Mature Driver Improvement Program in California

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California's Mature Driver Improvement (MDI) Program offers insurance-premium reductions to older drivers completing an accredited driver-improvement course. Driving records of five cohorts (1988–1992) of course graduates and comparison drivers were analyzed. MDI subjects were volunteers; comparison subjects were sampled randomly from the automated driver file. Unadjusted 6-, 18-, and 30-month subsequent total crash rates of MDI and comparison drivers did not differ significantly between groups ($p < .10$, two-tailed) for any cohort or record length. Unadjusted fatal and injury crash rates showed significant differences in favor of the MDI group in the first two cohorts and a significant difference in favor of the comparison group in a later cohort. The unadjusted accident rates indicate no justification for offering insurance discounts to those completing the course after 1989. All between-group differences on unadjusted citation rates were significant, favoring the MDI group. Analyses of covariance showed, in two cohorts, significant differences favoring the comparison group on adjusted total crashes. In two cohorts there were significant differences on adjusted fatal and injury crashes, one favoring the MDI and one the comparison group. On citations all adjusted differences were significant, favoring the MDI group. Analyses of two cohorts' 6-month data using generalized two-stage least-squares regression indicated that program completion was associated with more total and fatal and injury crashes and fewer citations.

The Mature Driver Improvement (MDI) Program was established in California by legislation that went into effect on July 1, 1987. The intent of this legislation was to encourage older drivers (ages 55 and above) to update their driving-related knowledge by enrolling in a 400-min classroom driver improvement course. Upon completion of the course, participants would be entitled over the next 3 years to receive automobile insurance premium reductions. The amount of the discount was to be determined by the insurer on the basis of actuarial and loss experience data, and a discount could be denied to an individual whose record reflected certain types of violations or accidents.

The program has now been in effect for 6 years. The law establishing it mandated that the Department of Motor Vehicles (DMV) develop the course curriculum and accreditation procedures for schools wishing to teach the MDI course. It also required until very recently that DMV report yearly to the legislature, giving tabulations of accident and citation rates for course graduates and for drivers of similar age who had not taken the course. Five such reports have been published, and the present paper gives an overview of their findings. First, however, the course curriculum and its rationale will be discussed.

From California Vehicle Code (CVC), Section 1675, the course curriculum is to include, but not be limited to, the following:

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1. How impairment of visual and audio perception affects driving performance and how to compensate for that impairment.
2. The effects of fatigue, medications, and alcohol, when experienced alone or in combination, on driving performance and precautionary measures to prevent or offset ill effects.
3. Updates on rules of the road and equipment including, but not limited to, safety belts and safe and efficient driving techniques under present-day road and traffic conditions.
4. How to plan travel time and select routes for safety and efficiency.
5. How to make crucial decisions in dangerous, hazardous, and unforeseen situations.

It was obvious to the DMV task force planning the curriculum that the problems of older drivers are very different from those of young drivers, "negligent operators" under California law, and the majority of persons taking a driver improvement course as part of the traffic violator school program for drivers who have been cited for a minor violation. The principal violation for the above groups is unsafe speed; older drivers, in addition to having a low violation rate relative to the driving population as a whole, are relatively unlikely to speed and relatively likely to incur right-of-way and sign-and-signal violations, particularly at intersections (*1*). More fundamentally, deliberate risk-taking and aggressiveness are not important factors in the behavior of older drivers; therefore a course curriculum aimed at this group should be very different from that aimed at young and "negligent" drivers.

From Janke (unpublished data), the following additional curriculum suggestions were listed:

- Older drivers should be reminded to receive periodic medical and vision examinations and to comply with their physicians' recommendations.
- They should be reminded to be even more careful than the average driver to leave a "space cushion" around their vehicles, giving them more time to react to evolving traffic situations.
- They should be encouraged to avoid (as they tend to do in any case) high-risk situations. As an example, they should avoid night driving, in which age-related declines in low-luminance acuity, contrast sensitivity, and tolerance of glare may pose a threat.
- They should be informed of traffic laws of which they may not be aware. For example, some older California drivers tend to expect passing drivers to be on their left and do not anticipate vehicles passing on their right.
- If they drive more slowly than surrounding traffic, they should be encouraged to stay to the right when possible, to mitigate the frustrations of other drivers. An exception (in addition to left turns) would be on California freeways, where the extreme right lane is a merging lane.

