A SIMULATION MODEL FOR ANALYZING THE NIGHT-TIME EMERGENCY HEALTH CARE SYSTEM IN JAPAN

Yusho Kasuga
Tokyo Institute of Technology
ksuga09@cs.dis.titech.ac.jp

Manabu Ichikawa
Tokyo Institute of Technology
ichikawa@dis.titech.ac.jp

Hiroshi Deguchi
Tokyo Institute of Technology
deguchi@dis.titech.ac.jp

Yasuhiro Kanatani
National Institute of Public Health
ykanatani@niph.go.jp

ABSTRACT

The current Japanese night-time emergency health care system can no longer meet patient demand due to the change in the patient's consultation behavior and the doctor's uneven distribution. We propose a technique for modeling the whole processes of night-time emergency health care, the patient's consultation behavior process, the patient transportation process, and the negotiation process between a medical institute and an ambulance in order to simulate the current situation of night-time emergency health care in Japan. To construct this model, we use an agent-based modeling(ABM) approach that can take each decision making of the patient, the medical institution, and the fire department into consideration. This model allows us to evaluate improvement plans, especially focusing on the hospital rotation and the facility location. This study aims to build a simulation tool to achieve a sustainable medical treatment system, an efficient use of the limited medical resource and an improvement of medical service level.

INTRODUCTION

Recently, the emergency patient's acceptance refusal is becoming a problem at night-time in the city outskirts in Japan. The cause that the medical institution cannot respond to the patient transportation includes "Unprofessional", "Doctor is treating other patient", "All bed is fulfilled", and "Absence of doctor", and so on. The acceptance refusal by the medical institution can cause the delay of the transportation time of the patient, and that becomes one of the important factors that control patient's prognosis. Therefore, an immediate improvement is necessary for the Japanese night-time emergency health care system. The causes of the increasing number of emergency patient's acceptance refusal are increasing demand of emergency patient caused by an aging society, and the doctor's uneven distribution caused by the clinical training system revision (Development Bank of Japan , 2009). The problem of the doctor's uneven distribution is especially serious. Differences of the number of doctors between districts or hospital departments have extended, while the total of the doctor increases gradually. As a result, in a part of the districts or the hospital departments, the number of doctor is insufficient, and that is the main cause of the increase in the number of the emergency patient's acceptance refusal at night (Okamoto, 2010).

For these reasons, a lot of cities and districts are working on the improvement of the night-time emergency health care system. Especially, daily rotation systems that offer treatment for severe patient who need hospitalization by cooperating with hospitals in the same district on a rotation basis have already been introduced in a lot of districts. However, the running conditions of daily rotation systems are different in each district, and currently daily rotation systems do not function optimally. Therefore, the construction of a new night-time emergency health care system is necessary to enhance the daily rotation systems (Ministry of Health, Labour and Welfare, 2008).

Generally, the Japanese night-time emergency health care system is composed of the emergency transportation section by the fire department, and the emergency medical treatment section by the medical institution. For improvement of the night-time emergency health care, technical improvement of both sections and close cooperation between them are important. Furthermore, it is necessary to consider the geographic population distribution, the facility location, and the differences in the patient's consultation behavior, the transportation route, and the treatment process according to the patient type in order to discuss the delay of the patient transportation time.

In this study, we construct a simulation model that reproduced the current night-time emergency health care system operated by the fire department and the medical institution. Moreover, the problem of the emergency patient acceptance refusal is reproduced as a dynamic process by considering the decision making of the patient, the fire department, and the medical institute. As a result, using this simulation model, we can evaluate an applicable improvement plan to the real situation. This study aims to build a simulation tool to achieve a sustainable medical treatment system, an efficient use of the limited medical resource and an improvement of medical service level.

METHODOLOGY

LITERATURE REVIEW

We can divide previous works that take a simulation approach to the problem of emergency health care roughly into two categories. One is the research about the ambulance transportation section operated by the fire department, and another one is the research about the emergency medical treatment section operated by the medical institution.

