

1 **Childhood physical maltreatment, perceived social isolation, and internalizing symptoms: A longitudinal,**
2 **three-wave, population-based study**

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30 **Abstract**

31 A number of cross-sectional studies have consistently shown a correlation between childhood physical
32 maltreatment, perceived social isolation, and internalizing symptoms. Using a longitudinal, three-wave design,
33 this study sought to assess the mediating role of perceived social isolation in adulthood in the association
34 between childhood physical maltreatment and internalizing symptoms in adulthood. We used data collected
35 from 1994 to 2008 within the framework of the Tromsø Study (N=4,530), a representative prospective cohort
36 study of men and women. Perceived social isolation was measured at a mean age of 54.7 years, and internalizing
37 symptoms were measured at a mean age of 61.7 years. The difference-in-coefficients method was used to assess
38 the indirect effects and the proportion (%) of mediated effects. Childhood physical maltreatment was associated
39 with an up to 68% (relative risk [RR]=1.68, 95% confidence interval [CI]:1.33-2.13) higher risk of perceived
40 social isolation in adulthood. Childhood physical maltreatment and perceived social isolation in adulthood were
41 associated with greater levels of internalizing symptoms in adulthood ($p<0.01$). A dose-response association
42 was observed between childhood physical maltreatment and internalizing symptoms in adulthood ($p<0.001$).
43 Perceived social isolation in adulthood mediated up to 14.89% ($p<0.05$) of the association between childhood
44 physical maltreatment and internalizing symptoms in adulthood. The results of this study indicate the need to
45 take perceived social isolation into account when considering the impact of childhood physical maltreatment on
46 internalizing symptoms.

47 **Keywords:** psychological well-being; psychological distress; social support; anxiety; depression; childhood
48 abuse; emotional distress; loneliness

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60 Introduction

61 In recent decades, there has been a great amount of research on how childhood physical maltreatment relates to
62 affective and internalizing disorders in adulthood [1-4], and reviews [5-7] have shown reasonable associations
63 between these variables. Childhood physical maltreatment can have enduring effects on brain development and
64 brain stress regulatory flow systems, which may confer increased vulnerability to internalizing symptoms (i.e.,
65 depressive and anxious symptomatology) in later life [8,9,3,1,2]. For instance, childhood physical maltreatment
66 may influence emotional abilities and alter sensory thresholds in ways that undermine effective emotion
67 regulation and create increased susceptibility to internalizing disorders in later life [10,11,4,1,12]. Other reports
68 suggest that childhood physical maltreatment influences internalizing symptoms through the social and
69 emotional impairments it provokes [13,4], such as poor social skills, impulsivity, reactive aggression,
70 behavioural problems, or excessive reassurance-seeking, as individuals with these impairments are likely to be
71 rejected by their normally-functioning peers [14,15,4,1].

72 An individual's functional social behaviour depends on their ability, capacity, and motivation for social
73 interactions, all of which play an important role in maintaining a social support network and social relationships
74 with peers [4,1]. The biological embedding hypothesis suggests that the childhood physical
75 maltreatment → internalizing symptoms association is partly driven by embedding or scarring that limits one's
76 ability to develop and maintain social relationships [16,17]. Several reports on the long-term influence of
77 childhood physical maltreatment have suggested it causes high emotional reactivity and decreased social
78 competency, which disturb an individual's ability to make and sustain supportive relationships, thereby
79 contributing to the development of internalizing symptoms [18,15,4,1]. Previous evidence has shown that poor
80 social conformity and negative interaction with friends in adulthood may be a consequence of childhood
81 physical maltreatment [18,10,1,4]. Specifically, childhood physical maltreatment is associated with deficits in
82 attention, mindfulness, and self-referential encoding [19,20,4]. For example, previous studies have indicated that
83 children who were physically maltreated showed errors in judgment in situations that required interpersonal
84 reasoning; in turn, these errors in judgement may lead to inappropriate social behaviour [21,22]. Deficits in
85 emotional self-regulation are also associated with externalizing behaviors, which in turn are associated with
86 peer-rejection [23,24,1,4,25]. Many of these symptoms do not occur in isolation, and most affect the quality and
87 quantity of the social bonds people cultivate in their lifetime [18,26,1,4]. For example, peers may perceive self-
88 focused individuals as especially annoying and abrasive [27]. Impaired emotion recognition and a negative
89 emotional bias could contribute further to internalizing symptoms via deficits in receptive communication

