ORIGINAL ARTICLE

Depressive symptoms as a risk factor for unintentional injury: a cohort study in a rural county

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Objective: The authors used data from a population based prospective cohort study to determine if depressive symptoms predicted incidence of unintentional injury.
Methods: The Keokuk County Rural Health Study, based in Iowa, is a prospective cohort study of health status that includes injury outcomes. Depressive symptoms were measured using the 11-item Center for Epidemiologic Studies Depression Scale at the beginning of the study on 1493 participants. Quarterly follow up phone calls were made to measure injury incidence.
Results: 471 injuries were reported for an overall injury rate of 9.8 per 100 person-years. Crude injury rates were significantly higher for those with depressive symptoms (p = 0.0003). Those with depressive symptoms had a 41% increased risk for injury after controlling for antidepressant medication use, gender, prior injury, income, and sleepiness (RR = 1.41, 95% CI 1.10 to 1.80). Depressive symptoms remained a risk factor for injury regardless of current antidepressant medication use (no medication use, RR = 1.43, 95% CI 1.09 to 1.88; medication use, RR = 1.31, 95% CI 0.76 to 2.26).
Conclusions: Depressive symptoms were found to be risk factors for unintentional injury. Medical practitioners should consider talking about safety with their patients, especially those reporting symptoms of depression, and recognize that an increased risk for injury remains until the depressive symptoms subside.

Post-traumatic stress disorders, anxiety syndromes, and depression commonly follow events such as unintentional falls,[1 2] motor vehicle crashes,[3 4] workplace injuries,[5] and traumatic brain injuries.[6–8] While many studies have examined depression as an outcome of injury, depression is rarely examined as a risk factor for injury, even though mechanisms exist to support this hypothesis. Medications used to treat depression have been linked with increases in a variety of occupational injuries, as well as accidental falls in the elderly.[9–12] Additionally, untreated depression has been correlated with symptoms that are risk factors for unintentional injury such as a lack of concentration and daytime drowsiness. The few studies that considered such psychological risk factors for injury have been cross sectional, making it difficult to determine which occurred first—the injury or the psychological symptoms.[13–15]

Depression affects approximately 121 million people worldwide and is among the world's leading causes of disability.[16] Furthermore, each year, injuries kill more than 5 million people worldwide and by 2020, injuries will be the third leading cause of death and disability worldwide.[17] Although depression and injury remain global public health problems, both are treatable and preventable. Depression can easily be diagnosed and treated, while minor modifications such as seatbelts, helmets, or smoke alarms often have significant effects on injury risk and mortality.

Here, we analyze data from a population based prospective cohort study to determine if depressive symptoms are a predictor of subsequent injury. The Keokuk County Rural Health Study provides a unique opportunity to examine depression, both treated and untreated, as a risk factor for unintentional injury in a longitudinal manner. To the best of our knowledge, this is the first prospective analysis to examine depression as a risk factor for unintentional injury in a large cohort.

METHODS

Study design and population

Our study is nested in the Keokuk County Rural Health Study (KCRHS). The KCRHS is a population based, 20 year prospective cohort study of health status and injury of a large stratified random sample of households located in a single rural Iowa county. The sample was randomly selected from a compiled list of all county households.[18] Of the 3749 households invited, 273 were not eligible, 1204 could not be reached by phone, and 1262 declined to participate. One thousand two households, with 1582 individual participants older than 18 years of age, participated in the first round of data collection.[18] This analysis used the 1493 participants, aged 18 years or older, participating in the second round of data collection. For a detailed description of the methods see Merchant *et al*.[18] The University of Iowa institutional review board approved the study protocol and data collection instruments.

Each adult participant received a medical and mental health screening and was interviewed in the clinic by trained staff members to investigate injury and disease incidence in relation to occupational, agricultural, and other environmental exposures. The first round of cohort data collection occurred between June 1994 and February 1998, with the second round between March 1999 and April 2004. This analysis used data collected during the second round. In addition to data collected during the clinic interviews, families were followed prospectively using quarterly phone calls to collect information about injury incidence.

