ORIGINAL ARTICLE

Vehicle year and the risk of car crash injury

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Objective: To quantify the association between vehicle age and risk of car crash injury.
Design and setting: Data from a population based case-control study conducted in the Auckland region in 1998/99 was used to examine the adjusted risk of car crash injury or death due to vehicle age, after controlling for a range of known confounders. Cases were all cars involved in crashes in which at least one occupant was hospitalized or killed anywhere in the Auckland region, and controls were randomly selected cars on Auckland roads. The drivers of the 571 case vehicles and 588 control vehicles completed a structured interview.
Main outcome measure: Hospitalisation or death of a vehicle occupant due to car crash injury.
Results: Vehicles constructed before 1984 had significantly greater chance of being involved in an injury crash than those constructed after 1994 (odds ratio 2.88, 95% confidence interval (CI) 1.20 to 6.91), after adjustment for potential confounders. There was also a trend for increasing crash risk with each one year increase in vehicle age after adjustment for potential confounders (odds ratio 1.05, 95% CI 0.99 to 1.11; p = 0.09).
Conclusion: This study quantifies the increased risk of car crash injury associated with older vehicle year and confirms this as an important public health issue.

The average age of cars being driven on public roads is increasing in high income countries.[1–3] In New Zealand, the mean light vehicle age was estimated to be 9.9 years in 1989/90 compared with 10.7 years in 1997/98.[2] The situation is similar in Australia, where the mean has risen from 6.1 years in 1971 to 10.7 years in 1998,[3] and the United States, where it rose from 5.6 years in 1977 to 8.3 years in 1995.[1] Studies examining the effect of increasing vehicle age on car crash injury have consistently found that older vehicles are more likely to be involved in a crash where an occupant is injured.[4–8] However, many of these studies have significant methodological limitations, including the use of cross sectional data and inadequate control of many important confounding variables, and few have quantified the increase in risk.

We examined the relationship between vehicle year and car crash injury or death using data from a population based case control study. This study measured many crash related variables and provided an opportunity to examine the risk relationship while adjusting for important confounding variables.

METHODS

The Auckland Car Crash Injury Study was a case-control study conducted in the Auckland region of New Zealand. The Auckland region has a population of about 1.1 million people.[9] The study base was defined as light vehicles driving on non-local public roads in the Auckland region. The methodology of the study has been published in full elsewhere.[10]

Recruitment

Recruitment took place between April 1998 and July 1999. Cases were selected by identifying eligible vehicles from the study base that were involved in crashes in which any occupant of the vehicle was hospitalised or killed during the recruitment period. Cases were identified through surveillance at the four hospitals that serve the Auckland region and through the Auckland coroner. During the study period 615 eligible case drivers were identified. Of these, interviews were completed for 571 drivers (93%).

Controls were recruited at approximately the same rate, and over the same time period, as cases. Control selection aimed to achieve a representative sample of all driving time for the study base during the recruitment period. Sixty nine roadside sites were randomly selected from a list of non-local roads in the Auckland region, and the day of week, time of day, and direction of travel were randomly assigned to each site. Control vehicles were then randomly identified by sampling all vehicles that passed the site during a defined period. These vehicles were stopped at the roadside sites and a suitable time for a telephone interview was arranged. From roadside surveys 746 control cars were identified. Of these, interviews were completed for 588 drivers (79%). There were no significant differences in age group, gender, or driving conditions, between control drivers who were interviewed and all eligible controls.

Data collection

Drivers of case and control vehicles were interviewed either by telephone or in person. Interviews were conducted by telephone for 204 (36%) case drivers and 576 (98%) control drivers. The interview was based on a structured questionnaire that covered multiple characteristics of the driver and the vehicle, and circumstances of the crash (or time of survey for control drivers). Drivers were asked to provide the year of manufacture of the car. Proxy respondents were interviewed for 57 (10%) case drivers and two (0.3%) control drivers who were fatally injured or unable to be interviewed for other reasons.

