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Sleep tracking: an integrative review, conceptual framework and future research agendas

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ABSTRACT

Sleep tracking has become a growing area of self-tracking, yet the breadth of users' interactions with sleep-tracking technology has not been comprehensively synthesised. To address this gap, this study analyzes 51 empirical research articles following a three-phase literature review process. Guided by a human–computer interaction framework, we organised the extant research into five components: (1) user, (2) sleep-tracking technology, (3) use context along with corresponding tasks, (4) use and impact (user-oriented outcomes) and (5) design insight (technology-oriented outcomes). The first three components represent the antecedents of sleep tracking, while the latter two capture its outcomes. Based on these insights, we present a synthesising framework to elucidate current research concerning users' interactions with sleep-tracking technology. Drawing upon our findings, we propose two future research agendas for research design: (1) balancing qualitative with quantitative methods and (2) strengthening theoretical foundations. For future research topics, we put forward four agendas: (1) respect for individual differences and their impact on sleep tracking, (2) sleep-tracking technology evolution, user-centered design and its compatibility, (3) the role of stakeholders and external environment and (4) impacts beyond benefits: underlying mechanisms of use, effective use, behavioural change and potential side effects.

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KEYWORDS
Sleep tracking; self-tracking; human–computer interaction; integrative literature review; antecedents; outcomes

1. Introduction

Sufficient and restorative sleep is vital to human health and well-being (Walker 2017). In essence, sleep is influenced by genetic, social, environmental, behavioural and healthcare factors (Buysse 2014; Walker 2017). Alarmingly, a recent survey of 36,000 respondents from 17 countries found that nearly 40% of individuals report experiencing fewer than three nights of quality sleep per week (ResMed 2024). The challenges of sleep tracking are manifold due to the unconscious nature of sleep (Ravichandran et al. 2017) and its entanglement with various variables, including sleep environment and lifestyle (Choe et al. 2011). Consequently, there is a growing focus on leveraging information technology (IT) to track and improve sleep (Cay et al. 2022).

Self-tracking, a particular form of IT use for monitoring health and well-being, has been widely studied for its impact on physical activity (Lin, Ling, and Rosenthal 2024; Zhou, Krishnan, and Dincelli 2022), stress (Lentferink et al. 2022), diet (Zečević et al. 2021) and weight loss (Lehto and Oinas-Kukkonen 2015). Within this broader context, sleep tracking has emerged as a prominent area of interest. Sleep tracking involves using technological tools to monitor, record and measure an individual's sleep (Feng, Mäntymäki, and Salmela 2022). Similar to self-tracking technologies (Lupton 2016) and behaviour change support systems (Oinas-Kukkonen 2013), sleep-tracking technologies aim to increase awareness of sleep and motivate positive health-related changes. Sleep-tracking technologies enable people to track their sleep automatically (Ravichandran et al. 2017), thereby helping to identify factors that contribute to sleep quality (Kuosmanen et al. 2022) and supporting users in making behavioural changes to improve their sleep (Goelema, Haakma, and Markopoulos 2014; Griffiths et al. 2022; Kuosmanen et al. 2022). Currently, sleep-tracking features have been embedded in various technologies, including wearable devices (e.g. smartwatches, wristbands, rings and headbands), non-contact devices (e.g. pads under the mattress), and mobile applications (Al Mahmud, Wu, and Mubin 2022; Goldstein 2020; Shelgikar, Anderson, and Stephens 2016).

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Sleep-tracking technologies have attracted increasing scholarly attention from various perspectives. For example, previous studies have developed technological solutions for sleep tracking (e.g. Nguyen et al. 2018; Wilson et al. 2017). Clinical studies have, in turn, explored the health impacts of sleep-tracking technology through trials and assessed their accuracy against diagnostic tools, such as polysomnography (e.g. Berryhill et al. 2020; Tuominen et al. 2019). Prior research has also explored user acceptance of sleep-tracking technologies (Kaitz et al. 2023; Quante et al. 2019), their impacts on users' use behaviours (Aji et al. 2022; Attie and Meyer-Waarden 2023), their influence on users' behaviour changes (Goelema, Haakma, and Markopoulos 2014; Kuosmanen et al. 2022), and the barriers and challenges of sleep tracking (Liang and Ploderer 2016; Liu, Ploderer, and Hoang 2015). Taken together, research on sleep tracking has surged in recent years. However, existing studies consistently and explicitly call for further investigation in this area (Baron et al. 2018; Cay et al. 2022; Choe et al. 2011; Hussain and Sheng 2022).

Despite the growing body of research on sleep tracking, existing literature reviews have not kept pace with the breadth and diversity of recent studies. Current literature reviews on self-tracking have primarily focused on physical activity (Attig and Franke 2020; Jin et al. 2022), underscoring the need for a dedicated review of sleep tracking literature. However, the extant literature reviews on sleep tracking have primarily focused on the technical aspects, such as the validation and accuracy (Baron et al. 2018; Haghayegh et al. 2019), design and evaluation (Aji et al. 2021), the design choices of sleep-tracking apps (Hosszu, Rosner, and Flaherty 2019), and the recent advancements in sleep technologies (Cay et al. 2022). In addition, prior review studies have adopted a clinical focus by examining the use of sleep-tracking data in sleep interventions (Baron et al. 2022) and the feasibility studies and clinical trials of mobile health wearable-based sleep monitoring (Guillodo et al. 2020). Taken together, these reviews largely frame sleep tracking as a measurement and intervention problem.

As a result, user and contextual perspectives on sleep tracking, including how people interpret, act on and sustain use of sleep data, remain under-synthesised. This omission is noteworthy, as the complexity of sleep (Choe et al. 2011) means that factors related to the user and their context play an important role in individuals' sleep and related behaviours when engaging with sleep-tracking technology. Indeed, user-related factors, such as chronotype and personality (Nguyen et al. 2018), as well as contextual influences, such as social influence (Leblanc et al. 2022) and support availability (Purnell et al. 2023), can significantly influence how individuals engage with sleep-tracking technologies. Therefore, there is a need for review studies that specifically focus on user-related and contextual factors.

Consequently, we propose our main research question (RQ): *What is the current state of research on sleep tracking from a human–computer interaction perspective, and what are the key agendas for future investigation?* To tackle this, we conducted an integrative literature review (Torraco 2005, 2016) on sleep tracking, focusing on users' interactions with sleep-tracking technology. This review synthesises current research on sleep tracking, identifies gaps in the literature and puts forward future research agendas. Guided by the human–computer interaction (HCI) framework by Zhang and Li (2005), we developed a theme matrix to organise existing research. We then categorised the identified themes into five components of the HCI framework: user, sleep-tracking technology, use context along with corresponding tasks, use and impact (user-oriented outcomes), and design insight (technology-oriented outcomes). The first three components serve as the antecedents of sleep tracking, whereas the last two reflect its outcomes. Lastly, we proposed future research agendas focusing on research design and topics related to sleep tracking. Overall, this review provides three theoretical implications that advance the understanding of sleep tracking from a holistic view, develop a synthesising framework for sleep-tracking research and extend the HCI framework. In addition, this review offers three practical implications for designers, highlighting the importance of multidisciplinary design teams, researcher-designer collaboration and user-centered design approaches.

2. Background

2.1. Sleep tracking

Sleep tracking, a branch of self-tracking, has emerged as a significant area of interest. Self-tracking practices are 'directed at regularly monitoring and recording, and often measuring elements of an individual's behaviours or body functions (Lupton 2016, 8).' This practice is often discussed under the notion of 'quantified self', a term coined by Wolf and Kelly to describe the 'phenomenon of detailed digitalized self-tracking' (Lupton 2016, 16). A wide range of self-tracking technologies has been developed to monitor various aspects of personal information, including activity, sleep, diet, weight, emotion and social interactions. Furthermore, the application

of self-tracking technologies has expanded beyond individual use to include the workplace.

Since sleep is one of the three pillars of a healthy lifestyle (Choe et al. 2011), growing public interest in sleep tracking has driven demand for related technologies. Sleep-tracking technologies enable users to obtain detailed insights into their sleep patterns, including metrics such as sleep duration, sleep stages and resting heart rate (Ravichandran et al. 2017). By analysing these sleep metrics, sleep-tracking technology can identify factors that hinder or enhance sleep and provide interventions, including notifications and recommendations, to help users improve sleep quality.

Compared to other forms of self-tracking, such as activity tracking and diet monitoring, sleep tracking is inherently more complex due to the nature of sleep itself. Sleep is a passive activity influenced by numerous physiological and environmental variables (Choe et al. 2011; Ravichandran et al. 2017). Sleep typically cannot be measured directly but needs to be inferred from other biological signals (Liang and Ploderer 2020). Without sleep-tracking technologies, users lack access to objective and quantifiable data about their sleep. Furthermore, in the context of activity tracking, users may gradually reduce their reliance on activity-tracking technologies by improving their activity performance and increasing their exercise levels autonomously. Habit formation is one reason for abandonment in activity tracking (Attig and Franke 2020). Conversely, sleep tracking primarily focuses on sleep quality, which is difficult to evaluate accurately solely through subjective perception. Therefore, sleep-tracking technologies are indispensable for providing quantified feedback for sleep monitoring and improvement. As a result, the relationship between users and sleep-tracking technologies tends to be more interdependent than between users and activity-tracking technologies.

2.2. The human–computer interaction framework

In this integrative literature review, we aim to emphasise the user and contextual perspectives in the context of sleep tracking, addressing the issue that previous literature reviews have focused solely on technology (Cay et al. 2022; Hosszu, Rosner, and Flaherty 2019). To this end, we adopted the HCI framework (Zhang and Li 2005) as a lens for data extraction from each article. The HCI framework (Zhang and Li 2005) provides a comprehensive view of the dynamics and richness of interaction between humans and technology, comprising five components: human, technology, interaction, context and task/job (see Figure 1). The human component encompasses user characteristics relevant to their interaction with IT, including demographics, physical and motor skills, cognition, emotions and motivation. The technology component encompasses hardware, software, information and services. Interaction is central to all actions, including design, use and impact. Thus, the interaction experience arises only when humans need technology to support their tasks in specific contexts.

Compared with other lenses, such as the persuasive systems design model (Oinas-Kukkonen and Harjumaa 2009), the framework of user experience over time (Karapanos et al. 2009) and the stage-based model of personal informatics systems (Li, Dey, and Forlizzi 2010), the HCI framework (Zhang and Li 2005) offers a broader sociotechnical perspective by simultaneously considering users, technology, tasks and context (Diederich et al. 2022). This comprehensive view is

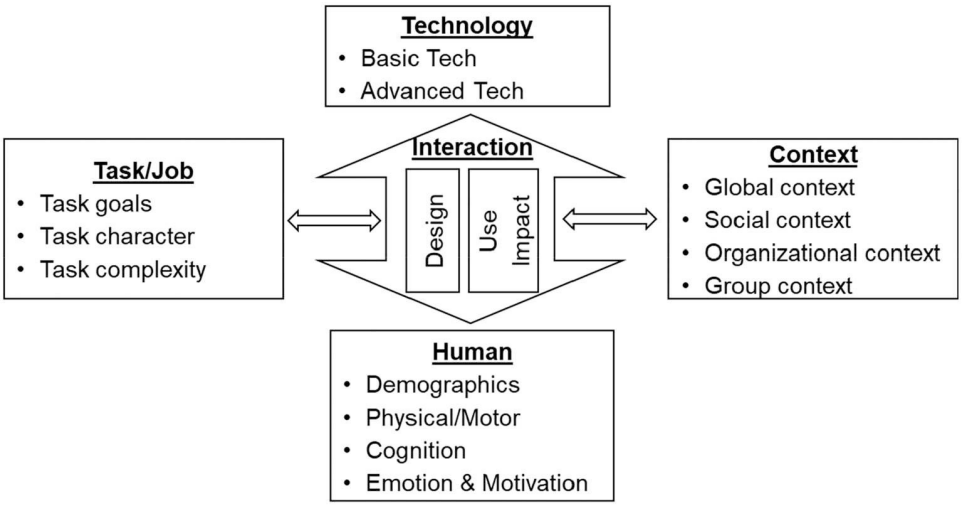

Figure 1. The human–computer interaction framework (Zhang and Li 2005).

well-suited for examining non-mandated activities, such as sleep tracking, where users' engagement is voluntary and strongly shaped by personal characteristics, technology features and situational contexts (Dhir et al. 2024). In comparison, the persuasive systems design model (Oinas-Kukkonen and Harjumaa 2009) emphasises technology design and evaluation; the framework of user experience over time (Karapanos et al. 2009) focuses on adoption behaviour over time; and the stage-based model of personal informatics systems (Li, Dey, and Forlizzi 2010) highlights users' collection and reflection of personal information. However, each of these perspectives tends to offer a single and narrow insight into specific aspects of technology use. In contrast, the HCI framework captures the complex and multifaceted nature of human–technology interaction by integrating behavioural, technological and contextual factors. Thus, the HCI framework provides a holistic lens for investigating how individuals interact with sleep-tracking technologies and how these interactions influence user experiences and technology design.