• They should be encouraged periodically to assess their own perceptual and psychomotor skills, in order to detect declines of aging and, if possible, compensate for them.

The curriculum as it finally evolved included as mandatory topic areas health and age-related physical changes as they affect driving performance, the effects on driving performance of medications and alcohol, rules of the road and defensive driving countermeasures, trip planning, and handling hazardous conditions. (The last topic included how to drive in fog, what to do when one's vehicle stalls, how to drive on slippery surfaces, and so forth.) Elective topic areas were also suggested, such as recreational vehicle safety and deciding when to stop driving. Course providers submit their lesson plans to DMV; these must follow the curriculum outline in order for the course to be accredited. MDI courses are monitored by the department, and in addition there has been a continuing series of legislatively mandated assessments of the subsequent driving records of course graduates.

With regard to assessment, the law had never required an evaluation of the course's traffic safety effect, asking only for comparative tabulations of the records of course graduates and of a comparison sample who had not taken the course. In fact, the program as established did not allow any definitive assessment of effect, since participation in the MDI program was voluntary, giving ample opportunity for self-selection bias to occur. To reduce the magnitude of such bias and add precision to the analysis, several covariates were used; their use will be described below.

Any traffic safety effect of such a course in terms of crash reduction was considered moot in light of a body of evidence, reviewed by Lund and Williams (*2*), suggesting no effect of defensive driving courses (DDCs) on crashes and only a slight effect (though in the desired direction) on violations. These authors noted that the general failure to show efficacy of DDCs against crashes is not because nothing was learned—on the contrary, the courses did seem to impart their intended knowledge. The difficulty, they believed, is that individual drivers taking such courses may have had little intention of changing their driving habits sufficiently to modify their accident risk. Drivers may take such a course for reasons extraneous to a concern for safety—because a court or employer has ordered them to or (relevant to the MDI program) to obtain an insurance discount. In the case of elderly drivers particularly, accidents are likely to be due to declining ability, probably not a factor that can be easily rectified by means of classroom instruction.

METHODOLOGY

The methodology of all five studies was essentially the same. For example, in the first study (*3*) the program graduate (MDI) group consisted of (all) drivers aged 55 or above who completed the MDI course between July 1, 1987, and June 30, 1988; later studies addressed successive yearly cohorts of first-time course graduates. Drivers who, at the time of selection, had never taken the course (the comparison group) were obtained by randomly sampling the department's automated driver file for drivers aged 55 or above and discarding any whose records showed that they had completed the program.

The date upon which an enrollee completed the course was considered to be his or her reference or "zero" date for determining prior and subsequent driving record. Drivers in the comparison group were randomly assigned the same reference dates as those in the MDI group, thus creating equivalent time windows within which to track the records of both groups.

In all five studies, 6-month post-course driving record variables for that year's cohort and follow-up driving record data for earlier cohorts (if any) were analyzed in two ways. In the first type of analysis, the groups were compared on unadjusted (raw) rates per time period of total accidents, fatal and injury (F/I) accidents combined, and total traffic citations, which appeared on the record as convictions, failures to appear in court or forfeit bail in connection with a citation (FTAs), or dismissals of a charge in consideration of attendance at a traffic violator school (TVSs).

Unadjusted accident and citation mean differences represented the net actuarial differences associated with MDI course completion. They were thus the differences in which insurers would be most interested, that is, those establishing whether a premium reduction was justified. Unadjusted rates were analyzed by means of one-way analyses of variance (ANOVAs) with treatment group as the sole factor.

In the second type of major analysis, covariate-adjusted rates on the same three dependent variables were analyzed in one-way analyses of covariance (ANCOVAs), again with treatment group as the sole factor. The covariates used were age, license class, gender, numbers of prior traffic accidents and citations, and ZIP code income, accident, and citation means (the latter being aggregated variables representing not individual subjects but their areas of residence). The alpha level used in all analyses was .10, two-tailed.