Analysis

We analysed the data using SUDAAN software to account for intracluster correlation of control data from the same site due to the cluster sampling. We calculated odds ratios and 95% confidence intervals using logistic regression. As well as unadjusted analyses, we adjusted for driver's age and sex, because of their strong *a priori* association with car crash injury.[11] We identified potential confounders from the

Table 1 Distribution of vehicle year and confounding variables for cases and controls*

	Cases (n = 571)		Controls (n = 588)	
	No	%	No	%
Vehicle year				
<1984	118	23.9	58	8.9
1984–88	157	31.8	164	31.0
1989–93	169	34.2	207	37.8
⩾1994	50	10.1	133	22.4
Age group of driver (years)				
<25	195	34.2	91	13.7
25–34	133	23.3	125	22.3
35–44	85	14.9	154	24.5
45–54	61	10.7	107	19.6
55–64	39	6.8	80	14.2
65+	58	10.2	31	5.6
Sex				
Female	198	34.7	226	41.3
Male	373	65.3	362	58.7
Education level				
Post-secondary	178	31.5	276	49.3
Secondary >3 years	137	24.2	154	25.1
<3 years secondary	252	44.4	157	25.6
Ethnicity				
White/European	313	54.8	444	74.7
Maori	117	20.5	61	9.2
Pacific Islands	86	15.1	36	6.1
Other	55	9.6	47	10.0
Self reported alcohol (standard drinks in previous 6 hours)				
0	418	76.4	537	95.4
1	15	2.7	15	1.8
2	20	3.7	21	2.7
⩾3	94	17.2	5	0.8
Marijuana use (last 3 hours)				
No	520	94.2	582	99.5
Yes	32	5.8	5	0.5
Time of day				
Not 2–5 am	525	91.9	571	99.6
2–5 am	46	8.1	17	0.4
Stanford sleepiness score				
1–3 (not sleepy)	447	87.7	578	99.0
4–7 (sleepy)	63	12.3	8	1.0
Number of passengers				
0	285	50.3	355	62.9
1	140	24.7	144	23.4
⩾2	142	25.0	88	13.7
Average driving (hours/week)				
⩽5	219	42.1	171	30.5
6–10	205	39.4	216	39.3
11–20	63	12.1	135	22.3
21–30	11	2.1	32	3.8
>30	22	4.2	27	4.1
Type of licence				
Never/disqualified	66	11.6	7	1.1
Learner/restricted	91	16.0	27	4.2
Full New Zealand car licence	402	70.8	546	93.1
Wearing seatbelt when crashed				
No	81	14.7	16	1.8
Yes	469	85.3	568	98.2
Vehicle insurance status				
Insured	322	56.5	514	88.3
Not insured	206	36.1	63	10.2
Don't know	42	7.4	11	1.5
Self reported speed (kph)				
0–30	87	16.9	78	13.9
31–50	113	21.9	229	41.5
51–80	196	38.1	220	33.7
>80	119	23.1	55	11.0
Current safety inspection certificate				
Yes	466	81.6	559	95.5
No	105	18.4	29	4.5
Engine size (cc)				
<2000	245	61.3	238	48.8
2000–2999	129	32.3	196	39.6
⩾3000	26	6.5	66	11.6

*Proportions of controls are adjusted for the cluster sampling design.

literature and included these in the analysis if they were significantly associated with car crash injury in our data after controlling for driver's age and sex. Compulsory periodic safety inspections commence in many countries when the vehicle is about five years old and insurance premiums rise when the vehicle is older than approximately 10 years. The vehicle year cut points we chose reflect these factors, while maintaining sufficient numbers of vehicles in each category. We thus calculated odds ratios for four groups of vehicle year of construction: before 1984 (about 15 years before the study); 1984–89 (about 10–15 years old); 1989–94 (about 5–10 years old), and after 1994 (newer than about five years). The most recently constructed group was taken as the reference group. We tested for trend in the effect of vehicle year by taking it as a continuous variable, and tested for interaction between driver's age, sex, and vehicle year using a cut point of $p = 0.01$, to allow for the relatively low power of tests of interaction.

RESULTS

The mean age of case drivers was 36.6 years and of control drivers 40.8 years. The case group was 65% male and the control group was 59% male. Table 1 shows the distributions of vehicle year and all confounding variables by case/control status.