90 [28,10,11]. However, it must be noted that these negative effects are not necessarily the result of childhood
91 physical maltreatment itself (as an event), but of the distress caused by childhood physical maltreatment [9,4,1].

92 The social support deterioration model [29] suggests that stressors such as childhood physical
93 maltreatment can damage a child's perception of available and helpful social support, which, in turn, can lead to
94 maladjustment [30,26,4]. Indeed, maltreated children may perceive their social network in a negative manner
95 [31,14,1,4]. Even when this network is based on mutual giving and receiving, they may not be able to perceive
96 this because of the difficulties they often face in interpreting the thoughts and feelings of others [31,14,1,4].
97 They are also less likely to be able to understand negative emotions such as anger and sadness, which can affect
98 the quantity and quality of the social relationships they maintain throughout their life [31,14,1,4].

99 The vulnerability-stress model suggests that childhood physical maltreatment causes heightened
100 sensitivity to subsequent stressors [32,33,4]. Maltreated children may be more sensitive when it comes to
101 detecting and perceiving threats to their security or cues of rejection [22]. As a result, they may perceive the
102 world as more socially threatening, making them avoid relationships with peers in order to protect themselves
103 from anticipated disappointment [34,20,35]. Sensitivity to peer rejection might result in more acute emotional
104 responses and a more negative interpretation of peer rejection due to an inability to properly regulate the
105 emotions that result from such social encounters [36,28].

106 The concept of 'loneliness loop', proposed by Hawkey and Cacioppo [37], may explain the association
107 between perceived social isolation and internalizing symptoms. Perceived social isolation refers to the
108 distressing feeling that occurs when there are discrepancies between one's desired and actual quantity of social
109 relationships [29,38,39]. Perceived social isolation can lead to dismissive or avoidant behaviour in social
110 relationships, because affected individuals have an expectation of negative social interactions and social
111 rejection, making them withdraw socially [37,40]. When combined with negative social expectations, this
112 inability to develop and maintain social relationships can elicit behaviours from others that confirm these
113 expectations [37]. Thus the self-reinforcing 'loneliness loop' may contribute to internalizing symptoms through
114 feelings of rejection, hostility, and pessimism [34,37,41].

115 Several studies [1,42-45,34,46,31,47-53,4] have assessed the mediating role of perceived social
116 isolation in the association between childhood physical maltreatment and internalizing symptoms in adulthood.
117 However, they had several limitations. First, assessing mediation with cross-sectional studies can lead to
118 questionable inferences [2,54], as studies have shown reciprocal associations between perceived social isolation

119 and internalizing symptoms [55,38,56]. Studies with dense temporal sampling are also vulnerable to these biases
120 [54]. A potential solution for establishing temporal order between perceived social isolation and internalizing
121 symptoms is a long follow-up period [54,4]. Other studies have shown that the association between childhood
122 physical maltreatment and internalizing symptoms is over-estimated in cross-sectional studies due to differential
123 misclassification error [2]. Despite this, most previous studies [43,42,1,45,34,47-49,51,31,52] have assessed the
124 association between childhood physical maltreatment and internalizing symptoms, or the association between
125 perceived social isolation and internalizing symptoms, at the same time point.

