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Before the damage is done: Early childhood hyperactivity difficulties in adolescents with deliberate self-harm – findings from the DALSC cohort

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Abstract

Background: Deliberate self-harm (DSH) is a growing issue among Danish adolescents, and a dramatic increase in the incidence of DSH has been observed since the turn of the millennium. The importance of early childhood factors on later development has been established, but research on the trajectories of DSH is still scarce, and longitudinal studies are much needed.
Method: Participants were 3,291 children and their mothers from The Danish Longitudinal Survey of Children (DALSC), a Danish population-based birth cohort from 1995. Logistic regression and mediation analyses were used to examine significant early childhood determinants of self-harming behavior in adolescence.
Results: The study found that 17.9% of the children had a history with DSH at the age of 18 years. A significant relationship was found between the likelihood of DSH at the age of 18 years and hyperactivity difficulties assessed through the Strengths and Difficulties Questionnaire (SDQ) at 3 and 7 years of age. Using a mediation model, it is documented that difficulties in peer relationships at the age of 11 years is a partial mediator explaining 19% of the variation.
Limitations: i) a vague definition of self-harm in the questionnaires; ii) lack of sample representation as children of lower socio-economic groups have lower participation rates, and only Danish-ethnicity children have been sampled; iii) possibility of omitted variable bias.
Conclusion: The adolescents engaging in DSH are experiencing a more complex range of psychosocial problems than those who do not have experience with DSH. The main finding of the study is that hyperactivity as a risk factor for the development of DSH in adolescence can be identified as early as 3–7 years of age. This relationship between the very early occurring hyperactivity and later DSH, to the best of our knowledge, has not previously been described.

Keywords: Deliberate Self-Harm; adolescents; hyperactivity; inattention; peer difficulties; cohort; mediation analysis

Introduction

A dramatic increase in the incidence of deliberate self-harm (DSH) has been observed since the turn of the millennium (1, 2). Studies have found prevalence rates between 7.5% and 46.5% in non-clinical samples (3). The numbers are even higher in clinical samples (4). DSH thus poses a serious mental health problem in modern society with serious consequences for the individuals who engage in DSH as well as for their family and peers.

The term DSH has been used inconsistently (5, 6), but in the present article DSH will be used interchangeably with self-harm and refers to any non-accidental act of self-injury carried out by a person, irrespective of their intent or motivation. DSH includes a wide range of behaviors, from serious suicidal acts to superficial damage of body tissues. Some researchers make a categorical distinction between suicidal and non-suicidal DSH (7). Although it makes sense to distinguish between non-suicidal and suicidal self-harm, it is difficult to maintain a categorical distinction because self-harm often involves multiple, changing or ambivalent motivations (8, 9). Thus, suicidal intent is best described as dimensional (10).

Most individuals performing DSH initiate the behavior before they are 18 years old (11), with the probability of onset peaking around the age of 14 to 16 years (12). The earlier onset, the more self-harming episodes, and the greater the number of different methods used in DSH, the greater the risk of suicidal behavior (13, 14). Most studies show that

the incidence of DSH is higher in females than in males (15).

The majority of studies on the background of DSH have focused on *correlates* to DSH. Among the identified correlates to DSH are being highly self-critical, low self-esteem (16), high levels of perfectionism (18), negative urgency (19), impulsivity (20, 21) emotional reactivity (22), emotional dysregulation (23), impaired mentalizing capacity (249), identifying as LGBTQ (25), and substance and alcohol abuse issues (26). Correlates can act as proximal stressors and increase the risk of DSH. The problem with correlates when the findings are based on cross-sectional studies is the risk of reversed causality. Risk factors specifically occur *prior* to the first episode of DSH (27), and in order to identify risk factors it is necessary to conduct prospective longitudinal studies with a focus on events taking place *before* the typical time of onset of DSH.

The development of DSH can rarely be explained by a single factor. In order to determine the trajectories of DSH, the interaction of protective factors and both distal and proximal risk factors must be studied, and possible mediating and moderating variables must be identified. The multi-determined pathways of DSH could be a sequence of distal vulnerability factors, for example insecure attachment to parents (28) or early adverse life events (29) leading to low self-esteem, self-criticism and perfectionism (30), which in turn makes the individual vulnerable to specific proximal stressors and ultimately increases the risk of DSH (31, 32). Proximal stressors could, for example, include interpersonal problems, bullying (33) or being exposed to DSH in media or among peers (34-36). Protective factors, on the other hand, such as self-compassion and perceived support from others, are found to buffer the impact of peer victimization and thus lower the risk of DSH (37, 38). The earlier a vulnerability factor appears, the greater is its significance for the individual's psychosocial development. It is therefore important to be aware of early risk factors across domains along with their interactions in order to design prevention and intervention programs for DSH (39).

