

Testing the Intergenerational Model of Transmission of Risk for Chronic Pain from Parents to
their Children: An Empirical Investigation of Social Transmission Pathways

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Abstract

Children of parents with chronic pain have higher rates of pain and internalizing (e.g., anxiety, depressive) symptoms than children of parents without chronic pain. Parental modeling of pain behaviour and reinforcement of child pain have been hypothesized to underlie these relationships. These mechanisms were tested in a sample of 72 parents with chronic pain and their children (ages 8-15). Standardized measures were completed by parents (pain characteristics, pain interference, child internalizing) and children (pain catastrophizing, pain over previous three months, and internalizing). In a laboratory session, children completed the cold pressor task (CPT) in the presence of their parent, and parent-child verbalizations were coded. Significant indirect effects of parental pain interference on child self-reported ($B = 0.12$, 95% CI: 0.01, 0.29) and parent-reported ($B = 0.16$, 95% CI: 0.03, 0.40) internalizing symptoms through child pain catastrophizing were found (parental modeling mechanism), and were not moderated by child chronic pain status. Significant indirect effects were found between parent pain-attending verbalizations and child self-reported ($B = 2.58$, 95% CI: 1.03, 5.31) and parent-reported ($B = 2.18$, 95% CI: 0.93, 4.27) CPT pain intensity and tolerance ($B = -1.02$, 95% CI: -1.92, -0.42) through child pain-attending verbalizations (parental reinforcement mechanism). While further understanding of the temporal relationships between these variables is needed, the current study identifies constructs (e.g., parent pain interference, child pain catastrophizing, parent reinforcement of child pain) which should be further examined as potential targets for prevention and intervention of pain and internalizing symptoms in children of parents with chronic pain.

Keywords: Chronic pain, Parents, Children, Social learning, Modeling, Reinforcement

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Parents play a critical role in children's pain [47,48]. Offspring of parents with chronic pain have higher rates of pain and internalizing (i.e., anxiety, depressive) symptoms than offspring of parents without chronic pain [35]. Improved understanding of factors underlying these relationships is needed [35,67]. Stone and Wilson's [67] model of intergenerational transmission of risk posits that parental chronic pain impacts children's pain and psychological functioning through several mechanisms (e.g., pain-specific social learning) impacting child vulnerabilities (e.g., pain-related cognitions), in this order. Pain-specific social learning is hypothesized to occur through parental pain modeling and/or reinforcement of child pain, as in other conditions [31,39]. In adolescents with abdominal pain, parental chronic pain predicted adolescent pain through parental modeling [65]. Modeling may be more salient in children with versus without chronic pain.

Parental pain modeling may occur through parents' pain interference (i.e., the extent that pain interferes with mental/physical/social activities [1]), which is highly correlated with adolescent- and self-reports of parent pain behaviour [66]. Parental pain interference may be a proxy for pain modeling by capturing parents' engagement in activities when in pain, which are likely observable to children. Greater parental pain interference is associated with greater child pain [24,36,80] and parent-reported internalizing [26]. Observing parental pain interference may impact children's outcomes through pain-related cognitions [67]. Greater pain catastrophizing is a robust predictor of poorer pain-related [27,51] and internalizing outcomes [22,27,51] in children with and without chronic pain [6,7,21,74] and is associated with more parental pain [81]. Greater parent and child pain intensity were associated through the mediator of higher child

pain catastrophizing in children with rheumatic disease [59]. Consistent with theory [67], observing greater parental pain interference may be associated with greater child pain catastrophizing, and in turn with greater child pain and internalizing.

Parent reinforcement of child pain is another proposed social learning mechanism for the transmission of risk for chronic pain [67]. Parental responses directing increased attention to (i.e. positively reinforcing) child pain predict poorer child chronic [52,61,62,76] and acute [13,25,45,63,77,79] pain-related outcomes. Parent pain-attending predicted children's decreased use of adaptive coping strategies [9,63] and increased pain-attending [77], in turn predicting higher child pain and distress [10]. Preliminary evidence indicates parents with chronic pain report more pain-reinforcing responses than other parents [80]. Consistent with theory [67], more parent pain-attending behaviours may predict more child pain-attending, and in turn predict poorer child pain outcomes in this population.