126 Second, most studies [43-46,48,50-53] based their conclusions on very small and selective samples,
127 which makes it impossible to generalise the findings to the general population. Finally, several studies
128 [46,31,47,48,50-52] did not present indirect effect estimates and corresponding confidence intervals. Other
129 studies [57,58] that assessed the associations between childhood physical maltreatment, perceived social
130 isolation, and internalizing symptoms in adulthood did not consider the mediating role of perceived social
131 isolation in adulthood in the analysis.

132 A review of the existing literature indicated that the mediating role of perceived social isolation in
133 adulthood in the association between childhood physical maltreatment and internalizing symptoms in adulthood
134 has not been assessed in a thoroughly comprehensive and systematic manner with a large and representative
135 study sample [4]. Therefore, using longitudinal data from the Tromsø Study, the aim of the present study was to
136 assess the mediating role of perceived social isolation in adulthood in the association between childhood
137 physical maltreatment and internalizing symptoms in adulthood.

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149 Material and Methods

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151 Study sample

152 The Tromsø Study is a longitudinal prospective cohort study and its participants are considered representative of
153 the adult population residing in the municipality of Tromsø [59]. With more than 60,000 inhabitants, Tromsø is
154 the largest city in Northern Norway. The present study has a three-wave design and includes data collected from
155 1994 to 2008 [59,4,3]. To be eligible for the present analyses, participants had to have participated in all of the
156 following surveys: Tromsø IV (1994-95), Tromsø V (2001-02), and Tromsø VI (2007-08) (N=4,530) [3,4]. The
157 exposure (childhood physical maltreatment) was measured retrospectively in 2007-08, the mediator (perceived
158 social isolation in adulthood) was measured in 1994-95, and the outcome (internalizing symptoms in adulthood)
159 was measured in 2001-02 [4]. The limitations of the study design are discussed at the end of this article.

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161 Ethical approval

162 This investigation was carried out in accordance with the latest version of the Declaration of Helsinki. The
163 Tromsø Study has been approved by the Regional Committee for Medical and Health Research Ethics, the Data
164 Inspectorate, and the Norwegian Directorate of Health. Written informed consent was obtained from all
165 individual participants included in the study.

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167 Study variables**168 *Exposure (childhood physical maltreatment)***

169 Self-reported information on childhood physical maltreatment was measured retrospectively in the Tromsø VI
170 questionnaire by two questions [1,2,9,3,4]: “Have you over a long period experienced any of the following as a
171 child?”. The possible responses were: i) ‘Being tormented, or threatened with violence’; and ii) ‘Being beaten,
172 kicked, or the victim of other types of violence’. Using responses to both questions, a separate cumulative
173 variable of childhood physical maltreatment was constructed as: 0=not exposed to childhood physical
174 maltreatment, 1= exposed to one childhood physical maltreatment (some), and 2= exposed to both childhood
175 physical maltreatments (severe) [2,9]. The internal reliability of childhood physical maltreatment was good in
176 the Tromsø Study [9].

177 *Mediator (perceived social isolation in adulthood)*

178 Perceived social isolation (i.e., a subjective judgement of the adequacy of social relationships) was measured in
179 Tromsø IV (mean age: 54.7 years) [4,3]. The operational definition of perceived social isolation in this study
180 was the perception that one's social needs were not met by the quantity of good friends [4]. Perceived social
181 isolation was measured in the questionnaire by the question "Do you feel that you have enough good friends?"
182 (yes=0, no=1) [4,3]. Those responding 'no' were categorised as socially isolated, while those responding 'yes'
183 were categorised as *not* socially isolated [4,3]. We recognize that this is a weak measure; the implications of this
184 are discussed at the end of this article.

