that has not received adequate prior attention is the differences among
the types of drivers and vehicles that use different elements of the roadway system over time
(10). For example, it is reasonable to assume that large heavy trucks are more likely to use the
interstate system during weekdays than they are to use local roads during weekends. Similarly,
younger drivers may comprise a larger proportion of drivers on local streets during weekend
nights than on interstates during rush periods. These kind of differences are not accurately
represented by traditional aggregate exposure metrics such as total vehicle-kilometers of travel
because of the difficulty in collecting the large amount and variety of needed data. The use of
induced exposure can thus provide an alternative means to achieve this stratification of data over
location and time and, as a result, can reflect the differences in driver characteristics for each
such combination. This stratification also improves the accuracy of the assumption regarding
the randomness of the not at-fault driver.

The quasi-induced exposure technique can also be used to develop measures of the
relative crash propensity or risk of different driver/vehicle types. The relative crash propensity
for a specific group of drivers/vehicles is estimated as the ratio of its proportion among the
responsible population group to its proportion among the non-responsible population group. For
both multiple and single vehicle crashes the denominator is the driver not at fault in multiple
vehicle cashes and the numerator is the corresponding at-fault driver for multiple vehicle crashes
and the single vehicle driver for single vehicle crashes. A group that is more frequently
represented among responsible than non-responsible drivers/vehicles is at greater than normal
.crash risk. Logistic regression models have been employed to statistically evaluate such ratios.

In summary, quasi-induced exposure analysis is a powerful technique for measuring
relative exposures of groups of drivers or vehicles to crash hazard as well as for estimating their
relative crash propensity. However, this method is still viewed with some skepticism by the
safety community and further proof and validation is needed. Thus, this research will develop a
mechanism to validate this approach and provide some preliminary comparisons with other methods. Having validated this approach, the method will become more widespread and will be utilized in many more analyses aiming to understand and improve safety trends.

RESEARCH APPROACH AND METHODOLOGY

Development of Trip Diaries for Travel Route Information

The basic tool for the data collection was a trip diary that allows for the development of exposure estimates for the various age groups of drivers. The objective of the diary was to collect both trip and driver information. Driver information collected included the driver age, gender, and household structure. Trip information provided data for the specific trip taken such as time of day, day of the week and trip purpose. Also important in this information was the type of roadways on which the individual driver selected for their designated route. This information would then allow for the development of travel patterns based on roadway classification, which could then be compared to the exposure information based on the quasi-induced exposure methods.

The determination of the roadway classification was considered essential and a method for recording this information was sought by testing numerous prototype trip diaries. The first pilot diary was based upon the concept that the driver is capable of determining the roadway classification that he/she is driving. To simplify the process and provide a usable scheme, five major roadway categories were provided: interstates, major arterials, minor arterials, collectors, and local streets. Participants were required to check the appropriate boxes indicating trip time and day of the week and then fill in the mileage driven on the appropriate category of roadway. This format allowed for the collection of the required information and provided a clear and easy method for entering the data for the participants. This type of data entry typically requires less effort from the participants, since they have to mark boxes and provide short descriptions of the route, as well from the researchers for the decoding of the diary. The pretesting of this diary showed that participants face significant problems in determining the classification of their route. Discrepancies between the real and perceived classification were observed, since most of the participants considered the majority of roads as locals (within city limits) or arterials (major
Therefore, an alternative method was required to capture these data.

Two new designs were considered to properly address the roadway classification problem. The first design used the same method as above to record the participant information and time of day and day of week by providing boxes that needed to be checked. The diary required the participant to write the name of the roadway and mileage for each leg of the trip to allow the research team to capture the classification of the roadways used. It was then up to the research team to match the roadway name to the roadway classification as designated by the Kentucky Transportation Cabinet (KYTC). However, several problems arose with this method in preliminary testing. Many roadways have segments with varied classification along their lengths and thus it was impossible to properly identify some roads with certainty. Another problem encountered was the use of local names to describe some roadways, which do not match the KYTC database. This created additional uncertainty on properly identifying the roadway classification. Moreover, a common complaint by the participants who completed these pilot diaries was that this approach required much higher level of detail. Therefore, this type of diary was considered inappropriate and a different approach was sought.

