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Disability symposium

Disability status: a risk factor in injury epidemiologic research

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ABSTRACT

Objective: We reviewed publications about nonfatal injuries among individuals with existing disabilities.
Methods: We identified original research articles reporting nonfatal injuries among individuals with disabilities by using three approaches: Search the PUBMED and MEDLINE electronic databases; scrutiny of the reference sections of identified publications; search of our own files. Studies that reported odds ratios or rate ratios of injuries for the disability variable and demographic variables of age, gender, race, and school education were included.
Results: A significantly greater risk of injuries was found among individuals with disabilities compared with their peers. Findings were consistent among studies in children, adults, and workers with disabilities. This association did not seem to be explained by physical environmental hazards alone or study bias. We found no original study that developed and evaluated injury prevention programs targeting individuals with disabilities.
Conclusions: Disability status should be considered as an important covariate in injury epidemiologic research, particularly in injury research among older populations and in children with special care needs. Future research is needed to develop and to evaluate multidisciplinary interventions to prevent injuries among individuals with disabilities.

Injury and safety research has recently emerged as an important new research area in studying secondary conditions in individuals with disabilities [1]. Secondary conditions, "any additional physical or mental health conditions that occurs as a result of having a primary disabling condition," [2] are an important concern facing individuals with disabilities [3,4], and injuries are considered one of top three secondary conditions by adults with disabilities (the other two are chronic pain and problems getting out/around) [4]. A recent systematic review and meta-analysis of observational studies on the risk of violence against adults with disabilities found that adults with disabilities, particularly those with mental illness, are at a higher risk of violence than are adults without disabilities [5]; similarly, results from a meta-analysis found that children with disabilities also face a greater risk of violent injury [6]. Although an increasing amount of evidence has demonstrated that individuals with disabilities also have a significantly increased risk for unintentional injuries [1], study methods and the definitions of disability vary widely, and no systematic literature review of this research has been undertaken. To summarize the existing evidence about the risk of nonfatal injuries among individuals with disabilities, we performed a systematic literature review of original epidemiologic studies to address three specific questions: Is disability status an important risk factor that should be considered together with sociodemographic variables in injury research? Are findings consistent in studies that investigated nonfatal injuries among children, adults, and workers with disabilities? What approaches were used in previous studies to define disability status?

Methods

Study identification

We used three approaches in identifying peer-reviewed articles for this literature review. First, we searched the PUBMED Central and MEDLINE to identify research studies that reported injuries among individuals with disabilities. Peer-reviewed articles were searched in the PUBMED Central with the use of the MeSH (Medical Subject Headings) terms "Wounds and Injuries/epidemiology"[Majr] AND "Disabled Persons"[Mesh]" as secondary endpoints. We used combinations of terms "injury," "injuries," "disability," and "disabilities," to search MEDLINE articles for injuries among individuals with disabilities. Second, reference sections of the identified publications were scrutinized for additional

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peer-reviewed articles that were not identified in the PUBMED and MEDLINE. Third, our team has been conducting research and publishing articles in peer-reviewed journals in the past 10 years. We searched our own files for additional publications.

Inclusion criteria

To be included in our literature review, publications had to meet the following criteria: (1) Published in English; (2) an original research article published in a peer-reviewed journal; (3) investigate injuries among individuals with existing disabilities; (4) include at least two out of four demographic variables age, gender, education, and race/ethnicity; (5) report odds ratios (OR) or relative risks (RR) for the disability variable and the demographic variables; and (6) report nonfatal unintentional injuries. Because systematic reviews and meta-analyses of the prevalence and risk of violence against adults [5] and children [6] with disabilities have been published recently, studies focused on violent injury were not included. We included studies when injury intent was unknown or not reported and those studies that reported unintentional and intentional injuries (harm by self or others). The third criteria excluded papers that reported disability caused by injuries. We excluded commentaries that lacked original research data.

Study selection

Studies identified from our literature searches were downloaded to a shared computer drive. Two researchers (HX and KW) independently reviewed each study and decided on study eligibility for literature review.

Disability definitions

The articles reviewed here use a number of disability definitions, including research studies which use concepts from the International Classification of Functioning, Disability and Health (ICF) [7]. The ICF provides three categories of problems with functioning: Impairments, activity limitations, and participation restrictions. These are seen as interconnected. In addition, the ICF recognizes the role of environmental and personal factors, although these are less frequently measured. The report by Altman [8] in this issue provides details on the issues involved in defining and measuring disability.

Results

The characteristics and sociodemographic and disability results of the 15 studies that met our inclusion criteria are listed in Table 1 [9–23]. Some high-quality reports, although not reporting the ORs or RRs separately for disability and demographic variables, are included in an Appendix because they provide important findings [4,24–31]. For each study in Table 1, Figure 1 provides the OR/RR and their 95% confidence intervals for the disability variables.

