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Pre-Surgical Screening Tools and Risk Factors for Chronic Post-Surgical Pain

Report

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Abbreviations

CI	confidence interval
CPSP	chronic post-surgical pain
EQ-3D-3	EuroQol-5 Dimensions-3
FDI	Functional Disability Inventory
HADS	Hospital and Anxiety Depression Scale
IASP	International Association for the Study of Pain
KSF	Knee Society function score
KSS	Knee Society score
MCS	mental component summary score
MMPI-2-RF	Minnesota Multiphasic Personality Inventory–2–Restructured Form
NRS	Numeric Rating Scale
ODI	Oswestry Disability Index
OR	odds ratio
PAIRS	Pain and Impairment Relationship Scale
PCS	physical component summary score
PPIS	PROMIS-Pediatric Pain Interference Scale
QST	quantitative sensory testing
SF-36	Short Form (36) Health Survey
SR	systematic review
TSK	Tampa Scale of Kinesiophobia
VAS	visual analogue scale
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index

Key Messages

- This report provides an overview of evidence regarding evidence-based risk factors and pre-surgical screening tools or assessments that may help identify individuals at risk for developing chronic post-surgical pain. This is not a systematic review and a formal critical appraisal was not performed.
- Our review identified 19 evidence-based risk factors for chronic post-surgical pain from published systematic reviews.
  - The most commonly reported chronic post-surgical pain risk factors were anxiety (7 studies), catastrophizing (pain or general) (catastrophizing is the tendency to exaggerate a situation in a negative manner [e.g., imagine the worst possible outcome]) (6 studies); depression (5 studies); and psychological distress (non-specific symptoms of depression, anxiety, and stress), kinesiophobia (fear of movement), and age (3 studies each). These risk factors were reported among various surgical procedures (e.g., mixed surgery types, total knee and hip replacements, spine surgery) and age populations (adult, pediatric, adult plus pediatric).
  - Definitive conclusions cannot be made regarding particular risk factors and their association with chronic post-surgical pain. The evidence was either mixed and/or associated with limitations in the methodology of the study and unclear whether the results may apply in groups other than those included in the studies.
- Our review identified 11 pre-surgical screening tools or assessments that were studied for their ability to predict chronic post-surgical pain. These included various quantitative sensory testing measures (e.g., mechanical, heat or cold, electrical), validated scales of other conditions, and screening tools.
  - Four of the identified screening tools or assessments were found to predict chronic post-surgical pain but their it is unknown whether they can be applied to broader clinical practice (i.e., various surgery types among different age groups). These were only investigated in 1 study among specific populations.
  - These 4 tools or assessments included a pain threshold evaluation performed with a sphygmomanometer (blood pressure monitor comprised of an inflatable cuff) in adults who underwent total knee replacement; the modified Tampa Scale of Kinesiophobia with 13-items (i.e., only the positively scored items) in pediatric patients who underwent orthopedic or general surgery; the Presurgical Psychological Screening algorithm in adults who underwent spine surgery; and the Pediatric Pain Screening tool in pediatric patients who underwent major musculoskeletal surgery.
  - The remaining screening tools or assessments that were identified reported either mixed findings or no association with chronic post-surgical pain in various surgical populations.
  - Definitive conclusions cannot be made for the use of pre-surgical screening tools or assessments to identify risk of developing chronic post-surgical pain.

Context

Chronic post-surgical pain (CPSP) is pain that develops or worsens following surgery and persists from the acute post-surgical periods (typically considered less than 3 months after surgery).[1] The transition from acute post-surgical pain to CPSP is complex and multifactorial,

influenced by psychological, socioeconomic, cultural, clinical, and biologic factors.[2] In the 2020 Canadian Pain Task Force Report, it was estimated that 1 in 4 people in Canada, aged 15 years or older, or 7.63 million individuals live with chronic pain.[3] In Canada in 2019, the total of direct and indirect costs of chronic pain ranged from $38.3 to $40.4 billion; thus, chronic pain had a significant impact on mental and physical health; family, community, and society life; and the economy.[3] Chronic pain may arise from various etiologies but CPSP in particular has a high incidence (i.e., rate) and is a significant cost driver in the context of health care spending.[4] Accordingly, CPSP can elicit a significant burden on health care resources as patients may require long-term multidisciplinary treatment through a combination of primary care, specialty care, and rehabilitation.[3,4]

Chronic pain management often takes a long time to initiate as the pain reported by patients may be misunderstood or diminished despite efforts by health professionals, and is complicated through its relation and presence alongside other diseases or health conditions.[3] Accordingly, chronic pain has a substantial impact on the quality of life of patients and caregivers particularly due to its potentially lifelong impact.[3] In Ontario, it was reported that the health-related quality of life of individuals with chronic pain is lower than those with other chronic diseases such as chronic obstructive pulmonary disease, diabetes, and heart disease.[3] Further, chronic pain disproportionally affects people in Canada as the level of education, psychological, social, and cultural factors in addition to biologic factors influence the severity and occurrence of pain (i.e., manifestation of pain) and perception or experience of pain.[3] This is further complicated by unequal access to health care among populations who experience systemic disadvantage, which may include certain racial and ethnic populations, individuals with an economic disadvantage (e.g., those who are uninsured and/or have a low-income), individuals with unstable living conditions, individuals with stigmatized health conditions (e.g., HIV, severe mental illness) and/or chronic health conditions, and women or other gender identities (i.e., identities other than cisgender men).[5]

Chronic pain is managed through a biopsychosocial approach and treatment includes pharmacological and/or surgical, physical, and psychological therapies.[3] To date, pharmacological therapies have consisted of short- and long-term opioid use; however, different strategies for pain prevention and management are being explored due to the increase in opioid-related overdose deaths in North America.[3] Notably, individuals with CPSP are at higher risk of persistent opioid use as opioid medications are commonly prescribed for post-surgical pain, which can result in long-term use and potentially opioid reliance or addiction.[3,4] Given the physical and psychological effects of CPSP on those who develop it, there is a considerable need to identify risk factors and screening tools or assessments to identify people at risk of developing CPSP.[3,4] This information would help facilitate timely pain management, appropriate administration of treatments, and more adequate preparation and efficient use of health care resources for pain management and prevention. For instance, knowledge of risk factors or use of effective screening tools or assessments could help identify those who are at high risk of developing CPSP to allow for pain management to be planned and initiated before surgery and implemented during the peri-surgical and post-surgical periods. Further, assessing the risk of CPSP could help guide clinical practice decisions, such as those related to prescribing opioids in an attempt to reduce opioid reliance and opioid-related deaths. Overall, risk factors and screening tools or assessments may predict the incidence of CPSP and allow for more effective planning related to managing resource distribution (e.g., hospitalizations, treatments) and other health care needs, which is particularly necessary during the current opioid epidemic and the COVID-19 pandemic as

these have introduced an additional burden on people seeking health care, the health care system, longer wait lists, and increased resource use.[3,4]

Overall, there is a need to identify risk factors and screening tools or assessments related to CPSP from the perspectives of patients, health care providers, and the overall health care system; this may address identified needs for improvement in patient and caregiver quality of life, reduction of out-of-pocket costs for the patient and health care system costs, and increased efficiency of health care resource utilization.

About This Report

This CADTH report identifies and provides brief summaries of literature on evidence-based risk factors of CPSP and pre-surgical screening tools or assessments that may be used to identify patients who are at increased risk of developing CPSP. This report adopted the definition of CPSP from the International Association for the Study of Pain (IASP). The IASP defines CPSP as "pain developing or increasing in intensity after a surgical procedure or a tissue injury (involving any trauma including burns) and persisting beyond the healing process, i.e., at least 3 months after surgery or tissue trauma."[1] Therefore, evidence was included in this report if pain was measured at 3 or more months after surgery. Of note, phantom limb pain was considered to be a distinct type of pain following surgery and is not discussed in this report. This report may provide insight into what may be considered and used to identify patients at risk for CPSP. For the purpose of this work, the focus is on general evidence-based risk factors (i.e., risk factors that may be associated with any individual who underwent surgery or risk factors common to a surgical specialty). Moreover, findings are separated for adult and pediatric patients, when possible, as CPSP may affect these groups differently. For instance, 1 study reported that the 1-year incidence of moderate to severe CPSP is approximately 22% and 12% for children and adults, respectively.[4] Additionally, as genetic testing is not widely available and accessible across all health jurisdictions (e.g., limited access in certain Canadian provinces and non-academic health centres), genetic risk factors were not summarized in this report. However, genetic risk factors of CPSP may exist such as the minor G allele of the *KCNS1* gene that was found to increase risk of CPSP in a meta-analysis and was identified from a systematic review (SR) of the literature of studies performed in adults. This gene codes for the alpha subunit of the potassium channel and has been associated with various states of chronic pain.[6] Moreover, interventions or services to treat or assist individuals with CPSP are beyond the scope of this report.

This is not a SR and does not provide a critical appraisal of the included studies. Rather, this report provides an overview of evidence available regarding evidence-based risk factors and pre-surgical screening tools or assessments that may help identify those at risk for developing CPSP.

Objectives

The key objectives of this CADTH report are as follows:

1. Identify and summarize literature on evidence-based risk factors of CPSP.

2. Identify and summarize literature on presurgical screening tools or assessments that may be used to identify patients who are at increased risk of developing CPSP.

As noted previously, genetic risk factors will not be summarized in this report given the inconsistency with access to genetic testing across health jurisdictions.

Methods

This narrative summary was informed by 1 literature search and a rapid scan of the literature conducted by an information specialist and may contribute to future projects regarding the prevention of CPSP.

Literature Search

A limited literature search was conducted by an information specialist on key resources including MEDLINE, PubMed, the Cochrane Database of Systematic Reviews, the International HTA Database, the websites of Canadian and major international health technology agencies, as well as a focused internet search. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were risk factors, screening tools, and post-surgical chronic pain No filters were applied to limit the retrieval by study type. Where possible, retrieval was limited to the human population. The search was also limited to English language documents.

Screening and Study Selection

One author independently screened titles and abstracts and performed article selection based on full-text review of articles. There were no restrictions regarding the population, comparator, study design, language, and year of publications; however, only articles published in English were reviewed. Articles were included in this report if they informed the 2 research questions (i.e., what are the evidence-based risk factors of patients at increased risk of chronic post-surgical pain and pre-surgical tools/assessments to identify patients who are at increased risk of CPSP). Thus, the broad requirements resulted in the inclusion of studies that assessed patients that underwent surgery and had a pain assessment at 3 months or more following surgery or had post-surgical pain that persisted for at least 3 months. Accordingly, patients of any age undergoing various surgery types for multiple indications (e.g., orthopedic, gynecologic, oncology surgeries) and numerous tools or assessments were used to measure pain (e.g., Visual analogue scale [VAS], Numeric Rating Scale [NRS], Brief Pain Inventory [BPI]). There were no strict criteria regarding the eligibility of evidence-based risk factors or pre-surgical tools/ assessments. However, studies evaluating pain relief were not considered. Similarly, evidence-based risk factors of focus were general; thus, relevant or applicable to any individual undergoing surgery (e.g., age, sex) or common to a particular surgery type or surgical specialty (e.g., knee function, scoliosis severity [Cobb angle]) and its measurement was considered to be broadly feasible. Risk factors that were not clearly defined in the included studies were not summarized in this report (e.g., patient's decision-making).

Articles were excluded if the timeline for pain assessments was not reported or unclear and if the findings combined measurements of pain at time points less than 3 months with time points of 3 or more months.

Synthesis Approach

Relevant articles identified from the information gathering were summarized narratively or listed in the appendix. Objective 1 (evidence-based risk factors) was informed by SRs and/or meta-analyses. Objective 2 (pre-surgical tools or assessments) was informed by all study designs. Appendix 3 lists the literature that reports on evidence-based risk factors CPSP from all study designs except for SRs and literature that reports on pain trajectories and risk or predictive scores or models. The latter constitute tools/assessments that may not include all pre-surgical components and may be based primarily on computative methods; thus, may be of potential interest to identifying patients who are at risk of developing CPSP. Narrative summaries (body of the report and Appendix 2) and the list of references (Appendix 3) of information pertaining to evidence-based risk factors are categorized based on age group (i.e., adults only, pediatric patients only, adult plus pediatric patients) and surgical specialty. Namely, pediatric age was based on the definition provided in the study or a range of at least 18 years of age. Surgical specialties were based on the Canadian Medical Association's specialty profiles and included cardiovascular and thoracic surgery, dermatology, general surgery, surgical oncology, neurosurgery, obstetrics/gynecology, ophthalmology, orthopedic surgery, otolaryngology (ENT), plastic surgery, and urology.[7]

Findings

Objective 1: Evidence-Based Risk Factors of CPSP

Summary of Findings by Risk Factor and Surgery Type

Anxiety (7 studies),[2,8-13] followed by catastrophizing (pain or general) (6 studies)[2,8,9,12-14]; depression (5 studies)[2,8,10,12,13]; and psychological distress,[2,8,10] kinesiophobia,[8,12,13] and age[10,13,14] (3 studies each) were the most reported risk factors among the reviewed SRs that included adults undergoing various surgery types, surgery for breast cancer, and total knee and total hip replacements; pediatric patients undergoing various surgery types; and adult and pediatric patients undergoing surgery for lumbar disc herniation. Altogether, the evidence was mixed and definitive conclusions regarding particular risk factors or a particular set of risk factors that are consistently associated with CPSP (i.e., serve as risk factors across all surgery types and age groups) were not reported. This is supported by mixed findings that were found when Hinrichs-Rocker et al. (2009) examined risk factors for different surgery types, which included hernia, thoracotomy, cholecystectomy, breast surgery, knee surgery, and spine surgery.[10] For instance, more studies reported younger age as a risk factor among hernia, thoracotomy, and breast surgeries but more studies reported younger age to not be associated with CPSP in cholecystectomy, knee, and spine surgeries. Within a surgery type and age group, conclusions could not be made to identify risk factors with consistent high-quality evidence as well. However, this is mostly attributed to the small number of studies informing these surgery-age categories. For instance, in adults who underwent various surgery types, mixed findings were found for anxiety as a risk factor. One meta-analysis found a low positive correlation specific to pre-surgical state and trait anxiety, another meta-analysis found increased odds for pre-surgical general anxiety but not pre-surgical pain-related anxiety, while the remaining SR deemed that pre and post-surgical anxiety have an unclear association with CPSP. However, findings for depression were more consistent as 1 meta-analysis found a low positive correlation of pre-surgical depression and the other study deemed pre and post-surgical depression to have a likely association but depression was not investigated in the

other meta-analysis. Of note, mixed findings may be attributed to this report being informed by narrative data syntheses and meta-analyses, a limited number of studies as this is not a comprehensive SR, and heterogeneity in surgery composition (e.g., varying proportions of surgeries among study samples with inherently higher or lower risk of CPSP) and risk factor and CPSP measurement (e.g., varying time points such as pre- versus post-surgical measurement periods and acute versus chronic post-surgical measurement periods). This heterogeneity likely introduced bias and confounding that will be described in detail in the Limitations section.

