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Review Article

Review Article

Human factors/ergonomics work system analysis of patient work: state of the science and future directions

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Abstract

Purpose: To demonstrate the use and value of the Human Factors/Ergonomics-based Systems Engineering Initiative for Patient Safety (SEIPS) family of work system models for studying and improving patient work.

Data Sources: We conducted a review of the published empirical literature applying the SEIPS family of work system models for patient work.

Study Selection: Included studies had to apply one of the SEIPS family of work system models to study patient work; be published in a peer-reviewed journal in English and include analysis of data. We identified 16 articles that met our inclusion criteria.

Data Extraction: For each study, we extracted settings and situations in which models were applied; research design; study methods; model(s) used; type and number of study participants; study objective(s); whether the study included an intervention; specific aspects of the model used; knowledge generated about patient work and benefits of using the models.

Results of Data Synthesis: Our analysis revealed that a majority of studies were conducted in the United States, used qualitative or mixed methods and employed a variety of data collection techniques to study adult patient populations with chronic illness and their informal caregivers and healthcare providers performing patient work in the home and clinical setting. The studies resulted in a variety of useful products, demonstrating several benefits of using the models.

Conclusion: Our review has demonstrated the value of using the SEIPS family of work systems models to study and improve patient and family contributions to health-related work.

Key words: human factors, ergonomics, patient work, work system, sociotechnical system

Introduction

Safety, quality, clinician well-being and health outcomes are products of health-related work performed in sociotechnical work systems [1]. To improve these outcomes, entities such as the US National Academies [2–5] and the World Health Organization [6] promote Human Factors/Ergonomics (HFE) methods. In particular, they recommend 'Human factors analysis, which has been used in other industries for crew resource management, shift management, ensuring patient and worker safety, and ensuring high-level, reliable performance in dynamic, high-risk settings, should be applied to

the health care setting' (p.180) [4]. Applying HFE to analyse and improve work systems is guided by 'work system models', which are theoretically sound and practical tools for researchers, practitioners, designers, policy makers and others [7–10].

Among several work system models, the Systems Engineering Initiative for Patient Safety (SEIPS) model and its subsequent adaptations were developed specifically for healthcare [7]. The SEIPS model integrated traditional work systems and systems engineering concepts with Donabedian's famous framework of healthcare quality, thus specifying the presence of:

- Interacting structural components of 'work systems'—person(s), tasks, tools and technology, organization and environment;
- Care-related and supporting 'work processes' produced and shaped by the system;
- Resulting 'outcomes' for patients, healthcare professionals, organizations and others; and
- Other systems concepts such as feedback loops representing the adaptive and dynamic nature of sociotechnical systems

In response to an increasing shift toward patient-centered care and patient/family engagement, SEIPS 2.0 made explicit the role of patients and other nonprofessionals who engage in health-related activities or 'patient work' [11]. Patient work is defined as the performance of effortful, goal-driven and consequential health-related activity by patients and other nonprofessionals, independently or in concert with healthcare professionals [12, 13]. SEIPS 2.0 proposed that patients, families and other nonprofessionals can be key actors in the work system and their work contributes to various outcomes [11]. Subsequent research introduced the Patient Work System (PWS), a model of the interacting work system components shaping the performance of patient work [14]. The PWS model focused specifically on the work of patients and their informal caregivers, and rearranged the work system components from the previous models into social-cultural, physical-spatial and organizational contextual factors that shape patient work processes. Additionally, the PWS model elaborated on prior conceptualizations of specific work system components such as persons, tools and tasks factors.

Since the publication of the SEIPS model in 2006, there have been many applications of the SEIPS family of models to study and improve the health-related work of healthcare professionals, reviewed elsewhere [8, 11, 15]. With increasing realization of the importance of patient and family contributions to health-related work [12], some have also applied these models to patient work. The purpose of this review is to demonstrate the use and value of work system models for studying and improving patient work.

Methods

We conducted a review of the published empirical literature applying the SEIPS family of work system models for patient work. We focused on applications of SEIPS [7], SEIPS 2.0 [11] and PWS [14] models because they are well recognized, frequently used and are similar to one another and to other highly regarded work systems models [9, 10, 16].

Inclusion and exclusion criteria

Included studies had to apply SEIPS [7], SEIPS 2.0 [1] or PWS [24] to study patient work; be published in a peer-reviewed journal in English and include analysis of data. Articles that studied professional work along with patient work were also included in this review. We excluded editorials, commentaries, reviews and articles applying the models to study only healthcare professional work.