Of the 15 original studies included for the comprehensive review, 8 studies reported injuries among children with disabilities, 3 reported injuries among adults with disabilities, and 4 focused on work-related injuries among workers with disabilities. Three studies used a prospective study design to collect injury data [12,18,23], and one used a case-control design [20]. Disability was determined in a variety of ways; special education [10–12] and government and Medicaid eligibility criteria [9,20,21,23], Short Form-12v2, version 2 Health Survey questions [22], and self-reports [13–19,22]. Five studies use ICF concepts in the survey questions [14–17,20]. Injuries were parent/guardian reported [17,20,21,23] or self-reported [13–16,18,19,22] in 10 studies, reported by teachers in 3 studies, [10–12] and determined using Medicaid claims data in 1 study [9]. All studies, except one study from Canada [13], reported that individuals with disabilities had a significantly greater risk than their controls for injuries.

Injury among children with disabilities

Some of the studies among children focused on specific types of disability or types of injury. For example, three of the studies shown in Table 1 only included children enrolled in special education schools [10–12] and one followed a cohort of children with intellectual disabilities (ID) [23]. Ramirez et al. [11] found that children with multiple disabilities and other disabilities had higher adjusted ORs (AORs) of injury than their peers with developmental disabilities. In this study, the associations between injury and age were not significant when included in multivariable models with disability status; males had a slightly increased odds compared with females [11]. When this same group of authors focused on head injuries, their multivariate model showed that age and gender were not significant variables, but disability status was significant. Specifically, when children with mental/emotional disabilities are used as the reference group, children with multiple disabilities had the highest incidence density ratio of head injury (2.4), followed by children with physical disabilities, incidence density ratio (1.8). In a third study in this population of students enrolled in special education schools, students with autism as well as students with multiple disabilities had greater crude sports injury rates when compared with their peers with ID [12]. However, the sports injury–adjusted RR for those with multiple disabilities was not significant. The adjusted rates of sports injury across gender and age groups did not differ [12]. In another study evaluating injury risk in a cohort with ID, age and gender were not significant variables; instead, epilepsy and the degree of psychopathology and sociability were important factors [23].

Ohio Medicaid claims data were analyzed by our research team, and the results indicate that the incidence of burn injuries among children with disabilities was significantly greater than those among children without disabilities [9]. In this study, gender, age, and race were also associated with burn injuries. Age had the strongest association, followed by disability status.

More recent work among children makes use of the ICF conceptualization of disability [17]. Only children who were limited in their social roles because of specific health conditions were defined as disabled in a 2005 study by Xiang et al. [17]. This study found that, even after controlling for sociodemographics, children with social role limitations from vision/hearing impairments, attention deficit/hyperactivity disorder, or chronic asthma had higher rates of nonfatal injuries compared with children without reductions in social role activities. In separate models for the four types of disability, the disability-specific AORs ranged from 1.65 to 2.18. Gender, age, and race also remained significant in the multivariable models.

Two studies from China comparing children with and without disability have recently been published [20,21]. Tsang et al. [21] found that the adjusted odds of unintentional injury in the home environment among children with ID was 2 when compared with children without disabilities. Zhu et al. [20] conducted a matched, case-control study and used an ICF-based definition of disability. They found the unadjusted OR of medically treated injury was 4.46 for children with disabilities compared with children without disabilities. These authors also explored the role of environmental factors in the home. Having a cat or dog in the home environment resulted in an increased OR of injury among children with or without disabilities.

Table 1
Summary of selected epidemiology studies of nonfatal injuries in individuals with disability

