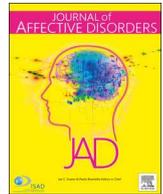




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Research paper

# Serious physical injury and depressive symptoms among adolescents aged 12–15 years from 21 low- and middle-income countries

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## ABSTRACT

**Background:** Little is known about the relationship between physical injury and depression in youths from low- and middle-income countries (LMICs). Therefore, the aim of this study was to analyze the association between serious physical injury and depressive symptoms among adolescents in 21 LMICs.

**Methods:** Data from the Global School-based Student Health Survey (2003–2008) were analyzed. Serious physical injury and depressive symptoms in the past 12 months were assessed with self-report measures. The association between serious physical injury and depressive symptoms was examined using multivariable logistic regression analysis and meta-analysis.

**Results:** The final sample consisted of 44,333 adolescents aged 12–15 years. After adjustment for sex, age, food insecurity, alcohol consumption, and country, an increasing number of serious physical injuries in the past 12 months was associated with increments in the odds for depressive symptoms in a dose-dependent fashion. Those who had  $\geq 6$  serious injuries (vs. no injuries) were 2.79 (95%CI = 2.23–3.48) times more likely to have depressive symptoms. The pooled odds ratio (OR) (95%CI) for the association between at least one serious physical injury and depressive symptoms obtained by meta-analysis based on country-wise estimates was 1.83 (1.67–2.01) with a moderate level of between-country heterogeneity ( $I^2 = 56.0\%$ ).

**Limitations:** This was a cross-sectional study and causality of the association cannot be deduced.

**Conclusions:** Serious physical injury may be a risk factor for depressive symptoms among adolescents in LMICs. Efforts to prevent physical injury and the provision of adequate health care for those who are injured may improve mental wellbeing among adolescents in this setting.

## 1. Introduction

Depression is one of the leading causes of years lived with disability in the world (Whiteford et al., 2013). The onset of depression usually occurs in childhood and adolescence (Kessler et al., 2007), and this mental disorder is frequent in youths (Merikangas et al., 2009). Adolescent depression can have a major impact on school attendance, addictive behaviors and suicidal ideation (Glied and Pine, 2002). Even depressive symptoms not reaching a clinical threshold have been linked to adverse outcomes (e.g., social impairment, decreased work productivity) (Oldehinkel et al., 1999). Depression is very common among children and adolescents in low- and middle-

income countries (LMICs), and previous research has found high rates of depression among adolescents in these countries (Yatham et al., 2018). Regrettably, there are numerous obstacles that impede the optimal use of mental health services dedicated to children and adolescents with depression in LMICs (e.g., lack of legislative frameworks, overloaded services, insufficient skilled human resources) (Juengsiragulwit, 2015). Therefore, identifying risk factors for depression or depressive symptoms in youth in LMICs is a public health priority.

In recent decades, several studies have investigated the impact of physical injury on depression and depressive symptoms in children and adolescents, with most of these studies reporting a positive and significant

**Abbreviations:** GSHS, global school-based student health survey; LMICs, low- and middle-income countries; PTSD, post-traumatic stress disorder

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**Table 1**  
Characteristics of the surveys and prevalence of serious physical injury and depressive symptoms.

Country	Country income level	Year	Response rate (%)	N <sup>a</sup>	Physical injury% [95%CI]	Depressive symptoms% [95%CI]
Argentina	UM	2007	77	1537	34.5 [31.7,37.4]	29.5 [25.9,33.4]
Botswana	UM	2005	95	1397	66.0 [62.4,69.4]	39.0 [36.6,41.6]
Chile (Metropolitan)	UM	2004	85	1972	36.1 [33.5,38.8]	30.8 [27.4,34.4]
China (Beijing)	LM	2003	99	2189	16.1 [13.9,18.7]	18.3 [16.9,19.8]
Ecuador (Quito)	LM	2007	86	1842	33.0 [28.6,37.7]	25.1 [21.6,29.1]
Grenada	UM	2008	78	1299	45.3 [42.0,48.7]	23.4 [21.2,25.8]
Guyana	LM	2004	80	1070	33.2 [29.2,37.4]	32.5 [28.4,36.8]
Indonesia	LM	2007	93	3022	45.6 [41.6,49.7]	21.0 [18.4,23.9]
Kenya	L	2003	84	2971	71.8 [67.6,75.7]	47.8 [45.5,50.2]
Lebanon	UM	2005	88	4524	32.0 [30.2,34.0]	36.1 [33.7,38.5]
Morocco	LM	2006	84	1986	44.5 [40.4,48.6]	36.5 [32.9,40.3]
Myanmar	L	2007	95	2227	28.4 [23.7,33.5]	14.7 [11.7,18.4]
Philippines	LM	2007	81	3484	45.1 [42.0,48.2]	36.6 [34.2,39.0]
St. Lucia	UM	2007	82	1072	46.9 [43.1,50.8]	23.3 [20.5,26.4]
St. Vincent & the Grenadines	UM	2007	84	1188	47.8 [41.6,54.0]	27.5 [24.3,31.0]
Tanzania (Dar Es Salaam)	L	2006	87	1757	39.9 [37.3,42.6]	23.7 [21.6,25.9]
Thailand	LM	2008	93	2675	46.3 [42.2,50.4]	16.6 [14.3,19.1]
Uganda	L	2003	69	1904	63.1 [58.0,67.9]	39.3 [36.0,42.7]
Uruguay	UM	2006	71	2882	25.6 [23.9,27.3]	16.6 [15.0,18.4]
Venezuela (Lara)	UM	2003	86	1970	6.0 [4.5,7.9]	22.2 [20.5,23.9]
Zambia	L	2004	70	1365	71.5 [65.0,77.2]	51.5 [47.4,55.6]

Abbreviation: CI Confidence interval; L Low-income; LM Lower middle-income; UM Upper middle-income.