A distal vulnerability factor for the development of DSH could be hyperactivity difficulties which have a significant impact on a person's psychosocial development. Hyperactivity is probably dimen-sionally distributed in the population (40) but hyperactivity difficulties have primarily been studied as a symptom of attention deficit hyperactivity disorder (ADHD). Studies have found that ADHD significantly increases the risk of DSH (41), and increased risk that even applies to subthreshold ADHD among adolescent inpatients (42).

ADHD is a heterogeneous disorder with a variety of presentations including hyperactivity/impulsivity symptoms, meaning acting rashly without consideration for long-term outcomes (e.g., having difficulties sitting still, being restless or overactive or having difficulty awaiting one's turn), inattention symptoms, meaning difficulty controlling attention (e.g., distractibility, difficulties with planning and organizing or lack of persistence), and a combination of inattention and hyperactivity/ impulsivity symptoms (43).

Studies have found that increased risk of DSH is primarily associated with symptoms of hyperactivity/impulsivity or with a combination of inattention and hyperactivity/impulsivity symptoms rather than with inattention symptoms alone (44-46). It makes sense to regard hyperactivity difficulties as a risk factor for DSH because hyperactivity difficulties compromises executive functioning and response inhibition which in turn leads to difficulties with emotion regulation – a common finding in individuals who engage in DSH (47-50).

It is unclear, however, whether hyperactivity per se accounts for increased risk of DSH or whether the increased risk is related to comorbid disorders or other mediating factors (e.g., social problems). More than 40% of children with ADHD have at least one comorbid mental disorder (51), and children with ADHD are generally at higher risk for both internalizing problems (e.g., anxiety or depression) (52, 53) and externalizing problems (e.g., deficits in social communication) (44, 54). Swanson et al. (44) found that adolescent externalizing behavior mediated the link between childhood hyperactivity problems (ADHD) and young-adult non-suicidal self-harm whereas adolescent internalizing behavior increased the risk of suicidal behavior. Both types may compromise the ability to cope with distress, and are therefore found to increase risk for DSH (55, 56).

In addition to increased risk of mental disorders children and adolescents with hyperactive and impulsive behavior have far more social problems not least in relation to peers (57, 58). They have fewer close friends (59) and more negative peer ratings of agreeableness (58, 60), and many of them feel rejected by their peers (61). In general peer difficulties affect quality of life negatively and constitute one of the most important proximal stress factors increasing the risk of DSH among adolescents (62). Feelings of rejection and of being a failure or a disappointment in relation to peers are the most common trigger of DSH among adolescents (63). Hawton & Harriss (64) found that nearly 9 out of 10 episodes of DSH were preceded by social isolation or interpersonal conflict, and a study of children under the age of 16 found that

almost 40% indicated that peer difficulties were the main precipitant to DSH and suicidal attempt (65).

Multiple studies have found that childhood hyperactivity difficulties and DSH in adolescence are mediated by mental disorders (56) but to the best of our knowledge, only one study has analyzed peer difficulties as a moderator for the development of DSH. In a longitudinal follow-up study of 228 girls aged 6–12 years with and without ADHD Meza et al. (46) found that peer difficulties (peer victimization) in adolescence acted as a significant partial mediator between poor childhood response inhibition and later DSH. Childhood response inhibition refers to the ability to postpone, withhold, or stop inappropriate behavior which is a measure of executive functioning. Furthermore, poor response inhibition is also a key facet of hyperactivity and probably also an aspect of early childhood hyperactivity (e.g., being restless overactive, and unable to stay still for long). The authors note that their study is based on a small and selected sample and question whether these findings can be generalized to male samples and to other diagnostic groups.

In a representative population-based sample of adolescents we want to investigate early risk factors for developing DSH. Based on the abovementioned studies (41, 46) we hypothesize that hyperactivity difficulties in early childhood constitutes a significant risk factor in developing DSH in adolescence, and that peer difficulties mediate the effect. The longitudinal design of the study offers a unique opportunity to follow persons engaging in DSH from birth through the challenging period of transition from childhood to adolescence, the time when most persons who develop DSH make their debut. This is, to the best of our knowledge, the first longitudinal study of a representative sample that investigates the relationship between DSH and early childhood hyperactivity.

Methods
Sample
The Danish Longitudinal Survey of Children (DALSC) is a Danish population-based birth cohort initiated in 1995 by The Danish Center for Social Science Research (VIVE). The original sample consisted of 6,000 children. They were randomly sampled among all children living in Denmark born from September 15 through October 31 in 1995 by mothers with a Danish citizenship, regardless of the mother's country of origin and also regardless of the father's citizenship and country of origin. Extensive data was collected from both the mother, the father and their child. The participants in this study were the children and their mothers. Six rounds of questionnaire surveys were conducted from the

initiation in 1995 until 2014, when the children reached 18 years of age. Detailed information about DALSC and the questionnaires is available at the birth cohort study website (https://aargang95.sfi.dk/).

