Health Problems with Electronic Document Handling – a longitudinal study

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Abstract

This study shows that electronic document handling (EDH) systems can result in increased risks of work-related musculoskeletal disorders, especially "mouse-arm syndrome", and stress-related mental and somatic symptoms. The effects of introducing an EDH system on the physical and psychosocial work environment, as well as on self-reported health and well being, were studied at four Swedish work places where clerical duties are performed. Data were collected on three separate occasions: before and 6 and 18 months after the introduction of the EDH system. The methods used were interviews, observation interviews, questionnaires, video recordings, technical measurements and expert observation and examination. The results showed an increase in time spent at visual display units (VDUs) and longer periods without taking a break at the

VDUs after introduction of the EDH system. Moreover, after the introduction of the EDH system, all of the data collection methods indicated (a) an increase in workload, (b) a greater number of repetitive and monotonous tasks, (c) participants felt more constrained, (d) a higher frequency in static work postures and (e) a diminution in task variability. The questionnaires revealed an increase in musculoskeletal symptoms and in psychological and psychosomatic complaints. The introduction of EDH systems can improve the effectiveness of work over the short run, but in order not to risk the health of the users an ergonomic strategy for the design of work organization, work systems, computer systems, job tasks and workstations is necessary.

Keywords: Information technology, electronic document handling, physical and psychosocial work environment, health and well being, musculoskeletal disorders.

1 BACKGROUND

Information technology (IT) is rapidly transforming working life. Today 66% of the Swedish work force use computers in their work. Thirty-five % of the women in the total work force and 30 % of the men use computers at least half of the working day (Arbetsmiljöverket, AV [The Swedish Work EnvironmentAuthority] 2001). Approximately one third of the work force have clerical office work and of course the use of computers is higher in that group; from 1989 to 1997 the proportion of computer users among office workers in Sweden increased from 65% to 90%. (Marklund 2000).

During the 1980s and 1990s, new techniques for document handling, in which paper-based information is replaced by electronic information, have been introduced at many work places. The aim of these new techniques is to ensure that information is made available when and where it is needed and that the speed, quality and effectiveness of document handling are increased. This technique has several names, including Automatic Document Handling, Electronic Document Interchange and Electronic Document Handling (EDH). Basically, EDH implies that information is first scanned from paper documents into a computer system, stored on computer media, presented on a computer screen and subsequently available for use within the computer system, often as part of a "work flow" system. This technology has had a great impact on physical and psychosocial working conditions and supposedly on the general health and well-being of individuals.

For several years, numerous studies have examined the health consequences of computerization and of VDU work at various work places. (Aronsson, Åborg, Örelius, 1988, Bergqvist, 1993). The initial health concerns were mainly directed toward physical attributes such as eyestrain and musculoskeletal symptoms. More recently, studies have focused on the stress-responses and psychological complaints of individual users of EDH systems. The use of computers at work has been found to produce an increase in mental and physical workload and an increase in the risk of somatic and mental health symptoms, especially eye strain, neck and shoulder problems and a variety of psychosomatic symptoms (Aronsson, Dallner, Åborg, 1994, Fernström & Åborg 1999, Punnett & Bergqvist, 1997). Recently, the "mouse arm-syndrome" has become a growing problem and that has gained considerable scientific interest (Sandsjö & Kadefors, eds. 2001). We now know that muscle disorders in computer users are related to both physical and psychosocial working conditions. There is also evidence suggesting that women have a

higher prevalence of symptoms than men (Aronsson et al. 1988, Sandsjö & Kadefors, eds. 2001). One striking finding of these earlier studies is that personnel working 6 hours per day, or more, at a computer show more symptoms of ill health in comparison with those working fewer hours (Aronsson et al. 1988, Wigaeus Thornqvist et al., 2001).

Computer systems are often poorly designed and not highly usable, (usability is defined by the international standards organization, ISO, as effectiveness, efficiency and satisfaction) (ISO 1998). This leads to inefficient use and to a variety of cognitive problems (e.g., confusion, lack of overview and memory overload) (Nielsen 1993, Åborg, Sandblad, Lif, 1998).

From the extensively used theoretical model for measuring stress at work known as the "demand-control model" (Karasek & Theorell 1990), it is possible to predict that this undesirable situation can produce stress reactions and stress-related diseases. The effects of poor cognitive ergonomics on musculoskeletal problems are not very well known.

We can conclude that we have quite a good picture of the general health consequences of office computerization. We have to apply that "old" knowledge to new work situations. We should carefully monitor the effects of introducing new information technology into the office. If we want to improve the situation we should try to find the most important factors related to the alarming health problems.

2 AIM

The aim of the study was to examine the effects of introducing an EDH system on the physical and psychosocial work environment, as well as on the self-reported health and well-being, of persons employed in office work.

3 DESIGN

Most studies concerned with VDU use and health effects are cross-sectional, comparing different groups of users. To understand the relations between different work-related environment factors, work content, use of specific techniques/computer systems and user reactions, these factors have to be studied over time. Thus, a longitudinal study design was used. Data were collected on three separate occasions: before and then 6 and 18 months after the introduction of an EDH system.