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186 *Outcome (internalizing symptoms in adulthood)*

187 Depressive and anxious symptomatology over the last two weeks were considered as indicators of internalizing
188 symptoms [1-4]. The Hopkins Symptom Checklist (HSCL-10) scale in the Tromsø V questionnaire (mean age:
189 61.7 years) was used to measure internalizing symptoms, which is widely used in epidemiological studies [1-4].
190 Respondents rated each of the 10 items in the HSCL-10 on a four-point scale, ranging from *not at all* (1) to
191 *extremely* (4) [1-4]. The HSCL-10 had an acceptable degree of internal consistency in this sample (Cronbach's
192 alpha: 0.86, mean inter-item correlation: 0.42, McDonald's omega coefficient for composite reliability: 0.87) [1-
193 4]. An HSCL-10 score between 1.0 and 4.0 was assigned by dividing the total score (sum of the 10 indicators)
194 by 10, where 4 represented the highest and 1 represented the lowest score on internalizing symptoms [3] (mean:
195 1.22, standard deviation [SD]: 0.33).

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197 *Confounding variables (Tromsø IV)*

198 The associations between childhood physical maltreatment, perceived social isolation, and internalizing
199 symptoms in adulthood are likely confounded by age, gender, living in Norway at age 1 year (yes, no),
200 childhood financial conditions, and mother's/father's history of psychiatric disorders [60,61,1,2,9,4,3]. Previous
201 studies have indicated that parental psychopathology may partially explain the association between childhood
202 maltreatment and internalizing symptoms [62,9]. Being raised in an environment with ample monetary and
203 parental resources may expose children to experiences that may aid in development of capacities, skills, and
204 connections that are conducive to social engagement and forming relationships [2,63,64,4].

205 Valid information on age and gender was obtained from Statistics Norway by using the unique personal
206 identification number of each participant. Mother's/father's history of psychiatric disorders was measured as:
207 'Does your mother/father have/has or your mother/father ever had psychiatric disorders? (yes, no) [3,4]. The

208 test-retest reliability of mother's history of psychiatric disorders and father's history of psychiatric disorders in
209 this sample were Kappa: 0.57 (95% CI: 0.52–0.62) and Kappa: 0.61 (95% CI: 0.53–0.69), respectively [3,4].
210 The variable childhood financial conditions was used as a proxy for childhood socioeconomic status, and was
211 measured retrospectively by the question: "How was your family's financial situation when you were a child?"
212 on a 4-point scale (1=very good, 2=good, 3=difficult, 4=very difficult) [64,1,2,9,3,54,4]. The test-retest
213 reliability of childhood financial conditions was good (Kappa_{weighted}: 0.61, 95% CI: 0.59–0.63) in this sample
214 [3,4].

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216 **Statistical analysis**

217 All analyses were conducted using Stata version 15. Imputed values were generated with multiple imputation
218 (MI) with chained equations to avoid any bias in the associations of interest introduced by excluding individuals
219 with missing data [54]. One hundred MI datasets were generated to help account for the uncertainty in the
220 imputation procedure. In order to increase the predictive power of the imputation procedure, all indicators of
221 HSCL-10 were included in the imputation models. A comparison between the complete-case (excluding
222 missing) and the MI datasets is presented with proportions (%), and mean (standard error) (Table 1). All
223 statistical analyses were performed on the MI datasets and both unadjusted (crude) and adjusted estimates are
224 presented.

225 No statistically significant multiplicative interactions between childhood physical maltreatment,
226 perceived social isolation, age and gender were observed (regressed on internalizing symptoms) in this sample.
227 The association between childhood physical maltreatment and perceived social isolation in adulthood was
228 assessed by Poisson regression analysis with a robust error variance [54]. Relative risks (RRs) and 95%
229 confidence intervals (CIs) are presented. The association between perceived social isolation in adulthood and
230 internalizing symptoms in adulthood was assessed by ordinary least square (OLS) regression analysis with a
231 robust error variance. OLS estimates (β) and 95% CIs are presented.

