

The fatigue enigma: towards an integrative theoretical framework across clinical conditions.

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The fatigue enigma: towards an integrative theoretical framework across clinical conditions

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ABSTRACT

Background: Fatigue is a complex phenomenon that presents persistent challenges for research and clinical care across multiple conditions.

Objective: To explore development of an integrative theoretical framework linking lived experience, underlying mechanisms, and the design and evaluation of interventions.

Methods: We conducted systematic scoping reviews to identify (i) systematic and narrative reviews of mechanisms or pathways of fatigue across clinical conditions, and (ii) systematic reviews and recent randomised controlled trials of interventions addressing fatigue. These reviews informed four consensus workshops with researchers, clinicians, and individuals with lived experience of fatigue that examined: (1) the meaning and evaluation of fatigue across conditions; (2) mechanisms and pathways; (3) evidence for outcomes and novel interventions; and (4) consensus development and program theory generation.

Key findings: We present a summary of the discussions across the workshops and highlight the challenges that remain in evaluating the utility of an integrative theoretical framework. Substantial conceptual ambiguity was identified in how fatigue is defined and how mechanisms, pathways, and interventions are categorised. Inconsistent terminology, measurement approaches, and theoretical specification limit synthesis across conditions, and the current evidence base remains insufficiently articulated to support a coherent cross-condition account.

Conclusion: Critical gaps remain in the use of common language, outcome measures, and theory-informed approaches to intervention development. Addressing these foundational

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limitations is necessary to determine whether an integrative framework for fatigue can be constructed, and whether this may support knowledge translation across diagnostic boundaries and hypothesis-driven research that is responsive to stakeholder priorities and delivers meaningful clinical benefit.

Introduction

Fatigue is commonly reported by individuals with a wide range of conditions, including neurologic, musculoskeletal, immunologic, endocrinologic, cardiorespiratory, gastroenterologic, reproductive, psychiatric, haematologic, metabolic, or infectious disorders, and cancer [1–5]. It affects functioning and quality of life, and the impact is even greater in individuals with multiple (more than one) long-term conditions [6,7]. Globally, one third of adults are now living with multiple long-term clinical conditions [8,9]. This poses a specific challenge to patients, clinicians and health systems, as clinical guidelines for the treatment of fatigue are typically targeted to a single condition [10–13].

Several interrelated biological systems are implicated in the mechanisms and experience of fatigue symptoms, requiring multidisciplinary working and communication across professions and disciplines. Emergent theories suggest that fatigue may be better conceptualised as a symptom prevalent across multiple chronic medical conditions, rather than a disease-specific symptom [14]. However, challenges and barriers to this approach are not insignificant [15] not least because fatigue itself is hard to characterise, with a multiple definitions and overlapping constructs [16–19]. In everyday usage, the English term ‘fatigue’ can encompass a broad range of phenomena, including exhaustion, tiredness, reduced motivation, and performance decline. Other languages may distinguish more explicitly between experiential tiredness and exercise-related performance decrement. Such linguistic and conceptual variability complicates attempts to share knowledge across conditions where fatigue is prevalent.

The severity and impact of fatigue (defined here as the experience reported by the individual) and fatigability (defined here as measurable physiological, neural, or functional indicators) are key overarching constructs, yet these are not synonymous and may not co-vary. Fatigue as a reported symptom and fatigue as an observable sign require explicit differentiation, particularly when integrating findings from acute experimental paradigms and chronic clinical populations. Temporal characteristics add further complexity: acute fatigue, often short-lived and adaptive, differs in its functional role and biological correlates from chronic fatigue, which may persist beyond adaptive timeframes and become disabling. There is no established core outcome set for defining or measuring fatigue and fatigability across conditions, professions and disciplines [20]. The resulting heterogeneity in definitions, constructs, and outcome measures hinder the synthesis of research findings across conditions and may limit progress in this important area.

We conducted a series of consensus workshops with experts in the field, including researchers, clinicians, and individuals living with fatigue (experts by experience). These workshops were informed by systematic scoping reviews of the literature on fatigue. By combining evidence synthesis with expert perspectives, we aimed to evaluate the feasibility of developing an integrative framework for understanding fatigue as a cross-

disciplinary and transdiagnostic phenomenon, while explicitly recognising its heterogeneity across contexts and conditions. Our objective was to evaluate the feasibility of generating a theoretically grounded account of this complex and ‘wicked’ problem that could link individualised lived experience, research into relevant mechanisms or pathways, and the design and evaluation of interventions. Such an account may provide a basis for translation of knowledge across clinical and diagnostic boundaries and for advancing hypothesis-driven research. Here, we present a summary of the evaluations and discussions that took place across the four consensus workshops, and the challenges that remain in moving towards an integrative theoretical framework of fatigue across clinical conditions.

