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# Q1 The effect of a gearshift interlock on seat belt use by drivers who do not 2 always use a belt and its acceptance among those who do

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## 7 A R T I C L E I N F O

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## A B S T R A C T

*Introduction:* Seat belts reduce the risk of fatal injury in a crash, yet in 2015, nearly 10,000 people killed in 19 passenger vehicles were unrestrained. Enhanced seat belt reminders increase belt use, but a gearshift interlock 20 that prevents the vehicle from being placed into gear unless the seat belt is used may prove more effective. 21 *Method:* Thirty-two people with a recent seat belt citation and who admitted to not always using a seat belt as 22 a driver were recruited as part-time belt users and asked to evaluate two new vehicles. Sixteen drove two vehi- 23 cles with an enhanced reminder for one week each, and 16 drove a vehicle with an enhanced reminder for one 24 week and a vehicle with a gearshift interlock the following week. Sixteen full-time belt users who reported al- 25 ways using a seat belt drove a vehicle with a gearshift interlock for one week to evaluate acceptance. *Results:* Rel- 26 ative to the enhanced reminder, the gearshift interlock significantly increased the likelihood that a part-time belt 27 user used a belt during travel time in a trip by 21%, and increased the rate of belt use by 16%; this effect 28 approached significance. Although every full-time belt user experienced the gearshift interlock, their acceptance 29 of the technology reported in a post-study survey was fairly positive and not significantly different from part- 30 time belt users. Six part-time belt users circumvented the gearshift interlock by sitting on a seat belt, waiting 31 for the system to deactivate, or unbuckling during travel. *Conclusion:* The gearshift interlock increased the likeli- 32 hood that part-time belt users buckled up and the rate of belt use during travel relative to the enhanced reminder 33 but could be more effective if it prevented circumvention. *Practical applications:* An estimated 718–942 lives 34 could be saved annually if the belt use of unbuckled drivers and front passengers increased 16–21%. 35

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## 45 1. Introduction

46 Devising countermeasures to increase the belt use of vehicle occu-  
47 pants who do not routinely buckle up can save thousands of lives  
48 every year. Seat belts reduce the risk of being fatally injured in a crash  
49 by 45% for front row occupants of passenger cars and 60% for front  
50 row occupants of trucks and vans (Kahane, 2000); however, not every  
51 vehicle occupant always uses a seat belt when driving or riding in a  
52 vehicle. A roadside observational study conducted by the National  
53 Highway Traffic Safety Administration (NHTSA) in the United States  
54 found 90% of front seat occupants observed during the daytime at  
55 controlled intersections in 2016 were using a seat belt (Li & Pickrell,  
56 2017). Although daytime belt use in the U.S. has increased nearly 20  
57 percentage points from 71% in 2000 to 90% in 2017, 9874 (48%) passen-  
58 ger vehicle occupants killed in motor vehicle crashes in 2015 were  
59 unrestrained in cases where restraint use was known (National Center  
60 for Statistics and Analysis, 2017).

A promising method for encouraging unrestrained vehicle 61 occupants to buckle up is using vehicle technology to cue belt use or 62 motivate belt use. For instance, two national surveys found that of occu- 63 pants who report not using a seat belt regularly, or part-time belt users, 64 a little more than half say they frequently forget to use a belt (Boyle & 65 Lampkin, 2007; Kidd, McCartt, & Oesch, 2014). Seat belt reminders 66 that provide a visual and/or auditory signal can cue forgetful part-time 67 belt users to buckle up. Seat belt reminders short in duration have not 68 been shown to be effective at increasing belt use (e.g., Geller, Casali, & 69 Johnson, 1980; Robertson & Haddon Jr, 1974), but enhanced seat belt 70 reminders with an auditory reminder lasting longer than 8 s have 71 been shown to increase belt use 3–6 percentage points (Ferguson, 72 Wells, & Kirley, 2007; Freedman, Levi, Zador, Lopdell, & Bergeron, 73 2007; Williams, Wells, & Farmer, 2002). More aggressive enhanced re- 74 minders with at least 90 s of a continuous or intermittent auditory 75 and visual signal and possessing other characteristics required by the 76 European New Car Assessment Programme (2015) are even more 77 effective at increasing belt use based on observations of seat belt use 78 (Krafft, Kullgren, Lie, & Tingvall, 2006; Lie, Krafft, Kullgren, & Tingvall, 79 2008). 80

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Part-time belt users cite other reasons for not always using a seat belt besides forgetfulness, such as taking a short trip (Boyle & Lampkin, 2007; Kidd et al., 2014). Belt use during short trips on and off public roadways (e.g., parking lots, private drives) is important considering that crash injury risk is elevated for unrestrained occupants relative to restrained ones even at low speeds (Viano & Parenteau, 2010). However, part-time belt users may be willing to tolerate visual and auditory signals from a seat belt reminder system when traveling on short trips unbelted, thereby limiting the efficacy of this technology.

Seat belt interlock systems that restrict a vehicle function until the driver's seat belt is fastened may be more effective than seat belt reminder systems for motivating part-time users to buckle up on every trip. Van Houten, Hilton, Schulman, and Reagan (2011) conducted a pilot test where a small sample of commercial drivers drove a vehicle with a system that increased accelerator pedal resistance when the driver was unbelted at speeds above 25 mph; resistance increased as vehicle speed increased. Van Houten et al. found that the system increased belt use from under 70% to 100%. Delaying unbelted drivers from shifting out of gear for periods as short as 8 s also has been found to increase belt use among fleet drivers (Van Houten et al., 2010; Van Houten, Malenfant, Austin, & Lebbon, 2005). However, these drivers disliked that the gearshift delay system required belt use when traveling on short trips.

