Health Impairment of System Engineers Working on Projects with Heavy Workload

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**Abstract**: It has been reported that many system engineers must work hard to produce computer systems, and some of them suffer from health impairment due to their hard work. The purpose of the present cross-sectional study was to investigate the situation of impaired health status of system engineers in projects with high job strain. Countermeasures against health impairment of the subjects in the projects with high job strain in practices of occupational health fields are discussed. The study subjects were five superiors and their 35 subordinates working on computer system projects with high job strain at a large computer systems corporation in the Tokyo area. The control group was comprised of three superiors and their 18 subordinates in the same corporation. From July to November, 2006, the above were interviewed by six occupational health nurses, who evaluated their health and recorded their health evaluation scores. The problems involved in producing the computer systems were sometimes very difficult to solve, even if they spent long hours working on them. The present study detected a tendency showing that healthy superiors' subordinates were unhealthy and unhealthy superiors' subordinates were healthy in the overload projects with high job strain, while this was not detected in the control groups. A few employees whose health deteriorated were faced with very hard jobs in the overload projects. This means that heavy workloads were unevenly distributed in the overload projects among superiors, and their subordinates, and the health of a few members with heavy workloads deteriorated due to the heavy workload. In order to improve such a situation, it may be important not only to commit the necessary number of employees whose working ability is high to the section but also to even the workload in the overload project by informing all members of the project the health impairment of a few members due to heavy workload, from the viewpoint of the practice of occupational health and risk management.

**Key words**: system engineers, heavy workload, uneven workload, superior and subordinate, health impairment.

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Abbreviations

AIDS: Acquired Immunodeficiency Syndrome

References


The UOEH Association of Health Sciences

Health Impairment of System Engineers

Table 1. Age by group and job rank

<table>
<thead>
<tr>
<th></th>
<th>Control group</th>
<th>Projects with high job strain</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superiors</td>
<td>40.7 ± 1.5</td>
<td>3 39, 42, 41</td>
<td></td>
</tr>
<tr>
<td>Subordinates</td>
<td>36.7 ± 6.0</td>
<td>18 27, 48, 36</td>
<td></td>
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<tr>
<td>P-value</td>
<td>0.25</td>
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</table>

| Superiors      | 40.4 ± 3.1    | 5 39, 46, 39                 | 0.39    |
| Subordinates   | 31.5 ± 4.9    | 35 24, 43, 32                | 0.0039  |
| P-value        | 0.0005        |                              |         |

No.: Number of subjects, Min.: Minimum, Max.: Maximum, Med.: Median, P-value: Wilcoxon test (years)

The mean, standard deviation, maximum, minimum, and median of age, and the number of subjects by group and job rank are shown in Table 1. The results of Wilcoxon tests for age differences between the groups and ranks are also shown in Table 1, indicating that the subordinates in the projects with heavy workload were younger than the subordinates in the control group. No notable differences between other backgrounds of the groups were found.

A sufficient number of control subjects could not be recruited because of immediate interview. We substituted some information on a periodic health examination of the corporation in 2008 for information on the appropriate control in the present study, though the purpose of the periodic health examination is different from that of the interview in the present study. The members were system engineers in a section without heavy workload as another additional control group. The numbers of superiors and their subordinates were 19 and 91, respectively. The means ± standard deviations of age for superiors and their subordinates were 41.1 ± 4.1 and 31.0 ± 2.9 years, respectively. No notable differences between backgrounds of the groups were found.

Health Evaluation Score

Information on heavy workload in a project of a section in the corporation under investigation was communicated suddenly to corporate executives. To obtain information on the health impairment of the employees working on the project with heavy workload, the corporation immediately ordered that they be examined thoroughly in order to conduct immediate countermeasures against health impairment. The interview for health with the employees by the occupational health nurses was started from July in 2006. After a few months, heavy workload in another project of the section was revealed. Then, the interview for health with the employees in another project of the section was also conducted. As a result, the employees in the projects of the section were interviewed from July to November, 2006, by six occupational health nurses, who evaluated their health and recorded their health evaluation scores.