Methods

Rapid scoping reviews

Two rapid scoping reviews were performed to inform the consensus workshops. The objectives of the reviews were to identify (1) systematic and narrative reviews of mechanisms or pathways of fatigue across any clinical condition and (2) systematic reviews and recent randomised controlled trials (RCTs) of interventions addressing fatigue across any clinical condition. These were addressed through two separate systematic literature searches. The Population, Concept and Context (PCC) framework was used to inform the eligibility criteria [21], as detailed in Table 1. For objective 2, the search for RCTs was restricted to the two calendar years immediately preceding the workshops as we were interested specifically in exploring contemporary interventions for fatigue.

Three databases were searched on the OVID platform: Medline, Embase and PsycINFO. For both searches, terms were mapped to the concepts of fatigue and chronic health condition. For (1), the concept of fatigue was combined with mechanism or pathway. For (2), the concept of fatigue was combined with intervention and either RCT or review. Full search strategies are shown in Supplementary Material 1.

The retrieved citations were collated, and duplicates were removed in EndNote version 20. Citations were then transferred into the web tool RayyanTM for screening. One reviewer (BT, BN or RJ) screened titles and abstracts using the inclusion criteria described

Table 1. Inclusion and exclusion criteria for scoping review.

	Inclusion criteria	Exclusion criteria
Population	Populations experiencing fatigue	Studies were excluded if they focused on cognitive fatigue, athletes recovering from acute exercise-induced fatigue, or fatigue related to treatment (e.g. radiotherapy). Studies were excluded if they focused on fatigue in acute viral infection, acute infectious disease, or HIV.
Concept	1: Mechanisms or pathways of fatigue 2: Interventions addressing fatigue	
Context	1: Systematic and narrative reviews 2a: Randomised controlled trials 2b: Systematic reviews	1: Primary research studies, discussion articles, opinion articles 2: Quasi-experimental studies, observational studies, narrative reviews
Date restrictions	1: Database inception to July 2023 2a: Jan 2022 to Dec 2023 2b: Jan 2001 to Dec 2023	
Language restrictions	1: English language 2: English language	

in Table 1 and all decisions were checked by a second reviewer (DE). Data from the full texts of eligible articles were extracted directly into Excel by one reviewer (BT, BN, RJ or RD) and checked by a second reviewer (DE). The manually extracted data included author(s), year of publication, study type (systematic review, narrative review, RCT), and study population(s). For systematic reviews and RCTs, study title was also extracted. Systematic reviews returned in search (1) were uploaded into NVivo software (Lumivero, Denver, CO, USA) and the mechanism(s) studied were highlighted and coded by one reviewer (BT, BN, RJ or RD) and checked by a second reviewer (DE). All studies (systematic reviews and RCTs) returned in search (2) were uploaded into NVivo software and the details of the interventions were highlighted and interventions then coded by one reviewer (BT, BN, RJ or RD) and checked by a second reviewer (DE). This coding was then recorded with the extracted study data. For interventions, it was also recorded whether the intervention was designed based on a model or theoretical framework (if this information was available).

Consensus workshops

An online launch event was held in July 2023 to advertise the workshops and attract interest (for details see Supplementary Material 2). This was followed by four online workshops between November 2023 and March 2024. Thirty-eight individuals participated across the four workshops, including seven individuals with lived experience of chronic fatigue. Those individuals that have consented to be named are listed in Supplementary Material 3. All workshops were facilitated and visually summarised by Scarlet Design Ltd. (Cardiff, Wales).

The first workshop (November 1, 2023) focused on what fatigue means to people with lived experience of different conditions and how it can be evaluated, with discussions about indicators of chronic fatigue that are important to consider in research across conditions. The second workshop (November 30, 2023) focused on mechanisms/pathways of fatigue, with discussions on mechanisms important to consider in research. These workshops were informed by results from the first aim of the rapid scoping review (to identify systematic and narrative reviews of mechanisms or pathways of fatigue across any clinical condition). The third workshop (January 18, 2024) focused on evidence for outcomes and novel interventions for fatigue, with five contemporary interventions [22–26] that were identified by the second aim of the rapid scoping review (to identify systematic reviews and recent RCTs of interventions addressing fatigue across any clinical condition) discussed in breakout rooms. The discussion rooms were focused on the theoretical/mechanistic underpinning for the interventions. The fourth workshop (March 13, 2024) was focused on deriving a consensus on identified issues and generating a program theory for cross condition fatigue.

