

The relationship between pain and suicidal vulnerability in adolescence:

A systematic review

Authors:

Verena Hinze (MSc)^a, Dr. Catherine Crane (DPhil)^a, Prof. Tamsin Ford (PhD)^b,
Dr. Ruta Buivydaite (DPhil)^a, Lin Qiu (MSc)^{a,c}, &
Dr. Bergljot Gjelsvik (PhD)^{a,d}

- a. Department of Psychiatry, University of Oxford, Oxford, UK
- b. University of Exeter Medical School, Exeter, UK
- c. Faculty of Psychology and Neuroscience, Maastricht University, Maastricht, The Netherlands
- d. Department of Psychology, University of Oslo, Oslo, Norway

Published in The Lancet Child & Adolescent Health (October, 2019)
DOI: [https://doi.org/10.1016/S2352-4642\(19\)30267-6](https://doi.org/10.1016/S2352-4642(19)30267-6)

Corresponding author:

Ms Verena Hinze

University of Oxford, Department of Psychiatry

Warneford Lane, Oxford, OX3 7JX

Email: verena.hinze@psych.ox.ac.uk (alternatively: verena.hinze@web.de)

The relationship between pain and suicidal vulnerability in adolescence
– A systematic review –

Summary

Leading suicide theories and research in adults suggest that pain may exacerbate an individual's suicidal risk. Although pain and suicidality both increase in prevalence during adolescence, their relationship remains unclear. We aimed to systematically review the empirical evidence for an association between pain and suicidality in adolescence (PROSPERO: [CRD42018097226](https://doi.org/10.1111/CRD4.2018097226)). In total, 25 observational studies, published between 1961 and December 2018, exploring the potential pain-suicidality association in adolescence (10-19 years) were included. Across various samples and manifestations of pain and suicidality, we found that pain approximately doubles adolescents' suicidal risk, with a few studies suggesting that pain may predict suicidality longitudinally. Although depression was an important factor, it did not fully explain the pain-suicidality association. Evidence on associations between pain characteristics and suicidality is sparse and inconclusive, potentially hiding developmental differences. Identification of psychological mediators and moderators is required to develop interventions tailored to the needs of adolescents in pain.

Introduction

Although suicide can affect people at all stages of life, it accounts for a major proportion of deaths amongst young people worldwide.^{1,2} Death by suicide marks the fatal endpoint of the suicidality risk spectrum, which ranges from cognitions about suicide and self-harm (i.e., suicidal ideation) through suicidal behaviours (i.e., the actual act of harming oneself irrespective of suicidal intent and levels of medical severity) to death by suicide.³ These non-fatal manifestations of suicidality are a common public health problem in adolescents (lifetime suicidal ideation: 29.9%; history of suicidal behaviour: 9.7%^{4,5}), particularly between the ages of 12 and 17 years.^{6,7} Thus, knowledge of the factors that promote risk and resilience to the development of suicidality and the transition from suicidal ideation to acts in adolescents is crucial.⁸

Leading theories of suicidality⁹⁻¹² and empirical research in adults¹³⁻¹⁵ emphasize the role of pain in increasing an individual's suicidal risk. However, pain is a complex phenomenon and little is known about which aspects of the pain experience, including sensory (e.g., pain sensitivity), cognitive (e.g., pain catastrophizing) and affective-motivational components of pain (e.g., unpleasantness of pain^{16,17}), confer an increased suicidal risk.¹⁸ Alternative ways of describing pain are by its duration and/ or the impact of pain on functioning. Whilst 'acute pain' is short-lived (i.e., < 3 months) and caused by an identifiable disease or injury,¹⁹ 'chronic pain' refers to an enduring primary health condition (i.e., ≥ 3 months) of persistent or recurrent pain that significantly impairs patients' wellbeing and functioning, despite treatment of an underlying medical condition.²⁰ In this review, '*pain*' refers to the presence of both acute and chronic pain conditions, aspects of the pain experience and functional impairment.

Although research has shown that prevalence rates of chronic pain tend to increase substantially from the age of 12 years onwards (median prevalence rate: 11-38%^{21,22}), little is known about the pain-suicidality association in adolescents. In keeping with the definition proposed by the World Health Organisation,²³ we define adolescence as a distinct developmental period, ranging from 10 to 19 years of age. During these critical years of development, young people undergo marked physical, neuro-cognitive and social changes that may precipitate or protect against the emergence of various (mental) health outcomes in adulthood.^{24,25} Pain during adolescence is predictive of pain in adulthood.^{22,26} However, the manifestation of pain may vary between adolescents and adults,^{21,27} and its effects may be particularly detrimental in adolescence, particularly by interfering with the adaptive development during this critical period.²⁸

Given the growing support for a relationship between pain and suicidality in adults (see Racine¹³, Rizvi et al.¹⁴ and Tang et al.¹⁵), establishing whether a similar relationship exists in adolescents has the potential to enhance our understanding of the interplay between physical and mental suffering in this age group, and to inform the development of prevention strategies.^{6,29}

In this paper, we report the findings of a systematic review designed to synthesise and critically evaluate the existing empirical evidence for an association between pain and suicidality in adolescence.

Methods

Search strategy and selection criteria

The protocol for the systematic review is compliant with the recommendations of the PRISMA statement³⁰ and was pre-registered in PROSPERO [[CRD42018097226](https://doi.org/10.1111/CRD4.2018097226)].

A comprehensive search strategy was used to identify candidate studies, developed in liaison with an information specialist and experts on pain and suicide research (see supplement 1). Literature searches were performed in Ovid Embase, Ovid PsycINFO, Ovid Medline, EBSCO CINAHL, PubMed, Web of Science, and Scopus, alongside checking of grey literature (ProQuest Dissertations and Theses; OpenGrey: opengrey.eu/), trial registers (ClinicalTrials.gov), conference proceedings (Web of Science and Embase), backward and forward citation screening and correspondence with authors of included studies, between June, 7th and December, 3rd, 2018. As the main database search yielded an additional key term (self-mutilation), the search was repeated on July, 3rd, 2018, focussing in the second round solely on self-mutilation as a measure of suicidality. An inclusive approach to eligibility assessment was taken. Studies were deemed eligible if they explored and provided data on the potential relationship between suicidality and pain in adolescence. No restrictions were placed on the type or the assessment of suicidality, pain or the research setting. In addition, studies (sampling both adolescents and adults) were included, provided data could be extracted for the subsample of adolescents (i.e., those aged 10 to 19 years²³). In order to minimise between-study heterogeneity, only observational studies (i.e., cross-sectional, cohort and case-control studies) were included.

Studies were excluded if (1) the study did not allow to establish an association between pain and suicidality, (2) no data could be extracted for adolescents, (3) the study focussed on clearly distinct populations (e.g., animal studies, military studies, prison cohorts, and end-of-life care), (4) they did not provide original data (e.g., reviews, editorials, or opinion papers),

(5) they did not use an observational study design (e.g., intervention studies, experimental studies and qualitative research), (6) they experimentally induced pain, (7) they used mixed measures of pain and suicidality (e.g., pain during self-harm) or measures of the perception of pain in comparison to other people, and (8) they were published in any other language than English. Furthermore, studies published before 1961 (the year of decriminalisation of suicide in England and Wales³¹) or after December 2018, and duplicates, were excluded from this review.

Using Covidence³², two independent reviewers (VH and LQ) performed the eligibility assessments between June, 7th and December, 3rd, 2018. Title and abstract screening was followed by full-text screening. Inter-rater reliabilities were calculated, using the percentage agreement with a threshold of ≥ 0.8 indicating acceptable inter-rater reliability. Between-rater discrepancies were resolved through discussion and where necessary through involvement of a third independent reviewer (BG).

Data extraction and quality assessments

Two independent reviewers (VH & RB) performed the data extraction, using a standardised pre-piloted data extraction form (see supplement 2). Authors were contacted to provide missing (subsample) data where necessary. Two studies used the same dataset, as an already included study (Young-Hunt^{33,34}, Add Health^{35,36}). We decided to treat all four studies separately, as data on different measures, subsamples^{35,36} and follow-up waves^{33,34} were reported, precluding a combined discussion of the study results.

Two independent reviewers (VH & LQ) performed the quality assessments, using the Newcastle-Ottawa Quality Assessment Scale ([NOS]³⁷) for nonrandomised studies.^{38,39} Each study was evaluated on an item-basis to advance future research. Quality assessments were not used to determine eligibility, but to gauge the validity of the results and to generate guidelines for future research. Inter-rater reliabilities for the data extraction and quality assessments were calculated using the percentage agreement, and discrepancies between raters were resolved through discussion, and involvement of a third, independent reviewer (BG), if necessary.

Data synthesis

Given the large between-study heterogeneity in the exposure and outcome of interest, as well as in the population studied and statistics being used, a meta-analysis was considered to be inappropriate⁴⁰ and a narrative synthesis of aggregated and individual study findings was conducted, primarily using risk measures.

Role of the funding source

The first author, VH, is funded by the Oskar-Helene Heim Foundation and the FAZIT foundation. CC, is funded by the Wellcome Trust, Grant Number 107496/Z/14/Z. RB is funded by Defehr-Neumann foundation. BG is funded by the Faculty of Social Sciences, University of Oslo. The funding organisations had no role in the study design, data collection, data extraction, data interpretation, or writing of this report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The comprehensive search strategy yielded 8217 references (figure 1). After deduplication, 3806 were retained for title and abstract screening, of which 557 studies were considered for full-text review. Independent review resulted in a total sample of 25 studies. Interrater agreement across the study selection phases and the data extraction phase was high (selection: percentage agreement=86·5-99·9%; data extraction: percentage agreement=97·7%).

The majority of selected studies had been published in the last decade (n=20^{33,34,36,41-57}; 80% published after 2010; table 1). Studies were geographically diverse, and mainly based on community samples (n=17^{33-36,43,44,46-51,53,55,57-59}), using cross-sectional designs (n=18^{35,41,43,46,47,49-61}). Eighteen studies recruited participants aged 10 to 19 years,^{33-36,42,45-48,50-53,57-61} whilst in 7 studies data on adolescents within a broader age sample were made available by the authors.^{41,43,44,49,54-56}

Study quality was assessed (see supplement 3), with substantial interrater agreement (percentage agreement=77·7-83·3%). Although 17 studies scored positively on at least half of the assessment criteria,^{33-36,42,44-48,50-53,58,59,61} study limitations became apparent in several domains, including the assessment of the exposure (i.e., pain; n=17^{33-35,41,42,45,47-51,53,55-57,59,60}) and the outcome (i.e., suicidality; n=16^{34-36,41,47,49-53,55-60}). Other major limitations involve the failure to justify sample size (n=9^{41,43,49,54-57,60,61}), inappropriate use and reporting of statistical tests (n=7^{41,43,49,54-57}), high number of non-respondents (n=7^{35,43,49,52,56,58,60}) and failure to control for potential correlates, such as age, gender and/ or depression (n=6^{41,43,49,54,56,60}).

Table 2 shows the individual study results, structured around the type of suicidality and the level of support provided for the potential pain-suicidality association. The majority of studies reviewed provided support for the hypothesised pain-suicidality association in adolescence. In three studies the relationship between pain and suicidality remained unclear, as no test statistics were available.^{43,54,56}

Seven community-based studies^{34-36,46,47,58,59} and four clinical studies^{42,45,52,61} explored links between pain and suicidal ideation. In most of the community-based studies, pain increased the odds of suicidal ideation (e.g., see Halvorsen et al.⁴⁷; Wang et al.⁵⁹). Specifically, of the 4.5 to 17 percent of adolescents in community samples reporting suicidal ideation,^{34-36,46,47,58,59} adolescents with pain reported significantly higher levels of suicidal ideation compared to those without pain (with pain: 7.2-23.9% vs. no pain: 3.5-6.2%).^{46,47,59} However, probability estimates varied greatly between community samples (aOR=1.2-4.9; see table 2), and the statistical significance of the associations appeared to depend largely on the degree of control for covariates. All studies focussing on community samples accounted for demographics (n=7^{34-36,46,47,58,59}), consistently showing that pain increased the odds of suicidal ideation. This association persisted when additionally controlling for health-related factors (n=3^{34,35,46}), but inconsistencies appeared when studies also accounted for depression and other psychiatric symptoms (n=5^{34,36,46,47,59}). In one study, pain was significantly associated with suicidal ideation after additionally controlling for psychiatric symptoms (aOR=1.8, 95%CI=[1.4-2.4]).³⁴ However, in other studies this association mostly diminished to non-significance after controlling for depression (see Halvorsen et al.⁴⁷; Fuller-Thomson et al.⁴⁶; Wang et al.⁵⁹; Van Tilburg et al.³⁶). When focussing on clinical samples of adolescents in pain (n=4^{42,45,52,61}), three studies found significant associations between pain and suicidal ideation (aOR=1.0-7.8^{45,52,61}; percentage with suicidal ideation: 20-22%^{52,61}, suicidal ideation with pain: 22% vs. without pain: 5.3%⁴⁵), which were no longer apparent after controlling for demographics and depression.^{52,61} One study did not reveal any association between pain and suicidal ideation (suicidal ideation with pain: 34.7% vs. without pain: 27.5%).⁴²

Nine studies explored the association between pain and suicidal behaviour,^{33,35,36,41,48,50,53,57,60} of which seven studies recruited community samples^{33,35,36,48,50,53,57} and two studies focussed on adolescents in psychiatric services.^{41,60} In community samples, pain increased the odds of suicidal behaviour, with large differences in probability estimates between community samples (aOR=1.2-9.0; see table 2), as a function of the degree of control for other correlates. Specifically, 1 to 21.4 percent of community adolescents reported suicidal behaviour.^{33,35,36,48,50,53,57} Adolescents with pain reported higher levels of suicidal behaviour than those adolescents without pain (with pain: 6-78% vs. without pain: 1.3-31.1%)^{48,50,53} and adolescents with pain reported higher rates of suicidal behaviour than no suicidal behaviour (7.9-61.8 vs. 3.4-39.2).^{33,57} All community-based studies (n=7^{33,35,36,48,50,53,57}) accounted for demographics either in the study design⁴⁸ or through adding them as covariates (e.g., see Junker et al.³³), and provided support for an association between

pain and suicidal behaviour. In most studies, this association remained significant when adding behaviour- and health-related factors as covariates ($n=4^{35,48,53,57}$). However additional control for psychiatric symptoms ($n=4^{36,48,50,53}$), resulted in diminished associations. Of those studies that focussed on adolescents in psychiatric services ($n=2^{41,60}$), one study found a significant association between pain and suicidal behaviour ($OR=2.3-2.7$).⁶⁰ Specifically, of the overall sample of adolescents in psychiatric services, 35.7 to 48.8 percent reported one type of suicidal behaviour. It remained unclear how many of those adolescents were also experiencing pain.⁶⁰ However, adolescents who showed aggressive compared to non-aggressive suicidal behaviours did not significantly differ in their report of pain (aggressive suicidal behaviour and pain: 11.8-17.6% vs. non-aggressive suicidal behaviour and pain: 9.4-34.4%).⁴¹ Neither study accounted for other correlates.