For the interview, information was gathered from (i) a simple self-administered questionnaire which the subjects filled out just before the interview regarding physical symptoms, mental symptoms, occupational environment, and daily life habits, (ii) most recent overtime work hours, and (iii) health checkups conducted previously. The occupational health nurses conducted discussions and drew up a manual before conducting the interview. The essential points of the interview as written in the manual were to obtain information on the subjects’ mental and physical impairments, the causes, especially their hard jobs, of their health impairments they recognized,
Table 2. Health evaluation score

<table>
<thead>
<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>healthy</td>
</tr>
<tr>
<td></td>
<td>satisfied with the occupational environment with no heavy workload and no</td>
</tr>
<tr>
<td></td>
<td>symptoms</td>
</tr>
<tr>
<td>2</td>
<td>nearly healthy</td>
</tr>
<tr>
<td></td>
<td>able to adapt regarding symptoms and workload</td>
</tr>
<tr>
<td>3</td>
<td>follow-up</td>
</tr>
<tr>
<td></td>
<td>need to follow-up slight maladjustment to job with symptoms and complaints</td>
</tr>
<tr>
<td></td>
<td>of workload in the occupational environment and daily life</td>
</tr>
<tr>
<td>4</td>
<td>interview again</td>
</tr>
<tr>
<td></td>
<td>need to be interviewed again by the occupational health nurse because of</td>
</tr>
<tr>
<td></td>
<td>some maladjustment to job with some symptoms and complaints of workload in</td>
</tr>
<tr>
<td></td>
<td>the occupational environment and daily life</td>
</tr>
<tr>
<td>5</td>
<td>medical care</td>
</tr>
<tr>
<td></td>
<td>need medical care by a physician because of considerable maladjustment to</td>
</tr>
<tr>
<td></td>
<td>job with notable symptoms and complaints of workload in the occupational</td>
</tr>
<tr>
<td></td>
<td>environment and daily life</td>
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and what the subordinates wanted to say to their superior in order to improve various problems in the projects. The occupational health nurses intended to obtain information including the subjects’ true intentions (honne) as much as possible in the interview. A generally used evaluation criteria for health checkup (Table 2) was also drawn up in the manual. In the interview, the occupational health nurses noted especially the relationship between mental and physical health impairments of the subjects and their workloads, then synthetically evaluated the health status of the subjects using information obtained from the interview and the above three items (i–iii) and recorded their health evaluation scores. Each interview lasted 40–50 minutes.

The evaluation criteria for the health of the subjects (Table 2) has generally been used for several decades in occupational and community health fields in Japan [15–18], including the corporation under investigation. The occupational health nurses of the corporation investigated consider the scoring system to be appropriate. Regarding reproducibility, a retired occupational health nurse noted that the health scores of a few subjects compiled by two occupational health nurses were quite consistent with each other. The health evaluation score is considered to be a valid and reliable tool by the above supporting evidence, thus appropriate for the present study.

In the corporation investigated, a periodic health checkup for employees is conducted every autumn [19], and the occupational health nurses evaluate the health status of the employees in the same way as the present study. The occupational health nurses of the corporation investigated recognize the annual health checkup including interview to be sufficient, and most employees of the corporation are satisfied with the health checkup [19, 20]. Significant knowledge was obtained from the health checks conducted at the corporation [19–21].

Statistical Analysis

The data were analyzed after establishing that each individual could not be identified. It is written that anonymized information can be given to other institutes for scientific studies in the Ethical Guideline for Epidemiologic Studies by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare, Japan.

Non-parametric statistical analyses were conducted.
Results

In the interview, the occupational health nurses detected the following findings. The jobs of the system engineers were sometimes very difficult and they could not always solve the problems easily even if they spent long hours working on the problems in the projects with high job strain, and the health levels of some members of the projects deteriorated due to their jobs. This was perceived by almost all members of the projects with high job strain in the corporation studied, while it was not by employees in the control groups. Additionally, the nurses detected especially that the heaviest workloads in the overload projects were shifted to the small number of employees with health impairment. No marked stressors other than heavy workloads in the subjects under investigation were detected by the occupational health nurses. In the interview, no notable differences between the findings of the two projects with heavy workloads were found by the occupational health nurses. They detected that the indirect jobs of the control group did not contain high job strain.