Altogether, 19 factors assessed for association with CPSP were identified from 8 SRs[2,8-14]:

- Biologic — age, sex, race, health status, body mass index
- Psychological or mental health-related — anxiety, depression, catastrophizing (pain or general), optimism, psychological distress, kinesiophobia, other mental health-related factors
- Socioeconomic — social factors (e.g., support); education, employment, household-related, and income
- Pain level/ function— pre-surgical pain, acute post-surgical pain, knee function (total knee replacement in adults), disability (lumbar disc herniation in adults and pediatric patients), scoliosis specific factors (pediatric patients).

Table 1 summarizes the identified risk factors and are separated based on surgery-age categories (various surgery types in adults[8-10]; breast cancer surgery in adults[2]; total knee and total hip arthroplasty in adults[11,12]; various surgery types in pediatric patients[14]; and lumbar disc herniation surgery in adults and pediatric patients).[13] Table 3 (Appendix 1) summarizes the characteristics of the SRs that investigated risk factors of developing CPSP. Appendix 2 reports the detailed findings of the included of publications (i.e., results separated for each risk factor).

Objective 2: Pre-Surgical Screening Tools or Assessments for Identifying Patients Who Are at Increased Risk of Developing CPSP

Summary of Pre-Surgical Screening Tools or Assessments by Surgery Type

Nine articles were identified to summarize the use of pre-surgical screening tools or assessments to identify patients who are at increased risk of developing CPSP. Five studies reported on quantitative sensory testing (QST) with 1 cohort study reporting specifically on the use of a sphygmomanometer to assess pain thresholds in adults who underwent total knee arthroplasty.[15] The other 4 studies included the following investigations: SR of total joint arthroplasty (primary, unilateral) for osteoarthritis in adults[16]; SR of joint-related, thoracic-related, abdominal and gynecology-related and breast cancer surgeries in an unknown age group (not reported)[17]; cohort study of robot-assisted laparoscopic hysterectomy for adults with endometrial cancer[18]; and SR of orthopedic, gynecologic, abdominal, thoracic, lumbar discectomy, and other (breast cancer surgery and carpal tunnel release) surgeries in a predominantly adult population (1 included study had an age range of 17 to 23 years old).[19] Two studies reported on the use of scales validated for other conditions; namely, the Tampa Scale for Kinesiophobia (TSK) was investigated for children and adolescents who underwent general and orthopedic surgery,[20] and the Hospital Anxiety and Depression Scale (HADS) was assessed for adults who underwent lumbar spine surgery.[21] Two studies reported on the use of screening tools; namely, a Pediatric Pain Screening tool was assessed in pediatric patients who underwent major musculoskeletal surgeries[22] and the Presurgical Psychological

Table 1: Summary of Evidence-Based Risk Factors of CPSP Reported in SRs

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
Anxiety (7)	Low, positive correlation (state and trait anxiety) (MA) Consistently associated (narrative synthesis)	Increased odds (general anxiety — max effect scenario [highest OR]) (MA) Non-significant ORs (general anxiety — min effect scenario [lowest OR] and pain-related anxiety max and min effect scenarios) (MA)	Unclear association (pre and post-surgical)	Mixed findings at 3, 6, and 12 months after surgery Not a predictor when assessed with Functional Assessment of Cancer Treatment-Emotional Scale	Predictive role of post-surgical anxiety (of moderate to severe CPSP)	Positive relationship between post-surgical anxiety (48 hours after TKA) and CPSP risk (1 study)	—	Preliminary positive evidence[e]
Catastrophizing or pain catastrophizing (PC) (6)	Low, positive correlation (MA)	Increased odds (max and min effect scenarios) (MA)	—	No association (1 study)	—	Risk factor for night CPSP but not global CPSP (1 study)	Pre-surgical PC of parent associated with CPSP Pre-surgical PC of child (patient) not associated	Preliminary positive evidence[e]

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
Depression (5)	Low, positive correlation (MA)	—	Likely association (pre and post-surgical)	Mixed findings at 3, 6, and 12 months after surgery Not a predictor when assessed with Functional Assessment of Cancer Treatment-Emotional Scale (low mood)	—	Risk factor for global CPSP but not night CPSP (1 study)	—	Positive evidence[f] (specific to leg and back pain intensity)
Psychological distress (3)	Consistently associated (psychological distress) (narrative synthesis)	—	Likely association (pre-surgical chronic stress, pre-surgical psychological distress, and post-surgical psychological distress)	Increased odds (of CPSP at 8 months) (1 study)	—	—	—	—
Kinesiophobia (3)	Low, positive correlation (MA)	—	—	—	—	More CPSP in patients with high vs. low post-surgical	—	Preliminary positive evidence[e]

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
	No association (narrative synthesis of high-quality studies)					kinesiophobia (2 weeks after surgery)		
Age (3)	—	—	Unclear association (younger age)	—	—	—	No association (3 studies)	Preliminary positive evidence[e]
Sex (2)	—	—	Unlikely association (female)	—	—	—	No association (3 studies)	—
Other mental health-related factors (2)	Low, negative correlation (mental health but disorders NR) (MA)	—	Unclear association (low mental health care)	—	—	—	—	—
Social factors (2)	—	—	Unclear association (social support at work and from spouse)	—	—	Social support (6 weeks after surgery) — perceived positive social support associated with less CPSP and negative social support with	—	—

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
						more CPSP (1 study)		
Pre-surgical Pain (2)	—	—	—	—	—	—	Mixed results (2 studies)	Positive evidence[f]
Acute post-surgical pain (1)	—	—	—	—	—	Mixed results (post-surgical days 1 to 7, days 8 to 14, and week 2 to month 3)	—	—
Race (1)	—	—	Unlikely association (specific race NR)	—	—	—	—	—
BMI (1)	—	—	—	—	—	—	No association (1 study)	—
Health status (1)	—	—	Unclear association (pre-surgical general health and well-being and post-surgical health status with SF-36)	—	—	—	—	—

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
Optimism (1)	No correlation (MA)	—	—	—	—	—	—	—
Education, Employment, Household-related, Income (1)	—	—	Unlikely association (full-time employment and low education levels) Unclear association (marital status, household size, and income)	—	—	—	—	—
Knee function (1)	—	—	—	—	—	Mixed results for different outcomes (e.g., ambulatory status, ROM, WOMAC function) and time points (e.g., discharge, 2 and 8 weeks after surgery)	—	—

Outcomes (number of studies reporting)	Various surgery types, adults			Breast cancer surgery, adults	TKA and THA[a], adults		Various surgery types, pediatric patients	Lumbar disc Herniation surgery, adults and pediatric patients
	Giusti et al. (2021)[8] Pre-surgical risk factors	Theunissen et al. (2012)[9] Pre-surgical risk factors	Hinrichs-Rocker et al. (2009)[10b]	McCowat et al. (2019)[2] Pre-surgical risk factors	Hruschak and Cochran (2018)[11] (TKA and THA)[c]	Wylde et al. (2017)[12] (TKA only) Post-surgical risk factors	Rabbitts et al. (2017)[14] Pre-surgical risk factors	Dorow et al. (2017)[13d]
Disability (1)	—	—	—	—	—	—	—	Positive evidence[f] (specific to leg and back pain intensity)
Scoliosis specific factors (1)	—	—	—	—	—	—	No association (scoliosis severity [Cobb angle] and time since diagnosis) (1 study)	—

BMI = body mass index; CPSP = chronic post-surgical pain; MA = meta-analysis; max = maximum; min = minimum; NR = not reported; OR = odds ratio; PC = pain catastrophizing; ROM = range of motion; SF-36 = 36-Item Short Form Survey; SR = systematic review; THA = total hip arthroplasty; TKA = total knee arthroplasty; vs. = versus; WOMAC = Western Ontario McMaster Osteoarthritis Index.

[a]Arthroplasty procedures are more commonly known as a joint replacement.

[b]Inclusion criterion regarding when risk factors were evaluated was NR. However, timeline of measurement (e.g., pre or post-surgical) and other contextual information were reported (e.g., younger age, female gender).

[c]Inclusion criterion regarding when risk factors were evaluated was NR. However, relevant data of this report was specified to be evaluated after surgery (i.e., post-surgical anxiety).

[d]Inclusion criterion regarding when risk factors were evaluated was NR. Except for pre-surgical pain, the other summarized risk factors are not clear whether they are presurgical or post-surgical risk factors.

[e]Number of studies that documented a significant association between a risk factor and CPSP intensity outweighed the number of studies reporting no significant association by 2.

[f]Number of studies that documented a significant association between a risk factor and CPSP intensity outweighed the number of studies reporting no significant association by 3 or more.

Screening algorithm was assessed in adults who underwent orthopedic spine surgery.[23] No meta-analyses of the SRs were performed.

Table 4 (Appendix 1) summarizes the characteristics of the studies investigating pre-surgical screening tools or assessments to identify patients who are at increased risk of developing CPSP. Namely, it lists the pain assessment tools used to measure pain or to validate the pre-surgical screening tool or assessment of investigation, which were all self-reported evaluations except for the Danish-language questionnaire, in the investigation of QST in adults who underwent robot-assisted laparoscopy hysterectomy, for which it was not reported if it was self-reported.[18] Among the investigated pre-surgical screening tools or assessments, besides QST, the Pediatric Pain Screening tool[22] was self-reported but the Presurgical Psychological Screening algorithm[23] consisted of a review of medical records, psychometric testing, and a diagnostic interview. Appendix 2 reports the detailed findings of the included of publications (i.e., results separated for pre-surgical tool or assessment).

Table 2 summarizes the pre-surgical screening tools or assessments and are separated based on surgery-age categories. Various QST measures were investigated and categorized as mechanical sensory testing (e.g., mechanical pain intensity/threshold, pressure pain threshold, pain detection threshold), thermal sensory testing (e.g., heat, warm stimuli), cold stimuli sensory testing, electrical sensory testing, temporal summation of pain, conditioned pain modulation, and pain threshold evaluations elicited by a sphygmomanometer. Cold stimuli sensory testing and thermal (heat stimuli) sensory testing were the only measures to have consistent overall findings; namely, 2 included studies of this report found no associations with CPSP for cold stimuli sensory testing and 4 studies reported mixed findings for associations with CPSP. The remaining QST measures generally reported mixed findings for the ability to predict CPSP or no associations between the QST measure and CPSP. Electrical detection and electrical pain thresholds were found to be significantly associated with CPSP in the SR performed by Paredes et al. (2021)[16]; however, this was supported by 1 included study of the SR (2 included studies investigated electrical sensory testing; however, only 1 measured during the pre-surgical period). The use of a sphygmomanometer to elicit a pain threshold evaluation was concluded to predict CPSP; namely, ratings of severe pain of the stimulus were associated with worse outcomes such as pain and there was a negative correlation of VAS scores (pain perception of stimulus) and Knee Society scores (KSS) including pain.[15] Among the validated scales for other conditions, the HADS and TSK were not found to predict CPSP but the modified TSK with 13-items (i.e., only the positively scored items) was concluded to predict CPSP.[20,21] The Presurgical Psychological Screening algorithm and Pediatric Pain Screening tool were concluded to predict CPSP; however, revisions were suggested to improve the utility of the Psychological Screening algorithm; whereas, feasible application of the Pediatric Pain Screening tool in presurgical anesthesia and surgery consultation clinics was stopped.[22,23] Moreover, van Helmond et al. (2020) investigated QST in specific surgery types including orthopedic, gynecological, abdominal, thoracic, lumbar discectomy, breast cancer, and carpal tunnel release surgeries but concluded that QST was inconsistently associated with CPSP as findings were variable based on surgery type and for specific QST measures.[19]

Table 2: Summary of Pre-Surgical Screening Tools or Assessments for Identifying Patients at Risk of CPSP[a]

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
Quantitative sensory testing									
Mechanical sensory testing (e.g., mechanical pain intensity or threshold, pressure pain threshold, pain detection threshold)	Mixed findings 1 study found no association for mechanical pain intensity after TKA 1 study found no correlation with mechanical pain threshold 1 study found a significant association with pressure pain threshold but regression analysis found no association 1 study found no association with cuff algometry-pain	No significant differences in pressure pain threshold of lower back, leg, and arm; pain detection threshold with cuff pressure; and pain toleration threshold with cuff pressure (CPSP vs. without CPSP)	Association with CPSP for pressure pain threshold in 3 studies	No associations with CPSP Pressure pain threshold (3 studies; breast cancer surgery, TKA, surgical correction of funnel chest) and pressure tolerance thresholds (2 studies; major surgery of abdomen and spinal surgery) were not associated with CPSP Cuff-induced pain detection and cuff-induced pressure/pain tolerance thresholds not associated with CPSP in TKA (2 studies) Mechanical detection (2 studies; breast cancer surgery, surgical correction of funnel chest) and mechanical pain	—	—	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
	threshold (i.e., cuff pressure tolerance) after TKA			thresholds (2 studies; TKA, breast cancer surgery) not associated with CPSP					
Thermal sensory testing (e.g., heat, warm stimuli)	Mixed findings Warm detection threshold and heat pain threshold positively correlated (significant) with CPSP but not a predictor with linear regression (1 study) 3 studies found no significant association between heat pain threshold and CPSP 1 study found no correlation	Mixed findings Significantly lower heat pain thresholds in CPSP Decreased heat pain threshold was not a risk factor of CPSP with logistic regression No significant differences in warm detection threshold (CPSP vs. without CPSP)	Association with CPSP for warm detection threshold in 2 studies	Mixed findings Low warm detection threshold and low heat pain threshold predictor of CPSP (linear regression — 1 TKA study) 2 studies found no association with warm detection thresholds (groin hernia repair and breast cancer surgery) 8 studies found no association with heat pain threshold in various surgeries (e.g., TKA) 1 study found no significant association for suprathreshold heat stimuli with CPSP (thoracic surgery) but another study found it was a predictor of CPSP	—	—	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
	with suprathreshold heat pain intensity and CPSP			following hernia repair					
Cold stimuli sensory testing	No significant associations with cold detection and cold pain thresholds (2 studies)	—	—	No associations for cold detection and cold pain thresholds among various surgeries (e.g., TKA, breast cancer surgery, spinal surgery) 1 study found no significant association for suprathreshold cold stimuli with CPSP (thoracic surgery)	—	—	—	—	—
Electrical sensory testing	Electrical detection and electrical pain thresholds significantly associated (1 study)	—	Association with CPSP for electrical pain and electrical detection thresholds (1 study each)	Mixed findings — (3 studies) (e.g., 1 study found no association with electrical pain detection threshold after TKA but another found association between electrical pain threshold)	—	—	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
Temporal summation of pain	Mixed findings 2 studies found an association with CPSP after TKA with correlation and linear regression analyses. 1 of these studies also performed multivariate analysis that found no association 3 studies found no Significant association after TKA	No significant differences in temporal summation of pain in those with CPSP vs. without CPSP	Association with CPSP in 4 studies Only measure associated with more significant than non-significant associations with CPSP	Mixed findings 5 studies found an association (TKA, abdominal or laparoscopic hysterectomy) 3 studies found no association (TKA, arthroscopic shoulder surgery, breast cancer surgery)	—	—	—	—	—
Conditioned pain modulation	Mixed findings 1 study found a significant association	No significant differences in conditioned pain modula-	Association with CPSP in 3 studies	Mixed findings — 9 studies (e.g., association with hot water after thoracic surgery, no	—	—	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
	(with cuff pressure tolerance as stimulus) with CPSP measured at rest. No association was found for CPSP measured during movement or when pain threshold was the stimulus. 3 studies found no significant associations	tion in those with CPSP vs. without CPSP		association with cold water after TKA)					
Sphygmomanometer pain test (pain threshold evaluation)	—	—	—	—	Concluded to predict CPSP	—	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
Validated scales for other conditions									
HADS	—	—	—	—	—	—	Not concluded to predict CPSP (pain-specific outcomes [VAS leg and back] or pain-related and pain-combined outcomes [ODI, SF-36, EQ-5D-3])	—	—
TSK	—	—	—	—	—	TSK-13 (modified) concluded to predict CPSP (pain-related disability) but not TSK-17	—	—	—

Presurgical screening tool or assessment	Total joint arthroplasty, adults Paredes et al. (2021)[16] (SR)	Robot-assisted laparoscopic hysterectomy, adults Lunde et al. (2020)[18]	Various surgeries, predominantly, adults van Helmond et al. (2020)[19] (SR)	Joint-related, thoracic-related, abdominal and gynecology-related, and breast cancer surgeries, unknown age group Petersen et al. (2021)[17] (SR)	TKA, adults Bar Ziv et al. (2016)[15]	Orthopedic or general surgery, pediatrics Rosenbloom et al. (2020)[20]	Spine surgery, adults Carreon et al. (2020)[21]	Major musculoskeletal surgery, pediatrics Narayanasamy et al. (2022)[22]	Spine surgery, adults Marek et al. (2019)[23]
Screening tools									
Presurgical psychological screening algorithm	—	—	—	—	—	—	—	—	Concluded to predict CPSP May require revisions to improve its utility
Pediatric pain screening tool	—	—	—	—	—	—	—	Concluded to predict CPSP Feasible application	—

CPSP = chronic post-surgical pain; EQ-5D-3 = EuroQol-5 Dimensions-3; ODI = Oswestry Disability Index; SR = systematic review; TKA = total knee arthroplasty; TSK = Tampa Scale for Kinesiophobia; SF-36 = Short Form (36) Health Survey; VAS = visual analogue scale; vs. = versus.