<sup>a</sup> Only includes those aged 12–15 years.

relationship (Ellis et al., 1998; Han et al., 2011; Jenness et al., 2017; Kepple et al., 2012; Kostev et al., 2019; Sabin et al., 2006; Williams et al., 2015; Zatzick et al., 2008). The association between physical injury and depression at a young age may involve mediators such as disability, post-traumatic stress disorder (PTSD) and school dropout. Although the previous studies are of particular interest, they display some important limitations. These studies used clinical samples and often lacked a control group (Ellis et al., 1998; Han et al., 2011; Sabin et al., 2006; Zatzick et al., 2008), while only a few had a large sample size (Jenness et al., 2017; Kepple et al., 2012; Kostev et al., 2019; Williams et al., 2015). In addition, all of this research was conducted in high-income countries and there are no studies specifically on this topic from LMICs. This is a major omission as the vast majority of physical injury-related deaths (90%) and disability adjusted life years (94%) occur in LMICs (Hyder, 2013). Moreover, although there is some evidence pointing to a positive association between physical injury and depression among adults in LMICs (Jacob et al., 2019), it is difficult to extrapolate these results to younger populations for several reasons. First, the cause of the injury may differ between adolescents and adults. For example, physical injuries occur frequently during sports or leisure activities and at school in adolescents (Räisänen et al., 2018), whereas road traffic accidents are the major cause of injury in adults (Jacob et al., 2019). Second, there are major differences in the symptomatology of depression between adolescents and adults. In particular, vegetative symptoms (e.g., appetite change, loss of energy, insomnia) are more common, and anhedonia, loss of interest and concentration problems less frequent in adolescents than in adults (Rice et al., 2019). Finally, causes of depression due to injury may differ between children and adolescents (e.g., maltreatment, bullying by peers, school dropout) and adults (e.g., financial problems, job loss, assault).

Taking these facts together, and given that physical injury is highly prevalent among adolescents in LMICs (Cai et al., 2018), analyzing the potential impact of physical injury on mental health in adolescents living in these countries is of particular importance. Therefore, the goal of this study was to analyze the association between serious physical injury and depressive symptoms among adolescents aged 12–15 years from 21 LMICs.

## 2. Methods

### 2.1. The survey

Publicly available data from the Global School-based Student Health

Survey (GSHS) were analyzed. Details on this survey can be found at <http://www.who.int/chp/gshs> and <http://www.cdc.gov/gshs>. Briefly, the GSHS was jointly developed by the WHO and the US Centers for Disease Control and Prevention (CDC), and other United Nations allies. The core aim of this survey was to assess and quantify risk and protective factors for major non-communicable diseases. The survey draws content from the CDC Youth Risk Behavior Survey (YRBS) for which test-retest reliability has been established (Brener et al., 1995). The survey used a standardized two-stage probability sampling design for the selection process within each participating country. For the first stage, schools were selected with probability proportional to size sampling. The second stage involved the random selection of classrooms which included students aged 13–15 years old within each selected school. All students in the selected classrooms were eligible to participate in the survey regardless of age. Data collection was performed during one regular class period. The questionnaire was translated into the local language in each country and consisted of multiple choice response options; students recorded their response on computer scannable sheets. Countries were allowed to not include all questions in the standard GSHS questionnaire. All GSHS surveys were approved, in each country, by both a national government body (most often the Ministry of Health or Education) and an institutional review board or ethics committee. Student privacy was ensured through anonymous and voluntary participation, with informed consent being obtained as appropriate from the students, parents and/or school officials. Data were weighted for non-response and the probability of selection. Specifically, a weighting factor was applied to each student record to adjust for non-response and for the varying probabilities of selection. The weight used for estimation in this survey is given by:  $W = W1 * W2 * f1 * f2 * f3$  ( $W1$  = the inverse of the probability of selecting each school;  $W2$  = the inverse of the probability of selecting each classroom;  $f1$  = a school-level nonresponse adjustment factor calculated by school size category (i.e., small, medium, large);  $f2$  = a student-level nonresponse adjustment factor calculated by classroom; and  $f3$  = a poststratification adjustment factor calculated by sex within grade).

From all publicly available data, we selected all datasets from LMICs that included the variables used in the current analysis. If there were more than two datasets from the same country, we chose the most recent dataset. A total of 21 countries were included in the current study. The characteristics of each country or survey are provided in Table 1. For the included countries, the survey was conducted between 2003

and 2008, and consisted of 5 low-income, 7 lower middle-income, and 9 upper middle-income countries based on the World Bank classification at the time of the survey. Data were nationally representative for all countries with the exception of Chile, China, Ecuador, Tanzania, and Venezuela where the survey was only conducted in selected areas.

