

Examining the macroergonomics and safety factors among teleworkers: Development of a conceptual model

Michelle M. Robertson^{a,*}, Lawrence M. Schleifer^b and Yueng-hsiang Huang^a

^aLiberty Mutual Research Institute for Safety, Hopkinton, MA USA 01748

^bRockville, Maryland, USA

Abstract. With the rising number of teleworkers who are working in non-traditional work locations, health and safety issues are even more critical. While telework offers attractive alternatives to traditional work locations, it is not without challenges for employers and workers. A macroergonomics approach or work system design for telework programs is proposed to address these new challenges. This approach explains the impact of organizational, psychosocial and workplace risk factors on teleworker's health and safety. A process for managing the health and safety of teleworkers is presented along with preventive strategies to provide an injury-free working environment.

Keywords: telework, macroergonomics, musculoskeletal symptoms, safety, psychosocial

1. Introduction

Telework, defined as working for an employer at an alternative work location, such as the home with an electronic link, is common for millions of Americans. According to the International Telework Association and Council (ITAC), more than 23.6 million people reported working as teleworkers in 2000. While telework offers an attractive alternative to traditional work locations, it is not without challenges for employers and employees [15]. These challenges include how to best manage employees who work at home rather than at the corporate site, implementation and support of the required information technology, the lack of social and group interaction, changes in job autonomy, the absence of mentoring and career development, balancing work and personal conflicts, extended work hours and workload, and sound risk management that addresses safety and health issues [15]. Designing effective communication strategies that allow managers and employees to define job responsibilities, set goals and job expectations, and regularly review work and performance are just some of the challenges that

organizations must address to implement successful telework programs [9]. Others include establishing policies and procedures regarding appropriate technology and equipment, and training employees to manage these technologies [15]. All these challenges can have an impact on employee morale, stress and musculoskeletal discomfort such as low back pain and upper extremity disorders. The manner in which these factors are addressed in telework will significantly impact not only the safety and health of the employee, but the organizational effectiveness.

This paper will first provide a literature background that frames the issues and challenges of telework. Second, a conceptual model is given that captures these macroergonomic issues based on the empirical data derived from the literature and case studies for understanding organizational outcomes in the telework environment. This conceptual model provides a diagnostic tool for identifying problems and issues to improve safety and health, as well as organizational performance in a telework environment. Further we will provide an outline for a macroergonomic process in managing the safety and health of teleworkers. Additionally, this approach

* Corresponding author. E-mail: Michelle.Robertson@LibertyMutual.com.

explains the impact of organizational and psychosocial risk factors on teleworker's safety and health, which is also applicable to conventional office workstation design.

2. Literature background

It is estimated that over 17.2 million US office workers have telecommuted at least one day a week [16]. With new computer-based Information Communication Technologies (ICT), coupled with environmental and economic issues, patterns of office and computer work will be influenced, as teleworking is changing how these office employees are working, commuting and communicating [16,8,11]. Telework, a widespread practice that had steadily increased in the United States and abroad, allows employees and their tasks to be shared across settings away from a central place of business or physical organizational location [4,8,14]. Over the last several years, both private industry and the federal government have encouraged these alternative workplace changes, many of which have been observed to be beneficial to the economy, to the environment, and to the quality of family life [1]. More recently, the federal government, encouraged by congressional legislation and the Office Program Management (OPM) telework directive, is further supporting this initiative by developing telework programs including flexible and alternative office workspaces [17].

However, there is insufficient research to determine whether telecommuting is positive or negative for employees, regarding the safety and health effects [9,3]. Working at home may reduce stress and injury risk by harmonizing work and family demands and minimizing daily commutes. Positive factors frequently reported include the elimination of office stress, individual tailoring of work environments, greater accommodation of the disabled, reduced rates of sickness absenteeism, increased productivity, better sense of control over the job and workplace, and a higher level of job autonomy [10,2,1]. Conversely, negative issues often raised are social isolation, career stagnation, family conflict, and higher perceived workload levels [19]. These presumed benefits need to be balanced against the risks from loss of safety and ergonomics oversight, introduction of occupational hazards into the home working environment, the blurring of work and

family roles, social isolation from peers and the constant feeling of being linked to the workplace.

This notion of balance and harmonization among work environment, technology, job design, psychosocial and organizational factors, and their interactive effects on safety and health serves as the foundation for this project. An increased knowledge of these factors should provide guidance for improved telework programs. More effective safety practices can be developed, including work procedures and training programs. Additionally, the results of this study will likely form the basis of future intervention studies focusing on interactions between the physical environment, technology, psychosocial and organizational factors, job design as related to telework programs and managing the safety risks of these types of lone workers.