[a]This table does not comprehensively list all the results; thus, for studies that found mixed findings, examples demonstrating the variability are provided in this table. Refer to Appendix 2 for detailed results.

Limitations

This report may not provide an entirely comprehensive review of evidence-based risk factors of CPSP and pre-surgical screening tools or assessments to identify individuals at risk for CPSP. The summarized evidence should be interpreted with caution due to methodological limitations and limited generalizability; as well, a formal critical appraisal was not performed for this report. Of note, these limitations pertain specifically to the summarized literature (i.e., 8 SRs informing risk factors and 9 studies informing pre-surgical screening tools or assessments related to CPSP) and not the articles listed in Appendix 3.

Evidence-based risk factors of CPSP were informed by 8 SRs, from which, 19 factors assessed for association with CPSP were identified and summarized. Further, 9 articles informed the use of QST, validated scales of other conditions, and screening tools administered before surgery. The summaries in this report are informed by evidence with a disproportionate representation of surgery types. Among the evidence that included specific surgery types, there was the greatest representation of orthopedic surgeries, particularly joint arthroplasties (i.e., replacements). However, given the broad criteria used to include studies in this report, it cannot be determined whether the greater representation of orthopedic surgeries are due to a greater likelihood of CPSP following orthopedic surgeries or if there is a greater tendency to publish studies in this surgical specialty. These considerations may be answered by a well-designed, comprehensive SR. Further, the evidence that included various surgery types, consisted of various proportions (i.e., percentages) of these surgery types. Heterogeneity in surgery composition may confound results due to the varying severity of the indication a surgery is intended to treat; invasiveness of the procedure; and the limited mobility, function, and independence of the recovery period. Thus, certain surgery types may be inherently associated with a higher or lower risk of CPSP. For instance, 1 SR that investigated adults who underwent various surgeries found a trend (i.e., not statistically significant) that there was a greater number of statistically significant predictors identified in musculoskeletal surgery compared to other surgery types (67% versus 36%) among the included evidence of this SR.[9] Specific to summarized risk factors, there was a greater representation of psychological or mental health-related factors with anxiety (7 studies), followed by catastrophizing (pain or general) (6 studies), depression (5 studies), and psychological distress, kinesiophobia, and age (3 studies each) being the most reported risk factors. Most of the other biologic, psychological or mental health-related, socioeconomic, and pain level or function risk factors were identified from 1 or 2 SRs.

Evidence of risk factors and pre-surgical tools or assessments consisted of a mix of study designs and analysis types. For instance, the former was informed by narrative data syntheses and meta-analyses and the latter was informed by observational studies and SRs but no meta-analyses were performed. The evidence from SRs were only included in this report if they were clearly reported; namely, outcomes or risk factors with unclear definitions and/or measurements (e.g., how and when it was measured) were not summarized since the source publications were not accessible. Vitality, patients' decision-making, and self-efficacy are examples of risk factors that were not summarized in this report. However, some of the risk factors included in this report were not clearly defined, as they were not defined in the source publication such as "mental health" and "low mental health care" (i.e., the specific disorders were not reported).

Evidence was included (in the main body of the report and the appendices) if pain was assessed at 3 or more months after surgery, which resulted in differences of the pain

assessment of included studies that could variably influence the findings. Namely, if the study did not specify between new onset pain and persisting pain related to surgery, the findings may be combined with these types of pain, which limits generalizability. For instance, pain reported at 4 months that is new versus pain that is present at 4 months and has persisted since surgery have different clinical and health care resource implications and effects on the quality of life of patients and caregivers. Notably, this is a greater consideration for studies with later measurement time points (e.g., year after surgery) as the pain is less likely to be directly related or entirely related to surgery as time progresses further from the surgery. It is important to distinguish these pain types; namely, a patient with CPSP that started during the acute post-surgical period may require more integrated health care (e.g., more treatments, more appointments with potentially multiple clinicians such as a general practitioner, physiotherapist, and specialist) compared to a patient who develops new pain or experiences non-persisting pain during the CPSP period (if the only health concern for these patients was pain). Therefore, findings combined with new pain or non-persisting pain would not be informative. Nevertheless, distinguishing between these types of pain sometimes may not be possible (e.g., new pain could present at the same time as persistent pain in similar regions of the body) and may be particularly difficult to correctly disclose through self-report, recall-based measures. Furthermore, various recall periods of the pain assessment may limit generalizability. Some studies specified that participants reported on pain from the past 24 hours versus others reported on the past week. Many pain assessments that are standard in clinical practice are evaluated with self-reported measures, which are inherently at risk of recall bias; however, a longer reference recall period would likely introduce greater risk. Therefore, the inclusion of studies with different combinations of recall periods may confound the results with varying amounts of recall bias. Overall, studies with later measurement periods and/or a longer period of recall for the pain measurement are more susceptible to recall bias.

Further, earlier periods (e.g., 3 to 4 months after surgery) within the chronic post-surgical timelines may be associated with different physiologic and psychological factors that manifest in differences of pain perception compared to later periods (e.g., 1 year after surgery). For instance, an SR investigating CPSP in adults who underwent breast cancer surgery found mixed evidence for anxiety and depression as a predictor at 3, 6, and 12 months after surgery.[2] Moreover, as evidence of risk factors summarized in this report could have been measured pre-surgically and post-surgically, there may be effects of temporal confounding. Even acute versus chronic post-surgical measurement periods may influence the results differently. Namely, the acute post-surgical period ranges from recovery in the hospital, a period of the greatest intensity of pain and reliance on medication, to rehabilitation at home (for the majority of most patients). Pre-surgical and specific post-surgical time periods are associated with their own combination of clinical considerations that may influence the findings differently. During the early acute post-surgical periods (i.e., hospital recovery), frequent care from health care providers and patient recovery state may introduce observation and recall bias, respectively. For instance, 1 SR investigating CPSP risk factors in adults who underwent total knee arthroplasty found mixed evidence for acute post-surgical pain as a risk factor. However, acute post-surgical pain as a risk factor was measured at various time points and separated into 3 categories: days 1 to 7, days 8 to 14, and week 2 to month 3. The first 2 periods likely included recovery in the hospital; whereas, the latter likely represented a more stable recovery period (i.e., without the need for hospital care). In addition, the included evidence with various follow-up (measurement) time points was susceptible to attrition bias. If the analysis of these studies were only performed among those with CPSP, there was an increased risk of attrition bias and reduced samples as less people will

experience pain at these time points. For instance, a few of the studies listed in Appendix 3 did not perform regression analyses at later time points because the samples were too small.

Other considerations include the use of various tools to measure pain and the administration of these tools in different languages of which, many were self-reported tools. In general, interpreting evaluations of pain require the consideration of inherent limitations of pain perception, which is subjective and often measured with self-reported measures. Pain perception is further complicated by the localization and intensity; namely, pain may be present in 1 location, multiple locations, or systemic — felt throughout the entire body. When pain is systemic or present in multiple locations this may influence the intensity; additionally, pain intensity can vary in different locations as well. The inclusion of evidence informing the summaries in this report were a mix of presence and intensity self-reported ratings, which introduces heterogeneity and is at high risk of recall bias. Namely, among the SRs there could have been studies administering scales in different languages that were not reported. It is understandable that different tools exist and are used and validated in clinical practice; however, not all scales of the summarized evidence or the language in which the scale was administered were confirmed to be validated (e.g., scales may be validated in 1 language but not another). Given the semantics of language and related cultural and societal factors that may influence pain, there may be considerable heterogeneity in the amount of confounding and bias introduced by the use of different tools across various languages. Additionally, scales have different rating systems and score ranges to represent different levels of pain; thus, without the use of equivalence scores or standardization, the use of different pain scales may not be meaningful. For instance, in 1 of the included observational studies that investigated the use of QST to identify patients at risk for CPSP among adults who underwent robot-assisted hysterectomy, a Danish questionnaire that was validated in a study of 10 patients for hysterectomy of benign indications was used.[18] This was a single-centre study in Denmark; therefore, the use of a Danish-language questionnaire may be feasible for this study population. However, the questionnaire was validated for benign indications whereas, this study[18] included patients with endometrial cancer. Therefore, the Danish-language questionnaire may not be appropriate for this single-centre study and its ability to identify CPSP compared to other validated scales used within the evidence informing the summaries of this report is unknown.[18] Overall, the included evidence in this report does not discuss socioeconomic and cultural factors in great detail, which is an important consideration of chronic pain or CPSP as some populations experience inadequate access to care due to systemic barriers and these factors can influence pain manifestation (i.e., cause of pain and features of pain such as intensity and location) and perception (i.e., experience of pain specific to an individual).[3] Among 8 SRs, 1 SR[10] reported on socioeconomic and cultural factors; namely, there was an unclear association regarding marital status, household size, and income and an unlikely association for full-time employment, low education levels, and race, but the specific race was not specified. As this was an SR, the demographics of the population informing these findings are not clear. Similarly, the included evidence did not assess the risk of CPSP in the context of rural health care. Rural health care may be associated with a reduction in the quantity of resources and the timeliness of accessing care, which could potentially increase the risk of developing CPSP.

Conclusions and Implications for Decision- or Policy-Making

This CADTH report was informed by 1 literature search and 1 rapid scan of the literature and summarized 8 SRs reporting evidence-based risk factors of CPSP and 9 pre-surgical screening tools or assessments for identifying patients who are at increased risk of developing CPSP. In this report, 19 risk factors were summarized and categorized as biologic (age, sex, race, health status, and body mass index), psychological or mental health-related (anxiety, depression, catastrophizing [pain or general], optimism, psychological distress, kinesiophobia, and other mental health-related factors), socioeconomic (social factors [e.g., support] and education, employment, household-related, and income), and pain level or function (pre-surgical pain, acute post-surgical pain, knee function [total knee replacement in adults], disability [lumbar disc herniation in adults and pediatric patients], and scoliosis specific factors [pediatric patients]). Anxiety followed by catastrophizing (pain or general) and depression were the most commonly investigated risk factors among SRs of adults undergoing various surgery types, surgery for breast cancer, and total knee and total hip replacements; pediatric patients undergoing various surgery types; and adult and pediatric patients undergoing surgery for lumbar disc herniation. Pre-surgical screening tools or assessments to identify individuals at risk for CPSP were categorized as QST, clinical scales validated for other conditions, and screening tools. Various QST measures were investigated and categorized as mechanical sensory testing (e.g., mechanical pain intensity/threshold, pressure pain threshold, pain detection threshold), thermal sensory testing (e.g., heat, warm stimuli), cold stimuli sensory testing, electrical sensory testing, temporal summation of pain, conditioned pain modulation, and pain threshold evaluations elicited by a sphygmomanometer. Cold stimuli sensory testing and thermal (heat stimuli) sensory testing were the only measures to have consistent overall findings; namely, 2 included studies of this report found no associations with CPSP for cold stimuli sensory testing and 4 studies reported mixed findings for associations with CPSP for thermal sensory testing. The remaining QST measures generally reported mixed findings for the ability to predict CPSP or no associations between the QST measure and CPSP. The HADS and TSK were not found to predict CPSP.[20,21] The use of a sphygmomanometer to elicit a pain threshold evaluation, modified TSK with 13-items (i.e., only the positively scored items), and the Presurgical Psychological Screening algorithm and Pediatric Pain Screening tool (2 screening tools) were concluded to predict CPSP in adults who underwent total knee arthroplasty, pediatric patients who underwent orthopedic or general surgery, pediatric patients who underwent major musculoskeletal surgery, and adults who underwent spine surgery, respectively.[15,20,22,23] However, these were all investigated by 1 study; thus, the generalizability of these findings is unknown.

Altogether, the evidence was generally mixed and associated with methodological limitations and limited generalizability. Risk factors that are consistently associated with CPSP (i.e., serve as risk factors across all surgery types and age groups) were not identified. Further, within a surgery type and age group, conclusions could not be made to identify risk factors with consistent high-quality evidence as well, which is likely attributed to the small number of studies informing these surgery-age categories. Similarly, the pre-surgical assessments and tools may not be generalizable to clinical practice. Overall, this is not a comprehensive SR; thus, the findings summarized in this report should be interpreted in the specific context they were investigated and not generalized across surgery types or extrapolated to time points that were not investigated. Accordingly, the mixed or inconclusive evidence of risk factors

and screening tools or assessments related to CPSP may be reflective of the absence of risk factors and screening tools or assessments that are common across or useful to administer in all patients and all surgery types (i.e., one size fits all) or may be due to the methodological limitations of this report and in included studies. Future studies that are well designed are needed as it still remains unclear if there are particular risk factors or pre-surgical screening tools or assessments related to CPSP that can be applied to the general population and/or specific surgery types. Future research could consider using specific definitions of CPSP and restrict evaluations of CPSP to validated scales. Namely, the measure of intensity or presence and reference period of pain (e.g., previous day or week) should be specified. Additionally, if multiple measurement time points are used, findings should be separated for the various time points and combined if it is appropriate. However, combined results should be reported in light of potential effects of temporal confounding. Although there was a considerably large volume of studies investigating risk factors of CPSP, there is still a need for future research of higher quality well-designed studies that investigate CPSP with a greater focus on a particular surgery type or surgical specialty and that consist of a study population that is more similar in characteristics such as medical history (e.g., diagnosis and severity of symptoms) to minimize confounding. As the identified studies were generally heterogenous with regard to the study population and surgery type, limitations of risk of bias and confounding may contribute to the mixed findings of this report. Namely, some risk factors are likened to a certain surgery type or surgical specialty, which warrants the focused research approach. Alternatively, identifying risk factors that may be relevant across the general population is useful as well. However, investigations that combine various surgery types may not result in clear conclusions due to confounding from surgical factors specific to certain types such as severity of surgical indication, invasiveness of surgical procedure, and recovery period considerations. Research related to CPSP that combines surgery types if it serves a logistic purpose such as to represent real-world practice rather than to increase sample size may be helpful in certain circumstances. For instance, combining all surgical procedures at a tertiary care centre to investigate CPSP in a tertiary care setting would be informative. Nevertheless, there are always considerations of confounding and limitations when combining surgery types and accordingly patient groups of different health contexts; therefore, the proportions of various surgery types should be equal or representative of clinical practice to be helpful for drawing conclusions and for CPSP decision-making. Alternatively, there was not a large body of evidence of pre-surgical assessments or tools to identify patients at risk for CPSP. This reflects a potential evidence gap and a particular need for this research as it may help to increase clinical efficiency and optimize health care utilization through better preparedness. Moreover, among the summarized evidence in this report and the articles listed in the Appendix there was a large volume of studies related to orthopedic surgeries, if this is an appropriate reflection of existing literature, there is a need for more literature of other surgery types.