Figures 1 and 2 show the relationships between the health evaluation scores of the superiors and their subordinates in the control group and in the projects with heavy workload. The Spearman correlation between the health evaluation scores of the superiors and their subordinates in the projects with heavy workload strain was negative with statistical significance \(P=0.024\) (Fig. 2), while the correlation for the control group was not significant \(P=0.21\) (Fig. 1). The results of the Kruskal-Wallis tests were the same as those of the Spearman correlations. The difference between the two correlations was statistically significant \(P=0.022\).

![Fig. 1. Relationship between health scores of superiors and their subordinates in the control group. Number of superiors: 3, Number of subordinates: 18, Spearman correlation \(r_o = 0.307 (P=0.21)\)](image)

![Fig. 2. Relationship between health scores of superiors and their subordinates in projects with high job strain. Number of superiors: 5, Number of subordinates: 35, Spearman correlation \(r_1 = -0.381 (P=0.024)\)](image)
subordinates in the section without heavy workload as an additional control group was 0.008 ($P = 0.94$) in a periodic health examination of the corporation in 2008. The health evaluation scores for superiors and their subordinates ranged from 2 to 5 and 1 to 4, respectively.

No notable differences between the health evaluation scores of the projects with high job strain and the control groups were detected among all subjects, including subgroups, by Wilcoxon tests. Differences between proportions of number of subjects whose health evaluation scores were 4 or 5 in the projects with heavy workload and control groups were not marked. No remarkable Spearman correlations between the health evaluation score and age were obtained. No notable results were obtained from the most recently recorded overtime work hours. These results are not shown in the tables or figures. The results of the parametric statistical analyses were the same as those of the non-parametric analyses.

In the interview, the occupational health nurses did not perceive a notable negative correlation between the health evaluation scores of the superiors and their subordinates in the projects with heavy workload strain. The negative correlation was revealed by the statistical analysis after the interview was finished.

**Discussion**

**Study Type**

We had no choice but to conduct a cross-sectional study with a small sample size for the following reasons. Information on heavy workload in the projects in the corporation under investigation was communicated suddenly to corporate management. The number of employees in projects with heavy workload is not large in the corporation. Such a heavy workload in a project cannot be forecast before employees suffer from overload work, and seldom lasts for a long period in the corporation. When a project is finished, the employees working on the project move on to other projects either within the same corporation or in associated corporations.

**Overload of System Engineers**

In the present study, system engineers with high job strain suffered from deteriorated health. Fatigue symptoms were found in system engineers with long working and short sleeping hours [12]. In system engineers, an association between job strain and degree of depression or mood scale was detected [13], while consistent associations between stressors and fatigue indexes in system engineers were not detected [9]. Many stressors to system engineers have been reported [10,22]. Shoji reported that many software engineers were not satisfied with their work and that “quantity of job” had the greatest influence on their mental health [8]. Tei showed a significant relevance of organization characteristics to health status, job dissatisfaction, and turnover intention of workers [11]. Many articles consistently detected that high job strain combining many elements affected the health status of system engineers. However, it is difficult to elucidate their health impairment by a few factors, because their health conditions are affected by many kinds of stressors, and diversities of working conditions in corporations and types of software produced are notable.
Uneven Workload

The Spearman correlation between the health evaluation scores of the superiors and their subordinates in the overload projects was negative with statistical significance, while the correlations in the control groups were not significant, and the differences between the two correlations were statistically significant. This indicates a tendency that healthy superiors' subordinates were unhealthy and unhealthy superiors' subordinates were healthy in the overload projects, while such a tendency was not detected in the control groups. In the interview, the occupational health nurses did not perceive this tendency. This finding has not been reported in any articles.

The differences between the health evaluation scores of the groups were not notable. In the overload projects, the health levels of most of the members had not deteriorated, but a small number of sensitive subjects indicated health impairment due to heavy workload. The occupational health nurses detected especially that the employees whose health deteriorated were faced with very hard jobs. The above may suggest that heavy workloads were unevenly distributed in the overload project among superiors and their subordinates and the health of a few members with heavy workloads deteriorated due to the heavy workload.