2.1. Knowledge gaps and methodology shortcomings

There is a large body of empirical evidence identifying several risk factors (e.g. physical environment and job design, psychosocial and work organization) that exist in the conventional office environment) and their link to work-related musculoskeletal disorders [18,6,22,24]. It has also been shown that a poor psychosocial work environment (poor task content, heavy psychological demands and poor social support) may contribute to musculoskeletal problems [6]. On the other hand, being less exposed to the negative psychosocial aspects of working in a conventional office appears to delay the onset of symptoms [13].

Telework studies present a mixed picture of the effects, as both negative and positive results have been reported. Thus, it appears that the existing evidence is inconclusive and contradictory [19,9]. Robertson [24] noted that few studies have examined the longitudinal effects of telework and the impact on teleworkers' safety risks as well as the managing of these risks. Even though telecommuting and alternative office workplace changes are growing, little is understood about the impact on the safety and health of teleworkers [25]. Few studies have examined the effects of telework over time on objective safety measures, such as accident rates, lost work days, absenteeism, and sick leave [2]. Survey results of the teleworker's experience [9], revealed that little research exists regarding safety and health management practices.

One qualitative cross-sectional study noted that 60% of teleworkers reported that they were left to

themselves to set up their home-based workstation with no ergonomics or technical advice [20]. Home-based telework was generally reported by workers as having a positive effect on their health, although potential problems arising from work station design, long hours and isolation were also identified [20]. Given that home-based telework is usually performed with a computer as the principal working tool, these risk factors of computer work are recognized for contributing to the development of musculoskeletal problems in the neck, shoulders, wrists, hand and lumbar regions [18]. In their sample of 33 teleworkers, Montreuil & Lippel [20] found that 54.5% complained of pain in their upper limbs, back or neck, which they attributed to inadequate furnishings, static posture and computer use, and lifting heavy objects [20].

Concerns have been raised that teleworkers are so committed to working at home that this may lead to less than optimal practices regarding health and safety. Teleworkers may expect to work long hours in order to ensure that their productivity meets or even surpasses expectations [21]. Moreover, having to respond to clients within a time constraint context and using computer equipment that is poorly adapted to the clients' needs may result in a situation that is conducive to the onset of musculoskeletal disorders as shown by Sznclwar et al. (1999).

The managers' perception regarding how telework influences their managerial role is also essential to understand, especially in managing the safety and health of remote, off-site workers. However, many telework studies focus on only the employees and not the managers who are in a supervisory role. As reported in Ilozor et al. [4] and Belanger and Collins [15], the majority of telework research focuses on work management processes, such as job satisfaction and family and life balance issues, and these perceptions are typically gathered by cross-sectional surveys. For example, in a recent meta-analysis of 46 cross-sectional survey studies [9], it was found that there were minimal detrimental effects on the quality of workplace relationships. However, if the duration of telework was more than 2.5 days a week, it had negative effects on coworkers' relationships. Conversely, the longer the telework duration, the more beneficial effects on work-family conflict were shown, along with job satisfaction, performance, turnover, and role stress. Telework has the potential for modulating these risk factors either positively or negatively. Thus, we will examine the effects of telework on psychosocial and organizational

perceptions, workspace design satisfaction, job and work organization factors and musculoskeletal health.

These aforementioned studies were limited in their examination of the inter-relationships among the proposed hypothesized factors, as relatively little is known about the safety ergonomics risks and their impact on teleworkers. Further, these existing studies were limited by focusing on only one element of telework, not encompassing a systems viewpoint or recognizing the multi-factorial nature of telework (e.g., workplace, psychosocial and organizational factors). Thus, given that telework is one of the fastest growing fields in the service sector, the need is apparent for interdisciplinary research aimed at the management of occupational safety and health of telecommuting office workers [5].

Empirical research in this area has been largely unsuccessful in explaining what happens after firms and employees adopt a telework arrangement, especially concerning managers' perceptions of the effects of teleworking. Moreover, many of the telework studies have weak study designs and methodological issues, such as cross-sectional surveys, no reference or control group. Little research has been conducted to understand how safety guidelines are designed and implemented to prevent injuries, minimize ergonomic risk factors and other personnel losses.

3. Macroergonomic model of telework

3.1. Macroergonomic framework and model

To conceptualize these macroergonomic issues related to home-based telework as noted in the literature, we conceived a model that structures the pertinent factors related to telework into three levels: organizational, group and individual. Within each of these levels, the sociotechnical elements (technological and personnel subsystem) and the physical work environment factors are identified as well as potential outcomes that could measure the success of the telework program. This micro-macroergonomics model captures various hypothesized workplace and job design, technological, psychosocial and organizational factors, related to telework, as reported in the literature and derived from exemplary industry case studies [See Figure 1] [23]. Incorporated into this model are the socio-technical system factors [12] as well as the balance model proposed by Carayon and Smith [7]. Our micro-macroergonomics model