Regarding the research about the ambulance transportation section, there is the analysis by Oyama (Oyama, 2000). Oyama works on the optimum location problem of the firehouse to minimize accommodation time, the duration from patient's calling an ambulance to the accommodation by the medical institution, and show the optimal location of the firehouse considering the patient demand. However, because the entire problem is modeled by the top -down approach as the patient division is not considered, and patient's emergency demand is modeled by a Poisson distribution, and detailed emergency elements like the difference in the transportation route are not considered. Moreover, this formulation is difficult to apply to a real problem, because the constraints of the medical institution that is involved in the patient accommodation, and the existence of patients who visits the medical institution on their own way are not considered.

Regarding the research about the emergency medical treatment section, there is an analysis by Matsumoto (Matsumoto, 2001). Matsumoto works on the optimization problem to minimize the patient's travel distance for the improvement of efficiency of the daily rotation system discussed in our study. As a result, it was shown that an improvement in patient's travel distance was expected by changing the rotation of the hospital. Discussion of the access cost of the night-time emergency health care in Japan requires having into account the patient's transportation time. For this reason, this study is also difficult to apply to a real problem.

METHODOLOGY OF THIS RESEARCH

In this study, we use an ABM approach to discuss the delay of the patient's transportation time. An applicable model is constructed by modeling the difference between the patient's consultation behavior and the patient's transportation route according to the patient's age, disease type, and disease level, at the same time, the consideration of characteristics of the population distribution and the facility location. Moreover, the patient accommodation condition of the medical institution is set as a constraint actually suited, and the current problem of the emergency patient acceptance refusal is reproduced by using a bottom-up approach. Using these methodologies, we aim to propose an applicable improvement plan to a real problem as a result.