First author, year reference [No]	Data source and sample size	Disability definition and severity of disability	Injury definition	Crude effect (OR/RR)*	Adjusted effect (OR/RR)*	Principal Findings
Children						
Sherrard, 2002 [23]	Prospective cohort of young people with intellectual disability in the ACAD program; n = 465 young people 5–29 years old	ACAD enrollment; Cohort subset is representative of the Australian known population with ID based on subject IQ levels; Reference groups: Variable dependent, e.g. those without epilepsy, those with lower sociability or psychopathology scores	Medically attended injury based on carer reports and medical records; included unintentional and intentional injuries described elsewhere [32]		Disability OR range: **1.02**–3.49 Age OR: 1.01 Gender OR: 1.47	Among those with ID, the presence of psychopathology, epilepsy, or an overly sociable temperament were associated with injury. Social and family variables had minimal influence on injury risk.
Ramirez, 2004 [11]	Retrospective review of 1994–1997 Pupil Accident Reports from 17 special education schools in Los Angeles; n = 6769 children 3–23 years old	Annual evaluation for special education services using California Department of Education definitions; Reference group: students with developmental disabilities	Physical trauma reported by the school staff in the Pupil Accident Reports; Included unintentional and intentional injuries		Disability OR range: 1.2–**1.7** Age OR range: 1.1–1.2 Gender OR: **1.2**	Children with multiple disabilities had the highest AORs. Males had a slightly increased AOR. The association between age and injury was weak and imprecise. Falls were the leading cause of injury.
Limbos, 2004 [10]	Retrospective review of 1994–1997 Pupil Accident Reports from 17 special education schools in Los Angeles; n = 6769 children 3–23 years old	Annual evaluation for special education services using California Department of Education definitions; Reference group: students with emotional/mental disabilities	Head injury was reported by the school staff in the Pupil Accident Reports; Intent was not assigned		Disability RR range: 1.0–**2.4** Age RR range: 0.6–1.2 Gender RR: 1.2	When compared with children with emotional/mental disabilities, the highest incidence density rate ratio for head injury was among children with multiple disabilities (RR = 2.4), followed by children with physical disabilities (RR = 1.8). Falls were the leading cause of head injury.
Ramirez, 2009 [12]	Prospective data collected for 2002–2003 season from 8 special education high schools; n = 210 high school athletes with disabilities	Annual evaluation for special education services using California Department of Education definitions; Reference group: students with ID	Injury episodes were defined as events resulting in immediate removal of the athlete from the session and medical treatment by school staff or transport to a hospital; intent was not reported	Disability RR range: 1.5–**4.6** Age RR range: 1.3–1.9 Gender RR: 1.1	Disability RR range: 0.9–**4.8** Age RR range: 1.5–1.7	High school athletes with autism had ~5 times the sport injury rate when compared with athletes with ID. The sport injury RR for those with multiple disabilities was not significant. Collision with another person was the leading cause of injury.
Xiang, 2005 [17]	Cross-sectional data from the 2000–2002 NHIS survey; n = 57,909 children 5–17 years old	ICF definition†; Activity limitations among children with four disabling conditions: vision/hearing, MR, ADD/HD and asthma; Reference group: Children without disabling limitations	Parent/guardian self-reported medically treated injuries; intent was not reported	Vision/hearing OR: **1.74** MR OR: 1.33 ADD/HD OR: **1.88** Asthma OR: **2.39**	Disability OR range: 1.16–**2.18** Age OR range: 1.19–**1.87** Gender OR range: **1.33**–**1.34** Race OR range: **1.99**–**2.12**	Children with disability had a significantly higher odds of nonfatal injuries compared with children without disability.
Chen, 2007 [9]	Cross-sectional data from Ohio Medicaid claims data fiscal year 2002; n = 551,992 children 0–11 years old	Met criteria of disability for Medicaid eligibility; Reference group: Nondisabled children in other Medicaid eligible groups	Burn injury cases identified in the Medicaid claims data; intent was not reported	Disability OR: **1.42** Age OR range: **1.75**–**7.2** Gender OR: **1.30** Race OR range: **0.67**–**0.88**	Disability OR: **1.80** Age OR range: **1.70**–**7.15** Gender OR: **1.29** Race OR range: **0.64**–**0.91**	Children with disability had a significantly higher incidence of burn injuries compared with children without disability.