Previous review studies adopted and adjusted the HCI framework (Zhang and Li 2005) to synthesise the current state-of-the-art in interacting with various technologies (Chi, Denton, and Gursoy 2020; Diederich et al. 2022; Rzepka and Berger 2018). For example, this framework has been used to structure information systems (IS) research on user interaction with AI-enabled systems by organising the literature into five components: user, system, interaction, tasks and context, and outcomes (Rzepka and Berger 2018). Similarly, in the context of AI device use in service delivery, the HCI framework has been applied to analyse research on human–AI service encounters, summarising the characteristics of users, AI devices, and tasks and contexts, as well as their interactions (Chi, Denton, and Gursoy 2020). In addition, the HCI framework has been adjusted to account for human, agent, context, perception and outcome in the context of conversational agents (Diederich et al. 2022). In summary, the HCI framework offers a robust guiding framework that accommodates the factors influencing how users interact with technology (Zhang and Li 2004).

3. Method

3.1. Research design

This literature review aims to synthesise the current state of sleep-tracking research and propose key agendas for future investigation. To determine the most appropriate review type, we followed the process outlined by Cronin and George (2023), presented in Figure 2. The purpose of this review corresponds to a 'redirect research', which seeks to structure existing knowledge to generate new knowledge, rather than 'adjudicating an issue' by eliminating errors or establishing 'settled science' on a given topic (Cronin and George 2023). In addition, this review aims to employ an existing theoretical framework to synthesise knowledge and propose a framework that bridges multiple communities of practice. According to the review type selection process

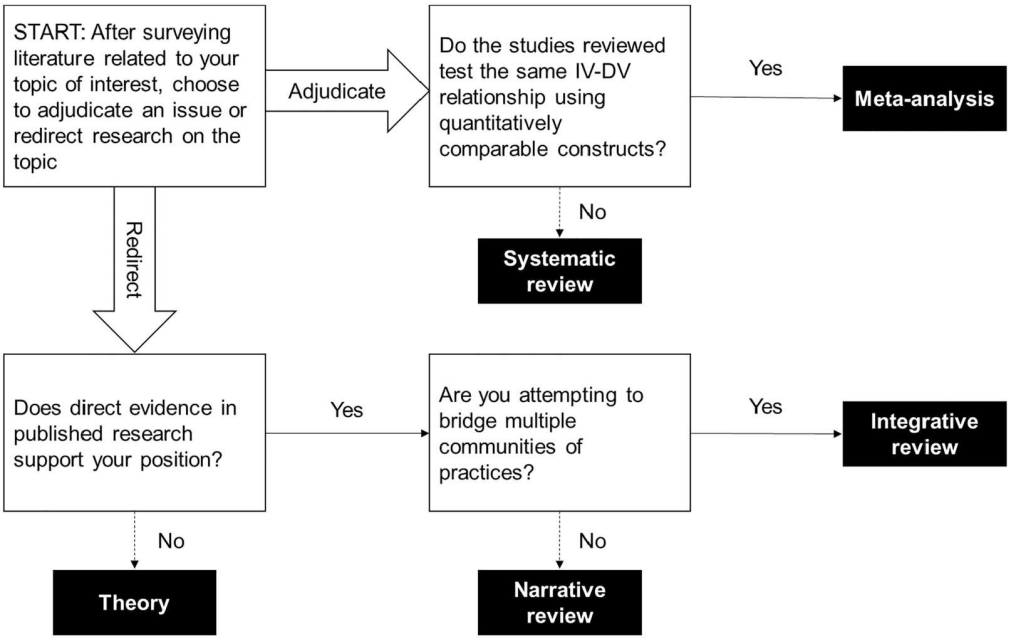

Figure 2. The choice of review type (Cronin and George 2023).

(Cronin and George 2023), we concluded that the integrative literature review (Torraco 2005, 2016) is the most appropriate approach for this study.

An integrative literature review is a distinct type of review that seeks to critique and synthesise the literature, particularly by integrating knowledge from the literature into a model or conceptual framework, thus offering a new perspective on a topic (Torraco 2005, 2016). An integrative review is appropriate for synthesising the accumulated knowledge concerning the relations of interests and identifying unsolved issues (Cooper 1982). Integrative reviews have recently gained traction as a method for synthesising knowledge in the IS field, as exemplified by reviews on blockchain (Santana and Albareda 2022), business model innovation (Schiavone, Paolone, and Mancini 2019) and emotions and consumer adoption of innovations (Valor, Antonetti, and Crisafulli 2022).

An integrative literature review is particularly well-suited for synthesising current research on sleep tracking, as its purpose is to integrate findings from diverse literature sets into a model or framework. Accordingly, we applied the HCI framework (Zhang and Li 2005) to guide our literature analysis and organise the findings. To ensure methodological rigour, we followed Torraco's (2005, 2016) process and checklist for organising and writing an integrative literature review. This process comprises three phases: (1) preparing to write the integrative literature review, (2) organising the integrative literature review and (3) composing the integrative literature review. According to the integrative literature review checklist (Torraco 2005), we checked whether our review met the requirements. Appendix 1 presents the implementation of the integrative literature review checklist in this paper.

Articulating the review's purpose is a key activity in the first phase of the integrative literature review process (Torraco 2005, 2016). Our review aims to generate new insights into sleep tracking by synthesising the state of the art, with a focus on users' interactions with sleep-tracking technology. To address the main RQ, this integrative literature review explores three specific sub-RQs:

> Sub-RQ1: How is research on sleep-tracking technology distributed across publication years, channels, methods, and theoretical foundations?
>
> Sub-RQ2: What antecedents and outcomes of sleep tracking have been identified?
>
> Sub-RQ3: What future research agendas can be derived from the current body of knowledge on sleep tracking?

The second phase, organising the integrative literature review, involves defining the review process, conducting the literature search and structuring a coherent conceptual framework for organising the literature (Torraco 2005, 2016). At this stage, we took two actions to ensure the review's procedural rigour. First, we executed the literature selection step in accordance with the systematic literature review process (Okoli 2015; Snyder 2019; Tranfield, Denyer, and Smart 2003), ensuring comprehensive coverage, the inclusion of high-quality studies, and a transparent and rigorous selection process. Second, we selected the five components of the HCI framework (Zhang and Li 2005) to serve as a guiding structure for analysing and synthesising the literature.

The third phase, composing the integrative literature review, involves conducting a critical analysis, synthesising knowledge to generate contributions, and reporting the review (Torraco 2005, 2016). At this stage of the process, we employed a concept matrix (Webster and Watson 2002) to illustrate how the themes were identified and categorised into the components of the HCI framework (See Appendix 5). The coding process was conducted deductively, guided by the five components of the HCI framework (Zhang and Li 2005), while allowing for flexibility to capture emerging subthemes. The first author conducted the initial coding and generated preliminary themes, which were subsequently reviewed and refined in discussions with the second author to ensure consistency and conceptual alignment. This iterative process was designed to enhance the reliability of the analysis and supported the development of a synthesising framework of research on sleep tracking (See Figure 5). Building on this framework, we then moved forward to analyse the literature to derive new insights and identify potential future research agendas. Finally, all authors reviewed and commented on the manuscript to further improve the clarity and coherence of the review.

3.2. Article search process

To ensure comprehensive coverage, quality of literature, and a transparent and rigorous review process (Victor 2008), we executed the selection step following the systematic literature review process (Okoli 2015; Snyder 2019; Tranfield, Denyer, and Smart 2003). The first two authors discussed and refined the search strategy, including the databases, search syntax, inclusion and exclusion criteria, and quality appraisal criteria.

3.2.1. Databases and search syntax

We conducted the article search across five academic databases: Scopus, Web of Science (WoS), PsycINFO,

the Association for Information Systems eLibrary (AIS eLibrary), and the Association for Computing Machinery Digital Library (ACM Digital Library). The WoS and Scopus were selected for their broad and multidisciplinary coverage, enabling the identification of eligible studies across diverse domains. In addition, because this article primarily examines sleep tracking from a human–computer interaction perspective, we included PsycINFO, AIS eLibrary and ACM Digital Library to capture more specialised literature from the behavioural and social sciences, IS, and computer science fields, respectively.

We searched relevant articles using specific keywords, language preferences, and document type filters. Specifically, we focused on papers whose topics (title, abstract, and keywords) contain the following terms: 'sleep track*,' 'sleep monitor*,' 'sleep sens*,' 'sleep technolog*,' 'sleep app*,' or 'sleep device*.' These search terms were selected to ensure broad coverage of studies on sleep-related technologies, with particular emphasis on tracking purposes, devices, applications, and sensors. In addition, we further narrowed the search to include only journal and conference papers published in English. The search syntaxes are presented in Appendix 2.

3.2.2. Inclusion and exclusion criteria

To ensure that all papers are relevant and applicable to the research question (Okoli 2015), we developed inclusion and exclusion criteria to refine the search results. Specifically, we only included papers published in scholarly journals or conferences with referee practices (IC1), reporting empirical studies (IC2), with main topics containing one or more of the predefined search terms (IC3), and written in English (IC4). Conversely, we excluded papers if they were duplicates (EC1), if their main topic did not contain user interactions with sleep-tracking technology (e.g. manual sleep tracking, sleep assessment, sleep therapy, animal sleep tracking) (EC2), or if their research subjects were not sleep-tracking users (e.g. technology validation, accuracy assessment, design science, and biomedical research) (EC3). The inclusion and exclusion criteria are detailed in Appendix 3.

3.2.3. Quality appraisal criteria

As the quality of a literature review relies on the rigour of the reviewed papers (Okoli 2015), the quality appraisal process is crucial for filtering out papers that fail to meet the required standards, thereby ensuring the overall quality of the literature review. Building on prior review studies, we established quality appraisal criteria focusing on article structure (Sollaci and Pereira 2004), research process (Almalki, Gray, and Martin-sanchez 2016), and publication channel (Feng et al. 2021; Idri, Amazal, and Abran 2015). Evaluating the article's structure ensures the comparability and accessibility, as the essential information, such as introduction, methods, results and discussion, is presented in a standardised and readily identifiable format (Sollaci and Pereira 2004). Assessing the research process helps verify the reliability and validity of the data collection and analysis. Additionally, we considered publication channels to ensure dissemination through recognised and stable channels. For this purpose, we relied on the Journal Citation Reports (JCR, https://jcr.clarivate.com/jcr/home) from Clarivate, which provides an objective and systematic evaluation of leading journals based on citation data, and the CORE (http://portal.core.edu.au/conf-ranks/), a conference ranking portal that focuses on computer science and information technology. Finally, to ensure the inclusion of high-quality and highly relevant studies, as well as to enhance the efficiency of this review's findings, we followed prior research (Behera, Bala, and Dhir 2019; Idri, Amazal, and Abran 2015) and used 50% of the maximum quality score as a cutoff point for including papers in the final sample. Table 1 outlines the quality appraisal criteria.

3.2.4. Article screening and quality appraisal

The article screening was conducted collaboratively by the first two authors, with a continuous exchange of information throughout the procedure to ensure consistency and reliability. Initially, the database search identified 6191 articles. After eliminating 2416 duplicates, we conducted a two-round screening using the inclusion and exclusion criteria. In the first round, we

Table 1. The quality appraisal criteria.

Criterion	Description
QA1	The study is a fully structured article that includes four basic sections: introduction, methods, results and discussion. The answers are Yes (+2) and No (+0).
QA2	The study describes the research process unequivocally and in sufficient detail. For example, a survey study reports the survey instrument, a qualitative study reports the coding and categorisation process, and an experimental study reports the detailed procedures of the experiment. The answers are Yes (+2), Partially (+1) and No (+0).
QA3	The study was published in a reliable and recognised journal and conference: 1. Journal ranking based on JCR: Q1 (+2), Q2 (+1.5), Q3 (+1), Q4 (+0.5) and no JCR ranking (+0). 2. Conference ranking based on CORE: A* (+2), or A (+1.5), B (+1), C (+0.5) and no ranking (+0).

