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Review Article

Increased risk of unintentional injuries in adults with disabilities: A systematic review and meta-analysis

Xiuquan Shi, M.D., Ph.D.[a,b], Krista K. Wheeler, M.S.[a], Junxin Shi, M.D., Ph.D.[a], Lorann Stallones, M.P.H., Ph.D.[c], Shanthi Ameratunga, M.B.Ch.B., Ph.D.[d], Tom Shakespeare, Ph.D.[e], and Huiyun Xiang, M.D., M.P.H., Ph.D.[a,*]

[a]*Center for Injury Research and Policy, The Research Institute at Nationwide Children's Hospital, The Ohio State University College of Medicine, OH, USA*

[b]*Department of Epidemiology and Health Statistics, School of Public Health, Zunyi Medical College, Zunyi, PR China*

[c]*Colorado Injury Control Research Center, Colorado State University, CO, USA*

[d]*Section of Epidemiology & Biostatistics, School of Population Health, Faculty of Medical & Health Sciences, University of Auckland, Auckland, New Zealand*

[e]*Norwich Medical School, University of East Anglia, Norwich, United Kingdom*

Abstract

Background: An increased risk of unintentional injuries among individuals with disability has been reported in many studies, yet quantitative syntheses of findings from previous studies have not been done.

Objectives: We conducted a systematic review and meta-analysis to characterize the relationship between pre-existing disability and unintentional injuries.

Methods: We searched 14 electronic databases to identify original research published between Jan 1, 1990 and Feb 28, 2013. Included studies reported the odds ratio (OR) or relative risk (RR) of unintentional injuries in adults 18+ years of age with pre-existing disabilities compared with adults without disabilities. Twenty six eligible studies were included covering 54 586 individuals with disabilities. We conducted quality assessments and then analyzed the pooled effects using random-effect models.

Results: The pooled OR of unintentional injuries was 1.77 (95% CI 1.51–2.07) for all studies in individuals with disabilities compared with individuals without disabilities. The pooled ORs were 1.87 (95% CI 1.52–2.30) for overall unintentional injuries, 1.64 (95% CI 1.39–1.94) for falls-related injuries, 1.62 (95% CI 1.24–2.13) for occupational injuries, and 1.91 (95% CI 1.59–2.30) for non-occupational injuries.

Conclusions: Compared with adults without disabilities, individuals with disabilities are at a significantly higher risk of unintentional injuries. Evidence about the association between cognitive disabilities and unintentional injuries is weak. Future researchers are encouraged to use International Classification of Functioning, Disability and Health (ICF) to classify disability and use rigorous evaluation methods to assess and implement the most appropriate injury prevention efforts to mitigate the risks identified.

Keywords: Disability; Unintentional injuries; Falls; Occupational injuries

The 2011 World Report on Disability, published by the World Health Organization (WHO), estimated that more than 1 billion people around the world live with some form of disability, and 110–190 million people have very significant difficulties in functioning.[1] Due to the aging population and the increasing numbers of individuals with chronic health conditions, the prevalence of disability is expected to increase rapidly in the coming years in high-income countries[2] as well as in low-income and middle-income countries.[3,4]

There is increasing awareness that individuals with disabilities are at raised risk of a range of health problems, in addition to their primary health condition.[1] One particular challenge is the significantly higher rate of injuries from both violence and unintentional causes in individuals with disabilities compared with their peers without disabilities. A recent systematic review and meta-analysis of

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* Corresponding author. Center for Injury Research and Policy, The Research Institute at Nationwide Children's Hospital, The Ohio State University College of Medicine, 700 Children's Drive, Columbus, OH, USA. Tel.: +1 614 355 5893; fax: +1 614 355 5897.

E-mail address: xiang.30@osu.edu or huiyun.xiang@nationwidechildrens.org (H. Xiang).

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observational studies on the risk of violence against adults with disabilities found that adults with disabilities, particularly those with mental illness, are at a significantly higher risk of being victims of violence than adults without disabilities.[5] Similarly, results from a meta-analysis found that children with disabilities also face a significant higher risk of having experienced violence.[6] The majority of studies conducted in developed as well as in developing countries have suggested that people with disabilities seem to be at an increased risk of unintentional injuries.[7,8] However, some studies reported that the difference of unintentional injury risk between individuals with and without disabilities is small and not significant.[9,10] One study, conducted by Lysaght and colleagues, reported a lower risk of all types of unintentional injuries in workers with intellectual disability compared with their peers without disability.[11] Some researchers have postulated that people with disabilities tend to participate in fewer sport activities or are more careful in their daily activities; therefore, they are less likely to sustain unintentional injuries than those without disabilities.[12]

Injuries are among the leading causes of mortality and morbidity around the world.[13] Injury can push families into poverty and poverty increases the risk of subsequent injury, resulting in the 'injury-poverty trap.'[14−16] This issue may be particularly important for individuals with disabilities, with injuries potentially exacerbating health conditions and related financial hardship. Although researchers have investigated unintentional injuries in individuals with disabilities, the types of injuries and the definitions of disability in previous studies vary widely, and no quantitative syntheses of the existing evidence have been done. Because the activities and injury patterns of adults and children are different, we first conducted a systematic review and meta-analysis of studies of unintentional injuries in adults with disabilities. We aimed to synthesize the evidence on injury risk in adults with disabilities, to assess the quality of previous studies, and to identify the need for interventions and effective programs that could reduce the risk of unintentional injuries in adults with disabilities.

Methods

Databases and search strategy

We searched 14 databases (Medline, CINAHL, PsycINFO, ERIC, Alt Health Watch, Sport Discus, Scopus, ISI Web of Knowledge, Cochrane Library, Clinical Key, CAB Abstracts, Global Health, Health and Safety Science abstracts, and National Agriculture Safety databases). Our literature search was limited to studies published between Jan 1, 1990 and Feb 28, 2013 without language restrictions.