Outcome

Injuries were defined as traumatic events that restricted normal activities for at least four hours, that caused any loss of awareness or memory for any length of time, or that

Abbreviations: CES-D, Center for Epidemiologic Studies Depression Scale; KCRHS, Keokuk County Rural Health Study.

required professional medical care. After the clinic interview, participating households were contacted an average of every three months by a trained interviewer. One adult was asked to recall the accidents and injuries experienced by each family member. Out of the 471 injuries included in this analysis, 127 (27%) of the phone respondents were a family member of the injured person and not the injured person themselves. Information collected on the injury included: date of injury, injury location, body part(s) affected, type of injury, lost school/work days, activity at time of injury, medical care received, and recovery progress. Injuries included in this analysis were those occurring any time after the second round clinic interview until the end of the follow up period in June 2004.

Primary risk factor

The primary risk factor was the presence of depressive symptoms measured by the abbreviated 11-item Center for Epidemiologic Studies Depression Scale (CES-D scale) at the time of the clinic interview. Participants were considered to have depressive symptoms if their total score was greater than or equal to eight.[19 20] The 11-item CES-D scale is a shortened version of the original CES-D; a self-report index of depressive symptoms with high internal consistency reliability.[19] The abbreviated CES-D tap the same dimensions as the original and little reliability is sacrificed.[19]

Information on antidepressant medication use was determined from prescription medications that participants were asked to bring to their clinic interview. Medications included in this analysis were selective serotonin reuptake inhibitors (SSRIs), tricyclic antidepressants (TCAs), heterocyclic antidepressants, and monoamine oxidase inhibitors (MAOIs). Anti-anxiety medications were also included as they have side effects similar to those brought on by medications used to treat depression such as nervousness, lightheadedness, excitement, and insomnia. The presence of any one of these medications was considered medication use and coded as ''yes'' or ''no''. Length of time spent on the medication was not measured throughout the cohort study.

Other risk factors

We examined the following potential confounders chosen through prior research findings as being related to depression and injury risk: major demographics, sleepiness, prior injury, and potential alcohol problems. At the clinic interview, participants were asked a set of sleep questions that included frequency of snoring, frequency of waking up in the night, frequency of waking too early in the morning, hours of sleep per night, feelings of tiredness during the day, and difficulty getting to sleep. Number of sleeping hours was categorized into 7.5 hours or less and more than 7.5 hours a night. Participants were asked if they had an injury, as defined above, in the 12 months before the clinic interview. Prior injury was coded as ''yes'' or ''no''. Potential alcohol problems were measured using the CAGE questionnaire.[21] Adults who answered ''yes'' to two or more of these questions were classified as having potential alcohol problems.[21]

Statistical analysis

Injury rates per person-year were calculated and compared between different strata of demographic and potential confounding variables. Frequencies and cross tabulations were used to describe the potential confounders, injuries, and depressive symptoms. Pearson χ^2 tests were used for categorical data, *t* test for continuous variables, and Wilcoxon non-parametric tests for continuous variables with a non-normal distribution.

Table 1 Crude injury rates per person-year for adults in the Keokuk County Rural Health Study by demographic variables and by depressive symptoms

Variables	Person-years	Injury frequency	Injury rate	p Value
Depressive symptoms				
Yes	795.1	112	14.1	0.0003
No	4006.6	359	9.0	
On medication for depression				
Yes	383.5	61	15.9	0.0021
No	4418.2	410	9.3	
Gender				
Male	2129.6	233	10.9	0.0162
Female	2672.1	238	8.9	
Age (years)				
18–44	1393.1	119	8.5	0.1294
45–64	1836.6	186	10.1	
65–92	1572.0	166	10.6	
Marital status				
Married	3901.0	363	9.3	0.689
Divorced/separated/widowed	649.3	83	12.8	
Never married	251.5	25	9.9	
Education				
Less than high school	394.7	32	8.1	0.3641
High school graduate	2155.3	211	9.8	
More than high school	2251.7	228	10.1	
Injury 12 months before interview				
Yes	955.6	126	13.2	0.0018
No	3842.3	345	9.0	
Income				
<$20,000	490.6	67	13.7	0.0115
⩾$20,000	4186.5	393	9.4	
Hours of sleep per night				
<7 hours	1374.0	161	11.7	0.0173
⩾7 hours	3425.4	309	9.0	
High CAGE score				
Yes	516.4	63	12.2	0.13
No	4285.3	408	9.5	