Notes: 1. JCR: The Q1–Q4 means the journal is ranked in the quartiles of the categories each year. For example, Q1 is the first quartile of the categories and represents the top 25% of the categories. 2. CORE: In 2023, the proportions of A*, A, B and C levels were 7.65%, 14.92%, 28.96% (includes 0.77% of Australasian B) and 48.47% (includes 2.42% of Australasian C), respectively.

screened the articles based on their titles, abstracts, and keywords. In the second round, we screened the remaining articles based on full texts. Finally, to ensure the comprehensiveness of the article search, we included relevant articles identified through forward and backward citation chaining in our sample pool.

As a result of the screening process, we identified a pool of 51 papers, comprising 33 journal articles and 18 conference papers, published up to February 2025. The quality of each article was evaluated based on predefined quality appraisal criteria presented in Table 1. Appendix 4 further presents the quality score for each article. No papers were omitted at this stage because all exceeded the threshold of 50% of the maximum score. Hence, we moved forward with the pool of 51 studies. Figure 3 presents a visual summary of the article search and quality appraisal process.

4. Results

4.1. Final pool of articles included in the review

4.1.1. Publications by year and channel

As Figure 4 shows, the first article in the pool of reviewed studies was published in 2011 by Choe et al. (2011). Regarding the volume of publications, the year 2022 marked the peak with 13 articles.

Regarding the publication channels, the articles were distributed across various journals and conferences, with most venues featuring only one article. The top three journals—*Sensors*, *Behavioural Sleep Medicine*, and *Frontiers in Computer Science*—published three, two, and two articles, respectively. In terms of conference publications, the *Conference on Human Factors in Computing Systems (CHI)* was the most frequently utilised channel, hosting four articles, followed by the

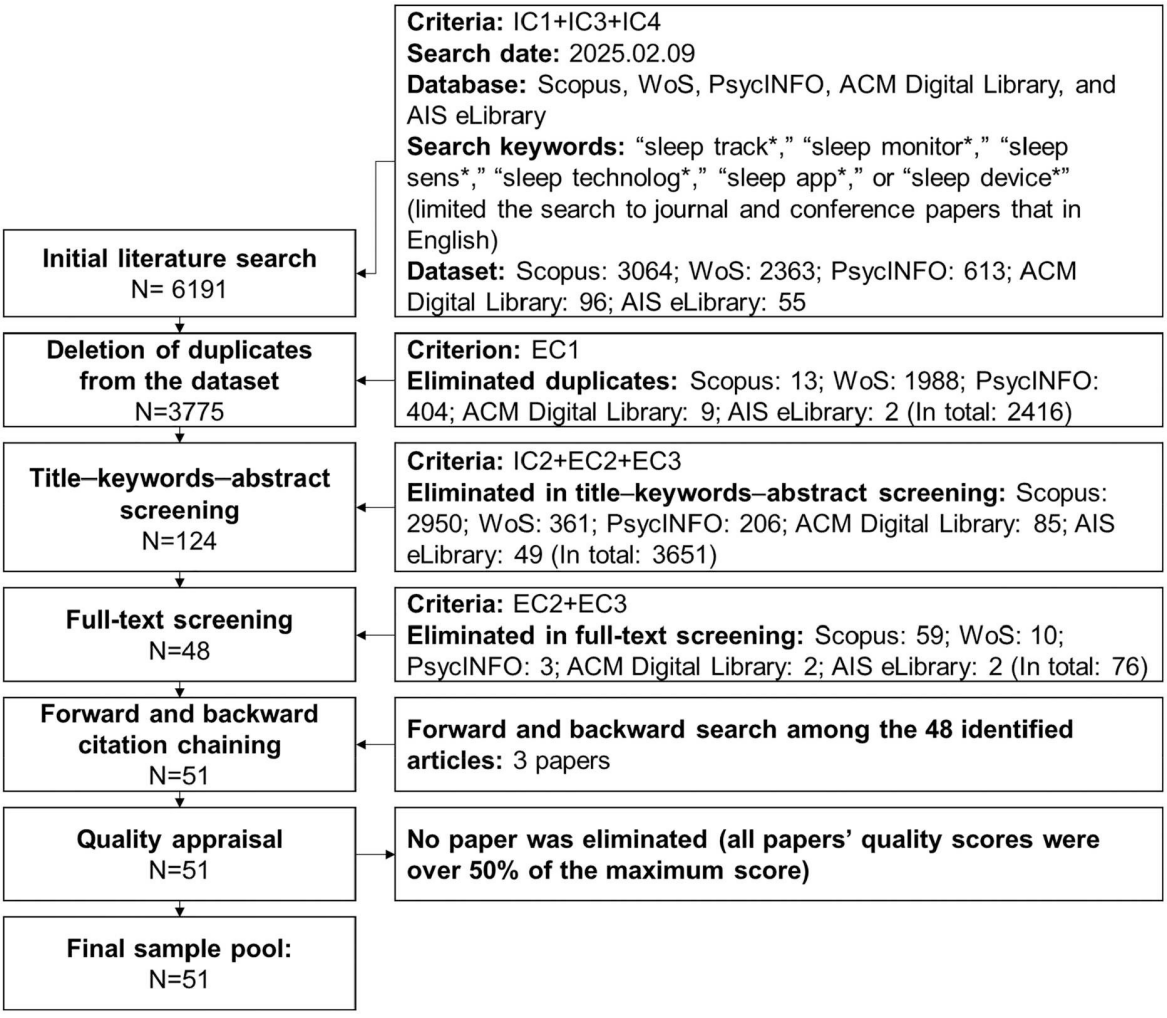

Figure 3. The article search and quality appraisal process.

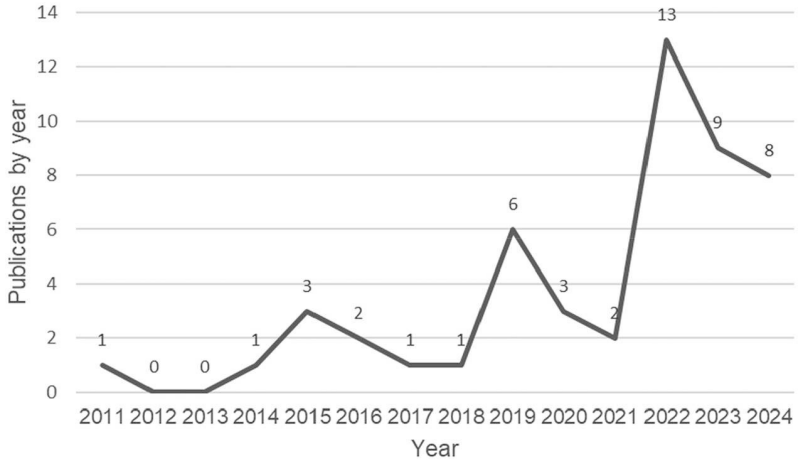

Figure 4. Distribution of articles by publishing year (articles published up to 2024).

Australian Computer–Human Interaction Conference (OzCHI), the *International Conference on Pervasive Computing Technologies for Healthcare (Pervasive-Health), and the Conference on e-Business, e-Services and e-Society (I3E), each* with two articles.

4.1.2. Distribution of articles by methods and theoretical backgrounds

We categorised the reviewed articles by their research methods into qualitative, quantitative and mixed-methods studies. Table 2 displays the respective results. Most studies (23 articles) employed qualitative data collection methodologies, using approaches such as interviews, case studies and focus groups. Other approaches included quantitative research methods (18 articles) and mixed-methods studies (10 articles).

With respect to theoretical backgrounds, most studies did not have an explicit theoretical lens, with only 11 out of 51 studies applying theories. However, a range of 12 theories underpins these 11 studies on sleep tracking, suggesting that no clear dominant theory exists. Table 3 provides information about theoretical backgrounds and research foci.

Table 2. The distribution of articles by study methods.

Research methods	Data sources	n (%) (N = 51)
Qualitative	Interview, case study, focus group, observation, auto-ethnography, data from online discussion forums (thematic analysis), survey (open-ended questions)	23 (45.10%)
Quantitative	Survey, experiment, trial, user-generated reviews from app stores (natural language processing)	18 (35.29%)
Mixed-methods	Survey combined with interviews; survey combined with open-ended questions (content analysis); group brainstorming combined with survey; focus group combined with app review and survey; survey combined with interviews and technology review	10 (19.61%)

4.2. The synthesising framework for sleep-tracking research

We used the HCI framework (Zhang and Li 2005) to guide the development of a concept matrix. This approach enables the structured presentation of insights from the reviewed articles in a structured way. Thus, we extracted and summarised five components of sleep tracking, encompassing user, sleep-tracking technology, use context along with corresponding tasks, use and impact (user-oriented outcomes), and design insight (technology-oriented outcomes).

The first three components represent the antecedents of sleep tracking, referring to factors identified in prior research that are associated with the interactions between users and sleep-tracking technologies, including technological characteristics, user attributes and use context, along with corresponding tasks. The final two components reflect the outcomes of sleep-tracking practice, encompassing user-oriented use and impacts, as well as design insights (technology-oriented outcomes) derived from accumulated use and impacts. Taken together, this framework suggests that interactions between sleep-tracking technologies and users within specific contexts for corresponding tasks shape users' use patterns and influence use outcomes, including behaviour, health, and well-being. The resulting user-oriented outcomes, in turn, provide empirical evidence that informs subsequent design insights.

Figure 5 summarises the review results, highlighting the factors investigated in the literature. The following subsections cover each component and the future research directions proposed by the literature.

Table 3. Theoretical backgrounds.

Reference	Theoretical background(s)	Research foci
Nuo et al. (2023)	Two-factor theory	User satisfaction when using the mHealth sleep application
Purnell et al. (2023)	Technology acceptance model (TAM)	Acceptability and usability of a wearable device for sleep health
Kuosmanen et al. (2022)	Expectation disconfirmation theory	Consumer-grade sleep-tracking technology evaluation from the perspective of ease-of-use, functionality and reliability and comfortability and sleep disturbance
Leblanc et al. (2022)	The unified theory of acceptance and use of technology (UTAUT)	Usability experience of a personal sleep monitoring device
Feng, Mäntymäki, and Salmela (2022)	Affordance theory	Affordances of sleep-tracking technology
Robbins et al. (2019)	Social cognitive theory	The characteristics of individuals who report using their mobile device for sleep tracking
Wang, Hugh, and Yang (2020)	Social cognitive theory	Mobile sensor-based community gaming for improving the effectiveness of sleep hygiene education
Nguyen et al. (2018)	Persuasive systems design model; behaviour change support system model; five-factor model of personality	Using individual personality traits and chronotype characteristics for personalised feedback
Attie and Meyer-Waarden (2023)	Uses and gratifications theory; technology acceptance model	The impact of sleep apps on Generation Z's well-being
Jakowski (2022)	Stage model of self-tracking technology use	The impact of self-tracking technologies on athletes
Feng, Mäntymäki, and Salmela (2023)	The person–technology fit model	Potential stressors attributed to sleep tracking executed through a smart ring

Appendix 5 presents details of the reviewed articles based on the concept matrix.

4.2.1. User

The first component is the user, referring to the end users of sleep-tracking technology. Within this dimension, existing research has identified three sub-themes: demographics, lifestyle and habits, and psychological factors.

