RESEARCH COMMUNICATION

Unified Modeling Language (UML) for Hospital-based Cancer Registration Processes

Naomi Shiki[1], Yuko Ohno[1]*, Ayumi Fujii[2], Taizo Murata[2], Yasushi Matsumura[2]

Abstract

Objective: Hospital-based cancer registry involves complex processing steps that span across multiple departments. In addition, management techniques and registration procedures differ depending on each medical facility. Establishing processes for hospital-based cancer registry requires clarifying specific functions and labor needed. In recent years, the business modeling technique, in which management evaluation is done by clearly spelling out processes and functions, has been applied to business process analysis. However, there are few analytical reports describing the applications of these concepts to medical-related work. In this study, we initially sought to model hospital-based cancer registration processes using the Unified Modeling Language (UML), to clarify functions. Methods: The object of this study was the cancer registry of Osaka University Hospital. We organized the hospital-based cancer registration processes based on interview and observational surveys, and produced an As-Is model using activity, use-case, and class diagrams. After drafting every UML model, it was fed-back to practitioners to check its validity and improved. Results: We were able to define the workflow for each department using activity diagrams. In addition, by using use-case diagrams we were able to classify each department within the hospital as a system, and thereby specify the core processes and staff that were responsible for each department. The class diagrams were effective in systematically organizing the information to be used for hospital-based cancer registries. Using UML modeling, hospital-based cancer registration processes were broadly classified into three separate processes, namely, registration tasks, quality control, and filing data. An additional 14 functions were also extracted. Many tasks take place within the hospital-based cancer registry office, but the process of providing information spans across multiple departments. Moreover, additional tasks were required in comparison to using a standardized system because the hospital-based cancer registration system was constructed with the pre-existing computer system in Osaka University Hospital. Difficulty of utilization of useful information for cancer registration processes was shown to increase the task workload. Conclusion: By using UML, we were able to clarify functions and extract the typical processes for a hospital-based cancer registry. Modeling can provide a basis of process analysis for establishment of eficient hospital-based cancer registration processes in each institute.

Key Words: Hospital-based cancer registry - unified modeling language (UML) - business modeling

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Introduction

Hospital-based cancer registries represent information sources for population-based cancer registries. These also provide a resource for evaluating treatment performance at relevant medical facilities, which is useful information to improve the quality of clinical care. Therefore establishing the processes for hospital-based cancer registry is an urgent issue. In Japan, hospital-based cancer registries were suggested as one of the functions of designated cancer care hospitals (Ministry of health and labor, 2008). As a result, there has been a steadily increasing number of medical facilities that implement hospital-based cancer registries. In order to prepare hospital-based cancer registries, Center for Cancer Control and Information Services in the National Cancer Center has assumed a central role in producing standardized registration formats and in conducting practical cancer registration seminars (Nishimoto, 2008; Okamoto, 2008; Sobue, 2008) .

There is, however, little systematic information available on work content, manpower, required time, management techniques, etc., which is necessary for successfully implementing cancer registries. Clarifying the functions and labor needed for a hospital-based cancer registry should be useful for the establishment of cancer registry at each medical facility.

In general, the work content of hospital-based cancer registry involves multiple departments such as clinical, pathology, and medical information. Therefore it is

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necessary to organize these complex work processes. In Japan, standardization is inadequate (Nishimoto, 2008), and currently registration procedures at each medical facility differ greatly depending on the hospital-based cancer registration system in use and the progress status in converting medical records to electronic form. In order to clarify the needed functions and labor, it is also necessary to compare work processes between multiple departments and facilities. In order to clarify functions and to undertake comparative analyses, it is necessary to model the subject of investigation.

For visualizing hospital-based cancer registration processes, we adopted Unified Modeling Language (UML), which in recent years has received attention in process analysis with business modeling techniques. UML is a unified language that represents organized processes and systems as diagrams (Penker et al., 2000). Because of its generality, UML is applied not only to systems development but also to a variety of other fields; there have been many reports on the utility of UML in process analyses involving the clarification of work processes and functions (Knape et al., 2003; Kumarapeli et al., 2007). There are however, very few reports of using UML modeling for cancer registration processes (Lyalin and Williams, 2005), and no reports with respect to hospital-based cancer registration processes. In this study we sought to model hospital-based cancer registration processes using UML and clarify the various functions involved.

Materials and Methods

For hospital-based cancer registries, a standardized registration format has been established. However, at medical facilities already conducting registrations, items and contents vary widely depending on the facility. The flow of processes involved in cancer registrations differs greatly depending on the medical record management system in use and the degree of progress in the conversion of medical records to an electronic format. Currently, these processes are introduced and implemented separately by each medical facility.

In view of the difficulty of establishing a "standardized" system for hospital-based cancer registries, in this study, we sought to understand the implementation of processes involved in cancer registry using a case study, and then to model hospital-based cancer registration processes using UML. In this study the subject case was the hospital-based cancer registry at Osaka University Hospital with 1076 beds (hereafter referred to as "the hospital"). The hospital is a specialty hospital and medical facility that endeavors to become a designated cancer care hospital. Along with the other hospitals in Japan, the hospital already has its own hospital information system and medical payment computer system.

Process of UML modeling

We conducted an interview and observational survey on work content with those responsible for implementing hospital-based cancer registries. The survey was conducted in August, 2008. We modeled the obtained information with UML and sought to specify the hospital-based cancer registration processes and the functions demanded in cancer registry at the hospital.

UML is an application built by unifying a model notational system based on object-oriented development techniques, and is used in NEEDS engineering and process analysis (Rumbaugh et al., 2005; OMG, 2008). There are 13 types of diagrams in UML. By representing organized processes and systems as diagrams, UML visualizes work contents and systems. In this investigation, we used use case, activity, and class diagrams to model the hospital-based cancer registration processes as the As Is model.

First, we produced activity diagrams of the hospital-based registration processes. An activity diagram is a so-called process flow chart. In an activity diagram, the processes performed by different organizations or systems are partitioned by borders called swim lanes. In addition, information and systems treated within processes are displayed as entities. Hospital-based cancer registration processes span across multiple departments and deal with various data types such as patient information. In conducting functional analyses of hospital-based cancer registration processes, it is necessary to organize complex processing steps. We therefore decided to first produce activity diagrams.

We then produced use case diagrams based on work contents clarified by the activity diagram. Use case diagrams provide a broad overview of the function and range of a system. Our goal with a use case diagram was to visualize the functions needed by the hospital-based cancer registry and the staff implementing registrations. We first extracted the work contents forming the core of hospital-based cancer registration as use cases. We then extracted the staff involved in hospital-based cancer registration processes as actors. With the extracted use cases and actors we produced a use case diagram.

Finally, using class diagrams we graphically represented the information utilized in hospital-based cancer registration processes, and the relationships that existed between the various types of information. Classes are abstractions of people or things that are handled within various processes. For hospital-based cancer registries, various types of data are employed. In this study, class diagrams were chosen in order to specify useable information and information needed for work processes. In describing the UML, we met successively with implementers of hospital-based cancer registrations, who provided feedback to ensure content accuracy.

Results

Composition of the hospital-based cancer registry office

The hospital-based cancer registration office was established in the medical information department. Two health information managers (one full-time, one part-time) primarily attend to registration tasks as cancer registrars. The full-time health information manager places priority on carrying out hospital-based cancer registration duties. The part-time health information manager attends to registration tasks in a helper capacity during times when hospital-based cancer registration duties are overloaded.

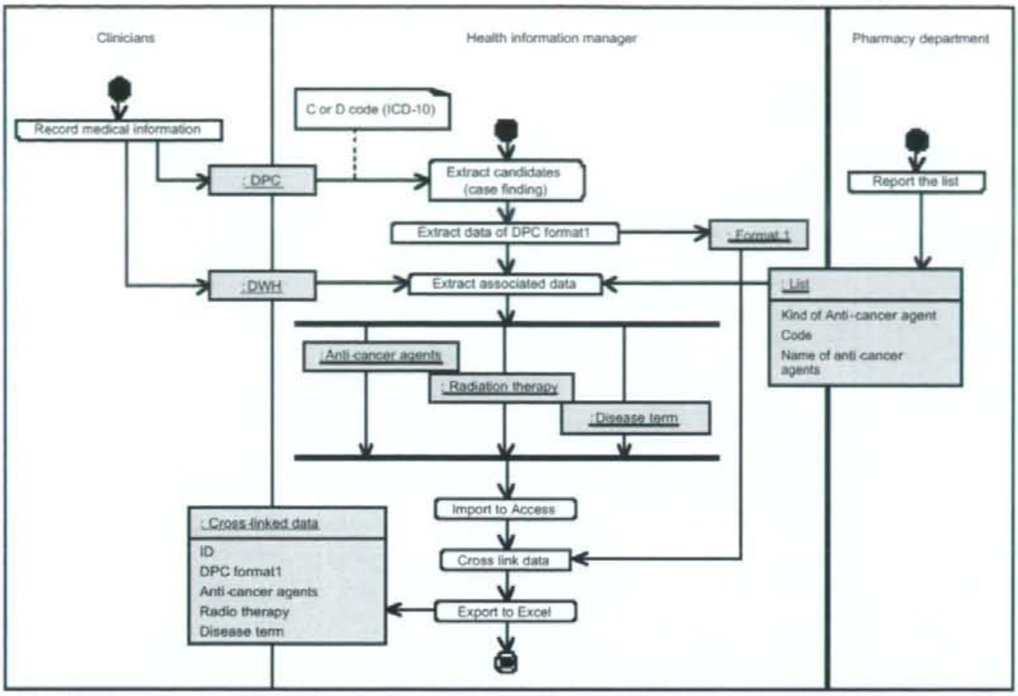

Figure 1. Activity Diagram for Registration Tasks (Case-finding)

Besides of the two registrars, another health information manager (not cancer registrar) takes charge of a part of duties.