In order to avoid all these issues, a new approach was chosen. The new trip diary consisted primarily of a map of the urban district of Fayette County with all roads shown. The county has a population of approximately 300,000, covers an area of 732 km², and has a roadway network of 2,152 km. While limiting the coverage area to only a county decreased the study area for which trips could be captured, matching information could be drawn from the crash database for the quasi-induced method as will be discussed later. In this diary, the participant was asked to trace on the map the route taken for the trip and to log specific trip information. This information consisted of the trip time of day, date, purpose, and starting and ending addresses. The pilot tests of this trip diary showed promising results with a 100% participant satisfaction regarding the ease of completing the diary. This format of trip diary was then selected as the final diary to be used in the study. A sample of this trip diary is shown in Appendix A. The trip diary also contained written directions on completing the information and a sample (completed) trip log for reference during the completion of the diary. A personal questionnaire was also included in the front to determine driver gender, age group, and household structure. The diary itself consisted of 30 street maps of the greater-Lexington, KY
area, the estimated number of trips to be taken during the ten-day study period.

**Data Collection**

Trip diaries were distributed to participants of varying age groups and gender in order to collect data for a sample of the Kentucky driving population as representative as possible. The distribution of trip diaries between age groups and gender groups was selected to match the distribution of such groups within the population of licensed drivers in Kentucky. Approximately 65 trip diaries were initially distributed. Table 1 shows the distribution of Kentucky drivers and the corresponding distribution of distributed trip diaries, as well as the number of returned diaries in each group. Diaries were distributed at central meeting locations such as places of work, universities, and meeting halls, as opposed to residential areas, in order to collect a sample of drivers living in different parts of the city. Upon delivery of the diaries, a brief description of the requirements was given and the general purpose of the study was explained. Volunteers were then sought in order to select participants who were more likely to complete the study and increase the response rate. After selection, additional directions were given to the participants where the data entry was further explained and contact numbers for future questions were provided. Participants were contacted in two sets, the first during the first part of February and the second during the middle of March. This approach was considered important in order to obtain varying dates of trip completion so that any potential weather related problems or date specific travel patterns could be avoided. Each participant was asked to fill out the diary for a period of ten days and log every trip taken during that period. The participants were asked to log only trips where they were the driver. The ten-day period allowed for a sample of trips capturing both weekend and weekday travel, which can be used for a further level of data disaggregation for comparisons to the induced exposure metrics. The participant was instructed to call the research team for collection of the diary upon completion. A reminder call was also given during the period that data were collected to identify potential problems and to ensure that the participants were completing the data.

Table 1. Age distribution of Kentucky licensed drivers and trip diary participants
## Table

<table>
<thead>
<tr>
<th>Age Group</th>
<th>18-34</th>
<th>35-64</th>
<th>Over 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licensed Drivers</td>
<td>885,265 (34%)</td>
<td>1,340,906 (52%)</td>
<td>348,491 (14%)</td>
</tr>
<tr>
<td>Diaries Distributed</td>
<td>22 (34%)</td>
<td>34 (52%)</td>
<td>9 (14%)</td>
</tr>
<tr>
<td>Diaries Returned</td>
<td>8 (31%)</td>
<td>10 (38%)</td>
<td>8 (31%)</td>
</tr>
</tbody>
</table>

### Travel Estimates

Completed trip diaries were entered into a database where driver and route information were stored. Routes were digitized utilizing ArcInfo, a UNIX-based Geographic Information System (GIS) that allowed for the identification of the roadway classification based on the KYTC categorization. Using the GIS the routes were overlaid with the county road database which allowed for the distance by road class for each route to be calculated. Each route was then joined with the personal and the trip specific information thus providing a complete data set for each trip taken. Average daily mileages were computed for each driver for each of the highway types he/she drove in combination with other trip information (e.g. time of day and day of week). This information was then extrapolated in order to determine the average annual urban mileage of each driver. The data was adjusted for the number of days that the trip diary was completed as well for the trips taken based on the day of week and time of day. Assuming that the sample of drivers selected was representative of drivers in Lexington, the average annual mileage for each age group was estimated using the average daily mileages. This mileage was then multiplied by the number of licensed drivers in Fayette County in each age category in order to determine the total Vehicle Kilometers Traveled (VKMT) for each age group. It was then possible to disaggregate this information by both driver characteristics and environmental factors, in order to develop an exposure metric that can be compared to the exposure metrics derived from the quasi-induced exposure method.