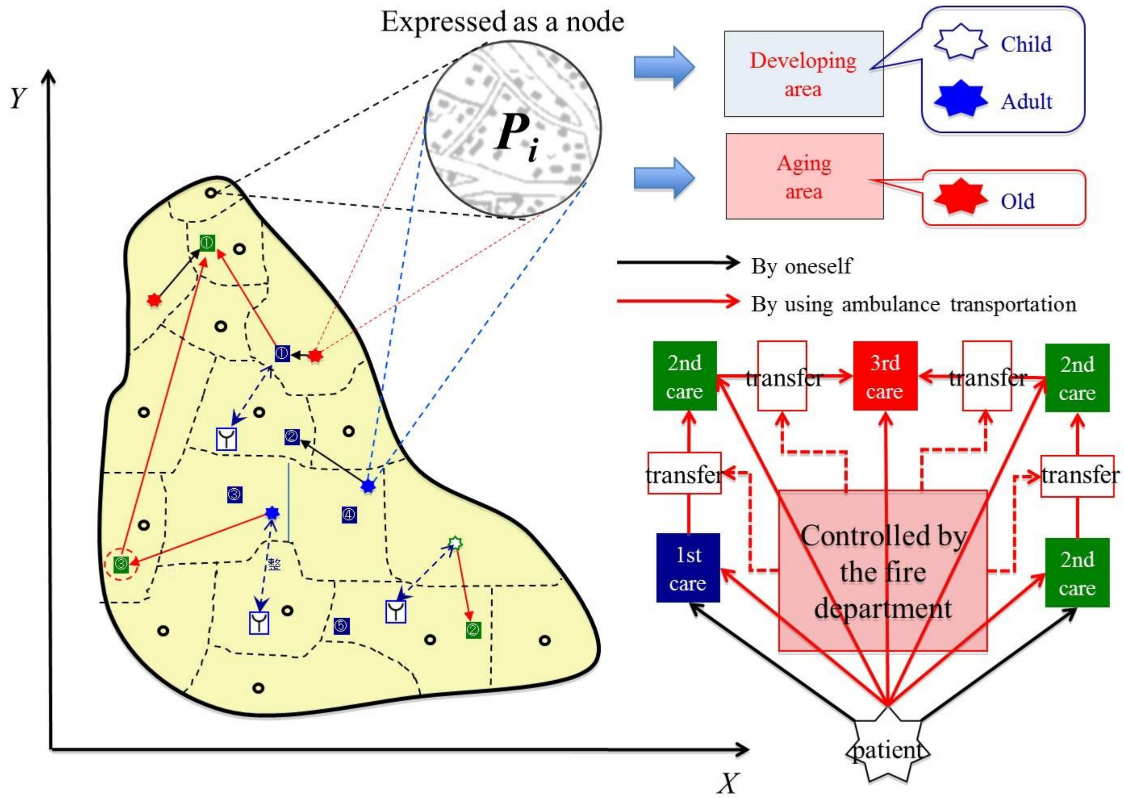
MODEL

OUTLINE OF THE MODEL

The medical institution, the firehouse, human, and the ambulance in the night-time emergency health care are modeled. Human is classified into three cohorts according to the age, and the patient is generated according to the incidence probability of each cohort. The medical institution has the diagnosis and treatment departments, and the patient consults the diagnosis and treatment department that is appropriate for one's disease type. At this moment, patients stochastically choose either of the two routes, consulting by oneself, by taxi or by private car, or using ambulance transportation according to the disease type, the disease level, and the age. If using ambulance transportation, the ambulance, not patient, selects the medical institution according to the patient type. After accommodating patient by the medical institution, the triage is done in the medical institute, and from the serious case, diagnosis and treatment will be done. The ambulance is requested again when transferring the patient is necessary after diagnosis and treatment, and it is transferred to a suitable medical institution.

In this study, a simulation model that reproduced a series of process in the night-time emergency health care at the above-mentioned is constructed. The situation treated in this study is shown in Figure 1.

The Situation Treated in this Study
Figure 1



DEFINITION OF THE MODEL

- **Place**

The place is a demand point where human lives, and it is expressed as a node. A set of place is defined as follow:

$$\textbf{Place}=\{P_i|\mathrm{i}=1,2,\ldots,p\}$$

A set of place has a coordinate values described as x_{Pi} and y_{Pi}. And a set of place has a population, a number of child described as cn_i, a number of adult described as an_i, and a number of old man described as on_i.

- **Medical institute**

Medical institute is defined as the place that has a role to accommodate patient and provide diagnosis and treatment, is expressed as a node. Medical institute's function level is divided into three types according to their service level. Each function level is defined as follow:

a. Primary-level emergency medical institute:

That can treat emergency patient who doesn't need inpatient hospital care.

b. Secondary-level emergency medical institute:

That can treat sever emergency patient who need inpatient hospital care.

c. Thirdly-level emergency medical institute

That can treat sever emergency patient who cannot be treated at the secondary-level medical institute.

Medical institute has diagnosis and treatment departments. Correspondence with the actual diagnosis and treatment department is shown in Table 1 as a definition of the diagnosis and treatment department that treated in this study.

A set of medical institute is defined as follow:

$$\textbf{Medical Institute}=\{M_j\,|\,\mathrm{j}=1,2,\ldots,m\}$$

A set of medical institute has a coordinate values x_{Pi} and y_{Pi}, a function defined as **FunctionType**=$\{FT_i$ | primary, secondary, thirdly$\}$, a condition of internal medicine defined as **InternalCondition**=$\{IC_j$ | not acceptable, acceptable$\}$, a condition of surgery defined as **SurgeryCondition**=$\{SC_j$ | not acceptable, acceptable$\}$, a condition of pediatric defined as **PediatricCondition=**$\{PC_j$ | not acceptable, acceptable$\}$, a number of bed described as bn_j, a department list of day shift described as $SettingDepartmentList_j$, a department list of night shift described as a $AcceptableDepartmetList_j$, and a waiting patient list of each

Definition of diagnosis and treatment departments
Table 1

Department in this study	Actual department
Neurology	Neurology, Neurosurgery
Cardiology	Cardiology, Cardiovascular Surgery
Gastroenterology	Gastroenterology, Gastrointestinal Surgery
Pulmonology	Respiratory Medicine, Thoracic Surgery
Psychiatry	Psychiatry
Urology	Urology
Internal	Internal medicine
Surgery	Surgery, Orthopedic Surgery, emergency
Pediatric	Pediatrics

hospital described as $WaitingPatientList_j$.

- **Firehouse**

Firehouse is defined as the place that is a waiting place for the ambulance, is expressed as a node. A set of firehouses is defined as follow:

Firehouse={F_k | i=1,2,…,f}

A set of firehouses has a coordinate values x_{Pi} and y_{Pi}, a list of place of incidence of patient is described as $IncidencePlaceList_k$, a list of medical institute divided by the function and the department described as $InternalPrimaryList_k$, $SurgeryPrimaryList_k$, $PediatricPrimaryList_k$, $InternalSecondaryList_k$, $SurgerySecondaryList_k$, $PediatricSecondaryList_k$, $InternalThirdlyList_k$, $SurgeryThirdlyList_k$, $PediatricThirdlyList_k$.