System overview

The hospital is constructing and enacting an original hospital-based cancer registry using an electronic medical records system. This involves a system in which the health information managers perform the registration tasks and complete the registry via confirmation from the attending doctors. The subjects targeted for hospital-based cancer registry are "hospitalized patients diagnosed with cancer on or after January 1, 2007."

At the hospital, both of electronic and paper medical records are employed. Nearly all information registered in the electronic medical records, including patient information, prescription contents, tests, and surgery information, etc., is stored in the Data Ware House (DWH), where it can be searched for specific clinical information. There is also a registration system for diagnosis procedure combination (DPC; Japanese case mix classification), which is also searchable for DPC information. Pathology reports are kept independent of the hospital information system but the report database can be searched with the cooperation of the pathology department.

For the electronic medical records system, a form (created with Microsoft Word) and template (created with Template Master) for use in hospital-based cancer registrations have been prepared (Fujii et al., 2008). Moreover, while The TNM Classification of Malignant Tumors is an item for which registration errors are likely to occur, mistakes can be decreased by selecting stage from a number of choices made as small as possible due to an input format using a hierarchical structure. In addition, information such as patient names can be obtained automatically from the electronic medical records. The registered data output is in the form of an XML file. This data is registered as is in the electronic medical records database and is stored in DWH, one patient one value one record, by overnight batch processing. Furthermore, information required for hospital-based cancer registration is extracted from the data stored in DWH, and after value code conversion, is stored in the hospital-based cancer registry database.

When filing data to the population-based cancer registry, the registered data extracted from the hospital-based cancer registry database are first read into Hos-CanR2.1 (Client server edition; free software of standardized registration system) to conduct quality control. After checking for errors with HosCan-R and correcting the mistakes, the data is then submitted in a specified format and posted to the population-based cancer registry.

UML modeling, Activity diagram

Figures 1-3 show the flow of hospital-based cancer registration processes using activity diagrams. From the organization of processes, we extracted broadly three processes; "registration tasks," "quality control," and "filing data to the population-based cancer registry" processes. In this study, "registration task" processes are shown in Figures 1 and 2, while "quality control" processes and "filing data to the population-based cancer registry" are shown in Figure 3.

In an activity diagram, each organization is partitioned by borders to organize the flow of and relationships

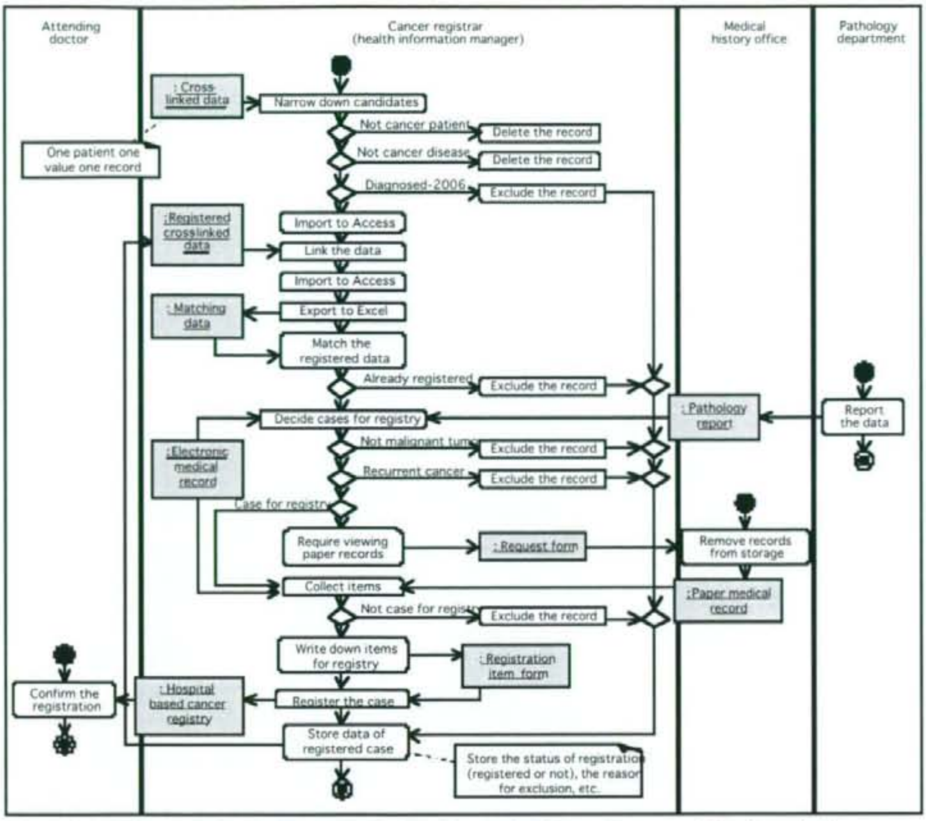

Figure 2. Activity Diagram for Registration Tasks (Narrowing Down Cases and Registration)

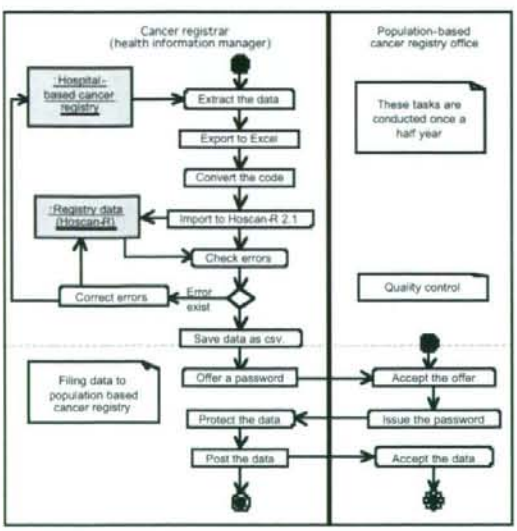

Figure 3. Activity Diagram for Quality Control and Filing Data to the Population-based Cancer Registry

between organizational processes. The data handled within work processes are shown as "entities," and specify the exchange of information between organizations. The "registration tasks " required task in the pharmacy department, pathology department and the medical history office. The work content therein primarily involved each department providing data to the hospital-based cancer registry office.

The flow of the various processes is indicated by arrows, specific types of which include "fork nodes" and "join nodes." This configuration shows that multiple processes are enacted in parallel and that subsequent tasks proceed only after the proceeding ones are completed. For example in Figure 1, data extraction is performed on multiple occasions, but cross-linking tasks cannot proceed unless the extraction task has been completed. Also, when work content changes depending on conditions, these branching points are shown by a diamond-shape known as a guard conditions. For instance in Figure 2, when records exist in which the disease name overlaps for a patient in cross-linked data, the overlapping record is deleted. In activity diagrams for the hospital, there were many guard conditions present in portions of the registration task, which primarily accompanied a decision about whether or not a patient was considered case for registration. This judgment is a complicated task and requires a high level of expertise. Its complexity was also confirmed in the activity diagram.

