Opportunities for chronic pain self-management: core psychological principles and neurobiological underpinnings

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One in five of the population lives with chronic pain. Psychological interventions for pain reveal core principles that can be used to create opportunities for chronic pain self-management in primary practice, across health-care settings, and at home. We highlight the different types of chronic pain and illustrate the psychoneurobiological mechanisms involved. We review core principles for psychological pain management, evaluate the evidence, and illustrate the underlying neurobiology involved. We provide practical advice for how to facilitate pain self-management in clinical practice. Finally, we discuss scientific caveats and practical obstacles to improvement, suggesting possible pathways to implementation.

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Introduction

Chronic pain, typically defined as pain that persists for 3 months or longer, affects at least 20% of the adult population worldwide and imposes a substantial burden on patients and society.[1–4] With the worldwide crisis of untreated pain, which is exacerbated in some geographies by the oversupply and overuse of opioid analgesics, there has been a renewed focus on how core psychological principles can be used to assist the self-management of chronic pain and its consequences, both in first meetings with patients in primary clinical settings and by patients at home. A variety of psychological interventions designed to promote chronic pain self-management are emerging. Some are therapy-assisted and some are administered using different technologies: via books, online apps, websites, or virtual reality and augmented reality at home.[5]

In a three-part consideration, we first review the different types of chronic pain and their underlying psychoneurobiological mechanisms. Second, we present a summary of the evidence on psychological interventions and developments, with a focus on psychological and neurobiological core elements to facilitate pain self-management. Third, we extract the underlying principles of successful pain treatment and emphasise how health-care providers can shift patient trajectories towards effective pain self-management. Finally, we discuss standards for scientific rigour, structural barriers, and the future for chronic pain management.

Chronic pain in adults

The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".[6] The notes accompanying the definition specify that "pain is always a personal experience that is influenced to varying degrees by biological, psychological, and social factors".[6,7] See the panel for further specifications of the definitions and classifications of pain.[6–9]

Short-lived (acute) pain is part of normal life. Approximately 70% of adults report at least one episode of pain a month (eg, muscle pain, headache, and menstrual pain), but typically this type of pain resolves and does not require clinical intervention.[10] Conservatively, 20% of the adult population—with a pooled prevalence ranging from 20% to 43%—report chronic pain, which is pain that lasts or recurs for 3 months or longer.[1–4] Most people have what is considered low-impact pain, but a substantial minority (approximately 5% of the overall population) report high-impact pain as characterised by disability and reduced social role participation.[11,12]

Chronic pain has now been recognised in ICD-11 as a disease in its own right.[13] ICD-11 distinguishes between chronic primary pain syndromes—such as chronic widespread pain, in which pain is not accounted for by another diagnosis—and chronic secondary pain syndromes, in which pain is related to another primary disease, such as cancer.[9] Based on the underlying pathophysiology, chronic pain can also be classified as nociceptive (related to tissue or potential tissue damage), neuropathic (related to disease or injury affecting the nervous system), or nociplastic (maladaptive changes that affect nociceptive processing and modulation without objective evidence of tissue or nerve damage).[7] The experience of pain is dynamic and its categorisation might change over time.

Search strategy and selection criteria

This is a narrative expert Review based primarily on meta-analysis. From June, 2023, to December, 2023, we searched databases on PubMed, EMBASE, Google Scholar, Scopus, and Ovid using the key words "Chronic pain", "Self-management" and "Psychol* Therapy", cross-referenced with key words for individual searches ("Epidemiology", "Mechanisms", "Cognitive Behavioural Therapy", "Communication" etc). There were no restrictions on language but high-impact publications, Cochrane meta-analyses, and reviews directly relating to pain and published within the past 3 years were prioritised. For the section on brain imaging studies of psychological interventions for chronic pain, a rapid review was conducted and the specific searches and selection criteria are listed in table 1.

Panel: Definitions and classifications of pain

The International Association for the Study of Pain (IASP) definition of pain[6,7]

Pain:

An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue injury.

Notes:

- Pain is always a personal experience that is influenced to varying degrees by biological, psychological, and social factors
- Pain and nociception are different phenomena: the experience of pain cannot be reduced to activity in sensory pathways
- Through their life experiences, individuals learn the concept of pain and its application
- A person's report of an experience as pain should be accepted as such and respected*
- Although pain usually serves an adaptive role, it may have adverse effects on function and social and psychological wellbeing
- Verbal description is only one of several behaviours to express pain; inability to communicate does not negate the possibility that a human or a non-human animal experiences pain

Etymology

Middle English, from Anglo-French peine, from Latin poena (penalty, punishment), in turn from Greek poin (payment, penalty, recompense).

ICD-11 classification of chronic primary pain and secondary pain syndromes

Chronic primary pain[8]

Defined as pain in one or more anatomical regions that:

- Persists or recurs for longer than 3 months;
- Is associated with significant emotional distress (eg, anxiety, anger, frustration, or depressed mood) or significant functional disability (interference in activities of daily life and participation in social roles), or both;
- Has symptoms not better accounted for by another diagnosis

Examples of diagnostic entities within this category are widespread pain (eg, fibromyalgia) and complex regional syndromes.