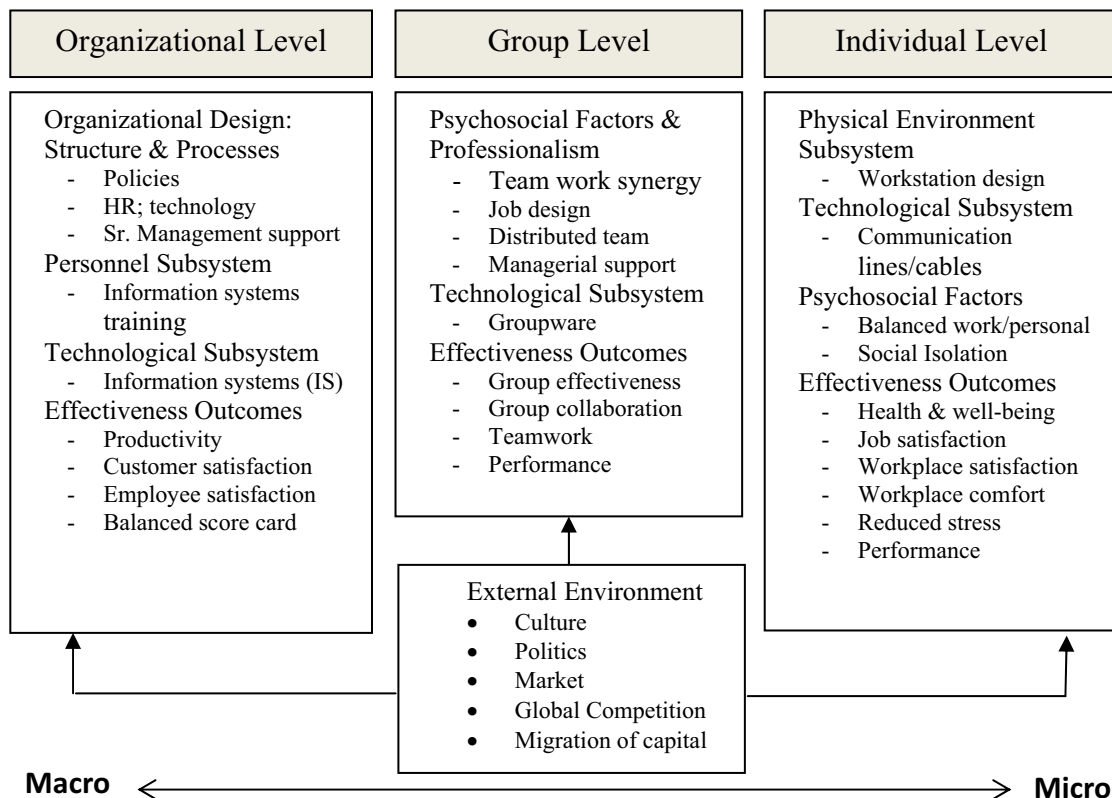
organizes and structures the identified risks and issues of teleworking into three levels (individual, group and organizational), as shown on top of Figure 1. Within each of these levels, the technological and personnel subsystems, psychosocial, and the physical work environment factors are identified along with the organizational design factors. Together, these subsystems, factors and the external environment comprise the overall work system design for teleworkers.

Potential effectiveness ratings and outcomes that could measure the success and impact of a telework program are given at the bottom of each level. Several reported business case studies [1,2] concluded that to have a successful telework program, these factors noted in the model should be addressed systematically at each of the levels and with the appropriate stakeholders.

3.2. Macroergonomics process: managing the health and safety of teleworkers.

Optimizing and managing the telework work environment is critical and it involves incorporating a macroergonomics safety process that is not only well designed, but sustainable. This process includes identifying key stakeholders, conducting a surveillance or worksite analysis, employee surveys, and measuring leading and lagging indicators in the telework environment. Detailed injury and hazard information obtained through surveillance efforts is also essential to design an evaluation system to monitor the telework program [23].

Figure 1. Telework – A Macroergonomics Work System Design Perspective



4. Conclusions

Teleworkers are faced with unique challenges and opportunities regarding their work and safety. To have a successful telework program, organizations need to design, implement and evaluate them with a systems oriented, macroergonomic approach such as that proposed in this paper. Based on the proposed model, we are implementing a telework field intervention to empirically explore the effects on teleworker's safety and organizational performance.

