Seniors face serious driving safety and mobility issues.

Driving Cessation and Health Outcomes in Older Adults

A LongROAD Study

July 2015

AAA Foundation for Traffic Safety

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Title

Driving Cessation and Health Outcomes in Older Adults: A LongROAD Study *(July 2015)*

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About the Sponsor

AAA Foundation for Traffic Safety
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Founded in 1947, the AAA Foundation in Washington, D.C. is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, from individual members, from AAA-affiliated insurance companies, as well as from other organizations or sources.

About LongROAD

Safe mobility is essential to healthy aging. Recognizing that lifestyle changes, along with innovative technologies and medical advancements, will have a significant impact on the driving experiences of the baby boomer generation, the AAA Foundation for Traffic Safety has launched a multi-year research program to more fully understand the driving patterns and trends of older drivers in the United States. This multi-year prospective cohort study is being conducted at 5 sites throughout the country, with 3,000 participants, tracking 5+ years of driving behaviors and medical conditions. The multidisciplinary team assembled to investigate this issue is led by experienced researchers from Columbia University, University of Michigan Transportation Research Institute and the Urban Institute.

The LongROAD (Longitudinal Research On Aging Drivers) Study is designed to generate the largest and most comprehensive data base about senior drivers in existence and will support in-depth studies of senior driving and mobility to better understand risks and develop effective countermeasures. Specific emphasis is being placed on issues related to medications, medical conditions, driving patterns, driving exposure, self-regulation, and crash risk, along with mobility options for older Americans who no longer drive.

Abstract

Objectives

Declining health is known to be a major cause of driving cessation. It is less clear what impacts driving cessation may have on subsequent health and well-being in older adults. This systematic review assesses the evidence in the research literature on the consequences of driving cessation in older adults.

Methods

Studies pertinent to the health consequences of driving cessation were identified through a comprehensive search of bibliographic databases. Included in the review were studies that presented quantitative data for drivers aged 55 years and older, used the cross-sectional, cohort or case-control design, and had a comparison group of current drivers.

Results

Sixteen studies met the inclusion criteria. Driving cessation was reported to be associated with declines in general health and physical, social, and cognitive functions, and with increased risks of admission to long-term care facilities and mortality. Meta-analysis based on pooled data from five studies examining the association of driving cessation with depression revealed that driving cessation almost doubled the risk of increased depressive symptoms in older adults (summary odds ratio 1.91, 95% confidence interval 1.61— 2.27).

Conclusions

Driving cessation in older adults appears to contribute to a variety of health problems, particularly depression. These adverse health consequences should be considered in making the decision to cease driving. To mitigate the potential adverse effects of driving cessation on health and well-being in older adults, intervention programs ensuring mobility and social functions may be needed.

Introduction

Car ownership and driving are highly correlated with independence and life satisfaction in older adults (Choi et al., 2014; Fonda et al., 2001; Marottoli et al., 1997; Ragland et al., 2005). In the United States and other industrialized countries, driving is often the most preferred mode of personal transport, is regarded as an important aspect of personal freedom and is associated with a sense of control over one's life (Bauer et al., 2003; Ragland et al., 2005; Windsor et al., 2007; Al-Hassani and Alotaibi, 2014). The capacity to drive is an important mechanism through which many adults, both young and old, fulfill their social roles and engage with their environments (Windsor et al., 2007). In addition, driving has been identified as an instrumental activity of daily living (IADL) (Al-Hassani and Alotaibi, 2014). In a study in Australia, driving was rated by older adults as the second most important ADL task, behind use of transportation but ahead of leisure, reading, and medication management (Fricke and Unsworth, 2001).

The issue of older driver safety is especially relevant given the growing older adult population; the proportion of the US population aged 65 years and older will increase from 13% in 2010 to 20% in 2040 (Colby and Ortman, 2014). Most adults continue driving in older age: of the 39.5 million adults aged 65 years and older in the United States, 81% held a driver's license (USDOT, 2011). These older drivers face unique challenges as driving is a complex task that requires a variety of skills including physical, cognitive, behavioral, and sensory-perceptual abilities (Yale et al., 2003; Frey, 2010). Due to age-related declines in health, physical and cognitive functions, driving becomes more difficult for older adults. Many older adults eventually reduce or stop their driving activities, which may have adverse health consequences (Foley et al., 2002; Harrison and Ragland, 2003; Edwards et al., 2009a).

Health problems are the most commonly cited reasons for driving cessation (Ragland et al., 2004; Adler and Rotunda, 2006). Several community-based studies have identified specific medical and socio-economic factors associated with driving cessation, such as recent hospitalizations, neurological disorders (e.g., Parkinson's disease and stroke), visual disorders (e.g., cataracts, retinal hemorrhage and macular degeneration), lower income, and unemployment (Freund and Marottoli et al., 1997, Marottoli et al., 2000; Szinovacz, 2002; Ragland et al., 2004; Freeman et al., 2005). Other factors that may precipitate driving cessation include advice and warning from a physician, crash involvement, and intervention from a family member (Fonda et al., 2004; Liddle et al., 2012; Redelmeier et al., 2012). In addition, socio-demographic variables such as age, sex, education, marital status, co-resident status, urban residence and geographic location may also influence the decision to cease driving (Dellinger et al., 2001; Johnson, 2002; Bauer et al., 2003; Ragland et al., 2004; Freeman et al., 2005).

The relationship between health status and driving cessation is likely mutually causative. That is, declining health may lead to driving cessation and driving cessation in turn may result in adverse health outcomes. While risk factors for driving cessation have been studied extensively (Dellinger et al., 2001; Freeman et al., 2005; Freund and Szinovacz, 2002; Marottoli et al., 1997, Marottoli et al., 2000; Ragland et al., 2004), there is less research examining the impact of driving cessation on health outcomes (Harrison and

Ragland, 2003). The objective of this review is to assess and synthesize evidence in the research literature on the health consequences of driving cessation in older adults.

Methods

This systematic literature review included a narrative synthesis and a meta-analysis. The meta-analysis component follows standard methodology and adheres to reporting and procedures outlined in the PRISMA and MOOSE guidelines (Moher et al., 2009).