## 2.2. Depressive symptoms

Those who answered affirmatively to the question “During the past 12 months, did you ever feel so sad or hopeless almost every day for two weeks or more in a row that you stopped doing your usual activities?” were considered to have depressive symptoms (Vancampfort et al., 2018).

## 2.3. Serious physical injury

The students were first presented with the following definition of a serious injury: “An injury is serious when it makes you miss at least one full day of usual activities (such as school, sport, or a job) or requires treatment by a doctor or nurse.” Subsequently, serious injury was assessed with the question “During the past 12 months, how many times were you seriously injured?” with answer options 0, 1, 2–3, 4–5, 6–7, 8–9, 10–11, and  $\geq 12$  times (original categories). This variable was used as a dichotomous variable (at least once or not) or a five-category variable (0, 1, 2–3, 4–5,  $\geq 6$  times). For the latter variable, we grouped all those who were injured  $\geq 6$  times into a single category as the numbers in the extreme categories were small. Data were also collected on details of the most serious injury that occurred in the past 12 months: “What were you doing?”; “What was the major cause?”; “How did the injury happen?”; “What was the injury?” with mutually exclusive answer options. The question “What was the injury?” was not asked in Morocco.

## 2.4. Control variables

The selection of the control variables was based on past literature (Jacob et al., 2019) and included sex, age, food insecurity, and alcohol consumption. These variables were included in the analyses because they are likely to be confounders in the association between serious physical injury and depressive symptoms in adolescents. For example, a previous study showed that alcohol-specific hospital admission is a risk factor for subsequent injury requiring hospitalization in young people (Lester et al., 2018), while levels of alcohol consumption were found to be positively associated with mental health problems (e.g., anxiety, depression) among young university students (Tembo et al., 2017). Since physical activity and sedentary behavior are likely to be mediators in the physical injury-depression relationship, they were not included as control variables in this study.

As in previous studies using the same dataset (Ashdown-Franks et al., 2019; Carvalho et al., 2019), food insecurity was used as a proxy for socioeconomic status as there were no variables on socioeconomic status in the GSHS. Food insecurity was assessed by the question “During the past 30 days, how often did you go hungry because there was not enough food in your home?” Answer options were categorized as “never”, “rarely/sometimes”, and “most of the time/always”. Alcohol consumption was defined as having had one drink containing alcohol for at least one day in the past 30 days.

## 2.5. Statistical analysis

Statistical analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged 12–15 years as most students were within this age range and the exact age outside of this age range was not provided. Using the overall sample, we conducted multivariable logistic regression analysis with depressive symptoms as the outcome and the five-category injury variable (0, 1, 2–3, 4–5,  $\geq 6$  times) or the circumstance, cause, or the type of the most

serious physical injury as the exposure variables. We also conducted country-wise analyses to assess whether there is between-country heterogeneity in the association between injury and depressive symptoms. The dichotomized injury variable (yes or no) was used for this analysis to obtain stable estimates, as the sample size in each country was small. We also calculated the Higgin's  $I^2$  which represents the degree of heterogeneity that is not explained by sampling error with a value of  $< 40\%$  often considered as negligible and 40–60% as moderate heterogeneity (Higgins and Thompson, 2002). A pooled estimate was obtained by combining the estimates for each country into a random effect meta-analysis. We also assessed the associations after deleting those who had a self-inflicted injury ( $n = 1182$ ) as that may have a different effect on mental health (Jacob et al., 2019).

All regression analyses were adjusted for sex, age, socioeconomic status (food insecurity), and alcohol consumption. Analyses using the overall sample were additionally adjusted for country by including dummy variables for each country in the model as in previous GSHS publications (Carvalho et al., 2019; McKinnon et al., 2016). All variables were included in the regression analysis as categorical variables with the exception of age (continuous variable). The sampling weights and the clustered sampling design were taken into account in the analysis using the Stata svy command, which uses the Taylor's linearization method. Results from the logistic regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at  $p < 0.05$ .

## 3. Results

The final sample consisted of 44,333 adolescents aged 12–15 years [48.1% males; mean (SD) age 13.9 (0.9) years]. Overall, the prevalence of injury and depressive symptoms was 43.7% (1 time 25.0%, 2–3 times 12.1%, 4–5 times 3.2%,  $\geq 6$  times 3.4%) and 27.4%, respectively. These prevalence rates varied widely between countries: injury 6.0% (Venezuela) to 71.8% (Kenya); depression 14.7% (Myanmar) to 51.5% (Zambia) (Table 1, Fig. 1). In particular, the highest prevalence rates of injury were concentrated in sub-Saharan countries. The distribution of the frequency of physical injury by the type of most serious cause of injury can be found in Appendix 1. Details regarding the circumstance, cause, and type of the most serious physical injury in the past 12 months are shown in Appendix 2. There was a large variation between countries. For example, injuries while playing or training for sports were common in Latin American countries (e.g., Argentina, Ecuador), while the proportion of gunshot wounds and self-inflicted injury were high in countries in Sub-Saharan Africa (e.g., Kenya, Zambia).