In the hospital, an original registration system was used. Standardized registration systems such as HosCan-R proposed by the National Cancer Center, enable the simultaneous extraction, registration and management of data. However, in the case of original systems, tasks such as data extraction from hospital information and data cross-linking arise (Figure 1). It is also recognized that

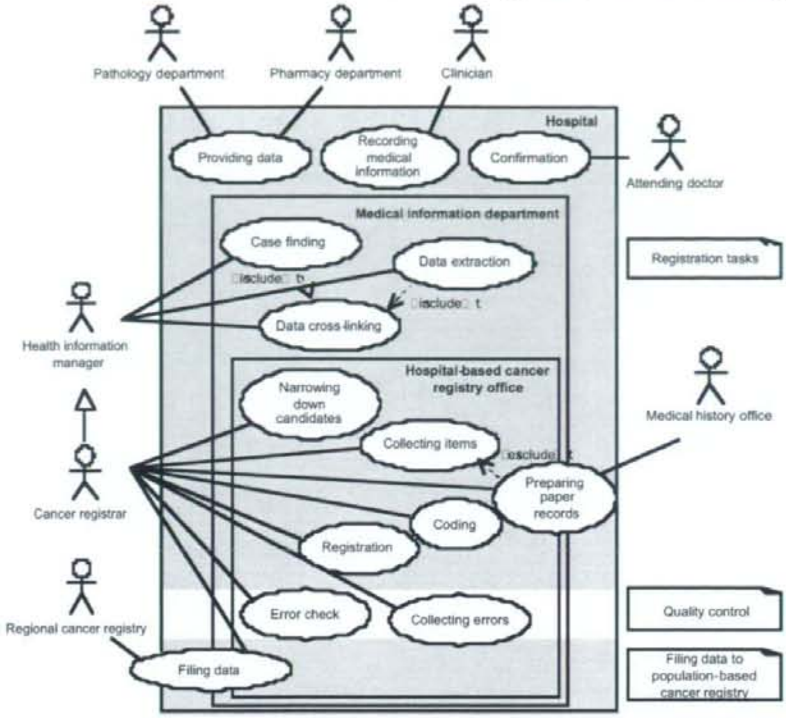

Figure 4. Use Case Diagram for a Hospital-based Cancer Registry

quality control needs to be performed separately (Figure 3). In addition, at the hospital, registration is done using electronic and paper medical records. Conditions requiring the viewing of paper medical records generated work tasks in the medical history office (Figure 2).

We note that follow-up of registered cases have not been implemented yet in the hospital, because the registry recently started.

Use-case diagram

Figure 4 shows the use case diagram for hospital-based cancer registration processes. On the basis of the activity diagram, we extracted 14 use cases. In addition to process implementers belonging to the hospital-based cancer registry office (health information managers as cancer registrars), we also extracted actors such as clinicians, pathology and pharmacy departments, and the medical history office. In addition, we extracted the population-based cancer registry office as an actor outside of the hospital.

In a use case diagram, the relationships between use cases are specified. One of the relations present in use case diagrams is "include." This is a relation in which a separate function is necessary when executing a particular function. For instance, "case-finding" and "data extraction" are essential when "data cross-linking". In this case, "case-finding" and "data extraction" are shown to be in an "include" relationship with respect to "data cross-linking". Separately, there is also an "exclude" relationship. This indicates a relationship in which under certain circumstances, a separate function is expanded whenever a particular function is executed. For example, when performing the "collecting items", "preparing paper records" is necessary only when examination of paper medical records is required. This sort of relationship is termed "exclude."

The rectangular border in use case diagrams indicates the range of a system. In the present investigation we extracted the 3 layers of "hospital", "medical information department", and "hospital-based cancer registry office", as systems. The use cases within each border represent the functions of each system. In addition, those responsible for enacting these functions are represented as the actors. The straight line connecting a use case and an actor indicates that the actor is responsible for enacting that function. For instance, the medical history office is responsible for "preparation of paper medical records" and is not in charge of any other use case. On the other hand, the cancer registrars are involved in many use cases. For hospital-based cancer registry, there is a need to decrease the clinician's burden as much as possible. In the hospital, the clinicians were only involved in "recording medical information" and "confirmation," which could be done during daily consultations.

Class diagram

Figure 5 shows the class diagram concerning information utilized in hospital-based cancer registrations. The definition of class includes workers and entities. Workers are staff who perform work tasks, and entities are passive objects operated by workers. In the present investigation, we extracted cancer registrars as workers. Their properties included occupation, employment system, expertise, and experience. These can be considered as

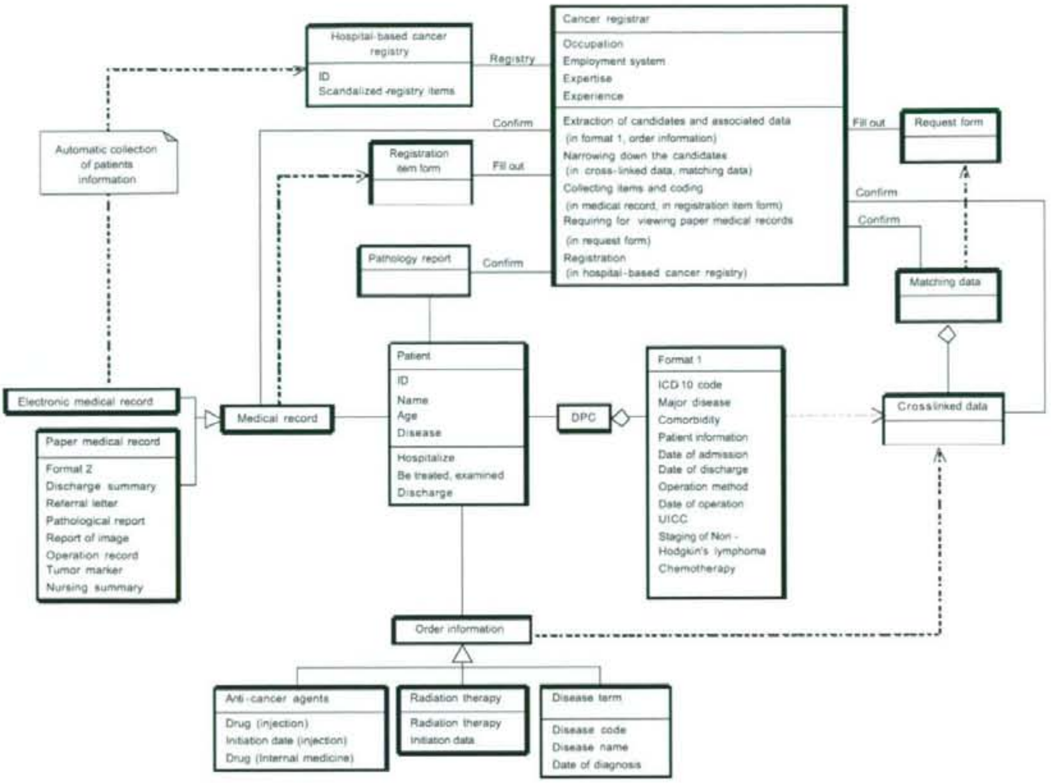

Figure 5. Class Diagram for Information Utilized in Hospital-based Cancer Registration Tasks

factors influencing the execution of hospital-based registration processes. In addition, the tasks shown in the activity and use case diagrams were suggested as operations. These can be considered the contents of the work performed by cancer registrars. Entities included DPC format 1, information for orders, clinical records, pathology reports, cross-linked data, matching data, request form (for viewing paper medical records), registration item form, hospital-based cancer registry, and other classes comprising these entities. The properties of each class are represented by the medical examination information possessed by each class (not shown in Figure 5).

A class diagram visualizes relationships between classes. Interclass relationships include "association," "generalization," "aggregation," and "dependencies." The present class diagram also confirmed a number of relationships. "Generalization" indicates a relation in which one of the related classes (superclass) is more general relative to the other (subclass). For example, information for orders is in a "generalization" relationship with information of anti-cancer agents, disease name, and radiation therapy. This relation is indicated by drawing a straight line from the subclass to the superclass and adding an open triangle marker at the end. Alternately, the "aggregation" interclass relationship indicates a relation in which a portion of the superclass is a subclass. For instance, matching data include data from cross-linked data, and so the relation between these classes is classified as "aggregation." In this case, a straight line is drawn from the subclass to the superclass and an open diamond marker is added at the end.

The class diagram shows that the process of extracting and narrowing down cases does not utilize pathological information, and that it is required to access the pathology report each time. This is because the pathology report is independent of the hospital information system. If, during the initial stages of registration tasks, the pathology data could be accessed and the data for cross-linked data could be linked, it is likely that the extracting and narrowing-down process could be simplified.

In deciding on cases for registration, medical records are examined and a decision is ultimately made on whether the patient will be registered. Then the necessary items are collected. During these processes, the informational resources particularly used as references include discharge summaries and letters of referral—sources for which clinical information is summarized. However, examination of the class diagram shows that letters of referral exist as a property of paper medical records. Viewing paper medical records requires filing a request for use, which can take considerable time.

Discussion

In the context of current demands for establishing processes for hospital-based cancer registry, it is necessary to clarify the functions and labor needed for these processes. In general, hospital-based cancer registration consists of complex processing steps. In addition, the work contents differ depending on each medical facility. For these reasons, it is necessary to visualize and model the processes when analyzing registration procedures.

We therefore focused our attention on a business modeling technique using UML, a technique that has gained much attention in recent years. By employing UML, which uses graphic representation as the principle in which to model processes, it is possible to clarify process functions. Furthermore, using a unified language such as UML raises the prospect that such a model can be adapted to comparative analyses of processes conducted by multiple facilities.