This study examined pain-specific social learning mechanisms in the intergenerational transmission of pain and internalizing [67], building on previous research by examining mechanisms in adults with chronic pain and their children, incorporating multi-informant assessment, and observing interactions during child pain. Hypotheses were 1) child pain catastrophizing mediates the relationship between parental pain interference and child chronic pain and internalizing symptoms (parental modeling), and these relationships are moderated by child chronic pain status, and 2) during experimental pain, parents' pain-attending verbalizations predict child pain through child pain-attending verbalizations (parental reinforcement). Given concerns about chronic pain biasing parent reports [33], self- and parent-reported child internalizing and pain intensity were collected.

Method

The data described in the current manuscript were collected as part of a larger study examining two separate research questions which are described in two papers. The current paper tests a theoretical model of the mechanisms through which parental chronic pain impacts child pain and mental health outcomes. The other paper examines the measurement of a novel construct, child catastrophizing about parental chronic pain, and the intra- and interpersonal effects of parent and child catastrophizing about one another's pain (Higgins et al., in preparation). The study procedures were approved by the IWK Health Centre Research Ethics Board with reciprocal approval from the Nova Scotia Health Authority Research Ethics Board.

Participants

Seventy-two parent-child dyads participated in the current study. Parents with chronic pain were recruited through a local adult pain management clinic ($n = 50$) and using community recruitment methods (e.g., posters placed in community locations, social media advertisements; $n = 22$). Parents were considered eligible for the current study if they: 1) had experienced pain for at least six months (consistent with the International Association for the Study of Pain recommendations for research on chronic pain; [69]; 2) had bodily pain over the previous four weeks rated as moderate, severe, or very severe on a verbal rating scale (from the Short Form-36 Health Survey; [78]), and 3) had an eligible child between the ages of 8 years 0 months and 15 years 11 months. Exclusion criteria for parents included cognitive impairments that would impact their ability to participate in study activities (e.g., dementia), not living with the eligible child at least 50% of the time, being unable to read, write, and speak English well enough to participate in study activities, or having uncorrected hearing or vision impairments.

Children were eligible to participate if they were the child of an eligible parent (one child per parent) and were between the ages of 8 years, 0 months and 15 years, 11 months. Exclusion

criteria for children included having developmental delays that would impact their ability to participate in study activities, inability to read, write, and speak English well enough to participate in study activities, having uncorrected hearing or vision impairments, or having contraindications to participating in the cold pressor task (e.g., blood or circulation disorders, current injury or history of frostbite to the non-dominant hand or arm; [2]).

Experimental Pain Task

Children completed the cold pressor task (CPT), a safe and ethically acceptable method for inducing brief, mild-moderate pain in the laboratory [8]. Children were asked to place their non-dominant hand in a bath of cold water ($10 \pm 0.2^{\circ}\text{C}$) up to their wrist. They were asked to keep their hand in the water for as long as they could, but were informed that they could remove their hand at any point if it became too uncomfortable or painful. Children were able to keep their hand in the water for a maximum of four minutes, but were not informed of this limit beforehand. These parameters are consistent with published safety guidelines for this task [2]. During the CPT, parents sat across from their child and watched, and dyads were asked to speak to one another as they normally would elsewhere. Parents' and children's interactions during the CPT were videotaped throughout the duration of time that the child's hand was in the water.

Measures

Demographics. Parents completed an author-developed questionnaire assessing demographic characteristics of themselves and their child including age, sex, racial/ethnic identity, level of education, and marital status. Parents were also asked whether any other members of the child's immediate or extended family had chronic pain.

Pain characteristics. Parents and children each reported on their own pain over the past three months using a questionnaire modified from previous research [50] and based on

established guidelines for pain assessment in research with children and adults [44,70]. Parents completed the written questionnaire while children completed the questionnaire verbally with a research assistant. The research assistant began by establishing the three month timeline (e.g., by asking children about the activities they had engaged in over the past three months) and asking children about any pain they may have experienced during this time period. They were asked to indicate which of these pains had occurred most often over the past three months, and answered questions about the location, duration, frequency, and usual intensity of this pain (using an 11-point numeric rating scale). Children were classified as having chronic pain if they had experienced pain (other than muscle soreness due to physical activity) at least once per week for at least the past three months. Parents completed the same questions in written form, and this information was used to characterize the sample.