Workshops 1 and 2 included presentations from invited speakers (Supplementary Material 2). All workshops included semi-structured breakout rooms, each moderated by one of the core project team (JD, MB, HD, RD, CD), and semi-structured full-group discussions moderated by Scarlet Design Ltd. The full-group discussions were recorded and transcribed for the purposes of exploring emergent themes.

Recognising the importance of a theory or systems perspective to inform complex intervention research, the overarching themes emerging from the discussions were

extracted and summarised in relation to the updated Medical Research Council (MRC) framework for developing and evaluating complex interventions [27]. The mapping of the discussion themes to the MRC framework (with particular reference to interventions, mechanisms of action of those interventions, stakeholder perspectives in relation to those interventions, and key uncertainties as precursors to efficacy or effectiveness evaluations) has informed the findings presented here.

Results

Scoping review

Mechanisms

We identified 43 systematic reviews and 90 narrative reviews of mechanisms or pathways of fatigue. These covered 71 different clinical conditions (Supplementary Material 4). Cancer and multiple sclerosis were the most common conditions, with mechanisms of cancer-related fatigue considered in 40 of the 259 reviews (15%) and mechanisms of fatigue in people living with multiple sclerosis considered in 34 (13%; Supplementary Figure 1). Most clinical conditions (51 out of 71; 72%) were considered in only one or two reviews of mechanisms or pathways of fatigue (Supplementary Material 4). Inflammatory processes and psychological factors were the most studied mechanisms, covered in 23 (53%) of systematic reviews each, followed by sleep (42%) and immune system (40%) (Supplementary Figure 2). The extracted data is available on the Open Science Framework (<https://osf.io/zdtw2/files>). These findings were used to inform workshops 1 and 2.

Interventions

We identified 36 RCTs of interventions for fatigue (published between January 2022 and December 2023) and 120 systematic reviews of interventions for fatigue (published between January 2001 and December 2023). Cancer was the most studied condition, with interventions for cancer-related fatigue considered in 60% of the identified studies (93 out of 156; Supplementary Figure 3). Most interventions were non-pharmacological, with exercise or movement, psychological and behavioural interventions the most common (Supplementary Figure 4). The overlap between the clinical conditions in which mechanisms were studied and the clinical conditions in which interventions were studied is shown in Supplementary Figure 5. The extracted data is available on the Open Science Framework (<https://osf.io/zdtw2/files>). These findings were used to inform workshop 3.

Key discussion areas

In workshop 1, individuals with lived experience of chronic fatigue and a range of different clinical conditions spoke about what fatigue meant to them, their experiences of communicating about their fatigue with clinicians and other individuals in their lives, the varying techniques used to track symptoms (mobile phone/computer applications, paper diary), the frustration with limitations of existing approaches to symptom tracking and reporting, the complexity of multiple conditions, and their own personal responses to sleep (Figure 1). The subsequent discussions on the experience of living with chronic fatigue covered

