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Young Drivers and Their Passengers: A Systematic Review of Epidemiological Studies on Crash Risk

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Abstract

A systematic review of the literature was conducted to appraise the evidence from epidemiological studies of crash risk in young drivers accompanied by passengers, compared with solo driving. Databases searched included the Cochrane Library, Embase, Scopus, Transportation Research Information Services, and Web of Science for studies published between January 1, 1989 and August 1, 2013. Epidemiological studies were selected for review if they focused on crashes of young drivers (≤24 years old) and included both a no-passenger comparison group and some measure of exposure to enable calculation of risk estimates. Fifteen articles (17 studies) were selected; seven studies reported on fatal crashes and 10 on nonfatal or combined fatal/nonfatal crashes. Studies on fatal crashes showed increased risk, compared with solo driving, for young drivers with at least one passenger (significant risk estimates ranging from 1.24 to 1.89) and two or more passengers versus solo driving (1.70–2.92). Increased risk was also found for fatal crashes and for combined or nonfatal crashes with male versus female passengers (1.53–2.66) and for younger versus older drivers (1.42–3.14). Results more clearly indicate increased risk for passenger presence in fatal crashes than that in nonfatal or combined fatal/nonfatal crashes. Findings of this review, based on correlational studies, support licensing policies that limit the presence and number of young passengers for young drivers.

Keywords

Systematic review; Traffic accident; Driver; Passenger; Adolescent; Young adult

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Traffic-related crashes are one of the main causes of morbidity and mortality for teenagers and young adults [1]. Some key studies have identified passenger presence and their number as important factors associated with increased fatal crash risk for teenagers [2]. This knowledge was the basis for the establishment of restrictions on passenger presence and number of peer passengers in several jurisdictions where teenagers have access to independent driving before the age of 18 (e.g., Australia, Canada, Israel, United States).

Research evidence that passenger presence is associated with teenage drivers' crash risk was established from population-based epidemiological studies. This research, however, is inconsistent, with some studies reporting discrepant findings of protective or no significant association between passenger presence and young drivers' crash risk. Methodological and conceptual differences between studies may explain discrepant findings, including different age of licensing in different countries (before 18 years vs. 18 years and older), sources of data (regional vs. national; same databases used in multiple studies), types of crashes (fatal vs. others), different age groups for drivers and passengers employed in the analyses, and measures of exposure (trips or mileage vs. culpability/responsibility studies vs. no exposure). A better understanding of the discrepant findings among epidemiological studies and a clearer picture of the factors affecting young drivers' crash risk is thus warranted and could help improve future development of graduated driver licensing (GDL) programs and psychosocial interventions, such as parent-teen and peer-based interventions.

A systematic review was conducted to examine the strength of the evidence for the relationship between presence and number of passengers as well as characteristics of drivers and passengers on crash risk for teenage and young adult drivers. Several research questions were examined. Compared with solo driving, in teenage and young adult drivers, what is the risk associated with (1a) one or more teenage or young adult passengers and (1b) one or more passengers, irrespective of passenger age. These questions were also examined for (2a) younger teenage drivers versus older teenage or young adult drivers and (2b) teenage or young adult drivers versus older drivers. Compared with solo driving, does the risk vary with (3) number of passengers; (4) driver gender; (5) passenger gender; and (6) gender of both passenger and driver.

Methods

Inclusion criteria

Studies were included in the review if the following criteria were met. First, the main outcomes were crashes. Second, the design of the studies was observational, including cross-sectional, case-control, and culpability/responsibility studies. In the present context, cross-sectional studies examined rates of drivers involved in a crash with passengers after accounting for exposure, compared with rates of drivers involved in a crash while solo driving after accounting for exposure. In case-control studies, drivers involved in a crash (cases) were compared with drivers with similar characteristics, but who were not involved in a crash (controls). More specifically, rates of cases and controls with passengers were compared with rates of cases and controls while solo driving. Culpability/responsibility studies are described by Asbridge et al. [3] as a variation of the case-control studies in which drivers' crash responsibility is considered. In these studies, rates of drivers at fault and not at fault with passengers were compared with rates of drivers at fault and not at fault while solo driving. Studies involving questionnaires, simulation, or observation on the road were not included. Third, studies examined the association between passenger presence and young drivers' (≤24 years old) crash risk; any grouping of young driver ages was acceptable (e.g., 16, 17, 16–20, 18–24). Fourth, studies included a no-passenger comparison group (i.e., solo driving) and a measure of exposure (e.g., kilometers driven, comparison of crashes at fault vs. not at fault) enabling calculation of risk estimates or allowing the calculation of estimates from data presented in the publication. Finally, articles needed to be available as full reports, peer reviewed, and published in English in journals or in organized proceedings.

Literature search strategy and selection

Relevant articles were identified by a comprehensive search performed by the research team guided by an experienced librarian. Databases searched included the Cochrane Library, Embase, Scopus, Transportation Research Information Services, and Web of Science for studies published between January 1, 1989 and August 1, 2013. An index term search was performed to ensure inclusion of all possible search terms. The following search terms (MeSH headings and text words) were used and adapted as appropriate for each database: (teen* OR adolescent* OR young adult* OR novice*) AND (driv* OR vehicle OR traffic OR car* OR automobile OR road* OR safe*) AND (passenger* OR friend OR confederate OR peer OR occupant) AND (crash* OR collision OR accident OR injur* OR fatal* OR death). Reference lists of selected articles and personal libraries of the team were also examined. The retrieved articles were examined in three stages by members of the research team for inclusion based on titles, abstracts, and full article review (see Figure 1).

Data extraction and synthesis of results

Two members of the team extracted information from the qualifying articles. Discrepancies in coding were discussed until consensus. Information collected from articles is shown in Table 1. We extracted authors' names, year of publication, country, study design, main outcome (e.g., fatal crashes), exposure (or types of comparison), database used and years, number of participants for main research question (Question 1a or Question 1b if no Question 1a), if studies included raw data, and age of drivers and passengers. Table 1 also describes if the article answered each of the research questions in the present study (Questions 1–6) and if main analysis adjusted for important risk factors or if other risk factors were examined separately.

Meta-analysis was not attempted as many studies lacked raw data, used the databases from the same sources, with overlapping years, or were heterogeneous (e.g., different age groups for drivers and passengers, different types of crashes). We therefore included studies with no raw data but with risk estimates and confidence intervals (CIs). Estimates were extracted from articles when they either directly or partially addressed the research questions (results not in italics in tables). The latter refers to situations in which estimates were provided in more detail than our initial research question. For example, Question 1 refers to the risk associated with the presence of one or more teenage or young adult passengers. If results were only provided for males and females separately, tables report these estimates, and we inferred significance if all separate estimates were significant (i.e., 95% CIs did not include

"1" or *p* < .05). In these cases, and when raw data were provided, we also calculated estimates that directly answered the research question (results in italics in tables), using usual relative risk/odds ratio and 95% CI formulas. We did not attempt to estimate standard errors without raw data, and we did not contact authors of the articles to obtain data for this review. Calculations of estimates and CIs might be affected by both rounding to a few decimals in source articles and adjustment based on sampling, which may result in narrower intervals that should be interpreted with caution. When unadjusted and adjusted estimates were provided, we show the unadjusted estimates in tables, but we only include the adjusted estimates in the summary of results. Ranges of estimates were provided only when results were consistent and when at least four or more studies had been conducted on the research question.

Quality and bias assessment

The quality of reporting of each study was assessed using a grid adapted from Orriols et al. [4], the Strengthening the Reporting of Observational studies in Epidemiology statement [5], and a checklist for quality assessment for cross-sectional and case-control studies [6]. Elements assessed included the reporting of study design, selection of participants, data collection (outcome, exposure or type of comparison, confounders), results, and discussion (the grid is shown in the Appendix). The reporting of studies was ranked as very good (≥90%), rather good (≥80% and <90%), or weak, but acceptable (≥70% and <80%). Studies ranking lower than 70% were not included in the review.

Results

Study selection

As shown in Figure 1, 3,918 articles were identified in the literature search, and titles were examined for inclusion (Step 1). Of these, 180 abstracts (Step 2) and 62 full articles (Step 3) were reviewed for inclusion. Main reasons for exclusion were articles that were duplicates, unrelated to research topic, or not fulfilling inclusion criteria. Others were review articles or editorials. The quality of reporting and bias assessment was conducted on 18 articles. The quality of reporting of three articles was evaluated at lower than 70% [7–9]. A total of 15 articles (17 studies) were finally included in the review: 60% were evaluated as very good, 20% as rather good, and 20% as weak but acceptable (see Table 1 for the ranking of each study).

Characteristics of the selected studies

Study design—As shown in Table 1, 11 of the 17 studies (15 articles) had a cross-sectional design. Seven of these studies used estimated exposure per number of kilometers driven [10–13] or per number of trips [2,12]. Other types of comparison were as follows: per number of crashes [2]; with injury versus without injury [14,15]; with fatal and severe injury versus others [16]; and with unsafe action versus safe action [17]. There were six culpability/responsibility studies comparing crashes at fault versus not at fault [16,18–22]. Although two of them described the design as a case-control study, we categorized them as culpability/responsibility studies because the controls were involved in a crash [21,22]. One of the articles allowed calculations for cross-sectional and culpability/responsibility investigations [16]. There was only one case-control study [23].

Countries, types of crashes, and databases—Table 1 shows that 10 of the 15 articles were from North America (nine in the United States and one in Canada), three from Europe (Italy, Spain, Sweden), and two from Oceania (Australia, New Zealand). Crashes were examined with the following categorization: fatal, injury and fatal combined, police reported (usually combining material, injury, and fatal), only injury, or only material. The studies are referred as fatal or as nonfatal or combined fatal/ nonfatal crashes (or combined and nonfatal crashes). Seven studies, all conducted in North America, examined fatal crashes. Six of them used the Fatality Analysis Reporting System (FARS), a database of all fatal crashes in the United States with years ranging from 1975 to 2010. Five of the six studies had overlapping years. The last study used a regional database. Ten studies examined combined or nonfatal crashes; two of these studies examined both fatal and combined or nonfatal crashes [10,13]. This category includes all the studies not conducted in the United States. Most studies used regional databases. Two articles examined more than one type of combined or nonfatal crashes [10,21]. Descriptive analysis suggested that the most meaningful way of presenting data in this review was by juxtaposing fatal and nonfatal or combined fatal/nonfatal crashes.

Other characteristics of selected studies

In 10 articles, drivers were aged 20 years or younger; in four of these articles, drivers aged 20–24 years were also examined (see Table 1). In the remaining five articles, drivers were aged 24 years or younger. Eleven of the 17 studies included raw data allowing calculations of estimates for the main research question (Question 1). Two of the remaining six studies did not provide sample sizes [18,22]; the four others had total sample size, but had some other missing information preventing the calculation of estimates [10,14,17].

Apart from describing results by age and sex stratification, about half of the studies also adjusted or accounted for potential confounders. Most common confounders were, in descending order: time of day, alcohol, day of the week, and safety belt use. Regarding other risk factors, 60% of the studies also examined other risk factors in the presence of passengers. Most common risk factors included, in descending order: time of day, single- or multiple-vehicle crash, day of the week, safety belt use, and alcohol.

