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Estimating Young Novice Drivers' Compliance with Graduated Driver Licensing Restrictions: A Novel Approach

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Abstract

Objective—Current methods of estimating compliance with Graduated Driver Licensing (GDL) restrictions among young drivers with intermediate driver's licenses—which include surveys, direct observations, and naturalistic studies—cannot sufficiently answer many critical foundational questions: What is the extent of non-compliance among the population of young intermediate drivers? How does compliance change over the course of licensure? How does compliance differ by driver subgroup and in certain driving environments? This paper proposes an alternative and complementary approach to estimating population-level compliance with GDL nighttime and passenger restrictions via application of the quasi-induced exposure (QIE) method.

Methods—The paper summarizes the main limitations of previous methods employed to estimate compliance. It then introduces the proposed method of borrowing the fundamental assumption of the QIE method—that young intermediate drivers who are non-responsible in clean (i.e., one and only one responsible driver) multi-vehicle crashes are reasonably representative of young intermediate drivers on the road—to estimate population-based compliance. I describe formative work that has been done to ensure this method can be validly applied among young intermediate drivers and provide a practical application of this method: an estimate of compliance with New Jersey's passenger restrictions among 8,006 non-responsible 17- to 20-year-old intermediate drivers involved in clean two-vehicle crashes from July 2010 through June 2012.

Results—Over the study period, an estimated 8.4% (95% CI: 7.8%, 9.0%) of intermediate drivers' trips were not in compliance with NJ's GDL passenger restriction. These findings were remarkably similar to previous estimates from more resource-intensive naturalistic studies (Goodwin et al., 2006; Klauer et al., 2011).

Conclusion—Studies can practically apply proposed methods to estimate population-level compliance with GDL passenger and night restrictions; examine how compliance varies by relevant driver, vehicle, and environmental factors; and evaluate the implementation of a GDL

provision or other intervention aimed at increasing compliance with these restrictions. Important considerations and potential limitations and challenges are discussed.

Keywords

Graduated Driver Licensing; GDL provisions; induced exposure; novice teen driver; probationary license; risky driving behaviors

INTRODUCTION

Motor vehicle crashes are the leading cause of adolescent death and injury (Centers for Disease Control and Prevention National Center for Injury Prevention and Control and Centers for Disease Control and Prevention 2013). To address this public health problem, US states have developed Graduated Driver Licensing (GDL) systems, which have both extended the learner's permit phase and introduced an intermediate license phase between the permit and full-privilege phases. During the intermediate phase, newly licensed young drivers are restricted from engaging in behaviors and situations known to increase their crash and/or fatality risk. These restrictions include passenger limitations and a ban on nighttime driving, two well-established risky driving behaviors among novice young drivers (Chen et al. 2000; Rice et al. 2003; Tefft et al. 2012; Williams 2003), and may also include bans on cell phone use or texting while driving and seat belt use requirements. Overall evaluations of GDL systems have consistently shown crash reductions; more targeted evaluations have also identified passenger and nighttime restrictions as important components of effective GDL systems (Chaudhary et al. 2007; Fell et al. 2011; Masten et al. 2013; McCartt et al. 2010).

The effectiveness of GDL passenger and nighttime restrictions on reducing the burden of young driver crashes depends largely upon intermediate drivers' compliance with them. Thus, it is important to fully understand the extent to which drivers comply with their state's passenger and nighttime restrictions. However, surprisingly little is known about compliance. The existing collection of studies—nicely reviewed by Masten et al. (2014)—has indeed advanced our understanding of novice driver compliance but for the most part has provided only very general estimates. Many critical questions remain: What is the extent of non-compliance among the population of young novice drivers? How does compliance change over the course of licensure? How does compliance differ by gender and age, among different sociodemographic subgroups, and in certain driving environments? To whom should we target interventions designed to increase compliance? None of the methods that are currently employed to estimate compliance among young novice drivers—which include surveys, direct observations, and naturalistic studies—can sufficiently answer these critical foundational questions. Further, the field currently lacks rigorous epidemiologic methods to determine the effectiveness of policies and programs that aim to increase novice driver compliance with GDL restrictions.

This paper proposes an alternative and complementary approach to estimating population-level compliance with GDL restrictions—a novel application of the quasi-induced exposure technique, a method used in traffic safety research to estimate driving exposure in the absence of more detailed information (e.g., vehicle miles traveled) (Lyles et al. 1991;

Stamatiadis and Deacon 1997). This method overcomes current methodological challenges to allow for examination of both population-level and subgroup-specific estimates in a relatively cost-effective manner. In addition to expanding the constellation of methods available to address compliance-related questions, the approach ideally can be more broadly applied to estimate the extent of certain hard-to-capture driving behaviors (e.g., nighttime driving) among subgroups of drivers and to evaluate the effects of policy-level interventions on these behaviors.