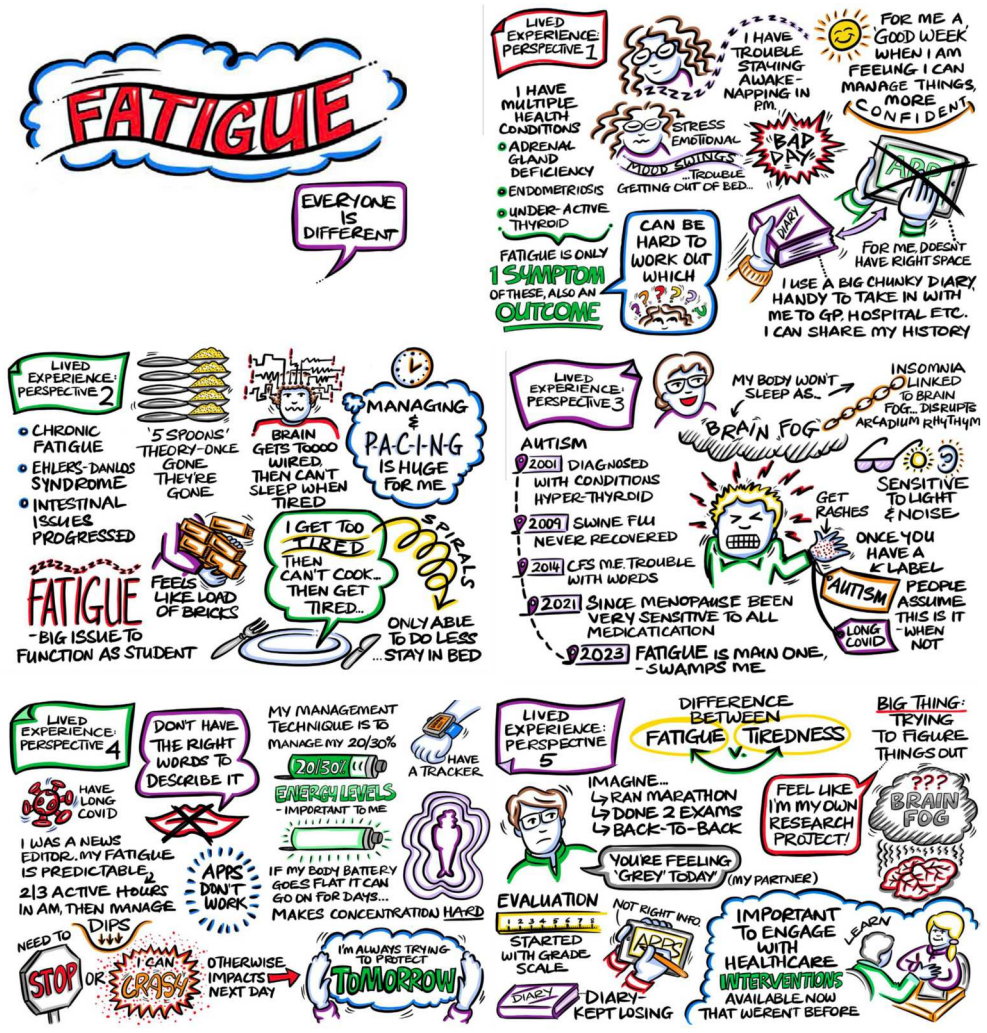


Figure 1. Illustrations depicting perspectives on chronic fatigue as described by individuals with lived experience in workshop 1.

themes of individuality, domains of experience, sleep, use of pacing/budgeting strategies, measurement burden, timescale of measurement, and relation of measurements to mechanisms (Table 2).

In workshop 2, discussions on the mechanisms and pathways of fatigue covered the importance of consistency in defining and measuring fatigue, integration of biological systems, learning from non-pathological fatigue, animal models, and across clinical conditions, biological/genetic markers and 'hidden' fatigue (Table 3).

In workshop 3, discussions on novel interventions for fatigue covered intervention content, intervention classification, theoretical approach, and outcome measures (Table 4). The MRC framework identifies six core elements that should be considered in the development and evaluation of complex interventions – context (the circumstances in which the intervention is developed, evaluated and implemented), programme theory (how the intervention (and specific components thereof) is expected to achieve its

Table 2. Themes of discussion on the fatigue experience.

Theme	Details
Individuality	The importance of individual experience and the personal model. The need to use measurement scales that capture individual experience. Recognition that many patients already use self-sourced/bespoke measures to record their experience, and the potential to use this data for patient-reported measures.
Domains of experience	The importance of emotional distress as well as physical distress The importance of the cognitive experience as well as the physical experience.
Sleep	The importance of differentiating sleepiness, tiredness (including the symptom of 'tired all the time' or 'TATT') and fatigue. The qualitative difference between restorative and non-restorative sleep. Measures of sleep quality rather than duration.
Use of pacing/budgeting strategies	Budgeting of energy day-to-day, and the transactional cost of physical and emotional activities. Perception of how much of budget has been used and the impact this has on day, and over longer timeframes. Potential use of ecological momentary assessment. Benefits and constraints of using objective measures of activity.
Measurement burden	Reporting symptoms for research purposes must not be overly burdensome for individuals. The need to weigh the benefit of composite scores from patient-reported outcome measures in reducing measurement burden against the loss of finer granularity. The need to balance the usability of any measurement tool against the value of the information gained.
Timescale	Fatigue levels often fluctuate; however, there is no clarity on the optimal timescale over which to measure outcomes.
Relation of measurements to mechanisms	The importance of including outcome measures that can indicate potential mechanisms of action of any intervention.