By using activity diagrams, it was possible to represent the flow of registration processes, including the exchange of information between departments. This diagram seems appropriate for processes that involve many exchanges of data such as seen in hospital-based cancer registry. In addition, by organizing the results of interview surveys using this diagram, we were able to classify the hospital-based cancer registration processes broadly into three process types—"registration tasks," "quality control," and "filing data to the population-based cancer registry." These work contents can be viewed as functions that are necessary for the successful enactment of hospital-based cancer registry. Currently, it is claimed by Center of Cancer Control and Information Services in the National Cancer Center, that hospital-based cancer registration processes can be divided into "registration (including quality control)," "summarizing information", "providing information," and "follow-up" (Sobue et al., 2007). However, in the case of the hospital, "quality control" needs to be performed separately due to the existing surroundings of the system. In such cases, it is likely to be necessary to take up quality control as a core process separate from the "registration" process. By analyzing the current state of affairs using UML, it is possible to extract precisely what processes and functions are necessary, depending on the conditions at each medical facility.

Because implementation conditions differ at each medical facility, functional analyses appropriate for each condition may be necessary. Using activity diagrams, we were also able to represent changes in work content under a variety of conditions, and to extract particularly complex task areas. Activity diagrams could be used to simply and clearly model the flow of hospital-based cancer registration processes that span across multiple departments. We suggest these diagrams are effective for understanding the characteristics of the various processes.

Use case diagrams statically specify the relationships between the functions, the range and responsible implementers of a system. When applied to hospital-based cancer registry, we were able to view each of the hospital departments as a range of the system, and were able to define the work contents forming its core as use cases, and those responsible for the work as actors.

Hospital-based cancer registration processes were classified broadly into three processes using activity diagrams, and were divided further into 14 use cases in the hospital. In use case diagrams, it is possible to position processes represented at border regions of a system as joint processes with other departments. In the case of the hospital, processes of "preparing of paper records" and "filing data" spanned across multiple departments. Another process outside of the hospital-based cancer registry office was "providing data", "recording medical information" and "confirmation."

The tasks of cancer registry require high expertise and workload. Thus, it is said that cancer registrars are needed from the view of reliability of data and efficiency in Japan (Nishimoto, 2008). In the hospital, cancer registrars mainly implement cancer registry so that clinicians' load is relatively small. To implement hospital-based cancer registry with the least possible burden on the clinic, it will likely be necessary to consider, for these processes that require coordination with other departments in particular, the efficient distribution of responsibilities and how they ought to operate ideally.

In a use case diagram, by defining the range of the system as the departments within the hospital, it is possible to extract processes that require coordination with other departments or that can be completed within a single department. Use case diagrams may be useful to considering the roles of each department in each task.

In class diagrams, we were able to summarize the information to be utilized and the relationships between the information. By considering cancer registrars as workers within the same class diagram, it is possible to simultaneously specify the factors involved in process execution, the information to be utilized, and the contents of the work.

In order to simplify the registration tasks, it is useful to have an information source in which the required information has been summarized. However, in the case of the hospital, it was necessary to view paper medical records. Moreover, while pathology report was useful in narrowing down cases and determining whether or not a patient was a case for registration, its use was limited. For hospital-based cancer registry, it has been recommended that multiple sources of information be used in order to prevent omissions and increase accuracy (Jensen et al., 1991). This suggests it is necessary to consider coordination with the hospital information system.

By considering those who implement the processes as workers, and the information handled as entities, class diagrams make it possible to see which processes require what information, as well as to identify what is lacking.

As seen above, the advantage of UML is its ability to simply and clearly specify complex processing steps by modeling on the basis of obtained information. In addition, UML can extract the functions demanded by a process, as well as identify problem areas (Knape et al., 2003; Kumarapeli et al., 2007). In investigating work issues, UML is extremely useful and applicable to hospital-based cancer registration processes. It may be possible to comparable analysis depending on facilities by modeling processes with UML, unified language. Moreover based on the modeled hospital-based cancer registration materials, it is possible that by conducting more detailed process analyses and quantitative task load surveys such as time study, useful material may be provided in preparing hospital-based cancer registries in the coming years.

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B-6

がん医療均てん化指標としてのがん患者受療動態と地域別生存率に関する研究

Study on the regional characteristics in the cancer patients' behavior and 5-year survival

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現在、わが国におけるがん対策としてがん医療の均てん化が進められているが、その評価指標については未だ十分に検討されていない。本研究では、大阪府がん登録資料に基づき、主要5部位とその他10部位について、二次医療圏別患者受療動態および地域別生存率の比較を行い、がん医療均てん化の評価を試みた。大阪府がん登録に記載されている患者住所と主治療医療機関の所在地が同じ地域である患者を地域内治療完結患者と定義し、地域別の治療完結患者の割合を完結割合として患者受療動態指標に用いた。

部位別でみると完結割合は罹患数の多い部位で高く、二次医療圏別では急性期医療機関の集中している地域で高い傾向がみられた。地域別の生存率は、患者居住地別では地域間差が小さいが、施設所在地別では地域間差がみられ、医療提供体制に地域差がある可能性が示された。このように完結割合は部位ごとの治療特性や地域の医療提供体制を反映していることが示唆され、今後、生存率と併せてみることで、がん医療均てん化を評価する指標の一つとなり得ると考える。

1. はじめに

現在、わが国におけるがん対策の一つにがん医療均てん化が掲げられており、均てん化実現のための施策の一つとして、がん診療連携拠点病院の指定が進められている。これは主要5部位(胃、大腸、肺、肝、乳房)における治療状況を主に検討されており、質の高いがん医療の提供と共に、二次医療圏内で治療が完結することが期待されている。しかし、患者受療動態という視点から地域における生存率の実態を論じた研究は極めて少ない。

本研究は、二次医療圏別にみた治療時の完結割合および地域別生存率の比較分析より、がん医療均てん化の評価を試みるものである。

2. 対象と方法

対象は、大阪府がん登録資料により、1980年から2002年の間にがんと診断された患者のうち、死亡情報のみの登録患者、死亡票により初めて把握された患者、再発届出のみの登録患者、重複がんで第2がん以降、上皮内がん患者、大腸粘膜がん患者、治療医療機関の特定されない患者を除いた256,841人である。対象者は二次医療圏別に8地域に区分した。

上記対象者について大阪府がん登録における患者住所(患者居住地)と主治療医療機関の所在地(施設所在地)が同じ地域である患者を地域内治療完結患者と定義し、地域別完結患者割合を完結割合とした。

まず、部位別、二次医療圏別の完結割合を算出した。次に、患者居住地毎に治療施設所在地別罹患数を算出し、二次医療圏間の患者移動を確認した。さらに、地域別5年相対生存率を算出し、患者受療動態分析結果との比較を行った。

なお、本研究は大阪府がん登録資料利用適否の審査を受け、承認を得ている(承認番号06-0009、平成18年11月22日承認)。

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3. 結果

対象患者数は、1980 年の 7,785 人から漸増し、2001 年には 13,145 人となったが、2002 年には 11,952 人と減少していた。

1)部位別治療完結割合

経年変化を図 1.1、1.2 に示す。2002 年における完結割合は最も高い部位で大腸がん(80.5%)、次いで胃がん(75.2%)で高く、精巣がん(63.0%)で最も低かった。期間を通しても大腸がん、胃がんは完結割合が高く、主要 5 部位に比較してそれ以外の部位では完結割合が低い傾向が認められた。

経年変化をみると、主要 5 部位において特に 1993 年以降の完結割合の上昇が認められた。主要 5 部位以外の部位では、患者数が少ないため値に大きなばらつきが見られるものの、一定若しくは上昇傾向にあり、特に子宮がん、白血病は 1990 年代以降、完結割合の大幅な上昇が認められた。

2)患者居住地別治療完結割合

患者居住地別の完結割合は、1980 年から 2002 年にかけて、大阪市は 90%付近で推移し、大きな変動は認められなかったが、豊能は 1992 年を境にそれまで 40%未満であったのが 60%以上に上昇していた。中河内は期間を通して完結割合が低かった。その他の地域では完結割合の増加傾向が確認された(図 2)。

3)二次医療圏間の患者移動

完結割合の経年変化の変曲点と考えられる 1993 年前後の患者受療動態の変化をみるため、期間を 1993 年以前と以後に区分し、患者居住地域毎に治療施設所在地内訳を算出した(図 3)。

多くの地域は、両期間とも自地域で受療する患者が 5 割を超えていた(大阪市、三島、北河内、南河内、堺市、泉州)。特に大阪市では地域内治療完結患者は 80%以上であった。また、いずれの地域も大阪市へ多くの患者が流出していた。

これらと対照的に、中河内は両期間とも自地域よりも大阪市の施設で受療する患者が多かった(56.9,52.6%)。また、豊能は 1993 年以前では中河内と同様の現象が確認されたが、1993 年以降大多数地域と同様、自地域での治療完結患者が 50%を超える結果となった。また、三島においては 1993 年以降で豊能での受療患者が増加していた。

4)地域別 5 年相対生存率の比較

主要 5 部位について、患者居住地別、施設所在地別に相対生存率を算出した(表 1)。大阪府全体の相対生存率は、1993 年前後で 49.5%から 54.5% と上昇した(主要 5 部位)。両期間中、治療施設所在地別で相対生存率が府全体より低い地域が多かった。治療施