Two studies examined the relationship between pain and death by suicide.^{44,48} One identified an increased risk for death by suicide ($HR=1.6$; $95\%CI=[1.2-2.3]$) in a community sample of adolescents with pain, compared to adolescents without pain (i.e., percentage of suicides: 20.4%; of which 6-62% reported pain vs. 32% without pain), which was no longer apparent after accounting for behavioural factors and psychiatric symptoms.⁴⁸ Another large population-based cohort study explored the risk of death by suicide in opioid users with chronic non-cancer pain, showing that no deaths were recorded as suicides in this sample.⁴⁴

Five studies explored longitudinal associations between pain and suicidality.^{33,34,36,44,48} Two found pain to be longitudinally associated with suicidal ideation, controlling for demographics, health-related factors and psychiatric symptoms,^{34,36} but only one of these measured and could thus control for suicidal ideation at baseline.³⁶ Three studies explored the pain-suicidal behaviour association longitudinally.^{33,36,48} Pain was not found to predict suicidal behaviour over a one-year follow-up period,³⁶ but pain predicted suicidal behaviour over a 33-year⁴⁸, after controlling for demographics and psychiatric symptoms. Furthermore, pain was longitudinally associated with self-harm hospitalisation over a period of 12-years, controlling for demographics.³³ However, as self-harm was not measured at baseline, no interferences can be drawn about the direction of this relationship.³³ Finally, pain was not predictive of death by suicide after controlling for behavioural factors and psychiatric symptoms in two studies.^{44,48}

One study showed that particularly comorbid pain, when three to five pain-sites were reported compared to fewer pain sites, increased the probability of suicidal ideation, after controlling for demographics and depression ($aOR=1.8$, $95\%CI=[1.3-2.5]$).⁴⁷ Specifically, 19.6 percent of adolescents with three to five pain sites reported suicidal ideation compared to 7.5 percent of adolescents with one or two pain sites and 4.5 percent of adolescents without

pain.⁴⁷ Four studies examined the relationship between pain frequency and suicidality.^{33,50,59,60} Of these, one study explored suicidal ideation, showing that more, compared to less, frequent pain, was significantly associated with suicidal ideation, after controlling for demographics and depression (aOR=1.7, 95%CI=[1.1-2.6]).⁵⁹ Specifically, the prevalence of suicidal ideation increased from 7.8 percent, for pain lasting less than one day, to 26.2 percent, for pain lasting between seven to 14 days, (overall 8.5% reported suicidal ideation in this sample).⁵⁹ Likewise, frequent pain was found to be associated with an increased risk of suicidal behaviour (OR=2.3-2.7),⁶⁰ and future self-harm hospitalisation, compared to individuals with less frequent pains (aHR_(sometimes/ often headaches/ stomach pain)=2.2).³³ Specifically, 41.3 to 64.2 percent of adolescents with frequent pains, compared to 35.8 to 58.8 percent with seldom/ never pain, reported self-harm hospitalisation at follow-up.³³ In keeping with these findings, recurrent pain was found to increase the odds of suicidal behaviour (aRR=1.4-1.8; recurrent pain: 6-20.5% with suicidal behaviour vs. no pain: 1.3-8.9% with suicidal behaviour), after controlling for demographics and psychiatric symptoms.⁵⁰ However, when exploring this relationship more thoroughly focussing on varying frequencies of suicidal behaviour and pain, the pain-suicidal behaviour association only remained significant for very frequent pain and up to three episodes of suicidal behaviour per year (aRR=1.6, 95%CI=[1.1-2.2]), and for specific pain locations, after controlling for demographics and psychiatric symptoms (see table 2).⁵⁰

Three studies explored pain severity as a risk factor for suicidality.^{48,52,53} One identified no association between severity and suicidal ideation after controlling for demographics and depression,⁵² and two found partial support for an association with suicidal behaviour in community samples.^{48,53}

One study explored the relationship between pain duration and suicidal ideation in a clinical sample of pain patients, showing that the association between pain duration and suicidal ideation severity (aOR=1.0, 95%CI=[1.0-1.0]) was mediated by depression.⁵² Other pain characteristics (i.e., family history of pain disorders and pain intensity) were not associated with suicidal ideation in pain patients.^{42,52}

Two studies explored the relationship between sensory (pain sensitivity and threshold) and affective (pain distress) components of the pain experience and suicidality in community samples.^{49,55} One study found significant group differences for pain distress, with higher levels being reported by adolescents with suicidal ideation (Med=40.5) compared to suicidal behaviour (Med=39.0) or healthy controls (Med=30.5).⁴⁹ For pain sensitivity significant group differences only became apparent when comparing adolescents with suicidal behaviour to healthy controls (suicidal behaviour: M=6.6-2.3 vs. healthy: M=5.7-2.2).^{49,55} Moreover,

higher pain tolerance was reported by adolescents with ideation and behaviour, compared to healthy controls, with no significant differences between the suicidal groups (suicidal ideation: $M=1.83$ ($SD=0.95$), suicidal behaviour: $M=1.80$ ($SD=1.05$), healthy: $M=1.60$ ($SD=0.82$)).⁵⁵

Lastly, six studies examined the association between physical disability and suicidality.^{35,42,46,51,52,59} In two community samples, the significant association between the amount of activities prevented by pain (aOR=2.0; 95%CI=[1.2-3.4]; suicidal ideation and some activities prevented by pain: 12.6% vs. no activities prevented: 3.5%),⁴⁶ as well as headache-related disability and suicidal ideation (grade I disability=7.5% vs. grade IV=44.4% with suicidal ideation; $p < 0.001$) was no longer apparent after controlling for demographics, health-related factors and depression.^{46,59} Likewise, two clinical samples showed that functional disability was not associated with suicidal ideation in pain patients,⁵² and that functional disability and pain-bother did not differentiate between the presence of suicidal ideation in adolescents with and without chronic pain.⁴² Finally, the level of mobility limitations did not moderate the relationship between pain and suicidal ideation or suicidal behaviour, in a community-based study controlling for demographics.³⁵ However, higher pain-related quality of life was significantly associated with lower levels of suicidality (aOR=0.97; 95%CI=[0.97-0.98]) in a community sample, after controlling for demographics.⁵¹

Figure 2 displays the results of this review, showing the different relationships between various manifestations of pain and suicidality in community and clinical samples of adolescents. Please note, that given the paucity of existing research and the large variety in the conceptualisation and measurement of each correlate, the evidence pertaining to specific correlates is rather limited and needs to be interpreted with caution (see supplement 4). Nevertheless, this systematic review has shown that the majority of studies reviewed provided support for the hypothesised pain-suicidality association in adolescence across the various manifestations of pain and suicidality, and the different samples being studied. Overall, we found higher prevalence rates of suicidality in community samples with pain compared to those without pain (suicidal ideation and pain: 7.6-17.7% vs. no pain: 3.6-6.2%; suicidal behaviour and pain: 6.63% vs. no pain: 1.3-39.2%), and in clinical samples (suicidal ideation and pain: 22% vs. no pain: 5.3%). Studies where the relationship was no longer apparent after control for other measured factors, were comparable to studies where this relationship remained in terms of their population, sample size and study designs, but those studies that provided only partial support generally explored more pain locations and types of suicidality, and controlled for more correlates, such as depression ($n=9/11$ vs. $n=2/8$, table 2). Across the different levels of support (full or partial support), similar associations have been found, namely around one- to two-fold

increase in odds of suicidal ideation and suicidal behaviour, considering various pain locations. However, these associations became less robust and mostly reduced to non-significance after controlling for psychiatric symptoms (table 2).

Discussion

This systematic review synthesised and evaluated existing evidence across 25 studies, published between 2006 and 2018, on the hypothesised pain-suicidality association in adolescents. In keeping with our hypotheses derived from the adult literature,^{13,15,18,62} we found evidence for an association between pain and suicidality in adolescents, across various samples and manifestations of pain and suicidality. Overall, we found higher prevalence rates of suicidality in community samples with pain compared to those without pain (suicidal ideation and pain: 7.2-23.9% vs. no pain: 3.5-6.2%; suicidal behaviour and pain: 6-78% vs. no pain: 1.3-31.1%), and in clinical samples (suicidal ideation and pain: 22% vs. no pain: 5.3%). In other words, pain doubles the risk of suicidality, with some studies suggesting that pain may predict suicidality longitudinally. Substantial between-study heterogeneity in the operationalisation and assessment of exposures and outcomes, as well as in the population sampled, study designs used, and the degree of control for important correlates, led to inconsistent findings. These inconsistent findings are in keeping with research in adults,^{18,62} and highlight the need for a systematic and consistent approach in research that aims to disentangle the complex relationship between pain and suicidality.

Studies in which the pain-suicidality association became non-significant after controlling for other variables, typically assessed the exposure and outcomes with validated tools (e.g., instead of single-item, non-validated questions), explored different pain locations and types of suicidality, thereby also providing a range of non-significant associations, and more rigorously controlled for psychiatric symptoms, such as depression, than studies that provided full support for this relationship. In keeping with the adult literature (see Hooley et al.⁶³; Spiegel et al.⁶⁴), depression stood out as an important factor in the relationship between pain and suicidality, as the association weakened after controlling for depression (e.g., see Fuller-Thomson et al.⁴⁶). Yet, this systematic review shows that, even after adjustment for depression, the pain-suicidality association still remained significant for subgroups that are characterised by more frequent and severe pains (e.g., headaches; see Koenig et al.⁵⁰; Hogstedt et al.⁴⁸). This suggests that the relationship between pain and suicidality is complex, and at least partially depends on mechanisms other than depression (see Racine¹³). Additionally the cross-sectional nature of most studies means that research is still largely agnostic to the issue of

whether depression acts as a confounder (increasing occurrence/reporting of both pain and suicidality), an intermediate mechanism (mediator) between pain and suicidality (e.g. pain > depression > suicidality), a moderator (e.g., the pain-suicidality association is stronger in the presence of co-morbid depression) or some complex interplay between these potential relationships. These proposed trajectories are consistent with a recent review, highlighting similar paths in which paediatric chronic pain and depression may co-occur and mutually maintain one another).⁶⁵ However, little is known about which of these trajectories are more likely and the respective correlates that may drive these associations of paediatric pain with depression, or indeed with suicidality.⁶⁵ Regarding suicidality, it is particularly relevant to explore these correlates to enhance our understanding of how changes in an initially adaptive state of acute pain may relate to maladaptive thoughts and behaviours. Feeling acute pain has a survival advantage, such that it signals harm and drives action to prevent future harm and promote recovery.⁶⁶ However, when pain becomes chronic it loses this advantage and is associated with increased distress and at its worst self-destructive behaviours.⁶⁶ In an attempt to better understand the complex pain-suicidality association in adults, a recent review has revealed psychological processes that are common to both conditions (e.g., psychological flexibility, future orientation and mental imagery).⁶⁷ However, it remains unknown whether these psychological processes may also drive the behavioural change that may explain the pain-suicidality relationship in adolescence. It is, therefore, essential to better understand the pain-suicidality trajectories and the potentially complex interplay with unique correlates in adolescence to identify these vulnerable youth.

Research in adults shows that common mental-health factors (e.g., depression and anxiety) mediate but do not fully account for the pain-suicidality association.⁶⁸⁻⁷⁰ As pain and psychiatric symptoms are highly comorbid during adolescence,⁷¹ it is crucial to better understand the potentially complex interplay between physical and mental health when explaining the pain-suicidality association. To date, most studies have solely explored depression as a mental health factor underpinning the pain-suicidality association in adolescence, and little attention has been given to other potential mental health factors, such as anxiety or childhood trauma (see Spiegel et al.⁶⁴), or psychological processes underpinning this association. Enhanced knowledge about and management of comorbid physical and mental-health risk factors may maximise treatment outcomes.⁷²

Exploring different aspects of the pain experience, we found that more pain sites, frequent and recurrent pain and pain-related quality of life (i.e., people's perceived impact of their pain on their physical, mental and social well-being⁵¹), were associated with suicidality,

which corroborates and extends existing research in adults.¹³ In addition, longer pain duration was associated with suicidal ideation. In keeping with the adult literature, this relationship diminished after controlling for depression, suggesting that over time suicidal ideation may become more closely associated with comorbid psychological symptoms instead of the duration of the physical symptoms.¹³ There are mixed findings for relationships with pain severity, pain sensitivity, distress and tolerance. Although physical disability has previously been found to be a predictor of suicidality in adult samples,⁶² the current review detected inconsistent findings in adolescents. Even though some studies detected an association (see Lewcun et al.⁵²), this relationship mostly diminished to non-significance, after controlling for psychiatric symptoms (see Fuller-Thomson et al.⁴⁶). This finding is in keeping with research suggesting that the correlates of physical disability differ by age.⁷³ Specifically, physical disability was strongly associated with affective distress in younger patients, compared to elderly where physical disability was strongly associated with pain severity.⁷³ This finding suggests that in young people the association between physical disability and suicidality may be more strongly driven by the comorbid psychiatric symptoms than in older adults. That is, physical disability may increase suicidal vulnerability through its effect on mental health (e.g., emotional suffering¹³), or mental health problems may impact physical health and physical disability (e.g., due to fatigue, reduced activity or sleeping difficulties), leading to increased suicidal vulnerability. As most research to date is cross-sectional, the direction of the effects awaits further scrutiny. Furthermore, other aspects of the pain experience, namely family history of pain, pain intensity and opioid use, were not found to be associated with suicidality in adolescents. As research on the relationship between aspects of the pain experience and suicidality in adolescence is very limited, mixed results, particularly when performing a range of subgroup analyses, may be attributable to a lack of power when exploring subgroups, adding moderators and controlling for various correlates. Hence, a systematic exploration of these factors and replication of existing research is warranted.