A search strategy was developed for each searchable database using a combination of free text or keywords to search throughout the full texts. We used search terms from two categories relating to disability (e.g., "disabilit*", "limit*", "disabl*", "deficien*", and "handicap*") and injury (e.g., "injur*", "hurt*", "trauma", "fall*"and "wound*"). Additional strategies included web-based searches for special literature (recently published abstracts or conference proceedings, or manuscripts in press), and the screening of reference lists of retrieved studies.

Definitions of disability and injury

A number of previous studies have defined disability as cognitive or physical disability. A newer definition of disability, used in more recent research, is based on the WHO International Classification of Functioning, Disability and Health (ICF).[4,17] In the ICF, disability is an umbrella term which refers to impairments of body function and structure, activity limitations, and participation restrictions. The ICF emphasizes the role of personal and environmental factors in definition of disability. We grouped the studies according to types of disability investigated: physical disability, cognitive disability, and ICF-based disability.

Injuries were defined as any injuries serious enough to require medical attention or treatment at a medical facility and that occurred in the 12 months preceding the study. Occupational injuries were defined as injuries that happened while at work, and all other injuries were defined as non-occupational injuries.[18] Definition of an injurious fall[19] was similar to the injury definition but limited to fall events. Because falls are a leading cause of unintentional injury among people with disabilities[18,20] fall-related injuries were the primary focus in some studies while other studies did not separate falls from the overall injuries. We considered overall injuries and fall-related injuries in separate analyses when the studies investigated both types of injuries.

Literature selection

All the retrieved studies were reviewed independently by two of four reviewers in two rounds of screening of the full-text copies. For inclusion, publications must meet all the following criteria: (1) published with an English language abstract; (2) original research published in a peer-reviewed journal; (3) studied injuries among individuals with pre-existing disabilities; (4) reported the exact age or age range, focused primarily on adults, age ⩾18 years old; (5) reported odds ratios (OR) or relative risks (RR) and their confidence intervals (CIs); or provided data so that we could compute these statistical measurements for the disability variable(s); and (6) provided clear definitions of disability and the injury event (non-fatal unintentional injuries) that met the study criteria.

Publications that met any of the following exclusion criteria were excluded from our meta-analysis: (1) review articles, letters, or other commentary papers that did not have original research data; (2) publications that investigated injuries that resulted in disabilities without mention of pre-existing disabilities (disability as an outcome of injuries); (3) no control group of persons without disabilities; and (4) insufficient demographic information reported; (5) reported only fatal injuries or intentional injuries (violence or suicide). The included studies were designed primarily to evaluate unintentional injury, i.e. falls, so intent is not always mentioned. When intentional injuries were mentioned and not specifically excluded in the considered studies, they were a very small fraction of the total injuries (<2%). When data from one study were reported in more than one publication, we used the most recent publication.

Any discrepancy between two reviewers in the two rounds of reviews was solved in a panel discussion. Details of our publication screening steps can be found in Fig. 1.

Quality assessment and data extracted

Other researchers have conducted quality assessment as a part of their systematic review[21] using the guidelines and criteria for strengthening the reporting of observational studies in epidemiology (STROBE).[22] In our meta-analysis, the quality of all included studies was assessed independently by two of four reviewers using the 22-items quality criteria in the STROBE. Discrepancies between two reviewers were found in a total of 3 papers but were solved in a group discussion that involved all four reviewers. After the quality assessment, one researcher extracted the needed data and another researcher checked for accuracy.

Statistical analysis

All analyses were conducted using the STATA software version 12.0 (StataCorp, Texas, USA). For a total of 20 studies, we extracted the original data (number of participants with and without disabilities and the number injured in each group). For the remainder of the studies that did not report these numbers, we extracted the crude ORs and the 95% CIs. The STATA software has the capacity to combine both types of data to calculate the pooled ORs and the 95% CIs. We first described the characteristics of the included studies, and then conducted heterogeneity tests to determine the best approach for pooling the studies' results. When heterogeneity (the degree of dissimilarity in the results of selected studies, I^2 statistic) was statistically