Chronic secondary pain[9]

Defined as syndromes that are linked to other diseases as the underlying cause for which pain may initially be regarded as a symptom. Examples of diagnostic entities within this category are chronic cancer-related pain and chronic postsurgical or post-traumatic pain.

Three main categories of chronic pain[7]

- Nociceptive pain arises from actual or threatened damage to non-neural tissue and is due to the activation of nociceptors
- Neuropathic pain is caused by a lesion or disease of the somatosensory nervous system
- Nociplastic pain arises from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing the pain

*The Declaration of Montréal, a document developed during the First International Pain Summit on Sept 3, 2010, states that access to pain management is a fundamental human right.

See Online for appendix

ICD-11 adopts a modern view of pain as a biopsychosocial phenomenon that is not explained solely by nociception and peripheral trauma. The experience of pain encompasses sensory-discriminative, motivational-affective, and cognitive-evaluative characteristics that function to protect an organism from both immediate and long-term harms.[14] The evolutionary origins of pain lie in the biological mechanisms for sensing and withdrawing from noxious stimuli seen in every species.[15] In humans and other mammals, nociceptive pathways carrying pain-related information to the brain are reciprocally connected systems thought to predict future threats at multiple time scales and levels of abstraction, from avoiding immediate bodily harm to organising goals and preferences. In humans, pathways involved in pain include systems for decision making, autobiographical memory, and self-regulation. All these systems might contribute to the pain experience; the suffering imposed by pain; long-term adaptations, such as changes in risk tolerance and approach-avoidance behaviour; and a patient's trajectory towards chronification or recovery.

A combination of mechanistic studies in animals and human clinical neuroimaging studies point towards the brain's involvement in promoting and maintaining pain after injury and insult. The pathways are broadly compatible with the sensory-discriminative, motivational-affective, and cognitive-evaluative dimensions of the pain experience (figure 1; appendix).[16–20] In non-human mammals, bodily injuries (eg, nerve injuries, chemical exposures, and metabolic disruptions) cause remodelling of neurons and glia in multiple brain regions,[16,21] including those involved in nociceptive signalling and others that are not known to be nociceptive but whose functions are related to the long-term regulation of behaviour and physiology. Pain-promoting neural changes can be grouped conceptually into five categories, although they are intertwined in brain circuits and not easily separable at the neural level. These categories are sensitisation in ascending nociceptive systems;[22,23] shifts towards pain facilitation in descending nociceptive modulatory systems;[24,25] remodelling of systems involved in threat learning and motivation, including enhanced representation of pain-linked cues and contexts in systems responsible for avoidance of future threats;[16,26] remodelling of systems involved in reward and exploration to promote behavioural and social withdrawal;[16,27] and alterations in medial prefrontal–subcortical and prefrontal–temporal systems involved in multiple aspects of higher-order cognition and motivation.[16] These last systems are thought to be involved in the joint regulation of behaviour and physiology based on how personal capacities interact with their situational contexts.[28,29] Regions in this category are associated with the Default Mode Network (DMN),[30] a network of cortical regions particularly active during spontaneous, internally directed thought and self-reflection (see figure 2) that is thought to be involved in human self-concept and self-regulation.[31] Thus, multiple pathways and networks are involved in the experience of pain, showing evidence of pain-driven pathophysiology in non-human animals and associations with clinical pain, hypersensitivity, and allodynia in humans.[32,33] Alterations in these pathways with treatments could potentially enhance or decrease multiple facets of chronic

	Description	Example
Education	Learning that pain is not always due to illness, injury, or disease; learning how pain behaviour might lead to undesired outcomes; learning the role emotion can play in pain severity	Responding to chronic pain as if it was acute pain might lead to dysfunctional avoidance, withdrawal, and substantial personal loss; what appears defensive and protective can actually be harmful
Problem framing	Identifying problem frames and how to define solutions; learning to experiment with alternative problem definitions and experiment with different solutions	Persevering or perseverating with any behaviour (eg, fixating on losses, taking medication, and sleeping in the daytime), even though they have not worked in the past
Values determination	Identifying what is important to oneself in life; recognising how much of life is not often in the service of these values; recognising how pain changes the focus away from what one values	Pain can distract one into working hard to do the wrong things; identifying what one values most in life can be powerful because it is rarely something we allow ourselves to do; identifying how pain and our response to pain frustrate our attempts to do what is important to us can be a valuable insight for change
Goal setting	Identifying goals and tasks that can help one reach those values; learning to break down tasks into manageable and achievable activities; pacing our attempts to meet those goals, which can take time and effort; establishing goal-contingent behaviour, not pain-contingent behaviour	Identifying a goal and the substeps to reach that goal; for example, if the value is independence and the goal is to wash one's own hair, then breaking down the goal into tasks and subtasks (eg, collecting necessary products, creating time, and working on physical mobility to raise arms above head)
Relaxation training	Identifying the role of physiological arousal and its effects on pain by bringing attention to the body; identifying how much of life is focused on the future and the past and bringing attention to the now; attempting different relaxation techniques for these purposes, such as mindfulness meditation, biofeedback, and yoga	Use a relaxation protocol or mindfulness meditation technique
Automatic thought detection and defusion	Recognising the automaticity of thoughts about pain and its feared consequences, and the strong and fixed belief in the reality of those thoughts, as if they must have intrinsic truth value; challenging their veracity and replacing them or observing them as separate from self; identifying core beliefs that underpin automatic thought and exploring how those beliefs shape outcomes	Common unhelpful thoughts: pain must be a signal of damage, something must have been missed, I cannot move because I have a damaged body, I am going to be overwhelmed by this pain and everything will go horribly wrong, or I will never be able to cope with this; core beliefs that underpin these automatic thoughts could be related to pain, body, or self: pain is always a sign of damage, pain is something my body is too fragile to cope with, or pain is something I cannot and should nor bear
Exposure	Identifying a feared object or setting; graded exposure to the characteristics of the feared object; learning that one can survive exposure to the feared object; challenging safety behaviours	Fear of entering a busy or crowded room because of being bumped into, which will make my pain so much worse; working slowly on doing what one least wants to do because it hurts, but recognising that doing it will be better in the long term; doing what one most fears and finding that it does not lead to the feared outcome (finding non-confirmatory evidence of fears)