Parent pain interference. Parents completed the PROMIS Pain Interference Short Form 8a measuring the extent to which pain limits or interferes with an individuals' functioning (e.g., physical and social activities) and enjoyment of life [1]. This measure contains eight items (e.g., "How much did pain interfere with your ability to participate in social activities?"), each responded to on a 5-point scale from "Not at all" to "Very much". Total scores can range from 8-40, and higher scores indicate greater interference with functioning. Evidence of the measure's internal consistency and validity (including construct, discriminant, and ecological validity) have been found in general samples and individuals with a variety of chronic health conditions including chronic pain [1,14,19]. The internal consistency of this measure in the current study was $\alpha = .95$.

Child pain catastrophizing. Children completed the Pain Catastrophizing Scale for Children [20] to assess trait tendency to engage in catastrophic thinking about their own pain

(e.g., “When I am in pain, I worry all the time about whether the pain will end”, “When I am in pain, I can’t keep it out of my mind”). Evidence of internal consistency and validity (including factorial, construct, and predictive validity) has been found for this measure in community samples and in samples of children with chronic pain ages 8 to 16 [20,49,51]. It is considered well-established in terms of its psychometric properties in youth with chronic pain [27]. In the current study, the internal consistency of this measure was $\alpha = .92$.

Child internalizing symptoms. Child and parent reports of child internalizing symptoms were collected using the Internalizing Problems composite scale of the Behavior Assessment System for Children [56], a widely used system of multidimensional clinical measures of children’s overall behaviour and emotional functioning. The Internalizing Problems composite scale assesses the child’s inwardly directed distress (i.e. symptoms of anxiety and depressive disorders). T scores ($M = 50$, $SD = 10$) for this scale were generated using the BASC-2 ASSIST computer scoring program. T scores of 70 or above on this scale represent clinically significant levels of internalizing symptoms [56]. Children completed the Self-Report of Personality Child version (for ages 8-11 years; 139 items) or Adolescent version (for ages 12-15 years; 176 items), comprised of items answered on true/false or 4-point response scales (ranging from “never” to “almost always”) assessing a wide range of behaviors and emotions. Parents completed the Parent Rating Scale Child version (160 items) or Adolescent versions (150 items); all items on the parent forms were answered using the 4-point response scale (“never” to “almost always”). Internal consistency scores for this sample were not available given the use of BASC-2 ASSIST scoring. However, evidence for the reliability (internal consistency and test-retest reliability) and validity (including factorial, concurrent, and discriminant validity) of both forms has been found [56]. In the original standardization sample for the measure, the internal consistencies of the

Internalizing Problems subscale were $\alpha = .95-.96$ in children and adolescents in the general norm sample and $\alpha = .94-.96$ in children and adolescents included in the clinical norm sample (including those with learning disabilities and attention deficit hyperactivity disorder [56]).

Child experimental pain outcomes. After completion of the CPT, children and parents were independently asked to rate the child's average pain intensity during the task using the Faces Pain Scale-Revised, a well-validated scale considered appropriate for assessing acute pain intensity in children ages 4-16 years [18,34]. Evidence of strong test-retest reliability and concurrent validity has been found [64]. This scale has also been used in studies to provide parent reports of child experimental and procedural pain intensity [6,11,63]. The scale includes six faces ranging from "no pain" to "very much pain", resulting in a score ranging from 0-10.

Children's pain tolerance during the CPT was measured as the time in seconds that the child kept their hand in the cold water, up to a maximum of four minutes (240 seconds). Given the typically bimodal distribution of this variable, it was dichotomized, with children classified as having reached the ceiling tolerance time or not.

