Visualizing the Impact of Interruptions in Nursing Workflow using a Time Process Study

Satoko Kasahara1), Yuko Ohno2), Atsue Ishii2), Hodaka Numasaki2)

1) Unit of Nursing, Cluster of Medical Sciences, Faculty of Research and Education, Kochi University
2) Course of Health Science, Graduate School of Medicine, Osaka University

Interruptions have been shown in medical settings to result in errors with serious and sometimes fatal consequences. The authors conducted an observational, time-motion study to examine the pattern of changes in workflow through the drawing of flowcharts based on different timings of interruption occurrences. Nurses were observed during their day-shift operations for two weekdays in two hospital wards of a public cancer treatment hospital. Among the total of 14,453 records, 1,413 represented interruptions (9.8%). Of these, 687 records (4.8%) represented the observed nurse interrupting someone else. The analysis focuses on 703 recordings (4.9%) representing someone interrupting the observed nurse and 23 recordings (0.2%) representing self-interruptions. Nurses were interrupted an average of 6 times per hour. To understand the effect of interruptions on the workflow, the timings of the interruptions were examined. Most interruptions, 70.8%, occurred during the transition between tasks, while 24.2% while the nurse was doing a task that did not directly involve the patient. Only 5.0% of the interruptions occurred during tasks in which the nurse directly dealt with the patient. Interruptions during indirect tasks and between tasks caused nurses to perform a task in response to the interruption 95.4% and 96.9% of the time, respectively. However, only approximately half (55.6%) of interruptions during direct tasks were responded to immediately; the remaining half were postponed. There was a significant difference in the occurrences of tasks stemming from an interruption (58.3% during direct care, 32.4% during indirect care, and 23.3% between tasks). There were three times more clinical decision points in the workflow during direct care and during indirect care than during scheduled transitions between tasks. The impact of an interruption depends on its timing. To manage interruptions effectively, it is crucial to understand this timing dependence.

Key Words: Interruption, Nurse, Workflow, Time-motion study

1. Introduction

A hospital nurse executes his/her job systematically, beginning the day by scheduling the work to be done for that day, and managing the complex task of taking care of multiple patients1).

As such, the complexity of nursing lies in the fact that the workflow is not linear; cognitive shifts are necessary, from one patient to another, or from one task to another 2-4); priority of orders may be repeatedly modified at any time as a result of clinical decisions based on fragmentary and unpredictable operations 5); simultaneous execution of
multiple tasks may be necessary \(^6,7\); compulsory shifts of attention caused by new unplanned tasks, and confusion due to interruptions from patients, hospital staff, ME or the medical system, arise \(^8,9\). In particular, work interruptions are one of the important problems in nursing management, as it relates to errors that affect medical safety and work efficiency \(^5, 10-12\). The adverse effect of interruptions on work efficiency has been discussed in the context of various occupations \(^13,14\) besides medical practice and nursing \(^15-23\), and in all cases it has been shown that unplanned interruptions occur in the workflow. As such, studies on the frequency and nature of interruptions in nursing operations, and studies on the correlation between interruption and risk exist, but there are no in-depth analyses on the effect of interruptions on workflow.

Thus, this study aims to elucidate the pattern of changes in workflow through the drawing of work process models based on different timings of interruption occurrences.

2. Method

(1) Study design

We conducted an observational, time-motion study on day shift nursing operations for two weekdays in two hospital wards, which comprised combined wards for internal diseases and surgery in gastroenterology, in a public cancer treatment hospital (14 wards, 509 beds). Although day shift work hours are from 8:30 to 17:30, our study included subjects' actual working hours from the beginning until the end of their shift, regardless of the time of day.

(2) Participants

The nursing system was a modular, continuous care system, with 2-3 modules per ward, and each module comprised 3 individuals, i.e., one module leader and two staff nurses. Each participant carried out different functions; the staff nurse exclusively cared for patients while the module leader, in addition to taking care of a similar number of patients as the staff nurse, also performed leader duties.

There were a total of 12 study subjects, including all 3 nurses in one module per ward.