Search strategy

Two authors (N.E.W., S.P.) along with research team members first conducted back-citation searches of four seminal articles on SEIPS [7], SEIPS 2.0 [11] and PWS [14, 17]. This search retrieved 435 articles. We then searched the MEDLINE, CINAHL and PsycINFO databases using the terms 'Systems Engineering Initiative for Patient Safety', 'SEIPS', 'SEIPS 2.0', 'patient work system' and 'PWS', which resulted in 118 articles. After removing duplicates, we conducted a title and abstract review and excluded 483 articles, retaining 70 articles for full text review. All authors met to discuss discrepancies and settle differences on interpretation of the inclusion/exclusion criteria. Articles were then assigned among N.E.W., S.P. and R.J.H. for full text review. Careful review resulted in 16 articles included in the present review.

Data extraction

Included articles were analysed to assess study characteristics and how the study used work system models. The authors discussed data elements of interest and developed a data extraction tool. Each author extracted the following data for their assigned articles: settings and situations in which models were applied; research design; study methods; model(s) used; type and number of study participants; study objective(s); whether the study included an intervention; specific aspects of the model used and knowledge generated about patient work. After initial data entry, all authors reviewed and revised the data matrix to ensure a thorough review.

Results

Study design, setting and sample characteristics

Of the 16 studies reviewed, 3 used SEIPS [18–20], 10 used SEIPS 2.0 [14, 18, 21–28] and 6 applied the PWS model to study patient work [14, 17, 28–31], with 2 studies using both PWS and SEIPS or SEIPS 2.0 [18, 28]. Most studies (10/16) used a qualitative research design [20, 22–28, 30, 31], five used mixed methods [14, 17–19, 21] and one used only quantitative methods [29]. A majority of studies were conducted in the United States [14, 17–20, 22–31], one compared United States and Singapore [29], and one took place in Israel [21]. All studies focused on acute or chronic medical conditions, with no studies investigating patient work of healthy people trying to remain healthy. Studies examined a broad range of medical domains including patients with cancer [28]; heart failure [14, 17, 18, 29]; outpatient parenteral antimicrobial therapy [27]; complex abdominal surgery [19]; diabetes [31]; asthma [17]; chronic obstructive pulmonary disorder [17] and multiple chronic conditions [25]. The studies also examined a broad range of phenomena including medication management [22, 25, 30], self-care and personal health information management for chronic illness [31], care transitions [19, 24], hospital visitor compliance with contact precautions [20], inpatient portal design [23] and intervention design [21]. Six studies included only patients [18, 25, 27–29, 31], two studied patients and informal caregivers [14, 17], one studied only informal caregivers [29], and four

Table 1 Study design and setting and sample characteristics

Article	Journal domain	Location	Research design	Data collection	Data Analysis	Model used	Population studied	Sample size	Study purpose
Abraham *et al.*, 2017 [26]	Pharmacy	US—Mid Atlantic	Qualitative	Interviews; Chart reviews	Content Analysis; Thematic analysis	SEIPS 2.0	Adult patients using LAI antipsychotic medications; Their healthcare professionals	6 Patients; 16 Healthcare professionals; 20 Charts	Examine pharmacist role in addressing care coordination and adherence challenges for patients taking LAI antipsychotics; explore patients' medication use experiences with LAI
Acher *et al.*, 2015 [19]	Surgery	US—Midwest	Mixed methods	Contextual inquiry; Semi-structured interviews	Thematic analysis; Secondary categorization; Descriptive quantitative analysis	SEIPS	Adult patients undergoing complex abdominal surgery	18 Patients; 6 Healthcare professionals	Evaluate how transitions of care relate to and influence readmission from the patient and clinician perspective
Doucette *et al.*, 2017 [25]	Pharmacy	US—Midwest	Qualitative	Semi-structured interviews	Content analysis	SEIPS 2.0	Adult patients taking medications for chronic conditions	13 Patients	Explore how well concepts from the SAHMM model can represent patients' in-home medication management
Gorman *et al.*, 2018 [28]	Human Factors/Ergonomics	US—Mid Atlantic	Qualitative	Secondary analysis of semi-structured interviews	Content analysis	PWS; SEIPS 2.0	Adult patients who were cancer survivors	30 Patients	Identify invisible and visible components of the work system

Table 1 (Contineud)