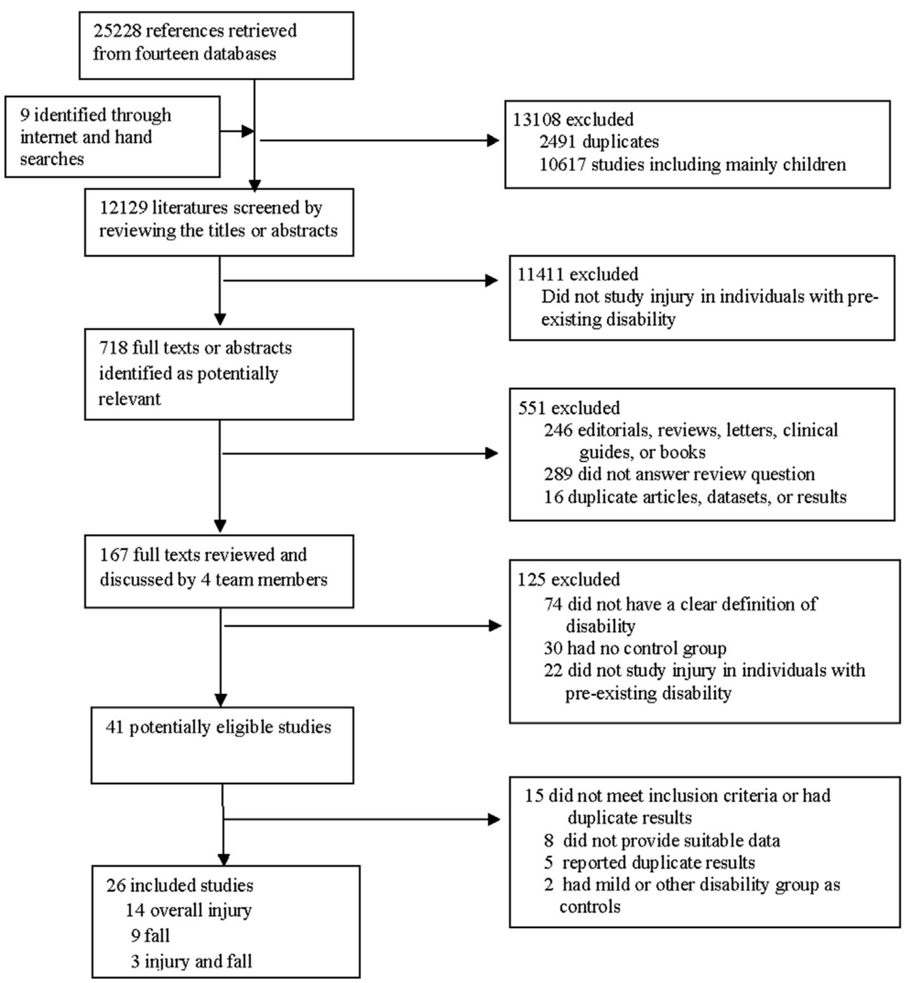

Fig. 1. Flowchart of study selection.

Table 1
Characteristics of all included studies

Ref. no.	Author (year)	Data source	Age	Gender	Occupation (Study population)	Definition and type of disability	Definition and type of injury	Design	Pre-existing disability determination	Quality assessment[a]
42	Zwerling (1993)	Medical history questionnaire	18–62	M = 751; F = 345	Worker (postal)	Disability history, not declared detail types	Work-related low back injury	CC	Medical questionnaire completed when hired	19–20
37	Poor (1995)	Medical records	35–96	M = 464 only	Elder	Vision impairment (blind and cataracts)	Hip fracture	CC	Vision impairment not likely a result of hip fracture	19–20
40	Stevens (1997)	Study to Assess Falls in the Elderly (SAFE) survey	⩾65	M = 284; F = 899	Elder	ADL limitations	Fall	CC	Disability before reference period for injury	19–20
44	Zwerling (1997)	NHIS (1985–1994)	18–65	M = 247,598; F = 212,229	Worker	Blind, deaf, and work limitations	Overall injury	Coh	Impairment prior to previous year, the injury reference period	19
34	Koski (1998)	Home-dwelling elderly survey	⩾70	M = 290; F = 495	Elder	ADL limitations	Fall	Coh	Prospective study, function assessed at baseline	19–20
43	Zwerling (1998)	Health & Retirement Study (1992–1994)	51–61	M = 2645; F = 2955	Worker	Self-reported disability	Overall injury	Coh	Two waves of data. Impairment from first wave.	20
41	Tousignant (2000)	Survey data from workers in Quebec, three industries	Unknown	Most male	Worker	Self-reported disability	Back injury	Coh	Cohort study, disability at baseline prior to injury assessment	21
9	Grant (2001)	Medical records of clients of a disability service agency	18–77	M = 63; F = 51	Resident	Medically diagnosed physical/sensory impairment	Fall	Coh	Cohort, impairment assessed prior to injury	17–18
27	Chi (2001)	Labor Insurance Bureau records	⩾18	M = 5030; F = 1297	Worker	Diagnosis by Council of Labor Affairs	Occupational injury	CS	Impairment related to work subsidy in records prior to work injury	15–16
10	Hsieh (2001)	Survey in nursing homes	⩾30	M = 135; F = 133	Nursing home residents	Developmental disability	Injury and fall	Coh	Disability assessed at baseline, injury assessed at follow-up	17
38	Sprince (2003)	Agricultural Health Study	⩾18	M = 452; F = 6	Farmer	Self-reported disability based on National Health Interview survey	Animal-related injury	CC	Authors use the term "pre-existing disability," not specific about how determined	19

39	Sprince (2003)	Agricultural Health Study	⩾22	M = 541 only	Farmer	Self-reported disability based on National Health Interview survey	Fall	CC	Authors use term "Pre-existing disability," not specific about how determined	19–20
26	Chau (2004)	Questionnaire by occupational physicians for workers	⩾18	M = 1760 only	Construction workers	Diagnosis of physical disability	Occupational injury	CC	Physician defined upon exam	17–18
20	Xiang (2005)	Colorado Disability Survey	⩾18	M = 1100; F = 1502	Resident	ICF-based disability	Injury and fall	CS	Disability for more than 12 months and prior to injury reference period	20
31	Gauchard (2006)	Household survey by phone	⩾15	M = 2936; F = 32,235	Resident	ICF-based disability	Fall	CS	Sensory and cognitive disabilities not likely a result of a fall	19–20
32	Gauchard (2006)	Questionnaire by occupational physicians for workers	Unknown	M = 2710 only	Worker	Diagnosis of physical disability, hearing and vision disorder	Work injury	CC	Determined by occupational physician	15
17	Brophy (2008)	NHIS (2004–2005)	⩾18	M = 57,001; F = 62,019	Resident	ICF-based disability	Overall injury	CS	Disability preceded reference period for injury	20
28	Clough-Gorr (2008)	UK, German, Switzerland multicenter study	⩾65	M = 724; F = 920	Elder	IADL limitations	Fall	Coh	Disability at baseline and injury at follow-up	21
35	Lamoreux (2008)	Population based survey in Singapore	40–80	M = 1568; F = 1698	Resident	Vision impairment	Fall	CS	The causes of vision impairment were known and not related to fall	19
25	Breslin (2009)	Canadian Community Health Survey (2003)	15–24	M = 7382; F = 6997	Worker	Medically diagnosed learning disabilities, dyslexia, ADD/ADHD	Occupational injury	CS	Learning disabilities diagnosis	17–18
29	Cox (2010)	Medical charts	⩾18	M = 63; F = 51	Resident	Vision impairment	Fall	CS	Vision impairment not likely result of the fall	17–18
30	Finlayson (2010)	Clients survey	⩾18	M = 273; F = 238	Resident	Intellectual disability	Injury and fall	Coh	Prospective cohort	19–20
36	Leff (2010)	Colorado Disability Survey	⩾18	M = 1073; F = 1438	Resident	ICF-based disability	Overall injury	CS	Disability prior to injury reference period	20–21
11	Lysaght (2011)	Workplace insurance claim records	Unknown	Unknown	Worker	Intellectual disability	Work injury	CS	Intellectual disability and work injury	19