Observed parent and child verbalizations during experimental pain task. Parents and children's verbalizations during the CPT were transcribed verbatim and coded utterance by utterance using a version of the Child and Adult Medical Procedure Interaction Scale Revised (CAMPIS-R; [10]) modified for use in the context of the CPT [45]. The CAMPIS-R is a well-established observational coding system for parent-child interactions during painful procedures, and the modified CAMPIS-R is considered to be approaching well-established [3]. Given that several parents and children discussed the parent's chronic pain during the cold pressor task, a subcode for these verbalizations was added to the coding system for the current study. Parent verbalizations were coded into three categories following previous studies [6,45,77]. The

primary focus for the current study was the attending talk category (i.e. verbalizations drawing attention to child cold and pain symptoms), which included four subcodes: 1) symptom-focused talk and commands to child, 2) sympathy to child, 3) procedure-related praise to child, and 4) procedure time talk and commands to child. Other coded categories were non-attending talk (i.e. verbalizations aimed at drawing attention away from child cold and pain symptoms; comprised of subcodes 1) non-symptom-focused talk and commands to child, and 2) humor to child) and other talk (i.e. represented verbalizations not fitting into the above categories; comprised of subcodes 1) other procedure talk and commands to child, 2) criticism to child, 3) parent talk about own pain symptoms, and 4) other talk to child such as sentences cut off before meaning could be ascertained and parents asking for clarification about child statements). Children's verbalizations during the CPT were grouped into two categories. The focus for the current study was on the child symptom complaints category, which was composed of four subcodes: 1) cold/pain symptom talk to parent, 2) anxiety talk to parent, 3) procedure time talk to parent, and 4) resistance talk to parent. The other coded category was child other talk, which included five subcodes: 1) child non-symptom focused talk to parent, 2) other procedure talk to parent, 3) child coping talk to parent, 4) child talk about parent pain symptoms to parent, and 5) other talk to parent. Proportion scores were calculated for each category (number of utterances made in each category divided by total number of utterances made by the participant) in order to account for between-participant differences in the number of utterances made during the CPT, consistent with previous studies [6,45]. These proportion scores were used in all analyses of coded variables.

Coding of all participant transcripts was completed by a primary coder who was trained on the coding system by the first author. The first author was trained on the coding system and

demonstrated inter-rater reliability with coded training videos developed for previous studies. The first author coded a randomly selected subset of 20% of the transcripts coded by the primary coder to determine inter-rater reliability. Excellent inter-rater reliability was established for both parent (subcode level: 90.10% agreement, $\kappa=0.85$, $SE=0.02$; code grouping level: 90.60% agreement, $\kappa = 0.85$, $SE = 0.03$) and child utterances (subcode level: 86.60% agreement, $\kappa = 0.81$, $SE = 0.03$, code grouping level: 93.20% agreement, $\kappa = 0.80$, $SE = 0.04$) [4].

Procedure

Parents and children attended one study visit, which began with completing informed consent and assent procedures. Children and parents completed the questionnaire and interview measures as described above, and children completed the CPT in the presence of their parent. The order of these tasks was counterbalanced across parent-child pairs (CPT first: $n = 36$ pairs; 50.00%). While completing the questionnaires, children were accompanied by a research assistant. Parents completed the questionnaires independently in a separate room, but could approach the research assistant at any time to ask questions. The study visit took approximately 90 minutes to complete, and parents and children were compensated for their time and travel expenses.

Data Analysis

Missing data on study variables was minimal (1.00%) and found to be missing completely at random (Little's MCAR test $\chi^2(3326) = 0.00$, $p = 1.00$). For participants missing 10% or less of a particular questionnaire, missing data was handled using expectation maximization imputation ($n = 3$ children, $n = 2$ parents) [23,40,68]. In mediation models with continuous outcomes, full information maximum likelihood was used [23,40], including to address missing data from two children who did not complete the pain catastrophizing measure.

Correlations were used to examine relationships between study variables and potential covariates (parent and child age, parent and child sex, parent chronic pain duration, first task completed during study visit) to be controlled for in mediation analyses. Where correlation coefficients were $r \geq 0.30$, a covariate was included in analyses involving that study variable [28].

Mediation models were tested with path analysis in R using lavaan [58]. Two theoretical models based on Stone and Wilson's theory [67] were tested with child-reported, parent-reported, and observed outcomes. The parental modeling mechanism was tested by examining the indirect effects of parental pain interference on child outcomes (child chronic pain status, child self-reported internalizing symptoms, parent-reported child internalizing symptoms) through the mediator of child pain catastrophizing. The parental reinforcement mechanism was tested within the context of the CPT; the indirect effects of parental attending talk during the task on child outcomes (child self-reported average pain intensity during CPT, parent-reported child average pain intensity during CPT, observed child CPT tolerance) through child symptom complaints were examined. Separate models were run for each outcome.