- **Human**

Human is classified into three cohorts according to the age. Each cohort is defined as follow:

a. Child: from 0 to 15 years.
b. Adult: from 16 to 64 years.
c. Old: over 65 years.

Human has a disease type and a disease level that determine the patient type after incidence as a patient. The definition of disease type divided based on the International Classification of Diseases (ICD) that is established by World Health Organization (WHO) is shown in Table 2. The definition of disease level and the necessary function level of medical institute corresponding with each disease level are shown in Table 3.

Definition of disease type
Table 2

Disease type	ICD code
Brain disease	a-0904, a-0905 within Ⅸ
Heart disease	a-0901, a-0902, a-0903 within Ⅸ
Digestive disease	Ⅺ
Respiratory disease	Ⅹ
Mental disease	Ⅴ
Sense organ disease	Ⅵ, Ⅶ, Ⅷ
Urologic disease	XIV
Internal disease	Ⅰ, Ⅲ, Ⅳ, XⅡ, XV, XVI, XⅦ, XⅧ, XX, XXI, XXⅡ
External disease	XⅢ, XⅨ

Definition of disease level and necessary function level of medical institute
Table 3

Disease level	Definition	Necessary function level
Slight	Disease level that doesn't need inpatient hospital care	More than primary
Moderate	Disease level that needs inpatient hospital care within 3 weeks	More than secondary
Severe	Disease level that needs inpatient hospital care over 3 weeks	More than secondary

A set of human is defined as follow:

Human=$\{H_i|$i=1,2,…,$h\}$

A set of human has an age class described as **Age-Class**=$\{AC_i$ | child, adult, old}, a disease type described as **DiseaseType**=$\{DT_s$ | s=1,2,…,10}={brain disease, heart disease, digestive disease, respiratory disease, mental disease, sense organ disease, urologic disease , internal disease, external disease}, a disease level described as **DiseaseLevel**=$\{DL_t$ | t=1,2,3}={slight, moderate, advanced}, a consultation route that represent the way of patient consultation described as **ConsultationRoute**=$\{CR_u$ | u=1,2}= {using ambulance transportation, by oneself }. A list of candidate medical institute for consulting that is referred by the patient choosing consultation route of by oneself described as *FeasinbleHospitalList$_i$*, a incidence probability according to the age class, the disease type, and the disease level described as $P_1\{AC_i \cap DT_s \cap DL_t\}$, a probability that patient choose the consultation route of using ambulance transportation described as $P_2\{(AC_i \cap DT_s \cap DL_t) \cap MM_u | u=1\}$, and a probability that patient choose the consultation route of by oneself described as $P_3 \{(AC_i \cap DT_s \cap DL_t) \cap MM_u | u=2\}=1-P_2$.