Eligibility

Studies were eligible for inclusion if they: 1) included community-dwelling adults aged 55 years and older; 2) examined the consequences of driving cessation; 3) used an epidemiologic design (cross-sectional, cohort, or case-control) that compared driving cessation to continued driving; 4) presented quantitative data on any health-related outcome (physical, social, emotional, etc.); and 5) were published in English language. No date restrictions were applied. Qualitative studies, letters, editorials, opinion pieces, commentaries and reviews were excluded. In this review, driving cessation was defined as total discontinuation of operating a motor vehicle for productive, social, spiritual or any other purposes. Studies that exclusively focused on driving reduction, which implies some continuation of driving, were excluded. Driving cessation could be voluntary or involuntary, with or without loss of driver's license.

Search Strategy, Data Sources and Extraction

A medical librarian was consulted to review the search strategy and terms (Appendix A). Relevant literature was identified through a comprehensive search of the following electronic databases on November 15, 2014: American Psychological Association PsycInfo (1967-present), Scopus (1960-present), Transport Research International Documentation (TRID)(1970-present), Medline OVID (1946-present) and MELVYL (the online catalog of the University of California library system) (1970-present). One author (SC) screened all the titles and abstracts using the inclusion and exclusion criteria. Studies with uncertain eligibility were reviewed in full-text using these criteria. For each included study, the following characteristics were abstracted: primary author, publication year, country of study population or where study data originated, study design, source of driving cessation status, comparison group, outcomes assessed, methods of outcome assessment, and results. For meta-analysis, two authors (SC and GL) independently extracted the data needed to calculate the individual odds ratio (OR) and summary OR for the health outcome.

Quality Assessment, Data Synthesis and Analysis

The quality of all included studies was evaluated using the Newcastle-Ottawa Quality Assessment Scale (Appendix B) as recommended by the Cochrane Collaboration on bias assessment. The best possible score varies by study design; a higher score indicates better quality. In this version of the scale, the highest possible score is 10 for a cross-sectional study and 9 for a cohort study. For the cross-sectional studies, the Newcastle-Ottawa

Quality Assessment Scale was modified to disregard the follow-up period and absence of outcome at the start of the study.

Because of the numerous possible health-related consequences for driving cessation, studies were grouped according to health outcomes for synthesis. The most common health outcomes were identified and verified for consistency in outcome assessment in order to determine their inclusion in the meta-analysis. Meta-analysis was considered for health outcomes that were measured consistently in at least five studies.

For each health outcome, the Q and I^2 tests were used to assess heterogeneity (Borenstein, 2009). A p value of ≤ 0.05 and an I^2 value above 0.5 were considered heterogeneous (Borenstein, 2009). Where visual examination of results and test statistics indicated homogeneity, results were combined quantitatively. The individual odds ratio (OR) for each study and the summary OR were calculated using the Comprehensive Meta-Analysis software (Biostat Inc., Englewood, New Jersey). A fixed effect model was used unless significant heterogeneity was present, in which case a random effects model would be preferred.

Data from each study was manually entered into the appropriate effect size column in the Comprehensive Meta-Analysis software; for studies reporting the standardized mean difference (d), results were converted to OR using the following formula (Borenstein, 2009):

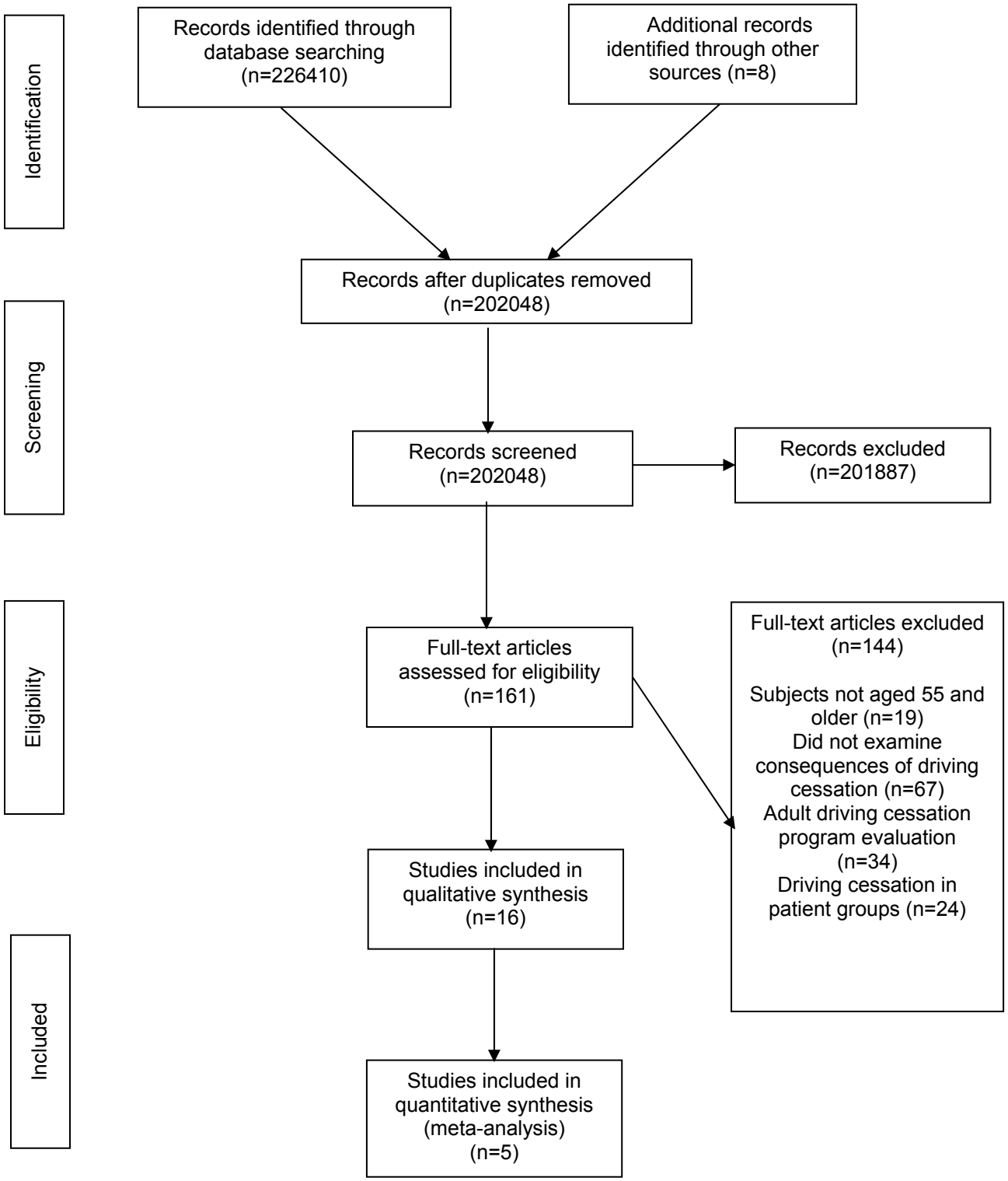
$$Log\ Odds\ Ratio = d\frac{\pi}{\sqrt{3}} \ ,$$