Mediation models were tested using MLR estimation for models with continuous outcomes and using WLSMV for models with dichotomous outcomes; standardized and unstandardized path coefficients are reported. In each model, indirect effects were tested using bias-corrected bootstrapped (5,000 samples) 95% confidence intervals [41,53]. If the 95% confidence interval for the indirect effect did not include 0, the indirect effect was considered significant [53]. Based on simulation study results, the current study was estimated to be adequately powered (power of 0.80 or higher) to detect indirect effects using bias-corrected bootstrapped confidence intervals in cases when both paths of the indirect effect were medium in effect size [29].

Moderated mediation was used to examine the secondary hypothesis that the parental modeling mechanism would be moderated by child pain status. Analyses followed established recommendations for this method [54] and were tested using lavaan syntax with MLR estimation and bias-corrected bootstrap confidence intervals (5,000 samples). Our sample size exceeded the required size for testing moderated mediation using bias-corrected bootstrapped confidence intervals with power of 0.80 or higher assuming medium sized direct effects [54].

Results

Demographics

Parent participants had a mean age of 42.91 years ($SD = 6.49$). Most parent participants were mothers ($n = 57$; 79.17%), and all parents reported being the participating child's biological parent. Parents identified most often as white ($n = 64$; 88.89%), followed by bi- or multi-racial ($n = 4$, 5.55%) and "other" racial/ethnic identities ($n = 4$, 5.55%). Regarding highest level of education completed, parents most commonly reported completing trade school or community college ($n = 27$; 37.50%). Others reported having some university education (at least one year; $n = 16$, 22.22%), having completed an undergraduate degree ($n = 10$; 13.89%) or high school education ($n = 10$; 13.89%), or completing graduate school or professional training ($n = 7$; 9.72%) or part of high school ($n = 2$, 2.78%). Most parents reported being married ($n = 47$; 65.28%) or in a common-law relationship ($n = 10$; 13.89%). The majority of parents reported that the participating child lived with them full time ($n = 62$; 86.11%) and that they typically spoke English together at home ($n = 71$; 98.61%). Twenty-two parents (30.56%) reported that another member of their or their child's extended family also has chronic pain.

Child participants had a mean age of 12.12 years ($SD = 2.45$) and were approximately evenly split between girls ($n = 39$; 54.17%) and boys ($n = 33$; 45.83%). Parent reports identified

children most often as white ($n = 57$; 79.17%), followed by bi- or multi-racial ($n = 9$, 12.50%) and “other” racial/ethnic identities ($n = 6$; 8.33%).

Descriptive Statistics

Parent pain characteristics are in Table 1. Back pain was the most common type of pain among parents. On average, parents reported the usual pain intensity for their most common pain over the past three months to be nearly 7 out of 10 (moderate pain [12]). Descriptive statistics and correlations among study measures included in the mediation models are provided in Table 2. Approximately one third of child participants had chronic pain based on self-report responses. The most common pain locations reported by children with chronic pain were the head ($n = 8$, 33.33%) and stomach ($n = 6$, 25.00%). Overall, children’s mean usual pain intensity of their most common pain over the past three months was 4.93 (SD = 2.08, range 1.00-10.00). Three children reported having had no pain over the past three months. Six children (8.33%) had Internalizing Problems composite scores that fell within the clinically significant range based on child report; based on parent report, 13 children (19.12%) scored in this range.

Potential Covariates

Correlations where $r \geq 0.30$ were identified between the child reaching ceiling CPT tolerance and child age ($r=0.36$, $p=.002$) and parent age ($r=0.38$, $p=.001$). Mediation analyses were run controlling for these covariates; however, given that the pattern and significance of results was the same as the results without covariates included, only the most parsimonious model is presented. No other correlations between potential covariates and study variables where $r \geq .30$ were found.

Testing Parental Modeling Mechanism

Figure 1(a) shows the path analyses testing the parent modeling mechanism with the outcomes child chronic pain status, child self-reported internalizing, parent-reported child internalizing, and child CPT tolerance. Tests of the indirect effects are in Table 3. Parent pain interference had significant indirect effects on child self-reported internalizing and parent-reported child internalizing through child pain catastrophizing, supporting the hypothesized parental modeling mechanism. The moderated mediation analysis indicated that there was no significant differences in these indirect effects for children with versus without chronic pain for the outcomes of child self-reported internalizing (-0.10 , $SE = 0.09$, 95% bootstrapped CI -0.37 , 0.01) or parent-reported internalizing (-0.09 , $SE = 0.12$, 95% bootstrapped CI -0.44 , 0.08). The indirect effect of parent pain interference on child chronic pain status through child pain catastrophizing was not significant (Table 3).