(*Continued*)

Table 1 (*Continued*)

Ref. no.	Author (year)	Data source	Age	Gender	Occupation (Study population)	Definition and type of disability	Definition and type of injury	Design	Pre-existing disability determination	Quality assessment[a]
33	Henry-Sanchez (2012)	Second Longitudinal Study of Aging	⩾70	M = 3678; F = 5572	Elder	ADL limitations	Fall	CS	Disability information from earlier survey, NHIS-D	21
18	Price (2012)	NHIS (2006−2010)	⩾18	M = 96,674; F = 87,002	Worker	ICF-based disability	Occupational and non-occupational injury	CS	Disability prior to injury reference period	21

NHIS, National Health Interview Survey; ICF, International Classification of Functioning, Disability and Health; ICD, International Classification of Disease; M, male; F, female; ADL, Activities of Daily Living; CC, case−control study; Coh, cohort study; CS, cross-sectional study.

[a] Total items of the 22 items in STROBE checklist identified in the paper by two reviewers.

significant, we used random-effect models to compute the pooled effects as opposed to fixed-effect models. We calculated pooled ORs and 95% CIs, and performed Z tests to evaluate the statistical significance of the pooled effects.

We conducted sensitivity analyses to evaluate the reliability of our results: showing the random-effect model and fixed-effect model results, by dropping those studies with the highest and lowest ORs, and by dropping those studies with the largest and smallest sample sizes. Publication bias, assessing whether studies with positive results were more likely to be published, were diagnosed by the funnel plot, Egger's test, and Begg's tests.[23,24]

We produced pooled effect estimates for overall injuries and fall-related injuries. We also produced pooled estimates for occupational injuries vs. non-occupational injuries, and for overall injuries by different types of disabilities (ICF-based disability, physical disability, and cognitive disabilities).

Results

General characteristics of included studies

From 25,237 abstracts, we identified 26 studies[9−11,17,18,20,25−44] which were eligible for inclusion (Fig. 1). Of the 26 studies, 11 studies[11,17,18,20,25,27,29,31,33,35,36] used a cross-sectional design, 7 studies[26,32,37−40,42] used a case−control design, and 8 studies[9,10,28,30,34,41,43,44] were cohort studies (Table 1). All of the selected 26 studies included reference groups of adults without disabilities or without a specific disability of interest. Their sample sizes ranged from 114 to 459,827 with a total sample sizes of 846,076, including 54,586 individuals with disabilities (one study, by Koski et al,[34] only reported the total participants and the OR and CI but did not provide the exact number of individuals with disability).

A total of 19 studies[9,10,17,18,20,25,27−31,33−36,40,42−44] reported their findings for both males and females. However, participants in seven studies focusing on farmers or workers were exclusively male[26,32,37] or predominantly male.[11,38,39,41] Five studies[28,33,34,37,40] focused on older adults (individuals aged greater than 65 years of age) and the other 21 studies included a broad age range of adults.

Geographically, the WHO region of the Americas was heavily represented, with 13 studies conducted in US[10,17,18,20,33,36−40,42−44] and four in Canada.[9,11,25,41] Six were from the European region and three studies were conducted in the WHO Western Pacific region (Fig. 2). No eligible studies were found in the WHO Africa and other regions indicating a paucity of data from low- and middle-income countries, which could be a result of our English language restriction.

All included studies had at least 15 of the STROBE checklist items, and the majority had 18−20 out of the total 22 items (Table 1). Missing items in the included studies