where π is the mathematical constant. The variance of the log odds ratio was calculated using this formula (Borenstein, 2009):

$$V_{LogOddsRatio} = V_d\frac{\pi^2}{3} \ .$$

A forest plot was created to show the distribution of the effect of driving cessation across each study. Funnel plots and Rosenthal's fail-safe N (Persaud, 1996) were used to assess publication bias.

Figure 1. Flow diagram of identification, review and selection of articles included in the systematic review of public health outcomes following driving cessation in older drivers



Adapted From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

Results

The comprehensive database search returned 226,410 potentially relevant results. A total of 24,362 duplicates were removed, leaving 202,048 citations to be screened. After excluding studies that clearly did not meet eligibility criteria, 161 studies were reviewed in full-text for eligibility (Fig. 1). Of these, 16 met the inclusion criteria and were included in this systematic review.

Study Characteristics

Twelve included studies were conducted in the United States, two in Australia, and one each in Finland and Kuwait (Table 1a). Two publications reported outcomes from the same population sample (New Haven Established Populations for Epidemiologic Studies for the Elderly, or EPESE) (Marottoli et al., 1997; Marottoli et al., 2000). All but one study (Siren et al, 2004) included adults of both sexes. The majority included adults aged at least 65 years.

Included studies used cohort (n=12) and cross-sectional (n=4) designs (Tables 1a and 1b). No case-control studies were identified. All included studies examined potential confounding factors (Table 2a). All but one examined health status as a covariate and the majority examined socio-demographic factors including age, gender, marital status, and education.

A variety of health outcomes were examined in the 16 studies, including general, physical, social, and mental health, entry to long-term care facilities, and mortality risk (Table 3).

Study Quality

Based on the Newcastle-Ottawa Quality Assessment Scale (Table 1a-c), all 12 cohort studies were of high quality, with an average assessment score of 7.2/9 (range 7 to 8). The four cross-sectional studies varied in quality, with two scoring 9/10 and two scoring 5/10.

Summary of Findings

General Health

Four studies evaluated general health outcomes through self-reported measures of participants. Edwards et al. (2009a) found a rapid decline in general health trajectory following driving cessation in adults aged 65 years and older over a 5-year period. O'Connor et al. (2013) found that non-drivers were significantly more likely than drivers to report having poor health as indicated by scores on the Short Form (SF-36) Health Survey, a widely used self-report measure of health-related quality of life.

Siren et al. (2004) noted that Finnish women drivers had a favorable assessment of their self-reported health status (59.4% reported good health) compared to ex-drivers (42.5% reported good health). Mann et al. (2005) also found that former drivers had poor overall health compared to current drivers. However, since both of the latter two studies were cross-sectional, it is possible that former drivers ceased driving due to poor health.

Physical Health

Out of the eight studies that found declines in physical functioning, three were cross-sectional (Mann et al.,2005; Liddle et al., 2012; Al-Hassani and Alotaibi, 2014), making it difficult to discern the temporality. However, these studies showed that former drivers had a markedly low participation in outside activities and diminished productivity in daily life activities compared to current drivers (Table 3). The association between driving cessation and reduced physical functioning was strong in longitudinal studies even after adjusting for socio-demographic factors and baseline health. Although Edwards et al. (2009a) reported a 6.7-point decline in the physical functioning domain of the SF-36 and a 12-point decline in the physical role domain of the SF-36, they examined a very small sample size of ceased drivers (n=37) in a cohort of 690 older adults.

Social Health

Social health refers to the capacity to interact in society, which can be measured by social engagement, social contacts and satisfaction with social roles and social support (O'Connor et al., 2013; Edwards et al., 2009a; Mezuk et al., 2008; Liddle et al., 2012; Curl et al., 2013; Al-Hassani and Alotaibi, 2014). The decline in social health following driving cessation appeared larger among women than among men (Edwards et al. 2009a). The reported declines in social health were not as rapid as those in physical health (Edwards et al., 2009a; Curl et al., 2013). For example, Mezuk and Rebok (2008) reported that over a 13-year period, driving cessation was associated with a 51% reduction in the size of social networks of friends and relatives, which was not mediated by the availability of or access to alternative transport. In addition, support from family and friends remained unchanged. Former drivers were likely to spend less time on social activities and to spend more time in solitary leisure or abandon previous social activities (Al-Hassani and Alotaibi, 2014; Liddle et al., 2014).

Cognitive Decline

In a longitudinal study, Mezuk and Rebok (2008) reported that former drivers had lower cognitive abilities, as measured by the Mini Mental State Examination, than current drivers. Similarly, Choi et al. (2014) found that former drivers had accelerated cognitive decline over a 10-year period compared with active drivers even after controlling for baseline cognitive function and general health. In a cross-sectional study, Mann et al. (2005) found that current drivers were healthier and had better cognitive functions than former drivers.

Entry into Long-term Care

Freeman et al. (2006) found that former drivers were nearly five times (hazard ratio 4.85, 95% CI 3.26 – 7.21) as likely as current drivers to be admitted to long-term care (LTC) facilities (e.g., nursing home, assisted living community, and retirement home). After adjusting for marital status or co-residence, Freeman et al. (2006) still found a strong association between driving cessation and LTC entry. Having no other driver in the house was independently associated with increased LTC entry (hazard ratio 1.72, 95% CI 1.15 – 2.57) (Freeman et al., 2006).