Additionally, studies that focus on populations with known health inequity concerns are important to understanding the experience of pain and risk factors for CPSP from those perspectives. Populations experiencing social inequities and discrimination are of considerable importance in Canadian policy and health care decision-making. These populations may include Indigenous peoples, people with an economic disadvantage (e.g., those experiencing poverty and/or non-stable housing, low-income), ethnic and/or immigrant communities, those with stigmatized health conditions (e.g., HIV, severe mental illness, addiction) and/or chronic health conditions, and women or other gender identities (i.e., identities other than cisgender men).[5] Pain perception and development of pain is related to biologic factors but also substantially influenced by psychological, social, and cultural

factors. This requires a tailored approach to pain prevention, management, and diagnosis to best meet the needs of individuals who may develop chronic pain or individuals with chronic pain. Namely, a tailored approach that integrates social and cultural needs are particularly important for those who experience systemic disadvantage and health inequities. Therefore, well-designed studies specific to these populations would help appropriately understand specific considerations related to chronic pain and CPSP from those perspectives.

Overall, chronic pain including CPSP, elicits a significant burden on health care systems and this burden is compounded by the ongoing opioid epidemic; therefore, there is a considerable need for high-quality, generalizable, and informative evidence reflective of particular health jurisdictions. Notably, there is a need for Canadian-specific evidence. As this report highlights the current evidence that exists in the literature and summarizes the associated findings, this report can contribute to the development of future research projects regarding the prevention of CPSP. Based on this review of the literature, anxiety, catastrophizing (pain or general), and depression were the most reported risk factors, which suggests that psychological factors are more frequently investigated and there is a particular research need for identifying biologic and socioeconomic and cultural risk factors of CPSP. Moreover, QST was most frequently investigated among the included evidence in this report, but the findings were generally inconclusive except for the use of cold stimuli, which was found to not be associated with CPSP among 2 studies. Moreover, in terms of efficiency, it may be practical to assess the validity of pre-existing clinical scales that encompass biologic, psychological, and socioeconomic and cultural factors for its use to assess CPSP. This report identified validation studies of the HADS and TSK, but many other clinical scales exist. Altogether, additional research is needed for more relevant and informative evidence to facilitate decision- and policy-making regarding risk factors and pre-surgical screening tools or assessments related to CPSP. Of note, CADTH has also conducted previous work on the prevention of CPSP, including a Rapid Response report in 2021 pertaining to screening tools for CPSP, which is available on the CADTH website (Screening Tools for Chronic Post-Surgical Pain (cadth.ca)).[24]

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Appendix 1: Characteristics of Included Publications

Table 3: Characteristics of Summarized SRs Informing Evidence-Based Risk Factors of CPSP

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
Giusti et al. (2021)[8]	Evaluating the role of psychosocial predictors of CPSP	• Arthroscopic rotator cuff repair • Total shoulder arthroplasty • TKA • Total hip replacement • Ankle and hind foot reconstruction • Lumbar surgery • Anterior cervical decompression with or without fusion • Coronary artery bypass graft with or without valve replacement • Groin hernia treatment • Hysterectomy or other gynecological surgeries • Liver donation • Pelvic laparoscopy • Meniscectomy • Mixed surgeries[b]	• Exclusion criterion of studies with no focus on adult participants. • Mean = 60.2	• VAS; VAS neck; VAS arm; VAS scores of > 3, > 14, > 11, > 0 • BPI; BPI scores of > 3 and > 4 • BPI-WPI • NRS; NRS walking > 3; NRS > 4; NRS increase • OKS pain • KOOS, KOOS pain score • SF-36-BP • MPQ[c] • PROMIS-P • KSS • WOMAC	• NR. Inclusion criterion of studies with a follow-up duration of at least 3 months[d]
McCowat et al. (2019)[2]	Identify psychological predictors of chronic pain following breast cancer surgery (and acute pain not included in this report)	Surgical breast cancer interventions: • Mastectomy or wide local excision including lymph node surgery (e.g., lymph node excision, axillary lymph node dissection, sentinel lymph node biopsy)	Inclusion criterion of 18 years or older	NR	"Pain lasting at least 3 months or longer (p.2)"

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
Hruschak and **Cochran (2018)**[11]	Evaluate psychosocial predictors in the transition from acute to chronic pain across various pain conditions in adults including CPSP	• THA and TKA for knee and hip osteoarthritis • Inguinal hernia repair	Range = 30 to 64 years (of all included studies — this range included patients with chronic pain that was not CPSP	NR	NR
Dorow et al. (2017)[13]	Identify sociodemographic, medical, occupational, and psychological risk factors associated with pain intensity following lumbar disc surgery	Surgery for lumbar disc herniation	Range = 12 to 82 years	• VAS (ranging from 0 to 10 or 100) (all studies) • Composite score of 3 scales (NR) for leg and back pain that recorded the most severe pain, least severe pain, and current pain (1 study)	This report focuses on the "medium-term (> 3 months and < 12 months)" and "long-term (≥ 12 months after surgery)". Positive evidence: difference in the number of studies reporting a significant association vs. no significant association, between prognostic factors and pain intensity, was ≥ 3. Preliminary positive evidence: difference in the number of studies reporting a significant association vs. no significant association was 2.
Rabbitts et al. (2017)[14]	Determine pre-surgical biologic (age and sex), medical (baseline pain severity and location) and psychosocial risk factors (anxiety, depression, sleep patterns, and pain catastrophizing of the child [i.e., patient] and anxiety and pain catastrophizing of the parent) associated with CPSP	• Spinal fusion, posterior spinal fusion • Ilioanal pull through • Medial patellofemoral ligament reconstruction (knee) • Osteochondral transplant (donor knee evaluated)	Inclusion criterion of 6 to 18 years of age	Measures of pain intensity • NRS • VAS Measures of quality of life[e] • SRS-22	Prospective studies assessing CPSP 3 to 12 months after surgery were included

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
	(prevalence or severity)	• Major orthopedic and general surgery • Lumbar disk herniation treatment		• SRS-23 • SRS-30 • Short Form-36	
Wylde et al. (2017)[12]	Identify early patient-related post-surgical risk factors for CPSP following total knee replacement	Primary total knee replacement mostly for osteoarthritis	Adults (mean or range and age cut off NR)	• WOMAC Pain • NRS • VAS • Verbal Descriptor Scale • American Knee Society Score pain question	≥ 6 months
Theunissen et al. (2012)[9]	Summarize evidence regarding associations between high levels of pre-surgical pain catastrophizing or anxiety with increased risk of CPSP	Musculoskeletal surgery (18 studies) • Lumbar disc • Lumbar surgery • Knee replacement • Knee arthroplasty, arthroscopic knee surgery • Shoulder (further details NR) • Hip arthroplasty, revision total hip arthroplasty Other types of surgery (11 studies) • Inguinal hernia repair • Hysterectomy • Prostatectomy • Nephrectomy • Breast (further details NR) • Thoracotomy	Adults (mean or range and age cut off NR)	• AAS (pain-related impairment) • Likert – pain intensity or change and pelvic pain affecting daily life • VRS – pain intensity or change • VAS – pain intensity or change and pain relief • BPI (pain intensity NRS scores) • CPSP presence (Macrae criteria) • DPQ (back pain, leg pain) • IASP criteria for Complex Regional	CPSP assessed as pain evaluated at least 3 months after surgery. Pain evaluations were limited to intensity and/or presence of pain or a composite score including pain presence or intensity at 3 months or longer following surgery

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
		• Lump or mastectomy • Lower limb amputation • Various types		Pain Syndrome • MKHQ • MPQ (pain rating index) • PPQ (intensity by VAS, presence rated by yes or no) • Presence of any breast surgery-related pain (yes or no) • Retrospective report of increased or new pain due to surgery • Satisfaction with surgical treatment (content/discontent) • SF-36 (subscale bodily pain) • WOMAC • MPI • Clinical Overall Score (COS; aggregate of pain intensity by VAS, clinical examination, the ODI, and analgesic use) • Poor outcome (aggregate of pain intensity [VAS], pain chart score, poor health) • Surgical outcome	

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
				score (aggregate of pain relief, return to work, medication use, limitation of physical activities)	
Hinrichs-Rocker et al. (2009)[10]	Assessing the relationship between psychosocial predictors and correlates with CPSP	• Hernia (e.g., open inguinal herniorrhaphy) • Knee surgery (e.g., TKA) • Spine surgery (e.g., fusion, decompression, or discectomy of the anterior cervical or lumbar spine) • Breast surgery (e.g., breast cancer treatment) • Thoracotomy • Cholecystectomy • Other surgeries (e.g., cardiac and GI surgery, nephrectomy)	Adults (mean or range and age cut off NR)	• NRS • VAS (0 to 100) • MPQ • WOMAC • SF-36 • UCSF Pain Service Patient Questionnaire • BPI • VDS • VRS • Wisconsin Brief Pain Questionnaire • Pressure pain threshold • Self constructed questionnaire • Multidimensional pain inventory pain interference scale • Health status questionnaire (pain score) • SCL-90-R • Adapted questionnaire (of	Included studies were required to have a minimum follow-up of 3 months and pain was required to last at least 3 months.

Study citation	Objective	Surgery type	Age (mean, range, or inclusion criterion)	Pain assessment tool[a]	CPSP definition time point of CPSP measurement
				the SF-36 and UCSF Pain Service Patient Questionnaire)	

AAS = Activity Assessment Scale; BPI = Brief Pain Inventory; BPI-WPI = Brief Pain Inventory—worst pain intensity; CPSP = chronic post-surgical pain; DPQ = Dallas Pain Questionnaire; GI = gastrointestinal; IASP = International Association for the Study of Pain; KOOS = Knee Injury and Osteoarthritis Outcome Score; KSS = Knee Society Score; MKHQ = Mayo Knee and Hip Questionnaire; MPI = West-Haven Yale Multidimensional Pain Inventory; MPQ = McGill Pain Questionnaire; NR = not reported; NRS = Numerical Rating Scale; ODI = Oswestry Disability Index; OKS = Oxford Knee Score; PPQ = Phantom Phenomena Questionnaire; PROMIS-P = Patient-Reported Outcomes Measurement Information System pain scale; SCL-90-R = Symptom Checklist-90-Revised; SF-36 = 36-Item Short Form Survey; SF-36-BP = 36-Item Short Form Survey — bodily pain subscale; SR = systematic review; SRS = Scoliosis Research Society; THA = total hip arthroplasty; TKA = total knee arthroplasty; UCSF = University of California San Francisco; VAS = Visual Analogue Scale; VDS = verbal descriptor scale; VRS = Verbal Rating Scale; WOMAC = Western Ontario McMaster Osteoarthritis Index.

[a]Pain assessment tools were only extracted if they were clearly reported (e.g., abbreviation defined) in the source publication.

[b]This SR and meta-analysis[8] included 3 studies that investigated "mixed surgeries." It was not reported what constituted the mix.

[c]MPI in source publication.[8]

[d]Authors reported an inclusion criterion of follow-up duration of ≥ 3 months. However, the follow-up duration of studies ranged from 1.5 months to 10 years (median = 6 months). In addition, 1 study was included that assessed pain catastrophizing and post-surgical pain in patients who underwent TKA with a follow-up of 2 to 12 months.

[e]5 of the 7 studies that used quality of life measures to assess pain frequency used validated scores from the pain domains. The remaining 2 studies used a single pain item from the SRS measures to assess pain frequency.

Note that this appendix has not been copy-edited.

Table 4: Characteristics of Studies Informing Pre-Surgical Screening Tools and Assessments for Identifying Patients at Risk of CPSP

Study citation and Study design[a]	Surgery type	Age (mean, range, or inclusion criterion)	Pre-surgical screening tool or assessment	Pain assessment tools	Follow-up period or CPSP definition and/or measurement
Narayanasamy et al. (2022)[22] **Prospective observational study**	Major musculoskeletal surgeries • Posterior spinal fusion for idiopathic scoliosis • Nuss procedure for pectus excavatum	Pediatric patients	Pediatric Pain Screening tool (modified from the 9-item Keele STarT Back Screening Tool) — self-report	Questionnaires completed at 3 to 6 months and 10 to 12 months after surgery • NRS • FDI • PedsQL • pain DETECT questionnaires	CPSP defined as NRS pain score of ≥ 4 based on the previous month or during pain assessment at 6 or 12 months after surgery
Paredes et al. (2021)[16] **SR**	Total joint arthroplasty (primary, unilateral) for osteoarthritis	Adults (age inclusion criterion of ≥ 18 years)	QST • Mechanical sensory testing • Temperature sensory testing (cold and heat [thermal] stimuli) • Electrical sensory testing • Temporal summation of pain • Conditioned pain modulation	Tools to measure pain intensity after surgery • VAS • NRS • WOMAC	CPSP defined as pain that was present ≥ 3 months after surgery CPSP was assessed in 13 studies. Timing of pain assessment ranged from 3 to 18 months after surgery
Petersen et al. (2021)[17] **SR**	Joint-related • TKA • Arthroscopic subacromial decompression • Arthroscopic shoulder surgery • Total knee and hip arthroplasty • Segment spinal surgery Thoracic-related • Thoracic surgery • Surgical correction of funnel chest Abdominal and gynecology-related surgery	Age mean, range, or inclusion criterion NR	QST • Mechanical sensory testing • Temperature sensory testing (cold and heat [thermal] stimuli) • Electrical sensory testing • Temporal summation of pain • Conditioned pain modulation	Tools to measure pain after surgery • Oxford shoulder score • WOMAC • VAS	CPSP defined as pain reported at least 3 months after surgery.