(1) Demographics

Several studies have examined users' demographics, including gender (Attie and Meyer-Waarden 2023;

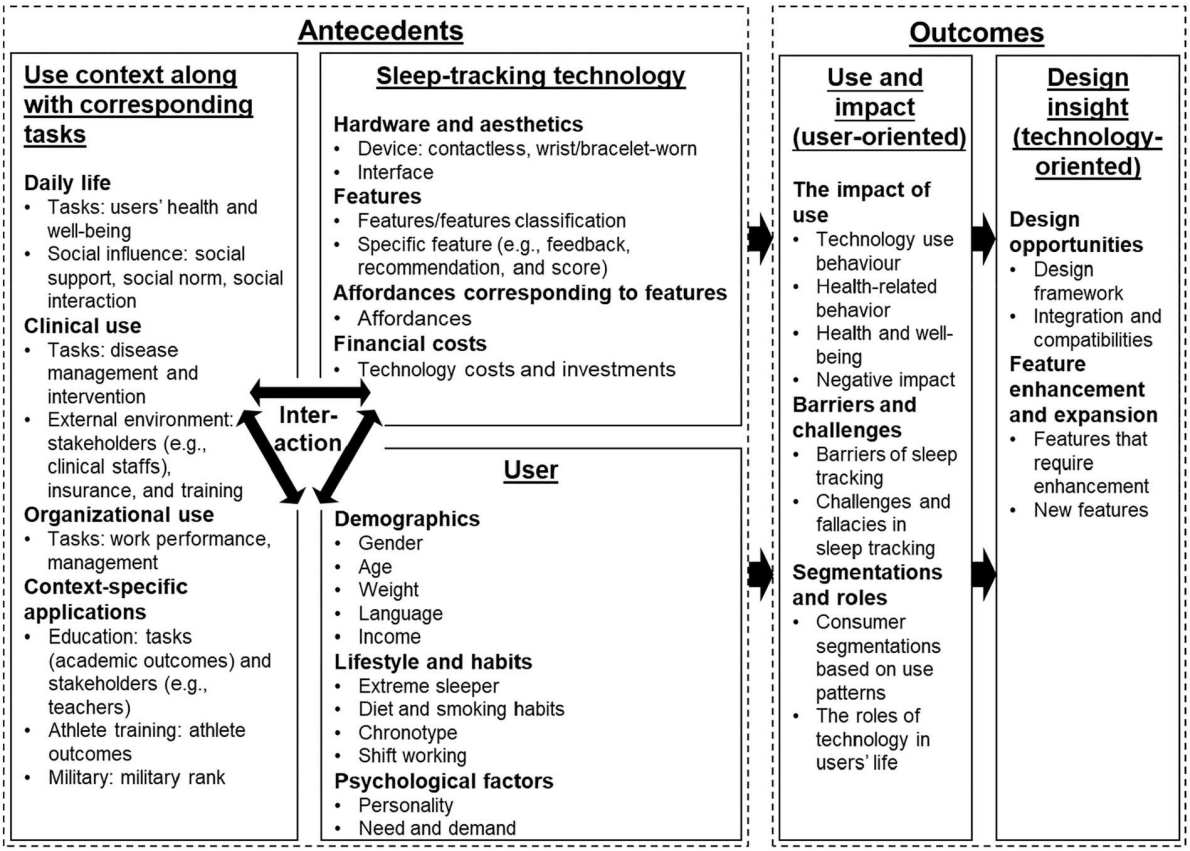

Figure 5. A Synthesising framework of research on sleep tracking.

Jakowski 2022; Makkonen et al. 2016; Matsangas, Shattuck, and McClernon 2024; Nolasco et al. 2023; Robbins et al. 2019), age (Barnes et al. 2023; Leblanc et al. 2022; Makkonen et al. 2016; Nolasco et al. 2023), weight (Nolasco et al. 2023), language (Purnell et al. 2023), and income (Quante et al. 2019; Robbins et al. 2019). However, findings remain mixed. Some studies have found that men and individuals with incomes above $75,000 are more likely to use a mobile phone for sleep tracking (Robbins et al. 2019), whereas others have reported higher adoption among men than among women (Makkonen et al. 2016). Additionally, non-native English speakers may encounter difficulties in translating sleep-tracking metrics (Purnell et al. 2023). Conversely, other research indicated that demographic factors do not significantly impact the use of sleep-tracking technology. For instance, age was not a barrier to using sleep-tracking technology among older adults (Leblanc et al. 2022), and adherence to sleep wearables shows no significant differences based on age or weight (Nolasco et al. 2023).

(2) Lifestyle and habits

Prior research has found correlations between users' lifestyles, habits and the use of sleep-tracking technology. For example, sleep-tracking technology has less effect on sleep duration for shift workers, but it can help combat fatigue by improving sleep efficiency (Devine et al. 2024). Chronotype has also been shown to influence the use of sleep-tracking technology, emphasising that design should align with users' life rhythms rather than normative standards of 'good sleep' (Karlgren and McMillan 2022; Nguyen et al. 2018). In addition, individuals with an 'excellent' diet were more likely to track their sleep than those with a poor diet, and smokers were more likely to track their sleep more than nonsmokers (Robbins et al. 2019). These results reflect complex health-related motivations: individuals with healthy lifestyles and habits may track their sleep to maintain their well-being, while those with health-risk lifestyles may be more conscious of their health risks, encouraging them to adopt sleep-tracking technology.

(3) Psychological factors

Prior research has explored users' psychological factors, including personalities and needs. In the context of sleep tracking, user personality can influence their behaviours (Attie and Meyer-Waarden 2023; Nguyen et al. 2018). For example, sanguine individuals, who tend to feel and express positive well-being, report experiencing more sensations of well-being after using the mHealth app (Attie and Meyer-Waarden 2023). Additionally, the Big Five personality traits framework has been applied to design personalised feedback for a sleep health behaviour change support system (Nguyen et al. 2018).

Studies have examined user needs, with a primary focus on the need for technological features (Aji et al. 2019; Oh et al. 2022; Schwartz et al. 2024). User prioritised features include sleep diaries, sharing sleep data with a doctor, and lifestyle tracking (Aji et al. 2019). Meanwhile, in consumer sleep technologies, users prioritise comfort, actionable feedback and ease of use (Oh et al. 2022). Based on user preferences for sleep-tracking features, validation and endorsement, research has found that consumers prefer devices with scientific evaluation and endorsement (Schwartz et al. 2024).

4.2.2. Sleep-tracking technology

The component of sleep-tracking technology depicted in Figure 5 includes technologies that can monitor sleep, such as wearable devices, apps and non-invasive techniques. Previous studies in this area have summarised the sleep-tracking hardware and aesthetics, features and corresponding affordances, and financial costs.

(1) Hardware and aesthetics

Prior research has examined the hardware and aesthetics of sleep-tracking technology. Wrist-worn technologies remain the most commonly used type of sleep-tracking (S. Zhang et al. 2019). However, prior research suggests that users often perceive them as providing less actionable guidance compared to sleep-related apps (S. Zhang et al. 2019). According to Kuosmanen et al. (2022), users generally prefer contactless sensing devices due to their ease of use. On the other hand, prior research has also reported that wrist-worn technologies do not significantly disturb sleep (Vandenberghe and Geerts 2015a). It is important because users value comfort (Oh et al. 2022), and discomfort may lead to discontinued use (Liu, Ploderer, and Hoang 2015). In addition, the perceived credibility of the interface and device affects users' assessment of the technology's credibility (Liang and Ploderer 2020).

(2) Features

The reviewed literature has examined the features of sleep-tracking mobile apps (Aji et al. 2019; Karasneh et al. 2022) and wearable devices (Feng, Mäntymäki, and Salmela 2022, 2023; Vandenberghe and Geerts 2015a). These features have been analysed and grouped according to different criteria. For instance, features of a

sleep-tracking smart ring have been categorised into eight groups: tracking, notifications, guidance and recommendations, scores and rewards, data sharing, and compatibility (Feng, Mäntymäki, and Salmela 2023). The functionalities of six sleep-tracking applications have been summarised into sleep cycle analysis, metrics and stage assessment, smart alarm, snoring and dream log, music and fitness integration (Karasneh et al. 2022).

Moreover, sleep-tracking features shape user experience (e.g. Karasneh et al. 2022; Nuo et al. 2023). They serve as criteria for evaluating the app's quality (Karasneh et al. 2022) and affect user satisfaction (Nuo et al. 2023). Sleep-tracking features also contribute to understanding the sleep-tracking affordances (Feng, Mäntymäki, and Salmela 2022) and stressors caused by the technology (Feng, Mäntymäki, and Salmela 2023). Additionally, prior research has explored artificial intelligence (AI)-enabled features, evaluating users' expectations and usability of the technology, and providing recommendations for further development (Oh et al. 2022).

Research has also investigated specific features, including feedback, recommendations and scores. For example, positive sleep scores can motivate users in the morning (Nagele and Hough 2024). However, other research has found no significant differences between positive and negative sleep feedback in terms of their effects on pre-sleep arousal and subjective sleep continuity in healthy sleepers (Robson, Ellis, and Elder 2022). In addition, the app information on sleep disturbances was often described as overly basic, complex, cumbersome and lacked a clear rationale and immediate feedback on data collection (Aji et al. 2019).

(3) Affordances corresponding to features

Previous research has identified the affordances of sleep-tracking technology corresponding to its features (Elmholdt, Elmholdt, and Haahr 2021; Feng, Mäntymäki, and Salmela 2022). For instance, four affordances of sleep-tracking smart rings were summarised, including dynamic goal setting, self-quantification, learning, and nudging (Feng, Mäntymäki, and Salmela 2022). In workplace self-tracking, three affordances of self-tracking technology have been identified, including the ability to remotely manage employees' health, gaining self-control through body visibility, and the potential to induce frustration and worry due to data opacity and a loss of control (Elmholdt, Elmholdt, and Haahr 2021).

(4) Financial costs

Financial costs may also influence users' adoption and tracking behaviour. The cost of the device may affect overall user acceptance in the initial stages of adopting sleep-tracking technology (Leblanc et al. 2022; Purnell et al. 2023). However, users are more likely to engage in long-term tracking if they have already invested money into their sleep-tracking apps (Aji et al. 2019).

4.2.3. Use context along with corresponding tasks

The third component, use context along with corresponding tasks, refers to the interaction background in which the sleep-tracking technology supports users' completion of tasks in a specific context. Prior research has investigated the use of sleep-tracking technology in daily life, clinics, organisations, education, athlete training and military settings. Studies have also highlighted specific user tasks and contextual characteristics across these contexts.

(1) Daily life

Research on sleep-tracking technology has primarily examined its use among general consumers in everyday life (e.g. Attie and Meyer-Waarden 2023; Kuosmanen et al. 2022; Quante et al. 2019). For instance, a survey has investigated the impact of sleep apps on the well-being of Generation Z (Attie and Meyer-Waarden 2023), and a study with interviews of 82 Oura Ring users has examined the lifestyle changes associated with sleep tracking (Kuosmanen et al. 2022).

Social influence also plays a significant role in users' daily sleep tracking. Positive social influence, such as peer support and acceptance from other users, has been shown to enhance the usability experience and support their self-management (Leblanc et al. 2022). Social interaction, such as communication across platforms, helps users evidence their self-tracked sleep data (Hine, Meadows, and Pritchard 2023). Additionally, sharing sleep data can motivate continued tracking, making sleep more communicable and connected (Lyall 2021).

(2) Clinical use

Prior studies have explored sleep-tracking technologies in clinical contexts to support patients' disease management and complement therapeutic interventions (e.g. Acosta et al. 2024; Aji et al. 2019; Kaitz et al. 2023; Ojalvo et al. 2023; Purnell et al. 2023). Research has evaluated the needs and preferences of individuals with sleep disturbances, highlighting the features of sleep tracking, alarms and personalisation (Aji et al. 2019). Research has also suggested that sleep-tracking technologies are easy to use and useful for people with chronic insomnia (Kaitz et al. 2023). These technologies can also

provide interventions to improve the effectiveness of therapy for patients (Aji et al. 2022; Griffiths et al. 2022), without exacerbating sleep problems in patients with insomnia (Ojalvo et al. 2023). Moreover, AI-driven sleep-tracking technology may save time and provide data-driven insights for nurses and healthcare providers (Acosta et al. 2024).

In addition, it is important to integrate sleep-tracking technologies effectively in clinical settings, emphasising alignment with hospital workflows, communication with patients, access to raw data, the provision of contextualised information, and data portability (Vandenberghe and Geerts 2015b). Moreover, prior research has highlighted the importance of considering patients' external environment (e.g. clinical staff, patients' family and peer influence) (Purnell et al. 2023), access to insurance (Purnell et al. 2023), training (Acosta et al. 2024) and staff engagement (Acosta et al. 2024).

(3) Organisational use

In organisational settings, sleep-tracking technology has been used to enhance employees' sleep quality (Barnes et al. 2023; Devine et al. 2024), improve work behaviours (Barnes et al. 2023), and support management initiatives (Elmholdt, Elmholdt, and Haahr 2021). For instance, prior research has suggested that wearing a Fitbit smartwatch with the SleepTank app can improve sleep efficiency (Devine et al. 2024). Similarly, employees who used headbands with closed-loop acoustic stimulation had higher work engagement and task performance (Barnes et al. 2023). Furthermore, sleep-tracking technology has been evidenced to support self-management and remote organisational management in the workplace (Elmholdt, Elmholdt, and Haahr 2021).

