admission according to the JCS, and more than half were admitted without existing comorbidities. Unadjusted mean hospital charges were $6,471, with a mean LOS of 21.97 days.

The hospitals in our sample consisted of general hospitals providing a range of services not limited to stroke care. Of the 36 hospitals, 27 were private-owned and 9 were publicly-owned. Twenty-nine of the hospitals were teaching hospitals, while 7 of the hospitals were not. The hospitals had a mean of 435 beds, with an inter-hospital range of 98 to 1,125 beds. More than half of the hospitals had ICUs, but only 2 of the hospitals had dedicated stroke care units. There was a mean of 98 doctors (range: 9~392) and 337 nurses (range: 45~1,138) in each hospital. Fourteen of the 36 hospitals in our sample had both neurosurgery and neurology departments, 15 hospitals had only one of the two departments, and 7 hospitals had neither (in which case stroke patients were warded in internal medicine or other departments).

Healthcare-Associated Infection Incidence

The overall HAI incidence in our sample was 16.4%. As seen in Figure 1, there was a large variation of HAI incidence at the hospital level, with a range from 4.7% to 28.3%. Seventeen of the 36 hospitals had HAI incidence proportions lower than the overall mean.

Risk-adjusted Hospital Charges and Length of Stay

The results of the linear regression analyses are shown in Table 2. The first model for both hospital charges and LOS (as dependent variables) included hospital stratification, while the second model excluded hospitals as independent variables. Tests for multicollinearity were performed and all variance inflation factors (VIF) values were found to be below 2.1 (data not shown).

With regard to hospital charges, the first model had an R^2 value of 0.764 ($P < 0.001$). Independent variables which showed significant association with hospital charges included age, sex, Barthel index, both types of stroke, Charlson score, LOS, surgery, CVC use, mechanical ventilation, dysphagia, ICU stay, all JCS levels, and 25 hospitals. LOS showed the strongest association with increased hospital charges (β= 0.781; $P < 0.001$). All independent variables in the second model ($R^2 = 0.711$; $P < 0.001$) except for CVC use and JCS levels 100~300 showed significant associations with hospital charges.

The first model for LOS ($R^2 = 0.308$; $P < 0.001$) showed that sex, Barthel index, both types of stroke, Charlson score, surgery, mechanical ventilation, dysphagia, ICU stay, all JCS levels, and 24 hospitals had significant associations with increased LOS. Mechanical ventilation, CVC use and JCS levels 100~300 had the highest standardized coefficients amongst the independent variables. In the second model, ($R^2 = 0.222$; $P < 0.001$), sex, atherothrombotic stroke, CVC use and mechanical ventilation showed no significant association with increased LOS.

After conducting risk-adjustment based on data from the first model, the overall mean hospital charges were $6,009 for uninfected patients and $9,076 for infected patients, resulting in an additional $3,067 associated with HAIs. LOS after risk-adjustment was 19.0 days in uninfected patients and 35.3 days in infected patients, with an additional 16.3 day-increase associated with HAIs. Mean hospital charges per day for uninfected and infected patients were thus $317 and $257, respectively.

Using data from the second model for both hospital charges and LOS, risk-adjustment was calculated at the hospital level. Figure 2 shows box-plot graphs of the risk-adjusted hospital charges and LOS for uninfected patients and infected patients by hospital.

After risk-adjustment, there was a hospital-level range of $3,824 (Hospital H6) to $7,710 (Hospital H28) for hospital charges in uninfected patients. For infected patients this range was $5,438 (Hospital H6) and $14,505 (Hospital H24). Therefore, additional charges associated with HAIs ranged from $434 to as high as $7,151 at the hospital level. The 25th, 50th and 75th percentile hospital charges for the uninfected patients were $5,305, $5,764 and $6,232, respectively. The 25th, 50th and 75th percentile hospital charges for infected patients were $6,379, $7,983 and $9,865, respectively. Hospitals H6 and H28 were identified as outliers with inordinately low and high hospital charges, respectively, for uninfected patients.