Tsang, 2012 [21]	Cross-sectional data from 2 mainstream and 3 special primary schools in Hong Kong (2009); n = 186 children 6–12 years old	Met criteria for ID of the Central Registry for Rehabilitation in Hong Kong, attending special schools; Reference groups: Nondisabled school children from mainstream schools; children with both ID and epilepsy diagnoses were compared with non-epileptic children (those with and without ID)	Parent/guardian reported unintentional household injuries	ID OR: **3.41** ID/epilepsy OR: **12.38** No significant or marginally significant relationships with unintentional household injuries for age, gender of child, or caregiver education	ID OR: **2.57** ID/epilepsy OR: **6.22**	Primary school age children with ID and epilepsy had higher odds of unintentional household injury when compared with children without those disabilities.
Zhu, 2012 [20]	1:1 Matched case-control study (2011); n = 2402, 1201 cases, 1201 controls	Met criteria of the China Disabled Persons' Federation and ICF definition,† disabling condition for ≥12 months before interview; Reference group: Nondisabled child matched on gender, age, and neighborhood	Parent/guardian reported medically attended injuries in past 12 months; intent was not reported	Disability OR: **4.46** Gender OR: 1.21 Age OR range: 0.91–1.31 Parent education OR: 1.90–**2.48**		Children with disabilities had a significantly higher prevalence of injury than age/gender/neighborhood matched children without disabilities.
Adults						
Xiang, 2005 [16]	Cross-sectional data from the 1999–2000 Colorado Disability Survey; n = 2713 adults 18 years or older	ICF definition†; Self-reported activity limitations and participation restrictions; Three levels of disability: no limitation, moderate limitation, and severe limitation	Unintentional injuries that resulted in medical treatment, or limited usual activities for a day or more in the past 3 months	Moderate disability OR: **1.50** Severe disability OR: **2.19**	Moderate disability OR: **1.87** Severe disability OR: **3.72** Gender OR: **1.66** Age OR range: 1.40–**3.32** Race OR range: 1.89–2.44 Education OR range: 0.70–0.99	Adults with disability had an increased risk of nonfatal unintentional injuries. The leading cause is falls.
Brophy, 2008 [14]	Cross-sectional data from the 2004–2008 NHIS; n = 135,091 adults ≥18 years	ICF definition†; Self-reported activity limitations and participation restriction; Three level of disability: no limitation, moderate limitation, and severe limitation	Self-reported medically treated injuries; intent was not reported	Moderate disability OR: **1.69** Severe disability OR: **2.54** Gender OR: **1.15** Age OR range: **0.80**–0.95 Race OR range: **0.64**–**0.83** Education OR range: 1.00–**1.25**	Moderate Disability OR: **1.68** Severe disability OR: **2.98** Gender OR: **1.25** Age OR range: **0.64**–1.05 Race OR range: **0.59**–**0.72** Education OR range: **0.83**–**1.23**	Adults with disability had an increased risk for nonfatal injuries. Falls were the leading cause of injury, and were more common among the moderately and severely disabled.
Xiang, 2008 [22]	Cross-sectional wave I data of the NESARC 2001–2002; n = 31,276 White and Black adults ≥18 years	Norm-based physical health score based on the SF-12V2 < 30	Self-reported unintentional injuries that resulted in medical treatment, or limited usual activities for more than a half day in the past 12 months		Disability OR for males: **1.60** Disability OR for females **1.79** Age OR range: **1.10**–**2.84** Race OR range: 1.10–**1.20** Education OR range: **0.91**–**1.17**	The significant association between obesity and nonfatal unintentional injuries was mediated substantially by disability.
Workers						
Zwerling, 1997 [19]	Cross-sectional data from the 1985–1994 NHIS; n = 459,827 nonfarm workers 18–65 years old	Self-reported impairments that kept workers from working or limited the kind or amount if work they could do	Self-reported occupational injuries in the last year that caused a residual limitation in the worker's ability to work at the time of the interview; Intent was not reported	Work limitations OR: **1.32** Age OR range: **1.24**–**1.25** Gender OR: **1.78** Race OR range: **0.74**–1.07	Work limitations OR: **1.36**	Work limitations were associated with a 36% increased risk of occupational injuries.

(*Continued on next page*)

Table 1 (*Continued*)

First author, year reference [No]	Data source and sample size	Disability definition and severity of disability	Injury definition	Crude effect (OR/RR)*	Adjusted effect (OR/RR)*	Principal Findings
Zwerling, 1998 [18]	Prospective cohort data from the 1992 Health and Retirement Study; n = 5600 nonfarm workers 51–61 years old	Self-reported impairments that limited their work capacity; vision and hearing impairment	Self-reported occupational injuries since last interview that required medical treatments or interfered with worker's work activities; intent was not reported	Work limitations OR: **1.74** Vision impairment OR: **1.81** Hearing impairment OR: **1.72** Age OR: 0.78 Gender OR: **1.45** Race OR: 1.03 Education OR: **2.35**	Work limitations OR: **2.15** (cross-sectional), **1.58** (longitudinal) Vision impairment OR: **1.53** (cross-sectional), 1.45 (longitudinal) Hearing impairment OR: **1.60** (cross-sectional), 1.35 (longitudinal)	Work limitations, vision impairment, and hearing impairment were associated with occupational injuries among older workers.
Breslin, 2009 [13]	Cross-sectional, population-based 2003 Canadian Community Health Survey; n = 14,379 persons 15–24 years old who were employed in the past 12 months	Self-reported medical diagnosis for dyslexia and other learning disability, ADHD/ADD	Self-reported occupational injuries during the 12-month period that limited respondent's normal activities; intent was not reported	Dyslexia OR: 2.72‡ Other learning disability OR: 0.78‡ ADHD/ADD OR: 2.08‡ Age OR range: 0.31–1.27‡ Gender OR: 2.39‡ Education OR: 0.91–3.24‡	Dyslexia OR: 1.89 Other learning disability OR: 0.63 ADHD/ADD OR: 1.06 Age OR range: 0.38–1.76 Gender OR: **1.65** Education OR range: 1.09–1.86	Unadjusted likelihood of occupational injuries was twice as high among young workers with learning disability or ADHD/ADD, but this elevated risk was eliminated after controlling for demographic and job characteristics.
Price, 2012 [15]	Cross-sectional NHIS 2006–2010; n = 183,676 workers, ≥18 years of age	NHIS survey questions based on the ICF†	Self-reported nonoccupational and occupational, medically treated injuries in the 3 months before the interview; Intent was not reported		Disability OR range: **2.35–2.39** Gender OR range: 1.09–**1.60** Age OR range: 0.88–**1.26** Race/ethnicity OR range: **0.66**–0.99 Education OR range: **0.75–1.93**	Disability status was associated with both nonoccupational and occupational injuries among U.S. workers. Falls were the leading cause of injury.