Table 2 Bivariate and multivariate analysis of risk factors for injury among 1493 Keokuk County Rural Health Study cohort members aged 18 years and older

Risk factor	Injury frequency	Bivariate RR (95% CI)	Multivariate RR (95% CI)
Depressive symptoms	259	1.54 (1.22–1.95)	1.41 (1.10–1.80)
On medication for depression	127	1.61 (1.19–2.18)	1.53 (1.13–2.09)
Males	655	1.28 (1.04–1.51)	1.34 (1.11–1.63)
Age range 18–44	420	1.0	
Age range 45–64 *v* 18–44	577	1.05 (0.83–1.34)	
Age range 65+ *v* 18–44	496	1.24 (0.94–1.64)	
Not married	328	1.31 (1.03–1.66)	
More than high school education *v* high school or less	706	1.07 (0.87–1.31)	
Prior injury	305	1.43 (1.14–1.79)	1.34 (1.06–1.67)
Income less than $20,000 a year	170	1.46 (1.09–1.96)	1.34 (1.00–1.80)
High CAGE score	177	1.25 (0.94–1.68)	.
Less than 7 hours of sleep	433	1.29 (1.05–1.60)	1.23 (1.00–1.52)

*Clustering by household accounted for using the generalized estimation equation.

Rate ratios (RR) and 95% confidence intervals (95% CI) were used to describe associations between depressive symptoms and subsequent injury adjusting simultaneously for the potential confounding variables of age, gender, marital status, education level, sleepiness, and potential alcohol problems. The effects of covariates in the multivariate model were tested by likelihood ratio tests. RRs were derived using the multivariate Poisson regression model in SAS with injury count as the outcome variable, adjusted for follow up time (Version 9.2, SAS Institute Inc, Cary, NC, USA). Person-time was accrued for each participant from the date of their clinic interview until the occurrence of an injury or the end of the follow up on 30 June 2004. Since individuals were nested within families, clustering was accounted for by using the generalized estimation equation method through proc genmod in SAS.[22]

RESULTS

KCRHS cohort demographics and statistics

The cohort used for analysis included 838 females (56%) with a mean age of 55.1 years (SD 16.0) and 655 males (44%) with a mean age of 55.9 years (SD 16.4). Seventy eight percent of our sample were married and 92% had at least a high school education. Two hundred and fifty nine people had depressive symptoms according to the CES-D (17%) and 127 participants (9%) were on at least one antidepressant medication at the time of the clinic interview.

Injury rates

Four hundred and seventy one injuries were reported over a mean follow up time of 3.2 years (SD 1.4 years) for an overall injury rate of 9.8 per 100 person-years. Crude injury rates were significantly higher among those with depressive symptoms, those on an antidepressant medication, males, those with an injury before the clinic interview, those earning less than $20,000 a year, and those who slept less than seven hours a night (table 1). Also, there was a trend indicating those with more education and those with CAGE scores indicative of alcohol problems had higher injury rates than their counterparts, but these trends were not statistically significant.

Bivariate and multivariate analysis

Table 2 presents the bivariate rate ratios and their confidence intervals for the association between the various risk factors and injury. Those with depressive symptoms had a significantly increased risk for injury (RR = 1.54, 95% CI 1.22 to 1.95). Being on an antidepressant medication was also associated with an increased risk for injury (RR = 1.61, 95% CI 1.19 to 2.18). Other significant risk factors for injury in the bivariate analysis included male gender (RR = 1.28, 95% CI 1.04 to 1.51), not being married (RR = 1.31, 95% CI 1.03 to 1.66), making less than $20,000 a year (RR = 1.46, 95% CI 1.09 to 1.96), having a prior injury (RR = 1.43, 95% CI 1.14 to 1.79), and getting less than seven hours of sleep (RR = 1.29, 95% CI 1.05 to 1.60).