Passenger presence (Question 1)—The first research question examined, in teenage drivers, the risk of crashes under the following conditions compared with solo driving: (1a) one or more teenage or young adult passengers and (1b) one or more passengers, irrespective of passenger age. As shown in Table 2, all 17 studies examined the association between young drivers' crash risk and presence of one or more passengers of any age (or passengers of an age equivalent or older than teenage years; Question 1b). When the information about passenger age was not provided, we assumed that any passenger age was included. Ten of the 17 studies also examined the association between young drivers' crash risk and presence of young passengers (Question 1a). Seven studies examined fatal crashes with passengers of any age (Question 1b; Table 2), four of them also examined the association with teenage passengers (Question 1a; Table 2). Results showed an increased risk of fatal crashes for teenage and young drivers with one or more teenage or young passengers (Question 1a) [2,12,13,20]. For risk of fatal crashes with any passengers (Question 1b), five of the seven studies showed an increased risk [2,12,13,17,20]; the two other studies showed nonsignificant results [10,18]. Most estimates showing increased risk ranged from 1.24 to 1.89 [2,13,17,20]. Results for combined or nonfatal crashes are presented in the second half of Table 2. Ten articles examined these crashes with passengers of any age (Question 1b); six of these articles also examined them with teenage passengers. Results of these studies were rather mixed with studies variously showing increased risk, protective, or nonsignificant associations. In summary, results of studies on fatal crashes provide rather consistent evidence of an increased risk with one or more teenage passengers or passengers of any age, compared with solo driving, with estimates generally less than 2.0. Results were mixed for combined or nonfatal crashes, with no clear evidence that teenage passengers or passengers of any age are associated with increased risk.

Driver age (Question 2)—One important Question (2a) is whether risk associated with passenger presence, compared with solo driving, is higher for younger teenage drivers than for older teenage or young adult drivers. Table 2 shows that six studies presented data for different ages or age groups, and three had raw data. The available literature does not provide clear indication that there is a difference in risk for younger teenage drivers than for older teenage drivers or young adult drivers.

Table 3 shows risk estimates with one or more passengers, compared with solo driving, for teenage or young adult drivers versus older drivers (Question 2b). Eleven studies examined risk of teenage or young adults and older drivers with passengers, and six articles had raw data allowing comparisons between younger and older drivers: two studies for fatal crashes and four studies for combined or nonfatal crashes. To provide comparable estimates between studies, the review focused on drivers younger than 65 years old, even if some studies calculated risk estimates for drivers older than 65 years old. Passenger carriage risk, compared with solo driving, was always higher for younger than older drivers for both fatal and combined or nonfatal crashes; risk estimates ranged from 1.42 to 3.14 [2,11,15,16,20,23].

Number of passengers (Question 3)—As shown in Table 4, the risks associated with number of passengers, compared with solo driving, were examined in nine studies (five for fatal crashes and six for combined or nonfatal crashes; two studies examined both). Five of the nine studies were about young passengers, whereas five included passengers of any age (one study reported on both). Studies generally presented results for some of the following categories: one, two, and three or more passengers versus solo driving. A few studies presented results for two or more passengers versus solo driving. We also calculated two categories when not included in initial studies to provide information about the potential benefits of some passenger regulations: two or more passengers versus solo driving and two or more passengers versus one passenger. In all the studies in which fatal crashes were examined, there was an increased risk, compared with solo driving, for drivers with two passengers and two or more passengers, with risk estimates from 1.70 to 2.92 [2,13,17,20].

Increased risk was also associated with carrying three or more passengers [2,13,17]. Three studies for which we compared two or more passengers versus one passenger showed an increased risk for each category examined [2,13,20]. For combined or nonfatal crashes, five studies examined the association with two passengers or two or more passengers versus solo driving: two studies showed increased risk; two had nonsignificant results; and one showed protective associations. Results for three or more passengers versus solo driving and for two or more passengers versus one were also mixed. In sum, results suggest increased fatal crash risk with two passengers and two or more passengers versus solo driving (both later referred as two or more passengers), with risk estimates ranging from 1.70 to 2.92.

Gender of driver and passenger (Questions 4–6)—Few studies examined if risk, compared with solo driving, varies with driver gender (Question 4), passenger gender (Question 5), and gender of both passenger and driver (Question 6). Fatal crash risk by driver gender with one or more passengers was examined in five articles, as shown in Table 5. Results for male and female drivers were mixed. Results of three studies for which we could compare risks for male and female drivers, both compared with solo driving, showed that passenger presence was associated with greater risk for male drivers [2,12,13]. Findings of the five studies on combined or nonfatal crashes were mixed for male and female drivers with one or more passengers versus solo driving and for comparison between male and female drivers.

Fatal crash risk by passenger gender was examined in two studies, as shown in Table 6. Risk was higher with both male and female passengers, compared with solo driving [2,11]. Three studies examined combined or nonfatal crashes by passenger gender. Results with male passengers were rather mixed (increased risk and nonsignificant associations), whereas results with female passengers were also mixed with nonsignificant and protective associations. We compared risk associated with male and female passengers, both versus solo driving, in four studies (two on fatal crashes and two on combined or nonfatal crashes). Risk estimates ranged from 1.53 to 2.66 [2,12,15,21].

Finally, risk associated with gender of both driver and passenger was examined. Two studies examined fatal crash risk, and results showed increased risk for all categories [2,12], except the male driver–female passenger category [2]. The comparison between male driver–male passenger versus the other categories of drivers and passengers also showed increased risk. Only one study examined the estimates for combined or nonfatal crashes; three of the four results were not significant, the male driver–female passenger category showed a protective association [22]. In summary, increased risk was only found for fatal crashes and for combined or nonfatal crashes with male passengers versus female passengers (estimates from 1.53 to 2.66).

Discussion

The goal of this review was to appraise the epidemiological evidence evaluating crash risk for young drivers with passengers, compared with solo driving. The literature provides evidence of increased crash risk with passengers for fatal crashes in the following situations: (1) with at least one passenger versus solo driving and (2) with two or more passengers versus solo driving. Increased risk with passengers, compared with solo driving, was also found for fatal crashes and for combined or nonfatal crashes (3) with male versus female passengers and (4) for younger versus older drivers.

Findings of this review suggest that passenger presence plays a stronger negative role in more severe crashes, a conclusion that received support from the strength of evidence between the two types of crashes examined here, but also within the combined or nonfatal crashes categories for studies that have compared more severe to less severe crashes [14–16] and from a naturalistic study [24] that investigated the association between passenger presence and crash and near crash risk. This study showed a protective effect of passenger presence for involvement in risky driving behavior and no significant effects on minor crashes and near crashes. Nevertheless, before making firm conclusions in this regard, the impact of potential confounders, such as measurement issues and the interaction of multiple factors, requires further attention. Although most studies on fatal crashes used the U.S. FARS database that adheres to a stringent data collection protocol, data on nonfatal or combined fatal/nonfatal crashes include diverse types of crashes that occurred in jurisdictions that may use disparate procedures (e.g., it is unclear to what extent presence and characteristics of passengers are systematically gathered for these crashes). Moreover, fatal crashes may arise from complex interactions between passenger presence and other factors such as driver/passenger characteristics, time (i.e., hour, day of the week), alcohol consumption, and safety belt use and be modulated by factors such as distraction and social influence in different ways than those for other types of crashes. Pending clarification of the influence of these potential confounders on the findings, however, results of the current review more clearly indicate increased risk for passenger presence in fatal crashes than those in nonfatal or combined fatal/nonfatal crashes.

Methodological issues with selected studies

Meta-analysis was not attempted as many studies used databases derived from the same source were heterogeneous in their methods or did not provide raw data. Although results appear stronger for fatal crashes, the following issues need to be considered. The U.S. FARS data were used in six of the seven studies on fatal crashes, and most studies examined crashes with overlapping years. This situation raises questions about the generalizability of the findings to other jurisdictions. Moreover, although 17 studies examined the association between the presence of one or more passengers and young drivers' crash risk, only a few examined some specific research questions, such as the effect of gender of driver and passenger (n =3). This constraint also warrants care in interpretation of results; accordingly, when there were consistent results, but less than four studies on a research question, ranges of estimates were not reported in the summary of data.

Several features differed between studies, such as countries where studies were conducted and driver and passenger age groupings, and it remains unclear if study differences could explain the discrepancies in the results. For example, regarding driver age, countries in North America and Oceania have a licensing age less than 18 years whereas the licensing age in many European countries is 18 years. Could differences between studies stem from the lack of 16- to 17-year-old drivers in Europe, cultural differences that would affect several aspects of the young driver's lifestyle, including transportation needs, access to public transportation, or some other reasons? These questions have not been systematically studied. Moreover, results from European countries were rather mixed; increased risk was found in the study from Italy [15], nonsignificant and protective effects were found in the study from Spain [22], and there was a protective association in the study from Sweden [11]. Concerning age groupings, more studies have examined passengers of any age than peer passengers. Lack of studies and wide age ranges of drivers and passengers may have hindered our ability to determine with confidence the extent to which the association between passenger presence and driver's risk varies with driver and passenger age. Of course, research is limited by the cell sizes available to conduct specific analysis and the information available in databases; hindering the ability of researchers to examine effects in narrow age ranges for both drivers and passengers. Future studies will need to address these questions.

Finally, among other methodological concerns encountered was the lack of raw data in many studies, precluding calculations of estimates. As meta-analysis was not possible, we decided to include studies with estimates and CIs and whose general quality was acceptable. Future research should report important information, such as raw data, to permit a more thorough evaluation of risk estimates. It is important to note, however, that we extracted data or risk estimates from some articles whose main thrust diverged from our research questions. For example, the goal of the Preusser et al. [20] study was to compare risk for younger versus older drivers (Question 2), but raw data were also available to calculate risk with one or more passengers versus solo driving (Question 1). In the present study, no attempt was made to contact authors, and the evaluation of quality was based on reported information and not on how the studies were actually conducted. Future articles should report in sufficient detail to allow a valid appraisal of their quality and sources of bias, as suggested by the Strengthening the Reporting of Observational studies in Epidemiology statement [5].

Future studies

Although cross-sectional studies can help to describe the scope of a problem, they do not provide evidence of a cause and effect relationship, here between passenger presence and crash risk. Other types of studies are needed to better appraise the association between passenger presence and driving risk, such as case-control studies with careful selection of participants including cases representative of the population examined and case-crossover studies, in which participants serve as their own controls. Moreover, randomized controlled experiments using simulation or test track methods could help to establish the causal link between passenger presence and driving risk and to support the hypothesized mechanism underlying increased risk, such as social influence and distraction [25,26]. Future studies should also focus on the types of passengers (siblings vs. friends) and driving experience. Very few studies with our inclusion criteria have examined these factors, a gap that could obscure important features to consider in GDL programs. Most jurisdictions in the United States that gradually allow exposure to driving with teenage and young adult passengers during the first months of the provisional license period, mainly target non-siblings. At the same time, there are no studies showing that increased risk is limited to the presence of nonsibling passengers. The effect of driving experience on crash risk is another poorly studied topic. Only one of the selected studies examined crash risk by types of license and age groups [13]. More studies that address these issues could help to establish if exceptions are supported by the data and to empirically estimate the appropriate time periods for passenger restrictions after licensing.