Research on the relationship between pain and suicidality during adolescence is emerging, with 18 studies that addressed the adolescent years specifically. However, the amount of evidence pertaining to the specific aspects of the pain experience that may exacerbate suicidal risk is rather limited and inconclusive (see supplement 5), which emphasizes the need for future research. Specifically, future research needs to address the above mentioned limitations by thoroughly assessing pain and suicidality, controlling for correlates other than depression, exploring aspects of the pain experience (e.g., pain frequency) and risk and resilience factors underpinning this link more thoroughly across samples and study

designs to elucidate under which conditions pain may be associated with suicidality during adolescence. As most research has been conducted with community samples, future research needs to explore how these findings translate to clinical samples of adolescents in pain. Most of the reviewed research aligns with findings from similar studies in adults, which suggest a two- to three-times increased risk of suicidality in adults with chronic pain (see Racine¹³), compared to the doubled risk identified here. This challenges the proposed developmental profile underlying the pain-suicidality association, although the presence of a similar associations may hide different underlying mechanisms. Research to date has explored the pain-suicidality association in adolescence based on hypotheses derived from the emerging research in adults without acknowledging and exploring potential developmental differences between adolescents and adults. Moreover, as the current systematic review elucidates, the existing literature is limited by the superficial exploration of the pain-suicidality association in adolescents, mainly focussing on the overall relationship rather than specific pain characteristics. This superficial investigation may hide developmental differences that may become apparent when considering different lifetime periods and aspects of the pain experience. Chronic pain is a stressful experience that is frequently perceived as uncontrollable and functionally impairing.⁷⁴ Hence, exposure to chronic pain during the sensitive adolescent period⁷⁵ may interfere with adaptive neuro-cognitive development (e.g., acquisition of self-regulatory skills) and social maturation (e.g., independence), making adolescents more susceptible to prolonged emotional difficulties and at its worst suicidality.^{28,75} However at the same time, adolescents are shielded from some of the harsher socioeconomic effects of chronic disabling pain that may be experienced in adulthood (e.g., inability to work), and they are likely to be living in a social context which provides support for daily tasks. These highly speculative hypotheses await further scrutiny, and a systematic exploration of developmental similarities and differences underpinning the pain-suicidality association in adolescents and adults is warranted to tailor early interventions to patients' needs.

There are several limitations pertaining to the current systematic review. First, as we focused on literature published in English, we cannot generalise these findings to research published in any other language. Second, the direction of the effects between pain and suicidality remains unclear, given the small number of cohort studies that allow a consideration of direction of causality in observed associations. In addition, the existing cohort studies were limited by the single assessment of the outcome at follow-up, which precludes conclusions to be drawn about the direction of the effects. By assessing pain and suicidality at multiple times throughout development, future studies should ideally enable stronger statements to be made

concerning the likely direction of effects. Third, the identified support for the pain-suicidality association during adolescence may be due to publication bias (see also supplement 4), which we were unable to formally test, because of the large between-study heterogeneity that precludes the use of forest plots as part of a meta-analysis. Finally the findings are limited by the covariates used in existing studies (mostly depression), and it is unclear whether other unmeasured and uncontrolled factors could fully or partially explain the pain-suicidality association during adolescence.

Despite these limitations, this is the first review that systematically explored the relationship between pain and suicidality during the critical years of adolescence – a distinct developmental period with marked increases in the report of pain²² and suicidality.^{6,7} This review is characterised by methodological rigor, including double data search, eligibility and quality assessments, and data extraction with substantial inter-rater reliability. Moreover, unpublished subsample data has been obtained for seven studies. Across studies, we found evidence to suggest that adolescents suffering from pain are at an increased risk of suicidal ideation and behaviour. Although depression was identified as an important factor in this association, the pain-suicidality association could not be fully explained by the presence of comorbid depression. Evidence on associations between pain characteristics and suicidality is sparse and inconclusive, potentially hiding developmental differences. Interventions are warranted that target key psychological mechanisms underpinning the pain-suicidality association in adolescence to prevent or intervene with the progression along the suicide spectrum in adolescents suffering from pain. In addition, routine screening for suicidal risk needs to be facilitated to provide timely help and support.

Contributors

VH, BG, and CC designed this study. VH, BG, CC, and TF reviewed the registered protocol. VH coordinated and performed the data searches, study selection, data extraction and quality assessments. LQ acted as second independent reviewer, performing the second data searches, study selection, and quality assessments. RB acted as second independent reviewer, performing the data extraction. BG oversaw the implementation and acted as a third independent reviewer to resolve conflicts. VH wrote the initial draft and RB checked the tables and numbers for accuracy. VH, BG, CC and TF contributed to revising the initial draft, leading to the final manuscript. All authors reviewed and approved the final manuscript before submission.

Declaration of Interests

We declare no competing interests.

Data Sharing

The corresponding study protocol and the EndNote libraries will be made available on the Open Science Framework at the time of publication (see <https://osf.io/>; project name: Pain and Suicidality in Adolescence).

Acknowledgements

This review was partially funded by the Oskar-Helene-Heim foundation, the FAZIT foundation, the Wellcome Trust, Grant Number 107496/Z/14/Z, the Faculty of Social Sciences, University of Oslo, and the Defehr-Neumann foundation. No other funding sources apply. We would like to thank all authors who shared their publications and made subsample data available. In addition, we would wish to gratefully thank the following people for their invaluable support: Ms Eli Harriss and Ms Karine Barker (Bodleian Libraries, University of Oxford) for their help in identifying all the existing literature on this topic; Professor Andrea Cipriani for his advice and comments on the study protocol; and Professor Keith Hawton for his advice and suggestions on the final manuscript.

References

1. Patton GC, Coffey C, Sawyner SM, et al. Global patterns of mortality in young people: a systematic analysis of population health data. *Lancet* 2009; **374**: 881–892.
2. World Health Organisation. Suicide. August 24, 2018. <https://www.who.int/en/news-room/fact-sheets/detail/suicide> (accessed May 09, 2019).
3. Bridge JA, Goldstein TR, Brent DA. Adolescent suicide and suicidal behavior. *J Child Psychol Psychiatry* 2006; **47**: 372–394.
4. Evans E, Hawton K, Rodham K, Psychol C, Deeks J. The prevalence of suicidal phenomena in adolescents: A systematic review of population-based studies. *Suicide Life Threat Behav* 2005; **35**: 239–250.
5. Hawton K, Saunders KEA, O'Connor RC. Self-harm and suicide in adolescents. *Lancet* 2012; **379**: 2373–2382.
6. Morgan C, Webb RT, Carr MJ, et al. Incidence, clinical management, and mortality risk following self harm among children and adolescents: cohort study in primary care. *The BMJ* 2017; **359**: DOI: <https://doi.org/10.1136/bmj.j4351>.
7. Nock MK, Green JG, Hwang I, et al. Prevalence, correlates, and treatment of lifetime suicidal behavior among adolescents. *JAMA Psychiatry* 2013; **70**: 300–310.
8. Klonsky ED, May AM. Differentiating suicide attempters from suicide ideators: A critical frontier for suicidology research. *Suicide Life Threat Behav* 2014; **44**: 1–5.
9. Joiner TE. Why people die by suicide. Boston: Harvard University Press, 2005.
10. Van Orden KA, Witte TK, Cukrowicz KC, Braithwaite SR, Selby EA, Joiner TE. The Interpersonal Theory of Suicide. *Psychol Rev* 2010; **117**: 575–600.
11. Klonsky ED, May AM. The Three-Step Theory (3ST): A new theory of suicide rooted in the “Ideation-to-Action” Framework. *International Journal of Cognitive Therapy* 2015; **8**: 114–129.
12. O'Connor RC, Kirtley OJ. The integrated motivational–volitional model of suicidal behaviour. *Philos Trans R Soc Lond B Biol Sci* 2018; **373**: e20170268.
13. Racine M. Chronic pain and suicide risk: A comprehensive review. *Prog Neuropsychopharmacol Biol Psychiatry* 2018; **87**: 269–280.
14. Rizvi SJ, Iskric A, Calati R, Courtet P. Psychological and physical pain as predictors of suicide risk: Evidence from clinical and neuroimaging findings. *Curr Opin Psychiatry* 2017; **30**: 159–167.
15. Tang NKY, Crane C. Suicidality in chronic pain: a review of the prevalence, risk factors and psychological links. *Psychol Med* 2006; **36**: 575–586.

16. Price DD. Psychological and neural mechanisms of the affective dimension of pain. *Science* 2000; **288**: 1769–1772.
17. Treede RD, Kenshalo DR, Gracely RH, Jones AKP. The cortical representation of pain. *Pain* 1999; **79**: 105–111.
18. Calati R, Laglaoui Bakhiyi C, Artero S, Ilgen M, Courtet P. The impact of physical pain on suicidal thoughts and behaviors: Meta-analyses. *J Psychiatr Res* 2015; **71**: 16–32.
19. Grichnik KP, Ferrante FM. The difference between acute and chronic pain. *Mt Sinai J Med.* 1991; **58**: 217–220.
20. Merskey H, Bogduk N. International Association for the Study of Pain. Classification of chronic pain: descriptions of chronic pain syndromes and definitions of pain terms. Seattle: IASP Press, 1994.
21. King S, Chambers CT, Huguet A, et al. The epidemiology of chronic pain in children and adolescents revisited: A systematic review. *Pain* 2011; **152**: 2729–2738.
22. Martin AL, McGrath PA, Brown SC, Katz C. Children with chronic pain: Impact of sex and age on long-term outcomes. *Pain* 2007; **128**: 13–19.
23. World Health Organisation. Age-Not the whole story. 2014. <http://apps.who.int/adolescent/second-decade/section2/page2/age-not-the-whole-story.html> (accessed March 5, 2018).
24. Cicchetti D, Rogosch FA. A developmental psychopathology perspective on adolescence. *J Consult Clin Psychol* 2002; **70**: 6–20.
25. Kim-Cohen J, Caspi A, Moffitt TE, Harrington H, Milne BJ, Poulton R. Prior juvenile diagnoses in adults with mental disorder: developmental follow-back of a prospective-longitudinal cohort. *Arch Gen Psychiatry* 2003; **60**: 709–717.
26. Brattberg G. Do pain problems in young school children persist into early adulthood? A 13-year follow-up. *Eur J Pain* 2004; **8**: 187–199.
27. Andersson HI, Ejlertsson G, Leden I, Rosenberg C. Chronic pain in a geographically defined general population: studies of differences in age, gender, social class, and pain localization. *Clin J Pain* 1993; **9**: 174–182.
28. Anastas T, Colpitts K, Ziadni M, Darnall BD, Wilson AC. Characterizing chronic pain in late adolescence and early adulthood: prescription opioids, marijuana use, obesity, and predictors for greater pain interference. *PAIN Reports* 2018; **3**: DOI: [10.1097/PR9.0000000000000700](https://doi.org/10.1097/PR9.0000000000000700).

29. Blakemore SJ, Mills KL. Is adolescence a sensitive period for sociocultural processing? *Annu Rev Psychol* 2014; **65**: 187–207.
30. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med* 2009; **6**: DOI: [10.1371/journal.pmed.1000097](https://doi.org/10.1371/journal.pmed.1000097).
31. Neeleman J. Suicide as a crime in the UK: legal history, international comparisons and present implications. *Acta Psychiatr Scand* 1996; **94**: 252–257.
32. Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org
33. Junker A, Bjørngaard JH, Bjerkeset O. Adolescent health and subsequent risk of self-harm hospitalisation: a 15-year follow-up of the Young-HUNT cohort. *Child Adolesc Psychiatry Ment Health* 2017; **11**: DOI: [10.1186/s13034-017-0161-8](https://doi.org/10.1186/s13034-017-0161-8).
34. Strandheim A, Bjerkeset O, Gunnell D, Bjornelv S, Holmen T L, Bentzen N. Risk factors for suicidal thoughts in adolescence--a prospective cohort study: the Young-HUNT study. *BMJ Open* 2014; **4**: e005867.
35. Alriksson-Schmidt AI. Depressive symptomatology and suicide attempts in adolescents with mobility limitations. Dissertation Abstracts International: Section B: *The Sciences and Engineering* 2008; **68(11-B)**: 7688.
36. Van Tilburg MA, Spence NJ, Whitehead WE, Bangdiwala S, Goldston DB. Chronic pain in adolescents is associated with suicidal thoughts and behaviors. *J Pain* 2011; **12**: 1032–1039.
37. Wells GA, Shea B, O'Connell D, et al. (2018). The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed February 15, 2018).
38. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions – Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011.
39. Seehra J, Pandis N, Koletsi D, Fleming PS. Use of quality assessment tools in systematic reviews was varied and inconsistent. *J Clin Epidemiol* 2016; **69**: 179–184.
40. Borenstein M, Hedges LV, Higgins JPT, Rothstein HR. Introduction to meta-analysis. Chapter 40: When Does it Make Sense to Perform a Meta-Analysis. Chichester: John Wiley & Sons, Ltd, 2009: p.357-364.

41. Bayramoglu A, Saritemur M, Akgol Gur ST, Emet M. Demographic and clinical differences of aggressive and non-aggressive suicide attempts in the emergency department in the eastern region of turkey. *Iran Red Crescent Med J* 2015; **17**: 1–6.
42. Bromberg MH, Law EF, Palermo TM. Suicidal ideation in adolescents with and without chronic pain. *Clin J Pain* 2017; **33**: 21–27.
43. Campbell G, Darke S, Bruno R, Degenhardt L. The prevalence and correlates of chronic pain and suicidality in a nationally representative sample. *Aust N Z J Psychiatry* 2015; **49**: 803–811.
44. Ekholm O, Kurita GP, Hojsted J, Juel K, Sjogren P. Chronic pain, opioid prescriptions, and mortality in Denmark: A population-based cohort study. *Pain* 2014; **155**: 2486–2490.
45. Eliacik K, Kanik A, Bolat N, et al. Anxiety, depression, suicidal ideation, and stressful life events in non-cardiac adolescent chest pain: a comparative study about the hidden part of the iceberg. *Cardiol Young* 2017; **27**: 1098–1103.
46. Fuller-Thomson E, Hamelin GP, Granger SJR. Suicidal ideation in a population-based sample of adolescents: Implications for family medicine practice. *ISRN Family Med* 2013; **2013**: DOI: [10.5402/2013/282378](https://doi.org/10.5402/2013/282378).
47. Halvorsen JA, Dalgard F, Thoresen M, Bjertness E, Lien L. Itch and pain in adolescents are associated with suicidal ideation: a population-based cross-sectional study. *Acta Derm Venereol* 2012; **92**: 543–546.
48. Hogstedt C, Forsell Y, Hemmingsson T, Lundberg I, Lundin A. Psychological symptoms in late adolescence and long-term risk of suicide and suicide attempt. *Suicide Life Threat Behav* 2018; **48**: 315–327.
49. Kirtley OJ, O'Connor RC, O'Carroll RE. Hurting inside and out? Emotional and physical pain in self-harm ideation and enactment. *International Journal of Cognitive Therapy* 2015; **8**: 156–171.
50. Koenig J, Oelkers-Ax R, Parzer P, et al. The association of self-injurious behaviour and suicide attempts with recurrent idiopathic pain in adolescents: Evidence from a population-based study. *Child Adolesc Psychiatry Ment Health* 2015; **9**: 1–9.
51. Lee PH, Yeh YC, Hsiao RC, Yen CF, Hu HF. Pain-related quality of life related to mental health and sociodemographic indicators in adolescents. *Arch. Clin. Psychiatry* 2017; **44**: 67–72.