Trip mileage collected was also aggregated into categories according to both driver characteristics and trip conditions. The trip diary provided for six age groups but the lack of
respondents in some of the groups required the regrouping of the drivers into three age groups (18-34, 35-64, and over 64 years). An original objective of the study was to examine gender differences among drivers. However, there were only five diaries completed by females and thus no gender analysis was conducted. Trip information was also aggregated by time of day (daylight and nighttime conditions), day of week (weekday (Monday-Friday) and weekend), and roadway class (Interstate, Major Arterial, Minor Arterial, Collectors, and Locals).

**Quasi-Induced Exposure**

The next step involved the exposure estimation based on the crash databases for the Commonwealth of Kentucky. To proceed with this, crashes in the 1996-1998 period were chosen from the Kentucky Accident Record System (KARS). In order to match the driver characteristics between the trip diaries and crashes, crash records were selected only if they occurred within the urban area of Fayette County, i.e. the study area. The measure of the crash causing propensity used in the quasi-induced exposure methodology is the relative accident involvement ratio (RAIR). The RAIR is calculated by taking the ratio of the percentage of at-fault drivers in a specific subgroup to the percentage of not-at-fault drivers from the same subgroup. Thus, the assumption is that the distribution of not-responsible drivers is a representative sample of the travel exposure of all drivers in that group.

In order to develop this ratio it was necessary to define at-fault and not at-fault drivers. The issue of assigning fault in a crash is determined from information contained in the crash database. Each crash entry includes a human factor category that indicates what each driver did to contribute to the crash occurrence. A driver that has an evident contribution to the crash occurrence is then considered to be the at fault driver. To avoid cases where biases may be introduced due to miscoding of the at-fault driver, crashes where both drivers or neither driver had a contributing human factor were excluded from the analysis. There were a total of 12% of crashes that were eliminated from the database due to an inability to clearly identify the responsible driver. The not-at fault drivers were then used as the exposure metric, which was compared to the exposure estimated by the VKMT obtained through the trip diaries. Therefore, not-at fault distributions were calculated for the same disaggregated categories as those
developed for the trip diary VKMT. For the 1996-1998 period there were 17,907 crashes in Fayette County for which the not-at fault driver was clearly identified.

**Comparison of Exposure Metrics**

The main objective of this effort is to compare the exposure estimates derived from the quasi-induced exposure method to those obtained from vehicle-kilometers of travel. Such a comparison would allow for determining the accuracy of the basic assumption in the quasi-induced method that the not-at fault driver could be considered as a random sample of the driving population. Moreover, this comparison will allow for comparing the quasi-induced exposure estimates with the more traditional measures of exposure, namely VKMT. The classification of the exposure data in Tables 2 and 3 in various categories allows for a better understanding of the exposure levels under different roadway and time combinations and provides the opportunity to examine such differing conditions. For each category, the percent distribution of the not-at fault drivers was compared to the distribution of the VKMTs derived from the trip diary by developing each distribution by age group for varying conditions.

The small number of trips retrieved from the 26 completed trip diaries and their 550 total trips as well as the small number of crashes in Fayette County during the study period did not allow for performing statistical tests. However, a qualitative analysis has been conducted and the results are presented in the next section.

**RESULTS**

The results from the qualitative analysis of the comparison between exposure methods are presented in this section. A summary of the data for each method is also included to provide for the context of these comparisons. Even though it was desirable to examine the combined effect of variables and by disaggregating the data on multiple levels, the low number of crashes and trips did not allow such an examination. Therefore, the analysis was limited to examination to only one level of the variables.