After adjustment for potential confounders, an increasing number of physical injuries in the past 12 months was associated with increments in the ORs for depressive symptoms in a dose-dependent fashion (Table 2). Compared to those who had no injury, those who had  $\geq 6$  injuries were 2.79 (95%CI = 2.23–3.48) times more likely to have depressive symptoms. In terms of the circumstance when the injury occurred, we found that playing or training for sport had the lowest OR (1.42) for depressive symptoms, while riding or driving in a car or other motor vehicle had the highest OR (2.09) (Table 3). Self-inflicted injury had similar ORs with injury inflicted by others (either by accident or on purpose). As for the major cause, the lowest OR was found for traffic accidents (OR = 1.46), while being attacked, assaulted, or abused by someone was associated with a particularly high OR (4.22). Regarding the type of the injury, gunshot wound had the highest OR (2.82) followed by concussion or other head or neck injury (OR = 2.73). Results were similar for analyses in both Tables 2 and 3 after the exclusion of those who had a self-inflicted injury.

Country-wise analysis showed that at least one serious physical injury in the past 12 months was significantly associated with depressive symptoms in all countries with the exception of Argentina (Fig. 2). The pooled OR (95%CI) obtained by meta-analysis with random effects was 1.83 (1.67–2.01) with a moderate level of between-country

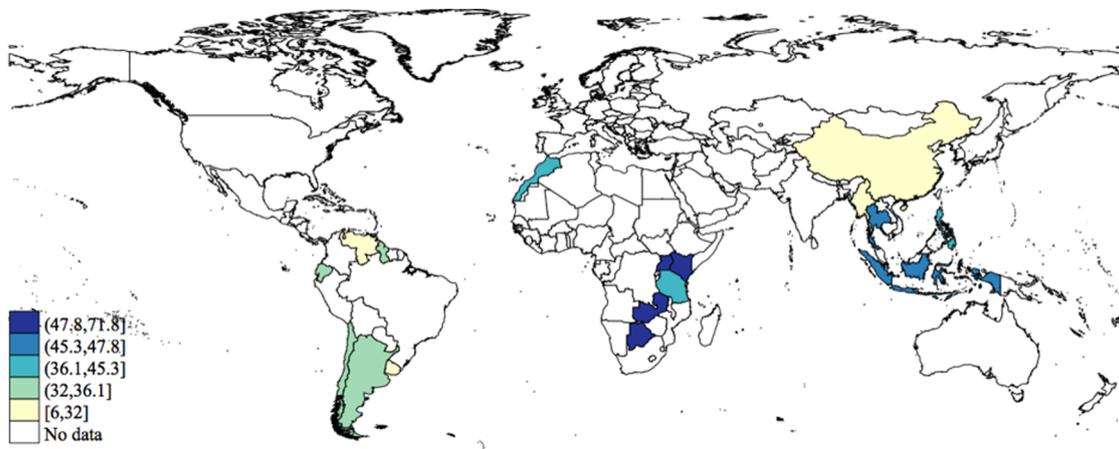


Fig. 1. Prevalence of past 12-month physical injury by country. Data from Chile, China, Ecuador, Tanzania, and Venezuela were from selected areas.

Table 2

Association between physical injury and depressive symptoms estimated by multivariable logistic regression.

Physical injury (past 12 months)	Physical injury		Self-injury excluded	
	OR	95%CI	OR	95%CI
0 time	1.00		1.00	
1 time	1.46**	[1.31,1.62]	1.44**	[1.29,1.60]
2–3 times	2.04**	[1.80,2.31]	2.02**	[1.79,2.29]
4–5 times	2.75**	[2.13,3.54]	2.65**	[2.03,3.46]
≥ 6 times	2.79**	[2.23,3.48]	2.88**	[2.25,3.68]

Abbreviation: OR Odds ratio; CI Confidence interval.

Models are adjusted for sex, age, socioeconomic status (food insecurity), alcohol consumption, and country.

\*\*  $p < 0.001$ .

heterogeneity being observed ( $I^2 = 56.0\%$ ). The exclusion of those with a self-inflicted injury did not appreciably alter the results (pooled OR = 1.80; 95%CI = 1.64–1.98) (data only shown in text).

## 4. Discussion

### 4.1. Main findings

The present study found a high prevalence of serious injury, and a dose-response relationship between the number of serious physical injuries and depressive symptoms among more than 44,300 adolescents aged 12–15 years from 21 LMICs. Participants with at least six injuries in the past 12 months had a 2.79-fold increase in the odds for depressive symptoms compared to those without any injury. Finally, there was a moderate level of between-country heterogeneity in the association between physical injury and depressive symptoms. The omission of self-injuries from the analysis had little impact on the results.

### 4.2. Interpretation of the findings

To the best of our knowledge, to date, this is the largest study examining the association between physical injury and depressive symptoms among adolescents, and the first study specifically on this topic from LMICs. However, there are several studies from high-income countries with a smaller sample size that have investigated this issue (Ellis et al., 1998; Han et al., 2011; Jenness et al., 2017; Kepple et al., 2012; Kostev et al., 2019; Sabin et al., 2006; Williams et al., 2015; Zatzick et al., 2008), and most of these studies have reported either a positive relationship (Williams et al., 2015) or high rates of depression

Table 3

Association between circumstance, cause, and type of the most serious physical injury in the past 12 months and depressive symptoms estimated by multivariable logistic regression.