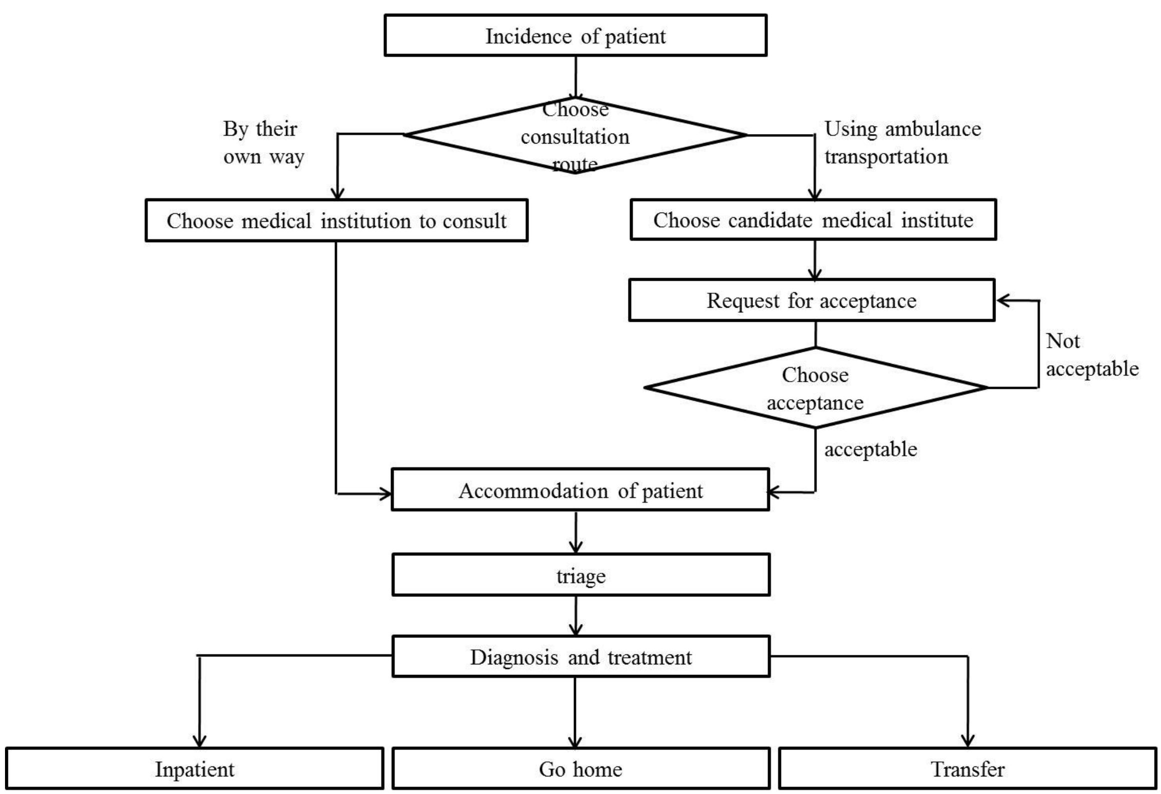
- **Ambulance**

  A set of ambulance is defined as follow:

Ambulance=$\{A_j|$j=1,2,…,$n\}$

A set of ambulance has an assigned firehouse described as **AssignedFirehouse**=$\{AF_k$ | k=1,2,…,$n\}$, and a

Flow of the model
Figure 2



list of candidate medical institute that is referred by the ambulance transporting a patient chooses consultation route of using ambulance transportation described as *CandidateHospitalList$_j$*.

FLOW OF THE MODEL

Flow of the model is shown in Figure 2. In this section, there are some explanations about the details of each phase of the model.

INCIDENCE OF PATIENT

- Patient is generated according to the incidence probability $P_1\{AC_i \cap DT_s \cap DL_t\}$.

CHOOSE CONSULTATION ROUTE

- Patient choose the consultation route according to the probability $P_2\{(AC_i \cap DT_s \cap DL_t) \cap MM_u | u=1\}$ or $P_3\{(AC_i \cap DT_s \cap DL_t) \cap MM_u | u=2\}$

CHOOSE MEDICAL INSTITUTE TO CONSULT

1. According to their own patient type, a patient who choose the consultation route of by oneself makes a list of candidate medical institutes, *FeasinbleHospitalList$_i$*, from *InternalPrimaryList$_k$*, *SurgeryPrimaryList$_k$*, *PediatricPrimaryList$_k$*, *InternalSecondaryList$_k$*, *SurgerySecondaryList$_k$*, or *PediatricSecondaryList$_k$*,
2. Within *FeasinbleHospitalList$_i$*, patient chooses the nearest one to consult, and moves to that medical institute.

- Correlation between patient type and diagnosis and treatment department is shown in Table 4.

CHOOSE CANDIDATE MEDICAL INSTITUTE

- According to the patient type, ambulance which transports the patient who choose the consultation route of using ambulance transportation makes a list of candidate medical institute, *CandidateHospitalList$_j$*, from *InternalPrimaryList$_k$*, *SurgeryPrimaryList$_k$*, *PediatricPrimaryList$_k$*, *InternalSecondaryList$_k$*, *SurgerySecondaryList$_k$*, *PediatricSecondaryList$_k$*, *InternalThirdlyList$_k$*, *SurgeryThirdlyList$_k$*, *PediatricThirdlyList$_k$*.