References

- [1] Apgar, M. (1998). The alternative workplace: Changing where and how people work. *Harvard Business Review*, 76(3), 121-136.
- [2] Bailey, D.E. & Kurland, N.B. (2002). A review of telework research: findings, new directions, and lessons for the study of modern work. *Journal of Organizational Behavior* 23, 383-400.
- [3] Becker F., Rappaport, A.J., Quinn, K.L. & Sims, W.R. (1993). Telework centers: An evaluation of the North American and Japanese experience. New York: Cornell University, International Workplace Studies Program, pp. 26, 33-34, 48.
- [4] Belanger, F., Collins, R.W. & Cheney, P.H. (2001) Technology requirements and work group communication for telecommuters. *Information Systems Research* 12(2), 155-176.
- [5] Borsch-Galetke, E. (1999). Work related health risks and illnesses-where is the need for action? *ErgoMed* 23(1), 31-33.
- [6] Bongers, P.M., de Winter, C.R., Kompier, M.A. & Hilderbrandt, V.H. (1993). Psychosocial risk factors for work-related musculo-skeletal disorders among newspaper employees. *Scandinavian Journal of Work, Environment & Health* 19(5), 297-312
- [7] Carayon, P. & Smith, M.J. (2000). Work organization and ergonomics. *Applied Ergonomics* 31, 649-662.
- [8] Davis, D.D. & Polonko, K.A. (2001). Telework in the United States: Telework American survey. Available on-line at: <http://www.workingfromanywhere.org/telework/twa2001.htm>.
- [9] Gajendran, R.S. & Harrison, D.A. (2007). The good, the bad, and the unknown about telecommuting: Meta-analysis of psychological mediators and individual consequences. *Journal of Applied Psychology* 92(6), 1524-1541.
- [10] Grzywacz, J.G., Casey, P.R. & Jones, F.A. (2007). The effects of workplace flexibility on health behaviors: A cross-sectional and longitudinal analysis. *Journal of Occupational Environmental Medicine*, 49, 1302-1309.
- [11] Harrington, S.S. & Walker, B.L. (2004). The effects of ergonomics training on the knowledge, attitudes, and practices of teleworkers. *Journal of Safety Research* 35, 13-22.
- [12] Hendrick, H.W. & Kleiner, B., eds. (2002). *Macroergonomics: Theory, methods, and applications*. Mahwah, NJ: Lawrence Erlbaum Associates.
- [13] Hill, E.J., Miller, B.C., Weiner, S.P. & Colihan, J. (1998). Influences of the virtual office on aspects of work and work/life balance. *Personnel Psychology* 51 (3), 667-683.
- [14] Karnowski, S. & White, B.J. (2002). The role of facility managers in the diffusion of organizational telecommuting. *Environment and Behavior* 34(3), 323-334.
- [15] Ilozor, D. B., Ilozor, B. D. & Carr, J. M. (2001). Management communication strategies determine job satisfaction in telecommuting. *Journal of Management Development* 20(6), 495-507.
- [16] International Telework Association and Council. (1999). U.S. Representative Frank Wolf announces five cities to be part of a federal telework pilot program. Available on-line at: <http://www.telecommute.org/policy/federal/wolf.shtml>.
- [17] Office of Personnel Management, Interagency telework site (2009), <http://www.telework.gov>.
- [18] Marcus, M. & Gerr, F. (1996). Upper extremity musculoskeletal symptoms among female office workers: associations with video display terminal use and occupational psychosocial stressors. *American Journal of Industrial Medicine* 29, 161-70.
- [19] McCloskey, D. W. & Igarria, M. (1998). A review of the empirical research on telecommuting and directions for future research. In: *The Virtual Workplace*. Hershey, PA: IGI Publishing, pp. 338-358.
- [20] Montreuil, S. & Lippel, K. (2003). Telework and occupational health: A Quebec empirical study and regulatory implications. *Safety Science* 41, 339-358.
- [21] NIOSH (2002). Document 116.
- [22] Rempel, D. M., Krause, N., Goldberg, R., Benner, D., Hudes, M. & Goldner, G. U. (2006). A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. *Occupational and Environmental Medicine* 63, 300-306.
- [23] Robertson, M., Maynard, W., & McDevitt (2003). Telecommuting: Managing the safety of workers in home office environments. *Professional Safety*, 48, (4) pp. 30-36.
- [24] Robertson, M., Telework: Macroergonomics and safety issues. In: *Proceedings of the 10th International Symposium on Human Factors in Organizational Design and Management*, P.Carayon, M. Robertson and B. Kleiner (Eds) CD ROM.
- [24] Sauter, S.L. & Swanson, N. (1996). An ecological model of musculoskeletal disorders in office work. In: *Beyond biomechanics: Psychosocial Aspects of Musculoskeletal Disorders in Office Work*, S.D. Moon and S.L. Sauter (Eds), London: Taylor & Francis, pp. 3-21
- [25] Spinks, W.A. (2002) A survey of home-based workers in Japan: Emerging health issues. *Journal of Occupational Health* 44, 248-253.
- [26] Sznalwar, L.L., Mascia, F.L., Zilbovicius, M. & Arbix, G. (1999). Ergonomics and work organization: the relationship between Tayloristic design and workers' health in banks and credit cards companies. *International Journal of Occupational Safety and Ergonomics* 5 (1), 291-301.