Psychological therapy for pain self-management involves a range of interventions. Classic interventions, such as cognitive behavioural therapy, involve combinations of the specific factors listed. All psychological interventions for pain self-management are delivered with a focus on many of the central non-specific factors.

Table 1: **Specific elements of psychological interventions for pain self-management**

pain and their long-term consequences for wellbeing. However, the details of which types of change are likely to be involved depend on the type of insult or injury, type of pain-related behaviour (or other social or affective behaviour), time of assessment during the chronification and recovery process, and other factors. Furthermore, although studies in non-human animals provide important evidence, it is not clear to date which human pathways and networks are directly involved in shaping the pain experience or are activated indirectly due to the widespread effects of chronic pain.

Psychological interventions and self-management

Psychological interventions for chronic pain cover a range of treatments informed by specific theories of behaviour change, from psychodynamic psychotherapy to behavioural and cognitive behavioural interventions. The classic interventions include core features of a thorough assessment of the maintaining influences on behaviour addressing unhelpful (often habitual) emotions, beliefs, and behaviours. These interventions often focus on promoting participation by strengthening the belief that one can effect meaningful change in one's life (self-efficacy), problem-solving skills, and confidence; identifying unhelpful thoughts in content and character; increasing insight into automatic fearful reactions to thoughts; and increasing exposure to novel ideas and behavioural consequences.[34] A common feature for most pain interventions is the focus on flexibly unlearning and relearning the value of a chronic pain signal, what it does and does not mean, and how it can be used differently to improve engagement with meaningful and valued life activities.[35] There are many techniques and technologies for delivering these core features of interventions and they emerge from different traditions of psychotherapy,[36] foundational experimental studies, and clinical experience.[37] Typical specific elements of classic pain interventions and non-specific elements of all psychological interventions are given in tables 1, 2.

A foundational Cochrane systematic review that was updated in 2020 provides comprehensive summaries of the evidence for psychological interventions for chronic pain.[38] The studies were selected if they were randomised controlled trials (RCTs) enrolling patients with chronic pain that compared a credible psychological treatment with a control condition (placebo, other active treatment, treatment as usual, or waiting list control), and had more than 20 patients per group at treatment assessment. 75 studies (9401 participants at end of treatment) were