Stylos and Janke (*3*) analyzed 6-month subsequent driving record data for the first cohort of MDI drivers, who took the course in 1987–1988 (the 1988 cohort). In succeeding analyses (*4–7*), another year's worth of post-course data was added to the driving records of earlier cohorts and analyzed, along with the 6-month subsequent data for that year's cohort, in the manner described above. In the 1992 study, the 1988 cohort of Stylos and Janke (*3*) was dropped from the analysis after 30 months of follow-up, and in the 1993 study the 1989 cohort of Berube and Hagge (*4*) and the 1990 cohort of Foster (*5*) were dropped as well, after 30 months and 18 months of follow-up, respectively.

In follow-up analyses of previous MDI and comparison cohorts there was always some loss of subjects through attrition, and comparison group drivers who had taken the course within the preceding year were of course dropped. Therefore covariates were recalculated each year for use in the ANCOVAs. The same covariates were used in the follow-up analyses as had been used in the 6-month analyses, the only exception being elimination of the ZIP code income covariate from the 1993 analysis because it was based on outdated 1980 census figures and 1990 figures were not yet available.

In extracting driver records, a full 3-month buffer was added to the end of the period being monitored to ensure getting a complete, or almost complete, record of the time length indicated. Otherwise the actual driving record length would have been shorter than its nominal length, because of the time lag between occurrence of an accident or issuance of a citation and update of the incident on the automated driver file.

Although not all were included in reports to the legislature, some supplementary analyses of the data were conducted. Those that were included were Foster's (*5,6*) comparisons, by means of two-way ANOVA and ANCOVA, of previous study cohorts on their 6-month driving records. The factors were treatment group

and year, and the analyses were done in order to determine whether the outcomes of the separate studies (the relative positions of the groups) varied significantly over time. The reason for making these comparisons only on the 6-month data was the expectation that training effects would be most likely to reveal themselves immediately following the course.

In supplementary analyses not included in the legislative reports, 6-month data from two cohorts, those of 1988 and 1991, were analyzed by means of a generalization of two-stage least-squares regression (*8*). Two-stage least squares is a technique used in econometrics (*9*); here the generalized version was applied because both assignment and outcome were (essentially) discrete. The rationale underlying use of this method was that in the MDI evaluations several important and potentially biasing variables were not measured, nor were they controlled through random assignment. Some of these variables were quantity and quality of risk exposure and the social responsibility and safety-related attitudes of the driver. Since some unmeasured or "latent" variables influenced both outcome and (self-) assignment to groups, the ordinary least squares (OLS) regression algorithm used by the ANCOVA computer program was not totally applicable; under such circumstances it commonly produces inconsistent (biased) estimators of treatment effects.

Two-stage least squares, an alternative procedure considered to be better under these circumstances, begins by developing two equations for each dependent variable, one representing assignment (treatment group) as a function of independent or exogenous variables and the other representing the outcome variable as a function of these exogenous variables (minus at least one "excluded variable"; see following paragraph) plus the assignment variable. This procedure allows the error terms in both equations to be correlated because of the presence of latent variables common to both. Similarly, the assignment variable itself is correlated, through its error term, with the error term in the outcome equation, again because of the latent variables affecting both assignment and outcome. In order to achieve consistent parameter estimates the error component must be eliminated from the assignment variable, and this is done by using predicted assignment rather than assignment per se in the outcome equation (*8*).

In addition, for the two-equation system to be identified (*10*)—meaning, in general, that no equation in a system is expressible as a linear combination of the remaining equations—at least one of the covariates from which assignment is predicted is chosen to be an excluded variable by virtue of its (relatively) high correlation with assignment and its (relatively) low correlation with outcome. The variable is designated as excluded because it enters into the outcome equation only through its contribution to predicted assignment; it is not included in the outcome equation in its own right. Results of the generalized two-stage least-squares procedure were compared with those of OLS analysis.

RESULTS

Prior Incident Rates

Table 1 shows 3-year prior rates per 100 drivers for total accidents, F/I accidents, and total citations. As shown, before taking the course, MDI subjects consistently evidenced a rate of traffic citations significantly lower than that of comparison subjects. In addition, where differences occurred on F/I accidents, the MDI group was either directionally or significantly superior to—that is, had a lower rate than—the comparison group. Total accidents, however, showed a different picture. In two cohorts the MDI group rate was significantly higher than the comparison rate, and in the remaining cohorts the MDI group was directionally though not significantly inferior.