(4) Context-specific applications

Prior research has also explored the effects of sleep-tracking technology in the context of education (Lau and Carney 2025; Wang, Hugh, and Yang 2020), athlete training (Jakowski 2022; Jakowski and Stork 2022) and military settings (Matsangas, Shattuck, and McClernon 2024). In the educational context, mobile sensors that provide sleep feedback have a positive influence on students' sleep and academic outcomes (Wang, Hugh, and Yang 2020). Additionally, stakeholders such as teachers, social workers and sleep researchers play a vital role in facilitating students' adoption of sleep-tracking apps (Lau and Carney 2025). However, in the context of athletes' training, no significant differences have been found between sleep-tracking app users and non-users, regardless of gender, sport type, competition participation, or training volume (Jakowski 2022; Jakowski and Stork 2022). One study in military settings found that higher-ranking military members had better participant compliance with sleep tracking than subordinates (Matsangas, Shattuck, and McClernon 2024).

4.2.4. Use and impact (user-oriented outcomes)

The component of use and impact (user-oriented outcomes) covers a range of topics concerning the outcomes of sleep tracking from a user's standpoint. Many studies have investigated this component, focusing on three key sub-themes: the impact of use, barriers and challenges, and segmentation and roles.

(1) The impact of use

The majority of research has examined the impact of sleep tracking on technology use (e.g. Aji et al. 2022; Attie and Meyer-Waarden 2023), health-related behaviour (e.g. Karasneh et al. 2022; Mitsutake et al. 2016), and health and well-being (Ojalvo et al. 2023; Ravichandran et al. 2017). In particular, considerable volumes of research have focused on the usage behaviour, including use intentions (Attie and Meyer-Waarden 2023), actual use (Attie and Meyer-Waarden 2023; Leblanc et al. 2022), continued use (Kaitz et al. 2023), user engagement (Aji et al. 2022), and adherence to wearing the device (Matsangas, Shattuck, and McClernon 2024; Nolasco et al. 2023). For example, prior research has shown that the perceived usefulness of sleep-tracking technology significantly affects both users' intention to use and real use (Attie and Meyer-Waarden 2023). In addition, factors such as personal meaning of technology, effort expectancy, performance expectancy, social influence, and facilitating conditions influence sleep self-management with sleep monitoring devices (Leblanc et al. 2022). Research has also found that veterans with chronic insomnia considered the sleep health information technology acceptable and were willing to continue using it (Kaitz et al. 2023). Furthermore, user engagement can be strengthened by integrating digital behavioural therapy (Aji et al. 2022) but weakened by poor design, bugs and ambiguous information (Aji et al. 2019). Regarding adherence to wearing the devices, while demographic factors such as age, weight and gender have little impact on adherence (Nolasco et al. 2023), compliance may decline over time in long-term use, particularly in the military setting (Matsangas, Shattuck, and McClernon 2024).

With respect to health-related behaviour changes, existing research demonstrated that sleep-tracking technology can promote healthy sleep habits (Griffiths et al.

2022; Karasneh et al. 2022; Quante et al. 2019; Ravichandran et al. 2017; Wang, Hugh, and Yang 2020). Prior studies have explored specific changes, including altering sleep schedules (Goelema, Haakma, and Markopoulos 2014; Kuosmanen et al. 2022), changing poor eating and drinking habits (Goelema, Haakma, and Markopoulos 2014; Kuosmanen et al. 2022), promoting physical activity (Griffiths et al. 2022; Kuosmanen et al. 2022) and assisting in the management of diseases that affect sleep (Ravichandran et al. 2017).

A body of research has evidenced that sleep-tracking technology can improve users' health and well-being. It helps users identify factors affecting sleep quality (Kuosmanen et al. 2022), gain a better understanding of users' sleep patterns (Quante et al. 2019), align their sleep experiences with tracked data (Nagele and Hough 2024) and increase sleep awareness (Goelema, Haakma, and Markopoulos 2014; Karasneh et al. 2022; Lau and Carney 2025; Ojalvo et al. 2023; Ravichandran et al. 2017). Ultimately, sleep-tracking technology contributes to improving sleep efficiency (Devine et al. 2024), sleep quality (Barnes et al. 2023; Shaforostov et al. 2024), sleep health (Lau and Carney 2025) and overall well-being (Attie and Meyer-Waarden 2023). However, current sleep-tracking technologies are not as effective as anticipated in improving sleep health (S. Zhang et al. 2019). Not all users were attracted by self-tracking technologies (Jakowski 2022; Jakowski and Stork 2022), and some doubted their efficacy in developing healthy sleep habits (Quante et al. 2019).

Several studies have also discussed the potential adverse outcomes of using sleep-tracking technology (Feng, Mäntymäki, and Salmela 2023; Feng and Mäntymäki 2024; Jahrami et al. 2024; Kuosmanen et al. 2022; Nagele and Hough 2024). Reported issues include technology-induced stress (Feng, Mäntymäki, and Salmela 2023; Kuosmanen et al. 2022), physical discomfort (Kuosmanen et al. 2022), and frustration caused by contradictory information from the sleep-tracking apps and the conflict with social commitments (Nagele and Hough 2024). Sleep-tracking stressors may result in behavioural and emotional strains (Feng, Mäntymäki, and Salmela 2023) and are linked to health anxiety (Feng and Mäntymäki 2024). In addition, orthosomnia, a condition where sleep-tracking users become overly focused on improving their sleep, leads to increased sleep-related anxiety and worsened sleep quality (Baron et al. 2017). Notably, evidence suggests that orthosomnia is present among individuals who use sleep-tracking devices (Jahrami et al. 2024). Conversely, other research indicated that tracking sleep does not exacerbate sleep worries in people with insomnia (Ojalvo et al. 2023). False sleep feedback did not negatively affect users' total sleep time and efficiency (Robson, Ellis, and Elder 2022).

(2) Barriers and challenges for users

Prior research has identified several barriers to the effective use of sleep-tracking technology (Acosta et al. 2024; Liang and Ploderer 2016; Ravichandran et al. 2017). For example, two key barriers to sleep health improvement associated with sleep sensors have been identified, including inconsistent inference about sleep quality and overemphasis on sleep stages (Ravichandran et al. 2017). Similarly, three obstacles to improving sleep have been identified: a lack of knowledge about normal sleep, difficulties in diagnosing the causes of sleep deprivation, and uncertainty regarding appropriate actions (Liang and Ploderer 2016). In a clinical context, trust in technology and resistance to change among nurses and healthcare providers have been found to be significant barriers to implementing an AI-driven sleep-tracking device (Acosta et al. 2024).

Beyond these barriers, users face additional challenges when using sleep-tracking technologies (Kuosmanen et al. 2022; Kuosmanen et al. 2022; Liu, Ploderer, and Hoang 2015; Quante et al. 2019), which can also generate fallacies (Liang and Ploderer 2020). Technical issues have created challenges, including battery runout, incorrect sleep detection, and synchronisation and data export issues (Kuosmanen et al. 2022). User-related challenges include maintaining continuity in tracking, establishing trust in the technology, handling data manipulation, and interpreting data (Liu, Ploderer, and Hoang 2015). Low app usage is also a challenge faced by users, such as forgetting to activate the app and experiencing initial confusion while navigating it (Quante et al. 2019). Moreover, users struggle to balance the data with personal perceptions and avoid compulsive behaviour caused by the constant availability of data (Kuosmanen et al. 2022). In workplace contexts, digital self-tracking for sleep also faces challenges, such as a lack of clarity in data and ambiguous spaces for autonomy and control (Elmholdt, Elmholdt, and Haahr 2021). The complexity of sleep and the black-box nature of the devices have become sleep fallacies among users (Liang and Ploderer 2020).

(3) Segmentations and roles

Previous research has categorised consumer segments based on usage patterns (Kuosmanen et al. 2022; Makkonen et al. 2016). Specifically, five archetypes of

sleep-tracking smart ring users have been distinguished according to their perceptions of the data: passive, aware, reactive, motivated and critical (Kuosmanen et al. 2022). Moreover, based on adoption patterns, self-tracking users can be segmented into four categories: pro-trackers, semi-trackers, interested and non-trackers (Makkonen et al. 2016).

Furthermore, research has examined the role of technology through users' perceptions and interaction with sleep-tracking technology (Nagele, Hough, and Dinnen 2022; Salmela, Valtonen, and Lupton 2019). When conceptualising sleep-tracking devices as social agents, they can be understood as taking on six roles in users' lives: teacher, informant, companion, therapist, coach and mediator (Nagele, Hough, and Dinnen 2022). In a research on understanding the impact of a specific research device in the qualitative research process, the sleep-tracking ring was considered an intimate research device (Salmela, Valtonen, and Lupton 2019). Researchers described the 'failed' process of experience with a sleep-tracking ring and identified different forms of intimacy and their effects (Salmela, Valtonen, and Lupton 2019).

4.2.5. Design insight (technology-oriented outcomes)

The design insight (technology-oriented outcomes) component covers topics concerning the technological outcomes of sleep tracking that emerge from accumulated evidence on user-oriented use and impacts. Unlike the sleep-tracking technology component, which examines the technology and design characteristics (e.g. hardware, aesthetics and features), this component primarily focuses on insights derived from empirical studies, emphasising design opportunities and feature enhancement and expansion in future sleep-tracking technologies. Drawing from user experience and feedback, previous research has identified several design opportunities and areas for enhancement in sleep-tracking technology. These insights serve as guidance for sleep-tracking designers to improve and innovate in this space.

(1) Design opportunities

Prior research has developed a design framework for sleep tracking based on six dimensions: goal, features, source, technology platform, stakeholders and input mechanism (Choe et al. 2011). Subsequent research has highlighted the balance between automation and control in sleep-tracking technology (Liu, Ploderer, and Hoang 2015; Vandenberghe and Geerts 2015a). Because sleep patterns vary among individuals, designers should consider more unique user groups, such as extreme sleepers (Karlgren and McMillan 2022) and families (Cherenshchykova and Miller 2019, 2020). Furthermore, designers should ensure integration and compatibility of sleep-tracking technology. Sleep tracking can be incorporated into established tools and strategies that have proven useful (Zhang et al. 2019), such as current wellness products already used by patients (Oh et al. 2022), platforms and agents offering sleep hygiene recommendations (Quante et al. 2019) and clinical sleep research (Vandenberghe and Geerts 2015b).

(2) Feature enhancement and expansion

Previous research has identified several features of sleep-tracking technology that require enhancements. These include offering personalised (Feng, Mäntymäki, and Salmela 2023; Feng and Mäntymäki 2024; Liang and Ploderer 2016; Nguyen et al. 2018; Oh et al. 2022; Shaforostov et al. 2024; Zhang et al. 2019), educational (Feng and Mäntymäki 2024) and actionable (Feng and Mäntymäki 2024; Ravichandran et al. 2017; Zhang et al. 2019) recommendations, increasing the transparency of algorithms and mechanisms (Feng, Mäntymäki, and Salmela 2023; Liang and Ploderer 2020; Liu, Ploderer, and Hoang 2015; Ravichandran et al. 2017), providing gentle and concise notifications (Feng and Mäntymäki 2024), and providing intelligible, accurate and flexible data (Liang and Ploderer 2016; Liu, Ploderer, and Hoang 2015; Vandenberghe and Geerts 2015a).

Additionally, several researchers have suggested adding new features in the future, such as game elements (Kaitz et al. 2023), community elements (Kaitz et al. 2023), subjective sleep quality assessment (Ravichandran et al. 2017; Shaforostov et al. 2024), long visualisation trends (Ravichandran et al. 2017) and instructions for action (Liu, Ploderer, and Hoang 2015). Moreover, sleep-tracking design should consider various internal and external factors affecting sleep (Shaforostov et al. 2024), such as user emotion (Vandenberghe and Geerts 2015a), home sleep setting (Oh et al. 2022), lifestyle factors (Liang and Ploderer 2016), cultural differences (Choe et al. 2011), variations in sleep practices (Choe et al. 2011) and sleep behaviours (Zhang et al. 2019). In addition, a new meaning of abstract biodata with multiple senses should be proposed and created to represent tangible and multisensory biodata in sleep tracking (Shaforostov et al. 2024).

4.3. Future research directions proposed by the literature

Drawing on the synthesising framework of research on sleep tracking (see Figure 5), we have categorised the future research directions presented in the reviewed studies into five components outlined above.

(1) User: The role of user characteristics in sleep tracking

Future studies should delve deeper into the impact of user demographics (Acosta et al. 2024; Attie and Meyer-Waarden 2023; Leblanc et al. 2022; Liang and Ploderer 2020; Matsangas, Shattuck, and McClernon 2024; Nolasco et al. 2023) and diverse backgrounds (Feng and Mäntymäki 2024; Leblanc et al. 2022; Nuo et al. 2023; Quante et al. 2019; Robbins et al. 2019). Moreover, user psychological factors, such as personality (Kuosmanen et al. 2022), self-efficacy (Feng and Mäntymäki 2024), motivation (Kaitz et al. 2023; Liang and Ploderer 2020) and community sleep needs (Lau and Carney 2025), warrant increased attention for future research.