Every nurse on duty carries an in-house wireless phone that is integrated to nurse call system.

(3) Ethical approval

Approval was obtained from institutional ethic committees prior to initiating the study. The patients' consent was obtained from the hospital director upon clarifying that the subjects of the study were the medical staff and not the patients. Ward staff consent was obtained from the nursing director.

Regarding the handling of patient and medical staff data, the hospital staff was asked to encode all patient and staff names with ID numbers, including the names written on recording forms, thereby ensuring that patient and staff names would remain secure within the hospital.

(4) Data collection

We used a continuous observation method in which one observer recorded one study subject's behavior. We investigated the nurses' day shift from the beginning to the end. The record included work start time and end time, location, work performed, and to whom a particular task was directed \(^24,25\).

In addition, after the investigation, study subjects were interviewed and checked as to whether they had missed or omitted any task, given any task to another individual, or
had left anything uncompleted.

(5) Data analysis
Since work content records in a time study are not based on a strict format, we needed a standardized terminology for recording, namely a task classification system, in order to statistically analyze them. We used the same task classification system that we employed in previous studies. It consists of a hierarchy of three layers: "main category" – "sub category" – "specific category".

For data entry, we used not only classification codes, but also entered freely written words, so as to enable a switch to a more appropriate classification in the future and to enable qualitative analysis.

Apart from the aforementioned task classification, work contents were classified into direct tasks and indirect tasks. Direct tasks were defined as services that were provided by a nurse in which direct interaction with a patient was involved, while indirect tasks were defined as those other than direct tasks.

The coding format for the data was defined by the Osaka Time-Motion Study Group of academic researchers and experienced clinical staff. The format consisted of up to 91 items for nurses. The documented records were organized and entered into a time-motion study database using a specific format devised by trained coding specialists.

The definitions and categories of interruption terms used in the study were consistent with the existing literature on interruptions in a level one trauma center. "Interruption" was defined as a brake in the performance of a human activity initiated by a source internal or external to the recipient with occurrence situated within the context of a setting or location. This break results in the suspension of an initial task to perform an unplanned task with the assumption that the initial task will be resumed.

The data on interruption was extracted from the time-motion study database, and recoded by the categories using the Hybrid Method to Categorize Interruptions and activities (HyMCIA).

The Time Process Study (TPS), which was proposed by Shiki et al., provided a new method for collecting data as well as for analyzing and visualizing work activity that compensates for the weaknesses of more conventional methodologies. TPS works by utilizing a Unified Modeling Language (UML) to identify and visualize how a business procedure functions.

We decided to use TPS, which is an easier and more expressive method, to analyze and visualize work activity after interruption.

3. Results
(1) Frequency of interruptions
As shown in Table 1, data on a total of 12 day-shift nurses, amounting to a total of approximately 122 hours, were analyzed. The number of analyzed records totaled 14,453. Among the total of 14,453 records, 1,413 represented interruptions (9.8%). Of these, 687 records (4.8%) represented the recorded nurse interrupting another individual, and these accounted for nearly half of all interruptions. The following analysis focuses on 703 records (4.9%) representing interruptions by another individual and 23 records (0.2%) representing self-interruptions.

The actual work time excluding breaks averaged 10 hours, 10 minutes and 36 seconds (SD: 46 minutes and 39 seconds) per nurse. The number of interruptions during work averaged 60.6 (SD: 11.3). Interruptions occurred on average 6 times per hour (SD: 1.3) and showed a variation ranging
from 4.2 to 9.5 times per hour.

Interruptions did not occur at regular time intervals but tended to be scattered; for example, multiple interruptions occurred in a short period of time.

(2) Timing of interruptions

To understand the effect of interruptions on workflow, the timing of the interruptions was examined. We illustrate an activity process chart of the nurses who were observed. The timings of interruptions could be classified into the following three types. Most interruptions, 70.8%, occurred during the transition between tasks (between tasks), while 24.2% occurred during indirect tasks; interruptions during direct tasks accounted for only 5.0%.