Factors that may be related to these differences were the sex composition of the groups—the MDI group was predominantly (about 60 percent) women, the comparison group more than 50 percent men; the license class composition of the groups—though few commercial drivers were represented in either group, MDI subjects were even less likely than comparison subjects to hold heavy-vehicle operator licenses; and the groups' average ages—for each cohort, these were about 69 for the MDI group and 66 for the comparison group at the time they first took the course. These factors would be expected (arguably, in the case of age) to favor the MDI group in driving record comparisons (*11*). On the

TABLE 1 Three-Year Prior Driving Record of Treatment Groups Within Cohort

Cohort / Group	Number	Rates per 100 drivers		
		Total Accidents	F/I Accidents	Citations
1988				
MDI	40,399	11.66	2.78*⁻	15.70*⁻
Comparison	75,064	11.33	2.97	23.40
1989				
MDI	45,520	12.04*⁺	2.97	15.79*⁻
Comparison	75,034	11.61	2.99	22.66
1990				
MDI	36,075	11.88	2.93	14.55*⁻
Comparison	65,620	11.67	2.93	21.78
1991				
MDI	38,719	11.80	2.83*⁻	15.51*⁻
Comparison	76,192	11.70	3.10	22.19
1992				
MDI	36,739	12.18*⁺	3.03	17.27*⁻
Comparison	75,082	11.28	3.03	22.64

Note: *⁺ indicates a statistically significant ($p<.10$) difference; MDI rate greater than comparison rate.
*⁻ indicates a statistically significant ($p<.10$) difference; MDI rate less than comparison rate.

other hand, MDI graduates were probably more likely to have vehicle insurance, by the nature of the course incentive, and therefore may have been more likely to report their property-damage-only (PDO) accidents to DMV. (Unlike PDO accidents, F/I accidents are generally reported by law enforcement, even if the involved driver does not report them.)

Unadjusted Subsequent Rates

Unadjusted subsequent rates per 100 drivers are shown in Table 2. As noted, these comparisons show actuarial differences, the ones an insurance company would find most interesting in deciding whether a group discount was justified. Across cohorts and time intervals (6 months, 18 months, and 30 months of follow-up) there were no significant differences on total accidents and no pervasive directional trend of obtained differences. On F/I accidents, there were significant differences in favor of the MDI group in the first two cohorts only; in later cohorts the only significant difference—in favor of the comparison group—appeared in the 6-month results for those taking the course in 1991. However, there were consistent significant differences across cohorts and time intervals in favor of the MDI group on citations.

Adjusted Subsequent Rates

The self-selected groups differed in many dimensions, some of which have been noted. To reduce bias and increase precision, incident rates were adjusted by means of the OLS algorithm for the covariates listed above in the Methodology section. Such adjustment, it was believed, would not enable strong inferences of cause-and-effect to be made in regard to the link between treatment and outcome but would make causal speculations more plausible than they would have otherwise been. Adjusted rates for the three dependent variables are shown in Table 3.

On total accidents, there were significant differences after adjustment only in two cohorts—1989 (at 30 months) and 1991 (at 18 months). These favored the comparison group. Two cohorts showed significant differences on F/I accidents, each difference occurring during the first 6 months after course completion. These differences were in opposite directions, that in the 1988 cohort favoring the MDI group and that in the 1991 cohort favoring the comparison group. Only on citations were there pervasive significant differences, in favor of the MDI group, in all cohorts and for all follow-up periods.

Analyses of Consistency of Study Results

In his 1991 report, Foster (*5*) compared the 1988, 1989, and 1990 cohorts on the 6-month criterion measures, seeking interactions between treatment group and year. His only significant finding was that for unadjusted F/I accidents there was evidence for a difference in study outcomes ($p = .09$) over the 3 years compared. This was attributed to the superior performance of the MDI group in the 1988 cohort. In Foster's (*6*) 1992 report, the 1988 cohort was dropped and the 1989, 1990, and 1991 study outcomes were compared. In that analysis he found no significant differences over time.

