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The effect of air temperature on labour productivity in call centres—a case study

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Abstract

The aim of this paper was to investigate the effect of air temperature on labour productivity in telecommunication offices. The study was conducted as a case study in two call centres because the work in the call centres can be considered to represent typical activities in the telecommunication industry. The study design consisted of an observational approach and an intervention approach. In Call Centre I, the productivity between two zones with temperature difference was compared. In Call Centre II, the intervention was conducted by installing cooling units to lower high temperature in the summer. Productivity was monitored both before and after the intervention, and it was measured as labour productivity by monitoring the number of telephone calls divided by the active work time. The indoor climate of both call centres was determined by measuring thermal climate and concentrations of relevant air pollutants as well as the acoustical environment and lighting levels. The study shows that productivity may fall by 5–7% at the elevated indoor temperatures.

Keywords: Air temperature; Labour productivity; Call centres; Air quality; Work environment; Intervention study; Observational study

1. Introduction

Productivity is one of the most important factors affecting the overall performance of any organisation, from small enterprises to entire nations. Increased attention has been paid to the relationship between the work environment and productivity since the 1990s. Laboratory and field studies show that the physical and chemical factors in the work environment may have a notable impact on the health and performance of the occupants, and consequently on productivity [1–4]. A common allegation is that improving the work environment results in productivity gain. This relationship, however, has been insufficiently explored. Generally, mainly anecdotal evidence of linkages between the indoor environment and productivity exist, whereas hard scientific data are sparse. One reason for the lack of data on such linkage may be that productivity as a concept is a multidimensional issue, and consequently there are numerous ways to define it. Actually, productivity is—or at least should be—universally defined as the ratio of output to input. However, there are a number of ways to conceptualise productivity in practice. Also the measurement of productivity is usually seen as rather complicated [5].

In this connection, the essential difference between field and laboratory research should be noted. If the primary emphasis is on the actual world, field investigations are generally conducted. In field studies, we have to make several compromises concerning the variables to be controlled, study design, available data, etc. In laboratory studies, on the other hand, which are usually based on short-term tests, the test conditions and the treatments are well controlled and repeatable. However, their link to the real world is weak. The direct measurement of labour productivity in office environments is difficult to accomplish, in call centres, however, the labour productivity can be directly measured because computerised systems are used for monitoring response and queuing times.

This study investigated the effect of elevated temperatures in the summer on the labour productivity in two call centres by long-term monitoring of both productivity and the indoor climate.

2. Methods

The study design consisted of an observational approach and an intervention approach. In Call Centre I, the productivity between two zones with a temperature difference was compared. In Call Centre II, the temperature was reduced by

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installing additional cooling capacity. Productivity was monitored before and after the intervention.

Call Centre I was located in the top floor of a business building. Eighteen female employees worked in six rooms (area 19 m^2) with 2–4 persons in the northern zone of the building and 16 women and 1 man in similar rooms in the southern zone of the same building. The number inquiry assignments were done with personal data terminals. The employees worked in two shifts under the same management. The northern and southern zones were equipped with separate HVAC systems. The supply air was filtered with the EU-6 class filters. According to the maintenance staff the recirculation air was not used in the summer. It was anticipated that the southern zone would be warmer and hence differences in productivity between the two work zones may occur.

Call Centre II was a landscape office (area 166 m^2) with 15 female employees. The HVAC system was equipped with the G-85 class supply air filters. According to the maintenance staff the system used the recirculation air in the heating season only. The intervention was carried out by installing of extra cooling units to lower high room temperatures in the summer. The labour productivity and air temperature as well as CO_2 concentrations were measured before and after the intervention. The other environmental factors, i.e. air contaminants, acoustical and lighting conditions were measured after the intervention only because the installation of the additional cooling capacity was expected to have an insignificant or no effect on these factors. The room air velocities were measured after the intervention because the smoke tests before the intervention did not show notable air movement in the occupied zone.

The computerised monitoring system recorded the number of calls, the total work time and the active work time of each employee in every shift. It was estimated that the best productivity indicator was the number of telephone communications divided by the active work time. The monthly average productivity of each employee from Call Centre I and the monthly group average from Call Centre II was available for this study. It is worth noting that the productivity data are presented in Sections 3 and 4 in relative values for confidentiality.

The indoor climate of the workrooms was characterised by measuring thermal climate, concentrations of relevant air pollutants, i.e. carbon dioxide, particles, TVOCs, microbes in the ventilation systems as well as acoustical environment and lightning levels. In addition to short-term measurements of these parameters, the room air temperature, supply air temperature and concentration of carbon dioxide were continuously monitored over four calendar months. The short-term measurements were done once during 1 or 2 days. The room air velocities were determined with a multi-point flow analyser with the omni-directional velocity probes. The averaging time of the velocity readings was 3 min. The exhaust air flow rates from the rooms were measured at the exhaust terminals by an air flow detector head and a hot-wire anemometer. The supply air flow rates and the temperature set point as well as other operating parameters of the HVAC system were taken from design documents, or the maintenance staff were consulted. The acoustical environment was characterised by measuring a reverberation time and a noise level. The scale of the noise level meter ranged from 50 to 100 dB.

The indoor climate questionnaires were administered once simultaneously with the indoor climate monitoring. The questionnaire inquired questions about the sensations of indoor air factors, symptoms related to the indoor air and the psycho-social environment of the workplace.

The measurement data were analysed with a spreadsheet package. The comparison of means was done in a conventional way by the one sample or paired *t*-tests.

3. Results

The mean air temperature was 23.6 °C (range 21.9–27.8 °C) in the northern zone and 25.2 °C (range 22.8–28.5 °C) in the southern zone in Call Centre I, respectively. The mean air temperature in Call Centre II before the intervention was 25.1 °C (range 20.9–29.6 °C) and after the intervention 22.6 °C (range 19.1–25.9 °C). The monthly means and standard deviations of the air temperature from July to November in both call centres are shown in Fig. 1. The corresponding time course of the recorded CO_2 concentrations is shown in Fig. 2. The CO_2 concentrations were approximately at the same level in both call centres. In Call Centre I, the monthly average of the CO_2 concentration in the southern zone was slightly lower than in the northern zone. In Call Centre II, the CO_2 levels were slightly higher after the intervention.

The results of the measured indoor parameters are summarised in Table 1. There was no notable differences in the particle concentrations, TVOC levels and CO_2 levels between the northern and southern zones in Call Centre I. The surface samples taken from the air conditioning systems did not reveal any indication of microbial growth. The levels of air-borne contaminants in Call Centre II were about at the same level excluding TVOC and number concentration of particles with diameter less than 0.3 μm which were roughly two-fold. Typical air velocity values based on the short-term measurements from both call centres ranged from 0.04 to 0.15 m/s. The exhaust flow rates in the rooms in the northern zone (range 43–47 l/s) were 25% lower than those in the southern zone (range 59–62 l/s). The visual inspection of the air conditioning system in Call Centre II indicated that the ducts and the fan were dustier than those in Call Centre I.

The lighting conditions in the northern zone were similar to those in the southern zone. The measured illuminance level of the desk surface ranged from 120 to 840 lx, and of the manual book surfaces from 50 to 600 lx. At some desks, the luminance contrast was high because of windows and lamps behind the monitor. The illuminance levels in Call Centre II ranged from 40 to 700 lx depending on the use of the lamps and the location of the windows.

According to the indoor air questionnaire, conducted once in both call centres, the percentage of the dissatisfied