Increased Risk of Mortality

There was a general agreement between the two studies that exclusively examined the relationship between driving cessation and risk of mortality. Edwards et al (2009b) found that driving cessation was a strong predictor for 3-year mortality risk, as non-drivers were four to six times as likely to die as drivers, after adjusting for baseline psychological, general health, sensory and cognitive abilities. O'Connor et al. (2013) found that 5-year mortality risk for non-drivers was 68% higher than drivers. The stronger association reported by Edwards et al (2009b) may be due in part to the fact that their study subjects were initially lower functioning and less healthy than those in the O'Connor et al. (2013) study.

Depressive Symptoms

Five cohort studies that examined the effect of driving cessation on depressive symptoms in older adults were included in a meta-analysis (Table 4). Four of the studies reported significantly greater depressive symptoms in ceased drivers, after adjustment for potential confounding factors. Effect estimates did not show significant heterogeneity ($Q=3.266$, $df=4$, $P < 0.514$; $I^2=0.000$), implying that the studies were fairly homogenous; hence, a fixed effects model was used. Overall, driving cessation almost doubled the risk of increased depressive symptoms in older adults (summary OR =1.91, 95%CI 1.61– 2.27) (Fig. 2). Rosenthal's classic fail safe N (Persaud, 1996), i.e., the number of new, unpublished, or null studies that would be needed to make the overall finding not significant, was 68. A cross-sectional study that used a different measure for depression also found increased depressive symptoms associated with driving cessation (Al-Hassani et al., 2014).

Table 1a. Characteristics of studies evaluating driving cessation for health-related outcomes

First author, Year	Study Subjects	Data Source	Study Design	Location	Study Time Period	Source of outcome information	Source of driving status information
Al-Hassani et al. 2014	114 community-dwelling adults aged 55 years and older	Convenience sample through Kuwait University	Cross-sectional study	Kuwait	2012-2013	Geriatric Depression Scale (GDS-15)	Study Questionnaire
Choi et al. 2014	9135 adults aged 65 years and older	Health and Retirement Study (HRS)	Cohort study	United States	1998-2008	Telephone Interview for Cognitive Status (TICS)	Health and Retirement Study (HRS)
Curl et al. 2013	4788 adults aged 65 years and older	Health and Retirement Study (HRS)	Cohort study	United States	1998-2010	RAND Corporation questionnaires	Health and Retirement Study (HRS)
Edwards et al 2009a	690 community-dwelling adults aged 65 years and older	Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study	Cohort study	United States	1999-2004	Center for Epidemiological Studies Depression Scale	Driving Habits Questionnaire (DHQ) within the ACTIVE study
Edwards et al 2009b	660 community-dwelling adults aged 63-97 years	Staying Keen in Later Life (SKILL) Study	Cohort study	United States	2004-2007	Social Security Death Index	Mobility questionnaire
Fonda et al. 2001	5239 adults aged 70 years and older	Asset and Health Dynamics Among the Oldest Old (AHEAD) Study	Cohort study	United States	1993-1988	Center for Epidemiological Studies Depression Scale	Asset and Health Dynamics Among the Oldest Old (AHEAD)
Freeman et al. 2006	1593 Salisbury, MD adults aged 65-84 years	Salisbury Eye Evaluation (SEE) Study	Cohort study	United States	1993-2003	Study Questionnaire	Study Questionnaire
Liddle et al. 2012	234 community-dwelling adults aged 65 years and older	Convenience sample from around urban Queensland, Australia	Cross-sectional study	Australia	2009-2011	Face-face interviews	Face-face interviews
Mann et al. 2005	697 adults aged 60-106 years, with at least one ADL difficulty	Rehabilitation Engineering Research Center on Aging, Consumer Assessments Study	Cross-sectional study	United States	2004-2005	The Consumer Assessment Study Interview Battery (CAS-IB)	The Consumer Assessment Study Interview Battery (CAS-IB)
Marottoli et al. 1997	1316 adults aged 65 years and older who lived in New Haven, CT	Established Populations for Epidemiologic Studies for the Elderly (EPESE)	Cohort study	United States	1982-1988	Center for Epidemiological Studies Depression Scale	Established Populations for Epidemiologic Studies for the Elderly (EPESE)

Table 1a. (continued)

Marottoli et al. 2000	1316 adults aged 65 years and older who lived in New Haven, CT	Established Populations for Epidemiologic Studies for the Elderly (EPESE)	Cohort study	United States	1982-1988	Established Populations for Epidemiologic Studies for the Elderly (EPESE)	Established Populations for Epidemiologic Studies for the Elderly (EPESE)
Mezuk et al. 2008	398 adults aged 60 years and older	Baltimore Epidemiologic Catchment Area Study (ECA)	Cohort study	United States	1993-2005	Likert scale	Baltimore Epidemiologic Catchment Area Study (ECA)
O'Connor et al. 2013	2793 community-dwelling adults aged 65 years and older	Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) Study	Cohort study	United States	1999-2004	Turn 360 Test, SF-36 health survey, Likert scale, family members death confirmation	Driving Habits Questionnaire (DHQ) within the ACTIVE study
Ragland et al. 2005	1772 Sonoma County, CA adults aged 55 years and older	Study of Physical Performance and Age-Related Changes in Sonomans (SPPARCS)	Cohort study	United States	1993-1994	Center for Epidemiological Studies Depression Scale	Study of Physical Performance and Age-Related Changes in Sonomans (SPPARCS)
Siren et al. 2004	1251 Finish women born in 1927 (aged 70 years and older)	Finish Vehicle Administration center	Cross-sectional study	Finland	2003-2004	Survey questionnaire	Driver license register
Windsor et al. 2007	700 community dwelling adults aged 70 years and older	Australian Longitudinal Study of Aging (ALSA)	Cohort study	Australia	1992-1994	Center for Epidemiological Studies Depression Scale	Australian Longitudinal Study of Aging (ALSA)

Table 1b. Driving cessation and outcomes of studies evaluating health-related outcomes