effect), stakeholders (different views and perspectives of service users and implementers), key uncertainties, intervention refinement, and economic considerations [27]. When aligned to this framework, the discussion themes highlighted areas that should be improved to move the field, namely: improved reporting of circumstances (contexts) relevant to the intervention, better understanding of mechanisms of actions to inform programme theory, clear communication of how stakeholder perspectives have been considered in relation to interventions, and rationale for selected outcome measures (in relation to the intervention components, programme theories or mechanisms of actions) as precursors to efficacy or effectiveness evaluations.

The discussions across all consensus workshops highlighted a perception of inconsistency in the way fatigue is defined, operationalised and measured across mechanistic and intervention research. To further explore this, we used Elicit AI (<https://elicit.com/>) to extract the definitions and measures of fatigue used across all 199 systematic reviews and RCTs identified in the scoping review. This data is available on the Open Science Framework (<https://osf.io/zdtw2/files>).

Discussion

Across both the rapid scoping review and the consensus workshops, substantial conceptual variability emerged in how fatigue is defined and how mechanisms, pathways and interventions are classified within research and clinical settings. Our findings highlight the absence of a coherent structure that links lived experience of fatigue, underlying mechanisms, and the design and evaluation of interventions for fatigue across clinical

Table 3. Themes of discussion on mechanisms and pathways of fatigue.

Topic	Details
Importance of consistency in defining fatigue	Inconsistency or lack of clarity in the definition of fatigue across studies critically hinders transfer of knowledge about mechanisms or pathways
Importance of consistency in measuring fatigue	Inconsistency or lack of clarity in the measurement of fatigue across studies critically hinders transfer of knowledge about mechanisms or pathways. The importance of using validated measures of fatigue. Discussions on the need for a core outcome set for fatigue, rather than fatigue being included as a measure in core outcome sets for specific clinical conditions.
Integration of biological systems	There are multiple candidate mechanisms and pathways underlying fatigue, from cellular to meta cognitive, and there is a need to consider the integration of interconnected systems.
Learning from non-pathological fatigue	It is largely unknown if there are mechanistic relationships between non-pathological fatigue and fatigue experienced in clinical conditions. It is unknown if experimental models of (non-pathological) fatigue can offer options to explore mechanisms of fatigue in clinical populations if knowledge transfer pathways are more robust.
Animal models	There is an opportunity for animal models of chronic fatigue to provide new theoretical underpinnings for the human experience of fatigue, with better translation of existing research.
Learning across clinical conditions	Fatigue experience across different clinical conditions may result from different or similar underlying physiological mechanisms. It may be possible to subtype fatigue based on common mechanisms (e.g. IL-6-mediated fatigue), rather than clinical conditions (e.g. post-stroke fatigue). Doing this could move fatigue away from being a symptom of a clinical condition and towards being a condition in itself – and allow for learning across clinical conditions that share the same fatigue subtyping.
Biological/genetic markers	There is a need for agreement on core biological markers that would be useful to indicate mechanisms across conditions. However, there is a need to consider measurement burden. It is unknown if there are key biological markers that are relatively easy to measure (e.g. salivary cortisol measures, buccal swab genetic testing) that could be identified as useful across conditions.
'Hidden' fatigue	There are some conditions where fatigue is still hidden (e.g. osteoarthritis). The failure to consider fatigue as an outcome in some clinical conditions indicates that there is still work to be done in uncovering the extent to which fatigue is present across conditions. This, along with inconsistent definitions and measures of fatigue, may limit current attempts to perform big data analyses to look at and cluster the experience of fatigue across clinical conditions.

Table 4. Themes of discussion on interventions, components and outcomes on fatigue.