Study citation and Study design[a]	Surgery type	Age (mean, range, or inclusion criterion)	Pre-surgical screening tool or assessment	Pain assessment tools	Follow-up period or CPSP definition and/or measurement
	• Groin hernia repair (laparoscopic and open) • Major abdominal surgery • Gynecologic laparoscopy • Elective abdominal or laparoscopic hysterectomy for benign indications Breast cancer surgeries				
Carreon et al. (2020)[21] **Longitudinal cohort**	Lumbar spine surgery	Adults (age inclusion criterion NR but range of means of study groups was 55.71 to 60.83)	HADS — self-report	Tools used for correlation investigations of HADS and HRQoL scores: • VAS for back and leg pain • ODI • SF-36 ◦ Physical composite summary score ◦ Mental composite summary score • EQ-5D-3	1-year follow-up
van Helmond et al. (2020)[19] **SR**	• Orthopedic • Gynecologic • Abdominal • Thoracic • Lumbar discectomy • Other	"No restrictions were placed on the population of study (p.1147)"[19] Mean age of patients in included studies ranged from 19 to 71[b]	QST • Mechanical sensory testing • Thermal sensory testing (heat stimuli) • Electrical sensory testing • Temporal summation of pain • Conditioned pain modulation	Tools to measure pain after surgery • VAS • NRS • WOMAC • AAS	Post-surgical pain assessed at ≥ 3 months after surgery
Lunde et al. (2020)[18] **Prospective, observational cohort**	Robot-assisted laparoscopic hysterectomy and bilateral salpingo-oophorectomy for treatment of	Adults (age inclusion criterion of 18 to 85 years)	QST • Mechanical sensory testing • Thermal sensory testing	Questionnaire mailed to patients 6 months after surgery (identify CPSP patients): • Danish-language	CPSP defined as moderate to severe (mean VAS score ≥ 3), persistent pain presenting on a daily

Study citation and Study design[a]	Surgery type	Age (mean, range, or inclusion criterion)	Pre-surgical screening tool or assessment	Pain assessment tools	Follow-up period or CPSP definition and/or measurement
	endometrial cancer		(heat stimuli) • Temporal summation of pain • Conditioned pain modulation	Questionnaire (32 questions) to measure CPSP following hysterectomy for benign indications developed by Brandsborg et al. (2007)[25] — validated in a pilot study of 10 patients (NR if self-reported) Pain measurement QST assessments: • Electronic VAS connected to the cuff pressure algometer to measure various QST outcomes (e.g., temporal summation of pain and pain detection threshold)	basis at 6 months after surgery
Rosenbloom et al. (2020)[20] **Non-randomized[c]**	General surgery • Thoracotomy • Thoracoabdominal • Nuss/Ravitch pectus repair • Sternotomy • Laparotomy • Laparoscopic-assisted: colectomy, ileostomy, J-pouches Orthopedic surgery • Osteotomy • Surgery for scoliosis • Plate insertion tibial/femur	Children and adolescents (age inclusion criterion of 8 to 17 years)	TSK — self-report	Tools used to investigate the predictive validity of the TSK: • FDI • PPIS	12 months after surgery
Marek et al. (2019)[23] **Validation study**	Orthopedic (spine surgery) • Spinal fusion • Artificial Disc Replacements • Laminectomy/	Mean age = 47.17 years	Pre-surgical Psychological Screening algorithm—review of medical records, psychometric testing,	Tools used to validate the algorithm: • ODI • MMPI-2-RF • PAIRS	Data reported from the 5-month follow-up (note: study is ongoing).

Study citation and Study design[a]	Surgery type	Age (mean, range, or inclusion criterion)	Pre-surgical screening tool or assessment	Pain assessment tools	Follow-up period or CPSP definition and/or measurement
	Discectomy/ Decompression Discogram/ Discography • Hybrid • Rhizotomy • Hardware Removal		and diagnostic interview		
Bar Ziv et al. (2016)[15] **Prospective cohort study**	TKA	Adults (age range = 56 to 88 years)	Sphygmomanometer Pain Test (QST — pain threshold evaluation)	Grading pain stimulus: VAS scale (100 mm) (self-report) Tools to measure pain after surgery: pain, limb alignment, knee stability, and range of motion were measured to calculate • KSSs • KSFs	Last follow-up time point (at least 2 years following surgery)

AAS = Activity Assessment Scale; CPSP = chronic post-surgical pain; EQ-5D-3 = EuroQol-5 Dimensions-3 Level; FDI = Functional Disability Index; HADS = Hospital Anxiety and Depression Scale; HRQoL = health-related quality of life; KSS = Knee Society score; KSF = Knee Society function score; MMPI-2-RF = Minnesota Multiphasic Personality Inventory–2–Restructured Form; NR = not reported; NRS = Numerical Rating Scale; ODI = Oswestry Disability Index; PAIRS = Pain and Impairment Relationship Scale; PedsQL = Pediatric Quality of Life measure; PPIS = PROMIS-Pediatric Pain Interference Scale; QST = quantitative sensory testing; SF-36 = 36-Item Short Form Survey; SR = systematic review; TKA = total knee arthroplasty; TSK = Tampa Scale for Kinesiophobia; VAS = visual analogue scale; WOMAC = Western Ontario McMaster Osteoarthritis Index.

[a]Study design based on the author of the publication's designation of the study design.

[b]One included study had a population with a range of 17 to 23.

[c]Rosenbloom et al. (2020) did not specify the study design, authors of this report designated the non-randomized study design.[20]

Appendix 2: Additional Findings of Included Publications

Note that this appendix has not been copy-edited.

Evidence-Based Risk Factors in Adults

Various Surgery Types

Three SRs[8-10] were included to summarize evidence-based risk factors in adults among various surgery types. Giusti et al. (2021) performed narrative data syntheses (i.e., summarized results) and random-effects meta-analyses.[8] Theunissen et al. (2012) performed random-effects meta-analyses.[9] Hinrichs-Rocker et al. (2009) categorized predictors or correlates of CPSP to have a likely association, unclear association, and unlikely association.[10] Giusti et al. (2021) and Theunissen et al. (2012) included studies that evaluated risk factors before surgery.[8,9] No inclusion criterion regarding when risk factors were evaluated was reported in the SR by Hinrichs-Rocker et al. (2009); however, the timeline of measurement (e.g., before or after surgery) and other contextual information were reported (e.g., younger age, female sex).[10] Of note, Giusti et al. (2021) reported an inclusion criterion of studies with a follow-up duration of ≥ 3 months.[8] However, the follow-up duration of included studies ranged from 1.5 months to 10 years (median = 6 months).[8] In addition, 1 study was included that assessed pain catastrophizing and post-surgical pain in patients who underwent total knee arthroplasty with a follow-up of 2 to 12 months.[8]

Table 3 summarizes the characteristics of the SRs that investigated risk factors of developing CPSP.

Age

Hinrichs-Rocker et al. (2009) reported that it was unclear whether younger age was associated with CPSP.[10]

Sex

Hinrichs-Rocker et al. (2009) reported that it was unlikely for there to be an association between sex (female) and CPSP.[10]

Race

Hinrichs-Rocker et al. (2009) reported that it was unlikely for there to be an association between race and CPSP.[10]

Health Status

Hinrichs-Rocker et al. (2009) reported that it was unclear whether pre-surgical general health and well-being (unclear how this was measured) and post-surgical health status evaluated with the 36-Item Short Form Survey (SF-36) were associated with CPSP.[10]

Anxiety

The narrative synthesis of Giusti et al. (2021) found that state anxiety (anxiety related to a certain context or situation) was consistently associated with CPSP.[8] Whereas the random-effects meta-analysis suggested that state anxiety and CPSP have a low, positive correlation (r [correlation coefficient] = 0.24; 95% CI [confidence interval], 0.14 to 0.33; P < 0.001) — heterogeneity between studies was deemed low (I^2 = 0.09). Similarly, trait anxiety (anxiety as part of personality or more chronic mental state) and CPSP were found to have a low, positive correlation (r = 0.13; 95% CI, 0.09 to 0.1; P < 0.001) — heterogeneity between studies was considered moderate (I^2 = 0.57).[8]

Theunissen et al. (2012) performed meta-analyses for general anxiety and pain-related anxiety among maximum effect and minimum effect scenarios.[9] In the maximum effect scenario, the pooled odds ratio (OR) for general anxiety suggested an increased odds of developing CPSP (OR = 1.76; 95% CI, 1.07 to 2.90). For all other meta-analyses, the CIs crossed 1, which suggests there was no effect of general anxiety (in the minimum effect scenario) and pain-related anxiety (in the maximum and minimum effect scenarios) on developing CPSP. Of note, the authors noted that maximum effect (i.e., highest OR) and minimum effect scenarios (i.e., lowest OR) were used to avoid overrepresentation of studies reporting more than 1 outcome. It was also reported that 10 of 22 included studies (45.5%) and 3 of 9 included studies (33.3%) reported general anxiety and pain-related anxiety, respectively, to have a statistically significant effect on CPSP. Among these significant associations, higher levels of anxiety predicted a worse outcome (presumably CPSP but this was not defined).[9]

Hinrichs-Rocker et al. (2009) reported that it was unclear whether (pre-surgical and post-surgical) anxiety was associated with CPSP.[10]

Depression

The meta-analysis by Giusti et al. (2021) found that depression and CPSP have a low, positive correlation (r = 0.16; 95% CI, 0.12 to 0.19; P < 0.001) — heterogeneity between studies was deemed low (I^2 = 0.44).[8]

Hinrichs-Rocker et al. (2009) reported that (pre-surgical and post-surgical) depression was likely to be associated with CPSP.[10] One study found that pre-surgical depression had a positive relationship with CPSP; namely, those with the most severe CPSP at 1 year after surgery had the most severe levels of pre-surgical depression. However, 1 study found that depression was not predictive of complex regional pain syndrome (specific diagnosable form of chronic pain characterized by damage or dysfunction of peripheral sensory neurons that may develop after surgery or other conditions such as bone fracture) at 3 months and 6 months after surgery.[10,26]

Catastrophizing (Pain or General)

The meta-analysis by Giusti et al. (2021) found that catastrophizing and CPSP have a low, positive correlation (r = 0.19; 95% CI, 0.11 to 0.27; P < 0.001) — heterogeneity between studies was considered high (I^2 = 0.77).[8]

Theunissen et al. (2012) performed a meta-analysis for pain catastrophizing.[9] In the maximum effect scenario, the pooled OR for pain catastrophizing suggested an increased odds of developing CPSP (OR = 2.37; 95% CI, 1.32 to 4.28). In the minimum effect scenario, the pooled OR for pain catastrophizing also suggested an increased odds of developing CPSP (OR = 2.13; 95% CI, 1.26 to 3.59).[9] It was also reported that 5 of 10 included studies (50%) reported pain catastrophizing to have a statistically significant effect on CPSP. Among these significant associations, higher levels of pain catastrophizing predicted a worse outcome (presumably CPSP but this was not defined).[9]

Optimism

The meta-analysis by Giusti et al. (2021) found no correlation between optimism and CPSP (r = −0.12; 95% CI, −0.25 to 0.01; P = 0.07) — there was high heterogeneity between studies (I^2 = 0.81).[8]

Psychological Stress and Distress

The narrative synthesis performed by Giusti et al. (2021) found that psychological distress was consistently associated with CPSP.[8] Of note, psychological distress is a term that describes or refers to non-specific symptoms of depression, anxiety, and stress.[27]

Hinrichs-Rocker et al. (2009) reported that pre-surgical chronic stress, pre-surgical psychological distress, and post-surgical psychological distress were likely to be associated with CPSP.[10] One study found that patients with failed back surgery had higher pre-surgical stress levels and another study found that a normal score on the Distress and Risk Assessment Method was a predictor for a positive outcome for patients with arm and neck pain. Of note, the rating to constitute a normal score, the type of surgical procedure, and when the assessment was performed were not reported.[10]

Kinesiophobia

The meta-analysis by Giusti et al. (2021) found that kinesiophobia and CPSP have a low, positive correlation (r = 0.13; 95% CI, 0.04 to 0.22; P < 0.001) — heterogeneity between studies was considered low (I^2 = 0.02).[8] However, the narrative synthesis suggested that kinesiophobia is not associated with CPSP from high-quality studies (quality assessments performed by the authors of this SR).[8]

Other Mental Health-Related Factors

The meta-analysis by Giusti et al. (2021) found that mental health (disorder not reported) and CPSP have a low, negative correlation (r = −0.17; 95% CI, −0.23 to −0.11; P < 0.001) — there was no heterogeneity between studies (I^2 = 0.00).[8]

Hinrichs-Rocker et al. (2009) reported that it was unclear whether low mental health care was associated with CPSP.[10]

Social Factors

Hinrichs-Rocker et al. (2009) reported that it was unclear whether social support from supervisor and co-workers and too much social support from spouse were associated with CPSP.[10]

Education, Employment, Household-Related Factors, and/ or Income

Hinrichs-Rocker et al. (2009) reported that it was unlikely for there to be an association between full-time employment and low education levels and CPSP.[10] Several studies (number not reported) demonstrated a correlation between late return to work and CPSP; thus, Hinrichs-Rocker et al. (2009) concluded that late return to work was associated with CPSP.[10] Whereas Hinrichs-Rocker et al. (2009) reported that it was unclear whether marital status, household size, and income were associated with CPSP.[10]

Surgical Breast Cancer Interventions

One SR was included to summarize evidence-based risk factors in adults who received surgical interventions for breast cancer.[2] Meta-analyses were not performed and studies were only included if they evaluated risk factors before surgery.

Anxiety

McCowat et al. (2019) found mixed findings of pre-surgical anxiety as a predictor of CPSP at various time points following surgery.[2] At 3 months after surgery, 1 study found that pre-surgical state anxiety increased the odds of CPSP with a weak association (OR = 1.08; 95% CI, 1.01 to 1.15). At 6 months after surgery, 1 study found a significant correlation between CPSP and state anxiety (r = 0.17) and trait anxiety (r = 0.23) with weak associations. However, multiple (other) studies did not find associations between pre-surgical anxiety and CPSP at 3 months, 6 months, or 12 months after surgery. Moreover, anxiety assessed with the Functional Assessment of Cancer Treatment-Emotional Scale did not predict CPSP.[2] Based on the SR by McCowat et al. (2019), the mixed findings cannot conclude if pre-surgical anxiety is a risk factor for CPSP in adults undergoing surgical breast cancer interventions.[2]

Depression

McCowat et al. (2019) found mixed findings of pre-surgical depression as a predictor of CPSP at various time points following surgery.[2] At 3 months after surgery, 1 study found a weak correlation (r = 0.17). Multiple (other) studies did not find associations between pre-surgical depression and CPSP at 3 months, 6 months, or 12 months after surgery. Moreover, low mood assessed with the Functional Assessment of Cancer Treatment-Emotional Scale did not predict CPSP.[2] Based on the SR by McCowat et al. (2019), the mixed findings cannot conclude if pre-surgical depression is a risk factor for CPSP in adults undergoing surgical breast cancer interventions.[2]

Pain Catastrophizing

McCowat et al. (2019) reported that 1 study found no associations between pain catastrophizing and CPSP at any time point following surgery to treat breast cancer.[2]

Psychological Stress and Distress

McCowat et al. (2019) reported that 1 study found that pre-surgical distress significantly increases the odds of CPSP at 8 months (OR = 2.05; 95% CI, 1.18 to 3.56) after surgery to treat breast cancer.[2]

Orthopedic Surgeries — Total Knee and Total Hip Arthroplasty (Replacement)

Two SRs were included to summarize evidence-based risk factors in adults who received total knee or total hip arthroplasties (replacements). The SR by Wylde et al. (2017) included adults who underwent primary total knee replacements (mostly for the indication of osteoarthritis).[12] The SR by Hruschak and Cochran (2018) investigated CPSP among different surgeries but the evidence informing this report was specific to adults who underwent total hip and knee arthroplasties for hip and knee osteoarthritis, respectively.[11] No inclusion criterion regarding when risk factors were evaluated was reported for the SR by Hruschak and Cochran (2018); however, data summarized in this report were specified to be evaluated after surgery (i.e., post-surgical anxiety). The SR by Wylde et al. (2017) evaluated post-surgical risk factors.[12] Meta-analyses were not performed for these SRs.