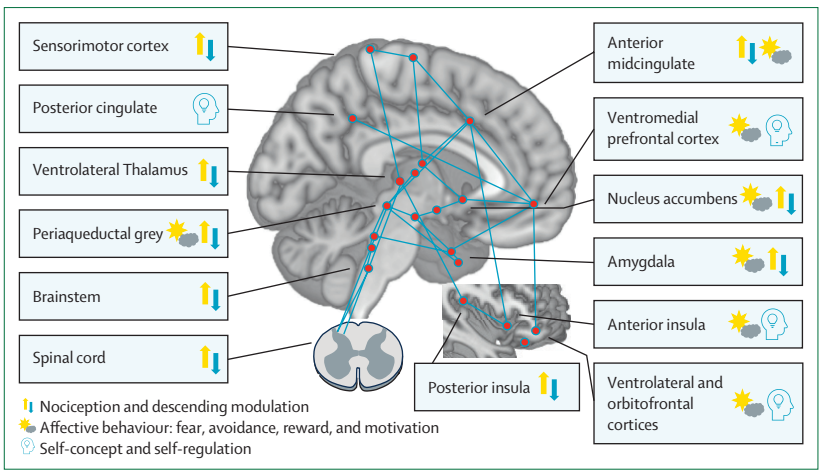

Figure 1: **Psychoneurobiological underpinnings of the experience of chronic pain**
The experience of pain encompasses sensory-discriminative, motivational-affective, and cognitive-evaluative characteristics. The neurobiological underpinnings of the pain experience are emerging and changes in multiple systems appear, including ascending pathways carrying pain-related information to the brain and descending modulation of nociceptive input; affective behaviours such as fear, avoidance, reward, and exploration; and in humans, some of these systems are also integral to our self-concept and self-regulation. The icons suggest some of the primary functions played by the key regions. Each region has multiple functions, in keeping with the interlinked nature of pain, motivation, and cognition. The information has been obtained from human neuroimaging and electrophysiological studies and the neuroplastic alterations in pathways and circuits that appear to contribute to pain behaviours are being elicited by mechanistic studies in non-human animals. The pink circles suggest brain regions that are altered in animal models of persistent pain, such as partial nerve injury, and the blue lines suggest anatomical connections that group them into pathways and systems. For further information on the emerging neurocircuitry underlying chronic pain, please see the appendix.

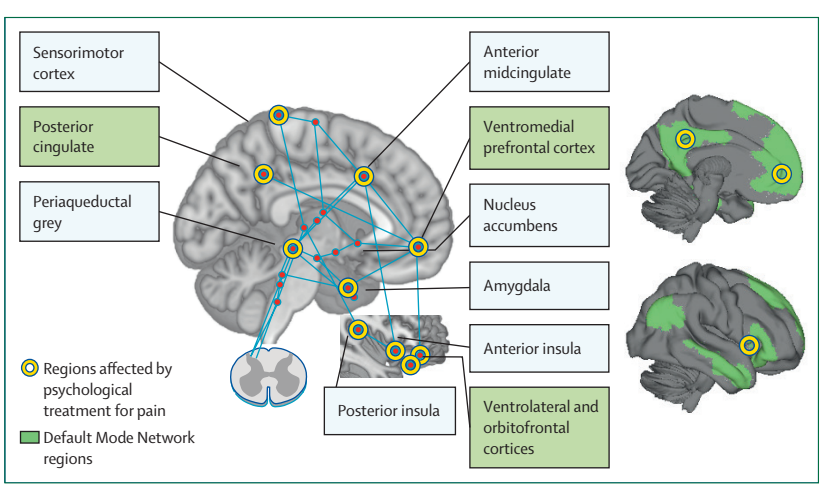

Figure 2: **Psychological interventions for chronic pain and alterations in neurobiological underpinnings**
Brain imaging studies suggest that psychological interventions for chronic pain could induce alterations in a subset of the regions (yellow circles) known to be involved in chronic pain in mechanisms studies (red dots; figure 1). The evidence base to date is small and immature, but the alterations appear to include reduced activity, connectivity, or both in regions associated with nociceptive processing and descending modulation (eg, sensorimotor cortices, periaqueductal grey, and posterior and mid-insula). The alterations also seem to involve changes in areas, highlighted in green, that are part of the Default Mode Network; a network of regions associated with the sense of self, self-regulation, and emotional experiences that has been suggested to help shape motivated behaviour and the bodily physiological processes. This emerging picture is incomplete, and further large-scale, well-controlled neuroimaging studies of psychological pain treatments are needed.

included, covering 59 studies on cognitive behavioural therapy, six studies on behavioural therapy, six studies on acceptance and commitment therapy, and four other studies (on short-term dynamic psychotherapy, emotional disclosure, emotional awareness and expression therapy, and psychodynamic therapy). The 59 studies of cognitive behavioural therapy emerge as the most robust and reliable evidence so far, with small but consistent effect sizes compared with treatment as usual, and very small effects compared with active control conditions.[38] Related treatments, such as acceptance and commitment therapy and emotion-focused therapy, are best considered at an early developmental stage due to fewer studies and less robust data.[38,39] Further sensitivity analyses of these data improved the precision of the analysis by including only trials with 50 participants in each treatment group and reassessing the evidence using criteria from the GRADE approach. By including only larger trials, the certainty of evidence improves for cognitive behavioural therapy versus treatment as usual and worsens for acceptance and commitment therapy for all analyses (outcome and comparators).[39] The focus of cognitive behavioural therapy and acceptance and commitment therapy has generally been on participation engagement with valued life activities despite pain. However, trials in the past few years have instead focused on directly altering the pain experience as the primary outcome.[40] These trials report large effects, but have yet to be replicated or independently scrutinised.