REQUEST FOR ACCEPTANCE

- According to *CandidateHospitalList$_j$*, an ambulance makes a request for accommodation of patient to the nearest one.
- If the request is refused, an ambulance makes a request to the second nearest one.
- If the request to the second nearest one is refused, an ambulance makes a request one after the other.

CHOOSE ACCEPTANCE

- According to the constraint of accommodation of patient, a medical institute chooses to accept or refuse the request of accommodation of patient from an ambulance.
- Constraint of accommodation of patient is defined as

Correlation between patient type and diagnosis and treatment department
Table 4

Disease type \ Age class	Child	Adult	Old
Brain disease	Pediatric	Internal	Internal
Heart disease	Pediatric	Internal	Internal
Digestive disease	Pediatric	Internal	Internal
Respiratory disease	Pediatric	Internal	Internal
Mental disease	Pediatric	Internal	Internal
Sense organ disease	Pediatric	Internal	Internal
Urologic disease	Pediatric	Internal	Internal
Internal disease	Pediatric	Internal	Internal
External disease	Surgery	Surgery	Surgery

follow:

[1] About a number of bed.

- $bn_j > 0$.

[2] About a condition of each diagnosis and treatment department.

- If the patient need a diagnosis and treatment by internal department,
- IC_j = acceptable.
- If the patient need a diagnosis and treatment by surgery department,
- SC_j = acceptable.
- If the patient need a diagnosis and treatment by pediatric department,
- PC_j = acceptable.

ACCOMODATION OF PATIENT

- Medical institute accommodate the patients who choose the consulting route of by oneself, and the patients who choose the consulting route of using ambulance, and meet constraint of accommodation of patient.

TRIAGE

- Because the secondary and thirdly emergency medical institutes have the role of treating sever patient, triage is done in those medical institute, and from the serious case, diagnosis and treatment will be done.

DIAGNOSIS AND TREATMENT

- Treating time of each patient that is determined according to their disease level is defined as *st* for the slight, *mt* for the moderate, and *at* for the advanced.
- During the treatment, a condition of each department of each medical institute, IC_j, SC_j, and PC_j, is set to "not acceptable".

INPATIENT, TRANSFER, GO HOME

- From the definition of disease level of patient, patient who have a moderate or advanced level of disease need to be inpatient, and the other one, slight level of disease will go back home after diagnosis and treatment.
- When the patient need to be inpatient,
    - if the medical institute they consult has a special department correspond with their disease type,
        - the patient can be inpatient in that hospital.
  - if the medical institute they consult has a special department correspond with their disease type,
    - the patient needs to be transferred to other medical institute that has a specialized department corresponding to one's disease type.
- Correlation between disease type and special department is shown in Table 5.

EVALUATION INDEX

In this study, we will evaluate the results of the simulation from the view of both the patient and the doctor who is the main stakeholder in the night-time emergency health

Correlation between disease type and special department
Table 5

Disease type	Specialized department
Brain disease	Neurology
Heart disease	Cardiology
Digestive disease	Gastroenterology
Respiratory disease	Pulmonology
Mental disease	Psychiatry
Sense organ disease	Internal
Urologic disease	Urology
Internal disease	Internal
External disease	Surgery

care system. The patient transportation time, until being accommodated from the incidence of disease, and the doctor working hour are evaluated.

Patient transportation time and the doctor working hour have a trade-off relation, if we optimize one side, the other side is deteriorated. Therefore, the improvement of the night-time emergency health care system is expected by deriving a preferable combination of both of these evaluation indexes. Then, in this study, we derive the preferable daily rotation system from the point of both the patient transportation time and the doctor working hour. An example of the rotation table that has been used in the daily rotation systems in Japan is shown in Table 6.

Moreover, the number of waiting patient of each hospital is used as an evaluation index for analyzing the balance between the distribution of medical resource and the distribution of patient demand. From the view of policy making, this type of analysis is necessary and indispensable.

Since we focus on the night-time, the road congestion situation is not considered in this study. Therefore, we assume that the ambulance moves at a fixed velocity at 60 km/h. Moreover, the speed of the taxi or private car, patient who choose consulting route of by their own uses, is assumed to move at a fixed velocity at 30 km/h that is the average speed in the residential area. And, we use Euclidean distance between the coordinates of each node as a traveling distance.