	Physical injury		Self-injury excluded	
	OR	95%CI	OR	95%CI
<b>What were you doing?</b>				
Playing or training for sport	1.42**	[1.22,1.66]	1.39**	[1.19,1.63]
Walking or running, but not as part of playing or training for a sport	1.69**	[1.44,1.99]	1.67**	[1.40,1.98]
Riding a bicycle or a scooter	1.48**	[1.20,1.81]	1.46*	[1.16,1.82]
Riding or driving in a car or other motor vehicle	2.09**	[1.52,2.88]	2.17**	[1.56,3.01]
Doing any paid or unpaid work	1.94**	[1.53,2.47]	1.92**	[1.49,2.47]
Nothing	1.58**	[1.28,1.94]	1.56**	[1.25,1.96]
Other	1.73**	[1.47,2.02]	1.73**	[1.47,2.03]
<b>What was the major cause?</b>				
I was in a motor vehicle accident or hit by a motor vehicle	1.46*	[1.18,1.80]	1.45*	[1.16,1.81]
I fell	1.54**	[1.35,1.76]	1.53**	[1.33,1.76]
Something fell on me or hit me	1.66**	[1.35,2.04]	1.69**	[1.36,2.11]
I was fighting with someone	2.37**	[1.87,3.01]	2.32**	[1.78,3.03]
I was attacked, assaulted, or abused by someone	4.22**	[3.07,5.80]	4.32**	[3.08,6.06]
I was in a fire or too near a flame or something hot	1.96**	[1.32,2.92]	1.86*	[1.23,2.80]
Other	1.49**	[1.30,1.70]	1.46**	[1.28,1.66]
<b>How did the injury happen?</b>				
Hurt myself by accident	1.47**	[1.32,1.64]		
Someone else hurt me by accident	1.90**	[1.65,2.18]		
I hurt myself on purpose	1.96**	[1.64,2.34]		
Someone else hurt me on purpose	2.05**	[1.66,2.53]		
<b>What was the injury?<sup>a</sup></b>				
Broken bone or dislocated joint	1.76**	[1.53,2.02]	1.73**	[1.50,1.99]
Cut, puncture, or a stab wound	1.72**	[1.42,2.09]	1.65**	[1.35,2.02]
Concussion or other head or neck injury	2.73**	[2.12,3.52]	2.74**	[2.09,3.59]
Gunshot wound	2.82**	[1.54,5.16]	3.10*	[1.53,6.26]
Bad burn	2.35**	[1.74,3.17]	2.13**	[1.51,3.00]
Lost all or part of a foot, leg, hand, or arm	2.21**	[1.39,3.53]	2.12*	[1.24,3.61]
Other	1.38**	[1.20,1.58]	1.36**	[1.18,1.57]

Abbreviation: OR Odds ratio; CI Confidence interval.

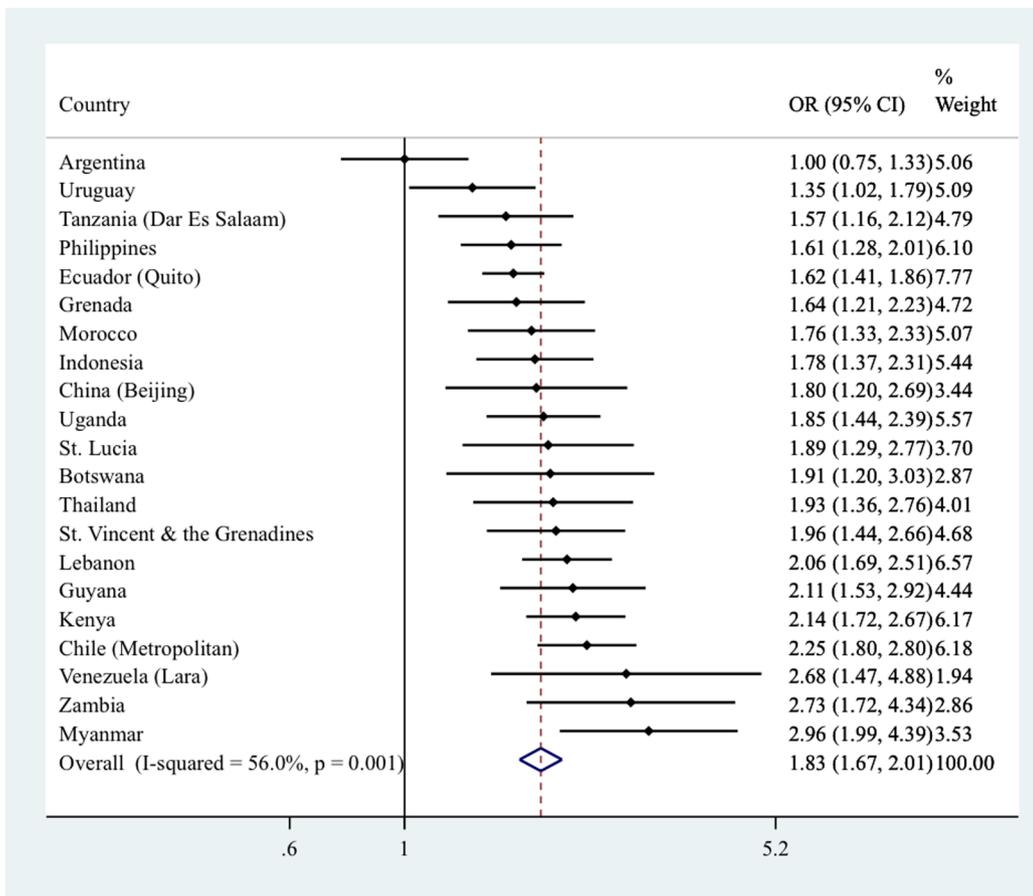
Reference category is no injury.