4 STUDY GROUPS

Four work places, three at two different government agencies, the Swedish Tax Administration and the Swedish Enforcement Administration, and one office at a private company, took part in the study.

One of the government agencies, the Enforcement Administration, discontinued using the EDH system and some participants from the other groups terminated the EDH work before the end of the study.

Of the original number of 56 respondents on the questionnaire 29 could be followed throughout the course of the study. A smaller group, all women, took part in interviews and video recordings before and after the introduction of the EDH system and in observation interviews at one occasion, 6 months after the introduction (see Table 1).

All participants performed standard administrative office work.

5 METHODS

The methods used to collect data included interviews, observation interviews, questionnaires, video recordings, technical measurements and expert observation and examination.

Technical measurements and **technical expert examinations** evaluated the computer equipment, work place layout, illumination, acoustics, thermal climate and any electric and magnetic fields that may be present. An experienced occupational health technician conducted these measurements and examinations. Most of the participants obtained new, modern 17" VDU screens during the study. The results of the technical measurements are not included in this paper, but the changes that occurred between the data collection occasions were so small that they were insignificant in both a scientific and a practical sense.

The **interviews** were semi-structured and concerned work content, workload, personal control, influence and participation in decision-making, peer and supervisory relations, social support, contact and collaboration. In the interviews that took place after the introduction of the EDH system the respondents were asked to express their view on the work with that system and on any changes that occurred in the work situation as a consequence of the presentation of the EDH system. Each interview lasted for about 90 minutes, took place at the respondents' workplace and was conducted by an experienced psychologist. Sixteen persons, all women, were interviewed before the introduction of the EDH system; of these, six continued to use the system during the entire study

period, and were interviewed after being exposed to the EDH system for18 months.

The usability of the EDH system was evaluated using an **observation interview technique**. An experienced evaluator observed and interviewed the users during their ordinary work with the system. In some cases, the interview was completed after the observation period. The evaluation procedure followed a recently developed method (Åborg et al. 1998) that is chiefly based on an interview guide. The guide contains a set of important aspects and support for their interpretation. The goal of the procedure is to identify usability and cognitive work environment problems. Eight persons, all women, at three work places served as participants in the usability evaluation.

The **questionnaires** concerned job content, physical and psychosocial work environment and mental and somatic health symptoms. The questionnaires were based on standardized, tested forms that have been widely used by the Swedish Foundation for Occupational Health and Safety for State Employees (Andersson & Åborg 1992). Before presentation of the EDH system, 60 persons were asked to fill in the questionnaires; of these, 56 (43 women and 13 men, mean age 44.0 years) completed the questionnaires. Six months after the EDH system was introduced, the same questionnaires described above were administered to 38 users of the system of whom 37 completed the questionnaires (36 women and 1 man, mean age 48.0 years). The questionnaires were given a third time to 29 users of the EDH system 18 months after its introduction. Twenty-two (all women, mean age 50 years) of these 29 users completed the questionnaires.

Video recordings were used to document work content, work postures and movements of the participants**.** Eighteen persons, all women, were studied before the EDH system was introduced; nine of these 18 persons were studied 6 months after its introduction. Recordings were done before lunch, after lunch or shortly after the participants' afternoon break. The duration of each recording was 100 minutes.

Method	Data collection 1 before	Data collection 2 6 months after	Data collection 3 18 months after
Questionnaire	n=56	n=37	n=22
Interviews	n=16		n=6
Observation interviews		n=8	
Video recordings	n=18	n=9	

Table 1. Methods

6 RESULTS

The interviews, questionnaires, video recordings and expert observations all showed an increase in time spent at VDUs, whereas total working time was unchanged. In addition, the results indicated that participants worked longer periods without taking a break at the VDUs after the introduction of the EDH system.

According to the data from the questionnaires, 80% of the respondents worked more than 6 hours per day at a VDU after they were exposed to the EDH system. In contrast, only 20% of the respondents worked more than 6 hours per day before exposure to the system.

All of the data indicated an increase in workload, an increase in repetitive and monotonous tasks, more constrained, a higher frequency in static work postures and less task variability after the introduction of the EDH system.

The video recordings revealed that the time participants spent looking at the computer screen increased from 20% to a little over 50% of the time measured. The use of the computer mouse increased from zero percent (the system used only the keyboard as an input devise before the introduction of EDH) to approximately 20%.

The visual quality of the documents presented on the VDUs was often not acceptable, according to the participants and the occupational health

technician conducting the technical expert examination**.** This was due to factors related to both the hardware and the software used. Despite a change to more efficient scanning equipment during the time of the study, 92% of the respondents still found the documents difficult to read on the screen. This event led to increased workload in terms of both mental and physical load (i.e. a strain on the participants' eyes and musculoskeletal system).