Despite the accumulating evidence supporting psychological interventions, few RCTs have attempted investigation of neurobiological mechanisms. We conducted a rapid review[41] of clinical RCTs of psychological interventions for pain with pretreatment and post-treatment brain and clinical measures in patients with chronic pain, and identified nine studies (table 3).[40–49] Four types of neural effects of psychological treatment emerge from these studies and are grouped by brain system, with at least two studies showing promise for each type of change. These themes are: changes in the DMN and interconnected subcortical regions involved in affect and descending modulation, such as the periaqueductal grey;[44,48] changes in lateral prefrontal systems[49] and orbitofrontal regions[45] important for context representation and self-regulation; reductions in anterior midcingulate and anterior insular activity,[40,50] regions associated with pain, interoception, and action selection; and altered connectivity between large-scale cortical systems, including the DMN, with anterior insula and somatomotor (eg, S1) regions.[16,21,40,42,46–48,51–53]

Collectively, these studies might be a first step towards identifying how psychological interventions target neurobiological processes associated with the sensory-discriminative, motivational-affective, and cognitive-evaluative dimensions of pain. However, at the time of writing this, it is unclear whether the observed changes reflect mechanistic changes directly linked to pain (eg, reduced central contributions to pain), changes in secondary characteristics (eg, fear and catastrophising), or changes secondary to pain reduction (eg, changes in nociceptive input). In addition, interpretation of

treatment-related changes in brain systems must continue to be undertaken with caution and in light of converging evidence from human and non-human studies.

These neuroimaging RCTs suggest that therapeutic benefits of psychotherapy are associated with brain areas that track pain in humans and animals (cingulate and insula) and with networks (eg, the DMN) that do not directly track nociceptive pain, but which appear to show alterations that support the chronic pain state.[33,54–62] For example, chronic pain is associated with grey matter decreases in regions associated with the DMN[20,63] and alterations in its functional connectivity[54–57] (which are more prevalent with longer pain duration[54]), including increased DMN connectivity with the insula[58] and somatomotor cortices,[57] and associations between DMN connectivity and peripheral inflammation.[51] DMN and associated mesolimbic structural and connectivity alterations have also been identified as antecedents of pain that might reflect vulnerability to chronification after insult.[57,59,61] For example, stronger connectivity of DMN-associated regions with nucleus accumbens,[59] a motivational centre, and sensorimotor regions[57] have been found to predict future pain chronification. A hub of the DMN, the ventromedial prefrontal cortex, could be a main source of descending modulation of nociceptive signalling because it projects to both descending modulatory pathways (eg, the periaqueductal grey) and mesolimbic regions (eg, nucleus accumbens). It can causally influence pain behaviour after nerve injury in animal models[16,52] and shows evidence for a prefrontal–periaqueductal grey–spinal descending pain regulation pathway in humans.[62] Beyond pain, it plays dual roles in influencing decision making and bodily physiology,[29,31] thereby potentially serving as a key interface between psychological interventions and psychoneurobiological changes in the experience of pain.

Confirmatory studies replicating effects with the same types of treatment and imaging measures are needed. Furthermore, it is important to be aware that imaging and electrophysiological signals might reflect mechanisms driving pain and intrinsically linked signals related to movement inhibition, autonomic responses, attention, and learning. Finally, it was only possible to identify a small number of neuroimaging studies of psychological treatments for chronic pain. It is an emerging field.[43] Further evidence from well-controlled, larger-scale neuroimaging studies of psychological treatments is needed.

Psychological interventions delivered by a qualified psychologist trained in pain management are rare—they can be considered a scarce resource—so large efforts have gone into protocolising, automating, and scaling interventions to reach a larger population (figure 3). A longer-term goal is to improve psychological interventions for chronic pain, making use of near real-time sensing and communication technology.[63]

	Description
Working alliance	Creating and maintaining a shared investment and commitment to the patient's desire for self-management; fostering mutual respect; finding opportunities for challenge while in alliance
Validation	Recognising and affirming the emotional validity of suffering; non-judgmental, non-reactive listening; resisting problem solving; promoting empathic witnessing
Behavioural activation	Moving in pain; moving in and upon the world; acting counter to pain
Practice	Homework tasks; planning and reward for practice of new skills
Reinforcement scheduling	Identifying the antecedents of problem behaviours; reinforcing alternate behaviours; scheduling the reinforcement to best fit the context

Psychological therapy for pain self-management involves a range of interventions. Classic interventions, such as cognitive behavioural therapy, involve combinations of the specific factors listed. All psychological interventions for pain self-management are delivered with a focus on many of the central non-specific factors.

Table 2: **Non-specific elements of psychological interventions for pain self-management**

A 2023 Cochrane meta-analysis reviewed psychological therapies delivered remotely to the patient using the internet or smartphone apps. The review included 32 RCTs with 4924 adults suffering from a variety of pain conditions and receiving interventions with no more than 30% contact time with a clinician.[64] Consistent with the meta-analysis of in-person delivered therapy, most evidence is for cognitive behavioural interventions, with 25 studies found to have a positive effect on pain intensity, functional disability, and quality of life with small but consistent effect sizes.[64] Thus, assisted interventions for pain self-management appear to have approximately similar abilities to help patients manage pain as in-person therapy. However, it is important to recognise that remotely delivered therapies have primarily shown an effect compared with no treatment, whereas in-person therapies have been compared with other active treatments.[65] It remains unknown exactly how to involve expert health-care professionals, whether in the design and development of an intervention only or also in its delivery. In fact, it is an ongoing discussion to what extent the effect of therapy can be separated from the therapist.[66] A limitation of many psychotherapy trials is structural dissimilarity between active and control conditions, which complicates blinding and adequate placebo control and means the effect of the intervention might be inflated.[67,68] Published guidelines for optimised placebo controls have the potential to strengthen the evidence base.[65,69]