At the hospital level, the minimum risk-adjusted LOS for uninfected patients was 12.3 days (Hospital H34) and the maximum LOS was 27.2 days (Hospital H1). The 25th, 50th and 75th percentiles for the uninfected patients were 15.9 days, 19.0 days and 21.4 days, respectively. For patients who had an HAI, the risk-adjusted LOS ranged from 21.8 days (Hospital H34) to 47.9 days (Hospital H8). The 25th, 50th and 75th percentiles for infected patients were 32.6 days, 34.2 days and 41.7 days, respectively. Additional LOS associated with HAIs ranged from 5.1 days (Hospital H4) to 25.1 days (Hospital H8). Hospitals H34 was identified as an outlier with exceptionally low LOS in infected patients.

Risk-Adjusted Mortality

After adjusting for patient and hospital variations, the adjusted odds ratio for the association of HAIs and mortality was 23.2 (P<0.001; 95% Confidence Interval: 12.5 – 43.2). The area under the ROC was calculated to be 0.995, while the Hosmer-Lemeshow statistic had a chi square value of 5.6 (P =0.69). HAI infection status, age, Charlson score, LOS, surgery, CVC use, mechanical ventilation, ICU stay, JCS levels 1~3 and JCS levels 10~30 were all positively associated with increased mortality.

Discussion

In this study, we identified HAI incidence in ischemic stroke patients from 36 Japanese hospitals, and conducted a multi-institutional analysis of the risk-adjusted economic and clinical outcomes associated with HAIs. Our data showed that 68% of the patients were alert upon admission, which was slightly less than the 74.8% reported in 2004 by Kimura *et al*[26].

The HAI incidence observed in our study (16.4%; range: 4.7-28.3%) was fairly similar to infection rates reported in other studies [3-9]. We also found significant increases in both overall hospital charges and LOS associated with HAIs. In order to verify the accuracy of our HAI identification method[20], we conducted a validation study using gastrectomy patients. HAIs identified by our method were compared with those identified by chart review. At the current sample size (n= 425), there is an 89% level of agreement of between the two methods, and Cohen's Kappa coefficient is 0.73, which is generally considered as having a "substantial agreement"[27]. Sensitivity and specificity are 0.86 and 0.91 respectively, showing a high level of accuracy in identification (unpublished data).

At the hospital level, we observed wide variation between healthcare institutions in both hospital charges and LOS. Hospitals such as H4 maintained a relatively low HAI incidence (8.3%), and also managed to control mean hospital charges for both uninfected and infected patients ($5,304 and $6,250, respectively). Hospital H4 also showed the lowest increase in LOS associated with HAIs at 5.1 days.

Hospital H32, on the other hand, had a low HAI incidence at 6.7%. Furthermore, HAIs were associated with an increase of only 13.6 days in LOS in this hospital. Despite this, mean hospital charges, while relatively low for uninfected patients ($4,922), was one of the most expensive for infected patients at $11,908. In comparison, Hospital H6 had a lengthy 21.2 days increase in LOS associated with HAI, but had the lowest hospital charges for both uninfected and infected patients ($3,824 and $5,438, respectively). Therefore, while the regression models show that LOS had the largest association with hospital charges, it is evident that other factors are also important.

Furthermore, in addition to having a high odds ratio associated with increased mortality, Hospital H28 was one of the most expensive hotels for both infected and uninfected patients, at $7,710 and $12,387 respectively. The mean age of the infected patients was 77 years in this hospital, while that of the uninfected was 70 years, and in general it was the older patients (aged greater than 85 years) that resulted in the longer LOS. This high representation of the elderly may explain the high values observed.

The mean hospital charges per day were found to be slightly higher in uninfected patients ($317 vs. $217). This could represent a possible loss of income to hospitals, as infected patients occupy bed-space that could potentially be offered to new patients. With an already lengthy LOS in Japanese acute care hospitals[24], the reduction of unnecessarily protracted LOS would be beneficial to an already strained healthcare system.