52. Lewcun B, Kennedy TM, Tress J, Miller KS, Sherker J, Sherry DD. Predicting suicidal ideation in adolescents with chronic amplified pain: The roles of depression and pain duration. *Psychol Serv* 2018; **15**: 309–315.
53. Liu X, Liu ZZ, Fan F, Jia CX. Menarche and menstrual problems are associated with non-suicidal self-injury in adolescent girls. *Arch Womens Ment Health* 2018; **21**: 649–656.
54. Park SP, Seo JG, Lee WK. Osmophobia and allodynia are critical factors for suicidality in patients with migraine. *J Headache Pain* 2015; **16**: 1–6.
55. Ren Y, You J, Zhang X, et al. Differentiating suicide attempters from suicide ideators: The role of capability for suicide. *Arch Suicide Res* 2019; **23**: 64–81.
56. Rozen TD, Fishman RS. Cluster headache in the United States of America: demographics, clinical characteristics, triggers, suicidality, and personal burden. *Headache* 2012; **52**: 99–113.
57. Tsai MH, Chen YH, Chen CD, Hsiao CY, Chien CH. Deliberate self-harm by Taiwanese adolescents. *Acta Paediatr* 2011; **100**: e223–e226.
58. Chan WSC, Law CK, Liu KY, Wong PWC, Law YW, Yip PSF. Suicidality in Chinese adolescents in Hong Kong: The role of family and cultural influences. *Soc Psychiatry Psychiatr Epidemiol* 2009; **44**: 278–284.
59. Wang SJ, Fuh JL, Juang KD, Lu SR. Migraine and suicidal ideation in adolescents aged 13 to 15 years. *Neurology* 2009; **72**: 1146–1152.
60. Reigstad B, Jørgensen K, Wichstrøm L. Pain in adolescent psychiatric patients. *Child and Adolescent Mental Health* 2006; **11**: 185–191.
61. Wang SJ, Juang KD, Fuh JL, Lu SR. Psychiatric comorbidity and suicide risk in adolescents with chronic daily headache. *Neurology* 2007; **68**: 1468–1473.
62. Fishbain DA, Lewis JE, Gao J. The pain suicidality association: a narrative review. *Pain Med* 2014; **15**: 1835–1849.
63. Hooley JM, Franklin JC, Nock MK. Chronic pain and suicide: understanding the association. *Curr Pain Headache Rep* 2014; **18**: DOI: [10.1007/s11916-014-0435-2](https://doi.org/10.1007/s11916-014-0435-2).
64. Spiegel B, Schoenfeld P, Naliboff B. Systematic review: the prevalence of suicidal behaviour in patients with chronic abdominal pain and irritable bowel syndrome. *Aliment Pharmacol Ther* 2007; **26**: 183–193.
65. Soltani S, Kopala-Sibley DC, Noel M. The Co-occurrence of Pediatric Chronic Pain and Depression: A Narrative Review and Conceptualization of Mutual Maintenance. *Clin J Pain* 2019; **35**: 633-643.

66. Asmundson GJ, Noel M, Petter M, Parkerson HA. Pediatric fear-avoidance model of chronic pain: foundation, application and future directions. *Pain Res Manag* 2012; **17**: 397-405.
67. Kirtley O, Rodham K, Crane C. Understanding suicidal ideation and behaviour in individuals with chronic pain: A review of the role of novel transdiagnostic psychological factors. *Lancet Psychiatry* in press.
68. Hassett AL, Aquino JK, Ilgen MA. The risk of suicide mortality in chronic pain patients. *Curr Pain Headache Rep* 2014; **18**: DOI: [10.1007/s11916-014-0436-1](https://doi.org/10.1007/s11916-014-0436-1).
69. Ilgen MA, Kleinberg F, Ignacio RV, et al. Noncancer pain conditions and risk of suicide. *JAMA Psychiatry* 2013; **70**: 692–697.
70. Jacob L, Haro JM, Koyanagi A. The association between pain and suicidal behavior in an English national sample: The role of psychopathology. *J Psychiatr Res* 2018; **98**: 39–46.
71. Tegethoff M, Belardi A, Stalujanis E, Meinschmidt G. Comorbidity of mental disorders and chronic pain: Chronology of onset in adolescents of a national representative cohort. *J Pain* 2015; **16**: 1054–1064.
72. Linton SJ, Shaw WS. Impact of psychological factors in the experience of pain. *Phys Ther* 2011; **91**: 700–711.
73. Edwards RR. Age differences in the correlates of physical functioning in patients with chronic pain. *J Aging Health* 2006; **18**: 56–69.
74. Compas BE, Jaser SS, Dunn MJ, Rodriguez EM. Coping with chronic illness in childhood and adolescence. *Annu Rev Clin Psychol* 2012; **8**: 455–480.
75. Andersen SL, Teicher MH. Stress, sensitive periods and maturational events in adolescent depression. *Trends Neurosci* 2008; **31**: 183–191.

Panel: Key Messages

- Leading suicide theories and research in adults suggest that pain may exacerbate an individual's suicidal risk. Although pain and suicidality both increase in prevalence during adolescence, their relationship remains unclear.
- Across various manifestations of pain and suicidality, we found that pain approximately doubles the risk of suicidality in community samples (suicidal ideation and pain: 7.2-23.9% vs. no pain: 3.5-6.2%; suicidal behaviour and pain: 6-78% vs. no pain: 1.3-31.1%) and clinical samples (suicidal ideation and pain: 22% vs. no pain: 5.3%) of adolescents.
- Although depression was found to play an important role in this association, the pain-suicidality association cannot solely be explained by the presence of comorbid depression. Furthermore, we identified a small number of studies that explored and found inconsistent evidence for associations between pain characteristics and suicidality.
- By identifying a final sample of 25 studies, this review further underscores the paucity of research with adolescents. In addition, the existing studies were limited by the assessment of pain and suicidality (e.g., single-item questions) and the degree of control for other correlates. Future research needs to address these limitations by thoroughly assessing pain and suicidality, controlling for correlates other than depression, as well as exploring aspects of the pain experience (e.g., pain frequency) and risk and resilience factors underpinning this link more thoroughly across samples and study designs. These studies may build on, but should not be restricted to, factors identified in the adult literature, in order to allow for a systematic exploration of potential developmental differences.
- These findings have important clinical implications, such that interventions need to be developed that target key psychological mechanisms underpinning the pain-suicidality link in adolescence to prevent or intervene with the progression along the suicide spectrum in adolescents with pain. In addition, routine screening for suicidal risk needs to be facilitated in order to provide timely help and support.

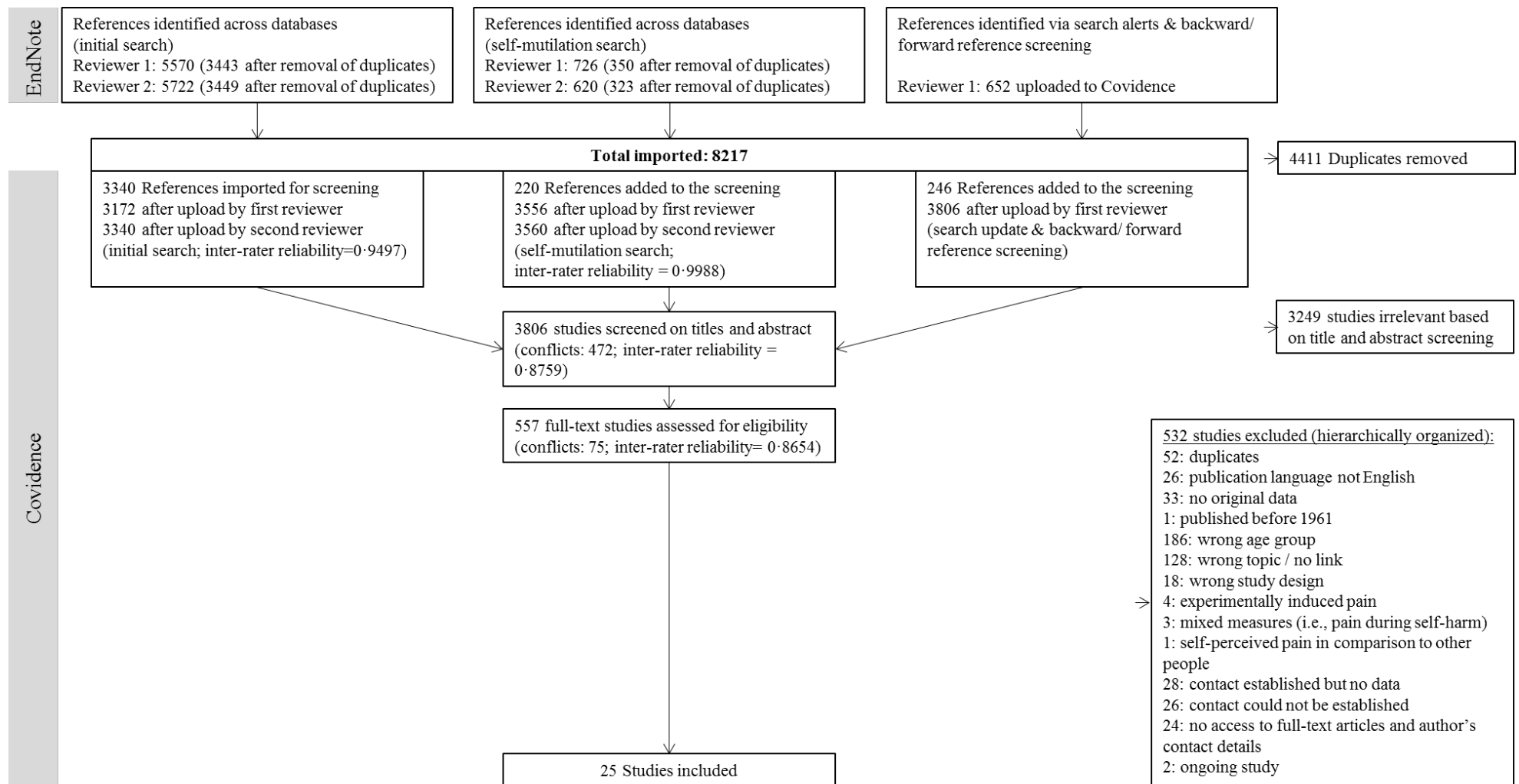


Figure 1. PRISMA flow-chart of the data search and eligibility assessment.

Table 1. Study characteristics (N=25)

Study	Country	Population	Age range (years)	Sample size (number of adolescents if different)	Type of pain	Method of pain assessment ^a	Type of suicidality	Method of suicidality assessment ^a
Suicidal ideation [SI] / suicidal risk (n=9)								
Cross-sectional study								
Fuller-Thomson et al., 2013 ⁴⁶	Canada	Community sample	15-19	5.788	Migraine headache, back problems, activities prevented by pain	Interview (-)	Suicidal ideation (past 12 months)	Interview (-)
Halvorsen et al., 2012 ⁴⁷	Norway	Community sample	18-19	3.775	Pain sites (composed of pain in the head, neck/ shoulder, arms/legs, stomach and back; past 12 month)	Self-report (-)	Suicidal ideation (past week)	Self-report (/)
Chan et al., 2009 ⁵⁸	China	Community sample	15-19	511	Chronic illness or pain	Interview (-)	Suicidal ideation (composed of lifetime & past year)	Self-report (/)
Wang et al., 2009 ⁵⁹	Taiwan	Community sample	13-15	3.963	Migraine diagnosis (with/ without aura), headache frequency, headache disability (past 3 months)	Self-report (+)	Suicidal ideation (past month)	Self-report (/)
Lewcun et al., 2018 ⁵²	USA	Adolescents diagnosed with amplified musculoskeletal pain syndrome (AMPS)	11-17	453	Family history of pain disorder Pain severity Pain duration (months) Functional disability	Patient registries (+), self-report (+), & interview (-)	Suicidal ideation (past two weeks)	Self-report (/)
Wang et al., 2007 ⁶¹	Taiwan	Adolescents diagnosed with chronic daily headache	12-15	122	Migraine diagnosis (yes/ no, with/ without aura)	Interview (+)	Suicidal risk (past month)	Interview (+)
Cohort study								
Strandheim et al., 2014 ^{b,34}	Norway	Community sample	T0: 13-15 T1: 17-19	2.399	Physical pain & tension problems (past year)	Self-report (/)	Suicidal ideation (past month)	Self-report (-)
Case-control study								

Eliacik et al., 2017 ⁴⁵	Turkey	Adolescents with vs. without non-cardiac chest pain	13–18	176	Non-cardiac chest pain	Diagnostic evaluation (+)	Suicidal ideation	Interview (-)
Bromberg et al., 2017 ⁴²	USA	Adolescents with vs. without chronic pain [CP]	12-18	186	Chronic pain; pain intensity & pain bother (past 3 months)	Self-report (+)	Suicidal ideation	Self-report (+)
Suicidal behaviour [SB] / self-harm (n=6)								
Cross-sectional study								
Liu et al., 2018 ⁵³	China	Community sample	12–18	5.813	Period pain (no, mild, moderate, severe)	Self-report (-)	Non-suicidal self-injury ([NSSI], lifetime & past year)	Self-report (/)
Koenig et al., 2015 ⁵⁰	Germany	Community sample	13-18	5.504	General pain (aches or pains), recurrent pain headache, abdominal pain/ stomach ache	Self-report (+)	Frequency of self-injury per year & suicidal attempt ([SA]; ever)	Self-report (+)
Tsai et al., 2011 ⁵⁷	Taiwan	Community sample	15-18	742	Headache	Self-report (-)	Self-harm (ever)	Self-report (-)
Bayramoglu et al., 2015 ⁴¹	Turkey	Adult suicide attempts	14-88	533 (n=145)	Chief complaint: Headache & Abdominal pain	Interview (-)	Type of suicide attempt (aggressive vs. non-aggressive)	Interview (-)
Reigstad et al., 2006 ⁶⁰	Norway	Adolescents attending the child & adolescent psychiatric services	12–18	129	Any frequent pain (composed of headaches, stomach pain, back pain & limb pain)	Self-report (-)	Self-harm (ever) & suicide attempt ([SA]; ever)	Self-report (-)
Cohort study								
Junker et al., 2017 ^{b,33}	Norway	Community sample	T0 to T1: 13-19	T0: 8.965 T1: 5.152	Migraine (≥ 6 months), frequent headache, stomach pain (past year)	Self-report (-)	Self-harm hospitalisation	Interview (+) & Patient records (+)
Death by suicide (n=1)								
Cohort study								
Ekholm et al., 2014 ⁴⁴	Denmark	Community sample	16-65+	13.127 (n=unclear)	Chronic non-cancer pain (past 6 months)	Self-report (-)	Death by suicide	Patient registries (+)
Suicidality (mixed assessments; n=9)								
Cross-sectional study								