The final model was chosen by entering all variables significant in the bivariate analysis in a full model and using likelihood ratio tests to choose the best overall model. The correlation between depressive symptoms and antidepressant medication use was measured and found to be only moderate ($\Phi = 0.17$); therefore, both variables were included in the final model. Depressive symptoms, as measured by the CES-D, increased the risk of injury 41% after controlling for antidepressant medication use, gender, prior injury, income, and sleepiness (RR = 1.41, 95% CI 1.10 to 1.80). Additionally, males, those on an antidepressant, those with a prior injury, those making less than $20,000 a year, and those getting less than seven hours of sleep a night were at an increased risk for injury.

To examine whether antidepressant medication modified the association between depressive symptoms and injury, the

Table 3 Multivariate poisson regression model of risk factors for injury among 1493 Keokuk County Rural Health Study cohort members aged 18 years and older stratified by antidepressant medication use

No depressive medication (n = 1330)			Depressive medication (n = 125)		
Risk factor	Injury frequency	RR (95% CI)	Risk factor	Injury frequency	RR (95% CI)
Depressive symptoms	210	1.43 (1.09–1.88)	Depressive symptoms	49	1.31 (0.76–2.26)
Males	615	1.46 (1.18–1.79)	Males	40	0.73 (0.41–1.29)
Prior injury	274	1.29 (1.00–1.65)	Prior injury	31	1.70 (0.95–3.06)
Less than 7 hours of sleep	405	1.20 (0.96–1.51)	Less than 7 hours of sleep	28	1.27 (0.70–2.30)
Income less than $20,000 a year	147	1.51 (1.10–2.08)	Income less than $20,000 a year	23	0.74 (0.35–1.56)

Table 4 Injury characteristics by depressive symptoms

Injury characteristic	Depressive symptoms, n (%)	No depressive symptoms, n (%)	p Value
Total	112 (24%)	357 (76%)	
Place injury occurred			0.054
Home/residential area	52 (47%)	158 (45%)	
Street/highway	15 (13%)	26 (8%)	
Work area	14 (13%)	78 (22%)	
Other	30 (27%)	87 (25%)	
External cause of injury			0.072
Accidental falls	59 (53%)	147 (41%)	
Motor vehicle/other road accidents	12 (11%)	23 (6%)	
Overexertion	11 (10%)	40 (11%)	
Struck accidentally	5 (4%)	30 (8%)	
Accidents caused by machines	5 (4%)	32 (9%)	
Other	20 (18%)	85 (24%)	
Body part			0.916
Head and face	18 (17%)	52 (16%)	
Neck and back	14 (14%)	57 (17%)	
Lower extremity	30 (29%)	96 (29%)	
Upper extremity	33 (32%)	102 (31%)	
Other	8 (8%)	22 (7%)	
Perceived disability			0.01
Severe/moderate disability	3 (3%)	3 (<1%)	
Condition improving	66 (62%)	169 (49%)	
Complete recovery	37 (35%)	170 (50%)	
Mean missed days of school/work (SD)	3.0 (12.2)	5.9 (18.0)	0.235

full model containing an interaction term between antidepressant medication (yes/no) and depressive symptoms (yes/no) was tested against a reduced model without this interaction term by means of likelihood ratio test. The interaction term was not significant. A variety of other interactions such as depression and gender, gender and antidepressant medication, and income and depression were tested and none were found to be significant. The full model was then stratified by antidepressant medication use (table 3). The presence of depressive symptoms remained a risk factor for injury regardless of the use of antidepressant medication. The RR for those on antidepressant medications did not reach statistical significance because of small sample sizes, however the trend was apparent (RR = 1.31, 95% CI 0.76 to 2.26).

