

New classification of medical staff clinical services for optimal reconstruction of job workflow in a surgical ward: Application of spectrum analysis and sequence relational analysis

Hodaka Numasaki^{a,*}, Hajime Harauchi^b, Yuko Ohno^c, Kiyonari Inamura^d,
Satoko Kasahara^c, Morito Monden^e, Masato Sakon^f

^aDepartment of Medical Physics and Engineering, Osaka University Graduate School of Medicine, Japan

^bDepartment of Radiological Technology, Kawasaki College of Allied Health Professions, Japan

^cDepartment of Health Promotion Science, Osaka University Graduate School of Medicine, Japan

^dDepartment of Business Management, Kansai University of International Studies, Japan

^eDepartment of Surgery and Clinical Oncology, Osaka University Graduate School of Medicine, Japan

^fNishinomiya Municipal Center Hospital, Japan

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Abstract

In order to optimize the job workflow of medical staff, clinical job workflow was investigated from the viewpoint of its periodicity and the strength of causal association among jobs. Time-motion study for the staff at a surgical ward was carried out. To detect the periodicity of the occurrence of each job element, its frequency histogram was determined, and the discrete Fourier transformation was applied. For the analysis on the strength of the relationship among the job-sequence, the sequence relational analysis was developed, which was the expansion of the relation analysis to the sequence process. The job elements were classified into five incident patterns based on the periodicity of each element and into three patterns based on the association with other job elements. Based on time-motion study data, job workflow patterns of medical staff were clarified based on the incident pattern of the job elements and the association with other job elements.

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1. Introduction

How to plan an efficient, effective, and safe hospital job workflow is a question of worldwide significance in hospital administration (Murray, 2002; Robert, 1998). Despite the number of reports discussing time-motion study in the medical field, as well as mathematical approaches, workflow continues to remain a major concern for hospital managers and medical staff (Harauchi et al., 1999; Hollingsworth et al., 1993; Ishii et al., 2002; Misener et al., 1987).

* Corresponding author. Tel./fax: +81 6 6879 2575.

E-mail address: numasaki@sahs.med.osaka-u.ac.jp (H. Numasaki).

In order to discuss the medical job workflow rationally, it is necessary to understand the actual job workflow quantitatively, modify the obtained information using computational analysis, measure each job element of the medical staff, and clarify the frequencies of actual medical job elements.

In this study, we propose a new classification of medical staff responsibilities, for optimal reconstruction of job workflow, using spectrum analysis and sequence relational analysis based on a series of time-motion data in a surgical ward in Japan. The classification has two viewpoints, the periodicity of job elements and the strength of interdependency among the job elements.

2. Materials

A time-motion study of the job workflow of medical staff (physicians, nurses, and nurse aides) was carried out from 1998 to 2001 in a surgical ward of a university hospital in Osaka, Japan. The time-motion study was performed for 24 consecutive hours. In order to maintain the accuracy of job element records, graduate students who were certified as nurses, radiological, and clinical laboratory technicians were assigned to record the medical staff job elements and their durations based on units per second (Finkler et al., 1993; Melissa and Betty, 1998; Thomas et al., 2000; Wirth et al., 1977). In the case of nurses, the ward used a primary nursing care system composed of three groups and three shifts per day (eight working hours per shift). All the members of the same group were observed for better understanding of the total number of job elements in the group.

Each observer recorded the job elements conducted by the nurse or physician in terms of “where,” “since when,” “until when,” “by whom,” “for whom,” and “what job element,” in a free format. No classified codes or templates were prepared before implementation of this study, in order to prevent prejudice and preconceptions of the observer. The recorded job workflow was checked in parallel with this study, in order to maintain accurate recordings.

During the total 23 study days of a four year study, all the job elements from a total of 188 staff members were recorded, and over 110,000 precise job element records were entered into the computer.

3. Methods

3.1. Classification of actual job elements by coding

The coding format for the observed data was defined by the Osaka Time-Motion Study Group, which consisted of academic researchers and experienced clinical staff members. Each category consisted of up to 175 items for nurses and 115 items for physicians. All the records of the job elements were uploaded on the time-motion database by trained specialists using a particular format.

3.2. Extraction of job element frequency using frequency analysis

Initially, each ward job element was investigated and categorized. Using all the data, identical job elements were grouped, and respective cumulative frequency histograms were plotted every 30 min, along with the time in days. Discrete Fourier transformation (DFT) was applied to the job element frequency data and a frequency analysis was performed. These steps were reiterated for each observed day and for each job element item.

3.3. Relational analysis of the job elements

The relationship between the job element sequences includes other aspects such as interdependency of some job elements. To measure this factor, we proposed a simple and effective procedure, referred to as root-mean-square (RMS), to determine the frequency difference between two different job elements at 10 min intervals throughout the day.

From the time-motion study database, the number of cases observed for every job element at 10 min intervals throughout the day was extracted. The RMS value of any two different job elements was calculated using the following expression:

$$RMS(\tau) = \sqrt{\frac{1}{T} \int_{-T/2}^{T/2} (f(t) - g(t + \tau))^2 dt}, \quad (1)$$

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