Models are adjusted for sex, age, socioeconomic status (food insecurity), alcohol consumption, and country.

<sup>a</sup> Morocco was not included due to lack of data.

\*  $p < 0.01$ .

\*\*  $p < 0.001$ .



**Fig. 2.** Country-wise associations between past 12-month serious physical injury and depressive symptoms estimated by multivariable logistic regression. Abbreviation: OR Odds ratio; CI Confidence interval. Models are adjusted for sex, age, socio-economic status (food insecurity), and alcohol consumption. Pooled estimate was obtained by meta-analysis with random effects.

in injury survivors (Ellis et al., 1998; Han et al., 2011; Kepple et al., 2012; Sabin et al., 2006; Zatzick et al., 2008). For example, one prospective cohort study conducted in the US that included more than 100 injured individuals aged between 12 and 18 years found that 30% of the sample experienced posttraumatic stress symptoms and 11% depressive symptoms, four to six months after the initial trauma (Sabin et al., 2006). Another study from the US showed that in a sample of 3604 adolescents aged 12–17 years, depression affected 11.2% of survivors of a motor vehicle crash and 5.7% of controls (Williams et al., 2015).

There are several potential mechanisms that might explain the association between serious physical injury and depressive symptoms in adolescents. First, although we did not have information on the level of disability caused by the injury, serious injuries may cause disabilities (Barker et al., 1996), and disability in turn can have a negative impact on mental health via pain, reduced social support and sense of mastery (Backe et al., 2018; Psouni et al., 2018). This may be particularly true in LMICs where rehabilitation centers for disabilities are often underdeveloped (Xiao et al., 2017). The fact that concussion or other head or neck injury (OR=2.73), gunshot wounds (OR=2.82), bad burns (OR=2.35), and loss of all or part of an extremity (OR=2.21) were associated with particularly high odds for depressive symptoms in our study may be reflecting this. Second, a recent meta-analysis that included 11 studies found that the prevalence of PTSD was around 20% in children and adolescents following road traffic accidents (Dai et al., 2018). In turn, PTSD influences the risk for first-onset major depression, while women with this disorder were found to be twice as likely to develop depression than controls (Breslau et al., 1997). The role played by PTSD in the physical injury-depression relationship is likely to be more important in LMICs than in high-income countries, as mental health care systems often lack sufficient human resources and basic infrastructure in LMICs (Juengsiragulwit, 2015). Finally, the high odds for depressive symptoms associated with concussion or other head or

neck injury may be explained by direct damage to the central nervous system, which in turn can directly affect depressive symptoms (Juengst et al., 2017).

We further observed a moderate level of between-country heterogeneity in the serious physical injury-depressive symptoms relationship. The large variation in the prevalence of circumstance, cause, or type of the most serious physical injury between countries, and the fact that these factors may impact depressive symptoms differentially as shown in our study, point to the possibility that the between-country heterogeneity might be explained by differences in the type of injuries experienced between countries. For example, the non-significant result observed in Argentina may be related to the fact that the predominant form of injury in this country was related with sport injuries, which were not strongly associated with depressive symptoms in our study. Alternatively, in Zambia, where one of the strongest associations was observed, serious injuries such as losing part of an extremity, gunshot wounds, and concussion or other head or neck injury were highly prevalent (Juengst et al., 2017; Mckechnie and John, 2014). On the other hand, this between-country heterogeneity may be related with factors such as availability of care for both injuries and mental health.

#### 4.3. Policy implications and areas for future research

Our study indicates that the prevention of physical injury may help reduce the burden of adolescent depression in LMICs. The most common forms of injury observed in our study were those that occurred during play or sports activities or from traffic accidents, while falls and fractures/dislocated joints were also common. Key measures to prevent sports injuries would be to develop physical and sports education at school (Street and Jacobsen, 2017). In terms of traffic accidents, enforcing laws on speeding, motorcycle helmets or on seat-belts is crucial (Routley et al., 2007; Wadhvaniya et al., 2017). Regarding falls, there

is an urgent need for international standards for playground equipment, and window guards should be required for high buildings (Jacob et al., 2019). In addition, taken together, our study results underline the importance of screening for depressive symptoms during the post-injury period. Parents, teachers, school nurses, and general practitioners may play a key role in this follow-up activity, and when adolescents who are at high risk of depressive symptoms or depression are identified, these adolescents should be referred to psychiatrists and psychologists. Buffering the impact of physical injury on depression requires strengthening primary care services and facilities, and improving the management of young victims of serious physical injury. Moreover, teaching children and adolescents about mental health is key to prevent depression, while promoting non-violence and communication skills is necessary.