PREVIOUS METHODS EMPLOYED TO ESTIMATE COMPLIANCE

Cross-sectional surveys often ask intermediate drivers whether they have ever violated a restriction or about the number of violations within a given time period (Brookland et al. 2014; Goodwin and Foss 2004; Goodwin et al. 2006; Harre et al. 1996; Williams and McCartt 2014; Williams et al. 2002). Estimates of non-compliance vary widely between studies and in various jurisdictions; for example, as noted by Masten et al. (2014), estimated rates of self-reported violation (at least once as an intermediate driver) of a GDL passenger restriction ranged from 26% to 92%. While survey methods have appropriately been used to capture individual-level compliance as a study exposure or an intended outcome of a randomized controlled trial (Hartos et al. 2001), these methods have also been used to evaluate the effect of state-wide interventions on compliance and to make broad generalizations about the prevalence of non-compliance among general intermediate driver populations (Williams and McCartt 2014; Williams et al. 2002). However, they have substantial methodological limitations in their utility to do so. Surveys have often reduced what theoretically is a continuous measure—the proportion of miles or trips in which a driver did not comply—into a categorical (e.g., ever: yes/no) or ordinal (e.g., how often: Likert scale) variable. By doing so, surveys may overestimate the true extent of young road users' non-compliance. Lack of representativeness and misclassification may be particular concerns when using survey methods given response rates, recall bias, and the sensitivity of behaviors being captured; although potential non-generalizability is often noted as a limitation, rarely is the potential magnitude and direction of bias of prevalence estimates discussed or carried through to more general discussions in which these estimates of non-compliance are cited. With respect to evaluating interventions, use of pre vs. post self-report surveys may lead to response-shift bias. This may occur when the intervention explicitly or inadvertently changes the subject's assessment and understanding of the concept being measured during the study period (Howard 1980); for example, the introduction of a nighttime restriction (and associated media) may enhance the accuracy of young drivers' reporting of driving during restricted hours in a post-intervention survey compared with a survey implemented prior to the intervention. Limited sample sizes often preclude in-depth assessment of subgroup differences. Finally, wide (and sometimes subtle) variations in the way questions are asked can preclude comparison across studies; for example some surveys ask about driving over the specific period (e.g., 10 p.m. to 5 a.m.), while others don't specify an endpoint (e.g., after 11 p.m.) (Brookland et al. 2014; Williams and McCartt 2014).

Direct observation studies typically focus on capturing (from outside the vehicle) young drivers' engagement in certain risky driving behaviors under a defined set of conditions. Under most circumstances these studies are unable to accurately measure “compliance” *per*

se because restricted drivers often cannot be easily identified without inspection of the driver's license (Foss et al. 2009; Goodwin et al. 2006). Further, data collection is sometimes limited to high school parking lots—which is helpful in that it ensures that a higher proportion of young drivers will be intermediate drivers—but may not typify adolescent driving behavior in other environments and may preclude accurate collection of certain important behaviors (e.g., rear passenger seat belt use).

Naturalistic driving studies, which utilize in-vehicle technology to capture driving behaviors, have yielded important data on young driver behavior not captured by other methods (Foss and Goodwin 2014; Goodwin et al. 2011; Klauer et al. 2011). This method has been used to provide trip-level estimates of engagement in restricted behaviors; as expected, these estimates have been substantially lower than those estimated via survey. For example, Goodwin et al. (2011) analyzed videos clips of newly licensed intermediate driver trips and found that two or more passengers (a rough estimate of non-compliance) were present in only 9% of clips. A primary strength of this method as it relates to compliance is that it provides researchers with the ability to observe behaviors among novice young drivers in a variety of driving conditions over an extended period of time. On the other hand, this method is very resource-intensive, making studies utilizing this method particularly costly to conduct; this often necessitates small sample sizes, limiting the statistical power available to assess compliance among different driver subgroups. Participants also tend to be mostly white and of higher socioeconomic status, and such studies likely draw from more motivated families that already prioritize safe driving and are thus more likely to have higher compliance rates than the general young driver population.