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233 **Assessing direct and indirect effects (through perceived social isolation in adulthood) of childhood** 234 **physical maltreatment on internalizing symptoms in adulthood**

235 The association between childhood physical maltreatment and internalizing symptoms in adulthood was
236 assessed by OLS regression analysis. Mediation analysis with the difference-in-coefficients method [54] was
237 used. Perceived social isolation in adulthood was included in the models to assess the indirect effects and the

238 proportion of mediated effects (%) [4,54]. If perceived social isolation in adulthood is an important mediator of
239 the childhood physical maltreatment→internalizing symptoms in adulthood associations, the effects of
240 childhood physical maltreatment ($\beta_{\text{Total Effect}}$) should decline when it is added to the regression model [4,54].
241 Four estimates are presented: total effects (adjusted for confounding variables), direct effects (adjusted for
242 confounding variables and perceived social isolation in adulthood), indirect effects (difference between total
243 effect and direct effect) [54], and proportion mediated (%) [2]. Standard errors were derived with bias-corrected
244 bootstrapping [54] for hypothesis testing, and 95% CIs are presented.

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268 Results

269 Compared to the respondents that did not participate in all three considered waves of the Tromsø Study (Tromsø
270 IV, Tromsø V, and Tromsø VI), the respondents in this study sample were likely to be female and older
271 ($p < 0.05$). Among the 4,530 individuals in this study sample, the majority were aged 55 years or older (56.2%) at
272 baseline (Tromsø IV) and 59.2% were women. Mother's history of psychiatric disorders was reported more
273 frequently than father's history of psychiatric disorders (5.8% and 2.0%, respectively). The majority (60.3%) of
274 the study sample reported having good or very good financial conditions in childhood; 4.9% reported some (any
275 type) childhood physical maltreatment, and 2.6% reported severe (both) childhood physical maltreatment (Table
276 1). A substantial proportion (16.1%) of respondents reported perceived social isolation in adulthood (Table 1).

277 As a first analytic step in testing direct and indirect effects, the associations between childhood physical
278 maltreatment, perceived social isolation in adulthood, and internalizing symptoms in adulthood were assessed.
279 In the fully-adjusted model, exposure to some (any type) childhood physical maltreatment was associated with a
280 68% ($RR_{\text{adjusted}} = 1.68$, 95% CI: 1.33-2.13) higher risk of perceived social isolation in adulthood, while exposure
281 to severe (both) childhood physical maltreatment was associated with a 57% ($RR_{\text{adjusted}} = 1.57$, 95% CI: 1.12-
282 2.21) higher risk (Table 2). In turn, perceived social isolation in adulthood was associated with greater levels
283 ($\beta_{\text{adjusted}} = 0.14$, $p < 0.001$) of internalizing symptoms in adulthood (Table 3).

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285 Direct and indirect effect of childhood physical maltreatment on internalizing symptoms in adulthood

286 A dose-response association was observed between childhood physical maltreatment and internalizing
287 symptoms in adulthood ($p < 0.001$). After controlling for confounding variables, exposure to some or severe
288 childhood physical maltreatment was associated with greater levels of internalizing symptoms in adulthood
289 ($p < 0.001$) (Table 4). Decomposition of total effects showed that there was a direct and an indirect effect of
290 childhood physical maltreatment on internalizing symptoms in adulthood ($p < 0.05$). Perceived social isolation in
291 adulthood mediated 7.25-14.89% ($p < 0.05$) of the association between childhood physical maltreatment and
292 internalizing symptoms in adulthood (Table 4).

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298 Discussion

299 In this study, we examined the relationship between childhood physical maltreatment, perceived social isolation,
300 and internalizing symptoms in a large, representative, and population-based sample of Norwegian adults.
301 Childhood physical maltreatment was associated with an increased risk of perceived social isolation, and both
302 childhood physical maltreatment and perceived social isolation were associated with greater levels of
303 internalizing symptoms. The results of this study showed that perceived social isolation mediates the association
304 between childhood physical maltreatment and internalizing symptoms.