Implications and Contribution

Although the causal relationship between passenger presence and crash risk is yet to be clearly established, results of this review provide circumstantial evidence that teenage passengers increase teenage driving risk, particularly fatal crash risk. These findings and results of evaluation of GDL program components [27,28] support the premise that passenger presence and their number should be introduced gradually. The findings that risk may be greater with multiple passengers and with male passengers are relevant for psychosocial interventions, such as parent–teen and peer-based interventions.

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References

1. World Health Organization. Global status report on road safety: Time for action. 2009
2. Chen LH, Baker SP, Braver ER, Li G. Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. JAMA. 2000; 283:1578–82. [PubMed: 10735394]
3. Asbridge M, Jill AH, Jennifer LC. Acute cannabis consumption and motor vehicle collision risk: Systematic review of observational studies and meta-analysis. BMJ. 2012; 344:e536. [PubMed: 22323502]
4. Orriols L, Salmi LR, Philip P, et al. The impact of medicinal drugs on traffic safety: A systematic review of epidemiological studies. Pharmacoepidemiol Drug Saf. 2009; 18:647–58. [PubMed: 19418468]
5. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. Prev Med. 2007; 45:247–51. [PubMed: 17950122]
6. Salmi, LR. Lecture critique et communication médicale scientifique. Paris: Elsevier Masson; 2012. 3ième ed
7. Chen LH, Baker SP, Braver E. The effect of young adult passengers on teenager driver death rates.
8. Cvijanovich NZ, Cook LJ, Mann NC, Dean JM. A population-based study of crashes involving 16- and 17-year-old drivers: The potential benefit of graduated driver licensing restrictions. Pediatrics. 2001; 107:632–7. [PubMed: 11335735]
9. Fu H, Wilmot CG. Effect of passenger age and gender on fatal crash risks of young driver. Transport Res Rec. 2008:33–40.

10. Doherty ST, Andrey JC, MacGregor C. The situational risks of young drivers: The influence of passengers, time of day and day of week on accident rates. Accid Anal Prev. 1998; 30:45–52. [PubMed: 9542543]
11. Engström I, Gregersen NP, Granström K, Nyberg A. Young drivers—reduced crash risk with passengers in the vehicle. Accid Anal Prev. 2008; 40:341–8. [PubMed: 18215567]
12. Ouimet MC, Simons-Morton BG, Zador PL, et al. Using the U.S. National Household Travel Survey to estimate the impact of passenger characteristics on young drivers' relative risk of fatal crash involvement. Accid Anal Prev. 2010; 42:689–94. [PubMed: 20159095]
13. Tefft BC, Williams AF, Grabowski JG. Teen driver risk in relation to age and number of passengers, United States, 2007–2010. Traffic Inj Prev. 2013; 14:283–92. [PubMed: 23441947]
14. Lam LT. Factors associated with young drivers' car crash injury: Comparisons among learner, provisional, and full licensees. Accid Anal Prev. 2003; 35:913–20. [PubMed: 12971926]
15. Orsi C, Marchetti P, Montomoli C, Morandi A. Car crashes: The effect of passenger presence and other factors on driver outcome. Safety Sci. 2013; 57:35–43.
16. Lee C, Abdel-Aty M. Presence of passengers: Does it increase or reduce driver's crash potential? Accid Anal Prev. 2008; 40:1703–12. [PubMed: 18760099]
17. Bédard M, Meyers JR. The influence of passengers on older drivers involved in fatal crashes. Exp Aging Res. 2004; 30:205–15. [PubMed: 15204633]
18. Geyer J, Ragland D. Vehicle occupancy and crash risk. Transport Res Rec. 2005; 1908:187–94.
19. Padlo P, Aultman-Hall L, Stamatiadis N. Passengers and other factors affecting the safety of young and older drivers. Transport Res Rec. 2005; 1937:7–13.
20. Preusser DF, Ferguson SA, Williams AF. The effect of teenage passengers on the fatal crash risk of teenage drivers. Accid Anal Prev. 1998; 30:217–22. [PubMed: 9450125]
21. Rice TM, Peek-Asa C, Kraus JF. Nighttime driving, passenger transport, and injury crash rates of young drivers. Inj Prev. 2003; 9:245–50. [PubMed: 12966014]
22. Rueda-Domingo T, Lardelli-Claret P, de Dios Lunadel-Castillo J, et al. The influence of passengers on the risk of the driver causing a car collision in Spain. Analysis of collisions from 1990 to 1999. Accid Anal Prev. 2004; 36:481–9. [PubMed: 15003593]
23. Lam LT, Norton R, Woodward M, et al. Passenger carriage and car crash injury: A comparison between younger and older drivers. Accid Anal Prev. 2003; 35:861–7. [PubMed: 12971919]
24. Simons-Morton BG, Ouimet MC, Zhang Z, et al. The effect of passengers and risk-taking friends on risky driving and crashes/near crashes among novice teenagers. J Adolesc Health. 2011; 49:587–93. [PubMed: 22098768]
25. Ouimet MC, Pradhan AK, Simons-Morton BG, et al. The effect of male teenage passengers on male teenage drivers: Findings from a driving simulator study. Accid Anal Prev. 2013; 58:132–9. [PubMed: 23727554]
26. Simons-Morton BG, Bingham CR, Falk EB, et al. Experimental effects of injunctive norms on simulated risky driving among teenage males. Health Psychol. 2014; 33:616–27. [PubMed: 24467258]
27. Vanlaar W, Mayhew D, Marcoux K, et al. An evaluation of graduated driver licensing programs in North America using a meta-analytic approach. Accid Anal Prev. 2009; 41:1104–11. [PubMed: 19664453]
28. Masten SV, Foss RD, Marshall SW. Graduated driver licensing program component calibrations and their association with fatal crash involvement. Accid Anal Prev. 2013; 57:105–13. [PubMed: 23672925]

IMPLICATIONS AND CONTRIBUTION

This review found increased crash risk among young drivers carrying passengers, compared with solo driving, particularly for fatal crashes. The findings support the premise of graduated driver licensing programs limiting the presence and number of young passengers with young drivers.

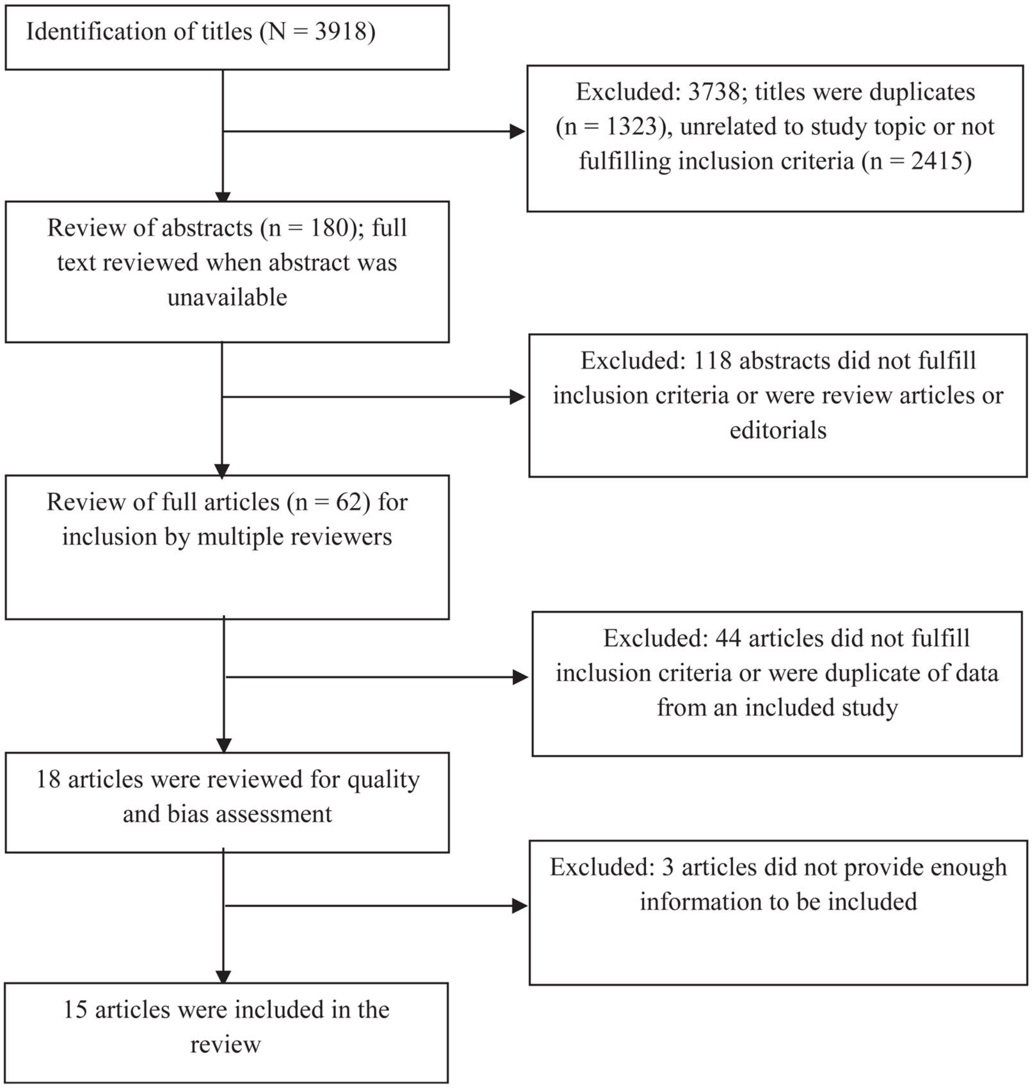

Figure 1.
Flowchart of study search and selection.