Article	Journal domain	Location	Research design	Data collection	Data Analysis	Model used	Population studied	Sample size	Study purpose
Holden *et al.*, 2015a [18]	Human Factors/Ergonomics	US—South	Mixed methods	Observations; Semi-structured interviews; Survey; Medical record review	Content analysis; Descriptive quantitative analysis	PWS; SEIPS 2.0	Older adult patients with heart failure; Their informal caregivers	30 Patients; 14 Informal caregivers	Understand the nature and prevalence of barriers to self-care performance of older adults with heart failure and their informal caregivers
Holden *et al.*, 2015b [14]	Emergency medicine	US—South	Mixed methods	Structured instrument with open-ended probes	Descriptive quantitative analysis; Content analysis	PWS; SEIPS	Older adult patients admitted to the ED with acute heart failure	31 Patients	Pilot test a sociotechnical systems-based instrument to assess the prevalence and nature of barriers among patients presenting to the ED with acute heart failure and to conduct a preliminary feasibility assessment of this instrument in the time-sensitive ED setting
Holden *et al.*, 2017 [17][a]	Human Factors/Ergonomics	3 study locations in US	Mixed methods	Focus groups; Medical record review; Observations; Semi-structured interviews; Surveys	Content analysis; Descriptive quantitative analysis	PWS	Patients with asthma;Patients with heart failure and/or chronic obstructive pulmonary disease; Older adults patients with heart failure and their caregivers	250 Patients; 35 Informal caregivers	Specify the role of macroergonomic factors in the patient work system
Keller *et al.*, 2017 [24]	Population health	US—Mid Atlantic	Qualitative	Contextual inquiry; Semi-structured interviews	Content analysis	SEIPS 2.0	Older adult patients transitioning from hospital to SHHC	24 Patients; 39 SHHC providers	Characterize barriers and facilitators to older adults' successful home medical device use during hospital/SHHC transition and characterize outcomes of inappropriate use

Table 1 (Contineud)

Article	Journal domain	Location	Research design	Data collection	Data Analysis	Model used	Population studied	Sample size	Study purpose
Keller *et al.*, 2019 [27]	Infectious disease	US—Mid Atlantic	Qualitative	Contextual inquiry; Semi-structured interviews	Content analysis focused on goal-directed task analysis	SEIPS 2.0	Adult patients recently discharged with OPAT	43 Patients	Understand how the home environment hinders safe performance of OPAT-related tasks, and how patients mitigate these safety hazards
Lim *et al.*, 2019 [29]	Cardiology	US—South; Singapore	Quantitative	Structured instrument	Chi-Squared test; Mann–Whitney test; Structural equation modeling	PWS	Adult patients admitted to the hospital or ED for acute heart failure	90 Patients	Compare self-care barriers reported by patients admitted for acute heart failure in two geographically unique populations
Look *et al.*, 2018 [30]	Pharmacy	US—Midwest	Qualitative	Focus groups	Thematic analysis	PWS	Informal caregivers who manage medications for older adults	29 Informal caregivers	Explore how informal caregivers manage medications for older adult care recipients by identifying the activities involved in medication management and the tools or strategies used to facilitate these activities
Seibert *et al.*, 2018 [20]	Infection control	US—Midwest	Qualitative	Researcher-administered surveys (i.e. open-ended interview)	Content analysis; Thematic analysis	SEIPS	Hospital visitors of patients with CDI	31 Visitors	Evaluate hospital visitors' compliance and perceptions of personal protective equipment use
Walker *et al.*, 2018 [23]	Biomedical informatics	US—Midwest	Qualitative	Focus groups with normative group technique	Content analysis	SEIPS 2.0	Leaders and technology experts at the medical center; Patient advisors	2 IT staff; 7 Healthcare professionals; 4 Patient advisors; 1 Chief quality and patient safety officer	Learn how best to implement and promote use of inpatient portals to benefit patient care, disseminate this knowledge to other hospitals and to the research community

Table 1 (Contineud)

Article	Journal domain	Location	Research design	Data collection	Data Analysis	Model used	Population studied	Sample size	Study purpose
Werner *et al.*, 2017 [22]	Human Factors/Ergonomics	US—3 sites in South, Northeast and Mid Atlantic	Qualitative	Contextual inquiry; Semi-structured interviews	Process mapping; Content analysis; Thematic analysis	SEIPS 2.0	SHHC providers; Older adult patients being discharged from SHHC and their informal caregivers	60 Patients; 33 Informal caregivers; 79 SHHC providers	Highlight the importance of using a process-level view in analysing distributed healthcare tasks through medication management
Werner *et al.*, 2018 [31]	Human Factors/Ergonomics	US—Midwest	Qualitative	Observation with verbal protocol as patients performed tasks in virtual simulated homes with debrief	Content analysis	PWS	Adult patients with diabetes	20 Patients	Understand how the sociotechnical system of the home shapes and is shaped by the cognitive work of personal health information management
Zisberg *et al.*, 2018 [21]	Geriatrics	Israel	Mixed Methods	Focus groups; Observations; Semi-structured interviews; Surveys	Content analysis; Descriptive quantitative analysis	SEIPS 2.0	Hospitalized older adult patients; Hospital leaders; Hospital healthcare professional	203 Patients; 11 Hospital leaders; 116 Healthcare professionals	Demonstrate the process of adapting a human factors framework as a guided model to articulate a site-specific, culturally based intervention to improve in-hospital mobility in older adults

[a]Holden *et al.*, 2017 was a combined analysis of three distinct studies.