Topic	Details
Intervention content	It is important to provide details on the content of an intervention and, where the intervention has multiple components, it is important to provide details on each component. This is often lacking. For each component of an intervention, it is important to identify the mechanisms that it is targeting. For example, do interventions that include acceptance therapy propose that there is a deficit in acceptance amongst the target population? There are checklists to guide the reporting of interventions, such as the template for intervention description and replication (TIDieR) checklist [28], but little evidence of use.
Intervention classification	An attempt was made to categorise the interventions identified in the scoping review (Figure 4). There was discussion around how this is best approached. It would be optimal to categorise based on the theoretical approach used in the design of the intervention, but there was insufficient information provided on intervention design to allow this.
Theoretical approach	It is important to provide details on the theoretical approach on which the intervention was based (e.g. programme theory, theoretical domains framework). Generally, there is insufficient information on the development of the intervention and a lack of a precision approach.
Outcome measures	Where fatigue is targeted by an intervention, it should be defined and appropriately measured (with a validated measure that aligns to the definition). Failure to define fatigue prevents comparison of results across interventions. Inconsistencies in the definition of fatigue hinder comparisons.

conditions. An integrative framework could provide a structured basis for comparing findings across contexts, clarifying theoretical assumptions, and informing the development and evaluation of interventions, and thus support cumulative progress in the field. However, the current evidence base remains fragmented and is insufficient to support a fully theoretically grounded account. Rather than rendering such a framework unattainable, our results clarify the conceptual and methodological work required to advance a structured understanding of fatigue across conditions. By making explicit the variability in definitions, constructs and classification approaches evident in the current literature, this work provides a necessary foundation for determining whether and how meaningful cross-condition comparison may be achieved.

The scoping review highlighted substantial inconsistency across mechanistic and intervention research in the way fatigue is defined, operationalised and measured. This conceptual variability is consistent with guidance from the International Society for Quality of Life Research (ISOQOL), which emphasises the importance of explicit construct specification in patient-reported outcome research [28]. ISOQOL distinguishes between fatigue as a subjective, self-reported experience and related constructs such as performance decrement or fatigability and highlights the need to clarify temporal characteristics and contextual relevance when selecting outcome measures. Such distinctions are particularly important in fatigue research, where the term is used to encompass phenomena ranging from acute physiological tiredness to persistent, disabling symptoms across chronic conditions. The absence of consistent specification regarding whether fatigue is conceptualised as a symptom, a sign, acute or chronic, physical or cognitive, contributes to the fragmentation identified in the present work. Greater clarity and consistency in construct specification are essential to reduce fragmentation and enable more coherent communication across research communities.

Mechanisms and pathways are investigated using varied conceptualisations of fatigue, limiting the extent to which findings can be meaningfully compared or transferred across contexts. In intervention studies, insufficient description of development processes, theoretical underpinnings (if any), the components of the intervention (and any control) and intended mechanisms of action, make it difficult to compare across studies. This lack of detail of how interventions are theorised to influence fatigue makes it challenging to classify approaches, evaluate the potential for an intervention to be tested in a different clinical condition or context, address further avenues of potential research along related or linked pathways, and creates barriers for synthesising findings through meta-analyses.

From a theoretical standpoint, many interventions for complex, chronic fatigue remain limited by gaps in understanding of context and by limited consideration of programme theory [27]. The process of intervention development should be transparent and theory-driven and importantly informed by the views of those with lived experience of fatigue, e.g [29,30].

It is clear from our review that stakeholder involvement represents a further area of under-specification. Outcome measures and the frequency with which they are measured should be selected with care and coproduced with patients so as not to oversample or impose unnecessary burden, and to allow the lived experience to be integrated into the research. We found that reporting rarely details how stakeholder engagement informed the understanding of inputs, activities, outputs and outcomes. Without explicit

integration of lived experience into intervention design and evaluation, efforts to construct an integrative framework remain incomplete.

Studies that test an intervention should detail the development of the intervention, the theoretical approach on which the intervention is based, the components of the intervention and control, and the mechanisms that the intervention is targeting [30]. We found that interventions that targeted fatigue were not sufficiently described to be able to understand the clinical contexts in which they were most suited or effective. Without this contextual clarity, it is difficult to assess the conditions under which interventions work, difficult to generalise findings across settings, and difficult to integrate into an integrative framework.

Mechanistic rationales for how interventions are expected to influence fatigue are also seldom articulated within intervention studies. Links between targeted biological pathways and overarching programme theories are seldom reported or discussed, and there is limited integration of insights from animal models of fatigue, human models of non-pathological fatigue, and human studies of pathological fatigue across clinical conditions. This fragmentation weakens the theoretical coherence necessary to evaluate the potential for cross-condition integration.