Analyses of crash data have been conducted to provide insight on questions related to young driver compliance (Carpenter and Pressley 2013; Chaudhary et al. 2007; Masten and Hagge 2004; Masten 2007). For example, researchers assessed the effects of a GDL passenger restriction by comparing pre- vs. post-restriction crash rates of young drivers, both overall and among those carrying passengers (Chaudhary et al. 2007). However, these studies were not able to isolate the full group of intermediate drivers for whom the restriction is applicable, instead relying on age as a proxy. Further, compliance among *crash-involved* drivers (which includes those at fault) does not likely reflect compliance in the general young driver population, which arguably is the intended outcome of interest in such a policy evaluation. For example, the fact that over half of fatally injured young drivers were not wearing their seat belt is a frequently-cited indicator of non-compliance; however, since not wearing a seat belt substantially increases the likelihood of a fatal injury, this figure likely overestimates non-compliance among the general population of novice drivers (Masten 2007). Estimates of nighttime and passenger restriction non-compliance from Carpenter and Pressley (2013) similarly provided important information on compliance among teens involved in fatal crashes. However, as the authors note they do not “capture...the actual rate of non-compliance” (pg. 116); their estimate is almost certainly an overestimate.

An *analysis of citations issued* for violation of GDL restrictions has also been previously employed in a recent study that aimed to estimate compliance among novice 16- and 17-year-old drivers (Masten et al. 2014). The study yielded estimates much lower than those found in survey research and lower than those found in naturalistic studies. However, given

the unknown and complex relationship between non-compliance with GDL restrictions and the likelihood of conviction for those restrictions, it is unlikely that convictions validly estimate true non-compliance. In virtually all US states, there is currently no way to identify an intermediate driver without conducting a traffic stop and visually inspecting the license, which likely severely limits law enforcement's ability to enforce GDL restrictions (Steenbergen et al. 2001). Further, we found that even when police interact with a crash-involved intermediate driver during restricted nighttime hours, the driver was cited for a GDL violation only 8% of the time (Curry et al. under review). Finally, we have previously demonstrated that citation issuance of moving violations among at-fault crash-involved young drivers varies greatly by factors that are independent of fault—including driver age, gender, and crash severity (Curry et al. 2014). Braitman et al. 2008 similarly found that only 40% of at-fault young Connecticut drivers received a citation. The same may be true for GDL violations.

APPLICATION OF QUASI-INDUCED EXPOSURE METHOD TO ESTIMATE COMPLIANCE

Description

The inherent limitations of these methods in measuring population-level compliance led to exploration of an alternative approach that can complement and extend the aforementioned methods—specifically an application of the quasi-induced exposure (QIE) method. This method was originally developed to estimate driving exposure in the absence of more detailed information like vehicle miles travelled using only a crash database itself (Lyles et al. 1991; Stamatiadis and Deacon 1997). Applied traffic safety studies have used this method to adjust estimates of associations between driver/vehicle factors and crash involvement for driving exposure (e.g., adjusted risk of crash involvement for young vs. older drivers) (Backer-Grøndahl and Sagberg 2011; Keall and Newstead 2009; Redondo-Calderon et al. 2001; Rice et al. 2003). The method's primary assumption is that the responsible driver in a clean two-vehicle crash—a crash with one and only one responsible driver—"randomly" selects the non-responsible driver from all those driving at that location and time; that is, non-responsible crash-involved drivers are reasonably representative of the driving population at the location and time of the crash. It is this primary assumption that can be utilized to address compliance-related research questions: If QIE's primary assumption is valid, then one can argue that compliance with GDL restrictions among non-responsible crash-involved intermediate drivers—who are representative of the general intermediate driver population—should also reasonably represent compliance among the intermediate driver population.

Notably, this method was employed once previously (albeit described using terms other than "compliance") by Jiang and Lyles (2010) to evaluate Michigan's GDL nighttime restriction. The authors compared pre- vs. post-GDL proportions of non-responsible young drivers' crashes that occurred during restricted nighttime hours. However, the study conducted only crude, age-based analyses and thus was not focused *per se* on measuring compliance levels. Interestingly, the authors concluded that a "shortcoming of quasi-induced exposure is that it can only produce a relative value. It can't answer a basic question such as, 'What is the crash

rate for the [young drivers] under post-GDL' or the like?" (pg. 490). Conversely, I believe that we *can* broaden QIE's utility by applying its primary assumption to address some very basic and important unanswered questions related to compliance with GDL restrictions and, more broadly, young driver engagement in certain driving behaviors.