Cleansing the DALSC dataset to account for children's missing participation in questionnaires in 2011 or 2014 reduced the number of observations to 3,746, of which 3,627 children responded to questions regarding DSH, leaving 119 missing. The dataset was further cleansed to account for mothers' missing participation in the 1996, 1999 or 2003 surveys, which meant the statistical analysis was ultimately based on 3,291 children.

Definitions and measures
Outcome measure: DSH
The questions regarding DSH in the DALSC questionnaires, were based on the Development and Well-Being Assessment (DAWBA) questions (https://dawba.info/). The participating children were asked about DSH in 2011 and 2014, when they were 15 and 18 years old. If participants responded in the affirmative to "over the last four weeks have you tried to harm yourself on purpose?" or "have you ever tried to harm or hurt yourself?" they were classified as engaging in DSH. There were no follow-up questions on whether the DSH involved suicidal intent. In 2014, when participants were 18 years old, they were asked whether they had ever attempted suicide. If the participants affirmed that they had attempted suicide but had negative responses to the questions regarding DSH, they were not classified as engaging in DSH. If the participants responded affirmatively to having thought about DSH but negatively to having tried DSH they were not classified as engaging in DSH. These questions allow us to identify children with a history of DSH.

Early childhood mental well-being
The key element of the analysis was to investigate to what extent hyperactivity difficulties in early childhood has an effect on the likelihood of developing DSH behavior as an adolescent. The child's hyperactivity difficulties were assessed through the Strengths and Difficulties Questionnaire (SDQ). The questions used to assess hyperactivity focus on whether the child was restless, overactive, easily distracted, had a low attention span and/or acted before thinking. The SDQ is an internationally recognized tool for assessing the mental health, well-being and functioning of children aged 2–17 years (https://www.sdqinfo.com). Consisting of 25 questions, the SDQ can be answered by children, parents and educators. In this case, the mothers participated. The SDQ focuses on five topics: hyperactivity difficulties, emotional symptoms,

behavioral symptoms, peer difficulties and the child's prosocial strengths. The answers were scored to produce a scale from 0 to 10 for each topic, with higher scores reflecting higher levels of difficulty. Each scale was categorized into three groups, indicating whether the child had a normal, borderline normal or abnormal score. The scales indicate whether the child has symptoms of an underlying disorder, but a diagnosis cannot be concluded based on this assessment alone. In DALSC, the SDQ was first used in 2003, when the children were 7 years old. However, in the 1999 questionnaire, when the children were 3 years old, the mothers were asked questions that are roughly similar to the SDQ questions. This makes it possible to compile a score for hyperactivity difficulties in 3-year-olds and a score for emotional symptoms in 3-year-olds that are equivalent to the SDQ scores. The questionnaires are available at the study website (https://aargang95.sfi.dk/).

Hyperactivity and emotional difficulties assessed at the age of 3 and 7 years were thus included as primary exposure variables in the analysis together with peer difficulties and conduct problems assessed at the age of 7 years.

Mothers' mental health
In each round of questionnaires, the mothers were asked a range of questions regarding possible mental health issues. They were asked whether they had been experiencing depression or anxiety since the previous interview, received treatment from a psychologist or psychiatrist or been admitted to a psychiatric hospital. The mental health questions given to the mothers in 1996–2003 produced a total of 12 variables. To express the underlying variability among these variables, a factor analysis was performed. The outcome of the factor analysis was two factor variables, as the 12 variables were divided into two time periods: 1996–1999 and 1999–2003. This makes good sense intuitively: a person who is experiencing anxiety, for example, will be more likely to experience depression or receive treatment during that same period of time. Hence, the two factor variables were included in the analysis as primary exposure variables to investigate to what extent mothers' mental health affect the likelihood of the child performing DSH.

Statistical analysis
Logistic regressions were performed to explore the association between the early childhood exposure variables and the risk of DSH in adolescence. Reverse causality was avoided by only including exposure variables assessed in early childhood. While we do not know when the self-harm takes place, previous studies show that self-harm typically begins during the early teenage years (3). The original model to be estimated contained 23 exposure variables, including a wide range of control variables regarding the child, the mother and their socioeconomic background. The original model was specified using backwards selection. Due to the gender difference in self-harming behavior (15), secondary analyses were performed to investigate the interaction effects between gender and the other significant exposure variables.