305 It must be noted that perceived social isolation as conceptualized in this study does not refer to *actual*
306 social isolation [4]. Indeed, maltreated individuals may perceive social isolation even when social opportunities
307 and relationships exist, because they lack the capacity to utilize these resources [40,4,1]. Accordingly, the
308 results of this study may not support the conclusion that “social support” mediates the childhood physical
309 maltreatment→internalizing symptoms association. Indeed, in a recent longitudinal population-based study [4],
310 “number of friends in adulthood” mediated only 3% of the association between childhood adversity and
311 internalizing symptoms in adulthood. The results of this study suggest that respondents with a history of
312 childhood physical maltreatment may develop internalizing symptoms in adulthood partly because they feel
313 dissatisfied or unfulfilled by the social connections they have, and not necessarily because they have fewer
314 social contacts or sources of support *per se* [65,4].

315 The stress buffering model and the stress process model suggest that perceived social isolation may
316 mitigate the psychological impact of childhood physical maltreatment on internalizing symptoms by attenuating
317 the stress appraisal response [66,67]. However, no statistically significant interaction was observed between
318 childhood physical maltreatment and perceived social isolation (data not shown), which is in agreement with
319 some [1,48,68], though not all [44,46,58] previous studies. Age and childhood financial conditions did not play
320 a moderating role in the association between childhood physical maltreatment and internalizing symptoms,
321 which is consistent with most [42,1,2,9], though, not all [69] previous studies. Some studies [34] have used
322 confounding variables to control for the association between this exposure (childhood maltreatment) and
323 outcome (internalizing symptoms in adulthood), but without adjusting for the association between the exposure
324 and the mediator (perceived social isolation), or between the mediator and the outcome. It is well established
325 that the decomposition of total effects into direct and indirect effects assumes no unmeasured or unaccounted-
326 for exposure-mediator, exposure-outcome, or mediator-outcome confounding [2,3,54]. Consistent with previous

327 studies, childhood physical maltreatment was associated with perceived social isolation [1,4]. Finally, consistent
328 with most [1,34,47,44], though not all [31,49,53,45] previous studies, perceived social isolation mediated the
329 association between childhood physical maltreatment and internalizing symptoms.

330 These results should be interpreted in the context of some limitations. Measurement of childhood
331 physical maltreatment, perceived social isolation, and internalizing symptoms relied on self-reports. Childhood
332 physical maltreatment was measured retrospectively with two items, and this occurred 13 years after the
333 measurement of perceived social isolation and 6 years after the measurement of internalizing symptoms.
334 Therefore, the possibility that perceived social isolation and chronic internalizing symptoms affected the recall
335 of childhood physical maltreatment is a potential concern for the interpretation of these findings. However, the
336 prevalence of childhood physical maltreatment in this study (4.9%) corresponds with that reported in other
337 studies from Norway [1,70-72]. Misclassification of childhood physical maltreatment maybe influenced by age,
338 state of mind, and current psychopathology [73,2,9,74]; however, other evidence suggests that these biases
339 should be fairly low [75-77,9,78-81]. Moreover, some other reports have suggested that subjects under-report
340 childhood physical maltreatment when it is measured retrospectively [82,83]. Recent studies that compared
341 associations of retrospective and prospective assessments of childhood physical maltreatment and health have
342 shown that the associations remained in the same direction; however, the associations between retrospective
343 childhood physical maltreatment and self-reported outcomes were over-estimated [74,84]. Accordingly, since
344 the measurement of internalizing symptoms in this study was self-reported, it is plausible that the total effects
345 and direct effects presented here are over-estimated, while the indirect effects may be under-estimated. Another
346 limitation of the study is that the precise timing or persistence of childhood physical maltreatment was not
347 measured [9,2]. The use of a single binary variable for perceived social isolation has methodological and
348 conceptual limitations [4,44,3]. Although the results of this study are consistent with most previous reports,
349 potential misclassification of perceived social isolation should be considered [2,9,54,44]. For instance, non-
350 differential misclassification of perceived social isolation would lead to an under-estimation of indirect effect
351 estimates (biased downwards); however, differential misclassification of perceived social isolation would lead to
352 an over-estimation of indirect effect estimates (biased upwards) [2,54,4]. Although perceived social isolation
353 was measured approximately 7 years earlier than internalizing symptoms, it is still possible that some
354 individuals might have been suffering from chronic internalizing disorders when they participated in Tromsø IV.
355 Indeed, history of internalizing symptoms is a strong predictor of internalizing symptoms in later life [85-87].
356 However, internalizing symptoms were not measured in Tromsø IV, and perceived social isolation was not