CDI = Clostridium difficile infection; ED = Emergency Department; HFE = Human Factors/Ergonomics; LAI = Long Acting Injectable; OPAT = Outpatient parenteral antimicrobial therapy; SAHMM = Systems Approach to Home Medication Management; SHHC = Skilled Home Healthcare.

studied the collaborative work of patients and healthcare professionals [19, 21, 22, 24]. None of the studies focused on or included pediatric patients. In-person data collection was performed in the home, in professional clinical settings (e.g. outpatient clinics, emergency department), and in both the home and professional clinical setting. One study used a virtual reality CAVE with virtual renderings of actual homes [31]. Most of the studies (10/16) were published in clinical journals with a broad range of clinical focus including pharmacy [25, 26, 30], infectious diseases [20, 27], surgery [19], cardiology [29], emergency medicine [14], geriatrics [21] and public health [24]. Table 1 provides details on study design, setting and sample characteristics.

Data collection methods

As seen in Table 1, a variety of methods were used to apply work system models for work system analysis, including semi-structured interviews [17–22, 24–26, 28, 29], focus groups [17, 21, 23, 30], structured questionnaires [18, 21], contextual inquiry [32] (i.e. a specific observation technique in which work tasks are observed with opportunistic questioning) [19, 22, 24, 27], chart review [14, 17, 26], surveys [14, 17, 20, 21] and observations [14, 17, 21, 31]. The two studies that used structured questionnaires also included open-ended questions in their questionnaire instrument. Although these studies noted some limitations with the questionnaires such as length, time to administer [18] and translation to another language [29], they were able to successfully identify and quantify work system barriers to patient work. One of the studies employing observations used a cognitive task analysis technique, asking participants to 'think aloud' during the observation. Half the studies (8/16) used multiple data collection methods [17–19, 21, 22, 24, 26, 27]. Seven studies combined either observation or contextual inquiry with semi-structured interviews [14, 17, 19, 21, 22, 24, 27]. Only 2 studies collected data longitudinally [18, 22], with one study collecting data over a 1-month period [18] and the other collecting data over an approximately 72-hour transition from the hospital to skilled home healthcare [22].

How work system models were applied to analyse patient work

Researchers used work system models for a variety of purposes (Table 2). Almost all of the studies (11/16) used the models to guide data collection, for example, to develop their interview guides or observation protocols [14, 17, 18, 20–23, 25, 26, 29, 30]. All studies used the model to guide data analysis [14, 17–31]. Seven studies adapted or specified the models [14, 17, 21, 23, 25, 28, 31]. Models were adapted to analyse and describe specific types of work such as older adults' self-care for heart failure, medication management, personal health information management and invisible work [14, 25, 28, 31]. The models were adapted by integrating other exiting models and frameworks from aging and healthcare [14], distributed cognition [31] and macroergonomics [18]. Studies that used PWS primarily focused on patients and caregivers and their self-care management processes. Some of the studies that used SEIPS 2.0 included professional work and topics beyond self-care management such as in-hospital mobility [21, 24, 26, 27]. One study applied SEIPS 2.0 to guide the design and effectiveness testing of an intervention to improve older adults' outcomes related to inpatient mobility [21].

We found variation across studies regarding which aspects of the models were used (Table 3). All studies examined work system structure, that is, interacting components such as person, task, technology or environment, although which components were examined differed by study [14, 17–31]. Most studies examined the original five SEIPS components: person(s) (13/16) [14, 18–26, 28, 29, 31]; tasks (14/16) [14, 18–26, 28–31]; tools and technology (13/16) [14, 18–22, 24–26, 28–31]; organizational context (13/16) [14, 17–22, 25, 26, 28–31] and physical environment (12/16) [14, 17, 18, 20–22, 24–26, 28, 29, 31]. Fewer examined the external environment (5/16) [18, 21, 22, 24, 25] or socio-cultural context (4/16) [17, 18, 28, 29], components from the newer SEIPS 2.0 and PWS models. One study examined primarily the more macro-level components of the PWS (physical context, organizational context, social context) [17]. Three studies described interactions between the components of the work system structure [17, 22, 31].