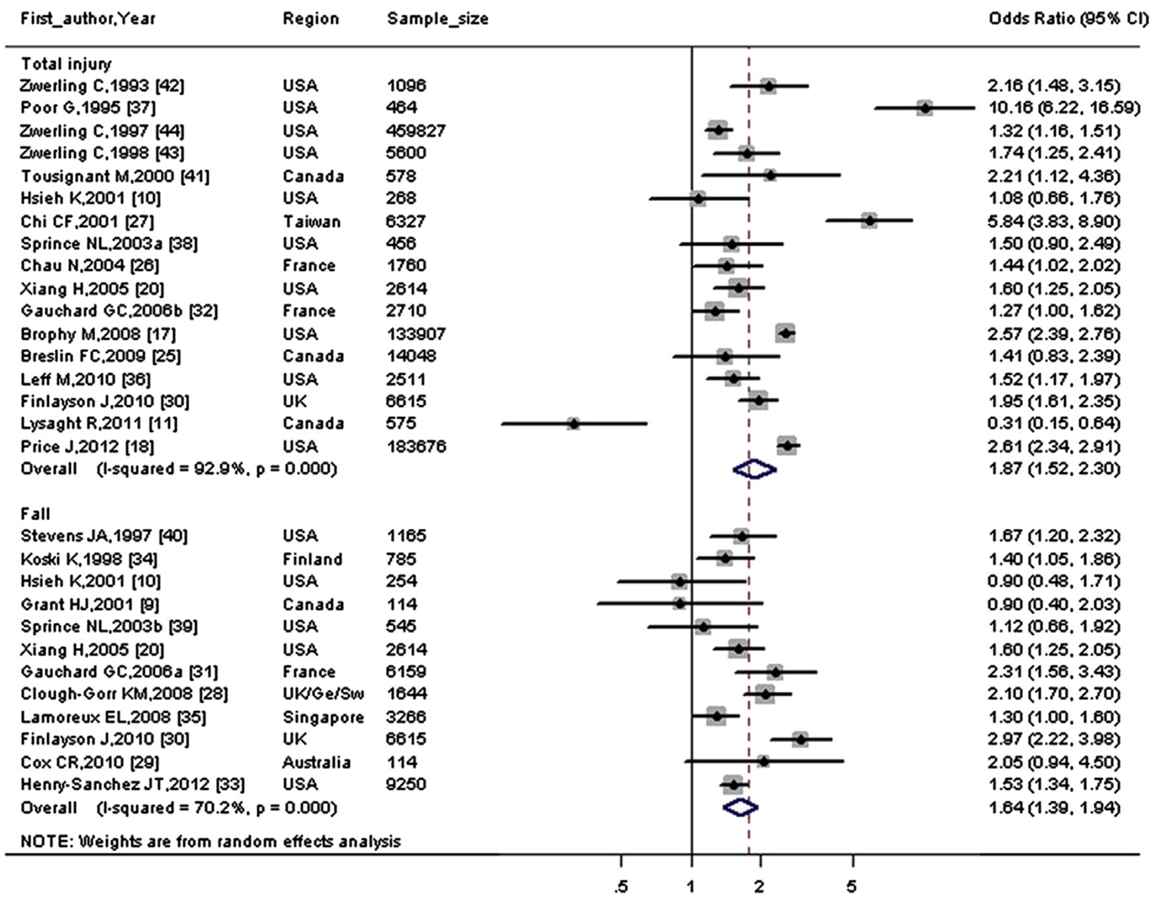

Fig. 2. Risk estimates of injury in people with disabilities for all injuries and falls.

were no discussion of study bias, participant recruitment procedures, statistical procedures, funding source, study sample size methods, or details about the subgroup, interaction, and sensitivity analyses.

Pooled effects and subgroup analyses

In this study, we used random-effect models to combine the overall effect of disability status on unintentional injury risk because there was significant heterogeneity ($I^2 > 70\%$) in the results of the included studies (Table 2).

Of the 26 included papers, 14 studies focused on non-fatal unintentional injuries, nine studies[9,28,29,31,33–35,39,40] focused on fall-related injuries, and three papers[10,20,30] focused on both injuries and falls. The pooled OR of injuries in adults with disabilities was 1.87 (95% CI 1.52–2.30; I^2 92.9%; $Z = 5.88$; $p < 0.001$) compared with adults without disabilities (Fig. 2). The pooled OR of fall-related injuries was 1.64 (95% CI 1.39–1.94; I^2 70.2%; $Z = 5.78$; $p < 0.001$).

Fig. 3 summarizes the pooled OR of occupational and non-occupational injuries. Eleven included papers[11,25–27,32,38,39,41–44] focused on occupational injuries, and 14 studies[9,10,17,20,28–31,33–37,40] focused on non-occupational injuries; one paper investigated both.[18] The pooled OR was 1.62 (95% CI 1.24–2.13; I^2 87.8%; $Z = 3.49$; $p < 0.001$) in the studies of occupational injuries; while the pooled OR was 1.91 (95% CI 1.59–2.30; I^2 90.6%; $Z = 6.87$; $p < 0.001$) in the subgroup studies of non-occupational injuries. The overall combined OR was 1.79 (95% CI 1.53–2.09; I^2 90.6%; $Z = 7.39$; $p < 0.001$).

Fig. 4 reports the pooled OR of injuries by types of disability reported in the original studies. More than half (14 papers) of the included studies[9,26,27,29,31,32,35,37–39,41–44] examined physical disabilities, five studies[10,11,25,30,31] considered cognitive disabilities, while 8 studies[17,18,20,28,33,34,36,40] considered ICF-based disability. One study reported both physical disability and cognitive disabilities.[31] After dividing the included studies into three disability type subgroups, we found that the pooled OR of injuries was 1.86 (95% CI 1.52–2.26; I^2 91.4%; $Z = 6.16$; $p < 0.001$) in studies which used ICF-based disability definitions, 1.93 (95% CI 1.46–2.56; I^2 88.6%; $Z = 4.57$; $p < 0.001$) in studies which investigated physical disabilities, and was 1.24 (95% CI 0.73–2.12; I^2 86.2%; $Z = 0.79$; $p < 0.001$) in studies which investigated cognitive disabilities. The overall combined OR was 1.77 (95% CI 1.51–2.07; I^2 90.6%; $Z = 7.14$; $p < 0.001$).

A subgroup analysis by the study design was performed (data not shown). We found a pooled OR = 1.94 (95% CI