Acceptance is critical to the viability of using vehicle technologies to increase belt use, but interlocks may not be acceptable. In 1973, NHTSA required that all new vehicles without passive restraints (e.g., airbags) have ignition interlocks that prevented the driver from starting the vehicle until the driver belt was in use (Transportation Research Board, 2003). The technology was so unpopular that Congress prohibited NHTSA from requiring interlocks or even allowing seat belt interlocks that prevent starting or operating a motor vehicle if an occupant is not using a seat belt as an alternate route to compliance with any motor vehicle safety standard. These restrictions were in place until 2012 with the enactment of the *Moving Ahead for Progress in the 21st Century Act of 2012* (MAP-21), which amended federal code removing the restriction on allowing interlocks as an optional means of compliance, but maintaining the prohibition against requiring them. Public sentiment about seat belt interlock technology has seemingly not changed and is especially low among those who do not always use a seat belt. A national telephone survey found low support for technology that prevented the vehicle from starting, from being shifted out of park, from exceeding a certain speed, or disabled use of an entertainment system among respondents who did not always use a seat belt, and only around half of respondents who always wore a belt supported each of these technologies (Kidd et al., 2014). However, few or none of the survey respondents likely had ever experienced any of the interlock technologies. Perceptions of a technology change following actual use and may change whether the technology is acceptable (e.g., Ghazizadeh, Lee, & Boyle, 2012).

No regulations yet have been proposed to permit seat belt interlocks as an alternative to a safety standard, but General Motors became the first manufacturer to offer a gearshift interlock in the U.S., beginning with specific 2015 model year fleet vehicles. General Motors' Seat Belt Assurance System prevents the driver from placing the vehicle in gear for 30 s after ignition unless the driver and, if present, front right passenger are belted. This technology may substantially increase belt use among part-time belt users (e.g., Van Houten et al., 2005; Van Houten et al., 2010) but may not be acceptable. Furthermore, it has the potential to aggravate full-time belt users who buckle up after placing the vehicle in gear. A national telephone survey found that among respondents who reported always using a seat belt when driving, about 15% did not routinely buckle up before putting the vehicle in gear (Kidd et al., 2014). Similarly, an observational study of 1600 drivers found that almost one-quarter buckled up after placing the vehicle in gear (Malenfant & Van Houten, 2008).

The current study extends on previous studies that evaluated gearshift interlocks (e.g., Van Houten et al., 2005, Van Houten et al., 2010) by assessing the effectiveness of using a gearshift interlock for increasing belt use among passenger vehicle drivers who do not routinely use a seat belt relative to an enhanced seat belt reminder. Drivers who received a seat belt citation and self-reported not always using a seat belt drove a vehicle with an enhanced reminder for one week. The next week, half drove a vehicle with a gearshift interlock, while the other half drove a vehicle with the same reminder system. It was hypothesized that the gearshift interlock would significantly increase belt use among part-time belt users compared with the week-to-week changes in belt use observed for part-time belt users who continued to drive a vehicle with an enhanced seat belt reminder. A secondary objective of the study was to evaluate whether full-time belt users and part-time belt users found the gearshift interlock acceptable. Based on findings from Kidd et al. (2014), it was hypothesized that full-time belt users would find the gearshift interlock more acceptable than part-time belt users who drove a vehicle with the gearshift interlock and find other technologies designed to increase belt use more acceptable too. Additionally, part-time belt users who drove a vehicle with the gearshift interlock were expected to report different opinions about acceptance of the technology than part-time belt users who did not drive a vehicle with the technology because they actually experienced it (e.g., Ghazizadeh et al., 2012).

## 2. Method

### 2.1. Recruitment

The recruitment process is illustrated in Fig. 1. Maryland residents were recruited within a radius of approximately 30 miles from Rockville, Maryland. This range included the counties of Montgomery, Frederick, Prince George, and Howard. Part-time belt users were defined as individuals who had received a seat belt citation and reported occasional or frequent seat belt nonuse while driving. Full-time belt users were defined as those who reported almost always or always using a seat belt while driving. Different methods were used to recruit part-time belt users and full-time belt users. Maryland has a primary enforcement seat belt law that requires all drivers and front seat passengers to use a seat belt. Contact information for individuals who had received a citation for not using a seat belt as a driver in Maryland between January 1, 2015, and June 8, 2016, was obtained from the Maryland Court System. Flyers were mailed to 7960 people inviting them to participate in a vehicle evaluation study. The flyer indicated that study participants would drive two 2015 or 2016 model year vehicles for one week each and provide feedback about their experience. The flyer also specified that the recipient must be between 25 and 60 years old and drive at least 5 days per week to be eligible.

In total, 735 people responded to the invitation. Researchers administered a short screener questionnaire to each potential participant over the phone to determine eligibility. The screener gathered information about respondents' personal vehicles, driving frequency, driving history, use of cellphones or navigation systems while driving, demographic information, medical history, vehicle insurance, and seat belt use. Respondents were eligible to participate if: they were 25–60 years old; were willing to use a Chevrolet Cruze as their personal vehicle; did not ride a motorcycle as their primary vehicle; reported driving 5 days or more each week; had been driving more than 3 years; provided proof that they carried the minimum amount of automobile insurance required in the state of Maryland; agreed to a driver's license check to verify they had fewer than 4 penalty points on their license, no serious traffic infraction in the past 3 years, and no police-reported crashes in the last year; did not report a seizure in the past year, a heart attack or a condition leading to a loss in consciousness or awareness in the past 6 months, and were not taking medications, 208 drugs, or substances that would impair driving ability; and were not 209

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