Table 2 How the SEIPS family of work system models have been applied to study patient work

Article	Guide study design	Develop/test data collection tool	Guide data analysis	Framework for results interpretation	Create new model or adapt or specify model	Guide intervention design
Abraham *et al.*, 2017 [26]	X	x	x	x		
Acher *et al.*, 2015 [19]	X		x	x		
Doucette *et al.*, 2017 [25]	X	x	x	x	x	
Gorman *et al.*, 2018 [28]	X		x	x	x	
Holden *et al.*, 2015a [18]	x	x	x	x		
Holden *et al.*, 2015b [14]	X	x	x	x	x	
Holden *et al.*, 2017 [17]	X	x	x	x	x	
Keller *et al.*, 2017 [24]	X		x	x		
Keller *et al.*, 2019 [27]			x	x		
Lim *et al.*, 2019 [29]	X	x	x	x		
Look *et al.*, 2018 [30]		x	x	x		
Seibert *et al.*, 2018 [20]	X	x	x	x		
Walker *et al.*, 2018 [23]	X	x	x	x	x	
Werner *et al.*, 2017 [22]	X	x	x	x		
Werner *et al.*, 2018 [31]	x		x	x	x	
Zisberg *et al.*, 2018 [21]	X	x	x	x	x	x
TOTAL	14/16	11/16	16/16	16/16	7/16	1/16

Table 3 Aspects of the work system model studied and examples

Aspect of the model studied	Examples	Associated Articles
Person	Demographics, Knowledge and experience, Comorbidities	Abraham et al., 2017 [26]; Acher *et al.*, 2015 [19]; Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015a [18]; Holden *et al.*, 2015b [14]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Seibert *et al.*, 2018 [20]; Walker *et al.*, 2018 [23]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
Tasks	Task ambiguity, Self-care complexity, Time demands	Abraham *et al.*, 2017 [26]; Acher *et al.*, 2015 [19]; Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015a [18]; Holden *et al.*, 2015b [14]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Look *et al.*, 2018 [30]; Seibert *et al.*, 2018 [20]; Walker *et al.*, 2018 [23]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
Tools and technologies	Access to technology, Availability of tools, Device characteristics	Abraham *et al.*, 2017 [26]; Acher *et al.*, 2015 [19]; Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015a [18]; Holden *et al.*, 2015b [14]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Look *et al.*, 2018 [30]; Seibert *et al.*, 2018 [20]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
Organization or Organizational context	Roles, Facilities and services, Resource availability	Abraham *et al.*, 2017 [26]; Acher *et al.*, 2015 [19]; Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015a [18]; Holden *et al.*, 2015b [14]; Holden *et al.*, 2017 [17]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Seibert *et al.*, 2018 [20]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
Physical/Internal environment or Physical context	Distance between places, Physical layout, Weather	Abraham *et al.*, 2017 [26]; Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015a [18]; Holden *et al.*, 2015b [14]; Holden *et al.*, 2017 [17]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Seibert *et al.*, 2018 [20]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
External environment	Community resources, Regulatory policy, Insurance policies	Doucette *et al.*, 2017 [25]; Holden *et al.*, 2015a [18]; Keller *et al.*, 2017 [24]; Werner *et al.*, 2017 [22]; Zisberg *et al.*, 2018 [21]
Social-cultural context	Interpersonal influence, Social support, Food culture	Gorman *et al.*, 2018 [28]; Holden *et al.*, 2015b [14]; Holden *et al.*, 2017 [17]; Lim *et al.*, 2019 [29]
Process	Medication management, Mobility monitoring	Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Keller *et al.*, 2017 [24]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]; Zisberg *et al.*, 2018 [21]
Outcome	Maintenance of functional status, Quality of life,	Doucette *et al.*, 2017 [25]; Gorman *et al.*, 2018 [28]; Keller *et al.*, 2017 [24]; Lim *et al.*, 2019 [29]; Walker *et al.*, 2018; Zisberg *et al.*, 2018 [21]
Interactions	Social influence and self-imposed rules, Community resources	Holden *et al.*, 2017 [17]; Werner *et al.*, 2017 [22]; Werner *et al.*, 2018 [31]
Feedback or Adaptation	Discharge instructions to patients, Strategies developed to overcome system barriers	Keller *et al.*, 2019 [27]; Walker *et al.*, 2018 [23]; Werner *et al.*, 2017 [22]