Table 1

Description of selected studies and evaluation of study quality and bias

Study (authors, year of publication; location; design)	Outcome (type of crashes)[a]	Exposure (or types of comparison)	Database or data setting, years	Number of participants[b]	Included all necessary raw data
Bédard et al., 2004; USA; cross-sectional	Fatal	(Crashes with unsafe action vs. safe action)	C and Co: FARS, 1975–1998	170,899	No
Chen et al., 2000; USA; cross-sectional	Fatal	Per 1,000 crashes and 10 million trips	C and Co: FARS, 1992–1997; GES, 1992–1997; E: Nationwide Personal Transportation Survey,[f] 1995	5,269	Yes
Doherty et al., 1998; Ontario, Canada; cross-sectional	Fatal Injury; material	Per 100 million driver-km Per million driver-km	C: Ontario Ministry of Transportation, 1988; E: survey from the Ontario Ministry of Transportation, 1988	96,024	No
Engstrom et al., 2008; Sweden; cross-sectional	Injury-fatal	Per 10 million km	C: national database called OLY/VITS, 1994–2000; E: national study, 1994–2000	22,487	Yes
Geyer and Ragland, 2005; USA; culpability	Fatal	(Crashes at fault vs. not at fault)	C and Co: FARS, 1992–2002	n/a	No
Lam, 2003; New South Wales, Australia; cross-sectional	Injury-fatal	(Crashes with injury vs. crashes without)	C and Co: Traffic Accident Database System, Roads and Traffic Authority, 1996–2000	107,283	No
Lam et al., 2003; Auckland, New Zealand; case-control	Injury-fatal	(Cases vs. controls)	Cases: prospective surveillance hospital records, 1998–1999; controls: random selection in same region, 1998–1999	229	Yes
Lee et al., 2008; Florida, USA; culpability and cross-sectional[g]	Police-reported crashes	(Crashes at fault vs. not at fault and fatal/severe vs. others)	C and Co: Florida Traffic Crash Records Database, 1999–2003 (on a portion of a freeway of about 60 km)	717	Yes
Ouimet et al., 2010; USA; cross-sectional	Fatal	Per 10 million vehicle trips and per 10 million vehicle miles traveled	C: FARS, 1999–2003; E: NHTS, 2001	4,900	Yes
Orsi et al., 2013; Pavia, Italy; cross-sectional	Injury-fatal	(Crashes with injury vs. crashes without)	C and Co: Pavia office of the Motorizzazione Civile, 2004–2005	673	Yes
Padlo et al., 2005; Connecticut, USA; culpability	Police-reported crashes	(Crashes at fault vs. not at fault)	C and Co: Connecticut Department of Transportation crash database, 1997–2001	60,263	Yes
Preusser et al., 1998; USA; culpability	Fatal	(Crashes at fault vs. not at fault)	C and Co: FARS, 1990–1995	77,607	Yes
Rice et al., 2003, California, USA; culpability[i]	Visible injury; severe-fatal injury	(Crashes at fault vs. not at fault; at night)	C and Co: California Highway Patrol statewide integrated traffic records system, 1993–1998	19,309	Yes
Rueda-Domingo et al., 2004; Spain; culpability[i]	Injury-fatal	(Crashes at fault vs. not at fault; two or more vehicles)	C and Co: Spanish National Registry of Traffic Crashes, 1990–1999	n/a	No
Tefft et al., 2013; USA; cross-sectional	Fatal Police-reported crashes	Per 100 million miles driven Per one million miles driven	C: FARS, 2007–2010; GES, 2007–2010; E: NHTS, 2009	13,559	Yes
Studies not included					

Study (authors, year of publication; location; design)	Outcome (type of crashes)[a]	Exposure (or types of comparison)	Database or data setting, years	Number of participants[b]	Included all necessary raw data
Chen et al., 1999; USA; cross-sectional	Fatal	Per 1,000 crashes	C and Co: FARS, 1988–1994; GES, 1988–1994	n/a	No
Cvijanovich et al., 2001; Utah, USA; culpability	Injury-fatal	(Crashes with hospitalization or death vs. without; crashes at fault vs. not at fault)	C: Utah hospital discharge and emergency databases, 1992–1996; Co: Utah motor vehicle crash records, Utah Division of Motor Vehicles driver license file, 1992–1996	n/a	No
Fu and Wilmot, 2008; Louisiana, USA; cross-sectional	Fatal	Per 100,000 licensed drivers[k]	C and Co: Louisiana police records, 1999–2004	n/a	No

Young driver age	Passenger age groups for present study[c]	Research questions answered[d]: 1a	1b	2a	2b	3	4	5	6	(1) Main analysis adjusted for confounders; (2) analysis examining other risk factors in presence of passengers		Evaluation of study quality and bias[e]
<20	Any	—	✔	—	✔	✔	—	—	—	**1**	—	Rather good
										2	—	
16, 17	13–19 ≥13 Any	✔	✔	✔	✔	✔	✔	✔	✔	**1**	—	Very good
										2	Other risk factors: time of the day (6:00–21:59; 10:00–11:59; 12:00–5:59)	
16–19; 20–24	Any	—	✔	✔	✔	✔	✔	—	—	**1**	—	Rather good
										2	—	
18–24	Any	—	✔	—	✔	✔	✔	—	—	**1**	Age, sex, day of the week (Monday–Thursday; Friday–Sunday), number of passengers	Very good
										2	Other risk factors: day of the week (Monday–Thursday; Friday–Sunday) with 1, 2, and 3 or more passengers; other combinations of variables such as risk for younger drivers compared with older drivers by day of the week and number of passengers, and so forth.	
15–19; 20–24	Any	—	✔	✔	✔	—	✔	—	—	**1**	Analyses adjusted for alcohol and safety belt use, time of the day, history of previous collisions, including being under the influence of alcohol or drugs before the event, history of suspended or revoked license and of citations for speeding and other moving violations	Weak, but acceptable
										2	Other risk factors: alcohol and safety belt use	
16–17; 18–19; 20–24	Any	—	✔	✔	—	✔	—	—	—	**1**	Analyses adjusted for sex, time of the day, day of the week, weather, road feature, alcohol, distraction, fatigue, speeding, risk taking behavior	Weak, but acceptable
										2	Analyses are also stratified by types of license	

Young driver age	Passenger age groups for present study[c]	Research questions answered[d] 1a	1b	2a	2b	3	4	5	6	(1) Main analysis adjusted for confounders; (2) analysis examining other risk factors in presence of passengers	Evaluation of study quality and bias[e]
≤24	≤24 Any	✔	✔	—	✔	✔	✔	—	—	Provides crude estimates adjusted for study design, but **1** Analyses also adjusted for sex, time of the day, alcohol, kilometers driven per week, and sleepiness **2** —	Very good
16–24	16–24 Any	✔	✔	—	✔	—	—	—	—	**1** Analyses accounts for confounding variables and also report results for alcohol and drug use, safety belt use, day of the week (weekend vs. weekday), time of the day (19:00–03:00 vs. others) and some interactions on all the risk factors **2** Other risk factors: see description previously mentioned and single vehicle versus multiple vehicle	Very good
15–20	16–20 ≥12	✔	✔	—	—	—	✔	✔	✔	**1** — **2** —	Very good
≤24	Any	—	✔	—	✔	—	✔	✔	—	**1** Analysis adjusted for gender, driving experience (in days), type of driving license, lost points (yes, no), day of the week (Monday–Friday, Saturday–Sunday), time of the day (days vs. night), type of collisions, area, road surface **2** Other risk factors: analyses presented separately with and without passengers for young and older drivers for each above confounders (except type of driving license, driving experience, and road surface) and adjusted for the other confounders	Very good
16–17; 18–20	16–20[h] Any	✔	✔	—	—	—	—	—	—	**1** — **2** Other risk factors: single-and two-vehicle crashes	Weak but acceptable
16, 17,18, 19; 20–24	13–19 Any	✔	✔	✔	✔	✔	—	—	—	**1** — **2** Other risk factors: time of the day (4:00–19:59; 20:00–03:59)	Very good
16–17	Teens Any	✔	✔	—	—	✔	—	✔	—	Provides crude estimates, but **1** Analysis also adjusted for driver age and sex, alcohol use, and time of the day **2** —	Very good
18–24	16–24 Any	✔	✔	—	✔	—	✔	✔	✔	Provides crude estimates, but **1** Analysis also adjusted for "psychological circumstances" including alcohol and sleepiness, safety belt use, speeding and administrative infractions, type of driver (professional or nonprofessional), physical disabilities, years since licensing, years of vehicle registration	Rather good

Young driver age	Passenger age groups for present study[c]	Research questions answered[d] 1a	1b	2a	2b	3	4	5	6	(1) Main analysis adjusted for confounders; (2) analysis examining other risk factors in presence of passengers		Evaluation of study quality and bias[e]
										2	—	
16, 17	≤20 Any	✔	✔	✔	—	✔	✔	—	—	1	—	Very good
										2	Other risk factors: time of the day (6:00–20:59; 21:00–23:59; 00:00–05:59) and single- and multiple-vehicle crashes	
16–19	Teens[j] 20–24 ≥Teens	✔	✔	—	—	—	—	—	—	1	—	Not included
										2	—	
16, 17	Any	—	✔	—	✔	✔	—	—	—	1	—	Not included
										2	Other risk factors: receiving a conviction for speeding or reckless driving	
16,17; 18–20	15–17; 18–20; 21 or more	✔	—	—	✔	✔	—	—	✔	1	All analysis used drivers aged 21 years or more as the reference group.	Not included
										2	—	

C = crashes; Co = type of comparisons; E = exposure; FARS = Fatality Analysis Reporting System; GES = General Estimates System; NHTS = National Household Travel Survey; n/a = not available in the article.

[a]The hyphen between two types of crashes indicates that both categories were combined in the source article. The terms “police-reported crash” indicates that the database includes most types of crashes: fatal; injury; and material crashes.

[b]The number of participants presented here is the total number to answer Question 1.

[c]“Any” describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[d]Compared with solo driving, in teenage and young adult drivers, what is the risk associated with (1a) one or more teenage or young adult passengers and (1b) one or more passengers, irrespective of passenger age. These questions were also examined for (2a) younger teenage drivers versus older teenage or young adult drivers and (2b) teenage or young adult drivers versus older drivers. Compared with solo driving, does risk vary with (3) number of passengers; (4) driver gender; (5) passenger gender; and (6) gender of both passenger and driver.

[e]For more details see section entitled “Quality and bias assessment” in the methods.

[f]The Nationwide Personal Transportation Survey was the initial name of the NHTS.

[g]Information in the article allowed analysis for culpability/responsibility and cross-sectional studies.

[h]This study also provided estimates with passengers aged 14–24 years; results were quite similar to those with 16–20 years old and are not shown here.

[i]This study was described as a case-control study in the source article, but the controls were involved in a crash. We classified it as a culpability/responsibility study.

[j]Passengers were described as teenagers, but no specific age range could be identified in the article.

[k]This study only fulfilled inclusion criteria for Question 2 because all analyses used drivers aged 21 years or more as the reference group, and no raw data were provided.