Ren et al., 2019 ⁵⁵	China	Community sample	15-21	930 (n=926)	Pain tolerance & Pain sensitivity	Self-report (/)	Suicidal ideation & attempts (past year)	Self-report (+; /; -)
Lee et al., 2017 ⁵¹	Taiwan	Community sample	11-18	6.150	Pain-related quality of life (past 2 weeks)	Self-report (+)	Suicidality (composed of four types of suicidal ideation & suicide attempts; past year)	Self-report (+)
Campbell et al., 2015 ⁴³	Australia	Community sample	16-85	8.841 (n=706)	Any chronic pain (composed of arthritis, migraines, back/neck problems; past 6 months) vs. no pain	Interview (/)	Suicidal ideation, plans & attempts (past 12 months)	Interview (/)
Kirtley et al., 2015 ⁴⁹	Scotland	Student sample	M _{age} =19·8 (SD=4·2)	351 (n=234)	Pain distress & sensitivity	Self-report (+)	Suicidal ideation & behaviour	Self-report (/)
Alriksson-Schmidt, 2008 ^{c,35}	USA	Community sample	M=15·96 (SE = 0·11)	22.261.000 (n=6.357 available for SI analyses; n=6.400 available for SA analyses)	Physical pain (composed of headache, stomach aches, joint pain; past 12 months)	Self-report (/)	Suicidal ideation [SI] & attempts ([SA]; past year)	Self-report (-)
Park et al., 2015 ⁵⁴	Republic of Korea	Hospital-based study of migraine patients	15-75	220 (n=23)	Migraine (composed of ever & now)	Self-report (+) & Interview (+) & Patient records (+)	Suicidality	Interview (+)
Rozen et al., 2012 ⁵⁶	USA	Patients, diagnosed with cluster headache, from the community	<20-61+	1.134 (n=7)	Cluster headache	Self-report (-)	Suicidality	Self-report (-)
<i>Cohort study</i>								
Hogstedt et al., 2018 ⁴⁸	Sweden	Swedish males, who were conscripted for compulsory military service in 1969 and 1970.	18-20	49.321 (suicide: N=619; Suicide attempt: N=1.102)	Headache, stomach pain, both symptoms collapsed as general pain	Self-report (-)	Death by suicide & suicidal attempts during follow-up	Patient registries (+)

Van Tilburg et al., 2011 ^{c,36}	USA	Community sample	11–18	T0: 9.970 T1: 9.925	(a) headache, (b) stomach ache/upset stomach, (c) aches, pains/ soreness in muscles or joints (past year)	Self-report (-)	Suicidal ideation & attempt (past year)	Self-report (-)
--	-----	------------------	-------	------------------------	---	--------------------	---	--------------------

Note. Studies are grouped by the type of suicidality being measured and the study design being used. Furthermore, they are grouped by the study population, with the most recent studies being presented first. Community samples: Depending on the scale of the study, some of the samples represent large-scale national or regional surveys.

- a. Validated tools are marked with (+) Validated single items/ questions taken, or single items/ questions taken from validated tools are marked with (/) and non-validated single items/ questions are marked with (-)
- b. Junker et al., 2017³³ and Strandheim et al., 2014³⁴ are partially based on the same dataset: Young Hunt.
- c. Alriksson-Schmidt, 2008³⁵ and van Tilburg et al., 2011³⁶ are partially based on the same dataset: Add Health.

Table 2. Study results, structured around the type of suicidality

Variables used to establish the pain-suicidality association						Results			
Study	Study design	Population	Type of pain	Type of suicidality	Control for covariates	Significant crude probability estimates [95%CI]; otherwise frequencies	Significant adjusted probability estimates [95%CI]	Number of tested and non-significant pain-suicidality associations	Study quality
Suicidal ideation/ suicidal risk (n=9)									
Full support									
Chan et al., 2009 ⁵⁸	CS	Community sample	Chronic illness or pain	Suicidal ideation (composed of lifetime & past year)	Demographics	OR=6.4 [2.5-16.2]	aOR=4.9, [1.7-14.3]	0	5/8
Strandheim et al., 2014 ^{c,34}	CH	Community sample	Physical pain & tension problems (past year)	Suicidal ideation (past month)	Demographics psychiatric symptoms & health-related factors	OR=2.7 [2.1-3.4]	aOR=1.8, [1.4-2.4]	0	6/9
Eliacik et al., 2017 ⁴⁵	CC	Adolescents with vs. without non-cardiac chest pain	Non-cardiac chest pain	Suicidal ideation	Demographics	Cases = 22% (n=22/100) vs. controls = 5.26% (n=4/76), p < 0.001	Not reported	0	6/9
Partial support ^a									
Halvorsen et al., 2012 ⁴⁷	CS	Community sample	Pain sites (composed of pain in the head, neck/ shoulder, arms/legs, stomach and back; past 12 month)	Suicidal ideation (past week)	Demographics & depression	OR _(1-2 pain sites) =1.5 [1.0-2.2]; OR _(3-5 pain sites) =4.7; [3.2-6.8]	aOR _(3-5 pain sites) =1.8, [1.3-2.5]	1: aOR non-sig for 1-2 pain sites	6/8
Fuller-Thomson et al., 2013 ⁴⁶	CS	Community sample	Migraine headache, back problems, activities prevented by pain	Suicidal ideation (past 12 months)	Demographics , depression & health-related factors	Migraine: Yes = 7.2% (n=425/5788) vs. no = 3.6% (n=5363/5788), p < 0.001 Back pain: Yes = 7.6% (n=482/5788) vs. no = 3.5% (n=5306/5788), p < 0.001 Activities prevented: Yes = 12.6%	a ₁ OR _(activities) =2.0, [1.2-3.4]	5: a ₁ OR _(controlling for demographics & health) non-sig for migraines & back pain; a ₂ OR _(controlling for depression) non-sig for migraines & back pain; activities prevented by pain	8/8

Wang et al., 2009 ⁵⁹	CS	Community sample	Migraine diagnosis (with/ without aura), headache frequency, headache disability (past 3 months)	Suicidal ideation (past month)	Demographics & depression	(n=216/ 5783) vs. no = 3.5% (n=5567/5783), p < 0.001 OR _(migraine diagnosis vs. no migraine) = 2.9 [2.3-3.6]; OR _(migraine no aura/ probable migraine vs. no migraine) = 2.4 [1.9-3.1]; OR _(migraine with aura vs. no migraine) =4.6 [3.0-7.0]; OR _(migraine with aura vs. no aura/ probable migraine) =1.8 [1.2-2.8]; higher headache frequency (3.6+-4.4 vs. 1.6 +-2.8 days/month; p< 0.001) headache-related disability (8.0+-19.7 vs. 2.5 +-7.9 p< 0.001)	aOR _(migraine with aura) =1.8 [1.1-3.0]; aOR _(frequency >7-14 days/month) = 1.7 [1.1-2.6]	2: aOR non sig. for migraine without aura/ probable migraine and headache-related disability	6/8
Lewcun et al., 2018 ⁵²	CS	Adolescents diagnosed with amplified musculo-skeletal pain syndrome (AMPS)	Family history of pain disorder Pain severity Pain duration (months) Functional disability	Suicidal ideation (past two weeks)	Demographics & depression	Not reported	a1OR _(pain duration) =1.0 [1.0-1.0] a2OR _(pain duration) = non-sig.	4: a1OR _(controlling for demographics) non-sig for family history of pain; pain severity; functional disability a2OR _(controlling for depression) : pain duration non-sig	5/8
Wang et al., 2007 ⁶¹	CS	Adolescents diagnosed with chronic daily headache	Migraine diagnosis (yes/ no, with/ without aura)	Suicidal risk (past month)	Demographics & depression/ anxiety	Migraine: OR=4.3 [1.2-15.5]	aOR _(migraine with aura vs. no migraine) =7.8 [1.4-44.6]	1: aOR non-sig for migraine without aura vs. no migraine	7/8
No support									
Bromberg et al., 2017 ⁴²	CC	Adolescents with vs. without chronic pain [CP]	Chronic pain; pain intensity & pain bother (past 3 months)	Suicidal ideation	Demographics & depression	none	Not reported	1: Cases 34.7% (33/95) vs. controls 27.5% (25/91), p > 0.05	6/9
Suicidal behaviour / non-suicidal self-injury (n=6)									
Full support									
Tsai et al., 2011 ⁵⁷	CS	Community sample	Headache	Self-harm (ever)	Gender & behaviour/ health-related factors	OR=6.5, [3.7-11.5]	aOR=9.0, [4.6-17.6]	0	3/8

Reigstad et al., 2006 ⁶⁰	CS	Adolescents in child & adolescent psychiatric services	Any frequent pain (composed of headaches, stomach pain, back pain & limb pain)	Self-harm (ever) & suicide attempt ([SA]; ever)	N/A	OR _(self-harm) =2.7, [1.3-5.6]; OR _(SA) =2.3, [1.1-5.0]	N/A	0	2/8
Junker et al., 2017 ^{c,33}	CH	Community sample	Migraine (≥6 months), frequent headache, stomach pain (past year)	Self-harm hospitalisation	Demographics	HR _(migraine) =2.7, [1.3-5.9]; HR _(headache) =2.7, [1.7-4.2]; HR _(stomach pain) =2.7, [1.8-4.3]	aHR _(migraine) =2.3, [1.1-5.1]; aHR _(headache) =2.2, [1.4-3.5]; aHR _(stomach pain) =2.2, [1.4-3.5]	0	6/9
Partial support^a									
Liu et al., 2018 ⁵³	CS	Community sample	Period pain (no, mild, moderate, severe)	Non-suicidal self-injury ([NSSI], lifetime & past year)	Demographics psychiatric symptoms & BMI & impulsivity	NSSI lifetime: OR _(mild-severe) = 1.3-2.0 ^f . NSSI past year: OR _(mild-severe) = 1.3-2.1 ^f .	NSSI lifetime: a2OR _(mild-moderate) = 1.2-1.3 ^f . NSSI past year _(mild-moderate) : a2OR=1.2-1.3 ^f .	2: a2OR _(adjusting for all covariates) : non-sig for severe pain and NSSI lifetime & past year	6/8
Koenig et al., 2015 ⁵⁰	CS	Community sample	Recurrent pain, as well as general pain (aches or pains), headache, abdominal pain/ stomach ache (for general, headache and abdominal pain: sometimes vs. very often)	Frequency of self-injury per year (1-3x/year vs. >3x/year) & suicidal attempt ([SA]; 1 SA vs. multiple SAs, ever)	Demographics & psychiatric symptoms	<u>Self-injury 1-3x/year:</u> RR _(recurrent vs. no pain) =3.0 [2.4-3.6]; RR _(general) =1.7-2.6 ^e . RR _(headache) =1.3-1.9 ^e . RR _(abdominal) =1.7-2.7 ^e . <u>Self-injury >3x/year:</u> RR _(recurrent) = 6.0 [4.4-8.2]; RR _(general) =2.0-3.2 ^e .; RR _(headache - very often) = 2.5 [1.5-4.1]; RR _(abdominal) =2.0-5.1 ^e . <u>One SA:</u> RR _(recurrent) = 3.6 [2.8-4.6]; RR _(general) =1.8-2.7 ^e .; RR _(headache - very often) = 2.6 [1.7-3.9]; RR _(abdominal) =2.2-2.3 ^e . <u>Multiple SA:</u> RR _(recurrent) = 5.5 [3.8-7.8]; RR _(general) =2.0-2.8 ^e .; RR _(abdominal) =1.7-5.8 ^e .	<u>Self-injury 1-3x/year:</u> a2RR _(recurrent) =1.4, [1.2-1.8] a2RR _(general pain - very often) = 1.6, [1.1-2.2]; <u>Self-injury >3x/year:</u> a2RR _(recurrent) =1.8, [1.3-2.6]; <u>One SA:</u> a2RR _(recurrent) =1.4, [1.1-1.8]; a2RR _(headache - very often) =1.6, [1.0-2.3]; a2RR _(abdominal pain-sometimes) =1.5, [1.1-2.1]; <u>Multiple SA:</u> a2RR _(recurrent) =1.8, [1.2-2.6]; a2RR _(abdominal pain - very often) =2.0, [1.1-3.5]	30: OR non-sig. for self-injury > 3x/year & headaches _(sometimes) ; one SA & headaches _(sometimes) ; multiple SA & headaches _(sometimes & very often) ; a1OR _(controlling for demographics) non-sig for self-injury 1-3x/year & headaches _(sometimes) ; self-injury >3 & headaches _(sometimes) ; one SA & headaches _(sometimes) ; multiple SA & headaches _(sometimes & very often) & abdominal pain _(sometimes) ; a2OR _(all covariates) : non-sig for self-injury 1-3x/year & general pain _(sometimes) & headaches _(sometimes & very often) & abdominal pain _(sometimes & very often) ; self-injury >3 & general pain _(sometimes & very often) & headaches _(sometimes & very often) & abdominal pain _(sometimes & very often) ; one SA & general	6/8

								pain _(sometimes & often) & headaches _(sometimes) ; abdominal pain _(often) ; multiple SA & general pain _(sometimes & often) & headaches _(sometimes & often) & abdominal pain _(sometimes)	
No support									
Bayramoglu et al., 2015 ⁴¹	CS	Adult suicide attempts	Chief complaint: Headache & Abdominal pain	Type of suicide attempt (aggressive vs. non-aggressive)	N/A	none	Not reported	2: Headache: 11·8% (2/17) vs. 9·4% (12/128), p=0·60 Abdominal pain: 17·6% (3/17) vs. 34·4% (44/128), p=0·37	2/8
Death by suicide (n=1)									
No support									
Ekholm et al., 2014 ⁴⁴	CH	Community sample	Chronic non-cancer pain (past 6 months)	Death by suicide	N/A	none	Not reported	1: Death by suicide: n=0	7/9
Suicidality (overall) & mixed assessments (n=9)									
Full support									
Lee et al., 2017 ⁵¹	CS	Community sample	Pain-related quality of life (past 2 weeks)	Suicidality (composed of four types of suicidal ideation & suicide attempts; past year)	Demographics	Not reported	aOR=0·97 [0·97-0·98]	0	5/8
Alriksson-Schmidt, 2008 ^{d,35}	CS	Community sample	Physical pain (composed of headache, stomach aches, joint pain; past 12 months)	Suicidal ideation [SI] & attempts ([SA]; past year)	Demographics & severity of mobility limitations	Not reported	aOR _(SI) =1·2, [1·2-1·3]; aOR _(SA) =1·2, [1·1-1·3]	0	5/8
Partial support^a									
Ren et al., 2019 ⁵⁵	CS	Community sample	Pain tolerance & Pain sensitivity	Suicidal ideation & attempts (past year)	Gender	Not reported	<u>Suicidal ideation [SI] vs. control</u> aOR _(pain tolerance) =1·4, [1·1-1·8] <u>Suicidal behaviour [SA] vs. control</u> aOR _(pain sensitivity) =0·63, [0·42-0·96]; aOR _(pain tolerance) =1·9, [1·2-3·1]	3: aOR non sign. for SI vs. control & pain sensitivity; for SB vs. SI & pain sensitivity/pain tolerance	2/8
Kirtley et al., 2015 ⁴⁹	CS	Community sample	Pain distress & sensitivity	Suicidal ideation & behaviour	N/A	Pain distress: z=2·4, p=0·018	Not reported	1: Pain sensitivity: z=1·0, p=0·300	0/8
Hogstedt et al., 2018 ⁴⁸	CH	Swedish males, who	Headache, stomach pain, both symptoms	Death by suicide & suicidal attempts	Demographics, psychiatric	Death by suicide: HR _(severe headache) = 1·4 [1·0-2·0];	Suicide attempt: aHR _(severe)	24: OR non-sig. for suicide & headache _(limited) , stomach	6/9