Six studies investigated process [21, 22, 24, 25, 28, 31] and six studies examined outcomes related to patient work [21, 23–25, 28, 29]. Studies investigating process identified several insights related to the interaction of patient work processes with the work system. For example, Gorman *et al.* found that communication processes could provide a connection between the visible and invisible work system [28]. Invisible work refers to patient work that is 'taken for granted by others [e.g. healthcare professionals] and thus implicitly valued less' [33]. Therefore, the invisible work system is 'composed of structural components that are literally or figuratively unseen or are undervalued by [healthcare professionals]' [28]. Further insights on patient work processes were identified in the study by Werner *et al.*, which concluded that focusing the work system analysis on a specific process can provide an understanding of patient work as it occurs over time and across boundaries, reveal emergent properties of a phenomenon and identify patterns of downstream causality [22]. One study focused on cognitive processes [31]. Outcomes were often noted, including self-care performance, patient engagement and satisfaction [23], and quality of life [25]. However, only two studies explicitly measured outcomes [21, 29]. In two studies, we could not determine what aspects of the model were studied [27, 30].

Products of work system analysis

A few of the studies produced work system models adapted to a specific context and suitable for future use in that context Table 4. These contexts included self-care for heart failure [14, 18, 29], medication management [25, 30], cancer survivorship [28] and personal health information management [31]. Holden *et al.* adapted SEIPS 2.0 to the specific context of older adults performing self-care for heart failure, producing the PWS model [14]. This model was subsequently used to study patient work in five other studies [17, 28–31]. Other studies advanced the models by adding the concept of an invisible work system [28], specifying the contextual factors of the work system [17], identifying the interaction between cognition and the work system [31] and identifying the presence of intermediate outcomes preceding more distal outcomes [24]. Authors suggested that model adaptations could be used to identify barriers and strengths [27], guide evaluation of inpatient portals [23], further study specific phenomena [31] and guide future research focused on quantifying and measuring work system elements to broaden the understanding of patient work and on understanding the work system of patients from specific communities [11]. Two studies used the work system models to develop and implement structured questionnaires to analyse patients' work systems [18, 29].

Other products of applying these models included providing a description of the work system [14, 17–19, 21–25, 28–31] and an enumeration of the work system barriers [14, 18, 21, 22, 24, 26, 29, 30] and facilitators [21, 24, 26, 30] Table 4. Authors noted the importance of these products for determining how the design of the work system was shaping patient work performance and related outcomes [18]. Further, authors were able to use these products to provide recommendations for how to redesign the system [19, 21–24, 31]. For example, Keller *et al.* used the results of the work system analysis to generate specific guidelines for the appropriate use of medical devices in the home [24]. One study used the work system model to redesign the system across six research phases. They used SEIPS 2.0 to guide activities at each stage to develop and implement an intervention to improve inpatient mobility. The authors demonstrated that their intervention improved outcomes for clinicians (e.g. attitudes toward inpatient mobility) and patients (e.g. improvement in actual mobility) [21]. The authors concluded that 'the SEIPS 2.0 model offers a comprehensive and flexible framework for developing a site-specific intervention to promote mobility. The model guides an in-depth exploration considering all persons and processes within a specific network while relying on local resources. Adopting this model may help create a sustainable intervention to significantly change clinical practice that promotes mobility and decreases negative hospital-associated patient outcomes'.

Discussion

We reviewed the body of literature that has applied the SEIPS family of work system models to study patient work. Our purpose was to demonstrate the use and value of these models when conducting HFE work system analysis. The reviewed studies reveal theoretical value for guiding projects and practical value for understanding patient work, studying work systems, and planning, implementing, or evaluating interventions. The studies serve as models for qualitative, quantitative or mixed method approaches to model-based work system analysis across populations and settings. Further, they produced contextualized models of care transitions, personal health information management, heart failure self-care and medication management for others to use to design and implement interventions, conduct clinical trials to test interventions and make policy changes. They also reveal areas needing additional research and future directions for applying work system models to study and improve patient work.

Taken together, the reviewed studies illustrate that the SEIPS family of models are flexible and adaptable to various contexts. These contexts include various places and processes of patient work, that is, the effortful health-related activity performed by patients, families and other nonprofessionals [12]. In other words, SEIPS models are applicable to the work of not only professionals but also nonprofessionals, and the collaborative work between the two. These models also have the breadth to account for complex phenomena and systems contexts, while offering some boundaries and categories to frame phenomena in a manageable way. This is especially relevant to patient work, which is complex and multilevel, collaborative, and distributed across time and settings [33–35]. Accordingly, authors of reviewed studies noted the benefits of specifying separate work system models for separate populations or settings and studying patient work at multiple system levels. Furthermore, the models had various uses, from framing a study to designing data collection methods, analysing data, interpreting findings and generating recommendations. They also have applications beyond research, with value for guiding implementation of new processes and technologies and guiding policy development. Structures inherent to the models, such as the finite list of work system components (person, task, tool and technology, organization, environment), could be used as tools, for example, as a checklist to ensure full coverage in a survey instrument or as a framework to communicate the results of a study. Although these tools were often seen in the reviewed literature, they have not been formally presented for systematic use. Authors of reviewed studies described myriad additional strengths of using the SEIPS family of work system models to study patient work. We summarize the top 10 reasons to use these models in Table 5.