357 measured in Tromsø V; therefore, the change in the mediator (perceived social isolation) or outcome
358 (internalizing symptoms) was not assessed [3,4]. It is plausible that childhood physical maltreatment may have
359 led to the development of internalizing symptoms in young adulthood, which in turn could have compromised
360 the self-reports of perceived social isolation measured later (i.e., those suffering from chronic internalizing
361 disorders could also be more likely to perceive social isolation later in life). Other evidence indicates that
362 respondents with a history of maltreatment attribute sadness to both positive and negative social situations,
363 which may affect their social skills over the life course [88]. Although childhood physical maltreatment was the
364 focus of the study, we cannot rule out that exposure to adverse events later in life (concern for intermediate
365 confounding [2,9,54]) might also have affected perceived social isolation and internalizing symptoms in
366 adulthood [1,4]. Sociable disposition is, at least in part, based on genetic factors [89,90]. Indeed, a substantial
367 proportion of one's risk of internalizing symptoms is also genetically determined [91,92,3]. The test-retest
368 reliability of self-reported parental history of psychiatric disorders was not high, which raises the concern that
369 we were not able to fully control for genetic dispositions [4]. However, other evidence suggests that childhood
370 physical maltreatment is associated with internalizing symptoms in childhood [93] and adulthood [2,3],
371 independent of genetic dispositions.

372 The strengths of this study are its three-wave design, and a representative sample of the adult
373 population of Tromsø. By determining childhood physical maltreatment, perceived social isolation in adulthood,
374 and internalizing symptoms in adulthood at different time points, spurious associations due to state of mind and
375 mood congruency bias were avoided [2,9,54]. Finally, missing values were imputed, which avoids the
376 possibility that attenuations in the coefficient for childhood physical maltreatment were due to selection bias
377 rather than mediation [9,54,4].

378 The results of this study indicate the need to take perceived social isolation over the life course into
379 account when considering the long-term impact of childhood physical maltreatment on internalizing symptoms
380 in adulthood [1,4]. As the mean age of the respondents was 61.7 years (median: 63) at the time internalizing
381 symptoms were assessed (in Tromsø V), the associations between childhood physical maltreatment and
382 internalizing symptoms in adulthood suggests that the consequences of childhood physical maltreatment persists
383 for several decades after its occurrence [94,9,1,2].
384 In summary, a dose-response relationship [9,1] was observed between childhood physical maltreatment and
385 internalizing symptoms, and this association appeared to be mediated substantially by perceived social isolation.

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651 Table 1. General characteristics of the study sample (n=4,530).

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	Characteristics	Complete-	Imputed
		case dataset	dataset
		n (%)	(%)
Age (in 1994)	Mean (standard error, SE)	54.69 (0.15)	– ^b
	25-34	302 (6.7)	– ^b
	35-44	352 (7.8)	– ^b
	45-54	1327 (29.3)	– ^b
	55-64	1852 (40.8)	– ^b
	65-74	697 (15.4)	– ^b
Gender	Male	1849 (40.8)	– ^b
	Female	2681 (59.2)	– ^b
History of psychiatric disorders, mother	Yes	262 (5.8)	– ^b
	No	4268 (94.2)	– ^b
History of psychiatric disorders, father	Yes	90 (2.0)	– ^b
	No	4440 (98.0)	– ^b
Living in Norway at age 1year^a	Yes	4081 (98.4)	98.4
	No	66 (1.6)	1.6
Childhood financial conditions^a	Mean (SE)	2.40 (0.01)	2.40 (0.01)
	Very good	120 (2.8)	2.8
	Good	2437 (57.5)	57.5
	Difficult	1547 (36.5)	36.5
	Very difficult	136 (3.2)	3.2
Childhood physical maltreatment	None	4198 (95.1)	– ^b
	Some	218 (4.9)	– ^b
	Severe	114 (2.6)	– ^b
Perceived social isolation	Not socially isolated	3485 (83.9)	83.9
	Socially isolated	669 (16.1)	16.1
Internalizing symptoms (HSCL-10)^a	Mean (SE)	1.22 (0.01)	1.27 (0.01)