Anxiety

Hruschak and Cochran (2018) reported that 1 study demonstrated a predictive role of post-surgical anxiety in the development of moderate to severe CPSP after total knee arthroplasty and total hip arthroplasty.[11] Similarly, Wylde et al. (2017) reported that 1 study found that patients with greater anxiety at 48 hours after total knee replacement were associated with a higher risk of CPSP defined as a NRS pain score greater than 3 at 4 to 6 months after surgery.[12] Based on these 2 SRs,[11,12] post-surgical anxiety may be a risk factor of CPSP in adults undergoing total knee arthroplasty and total hip arthroplasty.

Depression

Wylde et al. (2017) reported that 1 study found depression to be a risk factor for global CPSP but not night CPSP following total knee replacement.[12]

Catastrophizing

Wylde et al. (2017) reported that 1 study demonstrated that catastrophizing, at a previous point in time, was a risk factor for night CPSP but not global CPSP following total knee replacement.[12]

Kinesiophobia

Wylde et al. (2017) reported that 1 study found that patients reported more pain at 6 months following total knee replacement when they had high fear of movement versus low fear of movement at 2 weeks post surgery.[12]

Social Factors

Wylde et al. (2017) reported that 1 study assessing risk factors at 6 weeks after surgery found that perceived positive social support was associated with less chronic pain and negative social support with more chronic pain at 6 months after total knee replacement.[12]

Acute Post-surgical Pain

Wylde et al. (2017) evaluated acute post-surgical knee pain, defined as pain during the first 3 months after total knee replacement, as a risk factor for CPSP and found mixed results at various time points following surgery.[12] During acute pain post-surgical days 1 to 7, 3 studies found a positive relationship between acute post-surgical pain and CPSP at 6 to 12 months following total knee replacement (i.e., more severe acute post-surgical pain was associated with more severe CPSP). Of note, this association did not remain following adjustment for pre-surgical pain in 1 study. Another study found no association between acute post-surgical pain at 42 hours after surgery and CPSP at 4 to 6 months. During acute pain post-surgical days 8 to 14, no associations between acute post-surgical pain and CPSP were found based on 3 studies with risk of bias due to missing data or failure to control for confounding. During acute pain post-surgical week 2 to month 3, 1 study found that neuropathic pain, measured at 6 weeks after surgery, was moderately associated with pain at 39 to 51 months after surgery. Similarly, another study found global pain and night pain at 1 month and 3 months post surgery, respectively, to be associated with global pain and night pain at 6 months and 12 months. However, 1 study (single-centre with risk of bias) found that pain severity at 8 weeks post surgery was associated with pain at 6 months post surgery when assessed with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) but not the VAS. Another study found that pain severity assessed on day 30 post surgery was associated with pain severity at 6 months but not 12 months after surgery. The same study found that pain assessed at 3 months post surgery was not associated with pain severity at 6 and 12 months following surgery. Based on the SR by Wylde et al. (2017), the mixed findings cannot conclude if acute post-surgical pain is a risk factor for CPSP in adults undergoing total knee replacement.[12]

Knee Function

Wylde et al. (2017) evaluated post-surgical knee function following total knee replacement as a risk factor for CPSP and found mixed results at various time points following surgery.[12] No associations were found between CPSP and knee range of motion at discharge and ambulatory status at discharge (2 studies each evaluated these outcomes). One study assessed the association between CPSP with WOMAC pain scores at 6 months after surgery and knee function evaluated at 2 weeks and 8 weeks after surgery. An association was found between CPSP and WOMAC function score at 2 weeks but no association was found for WOMAC function score at 8 weeks. No association was found between CPSP and stair ascent (i.e., climb) speed at 2 and 8 weeks. Whereas an association was found

between CPSP and a 6 minute walk test at 2 weeks and 8 weeks.[12] Based on the SR by Wylde et al. (2017), the mixed findings cannot conclude if post-surgical knee function is a risk factor for CPSP in adults undergoing total knee replacement.[12]

Evidence-Based Risk Factors in Pediatric Patients

Various Surgery Types

One SR was included to summarize evidence-based risk factors in pediatric patients (i.e., inclusion criterion of 6 to 18 years of age) among various surgery types (e.g., major orthopedic and general surgery).[14] Only risk factors evaluated before surgery were summarized and meta-analyses were not performed.

Age

Rabbitts et al. (2017) reported that 1 study found no association between age and CPSP assessed as the presence of moderate or severe pain at 6 months and 12 months after surgery in pediatric patients.[14] Two other studies also found no association between age and CPSP but these studies may have included data collected at time points of less than 3 months following surgery. One study assessed CPSP as the rate of typical improvement and highest pain over 6 months and the other study based CPSP on a statistically modelled trajectory of pain over 12 months.[14]

Sex

Rabbitts et al. (2017) reported that 1 study found no association between sex and CPSP assessed as the presence of moderate or severe pain at 6 months and 12 months after surgery.[14] Two other studies also found no association between sex and CPSP but these studies may have included data collected at time points of less than 3 months following surgery. One study assessed CPSP as the rate of typical improvement and highest pain over 6 months and the other study based CPSP on a statistically modelled trajectory of pain over 12 months.[14]

Body Mass Index

Rabbitts et al. (2017) reported that 1 study found that pre-surgical body mass index was not associated with CPSP. Of note, CPSP was measured as the rate of typical improvement and highest pain over 6 months.[14]

Risk Factors Specific to Scoliosis

Rabbitts et al. (2017) reported that 1 study found that the scoliosis severity based on the Cobb angle and time since scoliosis diagnosis were not associated with CPSP.[14] Of note, CPSP was measured as the rate of typical improvement and highest pain over 6 months.[14]

Pain Catastrophizing

Rabbitts et al. (2017) reported that 1 study found that pre-surgical pain catastrophizing of the parent was associated with CPSP; however, pain catastrophizing of the child (i.e., patient) was not associated with CPSP.[14] Of note, CPSP was based on a statistically modelled trajectory of pain over 12 months.[14]

Pre-Surgical Pain

Rabbitts et al. (2017) evaluated pre-surgical pain as a risk factor for CPSP and found mixed results; 1 study found significant associations between pre-surgical pain and CPSP and another study did not find significant associations.[14]

Evidence-Based Risk Factors in Adults and Pediatric Patients

Surgery for Lumbar Disc Herniation

One SR was included to summarize evidence-based risk factors in adult and pediatric patients (i.e., age range of all included studies was 12 to 82 years of age) who underwent surgery for lumbar disc herniation.[13] Inclusion criterion regarding when risk factors were evaluated was not reported; thus, unless specified it was not clear whether they were evaluated before or after surgery. Meta-analyses were not performed.

Age

Dorow et al. (2017) found that the included evidence of this SR suggests that age may be associated with CPSP.[13] Namely, the number of studies documenting a significant association between age and CPSP intensity outweighed the number of studies reporting no significant association by 2. One study found that older age was associated with more intense pain over the medium post-surgical term. Another study found that age had no influence on CPSP in the long term (12 months or more after surgery). Based on the SR by Dorow et al. (2017), the mixed findings may conclude that age is a risk factor for CPSP in patients undergoing surgery for lumbar disc herniation in the medium post-surgical term (period beyond 3 months but less than 12 months) but not the long-term (12 months or more).[13]

Anxiety

Dorow et al. (2017) found that the included evidence of this SR suggests that anxiety may be associated with CPSP.[13] Namely, the number of studies documenting a significant association between anxiety and CPSP intensity outweighed the number of studies reporting no significant association by 2. One study found that higher levels of anxiety were associated with stronger pain over the medium post-surgical term (beyond 3 months but less than 12 months after surgery) and long post-surgical term (12 months or more after surgery).[13]

Depression

Specific to leg and back pain intensity, Dorow et al. (2017) found that the included evidence of this SR suggests that depression is associated with CPSP.[13] Namely, the number of studies documenting a significant association between depression and CPSP intensity outweighed the number of studies reporting no significant association by 3 or more. Higher levels of depression had an impact on pain intensity in the medium post-surgical term (beyond 3 months but less than 12 months after surgery) and long post-surgical term (12 months or more after surgery).[13]

Pain Catastrophizing

Dorow et al. (2017) found that the included evidence of this SR suggests that pain catastrophizing may be associated with CPSP. Namely, the number of studies documenting a significant association between pain catastrophizing and CPSP intensity outweighed the number of studies reporting no significant association by 2. Pain catastrophizing was significantly associated with worse pain in the medium post-surgical term (beyond 3 months but less than 12 months after surgery).[13]

Kinesiophobia

Dorow et al. (2017) found that the included evidence of this SR suggests that kinesiophobia may be associated with CPSP.[13] Namely, the number of studies documenting a significant association between kinesiophobia and CPSP intensity outweighed the number of studies reporting no significant association by 2. Kinesiophobia was significantly associated with worse pain in the medium post-surgical term (beyond 3 months but less than 12 months after surgery).[13]

Pre-Surgical Pain

Dorow et al. (2017) found that the included evidence of this SR suggests that pre-surgical pain is associated with CPSP during the medium post-surgical term (i.e., period beyond 3 months but less than 12 months).[13] Namely, the number of studies documenting a significant association between pre-surgical pain intensity and CPSP intensity outweighed the number of studies reporting no significant association by 3 or more. During the long post-surgical term (12 months or more after surgery), stronger pre-surgical pain was associated with more intense back pain; however, evidence for post-surgical leg pain was conflicting. Based on the SR by Dorow et al. (2017), the mixed findings may conclude that pre-surgical pain is a risk factor for CPSP in patients undergoing surgery for lumbar disc herniation in the medium post-surgical term (period beyond 3 months but less than 12 months) but not during the long-term (12 months or more).[13]

Disability

Specific to leg and back pain intensity, Dorow et al. (2017) found that the included evidence of this SR suggests that disability is associated with CPSP.[13] Namely, the number of studies documenting a significant association between disability and CPSP intensity

outweighed the number of studies reporting no significant association by 3 or more. Greater levels of disability (it was not reported how this was measured) was associated with more intense pain in the long post-surgical term (12 months or more after surgery).[13]

Presurgical Screening Tools or Assessments

Nine articles were identified to summarize the use of pre-surgical screening tools or assessments to identify patients who are at increased risk of developing CPSP. Five studies reported on QST with 1 cohort study reporting specifically on the use of a sphygmomanometer to assess pain thresholds in adults who underwent total knee arthroplasty.[15] The other 4 studies included the following investigations: SR of total joint arthroplasty (primary, unilateral) for osteoarthritis in adults[16]; SR of joint-related, thoracic-related, abdominal and gynecology-related and breast cancer surgeries in an unknown age group (not reported)[17]; cohort study of robot-assisted laparoscopic hysterectomy for adults with endometrial cancer[18]; and SR of orthopedic, gynecologic, abdominal, thoracic, lumbar discectomy, and other (breast cancer surgery and carpal tunnel release) surgeries in a predominantly adult population (1 included study had an age range of 17 to 23).[19] Two studies reported on the use of scales validated for other conditions; namely, the TSK was investigated in children and adolescents who underwent general and orthopedic surgery,[20] and the HADS was assessed in adults who underwent lumbar spine surgery.[21] Two studies reported on the use of screening tools; namely, a Pediatric Pain Screening tool was assessed in pediatric patients who underwent major musculoskeletal surgeries[22] and the Presurgical Psychological Screening algorithm was assessed in adults who underwent orthopedic spine surgery.[23] No meta-analyses of the SRs were performed.

Of note, van Helmond et al. (2020) reported findings separately for each surgery subtype (orthopedic, gynecologic, abdominal, thoracic, lumbar discectomy, and other) and across all surgery subtypes.[19] Across all surgery subtypes, 14 of 24 (58%) studies found a relationship between pre-surgical QST measures and CPSP. The most statistically significant associations were found in evaluations of orthopedic surgery followed by gynecological and abdominal, thoracic, lumbar discectomy, and carpal tunnel release surgeries.[19] Overall, temporal summation of pain, pressure pain threshold, and conditioned pain modulation (all pain-related QST measures) were most frequently reported to be associated with CPSP.

Table 4 summarizes the characteristics of the studies investigating pre-surgical screening tools or assessments to identify patients who are at increased risk of developing CPSP. Namely, it lists the pain assessment tools used to measure pain or to validate the pre-surgical screening tool or assessment of investigation, which were all self-reported evaluations except for the Danish-language questionnaire. This Danish-language questionnaire was used in the investigation of QST in adults who underwent robot-assisted laparoscopy hysterectomy, for which it was not reported if it was self-reported.[18] Among the investigated pre-surgical screening tools or assessments, besides QST, the Pediatric Pain Screening tool[22] was self-reported but the Presurgical Psychological Screening algorithm[23] consisted of a review of medical records, psychometric testing, and a diagnostic interview.