#### 4.4. Limitations

The study results should be interpreted in the light of several limitations. First, this study included students only, and there was no data on adolescents who did not attend or who dropped out of schools, potentially limiting the generalizability of the findings. Second, there was no information on disability, despite the fact that it may play an important role in the association between physical injury and depression. Third, although the question on depressive symptoms used in our study has been used in a multitude of previous studies using the same dataset (Balogun et al., 2014; Liu et al., 2020; Vancampfort et al., 2018), while it referred to core symptoms of depression, the fact that depressive symptoms were assessed with a single question, and the lack of validity studies for this particular question are limitations of this study. Future studies with validated measures or clinical assessment of depressive symptoms/depression are warranted. Fourth, the analysis on the circumstance, cause, and type of the most serious injury in the past 12 months was only based on the most serious injury and thus, there remains the possibility that the students were also exposed to other types of injury. Finally, this was a cross-sectional analysis, and thus, it was not possible to determine causality or temporality of the relationship. For example, depression may have led to physical injury via suicidal behavior, lack of attention or impairment of concentration (Dworkin et al., 2017; Patten et al., 2010).

## Appendix

### Appendix 1

The frequency of physical injury by the type of most serious cause of injury.

Major cause	Number of serious physical injuries in the past year			
	1 time	2–3 times	4–5 times	≥ 6 times
I was in a motor vehicle accident or hit by a motor vehicle	56.9	28.1	7.5	7.5
I fell	60.5	27.6	6.2	5.6
Something fell on me or hit me	50.5	28.5	10.3	10.7
I was fighting with someone	44.3	31.0	10.4	14.3
I was attacked, assaulted, or abused by someone	45.7	29.8	11.8	12.7
I was in a fire or too near a flame or something hot	49.0	24.5	6.8	19.7
Other	56.6	28.7	7.0	7.8

## 5. Conclusion

The results of this study indicate that serious physical injury may be a risk factor for depressive symptoms among adolescents in LMICs, highlighting the importance of better prevention of physical injury and better mental health care for injury victims in these countries. Further studies are needed to improve our understanding of the mechanisms underlying the association between physical injury and depression among youths in LMICs.

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## CRediT authorship contribution statement

**Louis Jacob:** Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Lee Smith:** Conceptualization, Writing - review & editing. **Josep Maria Haro:** Conceptualization, Writing - review & editing. **Andrew Stickley:** Conceptualization, Writing - review & editing. **Ai Koyanagi:** Conceptualization, Formal analysis, Funding acquisition, Writing - original draft, Writing - review & editing.

## Declaration of Competing Interest

None

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**Appendix 2**

Details regarding most serious injury (%) (restricted to those who had a serious injury).

<b>What were you doing?</b>	Playing or training for a sport	Walking or running, but not as part of playing or training for a sport	Riding a bicycle or a scooter	Riding or driving in a car or other motor vehicle	Doing any paid or unpaid work	Nothing	Other
Overall	31.7	16.0	11.5	7.2	8.1	12.8	12.9
Argentina	56.7	6.7	10.6	1.4	3.0	2.7	19.0
Botswana	31.5	15.0	18.7	3.4	13.7	9.1	8.7
Chile (Metropolitan)	48.1	12.4	9.0	1.5	2.1	2.8	24.0
China (Beijing)	20.9	18.1	13.7	1.7	4.0	13.7	27.9
Ecuador (Quito)	53.3	11.6	9.1	2.3	3.5	4.7	15.4
Grenada	22.5	13.3	10.4	2.2	8.0	10.4	33.2
Guyana	14.5	12.2	13.8	5.3	11.1	12.9	30.2
Indonesia	25.2	15.4	6.8	7.9	7.5	25.4	11.9
Kenya	28.0	27.4	19.2	5.5	8.0	8.0	3.8
Lebanon	31.0	11.6	13.0	4.8	4.8	11.4	23.4
Morocco	42.7	9.6	14.3	5.4	4.0	11.8	12.3
Myanmar	32.4	15.3	20.3	1.8	15.3	4.9	9.8
Philippines	26.3	19.0	10.5	2.3	11.8	16.6	13.5
St. Lucia	22.3	14.2	11.5	2.1	7.9	7.9	34.2
St. Vincent & the Grenadines	22.2	18.2	11.0	2.7	9.9	8.7	27.2
Tanzania (Dar Es Salaam)	36.1	21.1	12.7	1.6	5.1	17.7	5.7
Thailand	29.3	12.3	10.0	19.7	7.4	4.7	16.5
Uganda	36.5	18.5	15.2	2.3	11.5	7.2	8.7
Uruguay	51.3	7.1	11.8	4.7	2.8	2.8	19.5
Venezuela (Lara)	45.3	14.2	12.6	4.2	3.5	5.3	14.9
Zambia	32.6	22.7	10.0	4.0	15.0	10.5	5.2