Table 2
Results of sensitivity analysis

Type	Index	Two different analyzed models		By study effect (random-effect models)			By sample size (random-effect models)		
		Random-effect model (all eligible papers)	Fixed-effect model (all eligible papers)	Excluded max-effect paper	Excluded min-effect paper	Excluded max-&min-effect papers	Excluded max- sample size paper	Excluded min- sample size papers	Excluded max-&min-sample size papers
Injury	No. of included studies	17	17	16	16	15	16	16	15
	OR and 95% CI	1.87 (1.52–2.30)	2.14 (2.04–2.24)	1.71 (1.40–2.08)	2.00 (1.64–2.45)	1.83 (1.52–2.21)	1.92 (1.56–2.36)	1.92 (1.56–2.38)	1.99 (1.61–2.45)
	I^2 and 95% CI	92.9% (90.2–94.9)	92.9% (90.2–94.9)	92.0% (88.6–94.4)	92.4% (89.3–94.7)	91.2% (87.2–94.0)	91.0% (87.1–93.8)	93.1% (90.4–95.1)	91.2% (87.1–93.9)
	Overall Z, p-value	$Z = 5.88, p < 0.001$	$Z = 31.87, p < 0.001$	$Z = 5.31, p < 0.001$	$Z = 6.78, p < 0.001$	$Z = 6.28, p < 0.001$	$Z = 6.22, p < 0.001$	$Z = 6.04, p < 0.001$	$Z = 6.45, p < 0.001$
Fall	No. of included studies	12	12	11	11	10	11	10[a]	9
	OR and 95% CI	1.64 (1.39–1.94)	1.64 (1.52–1.78)	1.56 (1.36–1.78)	1.68 (1.42–1.98)	1.58 (1.38–1.81)	1.64 (1.34–2.01)	1.66 (1.40–1.98)	1.67 (1.35–2.07)
	I^2 and 95% CI	70.2% (46.1–83.5)	70.2% (46.1–83.5)	49.5% (0.0–74.7)	71.2% (46.9–84.4)	50.0% (0.0–75.8)	71.7% (47.8–84.6)	73.9% (51.0–86.1)	75.5% (52.9–87.3)
	Overall Z, p-value	$Z = 5.78, p < 0.001$	$Z = 12.22, p < 0.001$	$Z = 6.36, p < 0.001$	$Z = 5.99, p < 0.001$	$Z = 6.61, p < 0.001$	$Z = 4.81, p < 0.001$	$Z = 5.70, p < 0.001$	$Z = 4.721, p < 0.001$

[a] There were two studies excluded with the smallest sample sizes (both had an $n = 114$).

1.23–3.07), $I^2 = 90.3\%$ in the included case–control studies; a pooled OR = 1.63 (95% CI 1.32–2.02), $I^2 = 79.7\%$ in the eligible included cohort studies; and a pooled OR = 1.83 (95% CI 1.45–2.30), $I^2 = 92.9\%$ in the included cross-sectional studies. While the results show that the type of design was a source of heterogeneity; the pooled estimates have overlapping confidence intervals suggesting that the variability is acceptable.

Sensitivity analysis and bias diagnosis

We conducted sensitivity analyses by excluding studies with the highest and lowest ORs and by excluding studies with the largest and the smallest sample sizes to assess the stability of our analytic results (Table 2). We found small changes in the overall pooled OR and CIs, but none of the changes were statistically significant, suggesting that our meta-analysis results were stable.

We also assessed potential publication bias among the included studies using two approaches. First, we used funnel plots which were found to be symmetric, suggesting no bias in the included publications (figure not shown). Second, we used both Egger's and Begg's bias assessment methods.[23,24] The Begg's test had a $t = 0.08$ ($p = 0.934$) for studies that investigated overall injuries and a $t = 0.41$ ($p = 0.681$) for studies that focused on fall-related injuries. The Egger's test confirmed these findings with a $t = 1.29$ ($p = 0.216$) for overall injuries studies and a $t = 0.18$ ($p = 0.858$) for fall-related injuries studies, respectively. Results from both the funnel plots and bias tests indicated that the publication bias in our meta-analysis was negligible.

Discussion

The results of our meta-analysis, including 26 studies comparing adults with and without disabilities, show that disability status is associated with a higher risk of unintentional injuries. The odds ratio of injury seemed to be highest in individuals with physical disabilities or ICF-based disabilities and lowest in individuals with cognitive disabilities. While evidence is strong and consistent about unintentional injury risk in adults with physical disabilities and ICF-based disabilities, a great deal of uncertainty exists around the pooled injury risk estimates in adults with cognitive disabilities due to the small number of studies in different settings and the wide variation in the definition of cognitive disabilities.

Among the five studies included in the pooled injury estimates in individuals with cognitive disabilities, two studies reported a significantly higher risk of injuries,[30,31] two reported an elevated but not statistically significant risk of injuries,[10,25] only one reported a significantly lower risk of injuries in adults with cognitive disabilities.[11] In fact, this small study was the only one among all included 26 studies that reported a significantly lower risk of injuries. In this study, Lysaght et al conducted a retrospective analysis of