Table 2 shows the association between vehicle year and car crash injury. Vehicle year was significantly associated with car crash injury in the unadjusted model, and the odds ratio was attenuated but remained significant after adjusting for driver's age and sex. After adjusting for the confounders (driver's age, sex, education level, ethnicity, time of day, acute sleepiness score, marijuana and alcohol use before the crash, seatbelt use, driving exposure in hours per week, licence type, current vehicle safety inspection certificate, insurance status of the vehicle, number of passengers, travelling speed, and engine size), the odds ratio for vehicle year older than 1984 was further attenuated but there remained a significantly increased risk of car crash injury (odds ratio 2.88, 95% confidence interval (CI)1.20 to 6.91). The test for trend demonstrated increasing crash risk for every year increase in vehicle age after adjustment for the same confounders (odds ratio 1.05, 95% CI 0.99 to 1.11; $p = 0.09$).

Although objective evidence of alcohol consumption was obtained for the majority of participants, self reported alcohol consumption was used in the analysis because the data were more complete. Substituting objective alcohol consumption did not meaningfully alter the odds ratio. The effect of vehicle year remained significant when proxy respondents were excluded from the analysis, and when the model was adjusted for mode of interview. There was no evidence of interaction between vehicle year and age of driver ($p = 0.4$) or sex of driver ($p = 0.2$).

DISCUSSION

This study confirms the increased risk of car crash injury for occupants of older vehicles, and quantifies the risk associated with driving a vehicle manufactured before 1984 (or older than approximately 15 years of age in these data). For these vehicles, there was approximately three times the risk compared to vehicles manufactured from 1994 onward. It is estimated that between 14% and 21% of registered vehicles in high income countries are older than 15 years, making this an important public health issue.[1 2 12–14]

There are several possible mechanisms for the increased risk of injury we observed. Older cars might have a greater primary risk of being involved in a crash.[5] For example, there is evidence that older cars are more likely than newer cars to develop safety defects such as tyre and brake failure,[15] which

Table 2 Odds ratio (95% CI) between vehicle year and car crash injury

Vehicle year	Unadjusted	Driver's age and sex adjusted	Multivariable adjusted*
<1984	5.94 (3.47 to 10.16)	4.80 (2.68 to 8.58)	2.88 (1.20 to 6.91)
1984 to 1988	2.27 (1.44 to 3.57)	1.81 (1.14 to 2.88)	1.02 (0.52 to 2.01)
1989 to 1993	2.00 (1.28 to 3.13)	1.66 (1.05 to 2.62)	1.38 (0.72 to 2.64)
⩾1994	1.00	1.00	1.00

*Adjusted for driver's age, sex, education level, ethnicity, time of day, acute sleepiness score, marijuana and alcohol use before the crash, seatbelt use, driving exposure (hours/week), licence type, current vehicle safety inspection certificate, insurance status of the vehicle, number of passengers, traveling speed, and engine size.

could cause a crash. A second possible mechanism for the increased risk relates to ''crashworthiness'', or the secondary risk of severe injury to occupants when a car is involved in a crash.[5] As well as causing a crash, safety defects may increase the severity of the crash when it occurs. Studies of safety defects present in crashed vehicles estimate that about 12% of crashed vehicles had defects that were likely to have caused the crash or contributed to its severity.[15] Older cars are also much less likely than newer cars to have safety features, such as side impact systems and airbags, that are designed to protect occupants in the event of a crash. Prior studies of vehicles that have examined crashworthiness of vehicles by their year of manufacture suggest that crashworthiness improved between 1964 and 1997.[5 6 8] Our study supports these findings. However, in our data the increased risk of car crash injury for older vehicles persisted when we controlled for the vehicle having a current compulsory six monthly safety inspection certificate. A New Zealand review of more than 20 000 vehicles had similar findings.[16] Although inspections may not detect every important defect, this might suggest that accumulated safety defects are not the principal mechanism by which older cars increase the risk of car crash injury.

Non-vehicle factors such as driver characteristics might also contribute to the effect. For example, previous research has suggested an interaction between driver age and the effect of vehicle age on car crash injury.[4] We tested for, but did not find, such interaction in our data. There may be other factors associated with both driving an old car and car crash injury, such as risk taking behaviour or socioeconomic status. Although we adjusted for many of these variables, there may be residual confounding from these factors.

These data have several limitations that should be considered when interpreting our results. All variables used in this analysis were self reported, raising the possibility of recall bias, particularly in the measurement of confounders.