**Trip Diary Exposure**
The data from the trip diaries were analyzed to determine possible travel trends. The average driver in Fayette County was estimated to have completed 2,559.5 kilometers per year within the urban boundaries of the county. Of these kilometers, 12.6% were on Interstates, 31.0% on major arterials, 34.7% on minor arterials, 13.3% on collectors, and 5.9% on local streets. Approximately 83% of this mileage was completed in daytime and almost 80% in weekdays. There are approximately 205,000 licensed drivers in Fayette County and their age distribution is similar to that shown in Table 1. Using the average mileages for each category and the number of licensed drivers, annual VKMT were estimated for each of the categories of interest by age group (Table 2).

Table 2. Vehicle-kilometers of travel per year by age group

<table>
<thead>
<tr>
<th>Category</th>
<th>Values</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18-34</td>
</tr>
<tr>
<td>Roadway Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interstate</td>
<td>17,960,105</td>
<td>35,254,877</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>52,109,101</td>
<td>97,309,795</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>76,905,733</td>
<td>101,243,232</td>
</tr>
<tr>
<td>Collectors</td>
<td>29,408,267</td>
<td>29,995,576</td>
</tr>
<tr>
<td>Local</td>
<td>10,618,942</td>
<td>14,540,835</td>
</tr>
<tr>
<td>Time of Day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daylight</td>
<td>132,706,994</td>
<td>206,476,944</td>
</tr>
<tr>
<td>Nighttime</td>
<td>51,878,678</td>
<td>71,014,242</td>
</tr>
<tr>
<td>Day of week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday</td>
<td>158,765,440</td>
<td>227,952,832</td>
</tr>
<tr>
<td>Weekend</td>
<td>28,712,628</td>
<td>55,304,658</td>
</tr>
</tbody>
</table>

10
Quasi-Induced Exposure

The data from the KARS was grouped into the same categories as the trip diary data presented in Table 2. During the 1996-1998 period there were 17,907 crashes where the not-at-fault driver could be clearly identified. Among these crashes, 5% occurred on Interstates, 29% on major arterials, 28% on minor arterials, 5% on collectors, and 33% on local streets. Most of the crashes occurred during the daytime (86%) and on weekdays (81%). The crash data for the not-at-fault driver by age group data is shown in Table 3.

Table 3. Distribution of not-at-fault drivers by age group, 1996-1998

<table>
<thead>
<tr>
<th>Category</th>
<th>Values</th>
<th>18-34</th>
<th>35-64</th>
<th>Over 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Class</td>
<td>Interstate</td>
<td>436</td>
<td>483</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Major Arterial</td>
<td>2,657</td>
<td>2,295</td>
<td>285</td>
</tr>
<tr>
<td></td>
<td>Minor Arterial</td>
<td>2,509</td>
<td>2,230</td>
<td>274</td>
</tr>
<tr>
<td></td>
<td>Collectors</td>
<td>412</td>
<td>388</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Local</td>
<td>3,079</td>
<td>2,477</td>
<td>287</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Daylight</td>
<td>7,591</td>
<td>6,972</td>
<td>899</td>
</tr>
<tr>
<td></td>
<td>Nighttime</td>
<td>1,502</td>
<td>901</td>
<td>42</td>
</tr>
<tr>
<td>Day of week</td>
<td>Weekday</td>
<td>7,405</td>
<td>6,490</td>
<td>758</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>1,688</td>
<td>1,383</td>
<td>183</td>
</tr>
</tbody>
</table>

Comparisons

A percent distribution for each exposure metric was computed to examine whether there are any similarities between the two methods (Table 4). For every category examined, the exposure estimates from both the trip diary and the quasi-induced exposure are presented. It should be noted that the exposure is estimated within each category, i.e. the sum of the percentages of each row is equal to 100%. The data shown here indicate that in general there are differences for most of the
categories between the two exposure metrics. A closer examination though reveals that there are certain trends that may provide a potential explanation for these differences.