<b>What was the major cause?</b>	I was in a motor vehicle accident or hit by a motor vehicle	I fell	Something fell on me or hit me	I was fighting with someone	I was attacked, assaulted, or abused by someone	I was in a fire or too near a flame or something hot	Other
Overall	14.2	35.6	11.4	6.3	3.7	3.0	25.9
Argentina	4.2	36.7	9.0	3.1	2.7	0.9	43.4
Botswana	9.0	30.7	16.7	7.4	7.9	8.3	19.9
Chile (Metropolitan)	3.0	42.2	6.6	4.6	2.0	0.7	40.8
China (Beijing)	2.7	36.3	13.8	6.8	3.2	2.4	34.8
Ecuador (Quito)	6.3	52.1	9.1	4.1	1.0	0.4	27.0
Grenada	4.6	33.5	7.1	4.3	5.9	2.0	42.5
Guyana	9.9	29.9	10.8	6.4	4.5	1.7	36.9
Indonesia	17.9	43.8	6.3	3.1	2.4	1.6	24.9
Kenya	12.8	29.0	18.2	8.2	7.4	8.6	15.8
Lebanon	7.5	25.7	19.8	7.1	3.4	3.0	33.5
Morocco	11.0	44.0	9.1	8.2	2.7	3.5	21.5
Myanmar	10.2	46.1	16.7	6.4	2.0	4.6	14.1
Philippines	13.1	21.1	15.6	10.1	6.4	1.0	32.8
St. Lucia	4.7	36.0	6.7	5.9	2.0	1.1	43.7
St. Vincent & the Grenadines	5.6	30.1	9.2	10.2	2.9	4.0	38.0
Tanzania (Dar Es Salaam)	4.8	48.2	13.2	5.7	2.4	8.4	17.4
Thailand	20.6	34.6	9.1	7.0	1.9	1.5	25.4
Uganda	12.5	34.3	15.9	6.5	4.7	7.9	18.1
Uruguay	8.4	35.1	9.9	5.6	1.8	0.6	38.7
Venezuela (Lara)	9.8	50.6	4.3	9.0	3.1	1.4	21.8
Zambia	25.5	19.8	22.3	10.3	5.1	7.8	9.2

<b>How did the injury happen?</b>	Hurt myself by accident	Someone else hurt me by accident	I hurt myself on purpose	Someone else hurt me on purpose
Overall	54.2	28.0	8.1	9.7
Argentina	67.0	20.9	2.9	9.3
Botswana	34.5	21.5	24.1	19.9
Chile (Metropolitan)	64.9	18.5	2.9	13.8
China (Beijing)	62.0	22.3	2.5	13.2
Ecuador (Quito)	63.6	24.6	4.4	7.4
Grenada	51.4	21.5	9.1	18.1
Guyana	49.0	20.0	11.6	19.3
Indonesia	57.0	34.4	1.9	6.7
Kenya	40.0	23.5	23.4	13.1
Lebanon	56.0	30.0	4.9	9.1
Morocco	24.3	41.3	18.7	15.7
Myanmar	68.6	20.0	6.7	4.7
Philippines	57.2	24.4	5.9	12.5
St. Lucia	51.4	26.5	4.3	17.8
St. Vincent & the Grenadines	43.2	23.1	12.9	20.8
Tanzania (Dar Es Salaam)	64.1	27.8	1.7	6.5
Thailand	58.9	28.7	5.6	6.8
Uganda	46.8	24.6	15.2	13.4
Uruguay	67.7	18.9	6.5	6.9
Venezuela (Lara)	55.3	25.9	7.1	11.8
Zambia	33.1	28.7	20.7	17.6

(continued on next page)

## Appendix 2 (continued)

What was the injury?	Broken bone or dislocated joint	Cut, puncture, or a stab wound	Concussion or other head or neck injury	Gunshot wound	Bad burn	Lost all or part of a foot, leg, hand, or arm	Other
Overall	28.4	18.3	8.0	1.8	4.0	1.6	37.9
Argentina	33.3	12.0	10.3	0.4	2.0	0.5	41.4
Botswana	22.7	31.8	9.1	2.6	12.8	3.0	17.9
Chile (Metropolitan)	46.1	5.6	7.3	0.7	1.1	0.9	38.2
China (Beijing)	27.0	14.4	3.8	0.4	1.0	1.0	52.4
Ecuador (Quito)	32.0	9.2	10.8	0.5	1.6	0.9	45.0
Grenada	16.4	27.7	4.9	2.7	3.6	0.9	43.9
Guyana	19.8	26.6	3.5	0.9	6.3	1.8	41.0
Indonesia	40.8	8.9	3.7	0.8	3.5	1.2	41.1
Kenya	25.1	34.1	11.3	4.7	7.3	4.7	13.0
Lebanon	33.4	24.2	14.5	2.1	3.4	0.6	21.9
Morocco	NA	NA	NA	NA	NA	NA	NA
Myanmar	27.2	40.7	5.9	0.8	2.2	0.4	22.7
Philippines	19.1	19.5	13.6	1.7	1.0	0.9	44.3
St. Lucia	24.7	22.7	5.5	1.7	3.5	0.3	41.6
St. Vincent & the Grenadines	20.9	29.3	6.7	1.3	4.6	0.6	36.5
Tanzania (Dar Es Salaam)	23.4	22.5	14.7	2.1	12.4	4.5	20.4
Thailand	15.4	14.0	6.1	2.3	5.2	0.6	56.3
Uganda	28.7	36.5	8.4	1.7	6.7	3.5	14.5
Uruguay	33.9	8.3	7.9	0.0	2.1	0.6	47.2
Venezuela (Lara)	29.7	31.6	8.6	1.3	0.0	0.0	28.8
Zambia	22.6	19.3	14.0	5.6	8.0	7.5	22.9

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