G2SLS Analysis Results

As mentioned above, 6-month data for two cohorts, those for 1988 and for 1991, were analyzed by means of generalized two-stage least-squares (G2SLS) regression (*8*). (The generalized method was used in place of two-stage least squares, or 2SLS, because assignment was dichotomous and outcome essentially so. Use of two-stage least squares, appropriate for continuous variables, would in this case have resulted in consistent estimators but incorrect standard errors of the estimators.)

For both cohorts, Exuzides and Peck (*8*) chose subject's age at reference date as the excluded variable because it had relatively high correlations (around .20) with assignment and relatively low correlations (ranging from .00002 to .05) with specific outcome

TABLE 2 Unadjusted Subsequent Accident and Citation Rates per 100 Drivers

Cohort Group	Total Accidents			Fatal/injury accidents			Citations		
	6 months	18 months	30 months	6 months	18 months	30 months	6 months	18 months	30 months
1988									
MDI	1.74	5.72	9.16	0.41*⁻	1.41*⁻	2.31*⁻	2.10*⁻	6.33*⁻	10.56*⁻
Comparison	1.86	5.53	9.36	0.51	1.56	2.54	3.21	9.53	15.66
1989									
MDI	1.94	5.70	9.58	0.52	1.40*⁻	2.33*⁻	2.03*⁻	6.08*⁻	10.47*⁻
Comparison	1.92	5.77	9.50	0.51	1.52	2.54	3.22	9.57	16.04
1990									
MDI	1.92	5.67	--	0.50	1.40	--	2.05*⁻	6.69*⁻	--
Comparison	1.94	5.64	--	0.52	1.53	--	3.38	10.25	--
1991									
MDI	1.88	5.42	--	0.53*⁺	1.31	--	2.39*⁻	6.69*⁻	--
Comparison	1.82	5.23	--	0.46	1.37	--	3.50	10.00	--
1992									
MDI	1.82	--	--	0.44	--	--	2.15*⁻	--	--
Comparison	1.84	--	--	0.51	--	--	3.23	--	--

Note: *⁺ indicates a statistically significant ($p<.10$) difference; MDI rate greater than comparison rate.
*⁻ indicates a statistically significant ($p<.10$) difference; MDI rate less than comparison rate.

TABLE 3 Adjusted Subsequent Accident and Citation Rates per 100 Drivers

Cohort Group	Total Accidents			Fatal/injury accidents			Citations		
	6 months	18 months	30 months	6 months	18 months	30 months	6 months	18 months	30 months
1988									
MDI	1.79	5.73	9.42	0.42*-	1.47	2.38	2.52*-	7.43*-	12.37*-
Comparison	1.84	5.52	9.10	0.50	1.50	2.47	2.99	8.43	13.85
1989									
MDI	2.00	5.84	9.78*+	0.53	1.43	2.39	2.38*-	7.13*-	12.28*-
Comparison	1.86	5.63	9.30	0.50	1.49	2.48	2.86	8.52	14.24
1990									
MDI	1.94	5.78	--	0.51	1.42	--	2.45*-	7.93*-	--
Comparison	1.92	5.52	--	0.51	1.51	--	2.98	9.01	--
1991									
MDI	1.91	5.56*+	--	0.54*+	1.37	--	2.76*-	7.85*-	--
Comparison	1.78	5.09	--	0.45	1.31	--	3.13	8.84	--
1992									
MDI	1.86	--	--	0.46	--	--	2.48*-	--	--
Comparison	1.80	--	--	0.49	--	--	2.89	--	--

Note: *+ indicates a statistically significant ($p<.10$) difference; MDI rate greater than comparison rate.
*- indicates a statistically significant ($p<.10$) difference; MDI rate less than comparison rate.

variables. They also presented results using both ZIP code average income and age as excluded variables, but the correlation of income with assignment was very low (about .03 in each cohort), and its use together with age led to somewhat less interpretable results.

Table 4 shows, for the 1988 cohort's subsequent 6-month data on each dependent variable, treatment coefficients (effect sizes), their standard errors, and their *t*- and *p*-values for OLS and G2SLS.

A significant association between treatment and increased total accidents was shown by G2SLS. Although the treatment coefficient obtained using the OLS approach was in the opposite direction, it was far from significant. Both methods showed a significant association with F/I accidents, but the regression parameters had opposite signs. The OLS analysis showed the program to be associated with fewer F/I accidents, as described above, whereas the G2SLS analysis showed the reverse. On citations the findings were similar irrespective of method—a significant association with fewer citations.

