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A systems science approach to fatigue management in research and health care

Kathryn A. Lee, PhD, RN, FAAN, CBSM[a,*], Oliwier Dziadkowiec, PhD[b], Paula Meek, PhD, RN, FAAN[c]

[a] School of Nursing, University of California, San Francisco, San Francisco CA
[b] Center for Nursing Research, College of Nursing, University of Colorado at Denver, Aurora, CO
[c] College of Nursing, University of Colorado at Denver, Aurora, CO

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ABSTRACT

The purpose of this article was to highlight innovative analytic approaches in symptom science. Complex systems modeling is discussed using fatigue as an example. Fatigue is a common symptom among individuals of any age. It can be acute or chronic, and it can vary across the day and on weekends compared with weekdays. Fatigue can overlap with other symptoms, has many dimensions, and impacts daily function as well as society at large. With the complexities surrounding symptom science, innovative models are needed to advance our understanding of factors within the person, contextual and situational factors, and workplace or health care system factors that impact the symptom experience. Advances in methodologies, such as complex systems modeling, allow for more innovative methods to study the complexities of the symptom experience, design better ways to intervene and manage symptoms, and ultimately improve outcomes related to symptom management, quality of life, and health care utilization.

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Introduction

Fatigue is a common symptom that is experienced across the life span among different populations (Barroso & Voss, 2013; Hallowell, 2010; Gay, Lee, & Lee, 2004; Miaskowski et al., 2008). Fatigue can be related to either mental or physical exertion or both. It can be an acute cyclic phenomenon in healthy workers, and it can be a more chronic distressful experience for people living with a health problem. For most healthy children and adults, exertion accumulates during the day, creating a pattern of higher fatigue severity in the evening and relief from fatigue by resting or getting a good night of restorative sleep (Lerdal, Gay, Aouizerat, Portillo, & Lee, 2011). Without an opportunity to rest or get adequate sleep, which may occur with long work shifts, prolonged physical labor, or mentally challenging tasks, fatigue accumulates, and quality of life suffers (Hallowell, 2010). In individuals with a health problem, fatigue can also be related to their disease condition, medical therapy, or side effects of medications (Lerdal, Lee, Bakken, Finset, & Kim, 2012; Meek & Lareau, 2003; Voss, Dodd, Portillo, & Holzemer, 2006). Complicating the experience of fatigue for both healthy and ill populations is its overlapping features with other symptoms such as anxiety or depression, excessive daytime sleepiness, lack of motivation,

* *Corresponding author:* Kathryn A. Lee, School of Nursing, UCSF, Box 0606, San Francisco CA 94143-0606.
E-mail address: kathryn.lee@ucsf.edu (K.A. Lee).

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cognitive impairment, or feeling overwhelmed by accumulating daily stressors (Aouizerat, Gay, Lerdal, Portillo, & Lee, 2013).

In symptom science, it is fully acceptable to use a person's self-report to assess the symptom of interest. In other words, the person is the "gold standard" for valid and reliable measurement. To some extent, using validated measures of fatigue only serves to complicate an already complex phenomenon. These fatigue measures are often multidimensional in nature and include impact on physical and mental function over time rather than current experience of fatigue's frequency or severity. Many measures of fatigue conceptually overlap with measuring other symptoms (Aouizerat et al., 2013) including items on depression, low motivation, or sleepiness (Shen et al., 2006). This makes intervention trials even more complex to design and test because of the varying time frames and the various dimensions of symptoms assessed. A highly effective intervention may change the *severity* of fatigue but not its *frequency*, or it may alter the *distress* associated with the feeling but not the *severity*. Using the wrong measure or wrong time frame for measurement will only yield false-negative results. Fatigue measures and fatigue items within the Patient Reported Outcomes Measurement Information System (PROMIS) measures (Bevans, Ross, & Cella, 2014) should be evaluated by researchers for dimensions and time frames of relevance to the study design and population of interest.

Fatigue is only one example of just how complex symptom research can be. What is discussed in this article can be applied to a multitude of other symptoms. It can also be applied to more complex phenomena such as symptom clusters (Dodd, Miaskowski, & Lee, 2004). Complex systems science has been applied to other areas of health research such as nutritional security and obesity (Hammond, 2009; Hammond & Dubé, 2012). In this article, current knowledge about the symptom of fatigue is used to describe how complex systems modeling approaches can facilitate our understanding of symptom science and gaps in knowledge.

Types of Fatigue and Potential Mechanisms

Occupational Fatigue

In occupational health and safety, fatigue is primarily focused on physical capacity and work productivity (Hallowell, 2010). Fatigued workers are less productive, but they are also at particularly high risk for accidents and errors in the work environment and in the home setting (Caruso, 2014; Lee & Lipscomb, 2003). Policies are usually in place to allow for adequate rest periods to minimize fatigue and keep everyone safe, but there are no assessments of how fatigued a worker may be going to and from the workplace. This type of fatigue in a healthy employee can endanger the worker's health and well-being and impact social and family interactions. There are societal implications as well. Fatigue of workers puts society at risk, particularly for patients getting 24-hour hospital care and for passengers aboard planes, buses, trains, or ships. Occupational fatigue is of great concern to nurses and hospital administrators as well as labor unions and insurance companies (Han, Trinkoff, Storr, & Geiger-Brown, 2011).

Adding to the complexity of occupational fatigue is its overlapping features with stress, symptoms of anxiety or depression, or excessive sleepiness from short sleep duration. Most individuals, and their clinicians or workplace supervisors, cannot make distinctions between these confounding features (Akerstedt, Fredlund, Gillberg, & Jansson, 2002; Shen et al., 2006). Thus, the potential mechanisms for occupational fatigue are complex in nature and have implications for the health of individuals and society (Geiger-Brown et al., 2012). Figure 1 is an example of the complexity of fatigue in occupational health (Hallowell, 2010). Better analytic models for this type of fatigue will improve our understanding of mechanisms to target for more precise interventions to reduce the morbidity and mortality associated with occupational fatigue.

Disease-related Fatigue

Fatigue is epidemic among children and adults with health problems. Disease-related fatigue is primarily focused on physical and mental function and limitations that either affect adherence to medical therapy or reduce quality of life. Clinicians often see fatigue as a subjective indicator of poor health or inadequate nutrition. This fatigue complaint is often nonspecific and requires the clinician to explore many possible culprits that can be remedied with medical treatment, such as obesity, anemia, thyroid dysfunction, depression, pain, sleep disorders, or physical deconditioning and lack of exercise. Genetic studies are also finding associations between fatigue and cytokine genetic markers (Lee, Gay, Lerdal, Pullinger, & Aouizerat, 2014; Miaskowski et al., 2010; Voss et al., 2013). Fatigue can be a precursor of infection or a warning sign of inflammatory processes during impending exacerbations of immune disorders like rheumatoid arthritis or multiple sclerosis. In most studies of patient populations that include laboratory values for anemia, like hemoglobin or hematocrit, or include clinical indicators of disease progression like viral load with HIV infection, there are usually weak associations with fatigue. Other factors such as socioeconomic status or age and sex are more strongly correlated with fatigue than clinical indicators (Aouizerat et al., 2013).

If fatigue is not part of the disease process, it is often a side effect of medical therapy used to treat a health problem. An example of disease-related fatigue is cancer, with interventions that include chemotherapy and radiation (Lui et al., 2013; Miaskowski et al., 2011). Fatigue may be present as part of the initial cancer