To investigate whether the relationship between early childhood hyperactivity difficulties and DSH is explained through peer difficulties, a mediation analysis was performed. For a variable to be suitable as a mediator, it has to meet two conditions: the independent variable (hyperactivity difficulties) must correlate significantly with the mediator, and the mediator must correlate significantly with the dependent variable (DSH) (66). For the mediation analysis, hyperactivity difficulties at age 3 and age 7 was defined as one variable, rating hyperactivity difficulties on a scale from 0 to 20. The mediator, peer difficulties, was measured at age 11. Thus, the independent variable was measured at time t_1, the mediator at time t_2, and the dependent variable at time t_3, with $t_1 < t_2 < t_3$. Whether the mediator was present before the outcome variable is an assumption that is made, as we cannot know with complete certainty that the DSH did not begin before the age of 11, when the peer difficulties were measured. In the mediation analysis, the significant variables from the logistic regression were included as control variables. A bootstrap approach was applied to create confidence intervals (67). All statistical analyses were conducted in SAS Studio, and the mediation analysis was performed by using the 'PROC CAUSALMED' procedure.

Results
Descriptive results
Data from 3,627 children shows a DSH prevalence of 17.9%, meaning 17.9% have a history with DSH at the age of 18 years. Table 1 shows nearly three out of four children reporting DSH are female (72%). Up to the age of 18 years, 20% of the children reporting DSH had attempted suicide at least once. Nearly half (47%) of the children who have engaged in DSH have reported a mental disorder (e.g., depression, anxiety) or they have at least once been prescribed psychotropic drugs at the age of 18 years.

Table 2 shows that while only 2.5% of the DALSC sample had been diagnosed with ADHD, the share of respondents diagnosed with ADHD among those reporting DSH was 4.3%, which is 84% more than in the total sample. On the other hand, more than every third child diagnosed with ADHD (34.9%) had a history with DSH. Nearly half of the DSH

population (43.5%) showed symptoms of ADHD, as rated on the Adult Self-Report Scale (ASRS) (68), compared to 27.7% in the total sample. Two-thirds of children with an ADHD diagnosis showed according symptoms of ADHD, rated on the ASRS, but only 6.3% of the population showing ADHD symptoms on the ASRS had been diagnosed with ADHD by the age of 18.

TABLE 1. Comparing means by t-tests

Variable	DSH (n=649)		No DSH (n=2978)		p-value
	n	mean	n	mean	
Female	468	72,1%	1304	43.8%	<.0001
Suicide attempted (age 18)	125	19,5%	19	0.6%	<.0001
Mental disorder or psychotropic drugs (age 0–18)	299	47,1%	395	13.5%	<.0001

Note. The number of missing observations was 119 for self-harm; 0 for gender; 17 for suicide; 78 for psychiatric disorder

TABLE 2. DSH and ADHD

	n	Pct. of sample (n=3627)	Pct. of reported DSH	Pct. of ADHD diagnosed	Pct. of ADHD symptoms
DSH, total	649	17.9%	100%	34.9%	28.8%
ADHD diagnosed	95	2.5%	4.6%	100%	6.3%
ADHD symptoms	1037	27.7%	43.5%	68.4%	100%

Note. The number of missing observations was 119 for self-harm; 1 for ADHD; 8 for ADHD symptoms

Figure 1 shows how SDQ measures for hyperactivity difficulties, peer difficulties, emotional symptoms and conduct problems evolve from childhood into adolescence, dividing the sample into the DSH and the no-DSH population. For both groups, hyperactivity difficulties peaked at age 7, and while the DSH population has a constant higher share of persons with borderline or abnormal scores, the two groups follow the same trend. In the case of peer difficulties, the number of persons with borderline or abnormal peer difficulties peaked at age 15, when the share among those reporting DSH was nearly twice as high as the rest. The share of persons with borderline or abnormal emotional symptoms peaked at age 7 for those without DSH behavior, while it peaked at age 11 for those reporting DSH; at this age, more than a quarter of the DSH population showed symptoms. Conduct problems, on the other hand, peaked at age 7 for both groups, but while the non-normal share decreased with age for those without DSH behavior, it seemed to be an increasing problem at age 15 for the DSH population.

Early childhood risk factors for DSH
The significant associations between early childhood exposure variables and adolescent DSH are presented in Table 3. The exposure variables shown are those factors that significantly affect the risk of developing DSH behavior, while the signs of the coefficients show the direction of their impact. Figure 2, presenting the odds ratios and their confidence limits, illustrates that none of the confidence lines cross the reference line, meaning that they are significant. Ratios below 1 represent a negative association, while ratios above 1 represent a positive association. The graph can also be interpreted as showing the unstandardized effect size of each exposure variable at a one-unit-change.

As shown in Table 3 and Figure 2, being female increases the risk of DSH significantly. Females are at nearly four times greater odds (1/0.263 = 3.8) of developing DSH behavior than males. Hyperactivity difficulties measured at age 3 and age 7 were found to significantly increase the risk of DSH. Experiencing peer difficulties at age 7 was also found to significantly increase the risk of DSH. Hyperactivity measures and the peer measure are continuous variables; hence, the odds ratios show the change in odds if the measure is one unit higher on the scale. For example, having a hyperactivity score of 2 instead of 1 measured at age 3 increases the risk of developing self-harming behavior 1.07 times.