Key points

- The proportion of vehicles older than 15 years in high income countries is currently 14%–21%, and is increasing.
- Vehicle age is a known risk factor for car crashes and car crash injury, but the risk relationship has not previously been well defined.
- This study shows that occupants of vehicles manufactured before 1984 (older than about 15 years) have approximately three times the risk of car crash injury compared to occupants of newer cars.
- Interventions should aim to improve the safety of older vehicles, or reduce the number of older vehicles on the roads.

Bias may also be present due to variables, such as use of proxy respondent and mode of interview, that were differentially distributed between cases and controls. Adjusting for these variables, however, did not significantly change the effect of vehicle year, and it is difficult to predict the direction or extent to which the effect might be biased. It is also possible that the effect we observed was solely due to driver characteristics,[4] although we adjusted for several driver characteristics in our analysis. This study did not include in-depth crashed vehicle or crash scene analyses so we were not able to assess the contribution of factors such as impact forces or mechanical failures to the crash. We were not able to demonstrate a significantly increased risk of car crash injury for vehicle age groups newer than 1984. Larger studies could clarify the risk for these groups. However, our study is notable in comparison with previous studies because of our inclusion of a control group, as well as our ability to control for a range of confounding variables.

Our findings have important implications for road safety policy and practice. One possible solution may be to improve the safety of vehicles older than 15 years, for example by fitting safety features such as seatbelts and airbags to older vehicles. Other countermeasures might aim to reduce the number of vehicles older than 15 years being driven on the roads, including education campaigns about the risks associated with driving an older vehicle, increasing the cost of registering such vehicles, or increasing the stringency of periodic inspections for all vehicles. Further research, including cost benefit analyses, would be required to examine the potential outcomes of such measures.

CONCLUSION

The significant proportions of older vehicles being driven on the roads and the magnitude of the increased risk for these vehicles make this an important public health issue. Our study supports previous research in finding occupants of older vehicles to be at increased risk of car crash injury and provides important quantification of this risk. Given the trend for increasing age of vehicles being driven on the roads, this is likely to remain a road safety challenge.

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LACUNAE

Acrobats walk a fine line on new helmet laws

Trapeze artists, acrobats, and jugglers with one of the world's most famous circuses have been told to start wearing hard hats to comply with new European Union safety rules. The Moscow State Circus's insurers have warned the performers that they risk losing their cover if they are injured while not wearing the hats. ''It is bureaucracy gone mad, with a lot of help from the current compensation culture'', said Paul Archer, general manager of the circus, which is touring Britain. ''Our insurance premiums have rocketed in recent years and our insurers are always looking at ways to limit liability. This is just another barmy step in that process''.

However, the acrobats decided that they would perform without the headgear in coming shows. ''We have informed the insurers that we will wear hats when erecting the circus or during rehearsals, but it is ridiculous to suggest that the performers actually wear them during shows'', said John Haze, a spokesman for the 86 year old circus.

Goussein Khamdouleav, 48, who performs somersaults—without a safety net—as part of the highest indoor tightrope act in Europe, scoffed at the idea that a safety hat would be much use to him if he fell 15 metres to the ring below. He once fell 8 metres during a performance in Rio de Janeiro, breaking both arms and three of his ribs. ''A hard hat wouldn't have helped me then, and it won't help me now'', he said. ''Working in the circus, you get injured all the time. But you just have to get over it'' (contributed by Ian Scott; from an article by David Sapsted, *Daily Telegraph* (London), July 2003).

Speed and human ingenuity

A driver reports approaching a speed camera on a Sydney motorway and being passed by a motorcyclist doing at least 30 km/h over the limit. ''I smugly waited for the expected flash, comfortable in the thought that when this rapid rat receives the infringement, it will make him think again''. But, as the bike zoomed by the camera, he saw the rider's left hand reach back to shield the number plate from the lens. ''Surely one must acknowledge this ingenuity?''

Stitched up

Sitting in a bus going down Fulham Palace Road in London, Fiona Hewish saw a board sign outside an Italian restaurant ''that made the usual evening traffic more bearable''. It said: Discounts for senior citizens, students, and any patients with over 30 stitches. The restaurant is across the road from Charing Cross Hospital (contributed by Ian Scott; from the *Sydney Morning Herald*, July 2003).