Table 2

Risk estimates by type of crashes for teenage or young drivers with one or more teenage or young passengers (Question 1a) or any passengers (Question 1b) compared with solo driving

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger			(1b) Any passenger			Detail on type of crash
			Est.	95% CI	Age[a]	Est.	95% CI	Age[a,b]	
Fatal crashes									
Bédard et al., 2004	≤20	OR[c]	—	—		1.32	1.28–1.36	Any_1	With unsafe versus safe action
						1.70	1.63–177	Any_2	
						1.90	1.80–2.01	Any_3	
						2.15	2.00–2.31	Any_{4+}	
Chen et al., 2000	16–17	RR	*1.53*	*1.45–1.62*	13–19	*1.55*	*1.47–1.63*	≥13	Per 1,000 crashes
			1.45	1.30–1.60	$13–19_1$	1.45	1.30–1.60	$13–19_1$	
			1.71	1.50–1.94	$13–19_{2+}$	1.71	1.50–1.94	$13–19_{2+}$	
			—	—		2.47	2.12–2.86	$20–29_1$	
			—	—		2.71	1.78–4.10	$20–29_{2+}$	
			—	—		1.08	.91–1.26	30 or $more_1$	
			—	—		.97	.59–1.60	30 or $more_{2+}$	
	16		—	—		*1.65*	*1.53–1.78*	Any	Per 10 million trips
			—	—		1.39	1.24–1.55	Any_1	
			—	—		1.86	1.56–2.20	Any_2	
			—	—		2.82	2.27–3.50	Any_{3+}	
	17		—	—		*1.84*	*1.72–1.97*	Any	
			—	—		1.48	1.35–1.62	Any_1	
			—	—		2.58	2.24–2.95	Any_2	
			—	—		3.07	2.50–3.77	Any_{3+}	
	16–17		—	—		*1.78*	*1.69–1.87*	Any	
Doherty et al., 1998	$16–19_m$	RR[d]	—	—		*2.50*	$p < .10$	Any	Per 100 million driver-km
	$16–19_f$		—	—		*3.55*	$p < .10$		
	$20–24_m$		—	—		*1.23*	$p > .10$		

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger			(1b) Any passenger			Detail on type of crash
			Est.	95% CI	Age[a]	Est.	95% CI	Age[a,b]	
	$20–24_f$		—	—		*1.75*	*p* > .10		
Geyer and Ragland, 2004	$15–19_m$	AOR[e]	—	—		.97	.93–1.03	Any	At fault versus not at fault
	$15–19_f$		—	—		.71	.66–.77		
	$20–24_m$		—	—		1.13	1.07–1.19		
	$20–24_f$		—	—		.87	.80–.96		
Ouimet et al., 2010	15–20	RR	*4.91*	*4.61–5.23*	16–20	*1.72*	*1.63–1.81*	≥12	Per 10 million vehicle trips
	$15–20_m$		7.99	7.34–8.69	$16–20_m$	1.71	1.61–1.83		
	$15–20_m$		2.97	2.63–3.36	$16–20_f$	1.69	1.54–1.86		
	$15–20_f$		5.63	4.71–6.72	$16–20_m$				
	$15–20_f$		3.50	3.03–4.05	$16–20_f$				
	15–20		*5.39*	*5.06–5.74*	16–20	*1.49*	*1.41–1.57*		Per 10 million vehicle miles travelled
	$15–20_m$		9.94	9.13–10.81	$16–20_m$	1.50	1.41–1.60		
	$15–20_m$		3.29	2.91–3.72	$16–20_f$	1.46	1.33–1.61		
	$15–20_f$		4.06	3.40–4.85	$16–20_m$				
	$15–20_f$		4.36	3.78–5.04	$16–20_f$				
Preusser et al., 1998	16	OR[f]	*1.62*	*1.40–1.87*	13–19	*1.44*	*1.26–1.65*	Any	At fault versus not at fault
	17		*1.48*	*1.32–1.67*		*1.44*	*1.29–1.60*		
	18		*1.70*	*1.52–1.91*		*1.44*	*1.30–1.59*		
	19		*1.40*	*1.24–1.58*		*1.42*	*1.29–1.57*		
	16–19		*1.60*	*1.51–.170*		*1.46*	*1.39–1.54*		
	20–24		—	—		*1.24*	*1.19–1.29*		
Tefft et al., 2013	16	RR	*1.36*	*1.18–1.56*	≤20	*1.05*	*.92–1.20*	Any	Per 100 million miles driven
			1.03	.51–2.07	$≤20_1$	—	—		
			1.96	1.18–3.26	$≤20_2$	—	—		
			13.95	6.03–32.29	$≤20_{3+}$	—	—		
	17		*1.89*	*1.68–2.11*	≤20	*1.70*	*1.53–1.89*		
			1.66	1.20–2.31	$≤20_1$	—	—		
			1.98	1.23–3.20	$≤20_2$	—	—		

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger			(1b) Any passenger			Detail on type of crash
			Est.	95% CI	Age[a]	Est.	95% CI	Age[a,b]	
			3.43	1.01–11.68	≤20_{3+}	—	—		
	16–17		*1.73*	*1.58–1.89*	≤20	*1.47*	*1.35–1.60*		
			1.44	1.01–2.04	≤20_1	—	—		
			2.02	1.36–2.99	≤20_2	—	—		
			4.39	1.45–13.31	≤20_{3+}	—	—		
Nonfatal and combined fatal/nonfatal crashes									
Doherty et al., 1998	$16–19_m$	RR[d]	—	—		*2.29*	$p < .10$	Any	Injury; per million driver-km
	$16–19_f$		—	—		*1.91*	$p < .10$		
	$20–24_m$		—	—		*.70*	$p < .05$		
	$20–24_f$		—	—		*1.37*	$p > .10$		
	$16–19_m$		—	—		*1.87*	$p < .10$		Material; per million driver-km
	$16–19_f$		—	—		*1.58*	$p < .05$		
	$20–24_m$		—	—		*.53*	$p < .10$		
	$20–24_f$		—	—		*1.12*	$p > .10$		
Engstrom et al., 2008	18–24	RR[g]	—	—		*.39*	*.38–0.40*	Any	Injury-fatal; per 10 million km
			—	—		.41	.40–.43	Any_1	
			—	—		.31	.29–.34	Any_2	
			—	—		.21	.19–.24	Any_{3+}	
Lam 2003	16–17	AOR[h]	—	—		1.50	1.34–1.67	Any_1	Injury-fatal; with injury versus without injury
	18–19		—	—		3.28	2.07–5.20	Any_{3+}	
	20–24		—	—		1.42	1.24–1.62	Any_1	
			—	—		2.86	1.45–5.66	Any_{3+}	
			—	—		1.46	1.39–1.54	Any_1	
			—	—		2.45	1.27–4.73	Any_{3+}	
Lam et al., 2003	≤24	OR	*3.53*	*1.95–6.40*	≤24	*3.39*	*2.02–5.68*	Any	Injury-fatal; cases versus controls
			2.59	1.26–5.33	≤24_1	2.59	1.26–5.33	≤24_1	
			5.77	2.32–14.33	≤24_{2+}	5.77	2.32–14.33	≤24_{2+}	
						1.91	.64–5.68	>25_1	

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger			(1b) Any passenger			Detail on type of crash
			Est.	95% CI	Age[a]	Est.	95% CI	Age[a,b]	
						5.19	1.66–16.18	$>25_{2+}$	
		AOR	2.39	.91–6.29	$\leq 24_{1}$	2.39	.91–6.29	$\leq 24_{1}$	
			15.55	5.76–42.02	$\leq 24_{2+}$	15.55	5.76–42.02	$\leq 24_{2+}$	
						3.49	.69–17.79	$>25_{1}$	
						10.19	2.84–36.65	$>25_{2+}$	
Lee and Abdel-Aty, 2008	16–24	OR	*.62*	*.44–.86*	16–24	*.58*	*.42–.79*	Any	Police-reported; at fault versus not at fault
		Adjusted coefficient[i]	1.90	$p < .0001$		31.69	$p < .0001$	—	Police-reported; at fault versus not at fault
		Adjusted coefficient[i]	1.66	$p = .0046$		3.70	$p = .0049$	—	Police-reported; fatal/ severe versus others
Orsi et al., 2013	≤24	OR	—	—		*1.63*	*1.19–2.22*	Any	Injury-fatal; with injury versus without injury
		AOR	—	—		1.42	1.00–2.02[j]		
Padlo et al., 2006	16–20[k]	OR	*.85*	*.82–.89*	16–20	*.82*	*.80–.85*	Any	Police-reported; at fault versus not at fault
Rice et al., 2003	16–17	OR	*1.01*	*.95–1.07*	Teens[l]	*.88*	*.83–0.93*	Any	Visible injury; at fault versus not at fault
			1.15	1.06–1.26	Teens$_{1m}$	.22	.10–.46	30 or more$_{2+}$[m]	
			1.49	1.22–1.84	Teens$_{3+m}$	1.49	1.22–1.84	Teens$_{3+m}$	
			.80	.73–.87	Teens$_{1f}$				
			.69	.53–.90	Teens$_{3+f}$				
			1.00	.84–1.20	Teens$_{2mf}$				
			1.34	1.15–1.57	Teens$_{3+mf}$				
		AOR	1.03	.94–1.12	Teens$_{1m}$	.22	.11–.46	30 or more$_{2+}$	
			1.27	1.03–1.57	Teens$_{3+m}$	1.27	1.03–1.57	Teens$_{3+m}$	
			.85	.77–.93	Teens$_{1f}$				
			.69	.53–.90	Teens$_{3+f}$				
			.96	.80–1.15	Teens$_{2mf}$				
			1.20	1.03–1.41	Teens$_{3+mf}$				
		OR	*1.34*	*1.17–1.54*		*1.18*	*1.04–1.35*	Any	Severe-fatal injury; at fault versus not at fault
			1.67	1.38–2.03	Teens$_{1m}$	.26	.13–.48	30 or more$_{1+}$	
			2.37	1.55–3.52	Teens$_{3+m}$	2.37	1.55–3.52	Teens$_{3+m}$	

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger Est.	(1a) 95% CI	(1a) Age[a]	(1b) Any passenger Est.	(1b) 95% CI	(1b) Age[a,b]	Detail on type of crash
			.86	.68–1.08	$Teens_{1f}$				
			.82	.38–1.56	$Teens_{3+f}$				
			1.00	.61–1.56	$Teens_{2mf}$				
			2.11	1.52–2.87	$Teens_{3+mf}$				
		AOR	1.45	1.18–1.79	$Teens_{1m}$	.28	.15–.53	30 or $more_{1+}$	
			1.74	1.12–2.69	$Teens_{3+m}$	1.82	1.30–2.54	$Teens_{3+mf}$	
			.92	.72–1.17	$Teens_{1f}$				
			.84	.42–1.67	$Teens_{3+f}$				
			1.01	.63–1.60	$Teens_{2mf}$				
			1.82	1.30–2.54	$Teens_{3+mf}$				
Rueda-Domingo et al., 2004	$18–24_m$	OR	1.15	1.08–1.23	$16–24_m$	.41	.31–.54	$45–54_m$[m]	Injury-fatal; at fault versus not at fault
						1.15	1.08–1.23	$16–24_m$	
	$18–24_m$		.60	.56–.63	$16–24_f$	.52	.42–.63	$45–54_f$	
						.78	.58–1.03	$4–15_f$	
	$18–24_f$		.99	.84–1.17	$16–24_m$	.42	.29–.60	$45–54_m$	
						1.18	.66–2.14	$>64_m$	
	$18–24_f$		.86	.78–.96	$16–24_f$	.59	.41–.85	$>64_f$	
						.94	.70–1.26	$4–15_f$	
	$18–24_m$	AOR	.95	.87–1.04	$16–24_m$	.56	.38–.83	$4–15_m$	
						1.25	.61–2.53	$>64_m$	
	$18–24_m$		.63	.58–.68	$16–24_f$	.60	.39–.94	$>64_f$	
						.72	.58–.88	$25–34_f$	
	$18–24_f$		.88	.70–1.11	$16–24_m$	.60	.37–.97	$45–54_m$	
						1.81	.85–3.87	$>64_m$	
	$18–24_f$		.94	.82–1.07	$16–24_f$	.66	.41–1.04	$>64_f$	
						.94	.82–1.07	$16–24_f$	
Tefft et al., 2013	16	RR	.72	.33–1.57	$\leq 20_1$	—	—	Any	Police-reported; per one million miles driven
			1.10	.61–2.00	$\leq 20_2$	—	—		

Type of crash and study	Driver age[a]	Measure	(1a) Peer passenger			(1b) Any passenger			Detail on type of crash
			Est.	95% CI	Age[a]	Est.	95% CI	Age[a,b]	
			7.00	2.88–16.97	≤20_{3+}	—	—		
	17		1.38	.90–2.10	≤20_1	—	—		
			1.16	.68–1.99	≤20_2	—	—		
			1.67	.48–5.78	≤20_{3+}	—	—		
	16–17		*1.18*	*1.14–1.22*	≤20	*1.08*	*1.04–1.12*	Any	
			1.11	.70–1.75	≤20_1	—	—		
			1.16	.72–1.89	≤20_2	—	—		
			2.17	.70–6.77	≤20_{3+}	—	—		

Estimates and CIs that were extracted from articles are not in italics; those that were calculated to answer the specific research questions are in italics. Estimates and CIs were only calculated when there were raw data addressing the specific research questions. Calculations of estimates and CIs might be affected by both rounding to a few decimals in source articles and adjustment based on sampling, which may results here in narrower intervals that should be interpreted with caution.