Table 4. Percent distribution of exposure metrics by age group

<table>
<thead>
<tr>
<th>Category</th>
<th>Values</th>
<th>Exposure Metric</th>
<th>Age group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>18-34</td>
<td>35-64</td>
</tr>
<tr>
<td>Age</td>
<td>Diary</td>
<td>35.4</td>
<td>53.3</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>50.4</td>
<td>44.0</td>
</tr>
<tr>
<td>Roadway Class</td>
<td>Interstate</td>
<td>Diary</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>52.7</td>
<td>42.4</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>Diary</td>
<td>30.7</td>
<td>57.4</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>45.2</td>
<td>50.1</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>Diary</td>
<td>39.4</td>
<td>51.9</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>50.7</td>
<td>43.8</td>
</tr>
<tr>
<td>Collectors</td>
<td>Diary</td>
<td>42.7</td>
<td>43.6</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>50.0</td>
<td>44.5</td>
</tr>
<tr>
<td>Local</td>
<td>Diary</td>
<td>35.5</td>
<td>48.6</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>48.5</td>
<td>45.7</td>
</tr>
<tr>
<td>Time of Day</td>
<td>Daylight</td>
<td>Diary</td>
<td>34.4</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>49.1</td>
<td>45.1</td>
</tr>
<tr>
<td></td>
<td>Nighttime</td>
<td>Diary</td>
<td>38.2</td>
</tr>
<tr>
<td></td>
<td>QI</td>
<td>61.4</td>
<td>36.9</td>
</tr>
</tbody>
</table>
The data in Table 4 shows two main trends. The first trend noted was for the 35-64 age group which showed similar exposure levels based on both the quasi-induced exposure and the VKMT exposure derived from the trip diaries. The second trend observed was that for the over 64 age group which showed a VKMT exposure consistently 2 to 3 times higher than the exposure given by the quasi-induced method. Based upon the make-up of the trip diary participants for these two groups, possible explanations can be made for these differences in the data.

The 35-64 age group showed the smallest differences between the two exposure metrics and there were few instances where the differences were large. This was the largest age group participating in the study with a total of 10 participants. Participants in this age group were professionals who have a regular working schedule and thus most of the trips performed were work related. The starting and ending points of their trips were diversified and spread out throughout the urban area of the Fayette County. Even though they represent a small fraction of the driving population, they could be considered as a representative sample of the driving population in this age group due to the factors mentioned here. Therefore, it was somewhat expected that the exposure distributions derived from the trip diaries would match those derived from the quasi-induced method.

The participants of the over 64 age group were primarily selected from a senior citizens meeting forum. In general, participants in such forums are more active members of the community, in better health since they are able to attend the forum multiple times a week, and generally in the lower age range of the 65 and over category. Moreover, those people who were more apt to volunteer, were more likely to be persons who drove more as compared to other members of the group. Therefore, it is likely that the participants who were categorized as being in the third age

<table>
<thead>
<tr>
<th>Day of week</th>
<th>Weekday</th>
<th>Diary</th>
<th>QI</th>
<th>VKMT</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>36.7</td>
<td>51.9</td>
<td>52.7</td>
<td>10.6</td>
</tr>
<tr>
<td>Weekend</td>
<td></td>
<td>28.4</td>
<td>50.5</td>
<td>54.7</td>
<td>16.9</td>
</tr>
</tbody>
</table>

1 QI: Quasi-induced exposure
group (over 64 years) were in fact not really representative of that age group. These members were also seen to be as active drivers in daytime as in nighttime as well as in weekdays as in weekends. The travel reductions in adverse conditions that were noted in past research were not observed here, which also may be an indicator of a non-representative sample of the population. These observations point to a potential uncharacteristic driving pattern than normally attributed to the elderly driving population, giving them a higher exposure than the total population in that age group.

**SUMMARY AND CONCLUSIONS**

The research presented here collected trip data and route information from diaries. Participants were selected within the urban boundaries of Fayette County, KY and asked to fill a diary recording their trips on a map. The length of each trip was computed and estimates of vehicle-kilometers of travel were obtained for roadway classes, time of day, and day of week. These projections were then compared to the exposure estimates as obtained for the quasi-induced exposure to determine similarities between the two approaches for estimating exposure. The lack of a sufficient number of participants and routes did not allow for a rigorous evaluation of the original objective of the research. However, this effort being an exploratory approach on this subject allowed for establishing a methodology for further research and provided valuable lessons in developing the tools and collecting similar data in the future.