A function of occupational health is to even the workloads of the employees in such a group and to case the health impairment of the employees due to high job strain. It is necessary to take countermeasures against uneven workloads in an overload project with high job strain. In order to specifically improve the uneven workloads, it is important not only to even the workload in overload sections but also to commit the necessary number of employees whose working ability is high to those sections, i.e. flexible staff placement is required, taking into account the quality and quantity of a job. Flexible staff placement includes the right person in the right job.

It is necessary for healthy superiors whose subordinates are unhealthy and unhealthy superiors whose subordinates are healthy to be aware of the uneven health levels in their group as a countermeasure. When a few workers undertake the heavy tasks and the others take the residual easy tasks in a project, those who take the residual easy tasks should be aware of the situation. This will make it possible to reduce the heavy workloads of the few employees whose health has deteriorated and improve their condition. Moreover, healthy superiors whose subordinates are unhealthy may be poor at giving orders to their subordinates. In such a situation, inadequate managerial leadership by superiors may cause deteriorated health levels of the subordinates [23]. The occupational health nurses should fully inform all members, especially the healthy superiors whose subordinates were unhealthy and the healthy subordinates whose superiors were unhealthy, about the unhealthy status and uneven workload in their group with due consideration to privacy of each person.

We have sometimes observed situations in occupational health areas that the target subjects include some employees who are incapable so that heavy tasks are shifted to a few capable employees, whose health levels deteriorate as a result. Thus the few capable employees must do most of the tasks and many incapable employees do little work on the overload project, sometimes resulting in marked health impairment of the former.

The differences between the health scores of the projects with high job strain and control groups and those between proportions of number of subjects whose health levels deteriorated were not
notable, meaning that the health of many subjects did not deteriorate in the projects with heavy workload. The occupational health nurses detected that a small number of the members whose health deteriorated were faced with very hard jobs in the projects with high job strain. This indicates that high job strain in the projects affected the health of a small number of subjects.

In the present study, information on the personalities of the subjects was not precisely obtained. Investigating personalities of system engineers whose health levels deteriorate in projects with high job strain is necessary. The occupational health nurses could not determine the amount of the workload of the employees in the interview using an objective indicator. Therefore, it was impossible to show the relationship between an objective amount of workload and the health evaluation score of the employees, i.e., a dose-response relationship.

Bias and Confounder

The occupational health nurses had the preconception that the health evaluation scores of the employees in the overload projects with high job strain would be much worse than those of the control group because of the urgent corporate order for the employees to be examined thoroughly for health. However, no notable difference in the health evaluation scores of the groups was detected. In the interview, the occupational health nurses did not perceive any notable negative correlation between the health evaluation scores of the superiors and their subordinates in the projects with heavy workload strain. The negative correlation was revealed by the statistical analysis after the interview. Therefore, the negative correlation did not result from the preconception of the occupational health nurses. There were more or less biases in correlations between the health scores of the superiors and their subordinates in the groups because the health evaluation scores were evaluated by the six occupational health nurses. However, the biases almost disappeared in a comparison between the two correlations. Therefore, the significant negative correlation between the health scores of the superiors and their subordinates in the overload projects must be probable.

In the interview, the occupational health nurses evaluated the health status of the subjects and recorded their health evaluation scores. Most employees of the corporation are satisfied with the annual health checkup including the interview conducted at the corporation [19,20]. The occupational health nurses took a good 40–50 minutes for each interview in order to obtain as much information as possible on the true condition of the subjects in the present study. The occupational health nurses in the corporation are well informed of the subjects' occupational environment and job descriptions. Therefore, the occupational health nurses supposed that they could often estimate the subjects' true intentions regarding their health and occupational environment in the interview. Manuals for interviews and questionnaires are hardly useful for obtaining information including subjects' true intentions. There are few medical articles in which Japanese true intention was investigated [24]. Their true intentions, however, were useful for evaluating their health status and considering countermeasures against the deteriorated occupational environment by the occupational health sections. Therefore, the significance of the health evaluation scores in the present study must be notable from the viewpoint of practical occupational health.