Several questions raised by prior research are worth exploring. For instance, it is essential to examine how user traits and socioeconomic backgrounds influence individual behaviour and health outcomes (Leblanc et al. 2022), as well as how users' personalities affect their experience with data and recommendations (Kuosmanen et al. 2022). In addition, future work should explore dissemination strategies tailored to users with diverse backgrounds (Robbins et al. 2019) and establish user profiles to distinguish users based on gender and age (Liang and Ploderer 2020).

(2) Sleep-tracking technology: Emerging features and design innovations in sleep-tracking technology

Due to the emergence of new technologies, further research should explore the potential affordances of sleep-tracking technology, particularly in light of emerging features (Feng, Mäntymäki, and Salmela 2022). Moreover, future studies should more rigorously investigate how aesthetic aspects of technology, such as colour schemes, influence user engagement and perceived interface credibility (Liang and Ploderer 2020).

(3) Use context along with corresponding tasks: External factors in different contexts

While few papers have mentioned the important role of context and tasks in future research directions, the external factors in different contexts stand out as an area needing more attention. In the organisational context, future research could enhance our understanding of the impact of sleep-tracking technology on employees by considering the changes and crises in the working context (Barnes et al. 2023). Similarly, there is an emergent need to investigate how sleep-tracking technology impacts employee identity, behaviour and organisational politics (Elmholdt, Elmholdt, and Haahr 2021). In the educational context, support from stakeholders, including teachers, parents and social workers, is also essential for the adoption of sleep-tracking technology (Lau and Carney 2025).

(4) Use and impact: The bright and dark sides of sleep tracking

Existing research has suggested that future studies could explore the effects of sleep-tracking technology on technology use behaviours, including user responses to feedback and reminders (Goelema, Haakma, and Markopoulos 2014), as well as adoption and non-adoption behaviour (Makkonen et al. 2016). Beyond initial adoption, understanding long-term compliance (Matsangas, Shattuck, and McClernon 2024) and the long-term effect (Acosta et al. 2024) of sleep-tracking technology is crucial for engagement and continued use. Existing research also highlighted the need to explore dropout behaviours (Aji et al. 2022) and the challenges in maintaining engagement (Lau and Carney 2025). Moreover, further investigation is needed to explore how these technologies impact users' health-related behaviours and overall well-being, including healthy sleep awareness and sleep patterns (Liu, Ploderer, and Hoang 2015).

While most research has emphasised the positive impacts of sleep-tracking technology, prior studies have also noted potential negative effects that require attention in future research. These potential negative effects include increased screen time exposure before bed (Wang, Hugh, and Yang 2020), the risks of using a collaborative-competitive social interdependence approach (Wang, Hugh, and Yang 2020), the adverse effects of self-competition (Kuosmanen et al. 2022), and exacerbating sleep concerns (Ojalvo et al. 2023). The 'dark side' of sleep tracking cannot be overlooked, as its adverse outcomes may interact with and potentially disrupt sleep. Several research questions warrant further exploration, including the relationship between orthosomnia and insomnia (Jahrami et al. 2024) and the impact of health anxiety caused by sleep-tracking technology (Feng and Mäntymäki 2024). Additionally, coping strategies for IT-induced stress, as well as those for non-IT-related stress exacerbated by IT use, require

further examination within the context of sleep tracking (Feng, Mäntymäki, and Salmela 2023).

(5) Design insight: Addressing challenges in sleep-tracking technology

Prior research has indicated the need for further investigation into enhancing sleep-tracking technology to provide more effective services. Some key areas for future inquiry need to be taken into account, including the integration of sleep-tracking data with AI-generated data (Oh et al. 2022), the implications of overrated accuracy (Nagele and Hough 2024), and the impact of data immediacy and interactivity on the credibility of sleep-tracking technology (Liang and Ploderer 2020).

5. Discussion and conclusion

5.1. Key findings

This study conducted an integrative literature review of 51 scholarly articles from five databases to synthesise sleep-tracking research, with a specific focus on users' interactions with sleep-tracking technology. Overall, the current state of research on sleep tracking reveals an interdisciplinary yet growing body of work. Existing studies have examined antecedent factors related to user, technology, and user context, along with corresponding tasks, as well as outcomes related to user-oriented use and impacts and technology-oriented design insights. Nevertheless, the research on sleep tracking remains constrained by limited theoretical grounding and insufficient depth and granularity in analysing antecedent factors related to user, technology, context and task.

Specifically, we derive four key findings based on the review. First, current research is published across a wide range of journals and conferences, with the most frequently represented channels extending beyond traditional HCI venues. This distribution highlights the interdisciplinary nature of sleep-tracking research, with substantial contributions from fields such as health informatics, behavioural science and computer science. This trend echoes a growing call for interdisciplinary research on sleep tracking (Baron et al. 2018; Cay et al. 2022; Liang and Ploderer 2016). Multiple disciplines have examined the sleep-tracking phenomenon from their unique perspectives (e.g. Attie and Meyer-Waarden 2023; Tuominen et al. 2019; Wilson et al. 2017), highlighting the need to integrate these insights for a more holistic understanding.

Second, current research mainly employs the qualitative approach but provides limited theoretical grounding. Qualitative methods are generally well-suited for examining complex and dynamic phenomena in real-life environments (Turner, Cardinal, and Burton 2017). This preference for qualitative methods may be due to the complex nature of sleep, which is closely intertwined with lifestyle, habits, and situational factors (Buysse et al. 1989; Shochat 2012), posing challenges for conducting rigorous quantitative research. However, the limited use of theories in the literature indicates the absence of a clearly dominant theory. Reflecting the calls for interdisciplinary research on sleep tracking, theories from IS, behavioural science, and psychology can be applied to advance the exploration of sleep tracking.

Third, this study presents a synthesising framework to clarify current research on users' interactions with sleep-tracking technology and also points to valuable insights for future research. Drawing on the HCI framework (Zhang and Li 2005), this review synthesises current research into five components, which we further categorise into antecedents and outcomes. The distribution of these components reveals an imbalance situation with most research emphasising outcomes, particularly the impact of sleep-tracking technology on user behaviour, health, and well-being (e.g. Aji et al. 2022; Karasneh et al. 2022; Ojalvo et al. 2023). In contrast, antecedents such as users' characteristics and technological features have not been examined with sufficient depth and granularity. This gap highlights the need for more integrative research that examines antecedents in greater detail and systematically links them to outcomes, thereby providing a deeper understanding of sleep-tracking practices.

Moreover, most research examines sleep tracking in daily life (e.g. Attie and Meyer-Waarden 2023; Kuosmanen et al. 2022). While sleep-tracking technology is primarily positioned as consumer-based technology embedded in daily routines, its use in special contexts, such as hospitals, organisations and educational settings, has received little attention. Investigating these contexts, along with their stakeholders and external environments, may yield valuable insights to advance sleep-tracking research.

In addition, the synthesising framework for sleep-tracking research (Figure 5) primarily addresses the influence of factors related to users, technologies and specific contexts on both the user-oriented and technology-oriented outcomes. However, the underlying mechanisms of user behaviour changes and technological operation remain underexplored. Furthermore, current research on sleep tracking engages less deeply with users' reflection processes and stages.

This gap is particularly evident when compared with established models in personal informatics, such as the stage-based model of personal informatics systems (Li, Dey, and Forlizzi 2010). Thus, further work is needed to discuss user reflection and the underlying mechanisms.

Fourth, this review summarises future research agendas proposed by the literature and organises them according to the five components developed in our framework. Existing research on sleep tracking highlights the need for a more nuanced examination of these components, underscoring opportunities for deeper exploration in future studies. Building on this foundation, the future research agendas outlined in this paper aim to expand these proposed directions, thereby promoting the continued development of this field.

5.2. Future research agendas

Building on our analysis of the existing research distribution, HCI components in sleep tracking (see Figure 5), and future research directions proposed by the literature, we propose future research agendas, summarised in Table 4. These agendas are organised into two broad categories: research design and research topics. Regarding research design, we were informed by the distribution of existing research and identified two sub-agendas: research methods and theoretical backgrounds. Regarding research topics, drawing on the five components of the synthesising framework (see Figure 5), we outlined four agendas that focus on users, sleep-tracking technology, use context along with corresponding tasks, and use and impact. In this categorisation, sleep-tracking technology represents

Table 4. Agendas for future research on sleep tracking.

Future research agendas			Description
Research design	Research methods	Balancing qualitative with quantitative methods	• Conducting quantitative research: testing the causal relationships between sleep tracking and the existing antecedents and outcomes • Carrying out longitudinal research: exploring the long-term follow-up effects of sleep-tracking technology and how users' behavioural patterns change over time
	Theoretical backgrounds	Strengthening theoretical foundations	• Integrating theories from various fields, such as self-determination theory, the health belief model, the models of the nature and drivers of effective use, the model of effective use for a single affordance and stressor–strain–outcome • Developing a dominant theory that is suitable for sleep tracking or self-tracking
Research topics	User	Respect for individual differences and exploration of their impact on sleep tracking	• Recognising and understanding individual differences is a key to explaining user behaviours: diverse needs, preferences and characteristics • Exploring underemphasised topics: health status, health literacy and user traits (e.g. self-control and self-efficacy) • Examining user characteristics as antecedents and moderators
	Sleep-tracking technology	Sleep-tracking technology evolution, user-centered design and its compatibility	• Keeping up with the evolution of sleep-tracking technology: new technology and new features • Exploring user-centered design: how to design sleep-tracking technology that adapts to the unique characteristics and needs of individual users • Enhancing the compatibilities of sleep-tracking technology: privacy, data security and industry standards
	Use context along with corresponding tasks	The role of stakeholders and the external environment in sleep tracking	• Highlighting the role of stakeholders in sleep tracking: hospitals (e.g. healthcare professionals, nurses and caregivers), organisations (e.g. employers, departments and companies), education (e.g. teachers, parents and classmates) • Examining the influence of the external environment: support from family/hospital/organisation/school, social norms, workplace culture and peer pressure
	Use and impact	Impacts beyond benefits: underlying mechanisms of use, effective use, behavioural change and potential side effects	• Understanding the underlying mechanisms of sleep-tracking adoption/continued use/dropout, especially from the user and contextual perspectives • Going beyond the use of sleep-tracking technology to its effective use • Investigating behavioural change from a more granular analysis, with support from established behaviour change-related theories • Addressing the dark sides of sleep tracking: technostress, orthosomnia, mechanistic dehumanisation in the organisational context, the outcomes of technostress (techno-eustress and techno-distress) and coping strategies

both sleep-tracking technology itself and design insights (technology-oriented outcomes), as future research also includes design science.

5.2.1. Research design

(1) Balancing qualitative with quantitative methods

The reviewed studies largely acknowledge that their limitations are tied to the nature of their chosen research methods, such as selection bias and retrospective bias in interview-based research (e.g. Cherenshchykova and Miller 2020), limitations of sampled data in cross-sectional research (e.g. Feng and Mäntymäki 2024; Robbins et al. 2019), and social desirability bias in a survey (e.g. Barnes et al. 2023). As half of the studies in this review rely on qualitative research methods, future research should consider how quantitative methods could provide a more detailed understanding of sleep-tracking phenomena. For example, quantitative studies could help uncover causal relationships between sleep tracking and its identified antecedents and outcomes, addressing gaps left by existing research. Mixed methods (Feng, Mäntymäki, and Salmela 2023), which combine qualitative and quantitative insights, can also provide a more comprehensive understanding of the sleep-tracking phenomenon.

Additionally, prior research has recommended using longitudinal research designs for future investigations (Attie and Meyer-Waarden 2023; Liang and Ploderer 2020; Vandenberghe and Geerts 2015a). Incorporating longitudinal research approaches would provide valuable insights into the long-term effects of sleep-tracking technology, particularly in understanding the enduring behavioural changes, such as the formation of healthy sleep habits.