Future directions

Based on the results of this review, we note several opportunities for future research to further strengthen and expand upon the use of

Table 4 Products of the application of the SEIPS suite of work systems models to study patient work

Product	Associated Articles
Description of the system	Acher *et al*., 2015 [19]; Doucette *et al*., 2017 [25]; Gorman *et al*., 2018 [28]; Holden *et al*., 2015a [18]; Holden *et al*., 2015b [14]; Holden *et al*., 2017 [17]; Keller *et al*., 2017 [24]; Lim *et al*., 2019 [29]; Look *et al*., 2018 [30]; Walker *et al*., 2018 [23]; Werner *et al*., 2017 [22]; Werner *et al*., 2018 [31]; Zisberg *et al*., 2018 [21]
Enumeration of work system barriers	Abraham *et al*., 2017 [26]; Holden *et al*., 2015a [18]; Holden *et al*., 2015b [14]; Keller *et al*., 2017 [24]; Lim *et al*., 2019 [29]; Look *et al*., 2015 [30]; Werner *et al*., 2017 [22]; Zisberg *et al*., 2018 [21]
Enumeration of work system facilitators	Abraham *et al*., 2017 [26]; Keller *et al*., 2017 [24]; Look *et al*., 2015 [30]; Zisberg *et al*., 2018 [21]
Recommendations for system redesign	Acher *et al*., 2015 [19]; Keller *et al*., 2017 [24]; Walker *et al*., 2018 [23]; Werner *et al*., 2017 [22]; Werner *et al*., 2018 [31]; Zisberg *et al*., 2018 [21]
Redesigned system	Zisberg *et al*., 2018 [21]
Work system analysis tool	Doucette *et al*., 2017 [25]; Holden *et al*., 2015a [18]; Walker *et al*., 2018 [23]
New/adapted work system model	Doucette *et al*., 2017 [25]; Gorman *et al*., 2018 [28]; Holden *et al*., 2015b [14]; Holden *et al*., 2017 [17]; Walker *et al*., 2018; Werner *et al*., 2017 [22]; Werner *et al*., 2018 [31]

Table 5 Top 10 reasons to use the SEIPS family of work system models for studying and improving patient work

1. Provides framework for evaluating patient work in its full complexity, including multifactorial interactions
2. Can be used to design a work system that accounts for variation in care delivery or recipients of care
3. Enables the detection of difficulties and areas of improvement within the system
4. Allows for a determination of how changes may affect other parts of the system
5. Helps identify and address social determinants of health
6. Identifies different outcomes for different stakeholder groups—e.g. patients, professionals, organizations
7. Simultaneously comprehensive and flexible
8. Allows to extend beyond a 'one size fits all' approach to designing interventions
9. Facilitates mapping of interventions for specific sites or locales
10. 'Crucial to understanding the patient's perspective' [19]

these models for studying and improving patients' roles in health and healthcare:

- Advance the application of the work system models
    - Use Zisberg *et al*.'s study as a roadmap for applying the models to work system analysis for intervention design and implementation [21]. Models can be used to assess the potential for existing interventions to 'fit' within a work system as well as to determine and guide how interventions could be adapted or designed to better 'fit' the work system [8].
    - Expand work system analysis to further identify work system facilitators to patient work and to focus on understanding system feedback and adaptation. In so doing, these analyses can highlight key system resiliencies. System resiliency refers to the ability of the system to adapt in the face of disturbances, barriers and crisis, which can provide a useful model for improving quality and patient safety [27, 36].
    - Apply the models to understand and support the patient work of underrepresented groups. For example, future studies should focus on applying and adapting these models as appropriate to understand and support the patient work of patients living in rural areas, patients with disabilities or major impairment, patients of diverse race and ethnicity, patients with lower levels of education and socioeconomic status and patients who do not speak or read English.
    - Apply the models to understand and support patient work within the pediatric population. None of the reviewed studies included pediatric patients. Models should be specified and adapted to address patient work in pediatric populations, as it is possible their patient work and work system has some distinctions from those of adult populations.
    - Applying the models to understand and support the patient work of healthy individuals performing activities to remain healthy. All of the studies reviewed focused on patients with chronic illnesses. To fully understand and support patient work, future work must also investigate health promoting behavior [38].
    - Adapting the models to illustrate the informal or family caregiver work system. Although several of the studies included informal caregivers in their analysis, and one of the reviewed studies only included informal caregivers [30], the models have not been specified to the work of caregivers. However, in some cases, such as in caring for people with severe cognitive and/or physical limitations, the

caregiver likely performs a majority of the patient work. Thus, an increased understanding of the work system associated with that work has implications for the ability to design and implement interventions that 'fit' their caregiver work system.