LOS has been an issue with Japanese acute care hospitals, and Japan has the longest mean LOS amongst the OECD countries[28]. However, this may be due in part to acute care hospitals in Japan frequently including rehabilitation and palliative care among the provided services. This mixture of acute, subacute and chronic healthcare provision may also explain the wide variations that we observed between hospitals in hospital charges, LOS and mortality

Dedicated stroke units are a rarity in Japan, despite strong recommendations for the use of such units in the treatment of acute stroke patients published in guidelines in 2004[29]. Most hospitals in Japan manage acute stroke patients in general medical wards, and when intensive care was required, these patients were treated in standard ICUs. Since the patients who have had a stint in the ICU would represent more severe cases who required ICU treatment in addition to baseline stroke treatment, it would therefore be unsurprising for ICU stay to have significant and strong associations with hospital charges, LOS and mortality, as shown in our regression models.

HAIs have previously been shown to have positive associations with mortality[30]. Our data corroborates these findings, although we observed a stronger association between HAI s and increased mortality. While the clinical complications associated with stroke have been previously looked at[2, 6], most of these studies focused on single-institution databases. The use of a multi-institutional database in this study helps to increase the generalizability of our results, as well as allow for the interpretation of the results from each individual hospital within the context of other hospitals. Downstream studies could include qualitative studies in which particular characteristics in hospitals with low HAI incidences are identified, as well as elucidating problem areas in hospitals with higher HAI incidences. In this way, the quality of HAI control measures may be increased. Furthermore, the approximate cost-effectiveness of subsequent interventions to reduce infections may benefit from the estimations provided in this study.

The limitations of this study are that the identification method used is unable to specify the types of infections that occurred; therefore the infections identified in this study would potentially include cases of severe pneumonia together with relatively milder infections. As there were no standard stroke severity scales like the Japan Stroke Scale or the NIH Stroke Scale, we were unable to adjust for severity directly, but instead had to use the Barthel index and JCS as approximate proxies. Also, our database did not include the duration after onset at the time of admission, which may have an effect on the results. A multicenter study in Japan conducted by Kimura *et al* has shown that almost 37% of patients were admitted within 3 hours of onset, and 73% within 24 hours[26]. However, due to database limitations, we were unable to include this variable in our analysis. Finally, the hospitals used in this study are voluntarily part of a program known as the Quality Indicator/Improvement Project, in which participating hospitals voluntarily provide data for analysis for the purpose of improving healthcare outcomes. As such, there may be some selection bias involved and the hospitals used in this study may not be indicative of all hospitals in Japan.

Summary

In this study, the use of risk adjustment allows for a more meaningful interpretation of the economic and clinical outcomes from a multi-center database. Quantification of the increases in resource utilization associated with HAIs allows for more precise policy making and planning for interventions.

Due to the use of hospital charges, the economic outcomes here may be interpreted as cost estimation from a 3rd party payer perspective, which in an insurance-centric healthcare payment system such as the one existing in Japan, may be highly useful.

With a rapidly aging population in Japan, diseases such as ischemic stroke that are usually associated with the aged will become more prominent. This study analyzes the incidence and impact of HAIs in stroke patients, and highlights the salient need for interventions for their reduction in Japanese hospitals. Possible interventions could include further hand hygiene practice, dedicated infection control staff, high-risk patient identification and promoting antimicrobial stewardship protocols.

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Table Legends

Table 1: Patient characteristics and pre-risk-adjusted total hospital charges and length of stay

Table 2: Results of multiple linear regression models with hospital charges and length of stay as dependent variables, and a logistic regression model using mortality as the dependent variable. Two multiple linear regression models for each dependent variable are shown, in which the first model included hospital stratification and the second model did not.

Figure Legends

Figure 1: Healthcare-associated infection incidence at hospital level and in total.