(2) Strengthening theoretical foundations

Current research has employed several theories, including social cognitive theory from psychology (Robbins et al. 2019; Wang, Hugh, and Yang 2020), as well as the TAM (Purnell et al. 2023) and the UTAUT (Leblanc et al. 2022) from IS. Future research could benefit from integrating additional theories from other fields to deepen the understanding of sleep tracking. For example, researchers could apply the self-determination theory (Deci and Ryan 1985) to uncover the underlying mechanisms of using sleep-tracking technology. Meanwhile, the health belief model (Rosenstock 1960; Rosenstock, Strecher, and Becker 1988) could offer insights into users' changes in health behaviours. Following the models of the nature and drivers of effective use (Burton-Jones and Grange 2013) and the model of effective use through salient affordances (Burton-Jones and Volkoff 2017), future research could move beyond examining the use of sleep-tracking technology to its effective use. Researchers could also employ the stressor–strain–outcome framework (Koeske and Koeske 1993) to explore the potential dark side of sleep-tracking technology and adverse outcomes.

Furthermore, our analysis of the distribution of articles by theoretical background suggested that there is no clear dominant theory in sleep-tracking research. Given this absence of a dominant theoretical framework, further research should consider developing a robust theoretical foundation tailored to sleep tracking or extending existing self-tracking and personal informatics theories, such as the stage-based model of personal informatics systems (Li, Dey, and Forlizzi 2010) and persuasive systems design model (Oinas-Kukkonen and Harjumaa 2009), to better encompass the complexities of sleep tracking.

5.2.2. Research topics

(1) Respect for individual differences and explore their impact on sleep tracking

Current research has explored sleep tracking from a user's perspective, including demographics, lifestyle and habits, and psychological factors (e.g. Karlgren and McMillan 2022; Nguyen et al. 2018; Robbins et al. 2019). Recognising that users have diverse needs, preferences and characteristics, future research should explore how individual differences shape engagement with sleep-tracking technology. For example, future research should continue to pay more attention to the reasons behind user behaviours from a user needs perspective, since need satisfaction plays a crucial role in driving self-tracking, while need frustration hinders tracking behaviour and users' perceived well-being (James, Bélanger, and Lowry 2022; Jung and Kang 2022; Wannheden et al. 2021). Given the intrinsically personal nature of sleep, people may respond differently to the same sleep-tracking experiences due to their unique characteristics. Thus, future research could investigate individuals' diverse characteristics, such as levels of need satisfaction and frustration, to better understand why and how people use sleep-tracking technology.

Additionally, some underemphasised topics need further research. For example, users' health status and literacy level may influence their attitude towards adopting and engaging with sleep-tracking technology. Furthermore, user traits such as self-control (Baumgart and Wiewiorra 2016) and self-efficacy (Huang and Ren

2020) reflect individuals' capabilities and beliefs in their ability to modify and regulate their behaviour. Additional research is needed to investigate how these traits influence users' sleep tracking.

Future research should also investigate the causal relationship between user characteristics, engagement with sleep-tracking technologies, and the potential behavioural changes that may result from this engagement. Prior research has demonstrated that user characteristics, such as perceived severity (Beh et al. 2021), perceived vulnerability (Beh et al. 2021), and self-efficacy (Windasari, Lin, and Kato-lin 2021; Wittkowski et al. 2020), have been identified as both antecedents and moderators in the use of wearable technologies for fitness and health. Similarly, in sleep tracking, user characteristics may serve as antecedents that influence user engagement with the technology and as moderators that shape how they perceive and engage with it.

(2) Sleep-tracking technology evolution, user-centered design and its compatibility

Prior research has identified that the technical characteristics of sleep-tracking technology play a vital role in the interaction between users and sleep-tracking technology (Choe et al. 2011; Elmholdt, Elmholdt, and Haahr 2021; Feng, Mäntymäki, and Salmela 2022; Lyall 2021; Vandenberghe and Geerts 2015a). Aligning with the future research directions proposed by current literature, future studies need to keep pace with the rapid evolution of sleep-tracking technology. Key directions include investigating user perceptions and acceptance of emerging technologies and new features, such as electroencephalogram (EEG)-based tracking data, AI-assisted sleep recommendations, smart sensing platforms, and sleep in virtual reality.

In addition, researchers should explore how to design sleep-tracking technology that can accommodate individuals' unique characteristics and needs. Since the essence of sleep is an individualistic activity (Liu, Ploderer, and Hoang 2015), sleep-tracking technology with personalised features may increase users' acceptance and efficiency. Future research should focus on user-centered design and explore how to design and provide personalised services to effectively support improving users' sleep performance, general health, and well-being.

Current studies have highlighted the need to integrate sleep-tracking technology into existing health systems (Oh et al. 2022; Vandenberghe and Geerts 2015b). However, further research is required to explore how to enhance the compatibility of sleep-tracking technology for seamless incorporation into health ecosystems, thereby maximising its value and effectiveness. Such inquiries raise important questions about privacy, data security, and industry standards for metadata that require deeper investigation.

(3) The role of stakeholders and the external environment

Currently, research on the context and corresponding tasks in sleep-tracking studies has been limited, particularly beyond daily life settings, such as clinical, organisational and educational environments. To develop a more comprehensive understanding of sleep tracking, future research should explore the influence of stakeholders and external environments across different contexts. For instance, in a clinical setting, future studies should investigate how stakeholder support (e.g. healthcare professionals, nurses, and caregivers) influences patients' adoption and effective use of sleep-tracking technology. Similarly, in an organisational context, research could explore the role of organisational support (from employers, department heads, and the company) and assess whether workplace culture facilitates or hinders the implementation of sleep-tracking technology. In an educational context, several questions warrant further exploration. For example, how does collaboration between parents and teachers influence students' engagement with sleep tracking? Additionally, the impact of students' peer pressure remains an important area for further investigation.

(4) Impacts beyond benefits: underlying mechanisms of use, effective use, behavioural change and potential side effects

Many studies have examined the impacts of sleep-tracking technology on use behaviour, sleep-related behaviour, health, and well-being (e.g. Matsangas, Shattuck, and McClernon 2024; Ojalvo et al. 2023; Ravichandran et al. 2017). However, future research should explore these effects more specifically and nuancedly. First, it is crucial to investigate the underlying mechanisms that drive the adoption, continuance use and dropout of sleep-tracking technology, particularly from user and contextual perspectives. Understanding these mechanisms can provide deeper insights into engagement patterns and long-term sustainability.

Second, future research should move beyond examining the use of sleep-tracking technologies to exploring their effective use. Effective use refers to using a system in a way that facilitates the attainment of its intended goals (Burton-Jones and Grange 2013). Investigating

the effective use of sleep-tracking technology, such as combining affordance actualisation with the model of effective use (Burton-Jones and Volkoff 2017), can provide deeper insights into how users use sleep-tracking features in meaningful ways and achieve desired outcomes. In addition, how established effective use is maintained when negative incidents arise remains underexplored (Rieder 2025a). Ultimately, such insights can guide the design of more supportive sleep-tracking technology and services that enable users to enhance their well-being more effectively.

Additionally, future research should provide a more granular analysis of the potential effects of sleep tracking on behavioural changes. Prior research has highlighted behaviour changes in the context of self-tracking, with a specific focus on areas such as compliance intention in physical activity (Deranek et al. 2021; Ekpezu, Oinas-Kukkonen, and Wiafe 2023; Rieder and Rhyn 2020) and the connection between behaviour change and users' life circumstances and temporal contexts (Rapp and Boldi 2023). Research on sleep tracking should follow a similar direction. To strengthen this line of inquiry, well-established theories of behaviour change (Oinas-Kukkonen 2013), such as the transtheoretical model (Prochaska and Velicer 1997) and the theory of planned behaviour (Ajzen 1991), offer valuable foundations for examining how individuals adopt and sustain health-related behaviours. Building on these theoretical foundations, future research could investigate the roles of sleep-tracking technology across different stages of behaviour change in the transtheoretical model (Prochaska and Velicer 1997). Future research could also examine how such technologies influence users' intentions and their ability to sustain long-term behavioural change, as outlined in the theory of planned behaviour (Ajzen 1991). Embedding these theories into the design and evaluation of sleep-tracking technology would not only enhance theoretical depth but also yield practical insights to improve its effectiveness in supporting long-term sleep health.

While prior research has explored various challenges, barriers, and stressors associated with sleep tracking (e.g. Feng, Mäntymäki, and Salmela 2023; Liu, Ploderer, and Hoang 2015; Ravichandran et al. 2017), limited attention has been given to the side effects of these practices on users' health and well-being. This gap is particularly relevant in an era of increasing technology use, where behaviours such as smartphone use before bedtime (Alam et al. 2025), the use of work-related apps in the evening (Sumter et al. 2025), smartphone addiction (Nur and Dengiz 2025) and fear of missing out on social media (Tandon et al. 2020) have all been linked to poor sleep quality. Furthermore, current sleep-tracking technology often fails to fully meet users' expectations (Liang and Ploderer 2016; Zhang et al. 2019), highlighting the need to understand and address its potential unintended consequences. Future research should further investigate the dark sides of sleep tracking, including orthosomnia, technostress induced by sleep-tracking technology, and mechanistic dehumanisation in organisational settings (Messer and Lukas 2023). This vicious circle of stress and sleep problems underscores the importance of examining the unintended negative consequences of sleep-tracking technology (Feng, Mäntymäki, and Salmela 2023).

However, not all stress induced by technology is inherently harmful. For instance, techno-eustress can enhance motivation, while techno-distress may lead to anxiety or disengagement (Tarafdar, Cooper, and Stich 2019). The complex effects of technostress in the context of sleep tracking warrant further investigation. In particular, greater attention is needed to understand how users respond to and cope with negative incidents arising from sleep-tracking practices. Such coping strategies may involve disengagement-oriented responses or ameliorative responses aimed at improving outcomes (Rieder 2025a, 2025b). Crucial questions thus remain: How do users cope with the side effects of sleep tracking, and how do these coping strategies shape usage patterns? Understanding users' coping strategies can inform design improvements that mitigate these unintended consequences.

5.3. Theoretical and practical implications

5.3.1. Theoretical implications

This paper contributes to the theoretical foundations through three implications: advancing the understanding of sleep tracking from a holistic view, developing a synthesising framework for sleep-tracking research and extending the HCI framework. First, we build upon prior literature reviews that emphasise design and technological perspectives, providing a more holistic understanding of sleep tracking from user, technology, and contextual perspectives. In doing so, we identify future research agendas, highlighting underexplored topics that the existing synthesising framework has not yet fully addressed, thereby offering clear guidelines for researchers and designers.

Second, we contribute to the literature by developing a synthesising framework representing users' interaction with sleep-tracking technology. By integrating the HCI framework (Zhang and Li 2005), this study enables future research to go beyond prior work by systematically examining the antecedents and outcomes of interaction with sleep-tracking technology and

identifying research gaps grounded in the current state of knowledge.

Third, this study extends the existing HCI framework (Zhang and Li 2005) in three ways: (1) by integrating tasks with use context, as tasks were found to be embedded in and closely connected to use contexts, (2) by refining the interaction component into two distinct oriented outcomes, including use and impacts (user-oriented) and design insights (technology-oriented) and (3) by categorising the five components into antecedents and outcomes, thereby clarifying causal structure of interaction and making explicit the factors within the three antecedents and two outcomes. Altogether, these refinements extend the HCI framework and enhance its suitability for capturing the complex and multifaceted nature of sleep-tracking technology use.

5.3.2. Practical implications

This study offers three practical implications for sleep-tracking designers, emphasising the importance of multidisciplinary design teams, collaboration between researchers and designers, and user-centered design approaches. First, given that current sleep-tracking research spans multiple disciplines, the findings highlight the importance of establishing multidisciplinary design teams to develop sleep-tracking technology. Combining expertise from fields such as psychology, behavioural science and HCI, multidisciplinary design teams can provide a complementary perspective, enabling more holistic, user-centered and nuanced design solutions.

Second, this review creates new opportunities for collaboration between sleep-tracking designers and researchers. Research findings can provide valuable guidance for designers, particularly through the synthesised evidence on the components of sleep-tracking technology and the design insights identified as technology-oriented outcomes. Strengthening collaboration between researchers and designers can bridge the gap between theoretical knowledge and practical applications, thereby addressing real-world issues and research questions.

Third, the synthesising framework can support sleep-tracking designers in creating user-centered sleep-tracking technologies by highlighting relevant factors to consider during development and implementation. For example, when designing features for specific user groups, such as employees in workplace settings, designers should consider factors including employees' gender, age, leadership support and organisational culture. By tailoring design features, designers can maximise the potential benefits of sleep-tracking technology.