Quantitative Sensory Testing

Mechanical Sensory Testing

Total Joint Arthroplasty in Adults

Paredes et al. (2021) found mixed findings for the predictive role of mechanical sensory testing for pain following total joint arthroplasty; thus, its predictive ability remains unclear.[16] Namely, 1 study found no association between mechanical pain intensity and post-surgical pain at 6 months after total knee arthroplasty and another study found no correlation between mechanical pain threshold and post-surgical pain at 4 months after surgery. Regarding pressure pain threshold (evaluated with a digital algometer), 1 study found a statistically significant association of pain intensity ($r = -0.262$; P value = 0.039) with knee pressure pain threshold at 6 months after surgery; however, a regression analysis did not yield statistically significant results. Another study demonstrated that pressure pain threshold of the forearm was associated with pain measured with the WOMAC at 13 months but no association was found for the knee. Regarding cuff algometry-pain threshold (i.e., cuff pressure tolerance), 1 study found no association with post-surgical pain at 12 months after total knee arthroplasty.[16]

Robot-Assisted Laparoscopic Hysterectomy for Adults

Lunde et al. (2020) used a hand-held algometer to induce the pressure pain threshold (i.e., when the pressure stimulus becomes painful) and found no significant differences between those who developed CPSP and those who did not among lower back, leg, and

arm stimuli.[18] A cuff pressure algometer was used to investigate deep-tissue sensitivity and to induce the pain detection threshold (i.e., pressure that elicited a VAS score greater than 2) and pain toleration threshold (i.e., pain intensity was rated continuously from the first sensation of pain until the sensation of pain was intolerable and required termination of stimulus). No significant differences were found for the pain detection and pain toleration thresholds in those who developed CPSP and those who did not.[18]

Joint-Related, Thoracic-Related, Abdominal and Gynecology-Related, and Breast Cancer Surgeries in Unknown Age Group

Petersen et al. (2021) found that pressure pain and tolerance thresholds were not associated with CPSP.[17] Namely, 3 studies found no significant association between pressure pain threshold and CPSP intensity following breast cancer surgery, total knee arthroplasty, and surgical correction of funnel chest. Three studies found no significant association between pressure pain threshold and presence of moderate to severe CPSP following total knee arthroplasty (2 studies) and segmental spinal surgery. Similarly, 2 studies found that pre-surgical pressure tolerance threshold was not associated with CPSP intensity following major surgery of the abdomen and presence of CPSP following segmental spinal surgery. Moreover, Petersen et al. (2021) found that cuff-induced pain detection and cuff-induced pressure or pain tolerance thresholds were not associated with CPSP intensity among studies of total knee arthroplasty.[17] Namely, 1 study did not find a significant association between pre-surgical cuff-induced pressure pain thresholds and CPSP intensity, and 1 study did not find a significant association between pre-surgical cuff-induced pressure or pain tolerance threshold and CPSP intensity. Petersen et al. (2021) found that mechanical detection and mechanical pain thresholds were not associated with CPSP.[17] Namely, 2 studies found that pre-surgical mechanical detection thresholds were not significantly associated with CPSP intensity following breast cancer surgery and surgical correction of funnel chest.[17] Similarly, 2 studies found that pre-surgical mechanical pain thresholds were not associated with CPSP intensity following breast cancer surgery and total knee arthroplasty. One study found no association between mechanical pain thresholds and presence of moderate to severe CPSP following total knee arthroplasty.[17]

Various Surgeries in Predominantly Adult Population

van Helmond et al. (2020) found that 3 studies reported an association between pressure pain threshold and CPSP.[19]

Thermal Sensory Testing and Cold Stimuli Sensory Testing

Total Joint Arthroplasty in Adults

Paredes et al. (2021) found mixed findings for the predictive role of thermal sensory testing for pain following total joint arthroplasty; thus, its predictive ability remains unclear.[16] Namely, 2 studies did not find statistically significant associations between cold detection and cold pain thresholds and CPSP (time points not reported). Regarding warm detection threshold, 1 study found a significant positive correlation (r = 0.195; P = 0.012) with post-surgical pain at 12 months following total knee arthroplasty; however, warm detection threshold was not found to be a significant predictor when assessed with a linear regression model. Similarly, this same study found a significant positive correlation (r = 0.196; P = 0.012) between heat pain threshold and pain intensity at 12 months after total knee arthroplasty but heat pain threshold was not found to be a predictor with a linear regression model. Moreover, 3 studies did not find a significant association between heat pain threshold and CPSP (time points not reported). Further, 1 study did not find a correlation between suprathreshold heat pain intensity and post-surgical pain 4 months after surgery.[16]

Robot-Assisted Laparoscopic Hysterectomy for Adults

Lunde et al. (2020) administered a heat stimulation to investigate the warm detection threshold and heat pain threshold.[18] Significantly lower heat pain thresholds were found in those who developed CPSP compared with those who did not (range of thresholds = 11.0 to 42.6°C; P = 0.043). However, a decreased heat pain threshold was not found to be an independent risk factor of CPSP with a logistic regression analysis. Further, no significant differences were found for warm detection thresholds in those who developed CPSP versus those who did not.[18]

Joint-Related, Thoracic-Related, Abdominal and Gynecology-Related, and Breast Cancer Surgeries in Unknown Age Group

Petersen et al. (2021) reported mixed findings for the association between warm detection threshold and heat pain threshold with CPSP.[17] One study reported that low warm detection threshold and low heat pain threshold predicted high CPSP intensity after total knee arthroplasty in patients with knee osteoarthritis based on a linear regression model. Whereas 2 studies did not find an association between pre-surgical warm detection thresholds and intensity of CPSP among groin hernia repair surgery and breast cancer surgery. Similarly, 8 studies did not find an association between pre-surgical heat pain thresholds and CPSP intensity in various surgery types

including thoracic surgery, groin hernia repair, arthroscopic surgery of the shoulder, breast cancer surgery, total knee arthroplasty, and segmental spinal surgery. Petersen et al. (2021) reported that none of the included studies found an association with CPSP for cold detection thresholds and cold pain thresholds.[17] Petersen et al. (2021) reported that 2 studies found no statistically significant association between pre-surgical cold detection thresholds and CPSP intensity in total knee arthroplasty and breast cancer surgery.[17] Further, Petersen et al. (2021) reported that 2 studies investigating total knee arthroplasty did not find a significant association between pre-surgical cold pain thresholds with CPSP intensity, and 2 studies investigating thoracic surgery and segmental spinal surgery did not find a significant association between pre-surgical cold pain thresholds with moderate to severe CPSP.[17] Petersen et al. (2021) reported mixed findings for the association between suprathreshold heat and cold stimuli and CPSP.[17] One study found that pre-surgical high pain intensities at suprathreshold heat stimuli predicted the presence of moderate to severe CPSP following hernia repair. However, 1 study investigating thoracic surgery found that pre-surgical suprathreshold heat and cold stimuli were not significantly associated with the presence of moderate to severe CPSP.[17]

Various Surgeries in Predominantly Adult Population

van Helmond et al. (2020) found that 2 studies reported an association between warm detection threshold and CPSP.[19]

Electrical Sensory Testing

Total Joint Arthroplasty in Adults

Paredes et al. (2021) reported that 1 study found that electrical detection and electrical pain thresholds were significantly associated with post-surgical pain, measured at rest, at 18 months after surgery; electrical pain threshold was identified as a significant predictor of pain when a logistic regression model was used.[16]

Joint-Related, Thoracic-Related, Abdominal and Gynecology-Related, and Breast Cancer Surgeries in Unknown Age Group

Petersen et al. (2021) reported mixed findings for the association between electrical stimuli and CPSP.[17] One study found that pre-surgical electrical pain detection threshold was not significantly associated with CPSP intensity following total knee arthroplasty. Whereas another study found that a low pre-surgical electrical pain threshold predicted CPSP intensity following total knee arthroplasty. Similarly, another study found that pre-surgical electrical pain tolerance threshold was not associated with CPSP intensity after major surgery of the abdomen.[17]

Various Surgeries in Predominantly Adult Population

van Helmond et al. (2020) found that 1 study (each) reported an association between electrical pain and electrical detection thresholds and CPSP.[19]

Temporal Summation of Pain

Total Joint Arthroplasty in Adults

Paredes et al. (2021) found mixed findings for the predictive role of temporal summation of pain following total joint arthroplasty; thus, its predictive ability remains unclear.[16] Two studies found an association with CPSP at 12 months after total knee arthroplasty with correlation and linear regression analyses. However, 1 of these studies also performed a multivariate analysis in which temporal summation of pain was not found to be associated. Further, 3 studies found no statistically significant association between temporal summation of pain and CPSP (time points not reported) following total knee arthroplasty.[16]

Joint-Related, Thoracic-Related, Abdominal and Gynecology-Related, and Breast Cancer Surgeries in Unknown Age Group

Petersen et al. (2021) found mixed findings regarding temporal summation of pain.[17] Five studies, in total, found an association between high pre-surgical temporal summation of pain and CPSP intensity following total knee arthroplasty investigated with mechanical stimuli (3 studies) and presence of moderate to severe CPSP with mechanical stimuli in total knee arthroplasty (1 study) and abdominal or laparoscopic hysterectomy (1 study). Whereas, 3 studies, in total, found no association between pre-surgical temporal summation of pain and CPSP intensity following total knee arthroplasty with cuff stimuli (1 study) and arthroscopic shoulder surgery with heat stimuli (1 study) and presence of moderate to severe CPSP following breast cancer surgery (1 study, stimuli type not reported).[17]

Robot-Assisted Laparoscopic Hysterectomy for Adults

Lunde et al. (2020) used a cuff pressure algometer to investigate temporal summation of pain.[18] No significant differences were found for temporal summation of pain between those who developed CPSP and those who did not.[18]

Various Surgeries in Predominantly Adult Population

van Helmond et al. (2020) found that 4 studies reported an association between temporal summation of pain and CPSP.[19] Among the various QST parameters evaluated in this SR, temporal summation of pain was the only measure that was associated with more significant than non-significant associations with CPSP.[19]

Conditioned Pain Modulation

Total Joint Arthroplasty in Adults

Paredes et al. (2021) found mixed findings for the predictive role of conditioned pain modulation following total joint arthroplasty; thus, its predictive ability remains unclear.[16] Namely, 1 study found a statistically significant association between conditioned pain modulation (with cuff pressure tolerance as the stimulus) and post-surgical pain, measured at rest, at 6 months after surgery ($r = 0.57$, $P = 0.035$). However, in the same study, no significant association was found for peak pain levels, pain measured during movement, or when using pain threshold as the test stimulus. Further, 1 study and 2 studies did not find statistically significant associations with conditioned pain modulation and post-surgical pain at 6 and 12 months after surgery, respectively.[16]

Joint-Related, Thoracic-Related, Abdominal and Gynecology-Related, and Breast Cancer Surgeries in Unknown Age Group

Petersen et al. (2021) reported mixed findings regarding conditioned pain modulation.[17] Namely, associations between pre-surgical impaired conditioned pain modulation and CPSP intensity was found in 1 study after thoracic surgery with the conditioning stimuli as hot water and another study following major surgery of the abdomen with cold water. No association was found between pre-surgical conditioned pain modulation and CPSP intensity after total knee arthroplasty with tonic cuff pressure and cold water (2 studies each), surgical correction of funnel chest with cold water (1 study), and arthroscopic shoulder surgery with hot water (1 study). No association was found between pre-surgical conditioned pain modulation and the presence of moderate to severe CPSP after total knee arthroplasty with cold water, segmental spinal surgery with cold water (1 study each), and breast cancer surgery with hot water (1 study).[17]

Robot-Assisted Laparoscopic Hysterectomy for Adults

Lunde et al. (2020) used a cuff pressure algometer to investigate conditioned pain modulation.[18] No significant differences were found for conditioned pain modulation between those who developed CPSP and those who did not.[18]

Various Surgeries in Predominantly Adult Population

van Helmond et al. (2020) found that 3 studies reported an association between conditioned pain modulation and CPSP.[19]

Sphygmomanometer Pain Test (Pain Threshold Evaluation)

Bar Ziv et al. (2016) investigated the correlation between a pre-surgical pain stimulus and outcomes including pain at 2 years after total knee arthroplasty in adults.[15] This observational study consisted of a pain stimulus, applied before surgery, which was elicited by a sphygmomanometer inflated to 250 mm Hg for 30 seconds. The sphygmomanometer was placed on the proximal forearm at a distance of 5 cm distal to the elbow crease. Patients were asked to grade this stimulus using a 100-mm VAS scale. VAS scores were categorized as mild (0 to 44 mm), moderate (45 to 74 mm), and severe (more than 74 mm) and served as study comparison groups — referred to as VAS groups from hereon. Post-surgical clinical examinations were performed at 6 weeks, 6 months, followed by annually and evaluated pain and other measures (e.g., range of motion, limb alignment, Knee Society scores [KSSs] and Knee Society function [KSFs] scores). All study participants completed a follow-up of at least 2 years. The KSSs and KSFs were the main outcome measures after total knee arthroplasty. Of note, Bar Ziv et al. (2016) did not describe the scoring system; however, Scuderi et al. (2012) noted that KSSs include a rating of pain when walking on level ground and on inclined surfaces or stairs using a VAS score.[28]

Age did not differ between the VAS groups; however, a higher proportion of females were in the moderate and severe VAS groups compared to the mild VAS group. This suggests that age did not influence the perception of pain from the standardized stimulus but

female gender may have an effect on pain perception. Based on data collected at the last post-surgical follow-up session, patients in the severe VAS group had significantly worse KSSs (P = 0.0002) and significantly worse KSFs (P < 0.0001) compared to the mild and moderate VAS groups. This suggests that individuals who perceived the pain of the standardized stimulus, applied before surgery, to be severely painful had worse outcomes at a time point of 2 years or more after surgery compared to those who perceived the stimulus as mildly or moderately painful. The correlation coefficient for the relationship between the VAS score and the final KSS was r = −0.335 (P = 0.019), and the correlation coefficient between the VAS score and final KSF was r = −0.37 (P = 0.008). These data suggest a low, negative correlation between the perception of a standardized painful stimulus (applied before surgery) and final KSSs and KSFs. Namely, perception of more pain from the painful stimulus applied before surgery may result in worse KSSs and KSFs. The authors concluded that patients with a lower threshold for pain (higher VAS ratings) were more likely to have lower KSSs and KSFs (poorer outcome). Authors concluded that pre-surgical evaluation of pain thresholds of a standardized pain stimulus elicited by a sphygmomanometer may be used to predict post-surgical pain and function outcomes assessed with KSSs and KSFs as investigated in adults who received total knee arthroplasties.[15]

QST by Surgery Type

Orthopedic Surgery

van Helmond et al. (2020) reported that 7 studies (of 10) found a statistically significant relationship between pre-surgical QST and CPSP.[19] Majority (6 of 7 studies) of these studies evaluated individuals who underwent total knee replacement exclusively. Pre-surgical conditioned pain modulation (1 study), temporal summation of pain (2 studies), electrical threshold (1 study), heat threshold (1 study), and pressure threshold (1 study) were associated with CPSP measured at 6 to 18 months after surgery. Notably, 1 (of 7) study that included total knee and total hip replacement cohorts did not find an association between pre-surgical pressure pain thresholds in the knee replacement cohort at 12 months after surgery (association was found for the hip replacement cohort). Moreover, 4 of 7 studies demonstrated statistically significant relationships with univariate and multivariate analyses for the pre-surgical QST measures of temporal summation of pain, pressure pain threshold, and electrical pain threshold.[19]

Gynecological Surgery

van Helmond et al. (2020) reported that 2 studies (of 4) found a statistically significant relationship between pre-surgical QST and CPSP.[19] In 1 study of hysterectomy, pre-surgical temporal summation of pain was related to CPSP at 6 months after surgery. The other study found a relationship between tonic heat pain and pain improvement 8 months after vestibulecotmy.[19]

Abdominal Surgery

van Helmond et al. (2020) reported that 2 studies (of 3) found a statistically significant relationship between pre-surgical QST and CPSP.[19] In 1 study of open gastrointestinal surgery, pre-surgical conditioned pain modulation demonstrated a strong correlation with VAS pain scores measured at 6 months after surgery (Pearson correlation = 0.68; P = 0.02). Another study in hernia repair surgery found a relationship between pre-surgical tonic heat pain intensity and CPSP measured 6 months after surgery using multivariate analysis (OR = 1.3; 95% CI, 1.2 to 1.6).[19]

Thoracic Surgery

van Helmond et al. (2020) reported that 1 (of 2) study found a relationship between pre-surgical conditioned pain modulation and CPSP at 7 months after thoracotomy with a multivariate logistic regression analysis.[19]

Lumbar Discectomy

van Helmond et al. (2020) reported on 2 studies investigating pre-surgical QST in lumbar discectomy and found mixed evidence.[19] One study found a moderate relationship between pre-surgical warm detection threshold and a composite clinical score that included pain at 1 year after surgery: whereas, another study did not find any significant association between pre-surgical QST and CPSP.[19]