An example of the result obtained by using this model is shown as follows. The patient transportation time is shown in Table 7, and the doctor working hour is shown in Table 8. Moreover, the number of waiting patient of each

An example of expression of daily rotation system (m = 7)
Table 6

Day	Department	M_1	M_2	M_3	M_4	M_5	M_6	M_7
1	Internal	●						
	Surgery			●				
	Pediatric						●	
	…							
	…							
	…							
	Cardiology							●
2	Internal		●			●		
	Surgery				●			
	Pediatric							
	…							
	…							
	…							
	Cardiology							
⋮	⋮	⋮						
30	Internal					●		
	Surgery		●					
	Pediatric			●				
	…							
	…							
	…							
	Cardiology							●

medical institute is shown in Figure 3. Using these results, we can evaluate the health care planning from both a micro and a macro viewpoint. From a micro level, it is represented by the patient transportation time and the doctor working hour, and from a macro level, it is represented by the number of waiting patient of each medical institute.

CONCLUSION AND FUTUREWORK

In this paper, we propose a new technique of constructing simulation model that can take decision making of the patient, the fire department, and the medical institute into consideration by using an ABM approach. As a result, it is possible to derive an applicable improvement plan to a real situation focusing on the delay of patient transportation, which was not possible using traditional optimization approach. Regarding the construction and the execution environment of the simulation model mentioned above, we use SOARS that is a simulation language designed for social simulation (Ichikawa, 2007). We choose SOARS because it doesn't need an excellent program skill to modify the model.

As future work, we will collect the real data to forecast detailed emergency patient demand. Moreover, we will collect data from not only the investigation concerning the realities of the patient consultation behavior and ambulance transportation but also from a geographic viewpoint in that case. As a result of these works, it is possible to extend this model to deal with location problems and routing problems of the fire department, the medical institute, and the ambulance.

According to the opinion from some specialist,

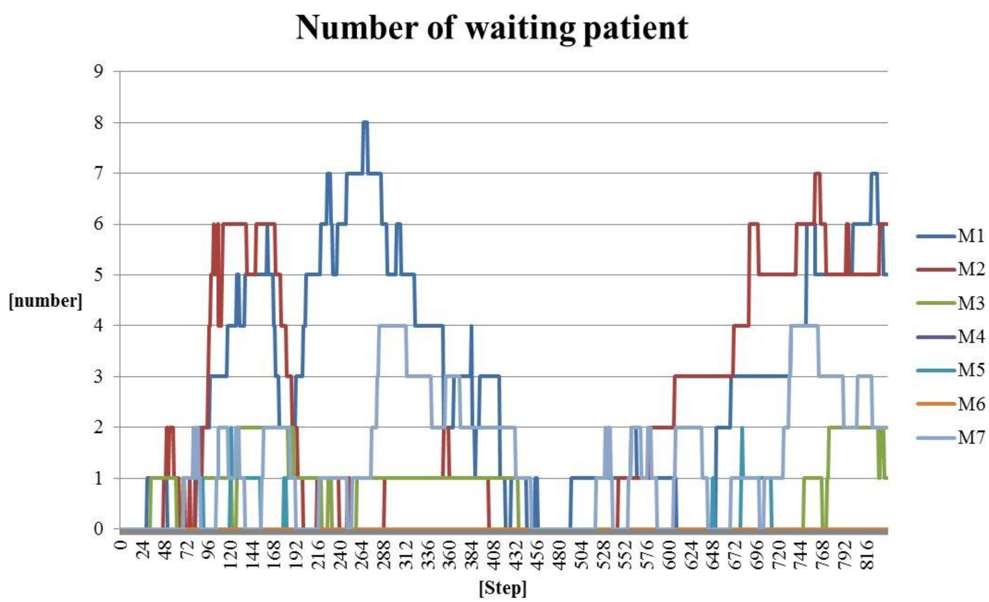
Patient transportation time [min] (patient who has an age class of child)
Table 7