Testing Parental Reinforcement Mechanism

Figure 1(b) shows the path analyses testing the parent reinforcement mechanism in the context of the CPT with the outcomes child self-reported average pain intensity, parent-reported average pain intensity, and child reaching ceiling CPT tolerance. Parent attending talk had a significant indirect effect on each of these outcomes through child symptom complaints (Table 3), supporting the hypothesized parental reinforcement mechanism.

Discussion

Results of the current study partially supported the hypothesized pain-specific social learning mechanisms underlying the intergenerational transmission of risk of chronic pain and related outcomes [67]. The parental pain modeling mechanism, represented by parental pain interference predicting child outcomes through child pain catastrophizing, was supported for child internalizing symptoms, but not for the presence of child chronic pain. These results are

consistent with studies examining relationships between parental pain and disability and child internalizing symptoms [27,38]. However, they differ from studies finding support for parental pain modeling in adolescents with functional abdominal pain (predicting adolescents' pain severity and disability [65]) and children of mothers with irritable bowel syndrome (predicting child-reported stomachache frequency and bother of gastrointestinal symptoms [39]). These differing results could be due to several factors. The results of the current study did not support child pain status as a moderator of the parental modeling mechanism. Parental pain modeling may have greater influence on the impact of child pain (e.g., children's disability [65]) rather than on its presence. Differences in questionnaires used between the current study (i.e. parental pain interference) and Stone and colleagues' work [65] (adolescent-reported parent pain behaviour) may contribute to the differing results. The parent pain behaviour measure examines a limited number of potential pain behaviours in which parents may engage (e.g., grimacing, thrashing). It may not capture idiosyncratic behaviours through which parents may model pain behaviour. Other factors beyond pain interference may contribute to the pain modeling mechanism; for example, parent-child communication about parental pain [71] could impact children's interpretations of parents' pain behaviours. Children may vary in their awareness of parental pain behaviour, perhaps due to differences in empathy [32].

The current cross-sectional results supported the parental reinforcement mechanism of transmission, with greater proportion of parental attending to child pain during the CPT being associated with greater child pain intensity and lower tolerance through the mediator of child pain-attending. This is consistent with previous studies of children's acute [13,25,45,63,79] and chronic pain [52,61,62,76]. Greater parent attending to child pain may contribute to the development of child chronic pain through its relationship with parent responses to child pain

expression. For example, parents who could more easily shift their attention to pain-related stimuli showed more pain control behaviours in response to increased child facial cues of pain [75], while those with reduced attention-shifting responded similarly regardless of child facial cues.

The results of the current paper were inconsistent with a previous study that did not find support for the parental reinforcement mechanism in adolescents with functional abdominal pain and their parents [65]. Several methodological differences may explain the divergent results. Firstly, the current study used a psychometrically sound observational coding system to identify parent and child pain-attending verbalizations during a laboratory pain task, while the other used a parent self-report measure of solicitous responding to child chronic pain. Social desirability or retrospective reporting bias may impact parents' reporting on their own solicitous responses. Secondly, parents and children may have acted differently during the novel experience of the CPT than in day-to-day child pain, although results of CPT studies often mimic those found in studies of acute and day-to-day pain [6,15,25] and parents and children report similar responding to one another during experimental and other pain contexts [6,77]. Finally, parents in the current study were a sample of adults with chronic pain with fairly high levels of pain intensity and interference [12,55] and higher self-reported average pain intensity than in the previous study [65]. Parents with more severe chronic pain may engage in more pain-reinforcing responses; in the current and previous studies of parents with chronic pain [80], those with greater pain interference engaged in more child pain reinforcing responses, as did parents with higher levels of depressive symptoms [30].