		were conscripted for compulsory military service in 1969 and 1970.	collapsed as general pain (categorised based on limited and severe symptoms)	[SA] during follow-up	diagnosis & other symptoms	$HR_{(severe\ stomach\ pain)}=1.5$ $[1.1-2.1]$; $HR_{(severe\ headache\ \&\ stomach\ pain)}=1.6$ $[1.2-2.3]$ Suicide attempt: $HR_{(limited-severe\ headache)}=1.1-1.9^{e.}$; $HR_{(severe\ stomach\ pain)}=2.1$ $[1.7-2.6]$; $HR_{(severe\ headache\ \&\ stomach\ pain)}=1.1-2.3^{e.}$	$headache)=1.5$, $[1.1-2.2]$	<p>pain^(limited) & headache/stomach pain^(limited); for suicide attempts & stomach pain^(limited)</p> <p><u>a1OR</u>_(controlling for psychiatric diagnosis) non sig. for suicide & headache^(limited-severe), stomach problems^(limited-severe), & headache/stomach problems^(limited-severe); for SA & headache^(limited), stomach problems^(limited), & headache/stomach problems^(limited)</p> <p><u>a2OR</u>_(controlling for other symptoms) non sig. for suicide & headache^(limited-severe), stomach problems^(limited-severe) & headache/stomach problems^(limited-severe); for SA & headache^(limited), stomach problems^(limited-severe) & headache/stomach problems^(limited-severe); for SA & headache^(limited), stomach problems^(limited-severe) & headache/stomach problems^(limited-severe)</p>	
Van Tilburg et al., 2011 ^{d,36}	CH	Community sample	(a) headache, (b) stomach ache/upset stomach, (c) aches, pains/ soreness in muscles or joints (past year)	Suicidal ideation & attempt (past year)	Demographics & depression	<p><u>Suicidal ideation:</u> $OR_{(headache-wave\ 1\&2)}=1.5-1.7^{e.}$; $OR_{(stomach\ pain-wave\ 1\&2)}=1.6-1.9^{e.}$; $OR_{(musculoskeletal\ pain-wave\ 1\&2)}=1.5-1.4^{e.}$</p> <p><u>Next-year suicidal ideation (excl. wave 1 SI):</u> $OR_{(headache)}=1.2$ $[1.0-1.5]$ $OR_{(stomach\ pain)}=1.4$ $[1.1-1.7]$;</p> <p><u>Suicide Attempt [SA]:</u> $OR_{(headache-wave\ 1\&2)}=1.4-2.1^{e.}$; $OR_{(stomach\ pain-wave\ 1\&2)}=1.8^{e.}$ $OR_{(musculoskeletal\ pain-wave\ 2)}=1.5$ $[1.1-2.1]$</p> <p><u>Next-year SA (excl. wave 1 SA):</u></p>	<p><u>Suicidal ideation:</u> $aOR_{(headache-wave\ 1\&2)}=1.3-1.4^{e.}$; $aOR_{(stomach\ pain-wave\ 2)}=1.4$ $[1.2-1.7]$; $aOR_{(musculoskeletal\ pain-wave\ 1)}=1.3$ $[1.1-1.5]$;</p> <p><u>Next-year suicidal ideation:</u> $aOR_{(headache)}=1.2$ $[1.1-1.5]$</p> <p><u>Suicide Attempt:</u> $aOR_{(headache-wave\ 2)}=1.6$, $[1.2-2.2]$; $aOR_{(musculoskeletal\ pain-wave\ 2)}=1.1$ $[0.8-0.9]$</p>	<p>14: <u>OR</u> non sig. for next-year suicidal ideation (excl. wave 1 SI) & musculoskeletal pain; for SA & musculoskeletal pain^(wave1); for Next-year SA (excl. wave 1 SA) & headache;</p> <p><u>aOR</u> non sig. for SI & stomach pain^(wave1)/musculoskeletal pain^(wave 2); for Next-year SI (excl. wave 1 SI) & stomach pain/musculoskeletal pain; for SA & headache^(wave 1) /stomach pain^(wave 1&2) / musculoskeletal pain^(wave 1); for next-year SA (excl. wave 1 SA) & headache/ stomach pain/ musculoskeletal pain</p>	7/9

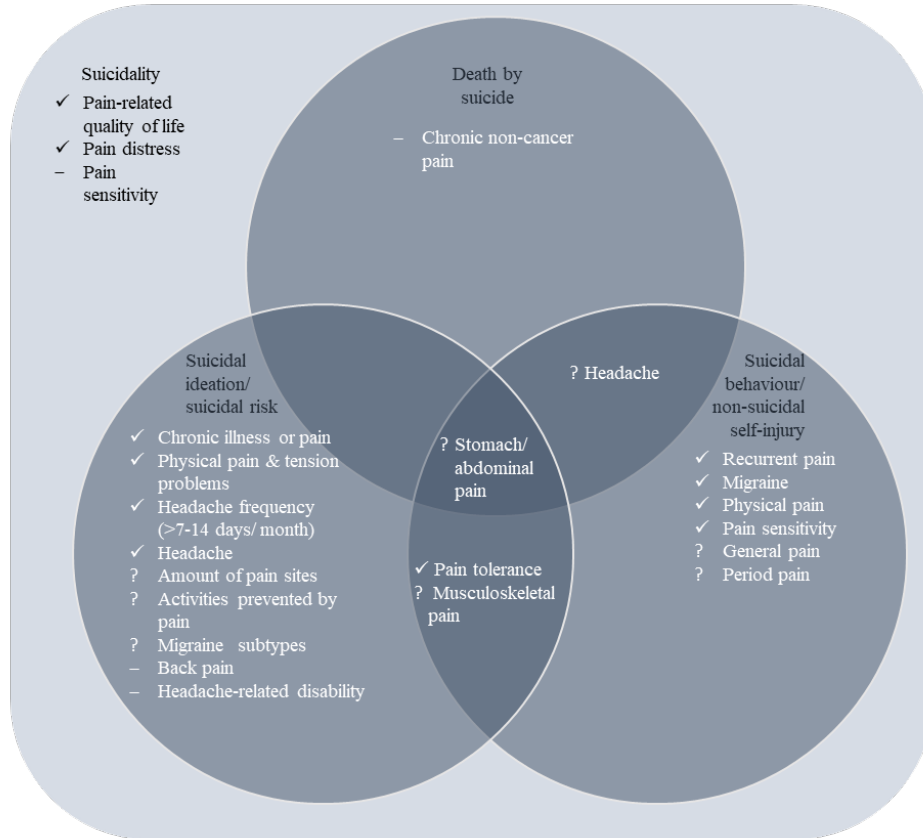
OR_(stomach pain)=1.6 [1.2-2.1]; OR_(musculoskeletal pain)=1.5 [1.1-2.1]

<i>Pain-suicidality association unclear^b</i>									
Campbell et al., 2015 ⁴³	CS	Community sample	Any chronic pain (composed of arthritis, migraines, back/neck problems; past 6 months) vs. no pain	Suicidal ideation, plans & attempts (past 12 months)	N/A	Suicidal ideation _(chronic pain) : 11.1% (10/90) vs. 3.2% (20/616) Suicidal plan _(chronic pain) : 7.8% (7/90) vs. 0.8% (5/616); Suicidal attempt _(chronic pain) : 6.7% (6/90) vs. 0.9% (6/616)	Not reported	Unclear	3/8
Park et al., 2015 ⁵⁴	CS	Hospital based study of migraine patients	Migraine (composed of ever & now)	Suicidality	N/A	Suicidal risk: yes=30.4% (7/23) vs. no=69.6% (16/23)	Not reported	Unclear	3/8
Rozen et al., 2012 ⁵⁶	CS	Patients, diagnosed with cluster headache	Cluster headache	Suicidality	N/A	Suicidal ideation: 71% (5/7); Suicidal behaviour: 14% (1/7); No suicidality: 29% (2/7)	Not reported	Unclear	0/8

Note. CS = Cross-sectional Studies; CH = Cohort studies; CC = Case-control studies; OR = crude odds ratio; aOR = adjusted odds ratio. Within the table outcomes are further structured around the level of support and the population.

- Results did not remain (or only partially remain) significant when controlling for covariates (e.g., depression) in multivariate models. Hence, results are reported for most significant outcomes: crude odds ratios (OR) or adjusted odds ratios (aOR), depending on whether or not the adjusted odds ratio still remained significant
- The results are unclear, as no test statistics were available and only frequencies were reported.
- Junker et al., 2017³³ and Strandheim et al., 2014³⁴ are partially based on the same dataset: Young Hunt.
- Alriksson-Schmidt, 2008³⁵ and van Tilburg et al., 2011³⁶ are partially based on the same dataset: Add Health.
- In these cases, pain has been divided into subcategories of varying severity levels and frequencies. To keep the table as concise as possible, we present the range of odds ratios over the different pain severity levels/ frequencies, instead of individual odds ratios. Therefore, confidence intervals are omitted.

Community samples



Clinical samples

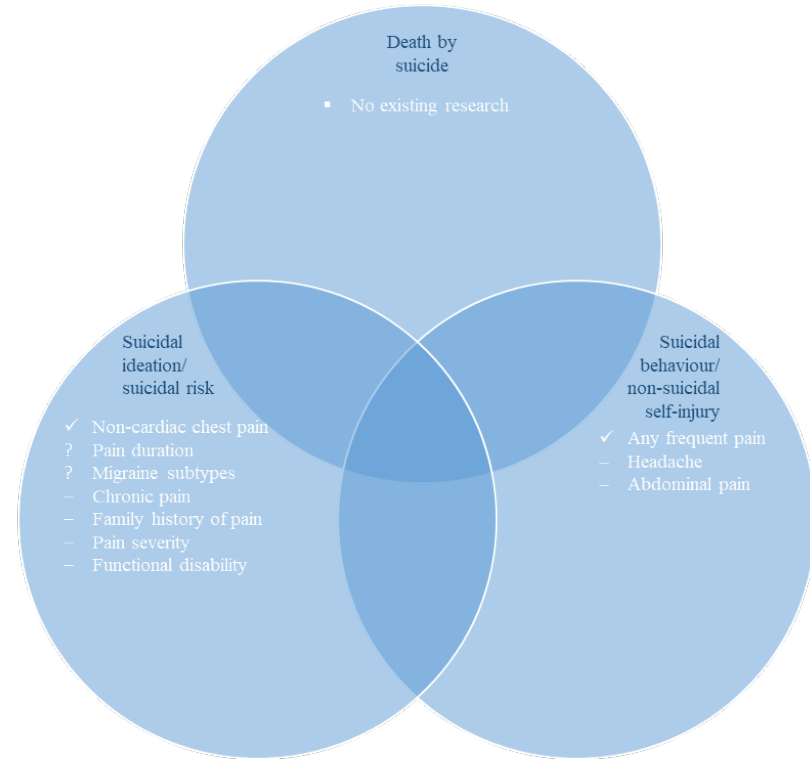


Figure 2. Schematic representation of the complex relationship between pain and suicidality in community and clinical samples of adolescents, respectively.

Note. The symbol ‘✓’ indicates correlates that were fully supported by the existing research, the symbol ‘?’ shows correlates for which we found mixed findings (e.g., significance of the association depended on specific subtypes and the level of control for other factors e.g., depression; see also supplement 4 for an overview of the conditions under which these correlates were found to be significant), and the symbol ‘-’ indicates correlates that were not found to be related to suicidality. Please note, that given the paucity of existing studies and the large variety in the conceptualisation and measurement of each correlate, the evidence pertaining to the specific correlates is rather limited.

Supplemental Material 1:**Systematic review search strategy in PubMed**

Group	Search terms	Category
1	((("Pain"[Mesh]) OR ((pain*[Text Word] OR headache*[Text Word] OR migraine*[Text Word] OR neuralgi*[Text Word] OR cephalalgia[Text Word] OR arthriti*[Text Word] OR osteoarthritis[Text Word] OR repetitive strain injur*[Text Word] OR fibromyalgi*[Text Word] OR irritable bowel syndrome[Text Word] OR hyperalgesi*[Text Word] OR allodynia[Text Word])))	Pain
2A	((("Suicide"[Mesh]) OR ((suicid*[Text Word] OR death wish[Text Word] OR non-suicid*[Text Word] OR nonsuicid*[Text Word] OR self-injur* behavi*[Text Word] OR self-harm*[Text Word] OR self-destruct*[Text Word] OR parasuicid*[Text Word] OR))))	Suicidality
2B	((("self mutilation"[MeSH Terms]) OR self mutilation[Text Word] OR self-mutilation[Text Word] OR selfmutilation[Text Word])	
3	((("Adolescent"[Mesh]) OR "Young Adult"[Mesh]) OR "Child"[Mesh]) OR ((adolescen*[Text Word] OR child*[Text Word] OR "young adult*" [Text Word] OR "young person"[Text Word] OR "young people"[Text Word] OR paedatric[Text Word] OR paediatric[Text Word] OR teen*[Text Word] OR pubesc*[Text Word] OR puber*[Text Word] OR youth*[Text Word] OR juvenile*[Text Word] OR minor*[Text Word] OR schoolboy*[Text Word] OR schoolgirl*[Text Word] OR girl*[Text Word] OR boy*[Text Word] OR kid[Text Word] OR kids[Text Word]))	Adolescence

These groups were combined as follows (1 AND 2A/B AND 3)

Note. 2A refers to the first round of searches. In the second round of searches (2B), we identified studies additionally focussing on self-mutilation, as a measure of suicidality.