Applying QIE's Primary Assumption

There are two critical steps in the pathway to ensure the appropriateness of applying QIE's primary assumption to estimate young driver compliance. First, crash responsibility must be validly determined in order to identify the population of non-responsible drivers in clean two-vehicle crashes. Historically, crash responsibility has been based on citations or moving violations listed on the crash report (DeYoung et al. 1997; Lardelli-Claret et al. 2011; Rice et al. 2003; Waller et al. 2001). However, there are two important limitations with this method that have been identified and we recently confirmed: (1) Citation issuance varies substantially by factors that are independent of fault (e.g., age, gender); and (2) This method does not capture driving behaviors that are not illegal but still indicative of fault, such as inattention (Af Wåhlberg and Dorn 2007; Curry et al. 2014; Jiang et al. 2012). Instead, these studies have endorsed using the presence of a hazardous or crash-contributing driver action to determine fault. Second, the primary assumption of representativeness should be validated to determine whether non-responsible young intermediate drivers in clean two-vehicle crashes reasonably represent the larger general intermediate driver population; several methods to conduct this validation have already been developed (Chandraratna and Stamatiadis 2009; Jiang and Lyles 2010; Lyles et al. 1991; Stamatiadis and Deacon 1997).

Estimating Non-Compliance

Once the population of non-responsible drivers in clean two-vehicle crashes is identified, the incidence of non-compliance among intermediate drivers (NC_i) is estimated by the following proportion: $NC_i = I_i/N$, where i is the restriction of interest, N is the total number of non-responsible intermediate drivers involved in two-vehicle crashes, and I_i is the number of non-responsible intermediate drivers who were non-compliant with restriction i at the time of their crash and is assumed to follow a binomial distribution. Further, the estimated *non-compliance ratio* would compare the prevalence of non-compliance for two conditions (e.g., time periods, driver subgroups, road environments). Confidence intervals can be obtained and significance testing conducted using the normal approximation if sample size permits.

Practical Application of Methods

An ongoing program of research aims to determine the suitability of state-wide licensing and crash data for applying the proposed methods and utilizing these methods to advance existing knowledge on intermediate drivers' compliance with GDL restrictions. In previous work, we linked two administrative data sources: (1) the New Jersey (NJ) Motor Vehicle Commission's licensing database, which contains detailed information on each NJ driver's progression through the NJ licensing process, as well as the date and type of all traffic-related citations; and (2) the NJ Department of Transportation's Crash Record Database, which contains all data collected on the NJ Police Crash Report for all police-reported crashes; details on this linkage are available elsewhere (Curry et al. 2013). Preliminary work

was conducted first to substantiate the appropriateness of assigning crash responsibility according to the presence of a crash-contributing driver action (e.g., inattention, following too closely, failure to yield) and subsequently to determine that non-responsible NJ intermediate drivers appear to be reasonably representative of the general NJ intermediate driver population; please see Curry et al. (2014, 2015).

Currently, we are applying these methods to answer several applied research questions. As an example, we aimed to estimate overall rates of non-compliance among NJ young intermediate drivers. Briefly, we identified all NJ intermediate drivers aged 17 through 20 who were involved in a clean two-vehicle crash from July 1, 2010 through June 30, 2012 and determined (using crash-contributing driver actions) not to be responsible for their crash ($n=8,006$). We then determined each driver's compliance with NJ's passenger restriction (one passenger unless parent/guardian is in vehicle) via information on the crash report. Crash time and passengers' ages are directly noted on the crash report; given that we could not confirm the presence of a parent/guardian, we conservatively estimated non-compliance as the presence of more than one passenger without at least one passenger aged 35 or older. Figure 1 shows for each six-month period, the point estimate and 95% confidence interval for intermediate drivers' non-compliance. Over the entire time period, an estimated 8.4% (95% CI: 7.8%, 9.0%) of intermediate drivers' trips were not in compliance with NJ's GDL passenger restriction; further examination of this question—including examination of compliance in specific driver subgroups and under certain conditions—is detailed elsewhere (Curry et al. under review).