654 ^aThe numbers for some variables do not add up to 4,530 due to missing values.

655 ^bThere were no missing values, so no imputations were made for these variables.

656 SE: standard error; HSCL-10: Hopkins Symptom Check List-10; scale (1.0–4.0), where 1.0 represents lowest

657 score on internalizing symptoms, and 4.0 represents highest score on internalizing symptoms.

Table 2. Association between childhood physical maltreatment and perceived social isolation in adulthood (n=4,530).

		Perceived social isolation			
		Crude		Adjusted	
		RR	95% CI	RR ^a	95% CI
Childhood physical maltreatment	None (ref)	1.00 (ref)		1.00 (ref)	
	Some	1.85 ^b	1.47-2.32	1.68 ^b	1.33-2.13
	Severe	1.78 ^b	1.29-2.47	1.57 ^c	1.12-2.21

^aAdjusted for age, gender, childhood financial conditions, living in Norway at age 1 year, and mother's/father's history of psychiatric disorders.

^b p<0.001

^c p<0.01

RR: relative risk; CI: confidence interval.

Table 3. Association between perceived social isolation and internalizing symptoms in adulthood (n=4,530).

		Internalizing symptoms			
		Crude		Adjusted	
		β^b	95% CI	$\beta^{a,b}$	95% CI
Perceived social isolation	Not socially isolated	reference		reference	
	Socially isolated	0.14	0.10-0.18	0.14	0.11-0.18

^aAdjusted for age, gender, childhood financial conditions, childhood physical maltreatment, living in Norway at age 1 year, and mother's/father's history of psychiatric disorders.

^bp<0.001

CI: confidence interval; HSCL-10: Hopkins Symptom Check List-10; scale (1.0–4.0), where 1.0 represents lowest score on internalizing symptoms, and 4.0 represents highest score on internalizing symptoms.

Perceived social isolation was measured in 1994-95, while internalizing symptoms was measured in 2001-2002.

Table 4. Direct and indirect effect (mediated through perceived social isolation) of childhood physical maltreatment on internalizing symptoms in adulthood (n=4,530).

		Internalizing symptoms			
		Total effect ^a	Direct effect ^b	Indirect effect ^a	Proportion mediated ^a
		β (95% CI)	β (95% CI)	β (95% CI)	% (95% CI)
Childhood physical maltreatment	Some ^c	0.11 (0.09-0.12) ^d	0.09 (0.09-0.11) ^d	0.02 (0.01-0.02) ^d	14.89 (5.81-16.86) ^d
	Severe ^c	0.20 (0.15-0.20) ^d	0.18 (0.13-0.18) ^d	0.01 (0.01-0.02) ^d	7.25 (6.59-15.93) ^e

^aAdjusted for age, gender, childhood financial conditions, living in Norway at age 1 year, and mother's/father's history of psychiatric disorders.

^bAdjusted for age, gender, childhood financial conditions, living in Norway at age 1 year, and mother's/father's history of psychiatric disorders + perceived social isolation in adulthood.

^cReference: None

^dp<0.001

^ep<0.05

CI: confidence interval; HSCL-10: Hopkins Symptom Check List-10; scale (1.0–4.0), where 1.0 represents lowest score on internalizing symptoms, and 4.0 represents highest score on internalizing symptoms.