5.4. Limitations

The limitations of this study must be acknowledged and considered for future research. First, as is typical for review studies, the scope was determined by the choice of databases, keywords and inclusion and exclusion criteria. To keep the review's scope manageable and conduct an in-depth analysis of the literature, we focused solely on empirical research on users' interactions with sleep-tracking technology. Therefore, future review studies could adopt a different strategy and incorporate, for example, grey literature and non-empirical studies.

Second, this integrative literature review examined and discussed only articles published up to the end of the review period. As sleep-tracking technology is a fast-growing area in self-tracking, it is crucial for future research to capture the latest developments and innovations. Future research should update and synthesise the new evidence into the adapted HCI frameworks (Zhang and Li 2005) on sleep tracking, thereby enhancing value in this field.

Third, we employed the HCI framework (Zhang and Li 2005) to guide our analysis of the literature. Future review studies could enhance the HCI framework by incorporating more granular components (Diederich et al. 2022), adopting different theoretical perspectives to guide the review, or developing the framework inductively based on the findings.

Declaration of AI use

ChatGPT (model 4-o1; 4.5; 5; 5.2) and Grammarly have been used to improve the writing of the paper.

Author contributions

CRediT: **Shan Feng:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Matti Mäntymäki:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing; **Ilias O. Pappas:** Writing – original draft, Writing – review & editing.

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Appendices

Appendix 1: The implementation of Torraco's (2005) checklist in this study

Phase 1 Before writing an integrative literature review (Section 1)	1. **Type:** Integrative literature review 2. **Need for an integrative literature review and expected contributions**: (1) **Needs:** (a) There is a growing call for further investigation in sleep tracking. (b) Existing literature review has not kept pace with the breadth and diversity of recent studies on sleep tracking. (c) There is a need for review studies on sleep tracking with a specific focus on user-related and contextual factors. (2) **Expected contributions:** (a) This review synthesized current studies in a framework. (b) It proposed future research agendas from the perspectives of research design and research topics.
Phase 2 Organizing an integrative literature review (Section 3.2)	1. **Theory/model-guided topic structure**: The HCI framework (Zhang & Li, 2005) 2. **Methods:** (1) **Sufficient description:** Sufficient. (2) **Literature selection:** Follow the steps of a systematic literature review in the article selection process and screening (3) **Keywords/procedures for searching:** "Sleep track*," "sleep monitor*," "sleep sens*," "sleep technolog*," "sleep app*," and "sleep device*" (4) **Database**: Scopus, Web of Science, PsycINFO, the Association for Information Systems eLibrary, and the Association for Computing Machinery Digital Library (5) **Criteria:** Inclusion and exclusion criteria, and quality appraisal criteria (6) **How was the literature screens:** Title–keywords–abstract screening and full-text screening (7) **How the main ideas and themes identified:** Extract themes from the literature based on the five components of the HCI framework
Phase 3 Writing an integrative literature review (Section 4–5)	1. **Critical analysis of literature:** The analysis discussed inconsistencies, omissions, and incomplete viewpoints in the existing literature. 2. **Synthesize knowledge from the literature**: A synthesizing framework for sleep-tracking research was proposed. 3. **Forms of synthesis to stimulate further research:** Future research agendas. 4. **The logic and conceptual reasoning:** A concept matrix was employed to illustrated how the themes were identified and categorized into components of the HCI framework (Zhang & Li, 2005). 5. **Provocative future research questions:** Future research directions were proposed for sleep-tracking studies from the perspective of research design and research topics.

Appendix 2: Research databases and search syntaxes

Database	Search syntax
Scopus	TITLE-ABS-KEY ("sleep track*" OR "sleep monitor*" OR "sleep sens*" OR "sleep technolog*" OR "sleep app*" OR "sleep device*") AND DOCTYPE (ar OR cp) AND LANGUAGE (English)
Web of Science	((TS = ("sleep track*" OR "sleep monitor*" OR "sleep sens*" OR "sleep technolog*" OR "sleep app*" OR "sleep device*")) AND LA = (English)) AND DT = (Proceedings Paper OR Article OR Early Access)
PsycInfo	Abstract: "sleep track*" OR "sleep monitor*" OR "sleep sens*" OR "sleep technolog*" OR "sleep app*" OR "sleep device*"Limited to academic journals and English
AIS eLibrary	All Fields: ("sleep track*" OR "sleep monitor*" OR "sleep sens*" OR "sleep technolog*" OR "sleep app*" OR "sleep device*")
ACM digital library	[Full Text: "sleep track*"] OR [Full Text: "sleep monitor*"] OR [Full Text: "sleep sens*"] OR [Full Text: "sleep technolog*"] OR [Full Text: "sleep app*"] OR [Full Text: "sleep device*"]

Notes: ar = article; cp = conference paper.

Appendix 3: The inclusion and exclusion criteria

Inclusion Criteria

IC1 The study is a full paper published in a scholarly journal or a conference with refereed practices.
IC2 The study contains empirical research.
IC3 The main topic (title/abstract/keywords) contains one or more of the search terms "sleep track*", or "sleep monitor*", or "sleep sens*", or "sleep technolog*", or "sleep app*", or "sleep device*".
IC4 The study is published in English.

Exclusion Criteria

EC1 Duplicate.
EC2 The main topic (title/abstract/keywords) does not contain users' interactions with sleep-tracking technology (e.g. manual sleep tracking, sleep assessment, sleep therapy, animal sleep tracking).
EC3 Studies in which the research subjects are not sleep-tracking users (excluded topics include sleep-tracking technology validation, accuracy assessment, design science about new technology, biomedical research and so on).

Appendix 4: Quality appraisal

Num	Reference	QA1	QA2	QA3	Sum
1	Lau and Carney 2025	2	2	1	5
2	Devine et al. 2024	2	2	1.5	5.5
3	Jahrami et al. 2024	2	2	1	5
4	Acosta et al. 2024	2	2	1.5	5.5
5	Schwartz et al. 2024	2	2	1.5	5.5
6	Feng and Mäntymäki 2024	2	2	0	4
7	Matsangas, Shattuck, and McClernon 2024	2	2	0	4
8	Shaforostov et al. 2024	2	2	0	4
9	Nagele and Hough 2024	2	2	1	5
10	Ojalvo et al. 2023	2	2	1.5	5.5
11	Attie and Meyer-Waarden 2023	2	2	2	6
12	Kaitz et al. 2023	2	2	0	4
13	Nolasco et al. 2023	2	2	1.5	5.5
14	Barnes et al. 2023	2	2	2	6
15	Nuo et al. 2023	2	2	2	6
16	Purnell et al. 2023	2	2	1	5
17	Karlgren and McMillan 2022	2	1	0	3
18	Kuosmanen et al. 2022	2	2	1	5
19	Kuosmanen et al. 2022	2	2	0	4
20	Leblanc et al. 2022	2	2	0	4
21	Robson, Ellis, and Elder 2022	2	1	0.5	3.5
22	Jakowski and Stork 2022	2	2	0.5	4.5
23	Nagele, Hough, and Dinnen 2022	2	1	2	5
24	Griffiths et al. 2022	2	2	0.5	4.5
25	Oh et al. 2022	2	2	1.5	5.5
26	Feng, Mäntymäki, and Salmela 2022	2	2	0.5	4.5
27	Karasneh et al. 2022	2	2	0.5	4.5
28	Lyall 2021	2	1	0	3
29	Cherenshchykova and Miller 2020	2	1	0	3
30	Aji et al. 2019	2	2	1.5	5.5
31	Robbins et al. 2019	2	1	1.5	4.5
32	Cherenshchykova and Miller 2019	2	1	2	5
33	Zhang et al. 2019	2	1	0	3

(*Continued*)

Continued.

Num	Reference	QA1	QA2	QA3	Sum
34	Quante et al. 2019	2	2	1	5
35	Nguyen et al. 2018	2	1	0	3
36	Ravichandran et al. 2017	2	1	2	5
37	Liang and Ploderer 2016	2	1	1	4
38	Vandenberghe and Geerts 2015b	2	2	0	4
39	Vandenberghe and Geerts 2015a	2	1	1	4
40	Liu, Ploderer, and Hoang 2015	2	1	1	4
41	Goelema, Haakma, and Markopoulos 2014	2	1	0	3
42	Jakowski 2022	2	2	1	5
43	Wang, Hugh, and Yang 2020	2	2	2	6
44	Liang and Ploderer 2020	2	2	0	4
45	Hine, Meadows, and Pritchard 2023	2	1	2	5
46	Salmela, Valtonen, and Lupton 2019	2	2	1.5	5.5
47	Makkonen et al. 2016	2	2	0	4
48	Feng, Mäntymäki, and Salmela 2023	2	2	0	4
49	Choe et al. 2011	2	1	2	5
50	Elmholdt, Elmholdt, and Haahr 2021	2	2	1	5
51	Aji et al. 2022	2	2	1	5

Appendix 5: Research theme matrices

		Users			Technology				Use context along with corresponding tasks				Use and impact (user-oriented outcomes)			Design insight (technology-oriented outcomes)	
Num	Reference	Demographics	Lifestyle and habits	Psychological factors	Hardware and aesthetics	Features	Affordances corresponding to features	Financial costs	Daily life	Clinical use	Organizational use	Context-specific applications	The impact of use	Barriers and challenges of sleep tracking	Segmentation and roles	Design opportunities	Feature enhancement and expansion
1	Lau and Carney 2025											x	x				
2	Devine et al. 2024		x								x		x				
3	Jahrami et al. 2024								x				x				
4	Acosta et al. 2024									x				x			
5	Schwartz et al. 2024			x					x								
6	Feng and Mäntymäki 2024								x				x				x
7	Matsangas, Shattuck, and McClernon 2024	x										x	x				
8	Shaforostov et al. 2024								x				x				x
9	Nagele and Hough 2024					x			x				x				
10	Ojalvo et al. 2023									x			x				
11	Attie and Meyer-Waarden 2023	x		x					x				x				
12	Kaitz et al. 2023									x			x				x
13	Nolasco et al. 2023	x							x				x				
14	Barnes et al. 2023	x									x		x				
15	Nuo et al. 2023					x			x								
16	Purnell et al. 2023	x						x		x							
17	Karlgren and McMillan 2022		x						x							x	
18	Kuosmanen et al. 2022				x				x					x			
19	Kuosmanen et al. 2022								x				x	x	x		
20	Leblanc et al. 2022	x						x	x				x				
21	Robson, Ellis, and Elder 2022					x			x				x				
22	Jakowski and Stork 2022											x	x				
23	Nagele, Hough, and Dinnen 2022								x						x		
24	Griffiths et al. 2022									x			x				
25	Oh et al. 2022			x		x			x							x	x
26	Feng, Mäntymäki, and Salmela 2022					x	x		x								
27	Karasneh et al. 2022					x			x				x				
28	Lyall 2021								x								
29	Cherenshchykova and Miller 2020								x							x	

(*Continued*)

Continued.

		Users			Technology				Use context along with corresponding tasks				Use and impact (user-oriented outcomes)			Design insight (technology-oriented outcomes)	
Num	Reference	Demographics	Lifestyle and habits	Psychological factors	Hardware and aesthetics	Features	Affordances corresponding to features	Financial costs	Daily life	Clinical use	Organizational use	Context-specific applications	The impact of use	Barriers and challenges of sleep tracking	Segmentation and roles	Design opportunities	Feature enhancement and expansion
30	Aji et al. 2019			x		x		x		x			x				
31	Robbins et al. 2019	x	x						x								
32	Cherenshchykova and Miller 2019								x							x	
33	Zhang et al. 2019				x				x				x			x	x
34	Quante et al. 2019	x							x				x	x		x	
35	Nguyen et al. 2018		x	x					x								x
36	Ravichandran et al. 2017								x				x	x			x
37	Liang and Ploderer 2016								x					x			x
38	Vandenberghe and Geerts 2015b									x						x	
39	Vandenberghe and Geerts 2015a				x	x			x							x	x
40	Liu, Ploderer, and Hoang 2015								x					x		x	x
41	Goelema, Haakma, and Markopoulos 2014								x				x				
42	Jakowski 2022	x										x	x				
43	Wang, Hugh, and Yang 2020											x	x				
44	Liang and Ploderer 2020				x				x					x			x
45	Hine, Meadows, and Pritchard 2023								x								
46	Salmela, Valtonen, and Lupton 2019								x						x		
47	Makkonen et al. 2016	x							x						x		
48	Feng, Mäntymäki, and Salmela 2023					x			x				x				x
49	Choe et al. 2011								x							x	x
50	Elmholdt, Elmholdt, and Haahr 2021						x				x			x			
51	Aji et al. 2022									x			x				