Figure 2: Box-plot graphs of risk-adjusted hospital charges per admission (in US$) and length of stay (in days) for infected and uninfected patients at the hospital level.

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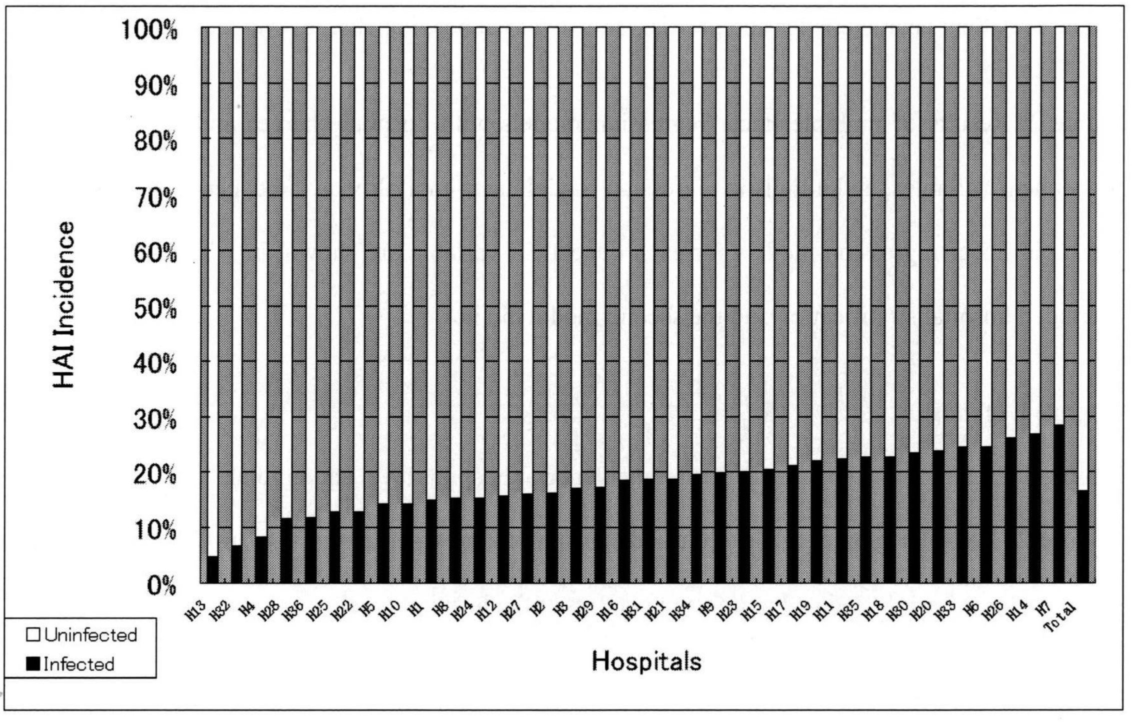
Conflicts of Interest: None



HAI Incidence
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
H13
H32
H4
H28
H36
H25
H22
H5
H10
H1
H8
H24
H12
H27
H2
H3
H29
H16
H31
H21
H34
H9
H23
H15
H17
H19
H11
H35
H18
H30
H20
H33
H6
H26
H14
H7
Total
Hospitals
Uninfected
Infected

1

Patient Characteristics		N=8,861	
		N	%
Age	75 years and below	4,470	50.4
	Above 75 years	4,391	49.6
Gender	Male	5,170	58.3
Barthel Index	0	1,778	20.1
	1~10	2,002	22.6
	11~15	1,241	14.0
	16~20	3,840	43.3
Type of Stroke	Atherothrombotic	1,881	21.2
	Embolic	916	10.3
	Others	6,064	68.5
Japan Coma Scale	0	6,022	68.0
	1~3	2,102	23.7
	10~30	520	5.9
	100~300	217	2.4
Charlson Score	0	4,711	53.2
	>=1	4,150	46.8
Surgery Performed		270	3.0
CVC Utilization		189	2.1
Mechanical Ventilation		105	1.2
Dysphagia		555	6.3
ICU Stay		244	2.8
Total Hospital Charges (mean)			US$6,471
Length of Stay (mean)			21.97 days
Mortality		257	2.9