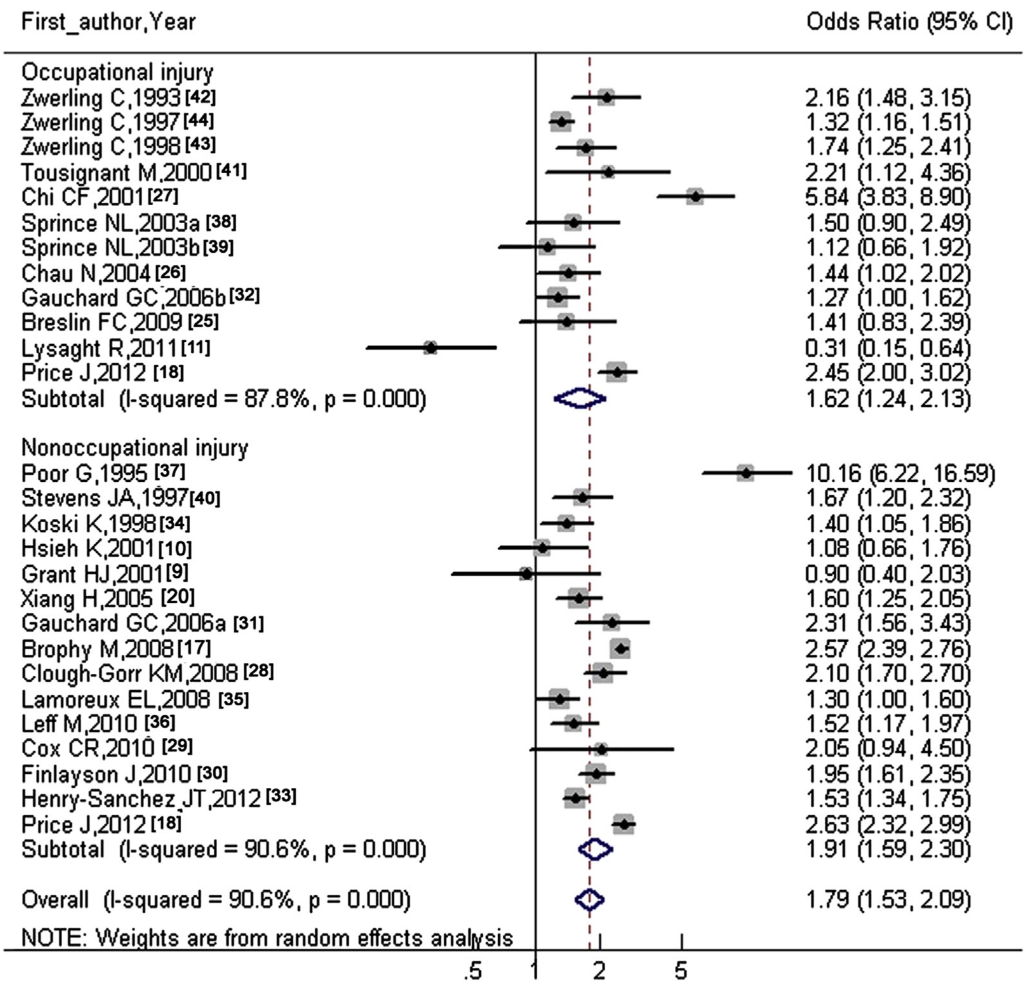

Fig. 3. Risk estimates of injury in people with disabilities for occupational and non-occupational injuries.

workplace insurance claim records for workers with and without intellectual disabilities and found a total of 45 injuries.[11] A limitation, reported by the authors, was that the workplace used in the study served as a training facility for workers with disabilities; therefore, findings from this study may not be generalizable to other workplaces. Additionally, this study shows lower claims rather than lower injuries and may reflect bias in seeking compensation. Only three of the selected five publications on cognitive disabilities used population-based survey data[25,30,31] and one study was conducted among a small sample of nursing home residents.[10] On the one hand, more high-quality studies of unintentional injuries in adults with cognitive disabilities are needed. On the other hand, ICF-based disability classification should be encouraged in the future studies. All studies that used the ICF-based disability found a consistent and statistically significant higher risk of unintentional injuries in adults with disabilities.[17,18,20,28,33,34,36,40] The advantage of the ICF-based disability classification is its multidimensional domains relating to anatomic body impairments, activity limitations, and participation restrictions in the physical, social and attitudinal environments.[45] Using ICF-based disability classification would make future studies around the world more comparable.

Our systematic review and meta-analysis found that fall-related injuries were the most frequent type of injuries among adults with disabilities. Of the 26 included papers, 9 studies[9,28,29,31,33–35,39,40] focused on falls, and 3 papers[10,20,30] focused on both overall injuries and falls. Of the 15 studies that focused on overall injuries, 4 investigated external causes of injuries suffered by individuals with disabilities.[11,17,18,38] Falls and overexertion were top two external causes of injuries among individuals with disabilities in these studies. Using 2004–2005 U.S. National Health Interview Survey (NHIS) data, Brophy et al reported that falls were the leading mechanism of injury regardless of disability status, but fall-related injuries were more common in adults with moderate and severe disabilities.[17] In the UK prospective cohort study among 511 adults with intellectual disabilities, fall was the leading cause of injuries.[30] However, many studies that focused on overall injuries did not have sufficient numbers of injury events for a meaningful analysis of the leading causes of injuries sustained by adults with disabilities.