Given the effort completed here, several conclusions can be drawn that indicate that this topic requires additional attention and further research. First, an examination of the travel patterns between the three age groups reveals that indeed each group has differing travel patterns. An analysis of the number of trips completed showed that the over 64 participants complete a larger percent of trips in the weekend (29%) than the other age groups (18% for 18-34 and 16% for 35-64 age group). The data in Table 2 also showed that there are different trends for VKMT among the age groups for each of the categories examined underscoring their differing travel patterns. Also when examining the travel purpose of these age groups, the over 64 age group again shows a marked difference as compared to the other two groups, having errands such as shopping, etc, as the purpose with the highest frequency of trips as compared to work trips: the highest frequency for the other two groups. This difference in trip purpose may
indicate that other factors, such as time of day, travel extent and frequency would be affected by
the differing travel purpose.

Past research has shown that different driver classifications in differing driving
conditions experience differing crash types. Therefore it is a necessity to develop a method of
estimating crash exposure, which can be disaggregated by differing conditions. Past research
has also shown that the crash propensity is affected by the roadway type and time of day and
thus exposure is also affected (1, 10). The results from this study indicate that indeed there are
differences among the various age groups of drivers on where and when they drive. Even if
accurate measures of VKMT were available, they could not be utilized to develop crash rates for
different age groups or times of day due to the variety of true travel from these drivers. This is
probably the most important finding of this exploratory effort. Moreover, the extensiveness of
the labor involved in estimating VKMT from even a small sample of drivers, as shown in this
study, calls for a method capable of developing exposure, which is readily available to
researchers as is the promise of the quasi-induced methodology.

Even with the limited number of trips logged in this study, promising results have been
found when comparing the estimated travel exposure developed by the trip diary study and
through the quasi-induced method. While this similarity is lost when the database is further
disaggregated by one or more variables, this absence can easily be attributed to the low number
of available trips for each division. By increasing the cells in disaggregating the data, a smaller
number of routes is available. Thus, the estimates become more dependent on the actions of one
driver and they are not representative of the population as a whole. The presence of similarity of
exposure for the 35-64 age group between the two methods indicates that further research is
indeed warranted in order to validate the quasi-induced exposure method and make it more
credible for future research applications.

Before the next step is taken however, some additional refinement of the methodology
and approach for the data collections are essential. The lessons learned from this effort are
valuable in developing a sound data collection tool and approach. While the trip diary format
that was chosen was the best choice out of those developed, problems arose throughout the
study. Several participants have commented on the size of the diary indicating that the 11\texttimes
17\texttimes paper size did not lend itself to an ease of carrying, making it hard to keep handily in the
car. This may have lead to a reduced number of trips recorded, an inaccuracy in recording of data or even not completing the diary and thus reducing the response rates. Other participants have expressed that the concept of the diary, recording routes on the maps, was too tedious and thus were less likely to properly fill out the diary. The decoding of the diaries also proved to be tedious in encoding the information into ArcInfo. Finally, the format of the diary limited the study area and the number of trips and location of trips logged by examining only trips occurred within the urban limits of Fayette County. Examination of rural travel with this methodology would prove to be near to impossible due to the larger extent of travel in rural areas, which could not be fit onto a readable map while still maintaining the ability to easily handle it. Moreover, if multiple urban study areas were to be researched a different map accompanied by a different ArcInfo coverage would need to be developed in order to accurately collect and process the information. The potential on using Global Position Systems and interactive computers for collecting similar data in the future could be utilized here and should be also explored.

This study, attempting to validate exposure metrics given by the quasi-induced method, has produced some promising results. It is believed that further research with the benefit of greater numbers will be able produce the same results and validate the method in more disaggregated conditions. However, of possibly even more importance than the lack of significant findings from this study is the finding that indeed frequency of travel and thus exposure varies by age groups, roadway types, time of day, and day of week.
REFERENCES


APPENDIX A

TRIP DIARY SAMPLE