The conceptualisation of fatigue as a whole-person experience influenced by multiple interacting systems also resonates with theoretical developments in stress research. Early formulations of stress as a non-specific adaptive response to diverse internal and external demands [31], and subsequent work in psychoneuroimmunology [32,33] and allostatic load [34], illustrate how broad constructs can evolve through interdisciplinary integration and increasing biological specification. While fatigue and stress are not synonymous, these developments provide a potentially informative parallel for future theoretical work in fatigue, particularly in considering how cumulative physiological and psychosocial demands may contribute to persistent symptoms.

The current level of conceptual and methodological specification within the literature limits the extent to which the feasibility of a theoretically grounded cross-condition framework of fatigue can be meaningfully evaluated. Progress toward such evaluation will depend on strengthening conceptual coherence and improving the transparency with which mechanisms, context, and intervention development are described. Addressing these gaps is a necessary step toward determining whether and how an integrative framework linking lived experience, biological mechanisms, and intervention design can be developed.

Conclusion

Our aim here was to identify opportunities for translating knowledge across clinical and diagnostic boundaries. The evidence-based workshops highlighted critical gaps in common language, common outcome measures, and theoretically informed approaches to intervention development that impede advancement towards a theoretically grounded, cross-condition account of fatigue. Addressing these gaps is not merely descriptive; it would provide a foundation for determining whether and how an integrative framework linking lived experience, biological mechanisms, and intervention design can be developed.

Progress in this area will require greater consensus on what fatigue is, what fatigue is not, and which validated measures should be used to measure it. Such efforts must be informed by authentic stakeholder involvement to ensure that theoretical refinement remains grounded in lived experience. In parallel, consensus on common or unique

biological and genetic markers of fatigue would facilitate performance of large-scale clustering studies to identify fatigue phenotypes/trajectories independent of clinical condition. These advances would support more precise, hypothesis-driven research and strengthen efforts to translate findings across clinical conditions, including among individuals with multiple clinical conditions.

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The GW4 Fatigue community consisted of researchers, clinicians, and individuals with lived experience of fatigue who attended one or more of four online workshops held between November 2023 and March 2024. Those who consented to be named are listed in Supplementary Material 3.

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Data availability statement

Data relating to the literature reviews are available on the Open Science Framework <https://osf.io/zdtw2/files>.

Notes on contributors

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Helen Dawes is a rehabilitation scientist and physiotherapist at the University of Exeter and Co-Director of the Rehabilitation Theme within the NIHR Exeter Biomedical Research Centre. Her research investigates the mechanisms and management of fatigue and its cognitive and physical correlates across neurological, post-viral, and chronic conditions. She leads translational research aimed at improving rehabilitation outcomes and interventions for individuals experiencing fatigue.

Ezio Preatoni is Senior Lecturer in Biomechanics at the University of Bath. His research lies at the intersection of human movement science, biomechanics, and sensor technology, with a focus on understanding how fatigue influences coordination, variability, and performance in sport and health contexts. His work contributes to developing novel approaches to quantify fatigue and to optimise recovery and performance in physically demanding settings.

Deborah Edwards is Principal Research Fellow at the Wales Centre for Evidence Based Care, Cardiff University. Her expertise lies in evidence synthesis and methodological development to support the design and implementation of complex healthcare interventions. She contributes to advancing understanding of fatigue through systematic evaluation of evidence.

Bethan Thomas was a doctoral researcher at Cardiff University at the time of this work, and is now a postdoctoral researcher. Her work focuses on the mechanisms underlying fatigue in long-term health conditions and explores physiological, sensory, and cognitive aspects of fatigue, with the aim of contributing to a better understanding of how fatigue develops and persists, and how it may be mitigated through targeted interventions. She worked as a research assistant within the GW4 network studying fatigue in people with multiple long-term conditions, from which is work is based.

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Caroline Dalton is Reader in Neuroscience and Genetics and Theme Lead for Living Well with Chronic Disease at the Advanced Wellbeing Research Centre at Sheffield Hallam University. Her research spans Long COVID and ME/CFS, physical-activity interventions, symptom monitoring, wearable devices and fatigue. She has authored intensive-longitudinal studies exploring within-person predictors of physical activity and fatigue in Long COVID, advancing understanding of symptom-activity dynamics.

Monica Busse Morris is a physiotherapist and clinical trials methodologist, specialising in mobility, lifestyle interventions and rehabilitation in complex chronic disease. She led major interventional trials in Long COVID, including a self-management support intervention (LISTEN trial) that reported significant reductions in fatigue impact. Her work bridges mechanism, mobility and rehabilitation strategy in fatigue-bearing conditions.

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