(3) Workflow change patterns in relation to interruption timing

Figure 1 shows a process model of a normal workflow with no interruptions. UML activity diagram was used and workflow change patterns for different interruption timings are indicated (Figure 2 and 3).

a. Points of clinical decision making

Of the Decision node (D) shown in the diagrams, D3 in Figure 2, and D3, D5 and D6 in Figures 3, represent the time points at which a clinical decision was required and nurses had to make a decision.

b. New tasks caused by interruptions

There was a statistically significant difference in the percentage of the occurrences of new tasks arising from interruptions with respect to the timing of interruptions. The highest percentage of occurrences of intervening tasks, 58.3% (vs. during indirect care, Fisher’s test, p<0.005, vs. between tasks, Fisher’s test, p<0.001), was during direct care, followed by tasks during indirect care, 32.4% (vs. between tasks, Fisher’s test, p<0.05), and tasks between tasks, 23.3%.

c. Response patterns to tasks caused by interruptions

The responses to the interruptions depended on the timing of the interruption; the response might be to take immediate action, to refuse to respond, or to postpone a response. Interruptions during indirect tasks and between tasks were immediately responded to 95.4% and 96.9% of the time, respectively. However, only approximately half (55.6%) of the interruptions during direct tasks were responded to immediately; the remaining half was postponed. Moreover, only one rejection (0.6%) occurred during an indirect task.

d. Interruption lag

The interruption of workflow caused a delay in the starting time of the next planned task, as well as a delay in the

---

Table 1. Results of analysis of the recorded observations

<table>
<thead>
<tr>
<th>Registered nurse</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation time (hh:mm:ss)</td>
<td>12:07:08</td>
</tr>
<tr>
<td>Observation time per RN (hh:mm:ss)</td>
<td>10:10:36</td>
</tr>
<tr>
<td>(8:42:48 – 11:12:06)</td>
<td></td>
</tr>
<tr>
<td>Total number of records</td>
<td>14453</td>
</tr>
<tr>
<td>Records per hour</td>
<td>118.5</td>
</tr>
<tr>
<td>Total number of tasks</td>
<td>10865</td>
</tr>
<tr>
<td>Tasks per hour</td>
<td>89</td>
</tr>
<tr>
<td>Total number of interruptions</td>
<td>1413 (9.8%)</td>
</tr>
<tr>
<td>Number of initiators</td>
<td>687 (4.8%)</td>
</tr>
<tr>
<td>Number of recipients</td>
<td>703 (4.9%)</td>
</tr>
<tr>
<td>Number of self-interruptions</td>
<td>23 (0.2%)</td>
</tr>
<tr>
<td>Interruptions per hour</td>
<td>11.6</td>
</tr>
<tr>
<td>Initiators per hour</td>
<td>5.6</td>
</tr>
<tr>
<td>Recipients per hour</td>
<td>5.8</td>
</tr>
<tr>
<td>Self-interruptions per hour</td>
<td>0.2</td>
</tr>
<tr>
<td>Percent of tasks interrupted</td>
<td>6.7%</td>
</tr>
<tr>
<td>Recipients</td>
<td>6.5%</td>
</tr>
<tr>
<td>Self-interruptions</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

---
starting time of the task that was created by the interruption. At all clinical decision time points, responding to the interruption at D3 resulted in a delay in the starting time of the next task, whereas a delay in starting time of the task created by the interruption was reduced. Postponing a response, however, yielded the reverse result. Interruptions during a task generated a workflow option to postpone the interruption again at D6, resulting in the lowest delay in starting time for the next task, whereas the starting time of the task created by the interruption was further prolonged.

"Interruption lag" is defined as the time lag between an interruption and the starting time of the task created by the interruption. As shown in Table 2, interruption lag was greatest, on average 9 minutes and 2 seconds, when the interruption occurred during a direct task. However, there were no significant differences in interruption lag with respect to the timing of interruptions. Maximum

---

Figure 1. A process model of a normal workflow
of interruption lag was almost one hour (52 minutes 48 seconds).