Divorce during the child's early years significantly increases the risk of DSH, by 1.6 times. The same is shown to be the case if the child's mother reported smoking cigarettes during the child's early years.
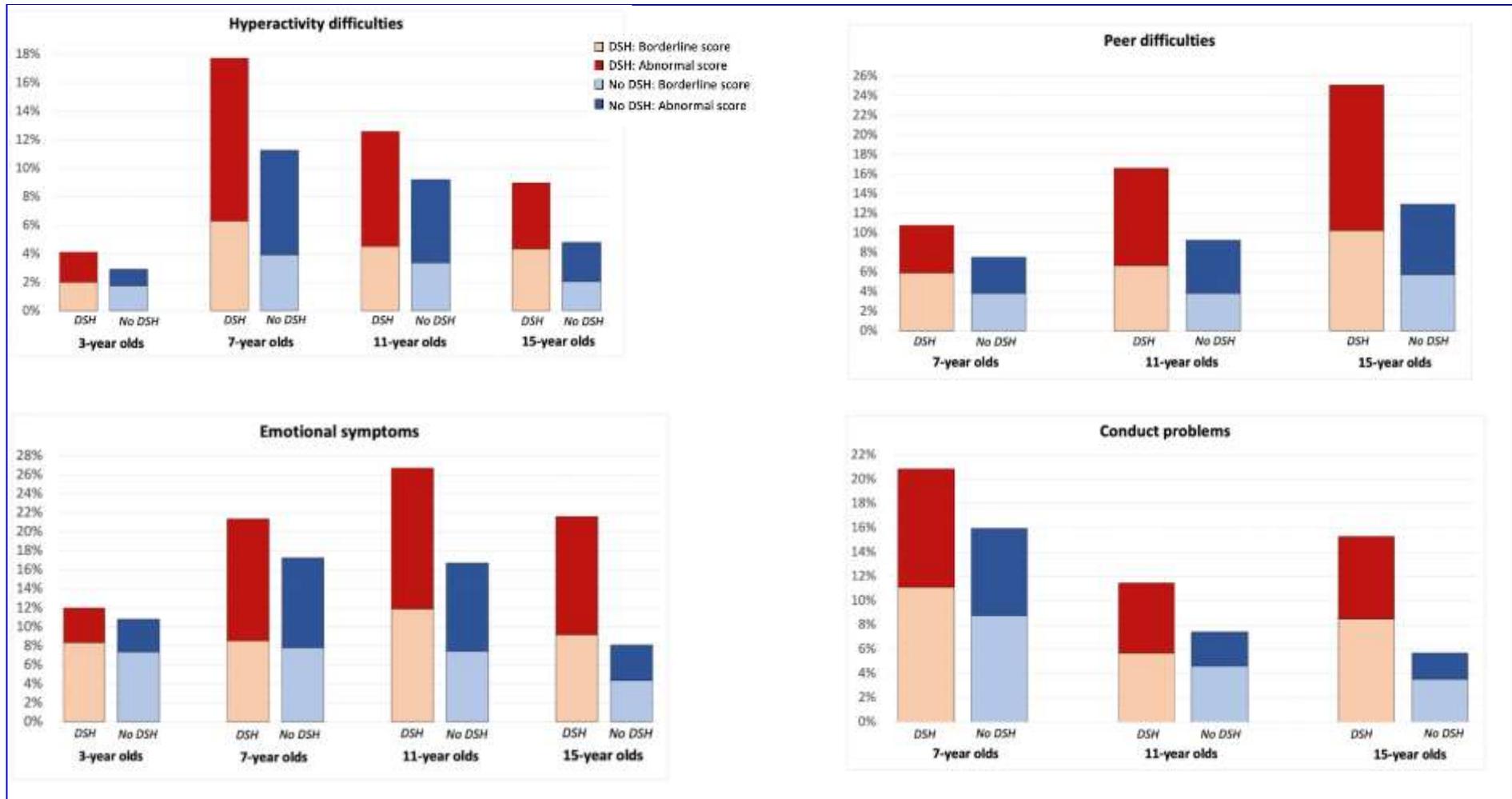
FIGURE 1. SDQ 1999-2011