+ = or more; 1 = 1 passenger; 2 = 2 passengers; 3 = 3 passengers; 4 = 4 passengers; CI = confidence interval; AOR = adjusted odds ratio; Est. = Estimate; f = female; m = male; OR = odds ratio (or crude odds ratio); RR = relative risk.

[a]Sections about driver and passenger age can also include details about gender and number of passenger if the data were only reported as such in articles.

[b]"Any" describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[c]This study used 99% CIs.

[d]This study presented crash rates for male and female drivers separately. We calculated estimates, but significance was provided in the article.

[e]Estimates and CIs for male and female drivers were extracted from figures in the article.

[f]There were no calculations on this specific research question in the article, but raw data were available.

[g]This article compared solo driving versus passenger presence; so, estimates and CIs were extracted from the article, and scores were inverted to answer the current research question.

[h]The article provided 27 estimates for one to three or more passengers, type of driver's license, and driver age group. We provide here the range of estimates for 25/27 significant results (see Table 4 for more details).

[i]The estimates come from a bivariate probit model accounting for confounders, such as alcohol and drug use (see Table 1 for more details). We calculated the OR for crashes at fault and not at fault, but raw data were not available for fatal/severe crashes versus others.

[j]This CI was reported significant in the article.

[k]This study also provided estimates with passengers aged 14–24 years; results were quite similar to those with 16–20 years old and are not shown here. There were no calculations on this specific research question in the article, but raw data were available.

[l] Passengers were described as teenagers, but no specific age range could be identified in the article.

[m] Only smaller to higher estimates are presented here for passengers of different age groups.

Table 3

Risk estimates with one or more passengers, compared with solo driving, for teenage or young drivers versus older drivers (Question 2)

Type of crash and study	Driver age group		Passenger age[a,c]	Measure	Younger drivers		Older drivers		Younger versus older driver age group with one or more passengers		Detail on type of crash
	Younger[a]	Older[a,b]			Est.	95% CI	Est.	95% CI	Est.	95% CI	
Fatal											
Bédard et al., 2004	$<20_1$	$40–49_3$	Any	OR[d]	1.32	1.28–1.36	.59	.55–.64	—	—	With unsafe versus safe action
	$<20_{4+}$	$20–29_2$			2.15	2.00–2.31	1.18	1.15–1.22			
Chen et al., 2000	16	30–59	Any	RR	*1.65*	*1.53–1.78*	*.72*	*.71–.74*	*2.28*	*2.11–2.47*	Per 10 million trips
	16_1	$30–59_1$			1.39	1.24–1.55	.78	.76–.79	—	—	
	16_2	$30–59_2$			1.86	1.56–2.20	.61	.60–.62	—	—	
	16_{3+}	$30–59_{3+}$			2.82	2.27–3.50	.70	.67–.71	—	—	
	17	30–59			*1.84*	*1.72–1.97*	—	—	*2.54*	*2.37–2.74*	
	17_1	—			1.48	1.35–1.62	—	—	—	—	
	17_2	—			2.58	2.24–2.95	—	—	—	—	
	17_{3+}	—			3.07	2.50–3.77	—	—	—	—	
	16–17	30–59			*1.78*	*1.69–1.87*	—	—	*2.47*	*2.34–2.60*	
Doherty et al., 1998	$16–19_m$	$25–59_m$	Any	RR[e]	*2.50*	$p < .10$	*1.50*	$p < .05$	—	—	Per 100 million driver-km
	$16–19_f$	$25–59_f$			*3.55*	$p < .10$	*.62*	$p < .05$	—	—	
	$20–24_m$	$25–59_m$			*1.23*	$p > .10$	—	—	—	—	
	$20–24_f$	$25–59_f$			*1.75*	$p > .10$	—	—	—	—	
Geyer and Ragland, 2004	$15–19_m$	$55–59_m$[d]	Any	AOR[f]	.98	.93–1.03	.68	.57–.81	—	—	At fault versus not at fault
	$20–24_m$	$25–29_m$			1.13	1.08–1.19	1.15	1.08–1.23	—	—	
	$15–19_f$	$40–44_f$			.71	.66–.77	.60	.53–.68			
	$20–24_f$	$30–34_f$			.86	.79–.95	.75	.61–.84			
Preusser et al., 1998	16–19	30–59	Any	OR			—	—	*2.13*	*1.07–2.19*	At fault versus not at fault
	$16_{w/}$	$30–59_{w/}$					—	—	4.72	4.32–5.15	
	$16_{w/o}$	$30–59_{w/o}$					—	—	2.28	2.05–2.53	
	$17_{w/}$	$30–59_{w/}$					—	—	3.52	3.26–3.80	

Type of crash and study	Driver age group		Passenger age[a,c]	Measure	Younger drivers		Older drivers		Younger versus older driver age group with one or more passengers		Detail on type of crash
	Younger[a]	Older[a,b]			Est.	95% CI	Est.	95% CI	Est.	95% CI	
	$17_{w/o}$	$30–59_{w/o}$					—	—	1.77	1.63–1.92	
	$18_{w/}$	$30–59_{w/}$					—	—	3.66	3.40–3.93	
	$18_{w/o}$	$30–59_{w/o}$					—	—	1.77	1.65–1.90	
	$19_{w/}$	$30–59_{w/}$					—	—	3.23	3.01–3.47	
	$19_{w/o}$	$30–59_{w/o}$					—	—	1.61	1.50–1.72	
	20–24	30–59					—	—	*1.81*	*1.76–1.86*	
	$20–24_{w/}$	$30–59_{w/}$					—	—	2.54	2.45–2.64	
	$20–24_{w/o}$	$30–59_{w/o}$					—	—	1.50	1.45–1.55	
Nonfatal and combined fatal/nonfatal crashes											
Doherty et al., 1998	$16–19_m$	$25–59_m$	Any	RR[e]	*2.29*	$p < .10$	*1.15*	$p > .10$	—	—	Injury; per million driver-km
	$16–19_f$	$25–59_f$			*1.91*	$p < .10$	*.43*	$p < .05$	—	—	
	$20–24_m$	—			*.70*	$p < .05$	—	—	—	—	
	$20–24_f$	—			*1.37*	$p > .10$	—	—	—	—	
	$16–19_m$	$25–59_m$			*1.87*	$p < .10$	*.86*	$p > .10$	—	—	Material; per million driver-km
	$16–19_f$	$25–59_f$			*1.58*	$p < .05$	*.38*	$p < .05$	—	—	
	$20–24_m$	—			*.53*	$p < .10$	—	—	—	—	
	$20–24_f$	—			*1.12*	$p > .10$	—	—	—	—	
Engstrom et al., 2008	18–24	25–64	Any	RR[g]	*.39*	*.38–.40*	*.26*	*.26–.27*	*1.47*	*1.42–1.52*	Injury-fatal; per 10 million km
	$18–24_1$	$25–64_1$			.41	.40–.43	.34	.33–.35	—	—	
	$18–24_2$	$25–64_2$			.31	.29–.34	.17	.17–.18	—	—	
	$18–24_{3+}$	$25–64_{3+}$			.21	.19–.24	.08	.08–.09	—	—	
Lam et al., 2003	≤24	>24	Same age group	OR	—	—	—	—	*3.14*	*2.19–4.50*	Injury-fatal; cases versus controls
	$≤24_1$	$>24_1$			2.59	1.26–5.33	.96	.58–1.59	—	—	
	$≤24_{2+}$	$>24_{2+}$			5.77	2.32–14.33	1.06	.34–3.30	—	—	
	$≤24_1$	$>24_1$		AOR	2.39	.91–6.29	.78	.42–1.46	—	—	
	$≤24_{2+}$	$>24_{2+}$			15.55	5.76–42.02	.30	.06–1.44	—	—	

Type of crash and study	Driver age group		Passenger age[a,c]	Measure	Younger drivers		Older drivers		Younger versus older driver age group with one or more passengers		Detail on type of crash
	Younger[a]	Older[a,b]			Est.	95% CI	Est.	95% CI	Est.	95% CI	
Lee et al., 2008	16–24	25–59	Any	OR	*.58*	*.42–.79*	*.36*	*.29–.45*	*1.59*	*1.16–2.18*	Police-reported; at fault versus not at fault
Orsi et al., 2013	≤24	>24	Any	OR	*1.63*	*1.19–2.22*	*1.15*	*.98–1.33*	*1.42*	*1.13–1.79*	Injury-fatal; with injury versus without injury
				AOR	1.42	1.00–2.02[h]	1.07	.90–1.26	—	—	
Rueda-Domingo et al., 2004	$18–24_m$	$25–34_m$[i]	$16–24_m$	OR	1.15	1.08–1.23	1.10	.99–1.22	—	—	Injury-fatal; at fault versus not at fault
	$18–24_m$	$25–34_m$	$16–24_f$		.60	.56–.63	.59	.54–.63	—	—	
	$18–24_f$	$25–34_f$	$16–24_m$		.99	.84–1.17	.95	.79–1.15	—	—	
	$18–24_f$	$25–34_f$	$16–24_f$		.86	.78–.96	.85	.75–.95	—	—	
	—	$55–64_m$	$16–24_m$		—	—	.62	.45–.86	—	—	
	—	$55–64_m$	$16–24_f$		—	—	.42	.31–.57	—	—	
	—	$55–64_f$	$16–24_m$		—	—	.54	.37–.77	—	—	
	—	$55–64_f$	$16–24_f$		—	—	.61	.45–.84	—	—	
	$18–24_m$	$25–34_m$	$16–24_m$	AOR	.95	.87–1.04	.98	.84–1.14	—	—	
	$18–24_m$	$25–34_m$	$16–24_f$		.63	.58–.68	.60	.54–.66	—	—	
	$18–24_f$	$25–34_f$	$16–24_m$		.88	.70–1.11	.91	.70–1.18	—	—	
	$18–24_f$	$25–34_f$	$16–24_f$		.94	.82–1.07	.88	.75–1.04	—	—	
	—	$55–64_m$	$16–24_m$		—	—	.66	.42–1.04	—	—	
	—	$55–64_m$	$16–24_f$		—	—	.55	.37–.81	—	—	
	—	$55–64_f$	$16–24_m$		—	—	.61	.37–1.02	—	—	
	—	$55–64_f$	$16–24_f$		—	—	.81	.54–1.23	—	—	

Estimates and CIs that were extracted from articles are not in italics; those that were calculated to answer the specific research questions are in italics. Estimates and CIs were only calculated when there were raw data addressing the specific research questions. Calculations of estimates and CIs might be affected by both rounding to a few decimals in source articles and adjustment based on sampling, which may results here in narrower intervals that should be interpreted with caution.