- Apply the models to understand and support patient work in countries other than the United States. A few of the studies reviewed were conducted in other countries, and one study sought to identify differences in patient work between the United States and Singapore [29]. More research is needed to expand upon these studies and develop a comprehensive understanding of PWS across countries and cultures. SEIPS-based patient work researchers in the United States should develop partnerships with those outside of the United States to broaden our understanding of patient work. This could be facilitated through presenting at and developing work system workshops for international conferences in HFE and healthcare quality and patient safety.
- Encourage use of SEIPS by those designing and implementing interventions for quality improvement and other similar efforts that are not research based by making an easy-to-use version of the model and simplified tools for model application.

- Advance the tools and methods for analysing the work systems in which patient work is performed
  - Adopt methods to quantify and/or mix data. Qualitative methods have many strengths and provide the necessary rich description of the work system being analysed. However, qualitative analysis has certain limitations, for example, being resource intensive to conduct. Future work should focus on advancing quantitative and/or mixed methods for work system analysis of patient work [36].
  - Evaluate and improve feasibility of tools for collecting quantitative data on work system barriers, facilitators, processes and outcomes. The two studies that used structured tools demonstrated feasibility of these tools, but also noted limitations related to the time required to administer the tool, and the translation of the tool. Future work should further refine and validate these tools for broad application.
  - Refine methods for systematically capturing and analysing system interactions, such as the configural diagramming method proposed in SEIPS 2.0 [11, 37].
  - Measure quality and safety outcomes and determine their connection to the work system structure. Zisberg and colleagues provide a framework for achieving this type of analysis [21].
  - Apply the concept of configuration proposed in SEIPS 2.0, which provides a framework for bounding the work system analysis. Configuration proposes that '…only a subset of all possible [component] interactions is actually relevant in a given work process or situation…Thus, for a particular process or situation, one can distinguish a configuration of a finite number of relevant elements that interact to strongly shape the performance of that process. (p. 6)' [11]. Our review found that some studies did not examine all work system components. While at first glance this may seem like an incomplete use of the models, there may be scientific reasons to bind the analysis in this way. Application of configuration can provide a scientific approach to bounding the work system analysis.
  - Capture and analyse data longitudinally. Only two of the studies reviewed collected data longitudinally, and these were only short periods of time [18, 22]. Given the long-term nature of managing chronic illness, it will be important for future work to apply methods to explore longitudinal data. A recent adaptation of SEIPS, SEIPS 3.0, highlights the importance of considering longitudinal data when studying patient work in that patient work is distributed over space and time across a 'patient journey' [38]. The patient journey has been described as 'the spatio-temporal distribution of patients' interactions with multiple care settings over time' [39] and also refers to the emotional and physical journey patients experience [40]. This model may serve as a useful framework for longitudinal data collection.
  - Develop and disseminate a toolkit to help translate work analyses products into intervention design/implementation. The process used in the Zisberg *et al.*'s study could serve as a foundation for a step-by-step process by which these models could be used in intervention design, implementation and evaluation of patient outcomes related to implementation.

Limitations

Certain limitations should be considered when interpreting the results of this review. We limited our inclusion criteria to only papers using the SEIPS family of work system models to study patient work. We recognize other frameworks that can be used to study patient work and recommend future literature reviews should include, and possibly compare them. A single researcher conducted the majority of the title and abstract screening, though based on multiple group discussions to produce clear inclusion and exclusion criteria. Some articles were excluded because they did not present sufficient information on their methods to meet inclusion. The heterogeneity of study methods and applications of SEIPS models required subjective judgments and limited structured comparisons across studies.

Conclusion

With the modern healthcare systems' increasing focus on patient-centered care and patient or family engagement, understanding and supporting patients' roles in their health and healthcare is paramount. To this end, the SEIPS family of work system models has demonstrated a particular value for studying and improving patient work. Specific future recommendations can be followed to advance methods and tools for applying these models to improve safety, quality, health and other outcomes for a diverse range of patient populations and settings.

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Data availability

No new data were generated or analysed in support of this review.

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