ACAD = Australian Child and Adolescent Development; ADD/HD = attention deficit/hyperactivity disorder; AOR = adjusted odds ratio; ID = intellectual disability; MR = mental retardation; NESARC = National Epidemiologic Survey on Alcohol and Related Conditions; NHIS = National Health Interview Survey; OR = odds ratio; RR = relative risk; SF = Short Form.

* Statistically significant OR/RR are bolded.

† ICF definition: *International Classification of Functioning, Disability, and Health* definitions include concepts and questions regarding impairments, activity limitations, participation restrictions, and possibly environmental and personal factors.

‡ Statistical significance not reported for crude odds ratios.

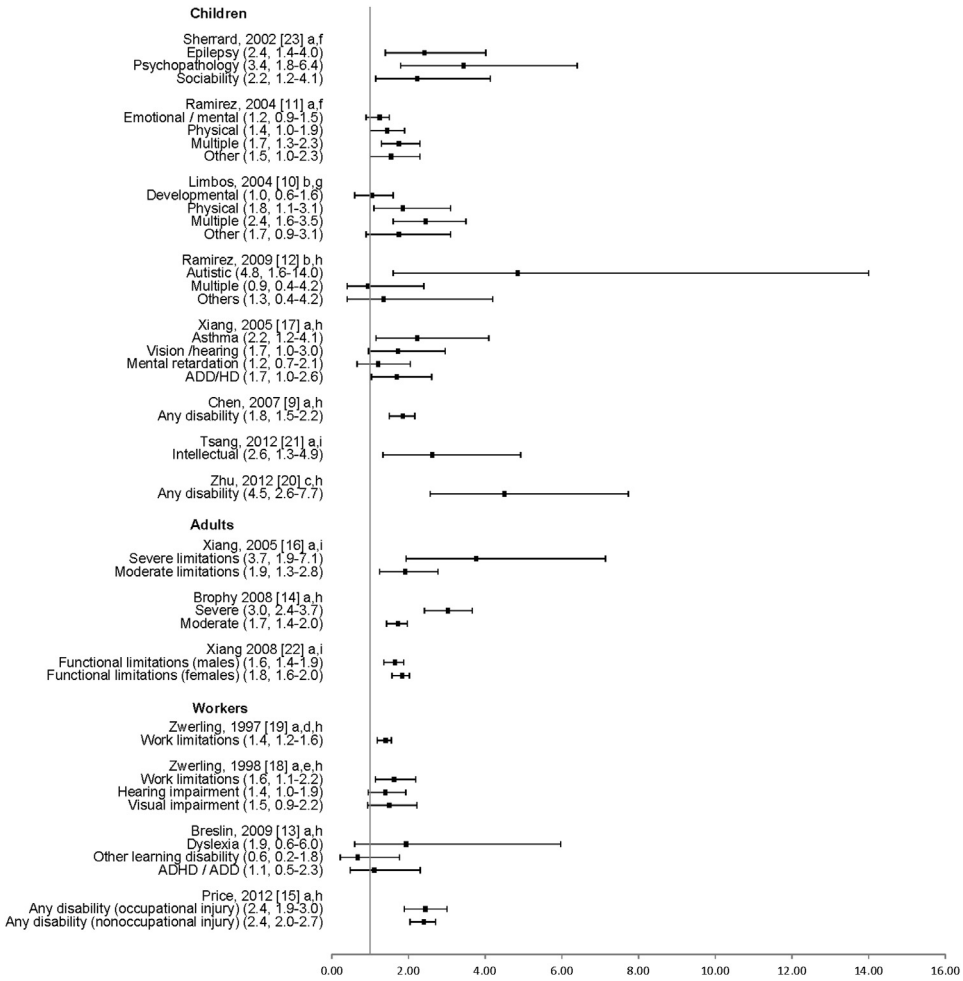

Fig. 1. Risk estimates of injury in people with disabilities (studies in Table 1). a = adjusted odds ratio; b = adjusted rate ratio; c = unadjusted odds ratio; d = impairment specific odds ratios based on the subset reporting conditions; e = longitudinal; f = included unintentional and intentional injuries; g = intent was not assigned; h = intent was not reported; i = unintentional injuries.