TABLE 3. Logistic regression of the specified model

Parameter		Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
			Analysis of maximum likelihood estimates		
intercept		-1.9419	0.0954	414.0452	<.0001
female	0	-0.6679	0.0543	151.4615	<.0001
Hyperactivity difficulties, 3 years		0.0685	0.0325	4.4403	0.0351
Hyperactivity difficulties, 7 years		0.0841	0.0224	14.1493	0.0002
Peer difficulties, 7 years		0.0839	0.0388	4.6803	0.0305
Parents divorced	0	-0.2348	0.0593	15.6575	<.0001
Maternal smoking	0	-0.2211	0.0503	19.3254	<.0001
Maternal mental health, 3-7 years		0.1205	0.0462	6.7893	0.0092

Note. N = 3,091. C = 0.707. Binary exposure variables are set to zero; hence, the coefficient signs show the effect on the risk of self-harm when the exposure variable is zero
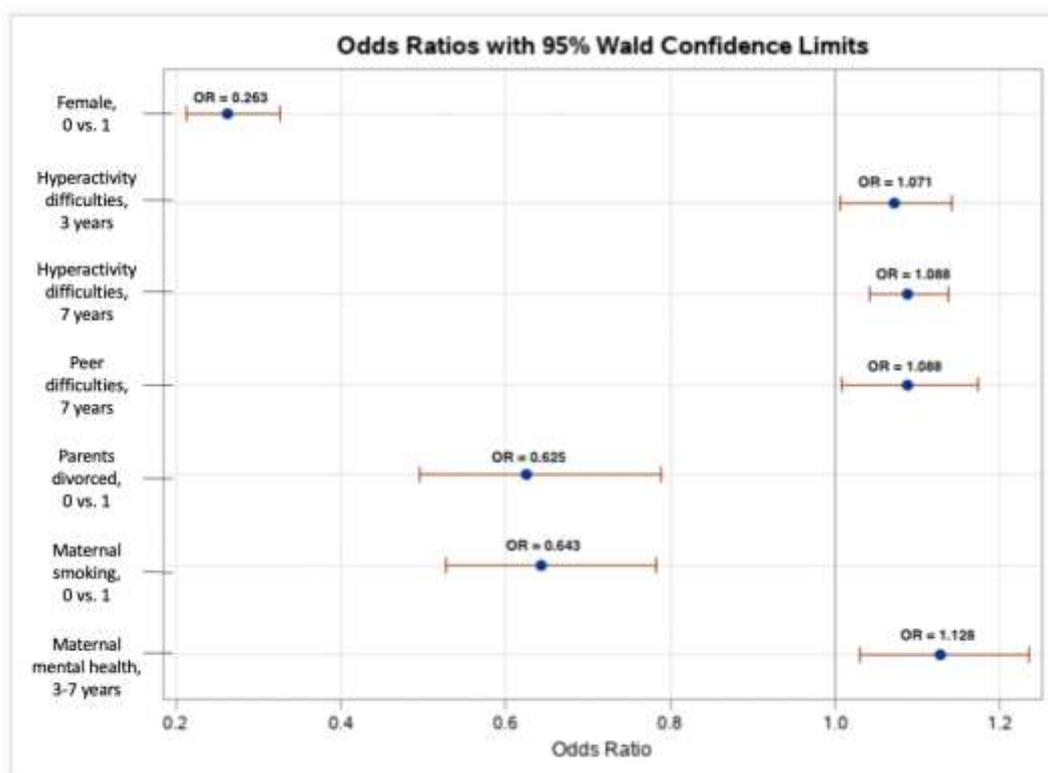
FIGURE 2. Odds ratios from the logistic regression of the specified model

The factor variable for maternal mental health difficulties when the child was aged 3–7 years is also shown to be significant, meaning that if the mother experienced mental health difficulties during the child's early years, the child was at greater risk of developing DSH behavior later.

Secondary analyses of interaction effects were conducted (supplementary Table A). All possible combinations of the significant exposure variables in the specified model were tested. The analysis of interaction effects indicates a gender effect. The specified model was tested on each gender, showing the only exposure variable presented in Table 3 having a significant impact on the risk of DSH among males was whether the mother smoked during the child's early years. The other variables are only significant for the female population.