The evaluation criteria for health of subjects (Table 2) has generally been used for several decades in occupational and community health fields in Japan [15–18], including the corporation
under investigation. However, the validation of health evaluation scores including reproducibility evaluated by occupational health nurses in interviews has not been investigated sufficiently. It is difficult to conduct a validation study in occupational health fields, because the evaluation criteria has been used for many years. Therefore, the limitation of the health evaluation scores in the present study should be recognized. However, the occupational health nurses of the corporation investigated consider the scoring system to be appropriate.

In general, the overtime work hours of employees in Japan are recorded correctly. No notable results were obtained from the most recent overtime work hours in the present study. The reason may be because in the year the interview was conducted, the employees in the corporation under investigation were not aware that overtime work hours had to be recorded correctly.

To obtain information on the health impairment of the employees working on the projects with high job strain, the corporation deemed it urgent that they be examined immediately and thoroughly. A sufficient number of control subjects could not be recruited because of the urgency. We had to substitute information from a periodic health examination of the corporation in 2008 for information on the appropriate control in the present study, though the purpose of the periodic health examination is different from that of the interview in the present study.

No notable confounding factors were detected in the present study. In particular, no remarkable Spearman correlations between health evaluation score and age were obtained, meaning that age was not a notable confounder. The occupational health nurses found no additional information other than the health deterioration of a few employees due to heavy workload in the projects with high job strain in the interview.

The interview for the employees in the two projects of the section with high job strain by occupational health nurses lasted about five months. In the interview, however, no notable differences between findings of the subjects interviewed earlier and later were found. The difference between workloads in the two projects was not marked, because the employees in each project had to do jobs of another project as assistance if necessary. No notable differences between backgrounds of the projects were found. Therefore, differences between the two projects must not be significant.

Conclusions

Healthy superiors’ subordinates were unhealthy and unhealthy superiors’ subordinates were healthy in the overload projects, while such a tendency was not detected in the control groups. No notable differences in the health evaluation scores of the groups were detected. The employees whose health deteriorated were faced with very hard jobs. This means that heavy workloads were unevenly distributed in the overload projects among superiors and their subordinates and the health of a few members with heavy workloads deteriorated due to the heavy workload. In order to improve such a situation, it may be important not only to commit the necessary number of employees whose working ability is high to the section but also to even the workload in the overload project by informing all members of the projects about the health impairment of a few members, workload, from the viewpoint of the practice of occupational health and risk management.
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過重労働プロジェクトに従事するシステムエンジニアの健康悪化

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要 旨：多くのシステムエンジニアはコンピュータシステム構築という過重労働に曝され、それによる健康悪化が報告されている。本研究の目的は、横断研究として、過重労働をしていた部署のシステムエンジニアの健康悪化の実情を研究することである。さらに、その健康悪化に対する対策も産業保健の実務の観点から論ずる。首都圏にある某コンピュータシステム作成企業で、過重労働負荷のプロジェクトに従事している男性システムエンジニアの上司5名とその部下35名、および対照群として通常の業務に従事している男性従業員の上司3名とその部下18名を対象とした。2006年7-11月に、その対象者の健康状況を把握するために、6名の保健師により保健面接を実施し、かれらの健康度を評価した。そのプロジェクトの過重労働内容は、時間をかけてもその遂行はかなり難儀なことが少なくなかった。過重労働負荷のプロジェクトでは、健康な上司の部下は不健康で、不健康な上司の部下は健康であることが検出されたが、対照群ではそうではなかった。過重労働負荷のプロジェクトで、健康度が悪化していた少数のシステムエンジニアには、とくに厳しい労働負荷がかかっていた。このことは、この職場では、上司とその部下間で過重労働の負荷が均等ではなく一部の人に過度に寄せていて、そのため過重労働負荷の作業者の健康度が悪化したことを示している。この状況を改善するために、業務処理能力の優れた作業者を必要量そのプロジェクトへ投入することのみならず、過重労働の負荷が不均等でその負荷により少数者の健康度が悪化していることを周知させて負荷を均等化させることは、産業保健の実務とリスクマネージメントの観点から重要であろう。

キーワード：システムエンジニア、過重労働、労働負荷の不均等、上司と部下、健康悪化。

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