It will be recalled that the ANCOVAs for the 1991 cohort showed significantly greater total and F/I accident rates for the MDI group at 18 months and 6 months, respectively, as well as significantly fewer citations in both follow-up periods. Application of the G2SLS methodology to the 6-month data gave the results shown in Table 5.

For total accidents, there was a highly significant positive association (i.e., increased accidents associated with course completion) according to the G2SLS analysis, but no association according to the OLS (ANCOVA) analysis, although the direction of both results was the same. For F/I accidents, both types of analy-

TABLE 4 1988 Cohort: 6-Month Data [adapted from Exuzides and Peck (8)]

Excluded variable	Age	
	OLS	G2SLS
Total accidents		
Treatment coefficient	-.00044	.0218
Standard error	.00084	.0039
t-value	-.519	5.52
p-value	.6036	<.0001
Fatal/injury accidents		
Treatment coefficient	-.00085	.0057
Standard error	.00044	.0021
t-value	-1.94	2.65
p-value	.0522	.0080
Total citations		
Treatment coefficient	-.0047	-.0109
Standard error	.0010	.0046
t-value	-4.57	-2.80
p-value	<.0001	.0173

TABLE 5 1991 Cohort: 6-Month Data [adapted from Exuzides and Peck (*8*)]

Excluded variable	Age	
	OLS	G2SLS
Total accidents		
Treatment coefficient	.00129	.0142
Standard error	.00083	.0035
t-value	1.55	4.12
p-value	.1205	<.0001
Fatal/injury accidents		
Treatment coefficient	.00102	.0035
Standard error	.00044	.0019
t-value	2.35	1.89
p-value	.0187	.0591
Total citations		
Treatment coefficient	-.0048	-.0220
Standard error	.0011	.0043
t-value	-4.43	-5.18
p-value	<.0001	<.0001

ses showed significant positive associations. The usual significant negative association with citations was apparent in both the OLS and G2SLS analyses.

DISCUSSION OF RESULTS

As seen above, the association of MDI course completion with citation reduction (relative to comparison drivers' performance) was pervasive throughout. It is true that MDI subjects also had significantly fewer citations in the 3 years before taking the course, but their superiority on this measure was shown on covariate-adjusted rates as well as unadjusted ones, suggesting that the program may reduce citations. On the other hand, Exuzides and Peck (*8*) wrote that this outcome should be regarded as questionable, noting the conflicting testimony of the accident data and also that the correlations of the excluded variable, age, with citations (magnitudes of .03 and .05 for the 1988 and 1991 cohorts, respectively) were large relative to the small size of the treatment effects. (Under the G2SLS model, these correlations optimally should have approached zero. In addition, the correlations of age with assignment were not high, being about .20.) Therefore, the authors concluded, the results could reflect a self-selection bias that was not removed by either the OLS or the G2SLS analysis. In fact, it is possible that there is no good candidate for an excluded variable in the MDI data, thwarting the attempt to minimize bias through a G2SLS analysis.

But if the program did in fact decrease citations, this would not necessarily be inconsistent with a failure to decrease accidents, as shown by the ANCOVA results in Table 3. Investigators (*12*) have often found educational programs to reduce traffic citations without reducing accidents. However, a significant increase in accidents with a decrease in citations may be an unprecedented finding, which, if real, is difficult to explain. Such an increase, in both total and F/I crashes, was shown in the subsequent 6-month data for both the 1988 and 1991 cohorts, using the G2SLS analytic method. The paradoxical nature of the results appears when it is considered that citations constitute the best predictor of crashes overall (*13*) and are often interpreted as an indicator of mileage or, in general, exposure to crash risk. More specifically, however, citations can be considered to index the amount of unlawful driving, which is not necessarily the same as the amount of driving per se.