Mediation model

The mediation model assumes that there are two causal paths feeding into the outcome variable: a direct effect of the independent variable (C) and the effect of the mediator (B). Furthermore, there is a path from the independent variable to the mediator (A) (66). As seen in Figure 3, paths A and B are both significant, meaning peer difficulties act as a mediator. The indirect effect, which is the effect of hyperactivity that translates into peer difficulties and then into DSH behavior, is shown to be significant. Thus, we find strong support for the hypotheses that peer difficulties act as a mediator between hyperactivity difficulties in early childhood and adolescent DSH. The mediation is only partial, however, as the direct effect is nonzero and significant but still smaller than the total effect. This suggests there might be other significant mediators as well.
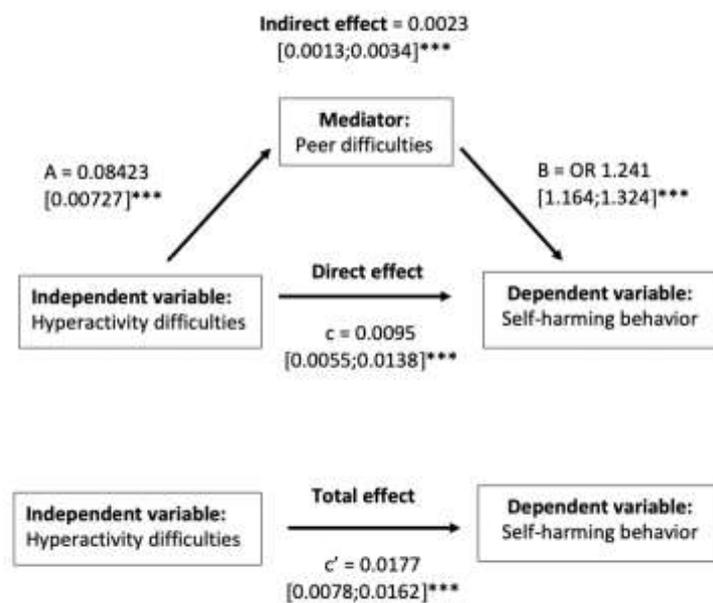
FIGURE 3. Mediation analysis
Note. ***= p < 0.0001; Each arrow represents a regression model (Baron & Kenny, 1986). A was performed as a linear regression with the following control variables: gender, maternal smoking, maternal mental health, parents' divorce. B was performed as a logistic regression, involving the same controls. The mediation analysis was performed as a bootstrap, and the parentheses shown are bootstrap CI. Percentage mediated = 19.3***

Discussion

Based on a representative sample of Danish children born in 1995 (N = 3,627), we investigated early childhood risk factors for DSH. We hypothesized that signs of hyperactivity difficulties in early childhood constitute a significant risk factor for developing DSH in adolescence, and that peer difficulties mediate the effect. We found that hyperactivity difficulties measured at age 3 and age 7 years significantly increase the risk of DSH and that difficulties in peer relationships at the age of 11 years are a significant partial mediator explaining 19% of the variation, but it did not cancel out the direct association between early childhood hyperactivity difficulties and adolescent DSH.

The correlation between hyperactivity difficulties and DSH has been described in several studies (41, 56) and this also is confirmed in our study. In addition to our finding that hyperactivity difficulties measured at age 3 and age 7 years significantly increase the risk of DSH we also found that nearly half of the children (43.5%) who had performed DSH showed symptoms of ADHD (as rated on the Adult Self-Report Scale (ASRS), and more than every third child (34.9%) diagnosed with ADHD had a history with DSH. These findings are in line with other studies that have found that both ADHD and ADHD symptoms (subthreshold ADHD) increase the risk of adolescent DSH (42, 56) and of several other comorbid psychiatric disorders (69).

Hyperactivity difficulties are usually considered a boy's problem. ADHD hyperactivity-impulsivity presentation occurs more than twice as frequently in boys as in girls, while girls diagnosed with ADHD are more likely to have the inattentive type (70). However, many girls with ADHD, particularly those with high impulsivity in their childhood, follow a heterotypical continuous developmental pathway, that puts them at a strikingly high risk of engaging in DSH (71). We found that 17.9% of the studied population at the age of 18 years reported that they had performed DSH at least once in their life which is roughly similar to what is found in other studies (72). Being female increases the risk of DSH significantly. The vast majority (72%) of the individuals in the group who had performed DSH are females. Females have a nearly four times higher risk of developing DSH behavior than males.

The high prevalence of females in the DSH group may have several explanations: more young females report feeling stressed by demands for perfection in most areas of life (73) and the link between peer problems and DSH may be particularly salient in females who – compared with males - appear to exhibit greater concern about how they are evaluated by peers (74). The observed gender difference with regard to engagement in DSH could be due to the fact that females are more likely to internalize their feelings and direct aggression towards themselves, while males tend to direct aggression outward, toward others (75). Finally fewer males than females perceive (and thus report) their self-harming behavior as DSH (76, 77).

We find peer difficulties being a significant partial mediator for hyperactivity difficulties. There exists several situations which can lead to partial (and not full) mediation (78). Firstly, partial mediation could be because hyperactivity difficulties has a direct effect on early childhood to DSH in addition to the indirect effect through peer difficulties. Secondly the partial mediation might be due to misspecification of the model, if there are other mediators not included. A third explanation for the partial mediation could be if peer difficulties actually fully mediates the effect for a specific part of the DSH population, but has no mediating effect for the rest of the DSH population. And lastly, partial mediation could be due to the fact that the variables are measured with error, thereby underestimating the effect of peer difficulties on DSH. In this case we assume the variables of the model will be measured with error to some degree, which opens up the possibility that peer difficulties actually fully mediates the effect of hyperactivity difficulties. However, it is also very plausible to think that the partial mediation is due to additional mediators or that peer difficulties only mediates for some of the children with hyperactivity difficulties .

