Expanding representations of individuals and their interactions within work system models
Rupa Valdez\textsuperscript{a}, Richard Holden\textsuperscript{b}, Pascale Carayon\textsuperscript{c}

\textsuperscript{a}Public Health Sciences, University of Virginia, Charlottesville, Virginia, USA; \textsuperscript{b}BioHealth Informatics, Indiana University, Indianapolis, Indiana, USA; \textsuperscript{c}Industrial and Systems Engineering, University of Wisconsin-Madison, Madison, Wisconsin, USA

1. Introduction
John Wilson (2000) noted “any acceptable definition of ergonomics must emphasise the need for, and the complementarity between, a fundamental understanding of people and their interactions and the practice of improving those interactions” (p.559). Work system models provide a means of systematically assessing the elements with which an individual interacts within the context of a complex sociotechnical system (Carayon, 2006). These models emphasize that systems outcomes are a product not only of individual actions, but of interactions between an individual, the tasks they perform, the tools/technologies they use to accomplish these tasks, and the physical and social environments in which these tasks are performed. Thus, work system models enable a fundamental understanding of interactions between an individual and other work system elements. Although the majority of work system models emphasize the need to understand the individual worker, less emphasis has been placed on creating models that explicitly represent the roles of and interactions between multiple individuals embedded in one or multiple work system(s) and the ways in which these interactions shape processes and outcomes.

2. Practice Innovation
The need for work system models that explicitly represent the roles of multiple individuals embedded in one or multiple work systems is particularly required when understanding and designing for complex sociotechnical systems like healthcare in which different types of actors such as patients, family members, nurses, physicians, and social workers jointly produce many processes and outcomes (Holden et al., 2013; Valdez, Holden, Novak, & Veinot, 2015). In this paper, we review existing work system models to assess how individuals are currently represented and propose ways of augmenting existing models to more explicitly represent the roles of multiple individuals within a complex sociotechnical system.

3. Sources of Information
We reviewed work system models identified by Carayon (2006) in addition to work system models published after this date that are specific to the context of healthcare (i.e., Carayon et al., 2006; National Research Council, 2011; Holden et al., 2013). Our proposed methods of representing more complex interactions between individuals within a work system are drawn from a synthesis of these models and from our collective experience applying work system models to the study of provider and patient work.

4. Findings
An analysis of existing work system models reveals four general methods for representing multiple individuals. In the first method, all individuals within an organization are considered as part of the “personnel subsystem” (e.g., Kleiner, 2004). The focus is on people as a collective entity, not on the characteristics of individual actors. In the second method, a single individual remains the focus of analysis, but is represented as embedded within a larger collective such as a group or team (e.g., Moray, 2000). In the third method, a single individual remains the focus of analysis but is represented as interacting with others either explicitly (e.g., Wilson, 2000) or implicitly within the context of an organizational environment (e.g., Carayon et al., 2006). In the final method, multiple individuals are simultaneously represented in the work system (e.g., Holden et al., 2013; Vincent, 2003). These latter models are healthcare specific and enable representation of both the healthcare professional and the patient as separate entities. Despite theoretically enabling simultaneous representation of multiple individuals, these models do not explicitly address the fact that these
individuals are likely to be embedded in only partially overlapping work systems in terms of tasks, tools/technologies, and physical and social environments.

We propose four ways of augmenting existing work system models to more systematically and holistically account for the roles of multiple individuals. First, future work system models should explicitly account for group and team level properties arising through the interactions of multiple individuals. Second, these models should enable representation of clusters of individuals performing the same role within a single work system (e.g., triage nurse within an emergency room) but who have different individual level characteristics (e.g., levels of expertise). Third, these models should enable representation of multiple types of actors who are embedded in distinct but coupled work systems (e.g., physicians and patients, nurses and caregivers). Tools such as configural diagrams (Holden et al., 2013) may then be modified to facilitate representation of interactions not only within one but across multiple interrelated work systems. Finally, these models should not be constrained to static representations of individuals’ roles but rather enable representation of the dynamic roles various individuals play over the lifespan of a process.

5. Discussion

Multiple individuals performing a variety of roles interact to produce outcomes within complex sociotechnical systems such as healthcare. Expanding work system models as specified above may facilitate deeper understanding of interactions between individuals and the work systems in which they are embedded. Such an understanding may then be used as a foundation for the design of interventions that address phenomenon involving multiple actors such as medication reconciliation, fall prevention, and diabetes management.

![Figure 1. Representations of the roles of multiple individuals within a work system.](image-url)
References