Injury among adults with disabilities

Three studies among adults are shown in Table 1 [14,16,22]. Each study utilized cross-sectional data to examine the association of disability on medically treated injuries. One study used data from one state and two used nationally representative datasets. Xiang et al. [16] used data from the 1999/2000 Colorado Disability Survey which utilized an ICF conceptualization of disability, which considered activity limitations and participation restrictions. Compared with adults without disability, those with moderate disabilities had an injury AOR of 1.87 and those with severe disabilities had an AOR of 3.72. In the multivariable model controlling for disability status and other confounders, younger age adults (18–24 years) had an elevated odds of injury (AOR, 3.32). Among males the AOR was 1.66. Race and education were not significant in the final multivariable model.

Using the 2004/2005 National Health Interview Survey (NHIS) to assess the association between disability and the risk of injury, Brophy et al. [14] found that adults with disabilities had an increased OR of injury. In the multivariable model, for moderate disabilities, the AOR was 1.68, and for those severe disabilities, the AOR was 2.98. Among males, the AOR was 2.25, the race AOR ranged from 0.59 to 0.72. Age was not significant. Those with some college had an increased odds of injury (AOR, 1.23) compared with those with a bachelor's degree.

Xiang et al. [22] evaluated disability's role in the association between obesity and injury using the National Epidemiologic Survey on Alcohol and Related Conditions. Males and females were considered in separate models. The final models contained age, race, poverty, education, the presence of a medical condition, body mass index categories, disability (assessed using the Short Form-12 version 2), and the number of injury behavioral risk factors. Disability remained a significant variable with an AOR of 1.60 in males and an AOR of 1.79 in females. Age, race, and education were significant variables in the models for both males and females. Additionally, the odds of injury increased with increasing numbers of reported behavioral injury risk factors.

Occupational injury among workers with disability

Four studies considered occupational injuries among those with disabilities. Two of the studies compared workers with impairments or health problems (i.e., work disabilities) that limited work capacity with those without limitations to work capacity [18,19]. These studies reported that work disability is associated with occupational injury. The first study used 1985 through 1994 NHIS data [19]. Gender, age, race, ethnicity, and work disability each had significant unadjusted ORs. The multivariable model considered different types of disability but only included variables for occupation, self-employment, and age. The second study examining

work disability was a prospective study of older workers, aged 51 to 61 years [18]. Work disability, gender, and education had significant unadjusted associations with occupational injury, but age and race did not. The multivariable models again did not include the sociodemographic variables, instead focused on disability type, occupation, job requirements, and self-employment.

Two studies examined disability, without regard to limitations in work capacity. Breslin et al. [13] compared young adults with learning disabilities with those without learning disabilities. In the multivariable model, neither learning disability nor age were significant variables. Education had a marginally significant association with injury. Males had a significant AOR of work-related injury. Price et al. [15] used data from the 2006 through 2010 NHIS to examine nonoccupational and occupational injury among U.S. workers. Multivariate models adjusted for gender, age, marital status, race/ethnicity, education, occupation, hours worked, self-employment, health insurance, and nativity. The AOR of nonoccupational injury and occupational injury among workers with disabilities were 2.35 and 2.39, respectively, compared with workers without disabilities. Although disability had the strongest associations with occupational and nonoccupational injury, males also had a significantly higher adjusted odds of occupational injury (AOR, 1.60). In the multivariate model for nonoccupational injury, those in the age category (18–34 years) had an AOR of 1.26, and lower odd ratios were seen among non-Whites. Those with less education had lower AORs of nonoccupational injury, but higher AORs of occupational injury.

Discussion

We systematically reviewed studies that reported the risk of nonfatal injuries among individuals with disabilities. To answer the question, "Should disability status be a covariate in most epidemiology research?", we restricted our consideration to studies that reported ORs or RRs for the disability variable and for at least two demographic variables. The magnitude of the ORs/RRs for the disability variable was at least the same or larger than the ORs/RRs for the demographic variables in almost all the studies reviewed.

Prevention

Our literature review provides evidence that addresses the first step of the public health approach to preventing injuries among individuals with disabilities: Identifying studies that describe the greater prevalence of injuries and the elevated ORs and RRs among individuals with disabilities compared with their peers without disabilities. The Appendix describes additional studies that did not meet the inclusion criteria for this systematic review, but also showed the increased risk for injuries among individuals with disabilities. Some studies have compared patterns of injuries, such as leading cause of injuries [10–12,14–16,20,21,24,27,32,33], injured body region [10–12,20,32], type of injury [10–12,14,20,26,27,32], and activity at the time of injury [10–12,14,16,20,26,27,32] between the two groups. This type of important evidence may be necessary in designing intervention programs targeting individuals with disabilities.