Overall, the current results suggest parental pain modeling is associated with higher levels of internalizing symptoms in children of parents with chronic pain, and that parental pain-

attending may be associated with children's pain experiences through greater child pain-attending. A similar pattern of results was observed for child self- and parent-reported internalizing. These results present the first examination of parental pain modeling as a mechanism underlying the relationship between parental chronic pain and child internalizing symptoms. While previous research has focused on intergenerational transmission of pain, children of parents with chronic pain are at risk for increased internalizing symptoms compared to other children [35]. Improved understanding of the mechanisms underlying these relationships is essential for developing effective prevention and intervention programs [35,67].

The study has several strengths, including empirically testing a theoretical model of intergenerational risk transmission in a sample of adults with chronic pain and their children. Previous research has often focused on clinical samples of children with chronic pain and their parents [59,65,77]. Assessment utilized multiple methods (psychometrically sound questionnaires and observational coding system) and informants (child, parent, trained coders), while much previous research has relied exclusively on questionnaires [39,65] or on parent-reported child variables [17,36,80]. This approach is particularly important given concerns of biased reporting by parents with chronic pain [33].

The current findings must be interpreted in the context of study limitations. The cross-sectional design limits the interpretation of the directions of relationships and has the potential for biased estimates of mediation parameters compared to longitudinal samples [42,43]. However, the current study met criteria for acceptable use of mediation in cross-sectional samples, including ordering variables based on a strong theoretical rationale [67], acknowledging the atemporal nature of the results and limitations of the design, and avoiding causal claims. It is possible that the observed relationships could be bidirectional, which was not examined with the

current study design. The transmission of risk from parents with chronic pain to their children is theorized to occur through multiple mechanisms, and only social learning was examined in this study; other mechanisms are likely involved in these relationships (e.g., genetics). This study also used parental pain interference to represent parents' modeling of overt pain behaviour to their children. While this construct correlates highly with adolescent- and self-reports of parental pain behaviour [66], parental pain behaviour was not directly assessed. Incorporating observational assessment of parental pain behaviour into future studies of these mechanisms could help disentangle these relationships. While the use of a child pain interview likely assisted with child understanding of the measure, social desirability may have influenced children's responses. The current sample of parents was largely mothers (79.17%) and identified as white (88.89%); thus the generalization of these results to fathers and parents of other races is unknown.

The present results highlight several areas that should be further examined to better understand their clinical implications. Consistent with family theories of pain and health [5,47,57,67], parents' own health and coping is associated with children's wellbeing. Improved understanding of the temporal and causal relationships between parental pain interference, children's pain catastrophizing, and children's internalizing symptoms could assist in identifying intervention targets. If parent pain interference is shown to negatively impact children's outcomes, then ensuring that parents with chronic pain can access appropriate pain management services might improve parent and child health outcomes. If further research clarifies that child pain catastrophizing and parental responses to child pain facilitate the intergenerational transmission of chronic pain and related outcomes, then programs could be developed to help children identify their cognitions about pain and teach alternative strategies to interpret and

respond to pain [72], and to educate parents with chronic pain about helpful ways to interact with their children during pain. Such interventions may be particularly important to this population given parents' worry about their children developing problems with pain [80], and could be incorporated into adult pain management programs along with support to connect parents with additional child resources as needed.

Additional research is needed to clarify the mechanisms underlying the vulnerability of children of parents with chronic pain to poorer pain and psychological outcomes. Longitudinal, prospective studies are needed to determine the temporal relationships between parental pain modeling, parental reinforcement of child pain, and child outcomes. Consideration of other variables such as parental mental health [16,31,46], neighborhood characteristics [60], and exposure to adverse childhood events [37,73] will also be important to disentangle the influences of these factors on child health in the context of parental chronic pain. Identification of children most at risk for poor outcomes (e.g., based on sex, racial/ethnic background, socioeconomic status) may assist in appropriately targeting interventions. While studies have focused on the important task of identifying potential risk factors in families with chronic pain, research on protective factors is also needed [35,67]. Several such factors have been hypothesized (e.g., pain acceptance [67]), and should be examined in future research. Research aimed at developing prevention and intervention programs for this vulnerable population should be a priority. Programs should be co-created with families with parental chronic pain so that such programs are not only evidence-based, but also relevant and feasible for intended users. Coordinated efforts from researchers, health professionals, and families are needed to improve our current understanding of pain-specific social learning and better support children of parents with chronic pain.

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