Injury characteristics

There were minor differences in the injuries experienced by those with depressive symptoms and those without (table 4). Four hundred and sixty nine of the injuries had corresponding injury data; 357 (76%) occurred to those without depressive symptoms and 112 (24%) occurred to those with depressive symptoms. Those without depressive symptoms were slightly more likely to have had the injury occur in a work area than those with depressive symptoms ($p = 0.054$). Those with depressive symptoms were significantly less likely to see themselves in complete recovery after the injury event than those without depressive symptoms ($p = 0.01$). There were no significant differences in the body part injured, the cause of injury, or the average missed days of work or school; however, those without depressive symptoms had a higher average missed days or work or school and were less likely to have had experienced a fall.

DISCUSSION

The Keokuk County Rural Health Study provided a unique opportunity to prospectively examine depressive symptoms as a risk factor for injury while controlling for a variety of known confounders, including antidepressant medication use and prior injury. Previous cross sectional research has pointed towards an association between injury and depression, but was unable to establish the direction of causality. Our prospective study found depression to be a risk factor for subsequent injury after controlling for gender, prior injury, income, and potential alcohol problems as measured by the CAGE questionnaire.

Sprince *et al* found that current depressive symptoms were associated with a farm work related injury in the prior year in a multivariate analysis (OR = 1.65, 95% CI 1.06 to 2.56).[15] Peele used a case control study to examine how psychological factors influence occupational injury.[23] She found that women who had depression symptoms were 6.2 times more likely to have had an occupational injury than those without depressive symptoms.[23] Finally, Poole *et al* used a case control study to compare psychosocial factors from a structured interview between victims of intentional trauma, unintentional trauma, and patients undergoing elective surgery at a trauma center.[14] Logistic regression analysis identified younger age, lower intelligence, antisocial personality, mental retardation, depression, and low income to be associated with an increased risk for trauma. Our prospective study builds upon this prior work by establishing depressive symptoms, measured at baseline, as a risk factor for subsequent injury.

While few studies have considered depression as a risk factor for injury, numerous studies have examined antidepressant medication use, specifically for falls in the elderly. All of the large, landmark studies in this area show antidepressant medication use to be a risk factor for falls; however, while most studies control for dementia, cognitive functioning, or functional ability, none control for depression or depressive symptoms.[24–28] While this body of research is extensive, it has not been clarified whether it is the psychotropic effects of the drugs, the symptoms of the depressive state, or an interaction between the two that puts an elderly person at an increased risk for a fall. This study demonstrates that depressive symptoms, in and of themselves, are a risk factor for injury, regardless of the use of antidepressants.

Our study has several limitations. Information on the injuries was obtained from self-report without validation with medical records. This raises the possibility of differential recall bias since it is possible that depressed and non-depressed people recall and perceive health related events differently.[29] However, as respondents were reporting on

tangible, acute events, we believe this bias to be minimized. Also, a single informant provided the data on the injuries for all family members and they may not have been aware of an injury, or know of the specific details. This occurred in 127 of the 471 injuries (27%). This may lower the total number of injuries reported for the cohort.

Finally, it is possible that depressive symptoms measured at the clinic interview would not persist into the follow up period. We re-analyzed the data and only included injuries occurring 24 months after the clinic interview and risk estimates were not affected (data not shown). Also, current research demonstrates that mild depression can be chronic and recurrent for as long as six years in many people.[30]

Our study also has unique strengths. To our knowledge, it is the only study examining depression as a risk factor for injury in a prospective and multivariate manner. This is a stable cohort whose members were comfortable with the study protocol and much effort was made to collect injury information by following participants over a long time period. In addition to using a reliable and valid screening tool to measure depressive symptoms, we were able to examine and control for the use of antidepressant medications.

Even though this study was located in a rural area of the United States, results from this study are generalizable to urban areas, as well as to areas outside of the US. Although urban and rural people may experience different types of injuries, we have no reason to believe that people in urban areas or in areas outside of the US experience depression differently from rural people.