First author, Year	Exposure and covariates assessed	Outcomes measured
Al-Hassani et al. 2014	Driving cessation, age, gender, marital status, education, self-rated health	Depressive symptoms (Geriatric Depression scale), perceived control, self-reported health and life satisfaction (Likert scale)
Choi et al. 2014	Driving cessation, baseline cognitive function, health status, age, gender, race, marital status, education	Cognitive function (HRS cognitive battery)
Curl et al. 2013	Driving cessation, gender, race, marital status, self-rated health status	Productive engagement and social engagement
Edwards et al. 2009a	Driving cessation, baseline depressive symptoms, general health, self-rated health, physical performance,	Depressive symptoms (CES-D** scale), self-rated health (Likert scale), physical performance (Turn 360 test), general health and functioning (SF-36***)
Edwards et al. 2009b	Driving cessation, age, health, visual acuity, baseline depressive symptoms, baseline cognitive function	Three-year mortality risk
Fonda et al. 2001	Driving cessation, spouse's driving status, age, race, gender, education, geographical location, baseline health, physical and cognitive functioning	Depressive symptoms (CES-D scale)
Freeman et al. 2006	Driving cessation, baseline health, cognitive function and depressive symptoms, demographic characteristics	Long-term care entry (interviewer-administered questionnaire)
Liddle et al. 2012	Driving cessation, health, ADL*, gender, age, living situation	Functional status (Physical self-maintenance scale, IADL scale), life satisfaction (Life Satisfaction Index), role participation (Role checklist), time use (semi-structured interview)
Mann et al. 2005	Driving cessation, age, race, sex, health status	Self-rated health status (OARS physical health scale), functional status (OARS IADL scale, Sickness impact profile, Functional independence measure), Mental status (Mini-mental status exam)
Marottoli et al. 1997	Driving cessation, health status, ADL*, age, sex, education, marital status, housing type	Depressive symptoms (CES-D scale)
Marottoli et al. 2000	Driving cessation, health status, ADL*, age, sex, education, marital status, housing type	Self-reported out-of-home activity levels (home interviews)
Mezuk et al. 2008	Driving cessation, age, race, education, self-rated health, cognitive function	Social network characteristics; friends and relatives (Likert scale)
O'Connor et al. 2013	Driving cessation, age, sex, race, education, health status, self-rated health, physical performance, geographic location,	Self-rated health (Likert scale), physical performance (Turn 360 test), general health and functioning (SF-36)
Ragland et al. 2005	Driving cessation, health status age, sex, education, marital status, cognitive function, baseline depression status,	Depressive symptoms (CES-D scale)
Siren et al. 2004	Driving cessation, physical health, psychological well-being, marital status	Self-rated health (self-reports), life satisfaction (Satisfaction life scale)
Windsor et al. 2007	Driving cessation, health and sensory function, age, gender, education, marital status, income, perceived control, baseline depressive symptoms	Depressive symptoms (CES-D scale), self-rated health and sensory function (Likert scale), perceived control (Expectancy of control subscale)

*ADL =Activities of Daily Living; **CES-D=Center for Epidemiologic Studies Depression Scale; ***SF-36= Short Form (36) Health Survey

Table 2a. Quality ratings for the 12 cohort studies included on the basis of Newcastle-Ottawa quality assessment scale

	Selection				**Comparability**		**Outcome**		**Total Score**
	Representative of exposed cohort	Selections of non-exposed cohort	Assessment of exposure	Absence of outcome at start of study	Comparability	Assessment of outcome	Follow-up period (≥ 6 months)	Adequacy of follow-up	out of 9 points
Choi et al. 2014	1	1	1	0	2	1	1	0	7 (high)
Curl et al. 2013	1	1	1	1	2	1	1	0	8 (high)
Edwards et al 2009a	1	1	1	0	2	1	1	0	7 (high)
Edwards et al 2009b	1	1	1	1	1	1	1	0	7 (high)
Fonda et al. 2001	1	1	1	0	2	1	1	0	7 (high)
Freeman et al. 2006	1	1	1	0	2	1	1	0	7 (high)
Marottoli et al. 1997	1	1	1	0	2	1	1	0	7 (high)
Marottoli et al. 2000	1	1	1	1	2	1	1	0	8 (high)
Mezuk et al. 2008	1	1	1	1	2	1	1	0	8 (high)
O'Connor et al.2013	1	1	1	1	2	1	1	0	8 (high)
Ragland et al. 2005	1	1	1	1	1	1	1	0	7 (high)
Windsor et al.2007	1	1	1	0	2	1	1	0	7 (high)

Table 2b. Quality ratings for the 4 cross-sectional studies included on the basis of the modified Newcastle-Ottawa quality assessment scale

	Representativeness of sample	Sample size	Non-respondents	Ascertainment of the driving cessation	Comparability	Ascertainment of the outcome	Statistical test	out of 10 points
Al-Hassani et al. 2014	2	0	1	1	2	2	1	9 (low)
Liddle et al. 2012	1	0	0	1	0	2	1	5 (low)
Mann et al. 2005	0	0	1	1	0	2	1	5 (low)
Siren et al. 2004	2	1	1	1	2	1	1	9 (low)
							mean	7.0

Table 3. Categorical health-outcomes associated with driving cessation for the 16 studies

Health Outcome Assessed	Author, Publication Year: Al-Hassani et al. 2014	Choi et al. 2014	Curl et al. 2013	Edwards et al. 2009a	Edwards et al. 2009b	Fonda et al. 2001	Freeman et al. 2006	Liddle et al. 2012	Mann et al. 2005	Marottoli et al. 1997	Marottoli et al. 2000	Mezuk et al. 2008	O'Connor et al. 2013	Ragland et al. 2005	Siren et al. 2004	Windsor et al. 2007	Number of Studies
Increased depressive symptoms	++			--		++				++				++		++	6
Decline in social engagement	++		++	++				++				--	++				6
Reduced functional status (role playing)	++			++				++	++				++				5
Increased cognitive decline		++							++								2
Decline in productive engagement (work, etc.)			--												++		2
Decline in general health				--					++				++		++		4
Increased risk of mortality					++								++				2
Decreased out of home activity levels											++						1
Increased dependency and loss of control								++								++	2
Increased risk of entry into long term care							++										1
Reduction in annual risk of car crash trauma																	1