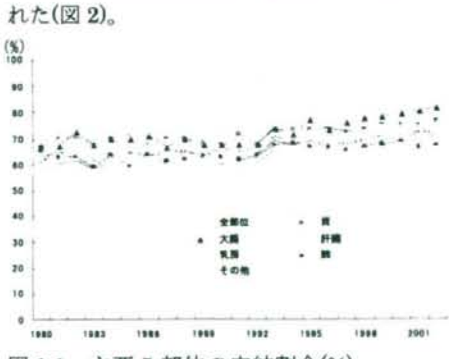


図 1.1 主要 5 部位の完結割合(%)

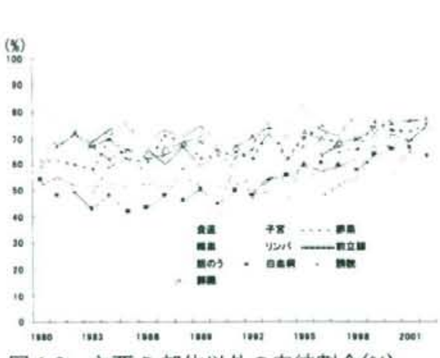


図 1.2 主要 5 部位以外の完結割合(%)

設所在地別でみると相対生存率が府全体より低い地域が 1993 年以前で多かったが、1993 年以降は減少していた。患者居住地別では、治療施設所在地別に比べて府全体より相対生存率が低い地域は少なかった。

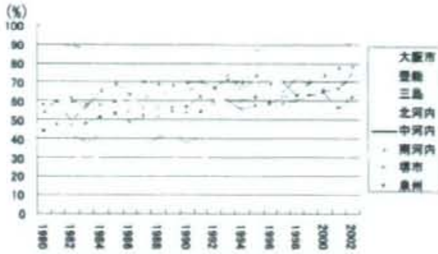
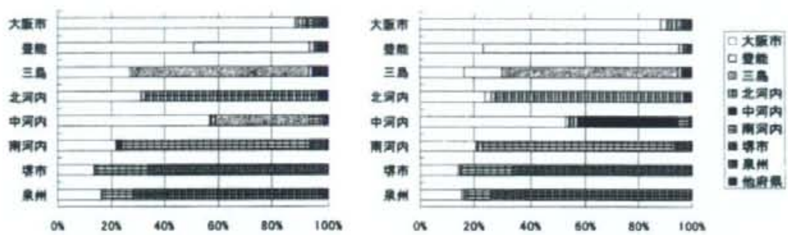


図 2 二次医療圏別の完結割合



1988-1992 年罹患者　　1994-1998 年罹患者

図 3 二次医療圏間の患者移動

表 1 地域別 5 年相対生存率(%)　　括弧内は標準誤差を示す

		主要5部位		胃		大腸	
		1988-92	1994-98	1988-92	1994-98	1988-92	1994-98
大阪府全体		49.5 (0.3)	54.5 (0.3)	53.7 (0.6)	59.7 (0.5)	61.8 (0.7)	64.6 (0.5)
患者居住地	大阪市	- (-)	51.6 (0.4)†	- (-)	57.2 (0.8)†	- (-)	62.5 (0.9)
	豊能	53.2 (0.8)*	58.0 (0.8)*	55.5 (1.4)	62.5 (1.4)*	64.1 (1.7)	68.4 (1.5)*
	三島	48.4 (1.1)	52.0 (1.0)†	52.7 (1.7)	61.8 (2.0)	60.8 (2.6)	66.0 (2.4)
	北河内	50.9 (0.8)	56.0 (0.8)	56.3 (1.4)	61.3 (1.3)	61.2 (1.9)	63.3 (1.6)
	中河内	48.4 (0.8)	55.1 (0.8)	52.7 (1.5)	59.9 (1.4)	63.0 (1.9)	64.2 (1.7)
	南河内	49.7 (1.0)	57.3 (0.9)*	53.2 (1.7)	61.2 (1.7)	64.0 (2.1)	66.6 (2.0)
	堺市	47.8 (0.9)	56.8 (0.8)*	51.8 (1.5)	59.4 (1.6)	58.9 (1.9)	64.3 (1.7)
	泉州	46.7 (0.9)†	56.0 (0.9)	52.4 (1.5)	60.1 (1.5)	59.5 (2.0)	67.4 (1.8)
施設所在地	大阪市	58.0 (0.6)*	55.6 (0.4)	60.7 (1.0)*	62.2 (0.7)*	71.1 (1.2)*	65.6 (0.8)
	豊能	49.2 (1.2)	58.9 (0.8)*	52.4 (2.1)	62.9 (1.5)*	62.7 (2.7)†	70.5 (1.6)*
	三島	40.7 (1.2)†	46.7 (1.2)†	47.1 (1.9)†	57.9 (2.4)	53.7 (3.2)†	61.7 (2.9)
	北河内	47.4 (1.0)	53.0 (0.8)	54.4 (1.7)	58.4 (1.4)	56.3 (2.4)†	59.7 (1.7)†
	中河内	46.6 (1.4)	50.0 (1.2)†	49.5 (2.2)	48.8 (2.1)†	54.4 (2.9)†	56.4 (2.3)†
	南河内	44.9 (0.9)†	53.1 (0.8)	50.2 (1.6)†	56.8 (1.7)	59.0 (2.1)	66.6 (1.8)
	堺市	42.8 (0.9)†	51.2 (0.9)†	49.3 (1.7)†	55.6 (1.7)†	55.0 (2.3)†	61.4 (1.9)
	泉州	44.4 (1.1)†	55.5 (1.1)	47.2 (1.8)†	56.5 (1.8)	52.1 (2.6)†	65.4 (2.2)
	他府県	57.0 (2.3)*	60.9 (2.2)*	66.9 (4.1)*	62.2 (4.8)	65.2 (6.3)*	64.3 (5.2)

		肝臓		肺		乳房	
		1988-92	1994-98	1988-92	1994-98	1988-92	1994-98
大阪府全体		18.1 (0.7)	25.8 (0.6)	15.9 (0.6)	23.0 (0.5)	86.0 (0.7)	85.5 (0.5)
患者居住地	大阪市	- (-)	23.2 (0.9)†	- (-)	21.7 (0.8)	- (-)	85.9 (0.9)
	豊能	18.2 (1.6)	26.2 (1.9)	16.3 (1.5)	23.1 (1.5)	89.2 (1.4)*	85.8 (1.4)
	三島	20.3 (2.1)	22.3 (2.0)	17.2 (2.0)	20.0 (1.8)	85.5 (2.5)	83.2 (2.1)
	北河内	19.4 (1.7)	29.4 (1.7)*	16.8 (1.5)	23.9 (1.6)	87.1 (1.7)	85.0 (1.5)
	中河内	18.0 (1.5)	30.2 (1.8)	14.8 (1.5)	22.7 (1.6)	86.5 (1.8)	85.3 (1.6)
	南河内	18.1 (1.8)	27.2 (2.3)	11.2 (1.5)†	21.5 (1.7)	87.1 (2.0)	87.2 (1.6)
	堺市	18.1 (1.7)	29.5 (2.2)	17.3 (1.4)	26.2 (1.7)	82.2 (1.8)†	86.1 (1.4)
	泉州	15.4 (1.6)	24.0 (2.0)	16.3 (1.5)	27.4 (1.9)*	83.2 (2.1)	83.5 (1.8)
施設所在地	大阪市	22.6 (1.2)*	27.1 (0.9)	21.6 (1.4)*	24.6 (0.8)	88.3 (1.0)*	85.8 (0.7)
	豊能	15.5 (2.6)	23.1 (1.8)	14.3 (1.8)	24.2 (1.6)	88.0 (2.6)	87.1 (1.3)
	三島	16.0 (2.1)	23.1 (2.3)	13.8 (2.0)	17.5 (1.8)†	79.2 (4.1)	81.1 (3.0)
	北河内	17.0 (1.9)	28.3 (1.7)	13.9 (1.6)	23.2 (1.9)	86.1 (2.2)	82.8 (1.8)
	中河内	8.4 (1.8)†	17.9 (2.3)†	8.4 (2.4)†	8.2 (2.2)†	88.5 (3.8)	84.4 (2.7)
	南河内	16.6 (1.5)	26.1 (2.0)	8.5 (1.1)†	13.6 (1.3)†	86.1 (1.8)	86.3 (1.5)
	堺市	13.8 (1.9)†	29.5 (2.8)	18.7 (1.3)	28.1 (1.4)*	79.5 (2.2)†	86.1 (1.8)
	泉州	9.3 (1.6)†	17.7 (2.3)†	12.2 (1.9)	23.3 (2.9)	81.5 (2.7)	82.3 (2.5)
	他府県	30.8 (3.6)*	23.4 (3.9)	26.4 (6.0)*	24.6 (6.0)	95.3 (4.3)*	88.0 (3.1)

*：大阪府府全体より有意に高い　†：大阪府全体より有意に低い　(5%有意水準、Z 検定)