Other — Breast Cancer and Carpal Tunnel Release Surgeries

van Helmond et al. (2020) reported that studies investigating breast cancer surgery did not find significant associations between pre-surgical QST and CPSP.[19] Findings for carpal tunnel release surgery were mixed at various time points in 1 study; a multivariate analysis

found a relationship between pre-surgical pressure pain thresholds in the forearm and NRS pain scores at 3 months after surgery but not at 6 and 12 months after surgery.[19]

Validated Scales for Other Conditions

HADS

Carreon et al. (2020) performed an observational study of adults who underwent spine surgery.[21] Associations were investigated between pre-surgical HADS scores and differences in pre and post-surgical scores of various questionnaires assessing pain. Pre-surgical scores were measured on the day of admission to hospital for surgery and post-surgical scores were measured at a time point approximately 1 year following surgery (questionnaires were mailed 1 year after surgery). Pain questionnaires included VAS for back and leg pain, Oswestry Disability Index (ODI), Short-Form 36, and EuroQol-5 Dimensions (EQ-5D). The VAS for back and leg pain are the only questionnaires specific to pain intensity. Associations were performed separately for the HADS-anxiety (A) scores and HADS-depression (D) scores. Of note, age inclusion criterion was not reported; thus, the focus on adults is based on the means and standard deviations that were provided for the investigated subgroups (range of means was 55.71 to 60.83 years).[21]

The HADS is a self-administered questionnaire consisting of a 4-point Likert-type scale scored from 0 to 3, which has been validated to identify symptoms of anxiety (generalized anxiety disorder) and depression (anhedonia). There are 14-items with anxiety and depression symptoms constituting 7 items each. The total score is the sum of 14 items; accordingly, the score for each domain (i.e., HADS-A and HADS-D) is the sum of the 7 respective items. A normal score indicates that anxiety and/or depression are probably absent, a borderline score indicates that anxiety and/or depression are possibly present, and an abnormal score indicates that anxiety and/or depression are probably absent. Higher values of the scores represent worse symptoms.[21]

The VAS for back and leg pain are self-administered questionnaires that measure pain intensity using a continuous scale (horizontal 100mm line) anchored by no pain (score of 0) to worst imaginable pain (score of 100). The respondent marks a line along the scale to represent their pain intensity. The score is recorded by measuring the distance between the respondents' mark and the starting anchor (score of 0). The ODI is a self-administered questionnaire measuring disability specific to low back pain.[29] It consists of a 10-item scale with each item scoring from 0 to 5 that transforms to a 0 to 100 scale. The following categories are represented by these corresponding scores: minimal disability (0 to 20), moderate disability (21 to 40), severe disability (41 to 60), crippled (61 to 80), and bed-bound or exaggeration of symptoms (81 to 100). The SF-36 is a 36-item self-administered questionnaire that evaluates bodily pain in addition to physical and social function, limitations in role due to physical health and mental health, vitality, and general health. Scores can be calculated separately for a physical component summary score (PCS) and mental component summary score (MCS). The EuroQol-5 Dimensions-3 (EQ-5D-3) Level consists of a VAS (EQ VAS) and a descriptive system. The EQ VAS measures the respondents' self-rated health using the end points — best imaginable health state and worst imaginable health state. The descriptive system consists of 5 dimensions (pain or discomfort, anxiety or depression, mobility, self-care, and usual activities), each scored with 3 levels (no problems, some problems, and extreme problems). The respondent indicates their health state by selecting the most appropriate statement in each of the 5 dimensions.[21]

Spearman correlations between 1-year change in scores were statistically significant for the EQ-5D and HADS-A (r = 0.21), EQ-5D and HADS-D (r = 0.22), and ODI and HADS-D (r = 0.16) and not significant for all other questionnaires (ODI and HADS-A, SF-36 PCS and MCS and HADS-A, SF-36 PCS and MCS and HADS-D, VAS Leg and Back and HADS-A, and VAS Leg and Back and HADS-D). All the coefficients were low ranging from −0.01 to 0.22. Namely, the correlation between VAS back and HADS-D was the only negative correlation but this was not significant, and coefficients were 0 for the correlation between SF-36 MCS and HADS-A and HADS-D but these were also not significant. The correlation coefficients of the VAS Leg and Back, scores specific to pain intensity, were weak and non-significant, which suggests no correlation (VAS leg and HADS-A [r = 0.01], VAS leg and HADS-D [r = 0.02], VAS back and HADS-A [r = 0.03], and VAS back and HADS-D [r = −0.01]). The authors concluded that the HADS-A and HADS-D are not associated with the extent of improvement after surgery of various health-related quality of life scores (e.g., 1-year change of VAS Leg and Back scores).[21] Authors concluded that the pre-surgical HADS may not be able to distinguish or predict changes in pain-specific outcomes (VAS leg and back) or pain-related and pain-combined outcomes (ODI, SF-36, EQ-5D-3) 1 year after lumbar spine surgery in adults.[21]

TSK

Rosenbloom et al. (2020) assessed the predictive validity of TSK and chronic pain and pain-related disability at 12 months after various surgery types, categorized among orthopedic and general surgeries, in children and adolescents (aged 8 to 17 years).[20] The predictive validity was investigated by examining correlations between pre-surgical TSK scores and post-surgical disability scores of the Functional Disability Inventory (FDI) and PROMIS-Pediatric Pain Interference Scale (PPIS) 12-months after surgery — both are self-reported questionnaires. The authors defined predictive validity as the "extent to which the TSK correlated with theoretically related constructs measured at a later time (p. 2004)."[20] Validity evaluations were performed on the standard TSK (17-item) and a modified 13-item TSK (TSK-13), which comprised of only the positively scored items. Evaluations of the standard TSK were deemed exploratory.[20]

The TSK is a 17-item self-report questionnaire that was designed to measure fear of movement-evoked pain and injury in adults. Items are scored from 1 to 4 on a Likert scale (strongly disagree, disagree, agree, and strongly agree). Higher scores represent greater kinesiophobia. Thirteen of 17 items are positively scored in which, a rating of 4 is associated with strong agreement. Whereas 4 of 17 items are negatively scored in which, a rating of 4 is associated with strong disagreement. The PPIS is an 8-item questionnaire that assesses how pain of the child (patient) has interfered with various aspects of life over the past 7 days (e.g., sleep, schoolwork, physical activities).[20] The FDI is a 15-item questionnaire that measures disability and physical function in youth with chronic pain[30]; namely, it assesses the extent to which the child (patient) experiences difficulties with completing daily activities and tasks (e.g., walking to the bathroom, being at school all day). The TSK was measured before surgery and the FDI and PPIS were measured at 6 and 12 months after surgery.[20]

Pre-surgical TSK-13 scores were weakly correlated with functional disability 12 months after surgery ($r = 0.17$, $P < 0.05$) and moderately correlated with pain-related disability ($r = 0.36$, $P < 0.001$). Pre-surgical TSK-17 scores were not correlated with functional disability 12 months after surgery ($r = 0.12$, $P = 0.085$) or pain-related disability ($r = 0.22$, $P = 0.061$).[20] The authors concluded an adequate predictive validity of TSK-13 for pain-related disability and poor predictive validity of the TSK-17 for functional and pain-related disability among children and youth who underwent various general and orthopedic surgeries.[20]

See the source publication for detailed findings regarding construct, convergent, and discriminant validity of the TSK.[20]

Screening Tools

Presurgical Psychological Screening Algorithm

Marek et al. (2019) evaluated the ability of a widely used Presurgical Psychological Screening algorithm to predict outcomes, including but not limited to pain, after various spine surgery types (e.g., spinal fusion, artificial disc replacements) in adults.[23] The data informing this study included self-report questionnaires completed at 5 months after surgery. Of note, this report will briefly summarize the findings related to post-surgical pain.

The Presurgical Psychological Screening algorithm consisted of a review of medical records, psychometric testing, and a diagnostic interview. The algorithm included the Pain and Impairment Relationship Scale (PAIRS) to measure the belief that pain is related to impairment and poor functioning, PAIRS scores were hypothesized to predict risk of poorer outcome after surgery. Please see Figure 1 (p. 917) in the source publication for the full screening algorithm.[23] In brief, the figure lists the various risk factor categories and associated points, adverse clinical features, and scoring categories. The risk factor categories included interview (e.g., job dissatisfaction, no spouse support, current or history [more than 2 years prior] of substance abuse), testing (e.g., pain sensitivity, PAIRS > 75, depression, anxiety, catastrophizing), and medical (e.g., pain at 6 to 12 months and more than 12 months [presumably after surgery], smoking, obesity) components. The scoring categories were excellent (score = 1): no psychological treatment, good (score = 2): post-surgical psychological treatment, fair (score = 3): compliance and motivation measures, poor (score = 4): non-invasive treatment, and very poor (score = 5): discharge recommended. These categories stratified patients into 5 levels of psychosocial prognosis for reduced spinal surgery outcome. The screening tool also included recommendations for elective spine surgery: proceed with surgery, delay surgery pending psychological intervention, and avoid surgery if not medically required.[23]

The validity of the Pre-surgical Psychological Screening algorithm was assessed through analyses of covariance with the algorithm categories as the independent variable (excellent, good, fair to very poor) and outcome measures such as pain and ODI as the

dependent variables. Patients in the excellent scoring category reported clinically and statistically better pain and ODI outcomes than patients in the good (small to modest effect sizes) and fair to very poor categories (large effect sizes). Similarly, patients in the excellent category reported better pain and ODI outcomes as compared to those in the fair to very poor category (modest effect sizes). Additionally, patients whose prognosis was categorized as fair to very poor reported more pain after surgery compared with patients who were categorized as excellent or good candidates for spine surgery.[23]

Moreover, correlation analyses with the Minnesota Multiphasic Personality Inventory–2–Restructured Form (MMPI-2-RF) items and pre-surgical algorithm items and pre and post-surgical outcomes (e.g., pain level, ODI) were evaluated. The MMPI-2-RF has been validated for use in spine surgery. Post-surgical pain level (correlation coefficient = 0.19; $P < 0.01$) and post-surgical ODI scores (correlation coefficient = 0.21; $P < 0.01$) were significantly correlated with MMPI-2-RF head pain complaints. Post-surgical pain level (correlation coefficient = 0.26; $P < 0.01$) and post-surgical ODI scores (correlation coefficient = 0.25; $P < 0.01$) were significantly correlated with PAIRS > 75. Further, algorithm items of catastrophizing and nonorganic pain signs items were associated with pre-surgical pain levels. The authors highlighted that the correlation between PAIRS scores and post-surgical pain and ODI scores suggest that patients' beliefs about the meaning of pain and its impact on behaviour can influence post-surgical pain, pain-related disability, and resulting treatment of back pain. As noted, the PAIRS was originally designed to measure the extent that patients with chronic low back pain believe their pain is related to impairment.[23]

Further, relative risk ratios were calculated to represent the risk of reporting a suboptimal outcome based on pre-surgical endorsement of Pre-surgical Psychological Screening algorithm items. However, these findings related to pain outcomes such as MMPI-2-RF head pain complaints and PAIRS > 75 were not clearly described. Please see Table 3 (p. 920) in the source publication for further details.[23]

The authors concluded that this study demonstrated that the Pre-surgical Psychological Screening algorithm functions as intended but may require revisions to improve its utility.[23]

Pediatric Pain Screening Tool

Narayanasamy et al. (2022) evaluated a Pediatric Pain Screening tool to identify individuals at higher risk of developing CPSP.[22] This tool is a pre-surgically administered 9-item self-report questionnaire modified from the 9-item Keele STarT Back Screening Tool, which has been investigated in adults with musculoskeletal pain. The Pediatric Pain Screening tool measures psychosocial (anxiety, depressive symptoms, catastrophizing) and physical (function, pain, sleep quality) factors. The Pediatric Pain Screening tool was originally developed to screen pediatric patients with chronic pain; thus, the authors investigated the utility of the Pediatric Pain Screening tool to predict CPSP among a prospective, longitudinal (observational) study of children undergoing major musculoskeletal surgery (i.e., Nuss procedure for pectus excavatum and spinal fusion for idiopathic scoliosis). Of note, study participants were excluded if they used opioids in the past 6 months and the publication stated that the authors used a predominantly pediatric cohort. Questionnaires were administered electronically (through a program called REDCap) or through the telephone. After surgery at 3 to 6 months and 10 to 12 months, patients were asked to complete the NRS to assess pain intensity, FDI, Pediatric Quality of Life measure (PedsQL), Pediatric Pain Screening tool, and painDETECT questionnaires. Electronic reminders were sent weekly up to a maximum of 3 reminders, thereafter, a telephone reminder was made. CPSP was defined as a NRS pain score of 4 or more over the previous month or during the time of pain assessment at 6 months or 12 months after surgery. Functional disability and quality of life after surgery (3 to 6 months and 10 to 12 months after surgery) served as secondary outcomes.[22]

Pre-surgical scores and physical sub-scores of the Pediatric Pain Screening tool were found to be predictive of CPSP. Among the 9-items of the Pediatric Pain Screening Tool, item 2 ("I can only walk a short distance because of my pain") and item 6 ("I worry about my pain a lot") resulted in significant differences of the response agreement of those who developed CPSP and those who did not. Pre-surgical Pediatric Pain Screening tool scores and sub-scores were correlated with anxiety (Childhood Anxiety Sensitivity Index), pain (painDETECT), pain interference, depressive symptoms, and insomnia (Insomnia Severity Index). Therefore, pre-surgical Pediatric Pain Screening tool scores and sub-scores reflect established risk factors of CPSP in adolescents (i.e., pre-surgical pain, pain interference, anxiety, depressive symptoms, and sleep disturbances). The authors highlighted that pain catastrophizing is a known risk factor of CPSP in adults but pain catastrophizing was not identified as a risk factor of CPSP in pediatric patients in this study.[22]

Predictive accuracy (area under the curve values) of the Pediatric Pain Screening tool for CPSP and functional outcomes ranged from of 0.62 to 0.76, which was noted to match other studies assessing chronic pain and psychosocial outcomes. Using methodology

of Youden's index, the authors determined that Pediatric Pain Screening tool threshold scores of 2 or more to represent a high risk of CPSP. Although, it was noted that Pediatric Pain Screening tool scores below 2 elicited a medium risk of CPSP (10 to 30%), which was attributed to the inclusion of higher risk surgeries in the sample. The authors concluded that the moderate area under the curve values suggests that other factors that are not captured by the Pediatric Pain Screening tool may contribute to the risk of CPSP (e.g., acute post-surgical pain, duration of surgery, sex [female]). In this study, the authors found that female sex significantly increased risk of CPSP.[22] Overall, the authors highlighted the need for the validation of the Pediatric Pain Screening tool in other surgery types with a study sample with greater racial diversity, and concluded the feasible application of the Pediatric Pain Screening tool in pre-surgical anesthesia or surgery consultation clinics to identify pediatric patients at risk for CPSP and to inform pre-surgical measures and post-surgical interventions to reduce or alleviate post-surgical pain or related conditions.[22]

See the source publication for details regarding evaluation of item endorsement, scale variability, test-retest reliability, and confirmatory factor analysis of the Pediatric Pain Screening tool.[22]

Appendix 3: Additional References

Note that this appendix has not been copy-edited.

Evidence-Based Risk Factors Reported in Non-SR Studies

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