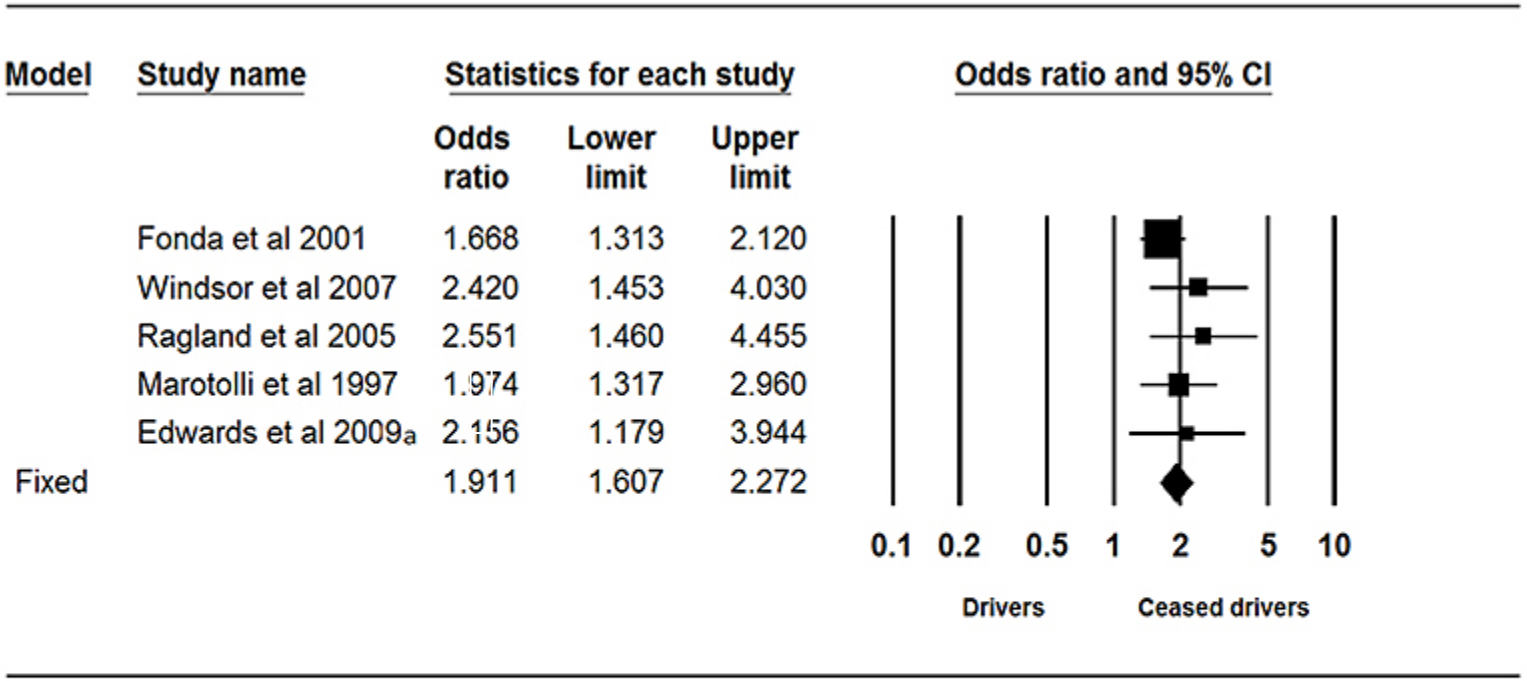
++ Significant association
-- No significant association

Table 4. Data extracted from the 5 studies included in the quantitative meta-analysis

	Author, Publication Year				
	Edwards et al. 2009a	Fonda et al. 2001	Marottoli et al. 1997	Ragland et al. 2005	Windsor et al. 2007
Data format	Raw difference (independent groups), SE	Cohort 2x2 (All cells)	Independent groups (means, p)	Independent groups (means, p	Independent groups (means, t)
Difference in means	0.01		4.1	4.0	2.19
SE	0.004				
Ceased driving (N)	37				
Drivers (N)	594				
Ceased drivers; depressed		113			
Ceased drivers; not depressed		217			
Drivers depressed		888			
Drivers Not depressed		2845			
Ceased drivers mean depression score			9.30	9.70	8.52
Ceased drivers Sample size			92	42	53
Current drivers mean depression score			5.20	5.70	6.33
Current drivers Sample size			502	1419	647
Independent groups p-value			.001*	.001*	
Independent groups t-value					3.41

SE=Standard Error *p<0.05

Figure 2. Forest plot, summary odds ratio and 95% confidence of association of depressive symptoms with driving cessation. The size of each square is proportional to the relative weight that each study contributed to the summary odds ratio. The summary odds ratio is indicated by the diamond. Horizontal bars indicate the 95% confidence interval. Heterogeneity: Q statistic: 3.266, df=4, P < 0.514. I^2=0.000



Discussion

This systematic review shows that driving cessation in older adults is associated with a variety of adverse health outcomes, particularly with increased depressive symptoms. These findings are generally consistent with a previous review (Harrison and Ragland, 2003), but update and expand their findings with more than 10 additional years of empirical research.

Evidence on the association of driving cessation with depression is robust and compelling. In addition to the consistent findings, depressive symptoms were measured using the Center for Epidemiologic Studies-Depression (CES-D) scale in all five cohort studies included in the meta-analysis. Moreover, these five studies were of high quality as indicated by the scores on the Newcastle-Ottawa quality assessment scale. With the exception of the Ragland et al (2005) study, the underlying populations studied were nationally representative samples of the US population. Due to the integral role that driving plays in personal identity and independence, driving cessation may lead to psychological reactions (Ragland et al., 2005). The association between driving cessation and increased depressive symptoms may be partly explained by the perceived loss of control that accompanies driving cessation (Windsor et al., 2007). Not much is known about the extent to which existing transition services and programs contribute to the maintenance of control beliefs and social functioning. However, studies have found that observed risk of worsening of depressive symptoms may not be mitigated by availability and access of alternative transport (Fonda et al., 2001; Mezuk and Rebok, 2008). Given the observational nature of the included studies, the possibility that driving cessation and depression are both consequences of some other common factor (e.g., declining health), cannot be completely ruled out. Nevertheless, additional research may identify effective interventions that can avoid the worsening of depressive symptoms associated with driving cessation (Choi and DiNitto, in press).

Prior research reported conflicting findings on the impact of driving cessation on general health. While some researchers found non-drivers to have more medical conditions and poorer health compared to drivers (Marottoli et al., 2000), others have reported the opposite (Campbell et al., 1993; Dellinger et al., 2001). There is growing evidence that driving cessation may exacerbate the decline in general health (O'Connor et al., 2013). The prospective nature of the Edwards et al. (2009a) study on health trajectories, adjusting for baseline covariates, offers compelling evidence to this effect. The conflicting evidence in the literature could be due to the fact that healthier people may adapt better to driving cessation compared to those in poorer health (Harrison and Ragland, 2003). Additional large, prospective studies, controlling for location and medical conditions are required to further establish the effect of driving cessation on health.