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4. 考察

完結割合は部位によって異なり、胃がん、大腸がんなど罹患数の多い部位で高く、精巣がんなど罹患数の少ない部位で低い傾向が認められた。これは罹患数の多い部位では治療法が普及し、二次医療圏内で治療が完結しやすいためと推察できる。対照的に罹患数の少ない部位で完結割合は低いものの、近年上昇傾向にあり、治療法の普及や施設の機能分担により患者居住地内での治療が可能になりつつあると言えるであろう。

二次医療圏別の完結割合は、急性期医療機関の集中している大阪市で高い一方、中河内は期間を通して低かった。患者調査(2002 年)による一般病床を対象にした入院患者の完結割合(63.6%)と本研究での完結割合を比較しても中河内は顕著に低い。交通網などの影響で、中河内では他地域でがん治療を受けている状況がある可能性が示された。

完結割合の経年変化をみると、1993 年以降に豊能で完結割合が上昇していた。これは、1993 年に大規模病院が大阪市から豊能に移転しており、それに併せて患者も移動し、また地域医療機関として通院するようになったためと考えられる。1993 年を境にした受療動態の変化は豊能に隣接する三島にも現れており、病院の移転など医療環境の変化が周辺地域の完結割合に影響することが示唆された。

部位別地域別の相対生存率をみると、特に治療施設所在地別で相対生存率の地域間差が認められた。二次医療圏毎で施設の診療成績に違いがある可能性が示唆された。但し、1993 年以降では相対生存率が低い地域が減少しており、相対生存率は平均化されつつあると考えられる。また患者居住地別では相対生存率に差がなくても、施設所在地別では相対生存率が低い地域がみられたことは、患者が他地域に移動し治療を受けることによって大阪府全体としては相対生存率の地域間差が緩和されているものと考えられる。

がん医療の均てん化の指標として、相対生存率は広くコンセンサスが得られている。本検討では、相対生存率を患者居住地別、施設所在地別に検討することによりがん医療の地域差が検討できることが示唆された。また完結割合を評価することにより、大阪府のように医療機関が多く交通網が発達している地域においても、居住地域内で治療が完結し、相対生存率が高い地域がある一方、他地域で受療して相対生存率が高い地域もあるということが示された。患者居住地別の相対生存率の検討のみではがん医療提供体制の評価に至らず、完結割合と生存率を併せて検討することが重要と考える。

本研究の限界として、大阪府がん登録に登録された患者を対象としているため、届出漏れ患者のために完結割合が変動する可能性はあるが、二次医療圏別の完結割合は部位ごとの治療特性や地域の医療提供体制を示しており、相対生存率と併せてみることで、医療均てん化を評価する指標の一つとなりうると考えられる。

(参考)

●：がん診療連携拠点病院
大阪府の二次医療圏

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Epidemiology Note

Trends of Centralization of Childhood Cancer Treatment Between 1975 and 2002 in Osaka, Japan

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Objective: To analyze the tendency to centralize childhood cancer treatment among cancer treatment hospitals in Osaka, Japan over a 28-year period.
Methods: The subjects were patients under the age of 15, newly diagnosed with cancer in Osaka between 1975 and 2002 ($n = 4738$). They were categorized into three groups by the time diagnosed (1975–84, 1985–93 and 1994–2002). The International Classification of Childhood Cancer was used as the disease classification. The degree of centralization was examined using a Pareto analysis, the Gini coefficient and the annual average number of cases per hospital.
Results: During this period, the number of children with cancer in Osaka has decreased by nearly half, from 2.1 to 1.2 million and the number of hospitals treating childhood cancer decreased from 37 to 20. However, the Pareto curve and Gini coefficient were almost constant (0.747, 0.737, 0.756 in Gini coefficient for the three diagnosed periods). The annual average numbers of cases per hospital were much low and marginally increased from 5.6 during 1975–84 to 6.1 during 1994–2002 in the hospitals that treated 90% of all cancers.
Conclusions: The degree of centralization appeared to be almost constant from 1975 to 2002 regardless of the decrease in hospitals treating cancer patients.

Key words: childhood cancer – centralization – population-based cancer registry

INTRODUCTION

Recent studies have suggested that there is a relation between better survival and hospital procedure volume (1–3). There also seems to be a relation between childhood cancer patients under the age of 15 referred to specialist centers and better survival (4–5).

The incidence rates of childhood cancer are very low and almost the same worldwide, and were 154 per million for boys and 158 per million for girls in Osaka in 2004 (6). So, centralization is thought to be particularly important to attain better survival for rare childhood cancers (4–5).

In fact, childhood cancer treatment has been centralized in the UK, Georgia and Germany (7–10), although the child and family are heavily burdened with ambulant treatment and hospital stays. For example, at 244 820 km^2 and with 11.1 million children in 2001, the UK has only 22 treatment centers, which have treated ~90% of newly diagnosed cases (~1350 cases per year in the early 2000s) (7–8). In Osaka with an area of 1898 km^2 and 1.3 million children in 1995, nine specific hospitals had treated ~70% of cases (~180 cases per year) during 1989–98 (11). This information suggests that childhood cancer treatment had been decentralized in Osaka (7–10).

The child population in Osaka has reduced by about half, from 2.1 million in 1975 to 1.2 million in 2005, because of a decreasing birth rate. According to this decline, the

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number of childhood cancer patients and the annual treatment volume per hospital should also have decreased. On the other hand, childhood cancer treatment was supposed to have been centralized to specific hospitals in 1990s mainly because of following three factors. First, the number of medical lawsuits increased and this led doctors to refer patients that were difficult to diagnose to specialists (12). Second, multi-center cooperative studies began to conduct larger scale investigations into childhood cancer so that patients could be treated at specific hospitals (13). Third, two large and specialized hospitals for pediatric medicine were built and a university hospital relocated to Osaka in the early 1990s.

We investigated the trend of centralization of cancer patients to specific hospitals from 1975 to 2002 using the data from the population-based Osaka Cancer Registry (OCR).

PATIENTS AND METHOD

DATA SOURCES

Osaka Prefecture is an area with 8.8 million people, and the population covered by the OCR was the largest in Japan till 2006. The proportion of death certificate only (DCO) cases was <2.9% for children under the age of 15 between 1981 and 89, and that of registered patients was estimated to be from 85 to 94% (14). We used this OCR as our source database.

SUBJECTS

Our subjects were patients under the age of 15 and newly diagnosed with cancer between 1975 and 2002 (5291 cases). We then excluded carcinoma *in situ* (two cases), patients who had no information on a treatment (153 cases), those who did not specify both treating hospital code and diagnosing hospital code (three cases), and those that received treatment in other prefectures (417 cases). The final number of subjects for our study was 4738.

We needed to know the number of patients by treatment hospital in order to investigate the degree of centralization. For the analysis, we principally used the treating hospital code (3741 cases). The diagnosing hospital codes were used only when the patients had no information on the treating hospital (997 cases).

The patients were then divided into three period groups by the diagnosed year: 1975–84 (1976 cases), 1985–93 (1661 cases) and 1994–2002 (1101 cases). We then used these data to investigate the centralization tendency.

CLASSIFICATION OF CHILDHOOD CANCER

Childhood cancer is histologically very diverse and some histological types occur in many different sites. Since 1996, the International Classification of Childhood Cancer (ICCC) has been used for international comparisons of statistical analyses (15). We used twelve diagnostic groups on the basis of ICCC in this research for our classification of childhood cancer.

METHOD

A Pareto analysis was used to investigate the centralization tendency for childhood cancer treatment. The process for the Pareto analysis was as follows.

A table was prepared to list the number of patients that each hospital treated, and the rows were arranged in descending order of the number of the patients. A column was added to this table that shows the cumulative percentage of the patients in descending order.

In order to find how many hospitals have treated childhood cancers, we counted up the cumulative frequency of hospitals when the cumulative percentage of patients was upper 50 and 75% and when it was 100% by year, diagnosed period and ICCC. We also plotted the Pareto curves with the cumulative percentage of hospitals and patients for the three diagnosed periods.

The Gini coefficient was also calculated as an index of the centralization of treatment for the three diagnosed period groups and the ICCC group. This is defined as follows (16):

$$\text{Gini} = \frac{1}{2n^2\bar{y}}\sum_{i=1}^{n}\sum_{j=1}^{n}|y_i - y_j|$$

Graphically, the Gini coefficient covers twice the area between the Pareto curve and the line of equality. The Gini coefficient ranges between 0 and 1. A 'one' means all the patients were treated at one specific hospital.

Furthermore, the annual average number of cases per hospital was calculated and compared with those of European countries and the USA (8–10).

We used R version 2.4.0 for all the analysis in this study.

RESULTS

The number of children in Osaka during this 28-year period decreased to nearly half, from 2.1 to 1.2 million. That of the hospitals treating childhood cancer also decreased from 37 in 1975 to 20 in 2002, and in particular, decreased from 37 in 1993 to 32 in 1994. After 1993, the number of the newly diagnosed patients drastically decreased from 161 in 1993 to 107 in 2002.