Age class	Disease level	Disease type	Mean
Child	Slight	Brain disease	29.56
		Heart disease	37.78
		Digestive disease	33.33
		Respiratory disease	37.63
		Mental disease	49.00
		Sense organ disease	33.33
		Urologic disease	29.00
		Internal disease	29.88
		External disease	44.00
	Moderate	Brain disease	27.99
		Heart disease	39.10
		Digestive disease	43.67
		Respiratory disease	34.68
		Mental disease	84.00
		Sense organ disease	34.87
		Urologic disease	31.14
		Internal disease	27.07
		External disease	29.75
	Advanced	Brain disease	28.87
		Heart disease	39.00
		Digestive disease	35.25
		Respiratory disease	41.30
		Mental disease	28.00
		Sense organ disease	29.00
		Urologic disease	33.00
		Internal disease	58.00
		External disease	33.33

Doctor working hour [hour] (doctor who works in M_1)
Table 8

Medical institute	Department	Hours
M_1	Neurology	168
	Cardiology	392
	Gastroenterology	-
	Pulmonology	-
	Psychiatry	-
	Urology	-
	Internal	392
	Surgery	392
	Pediatric	-

Number of waiting patients
Figure 3



“Although it is ideal to have a uniform rotation system, that would increase the workload of some specific departments”. From this point of view, it is important to concentrate on obtaining desirable daily rotation system in the future. For this reason, it will be necessary to clarify the method of analysis and the target function. Especially, the cost analysis intended for the working cost of the doctor is important. Therefore, we must fix an evaluation index through the investigation concerning doctor's working environment in the future.

In order to discuss the health care planning, it is necessary to analyze from a policy viewpoint. Therefore, we will conduct a monetary cost analysis under the assumption that we may need to hire additional doctors and/or may need to increase the budget.

As an application of this model to other situation, we think it is useful as a simulation tool for a crisis management under the case of emergency situations, pandemic or disaster. In this model, we can change incidence probability outside of a model. And we have reproduced general emergency health care system in Japan, composed of the emergency transportation section and the emergency medical treatment section. For those reasons, we can analyze a limitation of the current Japanese emergency health care system by changing incidence probability in the some specific areas. Moreover, we can consider the desirable system design to increase a limitation of the current Japanese emergency health care system. Although we only focused on a case of night-time emergency health care as one example of some emergency situations in this study, we aim that this model will be applied to some other emergency cases, and used as a tool for a crisis management.

As an application to other case, in the future, this model is useful as a simulation tool for a crisis management under the case of emergency situations such as pandemic or disaster. In this model, we can change incidence probability in order to examine such emergency situations. Moreover, we have reproduced general emergency health care system in Japan that composed of the emergency transportation section and the emergency medical treatment section. For those reasons, we can analyze a limitation of the current Japanese emergency health care system by changing incidence probability in the some specific areas. Therefore, we can consider the desirable system design to increase a limitation of the current Japanese emergency health care system. Although we only focused on a case of night-time emergency health care as one example of some emergency situations in this study, we aim that this model will be applied to some other emergency cases, and used as a tool for a crisis management.

REFERENCES

Development Bank of Japan (2009). "The Present Situation and Problems in Emergency Medical Care", retrieved from

http://www.dbj.jp/pdf/findicate/no130.pdf

Okamoto, Tanaka, Inoue, Yoshiwara, Ode (2010). "Positive examination concerning the realities of ambulance transportation

accommodation refusal", retrieved from http://www.fasd.or.jp/tyousa/pdf/21-6hansoukyohi.pdf

Ministry of Health, Labour and Welfare (2008). "Study committee concerning ideal way of emergency medicine in the

future", retrieved from http://www.mhlw.go.jp/shingi/2008/07/dl/s0730-21a.pdf

Oyama, Suzuki (2000). "Optimal location of ambulance considering transportation to hospital", The Operations Research

Society of Japan, retrieved from http://ci.nii.ac.jp/els/110003481174.pdf?id=ART0004102737&type=pdf&lang=en&host=cinii&order_no=&ppv_type=0&lang_sw=&no=1289818087&cp=

Matsumoto, Koshizuka (2001). "Pediatric facilities arrangement at nighttime focusing on traveling distance", retrieved from http://toshisv.sk.tsukuba.ac.jp/Thesis/H16_2004/final/200101050.pdf

Ichikawa,M.,Tanuma,H,Koyama,Y.Deguchi,H (2007). "SOARS for simulations of social interactions and gaming.

Introductuon as a social microscope", Proceedings of the 38th Annual Conference of the International Simulation and Gaming Association,P-36