Based on our findings, it appears that driving cessation may hasten declines in physical and social health among older adults. Older ex-drivers tend to have markedly reduced out-of-home activities as they substitute indoor activities for outside activities (Edwards et al., 2009a). Although older adults tend to find substitute activities to do around the home (Marottoli et al., 2000), those activities may not benefit physical functioning as much as productive work or volunteerism outside the home does. The health implications of markedly reduced physical functioning are profound in terms of worsening of underlying

physical and emotional problems, deconditioning, need for support with IADLs. As older adults transition to non-driving, programs should be in place to facilitate continued physical and social activities.

Although there were discrepancies in the assessment of social functioning following driving cessation, the findings are generally consistent. In some qualitative studies, older ex-drivers mentioned loss of spontaneity and the increasing need to plan things ahead of time (Bauer et al., 2003; Bryanton et al., 2010), which can limit opportunities for out-of-home social engagement and activities. Loss of social functioning appears to affect women more than men, but women who voluntarily cease driving seem better prepared to adapt to a non-driving lifestyle while those who are forced to stop had a more difficult transition (Bryanton et al., 2010). Due to lifestyle changes, many older adults may combine business or an important trip with social activities, such as combining a trip to the drug store with seeing a friend (Bauer et al., 2003). While declines in social activities may be gradual (Curl et al., 2013), they have been found to strongly mediate the association between driving cessation and mortality over time (O'Connor et al., 2013).

Ex-drivers tend to have lower cognitive abilities than current drivers. While most studies have shown that declines in cognitive abilities contribute to driving cessation, there is a paucity of studies focusing on the effect of driving cessation on cognitive abilities. Findings from Choi et al. (2014) indicate a possible bi-directional association between driving status and cognitive abilities.

Factors that are likely to precipitate mortality are also likely to affect driving status, making it difficult to establish a causal relationship between driving cessation and mortality. However, the two studies (Edwards et al., 2009b; O'Connor et al., 2013) included in this review adjusted for baseline covariates that could confound the association between driving cessation and mortality. Both studies strongly indicate that driving cessation could be a potential risk factor for mortality, possibly by worsening the diminishing functional capabilities of the normative aging process.

The aforementioned adverse health consequences notwithstanding, it is important to note that reducing or ceasing driving in older adults may confer some safety benefit. Redelmeier et al. (2012) reported a 45% reduction in the annual rate of crash injury in medically unfit drivers after they received warnings from their physicians.

Although this review provides an up-to-date synthesis of the research literature on driving cessation and health outcomes, it has several notable limitations. With the exception of Fonda et al. (2001), the studies examining the effect of driving cessation on depression included a depression scale rather than a clinical diagnosis, and thus were only able to look at changes on the scale rather than in the proportion of participants classified as medically depressed. In addition, the assessments of other health outcomes varied substantially across the studies reviewed. Additional longitudinal studies using standardized measures of health outcomes are needed to better understand the impacts of driving cessation on health and well-being in older adults. In addition, use of standardized measures could allow for quantitative synthesis in order to obtain robust estimates of effect size. Finally, this review was limited to studies published in English, and excluded qualitative studies, which can provide rich and deep—though not generalizable—information about the effects of driving cessation.

Conclusion

There is mounting evidence that driving cessation in older adults may contribute to a variety of health problems. Of special note is the apparent effect of driving cessation on self-reported depressive symptoms. Pooled data from five studies indicate that driving cessation nearly doubles the risk of increased depressive symptoms in older adults. The strength of the association between driving cessation and self-reported depressive symptoms is generally consistent across studies. This finding may be generalizable to the older adult population in the United States since the underlying population in four of the five studies came from nationally representative samples of the United States and the fifth came from a fairly comparable Western Australian population. This review also sheds light on other health outcomes of driving cessation, including declines in cognitive abilities, diminished physical and social functioning, and increased risks of long-term care entry and mortality. These adverse health consequences should be taken into consideration in the decision to cease driving. Access to alternative transportation may not necessarily mediate the association between driving cessation and increased depressive symptoms (Fonda et al., 2001; Mezuk and Rebok, 2008). Effective intervention programs to ensure and prolong mobility, physical and social functioning for older adults are needed.

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Appendices

Appendix A. Search strategy

The automated search used the following search strategy for indexed and non-indexed databases:
((driving cessation or driving discontinuation or driving retirement) or (health related outcomes or health events or (medical events) and (older adults or aged or adults).

MeSH terms for Medline OVID:
1) explode health outcomes/ and explode health events/and explode health consequences;
2) explode driving cessation/ and driving discontinuation/;
3) (explode old adults/ or explode aged/ / or explode frail/

PsycInfo:
(("driving"[Text Word]) OR "cessation"[Text Word]) AND "health"[Text Word]

Appendix B. Quality Assessment Tools

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE

CASE CONTROL STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Exposure categories. A maximum of two stars can be given for Comparability.

Selection

1) Is the case definition adequate?

a) yes, with independent validation *****

b) yes, eg record linkage or based on self reports

c) no description

2) Representativeness of the cases

a) consecutive or obviously representative series of cases *****

b) potential for selection biases or not stated

3) Selection of Controls

a) from same source population as cases ******

b) community controls *****

c) hospital controls

d) no description

4) Definition of Controls

a) no history of disease (endpoint) *****

b) no description of source

Comparability

1) Comparability of cases and controls on the basis of the design or analysis

a) study controls for _____ (Select the most important factor.) *****

b) study controls for any additional factor ***** (This criteria could be modified to indicate specific control for a second important factor.)