<table>
<thead>
<tr>
<th>Timing</th>
<th>Interruption lag Mean (Min - Max)</th>
<th>Resumption lag Mean (Min - Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between tasks</td>
<td>6m37s (0s – 52m48s)</td>
<td></td>
</tr>
<tr>
<td>During direct task</td>
<td>9m 20s (27s – 36m42s)</td>
<td>1m21s (0s – 6m20s)</td>
</tr>
<tr>
<td>During indirect task</td>
<td>4m32s (36s – 15m11s)</td>
<td>1m33s (0s – 32m16s)</td>
</tr>
</tbody>
</table>

Table 2. Interruption lag and resumption lag

e. Resumption patterns after interruption

It is necessary to resume the interrupted task after completing the intervening task. However, a negative reaction may ensue, such as forgetting to return to the primary task, shortening the task, or asking someone else to perform the task. However, in the survey conducted after completion of the investigation, the subjects of this study answered that there were no such negative reactions.
f. Resumption lag

We define "resumption lag" to be the time between the end of the interruption and resumption of the interrupted task. As shown in Table 2, the average resumption lag was 1 minute 21 seconds for direct task and 1 minute 33 seconds for indirect task. However, there were shown no significant differences in resumption lag with respect to the timing of interruptions. Maximum resumption lag was 32 minutes 16 seconds.

4. Discussion

(1) Frequent interruptions

The frequency of interruptions varies depending on the specific occupation and medical specialty. For example, in one case, an emergency room physician was interrupted 30 times in one hour

Figure 3. A process model of workflow interrupted during a task
nurses were interrupted approximately 11 times per hour. Moreover, it was reported that emergency room physicians were interrupted three times more often than primary care physicians. Potter et al. found that nurses experienced an average of 3.4 interruptions per hour and 47% of the interruptions occurred as they performed interventions. Ebright et al. reported that nurses experienced numerous interruptions while providing care on surgical units. In our study, the number of interruptions ranged from 4.2 to 9.5 with a mean of 6 per hour. Our study demonstrated that nurses were frequently interrupted and that 29.2% of the interruptions (24.2% during indirect care, 5.0% during direct care) occurred as the nurses were performing tasks, a lower rate than Potter's study found.

(2) Overtime work caused by interruption

We observed that a difference in the timing of interruptions implied a difference in the workflow-path and in the order of tasks. We also observed that the probability of traversing each path depended strongly on the timing of the interruption. The extra work time consists mostly of the time of interruption itself and that of intervening tasks. The interruption can also disrupt a task. The interrupted task should take longer if it is a direct task, which requires more concentration than an indirect one.

An important question is the extent such events disrupt a nurse's cognitive focus. There is an increasing possibility that such disruptions prolong the switching-time costs for the next task. When people perform highly complex tasks, they use a cognitive function called "executive control." It has two main activities: goal shifting (i.e., do this now rather than that) and rule activation (i.e., turning off the rule for one task and turning on the rule for another) that help people unconsciously switch from one task to another. Although these activities take only a few tenths of a second, repeated switching between tasks can add extra time to both tasks. The durations of these activities depend additively on rule complexity. Most nursing work consists of complex tasks such as transfer of patients who have cardiac problems (a direct task) and medication preparation (an indirect task). Therefore, when a nurse is interrupted during a task or alternates rapidly between interrupted and interrupting tasks, and it takes far longer to get the tasks done than it would they if the interruption had occurred during a transition between tasks. In addition, intervening tasks occur more often during indirect tasks or during transitions between tasks than during direct tasks. These observations suggest the importance of the timing of the interruption in relation to the amount of overtime work.

(3) Operational failures caused by interruption

Data from this study showed that the time interval of interruptions was not constant. Parker et al. found that a span of as short as 10 seconds between two interruptions can result in an individual forgetting to carry out a task. Ebright and colleagues described stacking to be a nurse's organizational skill in moving on to other care activities to prevent down time when she/he is not able to complete a care process. When interruptions occur frequently, a rapid increase in stacking arises. The probability of choosing to deal with an interruption and the risk incidence rate depend on the number of stackings at the time of the interruption, and the stacking capacity of the nurse. A rapid increase in stacking and stacking capacity are associated with the risk of errors in multitasking and time-pressure situations, and further study is needed to determine the extent of the problem.