The paradoxical outcome was found in the 2SGLS analysis; the ANCOVA results support it only to a limited extent. Citation rates of the MDI group, as seen above, were consistently significantly lower than those of the comparison group irrespective of analytic method. Using ANCOVA, on the total-accidents measure the MDI group was never found to have a significantly lower rate than the comparison group; directional trends, with one exception (the 6-month data for the 1988 cohort), favored the comparison group, and significant increases in accidents for MDI relative to comparison subjects were found in the 30-month data for the 1989 cohort and the 18-month data for the 1991 cohort. However, the picture was not as negative for F/I accidents, where the results might properly be described as mixed, being more favorable to the MDI group in the first two cohorts than in later ones. Where results of the two analytic methods are discrepant, there is reason to believe that the G2SLS analysis may be more valid; its purpose is to better control for latent (unmeasured) variables causing selection bias, and such uncontrolled bias—stemming in part, perhaps, from greater social responsibility and safety-consciousness among persons taking the course, especially when it first became available—may have accounted for the discrepant results. If it is accepted that the G2SLS analysis is in fact more valid, the paradoxical finding requires explanation.

Along these lines, and entering the realm of speculation, two factors may have been operative, either separately or (more likely) in combination. One of these is cause. Completing the course may have increased graduates' confidence in their driving abilities and caused them to drive more or in more challenging situations, exposing themselves to greater crash risk; at the same time it may have increased their knowledge of traffic laws and their motivation (possibly already high, considering the prior data) to obey these laws. Under this scenario it is conceivable that the course could increase exposure to accident risk but decrease citations—which,

as mentioned, reflect not only exposure but law violation. Perhaps the crashes of MDI graduates were more often nonculpable than those of comparison subjects; these incidents might more likely have been mediated simply by inability to avoid dangerous situations caused by others, perhaps in part because of slowed responses due to aging or to other impairments of aging. Under this scenario, MDI graduates' accidents would not as likely (relative to comparison subjects') have been caused by explicit law violations, nor would these graduates have been so likely in general to violate laws and incur citations.

The second factor is uncorrected bias. This is the tentative explanation invoked by Exuzides and Peck (*8*), who suggested in particular that the finding of decreased traffic convictions was dubious. Even if this finding is accepted as valid, however, uncorrected bias could still have been operative. Under the bias scenario the favorable characteristics of MDI subjects—hypothesized to have been more socially responsible and safety-conscious, on the average, than comparison subjects—could have led to fewer citations and more consistent reporting of PDO accidents to the authorities, as California law requires. This would lead to an artifactual appearance of more total accidents for MDI subjects than would otherwise be the case, but would not imply any increase relative to the comparison group in F/I crashes. It will be recalled that the ANCOVA results were mixed on F/I accidents and more negative in the case of total accidents, consistent with the hypothesized greater preexisting propensity of MDI subjects to obey the law by reporting their PDO crashes.

These patterns existed in the prior data as well, and it seems entirely possible that in the ANCOVA analysis some residual uncorrected bias remained. Analysis of the 6-month data using a "better" statistical technique (G2SLS) did not alter conclusions regarding citations (in fact, effect sizes became larger), but changed a significant reduction in F/I crashes to a significant increase (1988 cohort) while confirming the ANCOVA analysis by finding a significant increase for the MDI relative to the comparison group in the 1991 cohort. G2SLS methodology also found previously undetected significant increases in total accidents for the MDI group relative to the comparison group in both cohorts. Even though the 1988 MDI group, who took the course when it was first offered, was the one hypothesized to be most "select" through inclusion of especially safety-conscious drivers, the significant F/I reversal for this cohort is particularly difficult to explain if reduction of the resulting bias favoring the MDI group was the only factor involved. If (again) it can be assumed that the G2SLS analysis using age as the excluded variable is more correct than the ANCOVA, then it seems that a causal factor, most likely increased risk exposure, may have led to increased accidents for MDI drivers, the finding emerging only after bias had been reduced more effectively.

The above has been highly speculative. Abandoning such speculation, at a minimum the conclusion to be drawn from this series of studies must be that course completion is not associated with a reduction in crashes. There was initially an actuarial justification for offering an insurance discount to course graduates, apart from any consideration of cause. However, no such justification has been shown for cohorts taking mature driver training for the first time after 1989.

It should be noted that the G2SLS analysis, though it is more mathematically correct and adds plausibility to causal inferences, does not in itself definitively show cause. It could do so only if all of the variables influencing both assignment and outcome were controlled, as would be the case in a large-sample randomized experiment; such was not the case here.

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