Exposure

1) Ascertainment of exposure

a) secure record (e.g. surgical records) *****

b) structured interview where blind to case/control status *****

c) interview not blinded to case/control status

d) written self report or medical record only

e) no description

2) Same method of ascertainment for cases and controls

a) yes *****

b) no

3) Non-Response rate

a) same rate for both groups *****

b) non respondents described

c) rate different and no designation

CODING MANUAL FOR CASE-CONTROL STUDIES

SELECTION

1) Is the Case Definition Adequate?

a) Requires some independent validation (e.g. >1 person/record/time/process to extract information, or reference to primary record source such as x-rays or medical/hospital records) *

b) Record linkage (e.g. ICD codes in database) or self-report with no reference to primary record

c) No description

2) Representativeness of the Cases

a) All eligible cases with outcome of interest over a defined period of time, all cases in a defined catchment area, all cases in a defined hospital or clinic, group of hospitals, health maintenance organisation, or an appropriate sample of those cases (e.g. random sample) *

b) Not satisfying requirements in part (a), or not stated.

3) Selection of Controls

This item assesses whether the control series used in the study is derived from the same population as the cases and essentially would have been cases had the outcome been present.

a) From same source population as cases**

b) Community controls (i.e. same community as cases and would be cases if had outcome) *

c) Hospital controls, within same community as cases (i.e. not another city) but derived from a hospitalised population

d) No description

4) Definition of Controls

a) If cases are first occurrence of outcome, then it must explicitly state that controls have no history of this outcome. If cases have new (not necessarily first) occurrence of outcome, then controls with previous occurrences of outcome of interest should not be excluded.*

b) No mention of history of outcome

COMPARABILITY

1) Comparability of Cases and Controls on the Basis of the Design or Analysis

A maximum of 2 stars can be allotted in this category:

Either cases and controls must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the odds ratio for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

There may be multiple ratings for this item for different categories of exposure (e.g. ever vs. never, current vs. previous or never)

Age = *, other controlled factors = *

EXPOSURE

1) Ascertainment of Exposure

Allocation of stars as per rating sheet

2) Non-Response Rate

Allocation of stars as per rating sheet

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE

COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort

a) truly representative of the average _____ (describe) in the community *****

b) somewhat representative of the average _____ in the community *****

c) selected group of users e.g. nurses, volunteers

d) no description of the derivation of the cohort

2) Selection of the non exposed cohort

a) drawn from the same community as the exposed cohort *****

b) drawn from a different source

c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure

a) secure record (e.g. surgical records) *****

b) structured interview *****

c) written self report

d) no description

4) Demonstration that outcome of interest was not present at start of study

a) yes *****

b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis

a) study controls for _____ (select the most important factor) *****

b) study controls for any additional factor ***** (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome

a) Independent blind assessment *****

b) record linkage *****

c) Self-report

d) No description

2) Was follow-up long enough for outcomes to occur

a) yes (select an adequate follow up period for outcome of interest) *****

b) no

3) Adequacy of follow up of cohorts

a) complete follow up - all subjects accounted for *****

b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ %

(select an adequate %) follow up, or description provided of those lost) *****

c) follow up rate < ____% (select an adequate %) and no description of those lost

d) no statement

CODING MANUAL FOR COHORT STUDIES

SELECTION

1) Representativeness of the Exposed Cohort

Item is assessing the representativeness of exposed individuals in the community, not the representativeness of the sample of women from some general population. For example, subjects derived from groups likely to contain middle class, better educated, health oriented women are likely to be representative of postmenopausal estrogen users while they are not representative of all women (e.g. members of a health maintenance organisation (HMO) will be a representative sample of estrogen users. While the HMO may have an under-representation of ethnic groups, the poor, and poorly educated, these excluded groups are not the predominant users of estrogen).

Allocation of stars as per rating sheet

2) Selection of the Non-Exposed Cohort

Allocation of stars as per rating sheet

3) Ascertainment of Exposure

Allocation of stars as per rating sheet

4) Demonstration That Outcome of Interest Was Not Present at Start of Study

In the case of mortality studies, outcome of interest is still the presence of a disease/ incident, rather than death. That is to say that a statement of no history of disease or incident earns a star.

COMPARABILITY

1) Comparability of Cohorts on the Basis of the Design or Analysis

A maximum of 2 stars can be allotted in this category

Either exposed and non-exposed individuals must be matched in the design and/or confounders must be adjusted for in the analysis. Statements of no differences between groups or that differences were not statistically significant are not sufficient for establishing comparability. Note: If the relative risk for the exposure of interest is adjusted for the confounders listed, then the groups will be considered to be comparable on each variable used in the adjustment.

There may be multiple ratings for this item for different categories of exposure (e.g. ever vs. never, current vs. previous or never)

Age = *, other controlled factors =*

OUTCOME

1) Assessment of Outcome

For some outcomes (e.g. fractured hip), reference to the medical record is sufficient to satisfy the requirement for confirmation of the fracture. This would not be adequate for vertebral fracture outcomes where reference to x-rays would be required.

a) Independent or blind assessment stated in the paper, or confirmation of the outcome by reference to secure records (x-rays, medical records, etc.)*

b) Record linkage (e.g. identified through ICD codes on database records)*

c) Self-report (i.e. no reference to original medical records or x-rays to confirm the outcome)

d) No description.

2) Was Follow-Up Long Enough for Outcomes to Occur

An acceptable length of time should be decided before quality assessment begins (e.g. 5 yrs. for exposure to breast implants)

3) **Adequacy of Follow Up of Cohorts**

This item assesses the follow-up of the exposed and non-exposed cohorts to ensure that losses are not related to either the exposure or the outcome.

Allocation of stars as per rating sheet

Newcastle-Ottawa Scale adapted for cross-sectional studies

Selection: (Maximum 5 stars)

1) Representativeness of the sample:

a) Truly representative of the average in the target population. * (all subjects or random sampling)

b) Somewhat representative of the average in the target population. * (non-random sampling)

c) Selected group of users.

d) No description of the sampling strategy.

2) Sample size:

a) Justified and satisfactory. *

b) Not justified.

3) Non-respondents:

a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *

b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.

c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):

a) Validated measurement tool. **

b) Non-validated measurement tool, but the tool is available or described.*

c) No description of the measurement tool.

Comparability: (Maximum 2 stars)

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.

a) The study controls for the most important factor (select one). *

b) The study control for any additional factor. *

Outcome: (Maximum 3 stars)

1) Assessment of the outcome:

a) Independent blind assessment. **

b) Record linkage. **

c) Self report. *

d) No description.

2) Statistical test:

a) The statistical test used to analyze the data is clearly described and appropriate and the measurement of the association is presented, including confidence intervals and the probability level (p value). *

b) The statistical test is not appropriate, not described or incomplete