Our finding of peer difficulties as a partial mediator between early childhood hyperactivity and DSH is related to the study of Meza et al. (46), who found that teacher's ratings of negative peer social preference in adolescence emerged as a significant mediator between poor response inhibition during childhood and DSH in young adulthood. The authors question whether their findings can be generalized to male samples and to other diagnostic groups besides ADHD. Our study, however, confirms that the findings can be generalized to a larger representative non-clinical population. This is a very important, but perhaps not so surprising finding, since many studies document that hyperactivity difficulties generally cause major problems in relation to peers (79). It is also well documented that peer difficulties are one of the main reasons why young people develop DSH (62). However, peer difficulties, may both contribute to the development and maintenance of DSH (80, 81) and be a consequence of DSH (82, 83). This dynamic can easily develop into a vicious cycle driven by interpersonal problems with peers (84), loneliness (85), high rates of peer victimization and bullying (86), low level of perceived support (87), poor social self-worth (30), high levels of shame (88) and body image problems (89), all of which increase the risk of DSH. In short, hyperactivity difficulties compromises executive functioning and response inhibition which adversely affects mentalizing ability; conversely, decreased mentalization will inevitably reduce impulse control and increase the risk of DSH (90).

In the present study, we find that adolescents with a history of DSH in general were mentally disadvantaged and more distressed in comparison to adolescents who do not have a history of DSH. They were far more likely to have reported mental illness or having been prescribed psychiatric drugs at the age of 18 years (47.1%), and nearly a fifth of the children who have engaged in DSH reported attempting suicide (19.5%). The same trend has been found in other studies (91). Being an adolescent engaging in DSH is clearly painful and makes for a difficult life, which is why it is so important to prevent DSH before the damage is done.

Strengths and limitations

The present study has strengths that validate the results of the study but also limitations which should be kept in mind when the results are generalized to apply to the overall population.

The biggest strength of this study is the longitudinal prospective design and the vast amount of information in the DALSC data. This made it possible to produce a national analysis, recording the development of a child through six waves from

childhood into adolescence, which is the phase in life when the risk of mental illness and debut of DSH is greatest (92), while at the same time avoiding reversed causality.

The key limitations relate to the definition of DSH, as the questionnaire used does not clearly state what is meant by the term. Although we exclude suicidal behavior, it is still not entirely clear how the respondents perceive the question. Finally, we do not know what kind of DSH or how frequent and extensive the self-harming activity is. Previous studies show that interviewing about DSH without mentioning examples of it (e.g., cutting, burning or hitting yourself) generally produces a lower self-harm prevalence (72). Another limitation is the questionable representation of the sample. Previous studies have shown that compared to non-participants, the children participating in DALSC were more likely to have older mothers and mothers of higher-level socioeconomic backgrounds. The participating children were more likely to come from non-broken homes, to have better health and get better grades in school (93). Furthermore, only children with a mother holding Danish citizenship were sampled, leaving non-Danish nationalities underrepresented. It is important to keep this in mind, as the group in question – persons who have deliberately self-harmed – is a socially vulnerable group, and thus, the prevalence rate found is probably a lower bound of the true rate. When using stepwise modelling, the models tend to become over-fit, which halters the generalizing abilities of the results (94).

In conclusion, our main finding is that signs of hyperactivity difficulties as a risk factor for the development of DSH in adolescence can be identified as early as at 3–7 years of age. To the best of our knowledge, this relationship between very early occurring hyperactivity and later DSH has not previously been described. It is also the first time peer difficulties have been identified as a mediating factor between early childhood hyperactivity and adolescent DSH in a representative community sample. The finding that hyperactivity has a direct impact on the development of DSH as well as an indirect impact, in the sense that it is mediated by peer difficulties, makes good sense intuitively. Both of these findings are important for understanding the pathways, prevention and treatment of DSH.

Clinical significance
The findings of the study point to certain clinical implications and underscore the importance of being aware of hyperactivity difficulties in preschool children, as it may compromise their later relationships with peers and ultimately increase the risk of DSH, which is an indicator of decreased well-being as well as a risk factor for a wide range of psychosocial problems, including loneliness, social isolation, negative self-image, dropping out of education, alcohol and drug abuse, depression, eating disorders and other mental health problems, including suicidal behavior (95, 96). It is important to be aware of and act on the distal risk factors for DSH as early as possible. Once established, DSH is self-reinforcing and adolescents rarely seek treatment for DSH themselves. Even when they do, DSH is difficult to treat.

Disclosures
There are no conflict of interests.

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