+ = or more; 1 = 1 passenger; 2 = 2 passengers; 3 = 3 passengers; 4 = 4 passengers; CI = confidence interval; AOR = adjusted odds ratio; Est. = Estimate; f = female; m = male; OR = odds ratio (or crude odds ratio); RR = relative risk; w/= with passengers; w/o = without passengers.

[a] Sections about driver and passenger age can also include details about gender and number of passenger if the data were only reported as such in articles.

[b] Some articles have estimated risk for drivers older than the age of 65 years. In the present article, we try to provide comparable estimates between studies by focusing on drivers younger than the age of 65 years.

[c]"Any" describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[d]Only smaller to higher estimates are presented here for passengers of different age groups.

[e]This study presented crash rates for male and female drivers separately. We calculated estimates, but significance was provided in the article.

[f]Estimates and CIs for male and female drivers were extracted from figures in the article.

[g]This article compared solo driving versus passenger presence; so, estimates and CIs were extracted from the article, and scores were inverted to answer the current research question.

[h]This CI was reported significant in the article.

[i]Estimates for 35- to 54-year-old drivers are not presented here.

Table 4

Risk estimates with one or more passengers, compared with solo driving, by number of passengers for teenage or young drivers (Question 3)

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	1 Versus 0 Pass.		2 Versus 0 Pass.		3 Or more versus 0 Pass.		2 Or more versus 0 Pass.		2 Or more versus 1 Pass.		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	
Fatal crashes														
Bédard et al., 2004	<20	Any	OR	1.32	1.28–1.36	1.70	1.63–1.77	1.90	1.80–2.01	—	—	—	—	With unsafe versus safe action
								2.15	2.00–2.31[c]					
Chen et al., 2000	16–17	13–19	RR	1.45	1.30–1.60	—	—	—	—	1.71	1.50–1.94	*1.18*	*1.09–1.28*	Per 1,000 crashes
	16	Any	RR	1.39	1.24–1.55	1.86	1.56–2.20	2.82	2.27–3.50	*2.23*	*2.02–2.45*	*1.60*	*1.45–1.78*	Per 10 million trips
	17			1.48	1.35–1.62	2.58	2.24–2.95	3.07	2.50–3.77	*2.78*	*2.54–3.04*	*1.89*	*1.71–2.09*	
	16–17			*1.46*	*1.37–1.55*	*2.26*	*2.08–2.45*	*3.02*	*2.77–3.30*	*2.56*	*2.39–2.73*	*1.75*	*1.63–1.88*	
Doherty et al., 1998	16–19_m	Any	RR[d]	*1.60*	$p > .10$	—	—	—	—	—	—	*3.70*	$p < .10$	Per 100 million driver-km
	16–19_f			*2.15*	$p < .05$	—	—	—	—	—	—	*3.19*	$p < .05$	
Preusser et al., 1998	16	13–19	OR[e]	*1.23*	*1.04–1.45*	—	—	—	—	*2.37*	*1.94–2.90*	*1.93*	*1.55–2.39*	
	17			*1.19*	*1.04–1.36*	—	—	—	—	*2.11*	*1.79–2.50*	*1.78*	*1.48–2.13*	At fault versus not at fault
	18			*1.44*	*1.26–1.64*	—	—	—	—	*2.32*	*1.94–2.77*	*1.61*	*1.32–1.96*	
	19			*1.18*	*1.03–1.35*	—	—	—	—	*2.05*	*1.66–2.52*	*1.73*	*1.38–2.18*	
	16–19			*1.29*	*1.21–1.39*	—	—	—	—	*2.32*	*2.11–2.54*	*1.79*	*1.62–1.98*	
Tefft et al., 2013	16	≤20	RR	1.03	.51–2.07	1.96	1.18–3.26	13.95	6.03–32.29	*2.92*	*2.41–3.54*	*2.85*	*2.30–3.52*	Per 100 million miles driven
	17			1.66	1.20–2.31	1.98	1.23–3.20	3.43	1.01–11.68	*2.38*	*2.03–2.78*	*1.43*	*1.19–1.71*	
	16–17			1.44	1.01–2.04	2.02	1.36–2.99	4.39	1.45–13.31	*2.54*	*2.25–2.87*	*1.77*	*1.54–2.03*	
Nonfatal and combined fatal/nonfatal crashes														
Doherty et al., 1998	16–19_m	Any	RR[d]	*1.89*	$p < .10$	—	—	—	—	—	—	*1.81*	$p > .10$	Injury; per million driver-km
	16–19_f			*1.68*	$p < .05$	—	—	—	—	—	—	*1.47*	$p > .10$	
	16–19_m			*1.63*	$p < .05$	—	—	—	—	—	—	*1.54*	$p > .10$	Material; per million driver-km
	16–19_f			*1.50*	$p < .05$	—	—	—	—	—	—	*1.16*	$p > .10$	
Engstrom et al., 2008	18–24	Any	RR[f]	.41	.40–.43	.31	.29–.34	.21	.19–.24	*.29*	*.28–.30*	*.64*	*.60–.68*	Injury-fatal; per 10 million km
Lam, 2003	16–17_l	Any	AOR	1.71	1.15–2.53	2.58	1.67–4.00	3.28	2.07–5.20	—	—	—	—	Injury-fatal; with injury versus without injury
	16–17_{pr}			1.50	1.34–1.67	1.73	1.50–2.00	2.28	1.97–2.63	—	—	—	—	

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	1 Versus 0 Pass.		2 Versus 0 Pass.		3 Or more versus 0 Pass.		2 Or more versus 0 Pass.		2 Or more versus 1 Pass.		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	
	16–17$_{full}$			1.49	.93–2.38	2.01	1.07–3.80	1.98	1.05–3.74	—	—	—	—	
	18–19$_{l}$			1.37	.84–2.23	2.82	1.62–4.90	2.86	1.45–5.66	—	—	—	—	
	18–19$_{pr}$			1.42	1.24–1.62	1.98	1.65–2.39	1.76	1.41–2.20	—	—	—	—	
	18–19$_{full}$			1.42	1.31–1.54	1.74	1.54–1.97	2.27	1.97–2.61	—	—	—	—	
	20–24$_{l}$			1.73	1.10–2.71	1.91	1.04–3.50	2.45	1.27–4.73	—	—	—	—	
	20–24$_{pr}$			1.54	1.27–1.85	1.88	1.42–2.50	2.63	1.94–3.56	—	—	—	—	
	20–24$_{f}$			1.46	1.39–1.54	1.88	1.73–2.04	2.41	2.18–2.66	—	—	—	—	
Lam et al., 2003	≤24	≤24	OR	2.59	1.26–5.33	—	—	—	—	5.77	2.32–14.33	*2.33*	*.82–6.58*	Injury-fatal; cases versus controls
			AOR	2.39	.91–6.29	—	—	—	—	15.55	5.76–42.02	—	—	
Rice et al., 2003	16–17	Teens[g]	OR	*.96*	*.90–1.03*	*.99*	*.90–1.09*	*1.23*	*1.10–1.37*	*1.08*	*.99–1.17*[h]	*1.12*	*1.03–1.23*	Visible injury; at fault versus not at fault
		Teens$_{m}$		1.15	1.06–1.26	1.19	1.03–1.38	1.49	1.22–1.84	—	—	—	—	
		Teens$_{f}$		.80	.73–.87	.76	.64–.90	.69	.53–.90	—	—	—	—	
		Teens$_{mf}$		—	—	1.00	.84–1.20	1.34	1.15–1.57	—	—	—	—	
		Teens$_{m}$	AOR	1.03	.94–1.12	1.00	.86–1.17	1.27	1.03–1.57	—	—	—	—	
		Teens$_{f}$		.85	.77–.93	.79	.67–.94	.69	.53–.90	—	—	—	—	
		Teens$_{mf}$		—	—	.96	.80–1.15	1.20	1.03–1.41	—	—	—	—	
		Teens	OR	*1.24*	*1.05–1.45*	*1.28*	*1.03–1.61*	*1.87*	*1.47–2.36*	*1.51*	*1.26–1.80*	*1.22*	*1.01–1.48*	Severe-fatal injury; at fault versus not at fault
		Teens$_{m}$		1.67	1.38–2.03	1.68	1.21–2.30	2.37	1.55–3.52	—	—	—	—	
		Teens$_{f}$		.86	.68–1.08	1.08	.72–1.59	.82	.38–1.56	—	—	—	—	
		Teens$_{mf}$		—	—	1.00	.61–1.56	2.11	1.52–2.87	—	—	—	—	
		Teens$_{m}$	AOR	1.45	1.18–1.79	1.17	.82–1.68	1.74	1.12–2.69	—	—	—	—	
		Teens$_{f}$		.92	.72–1.17	1.16	.78–1.74	.84	.42–1.67	—	—	—	—	
		Teens$_{mf}$		—	—	1.01	.63–1.60	1.82	1.30–2.54	—	—	—	—	
Tefft et al., 2013	16	≤20	RR	.72	.33–1.57	1.10	.61–2.00	7.00	2.88–16.97	—	—	—	—	Police-reported; per one million miles driven
	17	≤20	RR	1.38	.90–2.10	1.16	.68–1.99	1.67	.48–5.78	—	—	—	—	
	16–17	≤20	RR	1.11	.70–1.75	1.16	.72–1.89	2.17	.70–6.77	*1.38*	*1.31–1.46*	*1.25*	*1.17–1.33*	

Estimates and CIs that were extracted from articles are not in italics; those that were calculated to answer the specific research questions are in italics. Estimates and CIs were only calculated when there were raw data addressing the specific research questions. Calculations might be affected by both rounding to a few decimals in source articles and adjustment based on sampling, which may results here in narrower intervals that should be interpreted with caution.

CI =confidence intervals; AOR =adjusted odds ratio; Est. =Estimate; f =female; full =full license; l =learner's permit; m =male; OR =odds ratio (or crude odds ratio); pr =provisional license; Pass. =passenger; RR =relative risk.