There are many individually branded and designed interventions claiming to assist pain self-management. Many of them focus on education or cite core psychological principles used in promoting change. The range of interventions might allow for new and appealing ways to engage patients in changing core beliefs, emotions, and behaviours to facilitate pain self-management, but the variety in branding and treatment content can be confusing for patients and health-care providers and complicate scientific replication. From an academic standpoint, testing mechanisms underlying common, transtherapeutic content could emerge as

	N	Pain condition	Treatment groups	Methods	Treatment duration (weeks)	Follow-up duration (months)	Key brain findings	Strengths	Limitations
Lee et al (2024)[42]	114	Fibromyalgia	CBT (n=55); pain education (n=26)	fMRI; connectivity	8	0	Reduced PCC–S1, PCC–M1, and PCC–aMCC during a catastrophising task	Assessors masked; expectancy assessed	Larger initial pain scores in CBT group
Ashar et al (2022)[40]	151	Chronic back pain	PRT (n=44); placebo (n=44); usual care (n=47)	Structural MRI; pain fMRI; connectivity	4	12	Reduced evoked back pain-related activity in aMCC and aINS; increased aMCC–S1 and aMCC–PCC connectivity	1-year follow-up; good adherence	Control groups unmatched for PRT structure (duration and frequency)
Seminowicz et al (2020)[43]	98	Migraine	MBSR+ (n=50); SMH (control; n=48)	Structural MRI; connectivity; MSIT; pain fMRI	16	13	No effects on primary MRI outcomes, but S2 and dpINS show reduced response during cognitive control task consistent with reduced pain-related interference	Assessors masked; matched control group (for sessions)	Selection bias risk as mostly college students
Beissner et al (2018)[44]	67	Pelvic pain	Integrative psychotherapy (n=32); waitlist (n=31)	Connectivity	12	3	Increased hippocampal connectivity with S1, insula, and thalamic regions; reduced connectivity correlated with reduced anxiety	Controlling for menstrual cycle (but self-report)	No report of assessor-masking; waitlist control
McCrae et al (2018)[45]	52	Fibromyalgia	CBT-I (n=14); CBT-P (n=16); waitlist (n=7)	Structural MRI	8	0	Increased cortical thickness in OFC and PCC for CBT for insomnia or pain; more prominent increases for insomnia	Assessors masked	Waitlist control
Lazaridou et al (2017)[46]	16	Fibromyalgia	CBT (n=8); pain education (n=8)	Connectivity	4	6	Reduced S1–insula connectivity; larger reductions correlated with larger reductions in catastrophising	Matched control group (for contact type and duration)	No control at 6-month follow-up
Smallwood et al (2016)[47]	25	Chronic sback pain	ACT (n=6); pain education (n=6)	Pain fMRI; connectivity	4	0	Decreased activation during evoked pain in DLPFC, S1, dpINS, aINS, and DMN regions (PCC, VMPFC, and TPJ)	Matched control group (for duration and frequency)	Low statistical power
Shpaner et al (2014)[48]	38	Chronic pain	CBT (n=19); pain education (n=19)	Connectivity	11	0	Decreased DMN network (OFC, hippocampus, and PCC): amygdala and PAG connectivity; decreases correlated with increased pain regulation self-efficacy	Randomisation stratified by sex and pain intensity	No report of assessor-masking
Jensen et al (2012)[49]	43	Fibromyalgia	ACT (n=19); pain education (n=15)	Pain fMRI; Connectivity	12	3	Increased painful stimulus-evoked activity in ventrolateral prefrontal cortex, anterior insula, and thalamus	Assessors masked; medication controlled in CBT-group	Waitlist control

A rapid review* of clinical RCTs of pain psychotherapy with pretreatment and post-treatment brain and clinical measures in patients with chronic pain identified ten studies. An initial search for combinations of treatments (psychotherapy, CBT, ACT, DBT, or exposure) and pain (pain, chronic pain, fibromyalgia, or lower back pain) and neuroimaging (imaging, fMRI, or PET) yielded 18 unique papers. After reviewing titles, abstracts, and study design for inclusion of chronic pain patients, randomisation to psychological (or combined) treatment or control, and treatment effects on post-treatment neuroimaging, nine studies met inclusion criteria. Studies are presented in reverse chronological order. In treatment groups, n=number of completers with brain data for analysis. Integrative psychotherapy is not a purely cognitive or behavioural treatment and also involves acupuncture and hypnosis. The variation in findings across studies is likely due to differences in aim, patient population, and methodology. ACT=acceptance and commitment therapy. aINS=anterior insula. aMCC=anterior midcingulate (dorsal anterior cingulate). CBT=cognitive behavioural therapy. DBT=dialectical behaviour therapy. DMN=Default Mode Network. dpINS=dorsal posterior insula. fMRI=functional MRI. MBSR+=enhanced mindfulness-based stress reduction. M1=motor cortex. OFC=orbitofrontal cortex. PAG=periaqueductal grey. PCC=posterior cingulate. PRT=pain reprocessing therapy. SMH=stress management for headache (a control). S1=primary somatosensory cortex. S2=secondary somatosensory cortex. TPJ=temporal-parietal junction. VMPFC=ventromedial prefrontal cortex. *A rapid review uses modified systematic methods to accelerate the review process while maintaining systematic, transparent, and reproducible methods.[41]