IMPORTANT CONSIDERATIONS

Interpretation

Compliance estimated via QIE methods are less comparable to those collected on most surveys—which measure compliance on the *driver* level—and more comparable to naturalistic studies, which measure driver trip- or mile-based compliance (Goodwin et al. 2011; Klauer et al. 2011). Indeed, 56% of intermediate drivers reported driving with more than one passenger other than a family member in the car in the past month on a 2011 survey of young NJ drivers (McCartt et al. 2013), while our analysis suggests that less than 10% of intermediate drivers' trips are in non-compliance with NJ's passenger restriction. A strength of the proposed method is that it supports both jurisdiction-wide and subgroup-specific estimates, as well as those under different roadway and environmental conditions. In fact, the value of disaggregated analyses is intrinsic within QIE's primary assumption—non-responsible drivers are a random sample of the driving population *at the time and place of the crash*; Stamatiadis and Deacon (1997) found that disaggregating by roadway type, time of day, and day of week (weekend or weekday) reduced bias in exposure estimation. Finally, it is important to note that this method inherently gives more weight to drivers who drive more, thus reflecting driver trips more than the drivers themselves; observed distributions are inherently designed to reflect distributions in the *driving* population, which may be different than the population of *drivers*.

Potential Limitations and Challenges

Several potential limitations and challenges deserve discussion. First, it is important to note that while the proposed method borrows QIE's primary assumption, it does not entail full implementation of QIE methodology; hence, some previous criticisms of QIE methodology are less relevant in this particular application. For example, in a commentary about GDL systems, Foss (2007) notes that "induced exposure measures [to obtain a measure of driving exposure] are dubious for the youngest drivers (whose limited ability to avoid potential dangers renders their involvement in 'not at fault' crashes disproportionate to their presence in traffic)" (pg. 190). While this is certainly a major limitation for studies that use QIE methods to compare crash involvement of drivers across the age spectrum, it may be less of an issue when applying QIE methods to compare different groups young novice drivers; that is, various groups of young drivers may not be as disparate to one another with respect to their likelihood of being involved as a not-at-fault driver in a crash relative to their presence on the road. On the other hand, this method will inherently produce estimates that are weighted toward the extent to which novice drivers comply in situations where two-vehicle crashes occur. Overall estimates will also be weighted toward groups that have relatively more presence on the road. Results should be interpreted with these issues in mind, and this speaks to the importance of further stratifying compliance rates by factors such as age, driving experience, roadway type, and time of day (Stamatiadis and Deacon 1997). Ideally, this method can also be applied more broadly to examine the extent to and conditions under which young drivers engage in certain driving behaviors (e.g., seat belt non-use, use of electronic equipment). However, misclassification bias is also of chief concern given the nature of data collection on police crash reports; this may be particularly true for behaviors that depend on the driver's willingness to disclose them, and thus the accuracy of such variables would be expected to be higher in studies that use naturalistic methods. Additionally, the structure of jurisdictions' crash reports may also compromise the ability to validly estimate compliance; for example, in some states passengers may only be noted on the report if injured. Finally, the ability to measure population-level compliance using this method is dependent on being able to accurately identify crash-involved intermediate drivers, which relies on access to high-quality driver licensing data and a subsequent high-quality linkage to identifiable crash data. Historically, it has been challenging for researchers to access identifiable traffic safety data given legislative and administrative barriers; even if successfully accessed, these datasets can be challenging to utilize for research purposes given their complex administrative nature.

Need for Validation

It is worth noting that few, if any, applied young driver studies that have employed QIE methods appear to have validated the primary assumption in their particular young driver (or any) sample (Keall and Newstead 2009; Kirk and Stamatiadis 2001; Preusser et al. 1998; Redondo-Calderon et al. 2001; Rice et al. 2003). Conduct of an internal study to validate QIE's primary assumption should be viewed as a critical preliminary step to ensure the appropriate application of QIE methods for this purpose.

CONCLUSION AND FUTURE WORK

Generally, we still know very little about to what extent novice young drivers comply with GDL restrictions and how compliance varies among driver subgroups and over time. This paper proposes that we can broaden the utility of QIE methods to address many important foundational questions related to compliance that have been difficult to answer via currently available methods. Once the suitability of QIE methods for this purpose has been ensured, studies can practically apply the proposed methods to: 1) estimate population-level young novice driver compliance with GDL passenger and nighttime restrictions, 2) examine how compliance varies by relevant driver, vehicle, and environmental factors, and 3) evaluate the implementation of a GDL provision or other intervention aimed at increasing compliance with these restrictions. Ideally, the method can also be applied more broadly to examine the extent to which and conditions under which drivers engage in hard-to-measure high-risk driving behaviors (e.g., seat belt non-use, use of electronic equipment); however, the validity of doing so depends highly on the availability and accuracy of this information as recorded on police crash reports.

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Figure 1.
Quarterly estimates of non-compliance with GDL passenger restrictions among New Jersey intermediate drivers, July 2010 – June 2012.