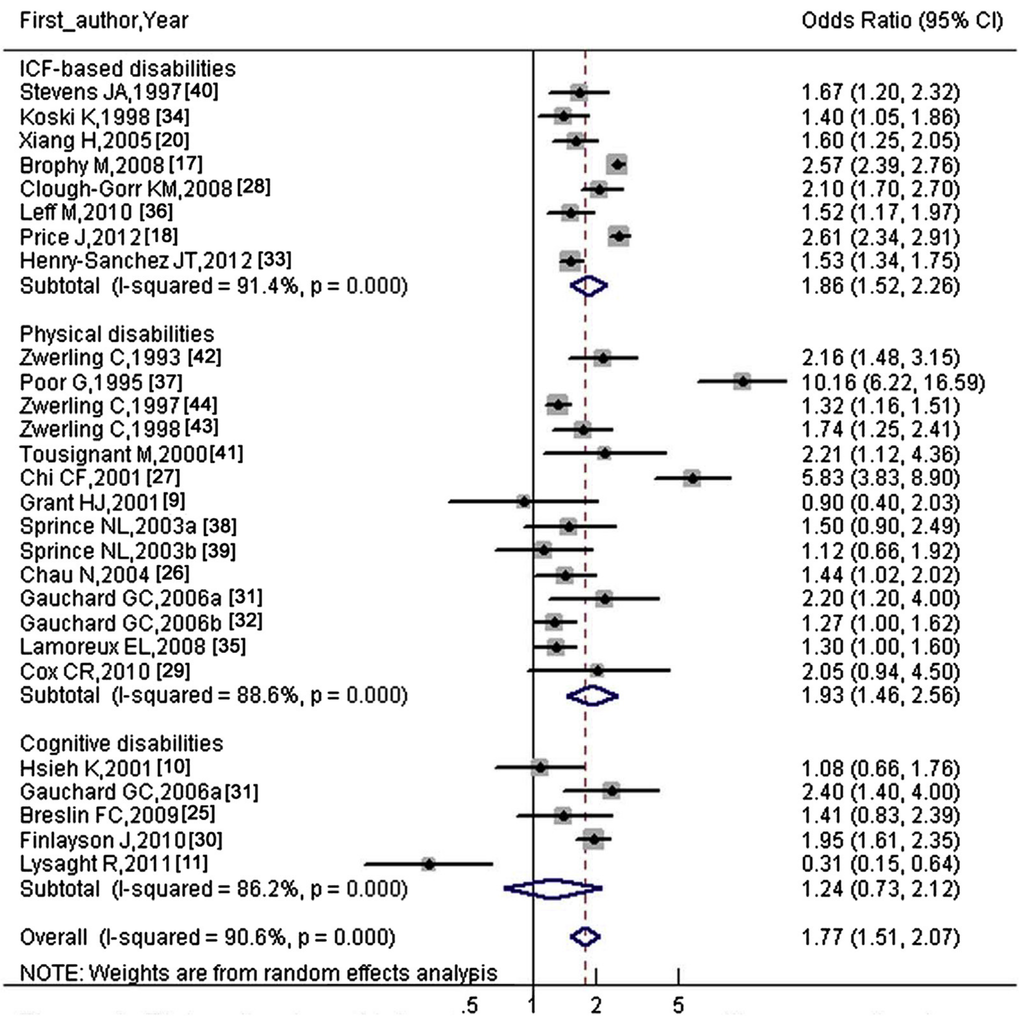

Fig. 4. Risk estimates of injury in people with disabilities according to definition and type of disability.

One special vulnerable population is workers with disabilities. About half of the 26 selected studies (12 studies) investigated occupational injuries suffered by adults with disabilities. The pooled estimate of OR of occupational injuries was significantly higher in adults with disabilities compared with their peers without disabilities. One study reported the risk of both non-occupational and occupational injuries using the 2006–2010 NHIS data and found that workers with disabilities were more likely than workers without disabilities to sustain both non-occupational and occupational injuries.[18] According to the American Community Survey, there are more than 6 million US workers with disabilities and they are employed in almost all industry sectors.[46] The World Health Survey in 51 countries reported employment rates of 52.8% for men with disability and 19·6% for women with disability, compared with 64.9% for non-disabled men, and 29.9% for non-disabled women.[1] Adults with disabilities who work in the informal economy do not often appear in labor market statistics, particularly in developing countries. Many people are understandably concerned that reporting an elevated risk of occupational injuries in workers with disabilities may discourage employers from hiring these individuals. In addition to safety concerns, employers often have concerns about productivity, absenteeism, high turnover, and costs associated with implementing accommodations in workplace and high insurance premium for workers with disabilities.[47] It is highly possible that some of the expressed concerns are misconceptions due to lack of direct experience of employing adults with disabilities.[47] Another important reason for some of the misconceptions is the lack of complete high quality data on occupational injury risk, patterns of occupation injuries, and medical care and expenditures for workers with disabilities. Occupational safety issues should be proactively addressed by government, funding agencies, disability advocacy groups, employers, trade unions and the community of individuals with disabilities.[18,48]

We have implemented several steps to ensure the quality of our meta-analysis. A pool of high quality original studies and assessment of potential bias in the selected publications are essential.[49] First, our inclusion criteria kept only the studies which reported unintentional injuries in individuals with pre-existing disabilities to ensure the clear temporal order of disability and injury,[36] especially in the cross-sectional studies. Second, literature selection and review in our study were conducted by following the recommended standard steps of systematic review and meta-analysis.[50] We implemented two rounds of independent reviewing of publications and one round of team discussion, which aimed to prevent potential paper selection bias by any individual researcher. Third, quality assessment of selected observational studies using the STROBE checklists indicated that the quality of the selected publications was moderate to high. However, our results should be interpreted in the context of several limitations. First, the operational definition of disability in the selected studies varied and different approaches were used to validate disabilities. In our pooled analysis, disability types included physical disabilities, cognitive disabilities, and ICF-based disabilities. Even in the same subgroup of disabilities, the definition of disability varied, such as the cognitive disabilities category which included mental disabilities, learning disabilities, and intellectual disabilities. Variation in operational definition of disability is an ongoing challenge in this discipline. Future studies are encouraged to use the ICF-based disability classification. Although a consensus regarding final operational items measuring disability has not been reached worldwide, ICF aims to provide a standardized disability classification for epidemiological studies to achieve comparability of data.[51] Another source of heterogeneity of our pooled analysis was the obvious variation of sample size between these included studies, ranging from 114 to 459,827. Second, the pooled risk estimates may overestimate or underestimate the associations between disabilities and unintentional injury due to the fact we present unadjusted ORs (stratified by disability definition, all injuries vs. falls, and occupational injury vs. non-occupational injury). Definitions and measurements of potential confounding variables (e.g., age, gender, family economic status, and other health conditions) varied significantly in the included studies; therefore, we could not conduct a meta-regression analysis to control for confounding variables. Third, workers with disabilities are less likely than workers without disabilities to be employed full time.[1,52] Ignoring working hours of workers could have introduced a bias by assuming that workers with disabilities had the same injury exposure time. Fourth, studies included in this systematic review and meta-analysis were from ten high-income countries and regions (USA, Canada, France, UK, German, Switzerland, Finland, Taiwan, Australia and Singapore). However, 80% of the world's populations with disabilities live in low-income and middle-income countries, in which fundamental injury risk data are absent, though they often have higher rates of injury and fewer support services than people in developed countries.[1,5] Finally, certain disabilities might have prevented some individuals from participating in the included studies and this could be a source of bias.

In summary, our review shows a significantly higher risk of unintentional injuries in adults with disabilities compared with those without disabilities. Although results of our review provided robust evidence that adults with disabilities are at significantly higher risk unintentional injuries than their peers without disabilities, evidence from original studies with well-designed injury prevention studies targeting individuals with disabilities was not found in the existing literature.[53] Identifying a higher risk of unintentional injuries in adults with disabilities is the initial step in the public health approach to prevention of injuries.[54] Future research should focus on health promotion and injury prevention in this high injury risk group, particularly in low and middle-income countries and in occupational settings. To foster opportunities for equitable engagement and participation in society, more research is needed to identify the types of physical and social environments that increase the vulnerability of people living with disabilities to preventable injuries.

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