Potter et al. said that a nurse begins her shift by reviewing each patient's priorities and then proceeds with an intended
set of care activities. However, a patient's clinical situation frequently changes and unplanned tasks resulting from interruptions frequently occur; nurses must frequently reschedule care activities by waiting for processes or by accessing resources. Potter et al. 3) found that a fourth of the interruptions preceded a cognitive shift and interruptions do move a nurse's attention from one patient to another, either because of the distraction or because the nature of the interruption requires a redirection in care. Their findings suggested the number of and timing of clinical decisions vary depending on the timings of interruption. Decision making after interruptions of direct or indirect tasks is three times more often than after interruptions during transitions between tasks. At such points, nurses use goal shifting and rule activation 30). Therefore, inappropriate judgments at each point create a high risk of errors. When a nurse makes a judgment after interruption of direct or indirect tasks in D3 situations, they could easily forget the proper subsequent task, omit certain actions or perform them incorrectly. Tasks resulting from interruption are immediately responded to in 90% of the indirect task situations. Since some interruptions that occur during indirect tasks are medication preparations, they may have serious consequences. More study is needed about this possibility. On the other hand, tasks resulting from interruption are 60% likely during direct task. Nurses stop the interrupted task and resume it only after completing intervening tasks. This suggests that inadequate judgment could increase the risk of error and degrade quality of care. It is also an important problem to examine the relations between an interruption and a proper division of roles among health care professions to reduce the risk, and to improve the quality of care in the future.

5. Conclusion

Nurses experienced frequent interruptions while providing care in hospital wards. This study raises concern about how interruptions affect nursing workflow, by diagramming UML about changes in the nursing workflow caused by interruption according to the timings of the interruptions. This method reveals the changing pattern and its content, time points of risk, and the effect on overtime work. The impact of interruptions in the nursing workflow varies depending on the timing of the interruptions. To manage the interruptions, it will be crucial to understand these differences.

Acknowledgment

We would like to thank all the nursing staff who allowed us to observe their work. This study was supported in part by a Grant-in-Aid for Scientific Research (B-15310119) and a Grant-in-Aid from the Ministry of Health, Labor and Welfare of Japan.

References


タイムプロセススタディを用いた
看護ワークフローにおける中断影響の可視化

笠原 聡子*1 大野 ゆう子*2 石井 豊恵*2 沼崎 穂高*2

*1 高知大学教育研究部医療学系看護学部門 *2 大阪大学大学院医学系研究科保健学専攻

業務中断は医療現場において時には深刻なエラーにつながるなど、看護管理上重要な問題である。そこで、連続観察法によるタイムスタディを実施し、中断発生のタイミング別に看護ワークフローのプロセスモデルを作成することで、中断による影響を検討した。調査対象は公立がん専門病院の成人混合病棟の日勤看護師のべ12名とした。その結果、全調査データ中1,413レコード（9.8%）が中断業務として抽出された。このうち、約半数は他者を中断する側であった。本研究では中断される側の703レコードと、自己中断の23レコードについて分析した。看護師は1時間あたり平均6回の中断をうけていた。また、中断を受けたタイミング別では、70.8%は業務から次の業務への移行途中に発生していたが、24.2%は間接業務の最中に生じていた。業務への移行途中および間接業務中では、それぞれ96.9%、95.4%とほぼすべての場合において、即座に中断を受けた業務に対応していた。しかし、直接業務中に中断が生じた場合には約半数の55.6%しか即時に対応しておらず、残りは後回しにされていた。また、看護師が臨床判断を要求されるポイントについては、業務への移行途中に比べて業務中では3倍も多くなっていた。

和文キーワード
中断、看護、ワークフロー、タイムスタディ

2010年4月19日受付；2010年7月12日受理
連絡先：〒783-8505
高知県南国市岡豊町小塚
Tel：088-880-2747
高知大学教育研究部医療学系看護学部門
笠原聡子
E-mail address: s-kasahara@kochi-u.ac.jp