Figure 1 shows the change in the Pareto curve and the Gini coefficient for all childhood cancer cases for the diagnosed period. The Gini coefficients were almost constant (0.747, 0.737, 0.756 for the three periods), and a weak centralization can be found during 1994–2002 when looking at the Pareto curve.

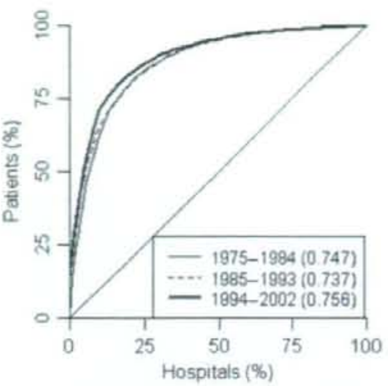

Figure 1. Pareto curve and Gini coefficient by diagnosed period. The Pareto curve shows a weak concentration between the periods of 1975–84 and 1994–2002; however, the Gini coefficient varied very little.

Table 1 shows each cumulative frequency of hospitals and the Gini coefficient by the ICCC and diagnosed period. Each cumulative frequency of hospitals slightly increased or was constant during 1975–84 and 1985–93, but reduced by about half during 1994–2002, except for the hospitals treating upper 50% of malignant bone tumors (VIII). The variations in Gini coefficient were small throughout all three periods. The Gini coefficients by the ICCC groups ranged from 0.275 to 0.665. The rarer the ICCC group was, the smaller the Gini coefficient was. In particular, the low level of centralization was shown for the rarely diagnosed groups: retinoblastoma (V), renal tumors (VI), hepatic tumors (VII), malignant bone tumors (VIII), carcinomas and other malignant epithelial neoplasms (XI) and other and unspecified malignant neoplasms (XII).

The annual average numbers of cases per hospital were less 2.2 in all hospitals during the three diagnosed periods (1975–84: 2.17, 1985–93: 2.15, 1994–2002: 2.18). In hospitals that treated upper 90% of all cancers, those were 5.6 during 1975–84, 5.5 during 1985–93 and 6.1 during 1994–2002. In the early 2000s, those were ~61.4 in the UK, ~60.9 in Georgia and ~32.4 in Germany (8–10). Even hospitals that treated upper 50% of all cancers, the annual average numbers of cases were 14.1 during 1975–84, 15.4 during 1985–93 and 20.4 during 1994–2002. Those were one-third the number compared with ~56.3 in Germany (10). In addition, during 1994–2002, for 10 out of 12 ICCC groups, the annual average number of cases per hospital was less than one person.

DISCUSSION

The trend of centralization of childhood cancer treatment was studied based on the population-based cancer registry in Osaka. Little was previously known about this trend. Our study is valuable because we used population-based data that had about an 85–94% registration rate for children, and we looked at the information for a 28-year period (14).

After 1993, each cumulative frequency of hospitals decreased to about half along with the number of newly diagnosed cancers, and the degree of centralization was almost constant during the three diagnosed periods. These results suggest that childhood cancers have continually been treated at many different hospitals, and the reduction in the number of cases also reduced each cumulative frequency of hospitals. From 1993 to 1994, each cumulative frequency of hospitals reduced approximately by one-third. Around 1993, three large hospitals completed or relocated, so this was supposed to have influenced the trend of hospitals that accessed childhood cancer.

The annual number of cases by the ICCC deserves attention in terms of absolute smallness (Table 1). Despite this smallness, patients were treated at many different hospitals. And the annual average number of cases per hospital has remained very small, which was much lower compared to that in the UK, Georgia and Germany. In addition, each diagnostic group includes many types of cancer and their different treatments. So, centralization to specific hospitals is necessary to improve survival.

Looking at the results, the rarer the ICCC group was, the smaller the Gini coefficient was. Of the types of cancer found in children, clinical trials have been mainly conducted on the more common tumors, such as leukemia (I) or lymphomas and reticuloendothelial neoplasms (II) (13,17). This would have helped to more centralize the more common types of childhood cancer. More influential reasons for doing this would be as follows. Patients were able to freely select and attend treatment hospitals in the Japanese medical system, although they did not usually have enough information on where were specialists. Of total 566 hospitals in Osaka, patients had to find an appropriate one under uncertainty and incomplete information (18). Regretfully, general practitioners had not strictly referred cancer patients to childhood cancer specialists.

From a statistical point of view, the Gini coefficient for a small sample is known to include a downward bias (19,20). The Gini coefficients of each category may have a downward bias, and look to lower centralization, particularly during 1994–2002. Each cumulative frequency of hospitals for sympathetic nervous system tumors (IV) was exceptional compared with those of the other diagnostic groups. This was due to the mass screening at 6 months of age for neuroblastoma (IVa) that was introduced in 1985 and had continued into the 2000s across Japan. As a result of overdiagnosis, the annual age-standardized incidence rate increased by about three times in children from the periods of 1970–84 to 1985–94 (21). Table 1 also shows the increase in the total number of cases of sympathetic nervous system tumors (IV). However, as <10 hospitals carried out mass screening in Osaka, each cumulative frequency of hospitals during 1985–93 is about equal to those during 1994–2002.

Table 1. Cumulative frequency of hospital, Gini coefficient, and number of cases by the International Classification of Childhood Cancer, and diagnosed period

	Diagnosed period	Cumulative frequency of hospitals			Gini coefficient	Annual no. of cases	Total no. of cases
		50%	75%	100%			
I Leukemia	1975–1984	8	17	63	0.619	57.3	573
	1985–1993	7	15	53	0.607	49.0	441
	1994–2002	4	8	36	0.631	37.1	334
II Lymphomas and reticuloendothelial neoplasms	1975–1984	7	16	48	0.524	18.3	183
	1985–1993	7	12	41	0.544	19.0	171
	1994–2002	4	9	26	0.487	11.6	104
III Central nervous system and miscellaneous intracranial and intraspinal neoplasms	1975–1984	5	11	43	0.642	40.9	409
	1985–1993	6	14	47	0.591	33.9	305
	1994–2002	4	10	33	0.564	19.2	173
IV Sympatheic nervous system tumors	1975–1984	4	8	24	0.552	11.9	119
	1985–1993	3	7	28	0.657	22.9	206
	1994–2002	1	3	15	0.665	17.8	160
V Retinoblastoma	1975–1984	2	4	8	0.431	7.6	76
	1985–1993	2	3	9	0.463	4.0	36
	1994–2002	1	2	5	0.357	3.9	35
VI Renal tumors	1975–1984	4	9	19	0.441	7.0	70
	1985–1993	5	11	25	0.451	7.1	64
	1994–2002	2	5	12	0.448	3.9	35
VII Hepatic tumors	1975–1984	4	7	16	0.404	4.1	41
	1985–1993	3	6	15	0.471	4.8	43
	1994–2002	2	4	9	0.370	2.6	23
VIII Malignant bone tumors	1975–1984	3	6	21	0.589	7.5	75
	1985–1993	3	7	23	0.575	8.6	77
	1994–2002	3	5	11	0.402	5.2	47
IX Soft-tissue sarcomas	1975–1984	6	14	34	0.484	9.7	97
	1985–1993	6	15	36	0.472	12.1	109
	1994–2002	3	6	19	0.518	8.1	73
X Germ-cell, trophoblastic and other gonadal neoplasms	1975–1984	7	17	44	0.505	13.9	139
	1985–1993	6	16	42	0.501	15.0	135
	1994–2002	4	10	23	0.413	7.1	64
XI Carcinomas and other malignant epithelial neoplasms	1975–1984	4	8	16	0.382	3.4	34
	1985–1993	5	10	16	0.275	3.0	27
	1994–2002	3	6	10	0.275	2.2	20
XII Other and unspecified malignant neoplasms	1975–1984	9	18	46	0.476	16.0	160
	1985–1993	5	12	23	0.383	5.2	47
	1994–2002	4	10	18	0.306	3.7	33
Total	1975–1984	7	15	91	0.747	197.6	1976
	1985–1993	6	15	86	0.737	184.6	1661
	1994–2002	3	8	56	0.756	122.3	1101

With the exception of neuroblastoma (IVa), the survival of many diagnostic groups in Osaka was lower than that in England and Wales and in the USA, and the report suggested that the reason for this was insufficient introduction and practice of chemotherapy (22). Our study suggested that the low centralization of patients is also related to the lower survival. Previous studies also suggested that the lower survival will also related to the treatment volume in the field of surgery or radiotherapy, although these subjects were adult cancers (23,24). Therefore, to centralize childhood cancer to specific hospitals and to perform a higher volume of procedures are important to ensure better survival. For the centralization of treatment, however, the burden children and their families must deal within their daily lives would increase. A social support system would be needed to achieve and maintain centralization.