This research suggests that a multifaceted approach is necessary when considering the relation between injury and mental health. We believe that depression and depressive symptoms have a unique effect on injury risk, independent from that of the risk associated with antidepressant medication use. Further work that would allow for the examination of subclasses of antidepressants, degrees of depressive symptoms, as well as interactions between the levels of depression and types of treatments, would help to further decipher these findings. These results should be validated in other populations and their causal mechanisms investigated. Medical practitioners should consider talking about safety with their patients, especially those reporting symptoms of depression, and recognize that an increased risk for injury remains until the depressive symptoms subside.

Key points

- Cross sectional studies have demonstrated an association between injury and depression, but this is the first study to indicate that depressive symptoms are a risk factor for injury in a prospective manner.
- This study found depressive symptoms increased one's risk for subsequent injury 41% after controlling for antidepressant medication use, gender, prior injury, income, and sleepiness.
- Depressive symptoms remained a risk factor for injury when stratified by antidepressant medication use, although not reaching statistical significance due to small sample sizes.
- In this study, depressive symptoms were a distinct risk factor for injury, independent of antidepressant medication use.

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COCHRANE CORNER

Road safety

The latest edition of the Cochrane Library (available at http://www.cochrane.org) contains a review which assesses speed enforcement detection devices for reducing road traffic injuries. Speed cameras have been a controversial topic in many high income countries where many people in the community feel that they are in place not for safety benefits but as a means of income generation for government. This review, from a group of reviewers at the University of Queensland, Australia, concluded that speed enforcement devices are a promising intervention likely to reduce the risk of motor vehicle crash and related injuries. However, the ability of the review team to make conclusions was limited somewhat by the quality of the studies.

Study design is an issue that seems to arise again and again in systematic reviews in road safety and several reviews have highlighted the relatively limited use of randomized controlled trial (RCT) designs. There are various reasons why there have been so few trials. Many research projects have been funded by government agencies keen for quick results, and as a result large complex studies that take years to complete are not funded. It is not always feasible to use an RCT design—for example, randomizing motorists to use of motorcycle helmets or not is not possible. However, RCTs do have clear benefits over other study designs in terms of validity and it is possible to incorporate such study designs into road safety evaluations.

As Wilson *et al* highlight in their review, RCTs can be used to evaluate the effectiveness of speed enforcement devices. Using a cluster trial design, it would be possible to randomly allocate areas of interest—intersections earmarked as traffic black spots for example—to either receiving a speed enforcement device or not. Data collection at all intersections before and after the introduction of the device would determine whether there had been reductions in average speeds, collisions, and injuries.

Researchers, policy makers, and funding agencies need to recognize that this may mean large, costly trials. However, when the widespread implementation of such controversial interventions as speed cameras is costly in itself, such trials should be considered. In fact, given the degree of debate in the community about the relative merits of speed enforcement devices, one would expect that results from a trial demonstrating reductions in serious crashes or injuries could only smooth the process.

On another note, new titles registered with the Cochrane Injuries Group include:

- Alcohol and drug screening of people whose work involves driving, for preventing injury
- Cycle paths and cycle lanes for the prevention of injuries in cyclists
- Interventions for preventing injuries in the agricultural industry
- Interventions for preventing injuries in the construction industry
- Motor vehicle road worthiness certification for preventing traffic crashes
- Parenting programmes for the prevention of unintentional injury in childhood
- School based primary prevention programmes for preventing violence
- Vision screening of older drivers for preventing road traffic injuries and fatalities.

We look forward to seeing the completed protocols and reviews. If you are interested in getting involved in the Injuries Group or if you have any ideas for new reviews, please contact us at cochrane_injuries@lshtm.ac.uk.

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1 **Wilson C**, Willis C, Hendrikz JK, *et al*. Speed enforcement detection devices for preventing road traffic injuries. *Cochrane Database Syst Rev* Issue 2, 2006.