[a]Sections about driver and passenger age can also include details about gender and number of passenger if the data were only reported as such in articles.

[b]"Any" describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[c]This study presented results for three and four or more passengers versus zero passenger and used 99% CIs.

[d]This study presented crash rates for male and female drivers separately. We calculated estimates, but significance was provided in the article.

[e]There were no calculations on this specific research question in the article, but raw data were available.

[f]This article compared solo driving versus passenger presence; so, estimates and CIs were extracted from the article, and scores were inverted to answer the current research question.

[g]Passengers were described as teenagers, but no specific age range could be identified in the article.

[h]This CI should have been rounded to 1.00 because the value up to three decimals is .998. We included .99 to facilitate the rapid appraisal of the table.

Table 5

Risk estimates with one or more passengers, compared with solo driving, by driver gender for teenage or young drivers (Question 4)

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	Male drivers with 1 or more pass. versus 0		Female drivers with 1 or more pass. versus 0		Male versus female drivers		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	
Fatal crashes										
Chen et al., 2000	16–17	13–19	RR	*1.63*	*1.54–1.74*	*1.43*	*1.31–1.55*	*1.15*	*1.03–1.28*	Per 1,000 crashes
		$13–19_{1m}$		1.71	1.53–1.92	1.51	1.33–1.70	—	—	
		$13–19_{2+m}$		1.99	1.74–2.26	2.40	1.98–2.89	—	—	
		$13–19_{1f}$		.98	.87–1.11	1.29	1.15–1.45	—	—	
		$13–19_{2+f}$		1.43	1.20–1.69	1.15	.99–1.33	—	—	
		$13–19_{fm}$		1.92	1.66–2.22	1.74	1.51–1.99	—	—	
Doherty et al., 1998	16–19	Any	RR[c]	*2.50*	$p < .10$	*3.55*	$p < .10$	—	—	Per 100 million driver-km
	20–24			*1.23*	$p > .10$	*1.75*	$p > .10$	—	—	
Geyer and Ragland, 2004	15–19	Any	AOR[d]	.97	.93–1.03	.71	.66–.77	—	—	At fault versus not at fault
	20–24			1.13	1.07–1.19	.87	.80–.96	—	—	
Ouimet et al., 2010	15–20	16–20	RR	*5.55*	*5.16–5.98*	*4.09*	*3.63–4.61*	*1.36*	*1.18–1.56*	Per 10 million VT
		$16–20_{m}$		7.99	7.34–8.69	5.63	4.71–6.72			
		$16–20_{f}$		2.97	2.63–3.36	3.50	3.03–4.05			
		16–20		*6.26*	*5.81–6.74*	*4.24*	*3.76–4.77*	*1.48*	*1.28–1.70*	Per 10 million VMT
		$16–20_{m}$		9.94	9.13–10.81	4.06	3.40–4.85			
		$16–20_{f}$		3.29	2.91–3.72	4.36	3.78–5.04			
Tefft et al., 2013	16–17	≤20	RR	*1.85*	*1.66–2.07*	*1.52*	*1.31–1.76*	*1.22*	*1.01–1.46*	Per 100 million miles driven
		$≤20_{1}$		1.67	1.12–2.50	1.16	.65–2.06			
		$≤20_{2}$		1.84	1.08–3.12	2.28	1.35–3.86			
		$≤20_{3+}$		3.57	.79–16.19	6.41	3.21–12.81			
Nonfatal and combined fatal/nonfatal crashes										
Doherty et al., 1998	16–19	Any	RR[c]	2.29	$p < .10$	*1.91*	$p < .10$	—	—	Injury; per million driver-km
	20–24			*.70*	$p < .05$	*1.37*	$p > .10$	—	—	
	16–19			*1.87*	$p < .10$	*1.58*	$p < .05$	—	—	Material; per million driver-km

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	Male drivers with 1 or more pass. versus 0		Female drivers with 1 or more pass. versus 0		Male versus female drivers		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	
	20–24			*.53*	$p < .10$	*1.12*	$p > .10$	—	—	
Engstrom et al., 2008	18–24	Any	RR[e]	*.43*	*.41–.44*	*.30*	*.28–.32*	*1.40*	*1.31–1.51*	Injury-fatal; per 10 million km
		Any_1		.48	.46–.50	.36	.33–.38			
		Any_2		.40	.38–.44	.24	.21–.28			
		Any_{3+}		.28	.26–.31	.16	.13–.19			
Orsi et al., 2013	≤24	Any	OR	*1.88*	*1.31–2.69*	*1.29*	*.68–2.45*	*1.45*	*.93–2.27*	Injury-fatal; with injury versus without injury
			AOR	—	—	—	—	—	—	
Rueda-Domingo et al., 2004	18–24	$16–24_m$	OR	1.15	1.08–1.23	.99	.84–1.17	—	—	Injury-fatal; at fault versus not at fault
		$16–24_f$		.60	.56–.63	.86	.78–.96	—	—	
		$16–24_m$	AOR	.95	.87–1.04	.88	.70–1.11	—	—	
		$16–24_f$		.63	.58–.68	.94	.82–1.07			
Tefft et al., 2013	16–17	$≤20_1$	RR	1.17	.72–1.90	1.05	.55–1.99	—	—	Police-reported; per one million miles driven
		$≤20_2$		1.04	.57–1.89	1.38	.78–2.44	—	—	
		$≤20_{3+}$		1.70	.37–7.89	3.47	1.73–6.96	—	—	

Estimates and CIs that were extracted from articles are not in italics; those that were calculated to answer the specific research questions are in italics. Estimates and CIs were only calculated when there were raw data addressing the specific research questions. Calculations might be affected by both rounding to a few decimals in source articles and adjustment based on sampling, which may results here in narrower intervals that should be interpreted with caution.

+ =or more; 1 =1 passenger; 2 =2 passengers; 3 =3 passengers; CI =confidence interval; AOR =adjusted odds ratio; Est. =Estimate; f =female; m =male; OR =odds ratio (or crude odds ratio); Pass. =passenger; RR =relative risk.

[a] Sections about driver and passenger age can also include details about gender and number of passenger if the data were only reported as such in articles.

[b] "Any" describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[c] This study presented crash rates for male and female drivers separately. We calculated estimates, but significance was provided in the article.

[d] Estimates and CIs for male and female drivers were extracted from figures in the article.

[e] This article compared solo driving versus passenger presence; so, estimates and CIs were extracted from the article, and scores were inverted to answer the current research question.

Table 6

Risk estimates with one or more passengers, compared with solo driving, by passenger gender for teenage or young drivers (Question 5)

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	Drivers with one or more versus 0 male pass.		Drivers with one or more versus 0 female pass.		Male versus female pass.		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	
Fatal crashes										
Chen et al., 2000	16–17	Any	RR	*1.88*	*1.77–2.00*	*1.08*	*1.01–1.17*	*1.73*	*1.60–1.88*	Per 1,000 crashes
		Any_1		1.76	1.58–1.95	1.08	.97–1.20	—	—	
		Any_{2+}		2.22	1.95–2.51	1.11	.96–1.26	—	—	
Ouimet et al., 2010	15–20	16–20	RR	*8.16*	*7.57–8.80*	*3.07*	*2.80–3.37*	*2.66*	*2.38–2.97*	Per 10 million VT
		$16–20_m$		7.99	7.34–8.69	2.97	2.63–3.36	—	—	
		$16–20_m$		5.63	4.71–6.72	3.50	3.03–4.05	—	—	
		16–20		*7.95*	*7.37–8.57*	*3.53*	*3.21–3.87*	*2.25*	*2.02–2.52*	Per 10 million VMT
		$16–20_f$		9.94	9.13–10.81	3.29	2.91–3.72	—	—	
		$16–20_f$		4.06	3.40–4.85	4.36	3.78–5.04	—	—	
Nonfatal and combined fatal/nonfatal crashes										
Orsi et al., 2013	≤24	Any	OR	*2.71*	*1.74–4.21*	*1.05*	*.69–1.58*	*2.58*	*1.52–4.40*	Injury-fatal; with injury versus without injury
			AOR	2.08	1.29–3.35	1.07	.68–1.69	—	—	
Rice et al., 2003	16–17	Teens[c]	OR	*1.19*	*1.11–1.29*	*.78*	*.72–.85*	*1.53*	*1.39–1.68*	Visible injury; at fault versus not at fault
		$Teens_1$		1.15	1.06–1.26	.80	.73–.87	—	—	
		$Teens_2$		1.19	1.03–1.38	.76	.64–.90	—	—	
		$Teens_{3+}$		1.49	1.22–1.84	.69	.53–.90	—	—	
		Teens		*1.74*	*1.47–2.05*	*.90*	*.73–1.09*	*1.94*	*1.56–2.41*	Severe-fatal injury; at fault versus not at fault
		$Teens_1$		1.67	1.38–2.03	.86	.68–1.08	—	—	
		$Teens_2$		1.68	1.21–2.30	1.08	.72–1.59	—	—	
		$Teens_{3+}$		2.37	1.55–3.52	.82	.38–1.56	—	—	
		$Teens_1$	AOR	1.03	.94–1.12	.85	.77–.93	—	—	Visible injury; at fault versus not at fault
		$Teens_2$		1.00	.86–1.17	.79	.67–.94	—	—	
		$Teens_{3+}$		1.27	1.03–1.57	.69	.53–.90	—	—	

Type of crash and study	Driver age[a]	Pass. age[a,b]	Measure	Drivers with one or more versus 0 male pass.		Drivers with one or more versus 0 female pass.		Male versus female pass.		Detail on type of crash
				Est.	95% CI	Est.	95% CI	Est.	95% CI	
		$Teens_1$		1.45	1.18–1.79	.92	.72–1.17	—	—	Severe-fatal injury; at fault versus not at fault
		$Teens_2$		1.17	.82–1.68	1.16	.78–1.74	—	—	
		$Teens_{3+}$		1.74	1.12–2.69	.84	.42–1.67	—	—	
Rueda-Domingo et al., 2004	$18–24_m$	16–24	OR	1.15	1.08–1.23	.60	.56–.63	—	—	Injury-fatal; at fault versus not at fault
	$18–24_f$			.99	.84–1.17	.86	.78–.96	—	—	
	$18–24_m$		AOR	.95	.87–1.04	.63	.58–.68	—	—	
	$18–24_f$			.88	.70–1.11	.94	.82–.107	—	—	

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CI =confidence interval; + =or more; 1 =1 passenger; 2 =2 passengers; 3 =3 passengers; 4 =95% CI; AOR =adjusted odds ratio; Est. =Estimate; f =female; m =male; OR =odds ratio (or crude odds ratio); Pass. =passenger; RR =relative risk.

[a] Sections about driver and passenger age can also include details about gender and number of passenger if the data were only reported as such in articles.

[b] "Any" describes studies including passengers of any age. When the information about passenger age was not provided, it was assumed that any passenger age was included.

[c] Passengers were described as teenagers, but no specific age range could be identified in the article.