In our study, although the identification of treating hospitals was the point, 997 cases did not have treating hospital codes so that the diagnosing hospital code was alternatively adopted. The bias derived from this substitution is assumed minor, because the proportion of cases that the diagnosing hospital code was same as the treating hospital one was 91.8% (3435 cases).

These data included newly diagnosed patients only, so that the specialists might feel that the small degree of centralization would not reflect the realization for childhood cancer treatment. Further study would be needed to investigate the centralization taking into account the succession of treatment.

We confirmed that the hospitals that treated childhood cancers decreased approximately by half during the 1990s, because childhood cancer decreased because of a lower birth rate. The degree of centralization seemed almost constant from 1975 to 2002. The annual average number of cases per hospital marginally increased, although it still was much lower compared with European countries and the USA.

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Conflict of interest statement

None declared.

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Workflow Analysis of Medical staff in Surgical Wards Based on Time-Motion Study Data

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Abstract

The aim of this study is to clarify the change over time in the elements of work (job elements) and their features, as well as the relationship between job elements and the type of job, job class, and the role of the hospital they are performed in. A time-motion study was conducted on the medical staff in the surgical wards of two hospitals. An analysis of roles bys by (a) type or class of job type, and (b) hospital function was conducted. The number of working hours was analyzed, as well as the ratio of working hours with respect to direct and indirect job elements. The job elements required for each medical staff member were proven to differ by type of job (doctors and nurses) and also by job class (nurse leaders and staff). When comparing between hospital the differences in job elements were proven not to be a result of differences in hospital function, but to result from the ward system (ward design and nursing system).

1. Introduction

It is well known that doctors and nurses are hard-working professionals. It is recognized worldwide that planning an efficient, effective, and safe job workflow is one of the most important problems in hospital administration [1], [2].

The number of medical staff, their abilities, and the function of the ward (hospital) must be accurately assessed, and the interrelation of these parameters should be clarified.

In this study, we surveyed the numbers of doctors and nurses working in hospitals with different roles. We aimed to clarify the change over time in job elements and their features, as well as the relationship between job elements and the type of job, job class, and the function of the hospital they are performed in.

2. Methods

2.1. Time-motion study

A time-motion study of the job workflow of medical staff (doctors and nurses) was conducted in a surgical ward at an advanced treatment hospital in Osaka, and at a regional general hospital in Hyogo. Both hospitals are in Japan. The study was conducted for 24 consecutive work hours in the advanced treatment hospital, and throughout a working day shift in the regional general hospital [3]-[6]. To maintain accuracy in job records, graduate certified nurses, radiological technologists, and clinical laboratory technicians were asked to record job elements and their durations in units per second. Each observer recorded job elements performed by the nurse or doctor involved in a free format, using the terms "where," "since when," "until when," "by whom," "for whom," and "which job element". Classified codes or templates were not prepared beforehand to avoid observer bias.

The recorded job workflow was checked in parallel to maintain accuracy and oversight of the documentation.

2.2. Classification of job elements by coding

The coding format for the observed data was defined by the Osaka Time-Motion Study Group, consisting of academic researchers and experienced clinical staff. The format consisted of up to 91 items for nurses and 105 items for doctors. The documented records of job elements were entered into a time-Motion database using a specific format devised by trained coding specialists.

The classification had a three-level hierarchy for doctors and nurses. The top level hierarchy was "main category," followed by "sub category" and "specified category."

2.3. Data analysis

Firstly, jobs were analyzed by job type or job class. The number of working hours was analyzed, as well as the ratio of working hours spent on direct and indirect job elements. Secondly, jobs were analyzed by hospital function. The number of working hours was analyzed, as well as the ratio of working hours spent on direct and indirect job elements. The results of this analysis were used as data in 2000 and 2004. The respondent doctors were residents in the advanced treatment hospital, and full-time doctors in the regional general hospital. Job analysis by hospital function was not conducted for doctors.

For nurses, the advanced treatment hospital used a primary nursing care system and the regional general hospital used a team nursing care system. Both hospitals had three working shifts per day (eight working hours per shift). Job analysis by hospital function was conducted for nursing staff in the regional general hospital and all nurses in the advanced treatment hospital.

Two "flags" were prepared to distinguish between simultaneously or ambiguously recorded jobs. The "Serial job elements" flag was used if an observer could not record the end of a job element because the medical staff member performed many job elements quickly one by one in a short period of time. The "Parallel job elements" flag was used if a staff member performed two or more job elements in the same unit of time. For example, carrying out vital sign measurements (e.g., recording body temperature) while observing patient status and explaining the status to the patient.

Two more flags were classified: The "Direct job elements" flag was used if doctors or nurses contacted patients directly and the "Indirect job elements" flag was used for job elements other than direct job elements.

3. Results

3.1. Analysis of jobs by job type or job class (advanced treatment hospital)

3.1.1. Working hours

Table 1 shows the working hours of doctors and nurses. When the working hours were calculated for serial job elements, those of doctors were about 45 minutes longer than those of nurses. For parallel job elements, the working hours of doctors were about 30 minutes longer

■ Table 1: Working hours of doctors and nurses (advanced treatment hospital)

Job type	Job class	Working hours (Serial)	Working hours (Parallel)	Serial / Parallel
Doctor	Resident	10:15:25	11:01:24	1.07
Nurse	Staff	9:31:17	10:31:44	1.11

■ Table 2: Percentages of working hours spent on direct and indirect jobs by doctors and nurses (advanced treatment hospital)

	Doctors		Nurses	
	Working hours	Ratio (%)	Working hours	Ratio (%)
Direct job elements	5:01:46	58.1	2:20:56	27.3
Direct job elements (preparation or cleaning up)	0:34:42	6.7	1:07:56	13.1
Indirect job elements	2:54:45	33.7	4:56:38	57.4
Indirect job elements (preparation or cleaning up)	0:08:04	1.6	0:11:12	2.2
Total	8:39:16	100.0	8:36:42	100.0

than those of nurses. Nurses had a higher ratio of parallel time to serial time than doctors.

3.1.2. Working hours spent on direct and indirect jobs

Table 2 shows the working hours spent on direct and indirect jobs for doctors and nurses. The percentage of working hours spent on direct jobs by doctors was higher than that of nurses, which was the opposite case to the percentage of working hours spent on indirect jobs. The percentage of working hours spent by doctors on "preparation or cleaning up", for direct and indirect jobs, was lower than that of nurses.

3.2. Analysis of jobs by job type or job class (regional general hospital)

3.2.1. Working hours

Table 3 shows the working hours of doctors and nurses. When the working hours were calculated for serial job elements, those of doctors and nurses were almost identical. For parallel job elements, the working hours of nurses were about one hour longer than those of doctors. Nurses had a higher ratio of time spent on parallel tasks compared to time spent on serial tasks than doctors.

For nurses, the working hours of leaders and staff were almost identical when they were calculated for parallel job elements. For serial job elements, the working hours of nurse leaders were about 40 minutes longer than those of nursing staff. Nursing staff had a higher ratio of time spent on parallel tasks compared to time spent on serial tasks than nurse leaders.

3.2.2. Working hours of direct and indirect jobs

Table 4 shows the working hours spent on direct and indirect jobs for doctors and nurses. The percentage of working hours spent by doctors on direct jobs was higher than that of nurses, which was the opposite case to the percentage of working hours spent on indirect jobs. The percentage of working hours spent by doctors on "preparation or cleaning up" for direct and indirect jobs was much lower than that of nurses.

For nurses, the percentage of working hours spent on direct jobs by nurse leaders was lower than that of nursing staff, which was the opposite case to the percentage of working hours spent on indirect jobs. The percentage of working hours spent on direct jobs (preparation or cleaning up) was almost identical for nurse leaders and staff. The percentage of working hours spent on indirect

■ Table 3: Working hours of doctors and nurses (regional general hospital)

Job type	Job class	Working hours (Serial)	Working hours (Parallel)	Serial / Parallel
Doctor	-	9:18:32	9:39:31	1.04
Nurse	All	9:14:19	10:24:22	1.13
	Leader	9:40:41	10:27:49	1.08
	Staff	9:03:47	10:22:59	1.15

■ Table 4. Percentages of working hours spent on direct and indirect jobs by doctors and nurses (regional general hospital)

	Doctors		Nurses					
			All		Leaders		Staffs	
	Working hours	Ratio (%)	Working hours	Ratio (%)	Working hours	Ratio (%)	Working hours	Ratio (%)
Direct job elements	4:53:49	66.9	2:34:27	30.4	1:39:36	18.6	2:56:24	35.5
Direct job elements (preparation or cleaning up)	0:02:55	0.7	0:42:26	8.4	0:45:45	8.6	0:41:06	8.3
Indirect job elements	2:17:03	31.2	4:51:04	57.4	5:47:50	65.1	4:28:22	54.0
Indirect job elements (preparation or cleaning up)	0:05:34	1.3	0:19:24	3.8	0:40:55	7.7	0:10:47	2.2
Total	7:19:21	100.0	8:27:21	100.0	8:54:06	100.0	8:16:39	100.0