Patterns of injuries were not significantly different in children with and without disabilities in the 1997 through 2005 NHIS study [27] and the 2006 through 2007 NEISS study [24]. Among adults, two studies using NHIS data showed that falls are the leading mechanisms of injury regardless of disability status [14,15]. These findings suggest that perhaps existing effective injury prevention strategies [34] targeting the general population may be effective in preventing injuries in people with disabilities. A recent review of risk factors and preventive strategies for injuries caused by falls in people with ID provides evidence that falls are common, but there is little evidence of effective interventions to prevent falls among people with ID [35]. The authors identified a few main risk factors and suggested that environmental safety, careful medical management, and exercise interventions may play an important role in minimizing unintentional injuries caused by falls among people with ID [35].

Very little original research has evaluated effective strategies that prevent injuries among individuals with disabilities [36,37]. The main factor that may have prevented the research community from conducting original research into effective injury prevention strategies targeting individuals with disabilities is the sample size needed for such a study and the challenge in recruiting individuals with disabilities. Others have argued that instead persons with disabilities should be included in mainstream studies [38].

Limitations

We found substantial variability in the disability definitions in the studies that we reviewed. Only two studies [14,16] we reviewed assessed the association between severity of disabilities and risk of injuries, a third is described in the Appendix [29]. All three reported a significant dose–response relationship between disability severity and the ORs of injury risk [14,16,29]. Future studies about injuries among individuals with disabilities not only need to use the newer ICF framework to classify disabilities, but also need to assess severity of disabilities. The ICF framework is likely to provide a disability classification system that allows comparisons between studies as well as promotes a systematic approach in injury risk factor assessment and injury prevention evaluation among individuals with disabilities.

Another limitation relates to our methods of identifying relevant articles. We did not search for articles lacking the terms 'disability' or 'disabilities.' We also did not use the terms like "falls" or "poisonings" to search for injuries. We might have included additional articles if we had included specific potentially disabling conditions like stroke [39,40], attention deficit disorder [41–43], or psychiatric disorders [44,45]. Although we were specifically interested in unintentional injuries, many of the reviewed studies included intentional and unintentional injuries [11,23] or they did not report intent and may include intentional injuries [9,10,12–15,17–20].

In conclusion, disability status seems to be an important risk factor in injury epidemiology research, particularly among special care needs children and older adults. In 14 of the 15 studies that reported ORs or RRs for disability and other demographic variables, a greater risk of injuries was found among individuals with disabilities compared with their peers. Findings about the significant association between disability status and secondary injuries are consistent among studies of nonfatal injuries among children, adults, and workers with disabilities. This association does not seem to be explained by physical environmental hazards alone [20,29] or study bias. No original study was found to develop and assess effective injury prevention strategies. Future research needs to use the ICF framework to promote comparisons between studies and to test multidisciplinary interventions in preventing secondary injuries among individuals with disabilities.

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Appendix

Studies that do not meet the inclusion criteria for the systematic review

Studies of youth, adults, and workers that do not report ORs or RRs for demographic variables have also found that individuals with disabilities are at significantly greater risk than their counterparts without disabilities [4,25–27,29–32,46–49]. These studies are not included in the systematic review. However, this Appendix briefly describes and provides risk estimates from some of them [4,24–31] (Fig. 2). A retrospective cohort study of 269,919 school children found the rate of injury among children with disabilities was over twice that seen in children without disabilities, and children with orthopedic disabilities had the greatest risk [31]. Using data from the 2003 to 2004 National Survey of Children's Health, Lee et al. [25] reported that children with certain developmental disabilities had a significantly greater risk of experiencing an injury that needed medical attention than children without disability after adjusting for gender, age, number of children in the household,