Table 3: **RCTs of psychological interventions for chronic pain that include neuroimaging techniques**

more essential than specific brands. For a prominent example of a mechanistic study, a large well-controlled trial comparing three different types of cognitive behavioural therapy for self-management of chronic pain showed that what matters are early changes in improving self-efficacy and reducing pain catastrophising achieved with different strategies.[70,71]

The absence of replication is even more pronounced in the use of digital therapeutics, which are developing rapidly with a focus on assisted pain self-management from smartphone applications to extended reality.[72] Some studies have published evidence of efficacy,[73–77] but most are evidence-free or have yet to publish, and not all are firmly based in therapeutic psychological principles. To illustrate, in a systematic review of 508 apps, only 12 included psychological components and only one had been tested in an RCT.[78] Critical analysis of the literature to date shows insufficient clinical robustness[79] and little

awareness of the potential placebo effect of the device itself.[65] However, novel formats such as virtual or augmented reality could still engage patients who otherwise might not have access to or interest in therapy.

Overall, there is good evidence to support cognitive behavioural therapies for the management of pain associated with disability and distress, promoting a return to typical function or engagement with valued life activities. Furthermore, there are interesting developments in treatments with a focus on altering the felt experience of pain that require further scrutiny.

How to create opportunities for pain self-management

Health-care professionals might profit from knowledge of the core principles outlined above and basic strategies for building a therapeutic alliance with the patient, thereby communicating to support patients in pain self-management.

When pain fails to be temporary, people are often confused on how to proceed and typically resort to unsuccessful strategies, despite their often negative outcomes, or they escalate avoidance to social withdrawal; not from choice, but from lack of choice.[80] This early stage of seeking explanation, diagnosis, and reassurance takes place in the community and normally involves primary care consultation. We have no illusions as to how challenging these consultations can be, as chronic pain is often experienced by clinicians as confusing and professionally difficult.[81] However, all community or health-care encounters offer an opportunity to alter the patient's trajectory to self-management.[82] Arguably, these health-care encounters could be improved by specific training in long-term conditions and pain,[83] but we suggest that all community and health-care providers can benefit patients by considering a broad biopsychosocial framework to guide those clinical encounters.[81,84]

Common features of the clinical encounter in chronic pain and ways to create opportunity for self-management approaches are summarised in figure 4. All of these features are found in cognitive behavioural therapy, but can be more powerful when delivered early and by a trusted, credible, and authoritative health-care provider.[39,85] First, acknowledging that the patient's pain is real and you are a supportive ally in understanding and aiding self-management is crucial.[86] Offering a brain-based explanation (as outlined above) can be a useful way to explain pain without observable pathology.[86] Second, a personal formulation within a biopsychosocial frame is needed, starting with an assessment of the patient's core beliefs. Although there are common belief systems in chronic pain, their instantiation will be idiosyncratic and it might be useful to ask for the best explanation they have ever been given for their pain to assess what is believed, how strongly that belief is held, and how metaphors and language are used in sense-making. Third, one can attempt to loosen the rigidity of any core belief that suffering is an inevitable consequence of chronic pain by exploring the veracity of beliefs with evidence of past outcomes. Saying you cannot do something is often an expression of fear of a negative outcome or negative appraisal rather than an unbiased summary of evidence. Fourth, one can attempt to move the focus away from pain towards function, recognising that repeated failed attempts to control pain have led to further disability. Fifth, hopeful and confident messages of change through self-management can be helpful. Focusing on valued activities and goals for achieving positive engagement in other areas of life can improve function with pain, reduce suffering and, in some cases, might result in indirect improvements in pain.

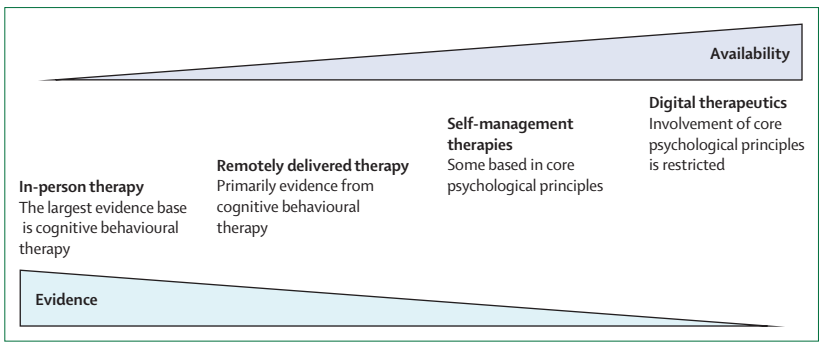

Figure 3: **Development in psychological-based interventions for chronic pain self-management**
Psychological interventions have developed from in-person therapy to internet-based and digital therapies and apps. In this process, therapies have become broadly available, although evidence is still scarce. To date, cognitive behavioural therapy trials provide the largest base of evidence. In large Cochrane reviews, in-person cognitive behavioural therapy interventions have shown effect compared with active control interventions,[39] and remotely delivered cognitive behavioural therapy interventions have shown effect compared with treatment as usual.[64] A variety of protocols to assist pain self-management have developed; some are based in core psychological principles and most are tested primarily in comparison to treatment as usual, so replication and carefully matched control conditions are needed.[65] The rapid development in digital therapeutics has insufficient evidence to date.