The questionnaires indicated that participants expressed an increase in musculoskeletal symptoms, especially with respect to the participants' right side (the right shoulder, arm and hand). In addition, the participants reported an increase in psychological and psychosomatic complaints. The participants reported an increase from 44 to 62% in neck and shoulder problems and an increase from 11 to 33% in forearm symptoms. In the third period of measurement, 18 months after the introduction of the EDH system, respondents described clear differences between the right and left side of their body. Seventeen percent of the respondents reported symptoms from the left forearm and 25% from the right; 18% reported problems with the left hand or wrist and 23% reported problems with the right hand or wrist; and 18% reported symptoms from the fingers on the left hand while 31% reported symptoms from the fingers on the right hand. Moreover, eye complaints were found to increase though only slightly. This low increase occurred because there were very few respondents that did **not** report symptoms already at the time of the first measurement occasion (i.e., before the introduction of the EDH system). The reporting of different psychosomatic symptoms increased during the 18-month follow-up period: headaches increased from 21 to 32%, palpitation of the heart increased from 11 to 20% and sleeping disorders increased from 16 to 20%. In contrast, the reporting of stomach symptoms decreased from 20 to 8%.

The problem with too high work demands was found to increase from 49 to 63%. One positive observation was that the number of people describing contact and collaboration with colleagues as very good increased from 30 to 84%; corresponding figures concerning contact and collaboration with the respondents' supervisors increased from 46 to 72%.

Fifty percent of the respondents reported that there was insufficient information about the EDH system before its introduction, whereas 42% indicated that there was too little information about the system after its introduction. Furthermore, before the system was put into practice, 86% of the participants reported that the opportunities for them to influence the introduction of the EDH system had been unsatisfactory; 81% of the participants felt this way after the system had been put into practice.

Participant satisfaction regarding help offered with computer-related problems decreased: before the introduction of the EDH system, 9% of the respondents reported being unsatisfied as compared with 38% 18 months after the system was introduced. Moreover, overall satisfaction with the physical ergonomics at the workstation decreased from 77 to 56%.

The interviews indicated that a majority of the respondents believed that the EDH system increased the effectiveness of their work. At the same time, the respondents asserted that they had experienced an increase in time pressure as well as an increase in mental and physical workload. Some work tasks (e.g., sorting documents and searching for mislaid documents) that were perceived as tedious and frustrating had decreased substantially after initiation of the EDH system.

Feelings of being "indentured" to the computer and totally dependent on the computer were frequently expressed. In combination with technical system disruptions (e.g., temporary breakdowns or unexpected long response times), which were common, this was expressed as an important stress factor.

Work collaboration and contacts with peers and supervisors had decreased, but were still considered by the respondents to be on an acceptable level. Although the situation was judged as acceptable today, many respondents expressed a fear that computerization would lead to less contact and collaboration in the future.

The observation interview technique to evaluate usability revealed a number of problems in the human-computer interaction, resulting in an increase in well-known risk factors related to musculoskeletal symptoms and problems with eyestrain. The most serious and frequent problems were lack of overview and poor consistency. Inadequate overview, caused by limited screen size and deficient software design, resulted in memory load when the users had to remember information from one part of the dialogue to another. Lack of overview also resulted in very frequent scrolling of the picture.

The interface design led to an extensive use of the computer mouse (i.e. the hand-operated data input device). Lack of consistency, in e.g. commands and symbols within and between systems that were used in parallel by the users caused unnecessary mental workload. Users sometimes could not predict the effect of an operation, they sometimes did not know whether different words or symbols could mean the same thing or whether different things could be done by the same action.

7 DISCUSSION

This study suggests that the introduction of an EDH system can result in greater risks in work-related musculoskeletal disorders, particularly "mouse-arm syndrome" and stress-related mental and somatic symptoms. We have strong reasons to believe that one major factor underlying the increase in musculoskeletal symptoms was the introduction of the computer mouse and a computer system that compels a high frequency of mouse clicking. Working long hours without a pause at a VDU, in combination with ergonomically poorly designed equipment and computer systems and high work demands, greatly heightens the risk of health problems. Technical problems, such as scanning equipment that does not give good visual quality and temporary cessation or unexpected long response times, are factors very stressful to computer users.

There are, of course, several interrelated mechanisms through which VDU work affects the users, mechanisms related to the person, the work and the technology used. We need to know a great deal more about the relationships among these factors, as well as the role played by new computer systems introduced into work places.

The effectiveness of work can improve over a limited period, but in order not to risk the health of the users a long-term ergonomic strategy for the design of work organization, work systems, computer systems, job tasks and workstations is necessary.

Health and work environment factors need to be given careful consideration before and during the development and implementation of new computer systems. This study shows that without such considerations there is an obvious risk that the introduction of EDH systems even worsens the situation for office workers already being exposed to well known health risks.

Field studies, especially when a longitudinal study design is used, are complex and influenced by a number of factors that researchers are unable to exert control over. Yet, to understand the intricate relations between work environment factors and user reactions, it is necessary to continue to use longitudinal field studies.

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