Supplemental Material 2:**Content of data extraction**

Domain	Variables
Study identification	Study ID First author Year of publication Publication title Study aim
Methods	Study design Country Data origin (i.e., new vs. existing study)
Population	Type of population Inclusion and exclusion criteria Sample size Missing data/ non-respondents Age Gender Ethnicity Study setting
Exposure	Type and prevalence rates of exposure Assessment methods
Outcomes	Type and prevalence rates of the outcome Outcome assessment
Data analysis	Statistical analyses Control for other correlates
Results	Main results on the pain-suicidality association Risk and resilience factors for suicidality in the context of pain
Conclusion	Conclusion on the pain-suicidality association Limitations

Supplemental Material 3:**Results of the quality assessments (N=25).**

Cross sectional studies	Representativeness of the sample	Sample size	Non-respondents	Ascertainment of the exposure	Comparability of groups ^a	Assessment of the outcome	Statistical test	Total (out of 8)
<i>Suicidal ideation [SI] / suicidal risk</i>								
Lewcun et al., 2018 ¹	-	+	-	+	++	-	+	5/8
Fuller-Thomson et al., 2013 ²	+	+	+	+	++	+	+	8/8
Halvorsen et al., 2012 ³	+	+	+	-	++	-	+	6/8
Chan et al., 2009 ⁴	+	+	-	+	+	-	+	5/8
Wang et al., 2009 ⁵	+	+	+	-	++	-	+	6/8
Wang et al., 2007 ⁶	+	-	+	+	++	+	+	7/8
<i>Suicidal behaviour [SB] / self-harm</i>								
Liu et al., 2018 ⁷	+	+	+	-	++	-	+	6/8
Koenig et al., 2015 ⁸	+	+	+	-	++	-	+	6/8
Bayramoglu et al., 2015 ⁹	+	-	+	-	-	-	-	2/8
Tsai et al., 2011 ¹⁰	-	-	+	-	++	-	-	3/8
Reigstad et al., 2006 ¹¹	+	-	-	-	-	-	+	2/8
<i>Suicidality & mixed assessments</i>								
Ren et al., 2018 ¹²	-	-	+	-	+	-	-	2/8
Lee et al., 2017 ¹³	+	+	+	-	+	-	+	5/8

Campbell et al., 2015 ¹⁴	+	-	-	+	-	+	-		3/8
Kirtley et al., 2015 ¹⁵	-	-	-	-	-	-	-		0/8
Park et al., 2015 ¹⁶	-	-	+	+	-	+	-		3/8
Rozen et al., 2012 ¹⁷	-	-	-	-	-	-	-		0/8
Alriksson-Schmidt 2008 ^{b,18}	+	+	-	-	++	-	+		5/8
Cohort studies	Representativeness of the exposed cohort	Selection of non-exposed cohort	Ascertainment of the exposure	Outcome not present at baseline	Comparability of groups ^a	Assessment of the outcome	Length of follow-up	Adequacy of follow-up	Total (out of 9)
<i>Suicidal ideation [SI] / suicidal risk</i>									
Strandheim et al., 2014 ^{c,19}	+	+	-	-	++	-	+	+	6/9
<i>Suicidal behaviour [SB] / self-harm</i>									
Junker et al., 2017 ^{c,20}	+	+	-	+	+	+	+	-	6/9
<i>Suicidality & mixed assessments</i>									
Hogstedt et al., 2018 ²¹	+	+	-	-	++	+	+	-	6/9
Ekholm et al., 2014 ²²	+	+	+	+	++	+	-	-	7/9
vanTilburg et al., 2011 ^{b,23}	+	+	+	+	++	-	-	+	7/9
Case-Control Studies	Selection Definition of cases	Representativeness of cases	Selection of controls	Definition of controls	Comparability of groups ^a	Ascertainment of the exposure	Same method of for groups?	Non-response rate	Total (out of 9)

<i>Suicidal ideation [SI] / suicidal risk</i>									
Bromberg et al., 2017 ²⁴	+	-	+	+	++	-	+	-	6/9
Eliacik et al., 2017 ²⁵	+	+	+	+	+	-	+	-	6/9

Note. The quality ratings are based on the Newcastle-Ottawa Scale (+: one star awarded; -: no star awarded). Studies were scored based on availability of data for adolescents (aged 10-19 years) - Therefore, the overall study quality may be different.

- a. Possible to give two stars (+: controlling for demographics; ++: additionally controlling for clinical factors e.g., depression).
- b. Alriksson-Schmidt, 2008¹⁸ and van Tilburg et al., 2011²³ are partially based on the same dataset: Add Health.
- c. Junker et al., 2017²⁰ and Strandheim et al., 2014¹⁹ are partially based on the same dataset: Young Hunt.

Supplemental Material 4:

Table illustrating the level of evidence for the correlates of suicidality in adolescents (*adjusted for other correlates)

Correlate	Positive studies	Significant under certain conditions	Non-significant studies	Negative studies	Unclear
Suicidal ideation/ suicidal risk (n=9)					
<i>Community samples</i>					
Chronic illness or pain	Chan et al., 2009* ⁴				
Physical pain & tension problems	Strandheim et al., 2014* ^{a19}				
Migraine		Wang et al., 2009* ^{c5}	Fuller-Thomson et al., 2013* ² Wang et al., 2009* ⁵		
Headache-related disability					
Headache frequency (>7-14 days/month)	Wang et al., 2009* ⁵				
Back problems			Fuller-Thomson et al., 2013* ²		
Pain sites		Halvorsen et al., 2012* ^{d5}			
Activities prevented by pain		Fuller-Thomson et al., 2013* ^{c2}			
<i>Clinical samples</i>					
Chronic pain			Bromberg et al., 2017 ²⁴		
Migraine		Wang et al., 2007* ^{c6}			
Non-cardiac chest pain	Eliacik et al., 2017 ²⁵				
Family history of pain			Lewcun et al., 2018* ¹		
Pain severity			Lewcun et al., 2018* ¹		
Pain intensity			Bromberg et al., 2017 ²⁴		
Pain duration		Lewcun et al., 2018* ^{c1}			
Pain bother			Bromberg et al., 2017 ²⁴		
Functional disability			Lewcun et al., 2018* ¹		
Suicidal behaviour / non-suicidal self-injury (n=6)					
<i>Community samples</i>					
General pain		Koenig et al., 2015* ^{f8}			
Headache	Tsai et al., 2011* ¹⁰ ; Junker et al., 2017* ^{a20}	Koenig et al., 2015* ^{g8}			
Migraine	Junker et al., 2017* ^{a20}				
Stomach / abdominal pain	Junker et al., 2017* ^{a20}	Koenig et al., 2015* ^{h8}			
Period pain		Liu et al., 2018* ⁱ⁷			
Recurrent pain	Koenig et al., 2015* ⁸				
<i>Clinical samples</i>					
Any frequent pain	Reigstad et al., 2006 ¹¹				
Headache			Bayramoglu et al., 2015 ⁹		
Abdominal pain			Bayramoglu et al., 2015 ⁹		
Death by suicide (n=1)					
<i>Community sample</i>					
Chronic non-cancer pain			Ekholm et al., 2014 ²²		
Suicidality (overall) & mixed assessments (n=9)					
<i>Community sample</i>					
Physical pain	Alriksson-Schmidt, 2008* ^{b18}		Hogstedt et al., 2018* ²¹		Campbell et al., 2015 ¹⁴
Headache		Hogstedt et al., 2018* ^{j21} ; Van			

Migraine		Tilburg et al., 2011* ^{b,k,23}		
Stomach pain		Van Tilburg et al., 2011* ^{b,l,23}	Hogstedt et al., 2018* ²¹	
Musculoskeletal pain		Van Tilburg et al., 2011* ^{b,m,23}		
Pain tolerance		Ren et al., 2019* ^{n,o,12}		
Pain sensitivity		Ren et al., 2019* ^{o,12}	Kirtley et al., 2015 ¹⁵	
Pain distress	Kirtley et al., 2015 ¹⁵			
Pain-related quality of life	Lee et al., 2017* ¹³			
Clinical sample				
Migraine				Park et al., 2015 ¹⁶
Cluster headache				Rozen et al., 2012 ¹⁷

- a. Junker et al., 2017²⁰ and Strandheim et al., 2014¹⁹ are partially based on the same dataset: Young Hunt.
- b. Alriksson-Schmidt, 2008¹⁸ and van Tilburg et al., 2011²³ are partially based on the same dataset: Add Health.
- c. Significant only for migraine with aura
- d. Significant only for 3-5 pain sites, but not for 1-2 pain sites
- e. Significant when controlling for demographics, but not when controlling for depression
- f. Significant only for very often general pain and self-injury 1-3x/year, all other associations were non-significant.
- g. Significant only for very often headache and one suicidal attempt, all other associations were non-significant.
- h. Significant only for sometimes abdominal pain and one suicidal attempt, as well as for very often abdominal pain and multiple suicidal attempts, all other associations were non-significant.
- i. Significant for mild to moderate period pain and non-suicidal self-injury in the past year and lifetime, but not significant for severe period pain.
- j. Significant for severe headache and suicidal attempts.
- k. Significant for headaches wave 1 and 2 and suicidal ideation, headache and next-year suicidal ideation, as well as headache at wave 2 and suicide attempt.
- l. Significant for stomach pain at wave 2 and suicidal ideation
- m. Significant for musculoskeletal pain at wave 1 and suicidal ideation, and musculoskeletal pain at wave 2 and suicide attempt.
- n. Significant for suicidal ideation vs. control
- o. Significant for suicidal behaviour vs. control

Supplemental Material 5: Bodily Location of Pain and Suicidality

Eight studies, conducted in community samples, focussed on pain occurring in specific bodily locations (table 3).^{2,5,7,8,10,17,20,23} Great between-study inconsistencies were revealed when considering specific pain locations. Two studies found support for an association between migraines and suicidal ideation (migraine=7.2 vs. no migraine=3.6%, $p < 0.05$ ²; OR=2.9; 95%CI=[2.3-3.9]⁵), which only remained significant for migraines with aura (aOR=1.8, [1.1-3.0]; migraine with aura: 23.9% vs. no pain: 4.5%⁵), when controlling for demographics, health-related factors and depression.^{2,5} However other studies revealed cross-sectional and longitudinal (i.e., next year) associations between headaches and suicidal ideation, that remained significant after controlling for demographics and depression (table 3).²³ Similar inconsistent findings were observed for the relationship between headaches and suicidal behaviour (n=5).^{8,10,17,20,23} Headaches were significantly associated with suicidal behaviour cross-sectionally (of those with suicidal behaviours: 31.3% reported headaches vs. no suicidal behaviour: 6.5% reported headaches, $p < 0.001$;¹⁰ aOR=1.6-8.96)^{10,23} and longitudinally over a follow-up period of 33 years,²¹ but not one year²³, as well as with future self-harm hospitalisation (self-harm hospitalisation and headache: 61.8% vs. no headache: 34.8%; aHR=2.2-2.3),²⁰ after controlling for demographics, behaviour- and health-related factors^{10,20} and psychiatric symptoms.^{21,23} Contrary to these findings, Koenig and colleagues⁸ showed that the initial significant associations between headaches and suicidal behaviour (RR=1.1-2.6; no frequencies provided) mostly vanished after controlling for demographics and psychiatric symptoms.⁸ Moreover, headaches were not found to be associated with death by suicide, after controlling for demographics and psychiatric symptoms.²¹ Five studies provided support for a relationship between stomach or abdominal pain and suicidality (table 3).^{7,8,17,20,23} The odds of suicidal ideation were 1.4 (95%CI=[1.1-1.5]; no frequencies provided) times higher in adolescents with stomach pain, compared to those without these pains, but stomach pain did not predict next-year suicidal ideation, after controlling for demographics and depression.²³ Furthermore, two studies showed that stomach pain was neither cross-sectionally nor longitudinally associated with suicidal behaviour (with pain: 9-60% vs. without pain: 31%)²¹ or death by suicide (with pain: 6-61% vs. without pain: 33%),²¹ after controlling for demographics and psychiatric symptoms.^{21,23} In contrast, when solely controlling for demographics, stomach pain was found to increase the odds of future self-harm hospitalisation by two-fold (aHR=2.2, 95%CI= [1.4-3.5]; suicidal behaviour: 37.1% vs. no suicidal behaviour: 19.6%²⁰). Likewise, two studies showed that, in most subgroup analyses, abdominal pain was associated with lifetime and past-year suicidal behaviour (aOR=1.2-2.0;^{7,8} lifetime – pain: 29.3-38.5% vs. no pain: 24%; past-year – pain: 22-31.1% vs. no pain: 17.8%⁸), after controlling for demographics, behaviour- and health-related factors, as well as psychiatric symptoms.^{7,8} Two studies examined the association between musculoskeletal or back pain and suicidality.^{2,23} Similar to stomach pain, musculoskeletal pain was found to increase the odds of suicidal ideation by 1.3 (95%CI=[1.1-1.5]; no frequencies provided) times, and the odds for reporting suicidal behaviour by 1.1 (95%CI=[0.80-0.92]; no frequencies provided) times, after controlling for demographics and depression.²³ This finding is inconsistent with another study, showing that the significantly higher frequency of suicidal ideation in adolescents with, compared to those without, back pain (7.6% vs. 3.5%, $p < 0.05$) vanished after controlling for demographics, health-related factors and depression.² Furthermore, musculoskeletal pain was not associated with next-year suicidal ideation or behaviour when controlling for demographics and depression.²³

Supplement Material 6:

Detailed information on the database search, as performed by the first reviewer (VH)

Database	Date searched	Search string	Number of articles retrieved
Initial Search			
PubMed (ncbi.nlm.nih.gov/pubmed/)	07.06.2018	((("Pain"[Mesh]) OR ((pain*[Text Word] OR headache*[Text Word] OR migraine*[Text Word] OR neuralgi*[Text Word] OR cephalalgia[Text Word] OR arthriti*[Text Word] OR osteoarthritis[Text Word] OR repetitive strain injur*[Text Word] OR fibromyalgi*[Text Word] OR irritable bowel syndrome[Text Word] OR hyperalgesi*[Text Word] OR allodynia[Text Word]))) AND ((("Suicide"[Mesh]) OR ((suicid*[Text Word] OR death wish[Text Word] OR non-suicid*[Text Word] OR nonsuicid*[Text Word] OR self-injur* behavi*[Text Word] OR self-harm*[Text Word] OR self-destruct*[Text Word] OR parasuicid*[Text Word]))) AND (((("Adolescent"[Mesh]) OR "Young Adult"[Mesh]) OR "Child"[Mesh]) OR (adolescen*[Text Word] OR child*[Text Word] OR "young adult*[Text Word] OR "young person"[Text Word] OR "young people"[Text Word] OR pedatric[Text Word] OR paediatric[Text Word] OR teen*[Text Word] OR pubesc*[Text Word] OR puber*[Text Word] OR youth*[Text Word] OR juvenile*[Text Word] OR minor*[Text Word] OR schoolboy*[Text Word] OR schoolgirl*[Text Word] OR girl*[Text Word] OR boy*[Text Word] OR kid[Text Word] OR kids[Text Word])))	811
Web of Science (Core collection; incl. conferences)	07.06.2018	TOPIC: (("Pain" OR pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND TOPIC: (("Suicide" OR suicid* OR "death wish" OR non-suicid* OR self-injur* behavi* OR self-harm* OR self-destruct* OR parasuicid*)) AND TOPIC: (("Adolescent" OR "Young Adult" OR "Child" OR adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pediatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	789
Medline (via Web of Science)	13.06.2018	((TOPIC: (((((((((((("Pain") OR pain*) OR headache*) OR migraine*) OR neuralgi*) OR cephalalgia) OR arthriti*) OR osteoarthritis) OR repetitive strain injur*) OR fibromyalgi*) OR "irritable bowel syndrome") OR hyperalgesi*) OR allodynia) AND TOPIC: (((((((((((("Suicide") OR suicid*) OR "death wish") OR non-suicid*) OR self-injur* behavi*) OR self-harm*) OR self-destruct*) OR parasuicid*)) AND TOPIC: (((((((((((((((("Adolescent") OR "Young Adult") OR "Child") OR adolescen*) OR child*) OR young adult*) OR "young person") OR "young people") OR pediatric) OR paediatric) OR teen*) OR pubesc*) OR puber*) OR youth*) OR juvenile*) OR minor*) OR schoolboy*) OR schoolgirl*) OR girl*) OR boy*) OR kid) OR kids))	1089
Scopus (scopus.com)	14.06.2018	(TITLE-ABS-KEY (("Pain" [mesh]) OR pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR "repetitive strain injur*" OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND (TITLE-ABS-KEY (("Suicide" [mesh]) OR suicid* OR "death wish" OR non-suicid* OR nonsuicid* OR self-injur* AND behavi* OR self-harm* OR self-destruct* OR parasuicid*)) AND (TITLE-ABS-KEY (("Adolescent" [mesh] OR "Young Adult" [mesh] OR "Child" [mesh]) OR adolescen* OR child* OR "young adult*" OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	1275
CINAHL (via ebscohost.com)	08.06.2018	ABSTRACT: (((("Pain") OR ((pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR "repetitive strain injur*" OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia))) AND ABSTRACT: (((("Suicide") OR ((suicid* OR "death wish" OR non-suicid* OR nonsuicid* OR "self-injur* behavi*" OR self-harm* OR self-destruct* OR parasuicid*))) AND ABSTRACT: (((("Adolescent") OR "Young Adult") OR "Child")) OR ((adolescen* OR child* OR "young adult*" OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids)))	95
Embase (via Ovid)	15.06.2018	Search field: select title, abstract, conference publication 1. (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis) OR 2. ("repetitive strain injur*")	759