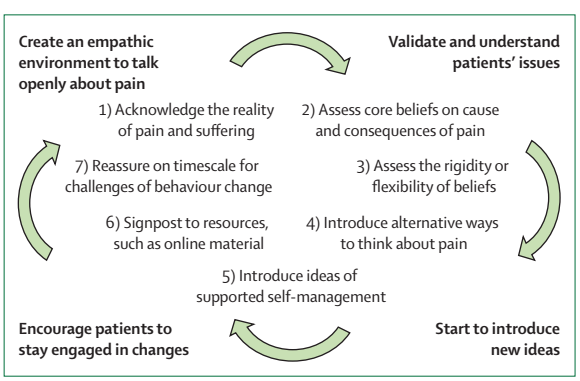

Figure 4: **Opportunities for promoting self-management in health-care consultations**
Both specific and non-specific content and approach should be planned and managed. Non-specific influences include courageously challenging fear and safety signals, setting realistic expectations, validating experiences, and delivering all with empathy and openness. Specific components include addressing the repetitive rigidity of thoughts and behaviours that do not serve positive outcomes. The emphasis is on function: how far beliefs bring about desired change or how far they promote the unwanted status quo. All behaviour happens in social contexts in which change requires opportunity, support, resources, and attention to maintenance, including managing inevitable setbacks.

Experimenting with new ways of coping (eg, exercising despite pain or setting goals to achieve personally valued outcomes) and awareness of unhelpful automatic thoughts of future catastrophes can be introduced. Sixth, building support using available patient-focused resources,[87] involving significant others, and helping them reinforce key messages and support treatment goals is important. The paucity of language and life examples for chronic pain should be acknowledged, recognising that successful self-management of chronic pain involves a cultural departure from the usual discourse of pain as a signal of damage not to be ignored.[88] And finally, as with many forms of learning, pain management skills take practice and can improve over time. It is helpful to introduce the idea that setbacks are an expected part of the process. There is unlikely to be a simple uninterrupted slope of improvement and occasional increases in pain need not be cause for alarm.

In the process, it is important to pay attention to common non-specific features of psychological interventions: maintaining an empathic non-judgmental attitude; validation of experience as real to the person; the setting and negotiation of realistic goals and expectations; and promoting courageous engagement with change in opposition to the dominance of fear avoidance.[89] It can be helpful to remember that successful self-management of chronic pain is a desired outcome and not a single intervention.

Future directions

We have argued that the principles of evidence-based psychological interventions can and should be applied more generally, not only in specialised pain care services, but also in health care more broadly. However, these principles emerge from the successful treatment of those with high-impact chronic pain, delivered by psychologists trained in pain management. However, some studies of attempts to broaden awareness to the community have been negative[90,91] and although we have argued for an emphasis on all clinical interactions being therapeutic opportunities, it remains unclear how far these low-intensity interventions can be delivered by non-psychologists, or exactly which content they should focus on. There is also need for a classification of intervention content and a standardisation of language of intervention to help innovation and evidence generation. Clarity over common features and components of intervention is needed. The specific and non-specific content and understanding dose, timing, order, and any interactive effects will also help guide the design of the placebo comparators necessary for establishing efficacy and safety.

Furthermore, greater investment in mechanistic studies is needed. The challenge is to bring together different levels of explanation. It could be possible to identify neurobiological changes associated with psychological interventions, but these only make sense in the context of well-defined cognitive or learning mechanisms. Furthermore, this mechanistic view is not just about change, but failure to change. A focus on treatment resistance, on how both pain and disabling pain behaviour can become stuck, is a priority for mechanistic studies to help overcome it.[92]

Finally, our shift from specialised health-care intervention to the community focuses on primary care and health-care consultations. We recognise that these clinical encounters are only one place in which beliefs about pain and pain behaviour are formed and reformed. A more systemic approach would include opportunities to apply these principles in the workplace[93,94] using social media,[95] in public health campaigns,[96] and ideally in a developmentally sensitive approach.[97,98] Ultimately, there is a need to incorporate a more sociocultural understanding of how to change the experience of pain.[88]

Contributors

All authors discussed the outline of the manuscript and contributed equally to its conceptualisation. LV had the initial contact with the editorial team, gathered the author group, and was primarily responsible for the outline of the manuscript. All authors searched for data and created the first draft for figures and tables. In addition, all three authors helped write and revise the manuscript for intellectual content and they agreed on the final version.

Declaration of interests

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