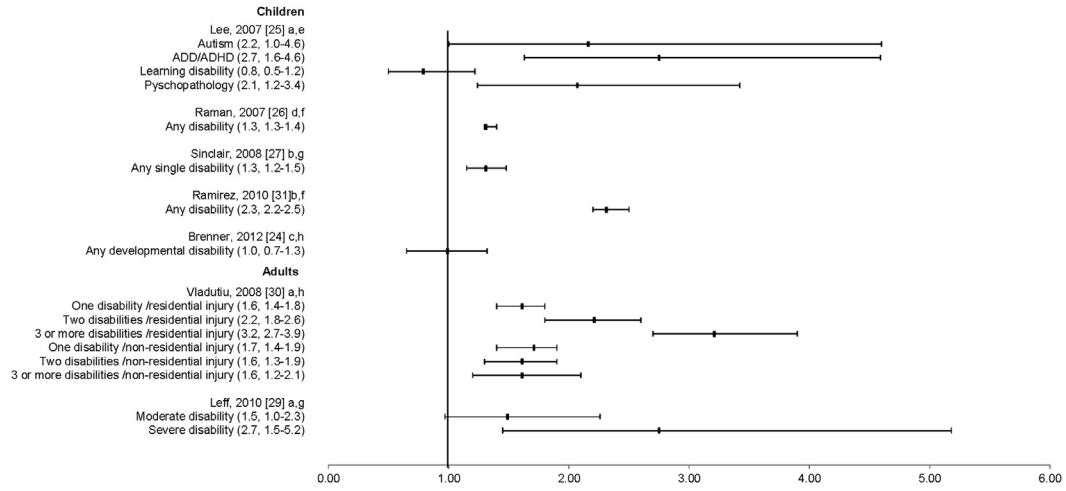

Fig. 2. Risk estimates of injury in people with disabilities (additional studies). a = adjusted odds ratio; b = adjusted rate ratio; c = unadjusted odds ratio; d = adjusted relative risk; e = intent was not assigned; f = includes unintentional and intentional injuries; g = intent was not reported; h = unintentional injuries.

race, and family poverty level. The adjusted odds ratio (OR) was 2.74 (95% confidence interval [CI], 1.63–4.59) for children with attention deficit/hyperactivity disorder and 2.06 (95% CI, 1.24–3.42) for children with psychopathology. The adjusted OR for children with learning disabilities was 0.78 (95% CI, 0.50–1.22). In contrast, Brenner et al. [24] also recently considered youth with different types of developmental disabilities using data collected in emergency departments (2006–2007 National Electronic Injury Surveillance System); only those youth with learning disabilities were found to have higher injury rates. Two other national studies used disability definitions based on functional limitations and participation restrictions [26,27]. Using 1997 to 2005 National Health Interview Survey (NHIS) and controlling for sociodemographic variables, Sinclair and Xiang [27] found that only children with emotional or behavioral problems had a significantly higher risk of injury compared with children without a disability (adjusted prevalence ratio, 1.50; 95% CI, 1.15–1.97); this study excluded children reporting multiple limitations. A cross-sectional study from Canada, the 2002 Health Behavior in School-aged Children Survey, interviewed 7235 students in grades 6 to 10 and found that students with disabilities had an adjusted relative risk of 1.3 (95% CI, 1.3–1.4) [26]. Consistent and significant associations were found between three kinds of injuries (medically treated injury, multiple injury, and severe injury) and different types of disabilities [26]. The authors hypothesized that children with disabilities have higher risk for injury than their counterparts owing to their inability to perceive and avoid environmental hazards.

Higher rates of nonfatal injuries were also reported for adults with disabilities [4,29,30]. Kinne et al. [4] reported an adjusted OR of injuries (OR, 3.12; 95% CI, 2.07–4.71) as a secondary condition among adults with disabilities using data from the 2001 Washington State Behavioral Risk Factor Surveillance Survey. Results from the 1999 to 2000 Colorado Disability Survey [29] and the NHIS [30] provide additional evidence that adults with disabilities are at a significantly greater risk of nonfatal, unintentional injuries than their peers without disabilities. The risk of injury in the residential environment among adults with disabilities were found to increase with increasing number of disabilities among adults who self-reported medically treated injuries in the 2004 to 2006 NHIS [30]. Results from investigating 6327 occupational injuries, collected by the Labor Insurance Bureau in Taiwan, indicated that injury rate in workers with disabilities was about four to seven times the injury rate in workers without disabilities for all gender and age groups [28]. Based on these findings, authors emphasized the importance of identifying injury risk factors associated with the working environment and have advocated for improving safety among workers with disabilities [28].

Environmental factors and an inability to perceive and avoid environmental hazards have been proposed as risk factors to explain why individuals with disability have a significantly higher risk of unintentional injuries than individuals without disabilities [26,29,30,50]. The only U.S. study we could find that specifically evaluated role of environmental factors in the association between disabilities and nonfatal injuries is a study from the 1999 to 2000 Colorado Disability Survey [29]. Twenty-five environmental factors were assessed by the Craig Hospital Inventory of Environmental Factors. Although environmental factors did attenuate the OR of injuries among adults with severe disabilities, disability status continued to be an independent risk factor for nonfatal injury after adjustment for environmental factors. Additionally, injured individuals with and without disabilities reported similar problems with environmental factors including physical environment, social attitudes, and policies [29]. Findings from this study suggest that environmental factors play some role in the association between disabilities and injuries. The reviewed case-control study from China also considered eight environmental risks in the home; only one environmental risk—having a cat or dog—was found to be associated with injury for both children with and without disabilities [20] A disproportionally high percentage of injuries among adults with disabilities occur inside the home [14,16], whereas studies among children with disabilities are less conclusive [27,51]. Vladutiu et al. [50] found that households with at least one resident with a disability had a lower proportion of household hazards when compared with households without a resident with a disability.