		<p>OR 3. ("irritable bowel syndrome") OR 4. (fibromyalgi* OR hyperalgesi* OR allodynia) 5. 1 OR 2 6. 3 OR 4 7. 5 OR 6 (summarising all search strings regarding PAIN) AND 8. (suicid* OR non-suicid* OR nonsuicid* OR self-injur* behavi* OR self-harm* OR self-destruct* OR parasuicid*) OR 9. ("death wish") 10. 8 OR 9 (summarising all search strings regarding SUICIDE) AND 11. ("Adolescent" OR "Young Adult" OR "Child") OR 12. (adolescen* OR child* OR "young person" OR "young people" OR pedatric OR paediatric) OR 13. (teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids) 14. 11 OR 12 15. 13 OR 14 (summarising all search strings regarding ADOLESCENCE) 16. 7 AND 10 AND 15</p>	
PsycInfo (via Ovid)	15.06.2018	See Embase search	570
ProQuest Dissertations and Theses	12.06.2018	Abstract search: ab(("Pain") OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND ab(("Suicide") OR (suicid* OR "death wish" OR non-suicid* OR nonsuicid* OR self-injur* behavi* OR self-harm* OR self-destruct* OR parasuicid*)) AND ab(("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	149
OpenGrey (opengrey.eu)	13.06.2018	((("Pain") OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND (("Suicide") OR (suicid* OR "death wish" OR non-suicid* OR nonsuicid* OR self-injur* behavi* OR self-harm* OR self-destruct* OR parasuicid*))) AND (("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	5
ClinicalTrials.gov	12.06.2018	Expert Search: ("Pain" OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND ("Suicide" OR (suicid* OR "death wish" OR non-suicid* OR nonsuicid* OR self-injur* behavi* OR self-harm* OR self-destruct* OR parasuicid*)) AND (("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	28
Date: 15.06.2018	Total search results: 5570	After de-duplication in Endnote: 3443	After de-duplication in Covidence: 3172 added
Self-mutilation search			
PubMed (ncbi.nlm.nih.gov/pubmed/)	03.07.2018	((("Pain"[Mesh]) OR ((pain*[Text Word] OR headache*[Text Word] OR migraine*[Text Word] OR neuralgi*[Text Word] OR cephalalgia[Text Word] OR arthriti*[Text Word] OR osteoarthritis[Text Word] OR repetitive strain injur*[Text Word] OR fibromyalgi*[Text Word] OR irritable bowel syndrome[Text Word] OR hyperalgesi*[Text Word] OR allodynia[Text Word]))) AND ("self mutilation"[MeSH Terms]) OR self mutilation[Text Word] OR self-mutilation[Text Word] OR	152

		selfmutilation[Text Word] AND (((("Adolescent"[Mesh] OR "Young Adult"[Mesh] OR "Child"[Mesh])) OR ((adolescen*[Text Word] OR child*[Text Word] OR "young adult*[Text Word] OR "young person"[Text Word] OR "young people"[Text Word] OR pedatric[Text Word] OR paediatric[Text Word] OR teen*[Text Word] OR pubesc*[Text Word] OR puber*[Text Word] OR youth*[Text Word] OR juvenile*[Text Word] OR minor*[Text Word] OR schoolboy*[Text Word] OR schoolgirl*[Text Word] OR girl*[Text Word] OR boy*[Text Word] OR kid[Text Word] OR kids[Text Word])))	
Web of Science (Core collection; incl. conferences)	03.07.2018	TOPIC: (("Pain" OR pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND TOPIC: (("self mutilation") OR "self-mutilation" OR selfmutilation) AND TOPIC: (("Adolescent" OR "Young Adult" OR "Child" OR adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pediatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	62
Medline (via Web of Science)	03.07.2018	TOPIC: (("Pain" OR pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND TOPIC: (("self mutilation") OR "self-mutilation" OR selfmutilation) AND TOPIC: (("Adolescent" OR "Young Adult" OR "Child" OR adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pediatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	155
Scopus (scopus.com)	03.07.2018	(TITLE-ABS-KEY (("Pain" [mesh]) OR pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR "repetitive strain injur*" OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND (TITLE-ABS-KEY (("self mutilation" [mesh]) OR "self mutilation" OR "self-mutilation" OR selfmutilation)) AND (TITLE-ABS-KEY (("Adolescent" [mesh] OR "Young Adult" [mesh] OR "Child" [mesh]) OR adolescen* OR child* OR "young adult*" OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	209
CINAHL (via ebscohost.com)	03.07.2018	ABSTRACT: (((("Pain") OR ((pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR "repetitive strain injur*" OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)))) AND ABSTRACT: (("self mutilation" OR "self-mutilation" OR selfmutilation)))) AND ABSTRACT: (((("Adolescent") OR "Young Adult") OR "Child")) OR ((adolescen* OR child* OR "young adult*" OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids)))	6
Embase (via Ovid)		Search field: select title, abstract, conference publication 1. (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis) OR 2. ("repetitive strain injur*") OR 3. ("irritable bowel syndrome") OR 4. (fibromyalgi* OR hyperalgesi* OR allodynia) 5. 1 OR 2 6. 3 OR 4 7. 5 OR 6 (summarising all search strings regarding PAIN) AND 8. (self-mutilation OR selfmutilation) OR 9. ("self mutilation") 10. 8 OR 9 (summarising all search strings regarding SELF-MUTILATION) AND 11. ("Adolescent" OR "Young Adult" OR "Child") OR 12. (adolescen* OR child* OR "young person" OR "young people" OR pedatric OR paediatric)	98

		OR 13. (teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids) 14. 11 OR 12 15. 13 OR 14 (summarising all search strings regarding ADOLESCENCE) 16. 7 AND 10 AND 15	
PsycInfo (via Ovid)	03.07.2018	See Embase search	38
ProQuest Dissertations and Theses	03.07.2018	Abstract search: ab(("Pain") OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND ab(("self mutilation") OR "self-mutilation" OR selfmutilation) AND ab(("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	2
OpenGrey (opengrey.eu)	03.07.2018	((("Pain") OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND ((("self mutilation") OR "self-mutilation" OR selfmutilation) AND ((("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	1
ClinicalTrials.gov	03.07.2018	Expert Search: ("Pain" OR (pain* OR headache* OR migraine* OR neuralgi* OR cephalalgia OR arthriti* OR osteoarthritis OR repetitive strain injur* OR fibromyalgi* OR "irritable bowel syndrome" OR hyperalgesi* OR allodynia)) AND ((("self mutilation") OR "self-mutilation" OR selfmutilation) AND (("Adolescent" OR "Young Adult" OR "Child") OR (adolescen* OR child* OR young adult* OR "young person" OR "young people" OR pedatric OR paediatric OR teen* OR pubesc* OR puber* OR youth* OR juvenile* OR minor* OR schoolboy* OR schoolgirl* OR girl* OR boy* OR kid OR kids))	3
Date: 03.07.2018	Total search results: 726	After de-duplication in Endnote: 350	After de-duplication in Covidence: 216 added
Additionally added			
Source	Date		Number of references identified
Search alerts	03.12.2018	CINAHL, Embase, Medline, PsycInfo, PubMed, Scopus & Web of Science, ProQuest, OpenGrey	552
Reference screening	03.12.2018	Studies that cited included studies (n=96); Reference lists of included studies (n=177)	273
Date: 03.12.2018	Total search results: 825	After de-duplication in Endnote: 652	After de-duplication in Covidence: 246 added

Note. The corresponding EndNote libraries will be made publically available on the Open Science Framework (see <https://osf.io/>; project name: Pain and Suicidality in Adolescence).

References Belonging to the Supplementary Material

1. Lewcun B, Kennedy TM, Tress J, Miller KS, Sherker J, Sherry DD. Predicting suicidal ideation in adolescents with chronic amplified pain: The roles of depression and pain duration. *Psychol Serv* 2018; **15**: 309–315.
2. Fuller-Thomson E, Hamelin GP, Granger SJR. Suicidal ideation in a population-based sample of adolescents: Implications for family medicine practice. *ISRN Family Med* 2013; **2013**: DOI: [10.5402/2013/282378](https://doi.org/10.5402/2013/282378).
3. Halvorsen JA, Dalgard F, Thoresen M, Bjertness E, Lien L. Itch and pain in adolescents are associated with suicidal ideation: a population-based cross-sectional study. *Acta Derm Venereol* 2012; **92**: 543–546.
4. Chan WSC, Law CK, Liu KY, Wong PWC, Law YW, Yip PSF. Suicidality in Chinese adolescents in Hong Kong: The role of family and cultural influences. *Soc Psychiatry Psychiatr Epidemiol* 2009; **44**: 278–284.
5. Wang SJ, Fuh JL, Juang KD, Lu SR. Migraine and suicidal ideation in adolescents aged 13 to 15 years. *Neurology* 2009; **72**: 1146–1152.
6. Wang SJ, Juang KD, Fuh JL, Lu SR. Psychiatric comorbidity and suicide risk in adolescents with chronic daily headache. *Neurology* 2007; **68**: 1468–1473.
7. Liu X, Liu ZZ, Fan F, Jia CX. Menarche and menstrual problems are associated with non-suicidal self-injury in adolescent girls. *Arch Womens Ment Health* 2018; **21**: 649–656.
8. Koenig J, Oelkers-Ax R, Parzer P, et al. The association of self-injurious behaviour and suicide attempts with recurrent idiopathic pain in adolescents: Evidence from a population-based study. *Child Adolesc Psychiatry Ment Health* 2015; **9**: 1–9.
9. Bayramoglu A, Saritemur M, Akgol Gur ST, Emet M. Demographic and clinical differences of aggressive and non-aggressive suicide attempts in the emergency department in the eastern region of turkey. *Iran Red Crescent Med J* 2015; **17**: 1–6.
10. Tsai MH, Chen YH, Chen CD, Hsiao CY, Chien CH. Deliberate self-harm by Taiwanese adolescents. *Acta Paediatr* 2011; **100**: e223–e226.
11. Reigstad B, Jørgensen K, Wichstrøm L. Pain in adolescent psychiatric patients. *Child and Adolescent Mental Health* 2006; **11**: 185–191.
12. Ren Y, You J, Zhang X, et al. Differentiating suicide attempters from suicide ideators: The role of capability for suicide. *Arch Suicide Res* 2019; **23**: 64–81.

13. Lee PH, Yeh YC, Hsiao RC, Yen CF, Hu HF. Pain-related quality of life related to mental health and sociodemographic indicators in adolescents. *Arch. Clin. Psychiatry* 2017; **44**: 67–72.
14. Campbell G, Darke S, Bruno R, Degenhardt L. The prevalence and correlates of chronic pain and suicidality in a nationally representative sample. *Aust N Z J Psychiatry* 2015; **49**: 803–811.
15. Kirtley OJ, O'Connor RC, O'Carroll RE. Hurting inside and out? Emotional and physical pain in self-harm ideation and enactment. *International Journal of Cognitive Therapy* 2015; **8**: 156–171.
16. Park SP, Seo JG, Lee WK. Osmophobia and allodynia are critical factors for suicidality in patients with migraine. *J Headache Pain* 2015; **16**: 1–6.
17. Rozen TD, Fishman RS. Cluster headache in the United States of America: demographics, clinical characteristics, triggers, suicidality, and personal burden. *Headache* 2012; **52**: 99–113.
18. Alriksson-Schmidt AI. Depressive symptomatology and suicide attempts in adolescents with mobility limitations. Dissertation Abstracts International: Section B: *The Sciences and Engineering* 2008; **68(11-B)**: 7688.
19. Strandheim A, Bjerkeset O, Gunnell D, Bjornelv S, Holmen T L, Bentzen N. Risk factors for suicidal thoughts in adolescence--a prospective cohort study: the Young-HUNT study. *BMJ Open* 2014; **4**: e005867.
20. Junker A, Bjørngaard JH, Bjerkeset O. Adolescent health and subsequent risk of self-harm hospitalisation: a 15-year follow-up of the Young-HUNT cohort. *Child Adolesc Psychiatry Ment Health* 2017; **11**: DOI: [10.1186/s13034-017-0161-8](https://doi.org/10.1186/s13034-017-0161-8).
21. Hogstedt C, Forsell Y, Hemmingsson T, Lundberg I, Lundin A. Psychological symptoms in late adolescence and long-term risk of suicide and suicide attempt. *Suicide Life Threat Behav* 2018; **48**: 315–327.
22. Ekholm O, Kurita GP, Hojsted J, Juel K, Sjogren P. Chronic pain, opioid prescriptions, and mortality in Denmark: A population-based cohort study. *Pain* 2014; **155**: 2486–2490.
23. Van Tilburg MA, Spence NJ, Whitehead WE, Bangdiwala S, Goldston DB. Chronic pain in adolescents is associated with suicidal thoughts and behaviors. *J Pain* 2011; **12**: 1032–1039.
24. Bromberg MH, Law EF, Palermo TM. Suicidal ideation in adolescents with and without chronic pain. *Clin J Pain* 2017; **33**: 21–27.

25. Eliacik K, Kanik A, Bolat N, et al. Anxiety, depression, suicidal ideation, and stressful life events in non-cardiac adolescent chest pain: a comparative study about the hidden part of the iceberg. *Cardiol Young* 2017; **27**: 1098–1103.