Independent Variables	Dependent Variable: Ln (Hospital Charges)			Dependent Variable: Ln (Hospital Charges)		
	R^2	0.764	***	R^2	0.711	***
	β	SE		β	SE	
Constant		0.018	***		0.015	***
Age > 75 years	-0.049	0.007	***	-0.050	0.007	***
Sex	-0.023	0.006	***	-0.019	0.007	**
Barthel Index	-0.070	0.001	***	-0.111	0.001	***
Atherothrombotic Stroke	0.049	0.009	***	0.028	0.008	***
Cardioembolic stroke	0.063	0.011	***	0.070	0.011	***
Charlson score	0.058	0.003	***	0.088	0.003	***
Length of Stay	0.781	0.000	***	0.748	0.000	***
Surgery	0.030	0.019	***	0.026	0.021	***
CVC use	0.021	0.029	**	0.006	0.032	
Mechanical Ventilation	0.035	0.029	***	0.033	0.032	***
Dysphagia	0.035	0.014	***	0.053	0.014	***
ICU stay	0.076	0.020	***	0.066	0.020	***
JCS Level 1-3 (Grade I)	0.033	0.009	***	0.048	0.010	***
JCS Level 10-30 (Grade II)	0.017	0.011	*	0.028	0.011	***
JCS Level 100-300 (Grade III)	-0.013	0.021	*	-0.011	0.023	
H1	-0.024	0.019	***			
H2	-0.016	0.024	**			
H3	0.005	0.028				
H4	-0.042	0.021	***			
H5	-0.083	0.021	***			
H6	0.011	0.049	*			
H7	0.040	0.023	***			
H8	-0.023	0.031	***			
H9	-0.007	0.025				
H10	-0.002	0.037				
H11	-0.016	0.044	**			
H12	-0.012	0.026	*			
H13	-0.041	0.045	***			
H14	-0.003	0.019				
H15	-0.021	0.041	***			
H16	-0.008	0.069				
H17	-0.003	0.042				
H18	0.010	0.045				
H19	0.022	0.017	**			
H20	-0.079	0.019	***			
H21	0.018	0.024	**			
H22	0.004	0.019				
H23	-0.027	0.025	***			
H24	-0.006	0.024				
H25	-0.020	0.024	**			
H26	-0.025	0.024	***			
H27	0.010	0.027				
H28	0.044	0.016	***			
H29	0.130	0.014	***			
H30	-0.021	0.017	**			
H31	0.059	0.017	***			
H32	0.014	0.024	*			
H33	0.060	0.024	***			
H34	-0.065	0.019	***			
H35	-0.021	0.027	***			

Independent Variables	Dependent Variable: Ln (Length of Stay)			Dependent Variable: Ln (Length of Stay)		
	R^2	0.308	***	R^2	0.222	***
	β	SE		β	SE	
Constant		0.031	***		0.025	***
Age > 75 years	0.015	0.012		0.037	0.013	**
Sex	0.020	0.012	*	0.014	0.012	
Barthel Index	-0.291	0.001	***	-0.252	0.001	***
Atherothrombotic Stroke	0.039	0.017	**	-0.003	0.015	
Cardioembolic stroke	0.060	0.020	***	0.020	0.020	*
Charlson score	0.100	0.006	***	0.094	0.006	***
Surgery	0.096	0.034	***	0.099	0.035	***
CVC use	0.011	0.054		0.026	0.057	
Mechanical Ventilation	-0.022	0.055	*	-0.012	0.058	
Dysphagia	0.106	0.025	***	0.079	0.025	***
ICU stay	0.086	0.036	***	0.051	0.036	***
JCS Level 1-3 (Grade I)	0.111	0.017	***	0.104	0.017	***
JCS Level 10-30 (Grade II)	0.129	0.020	***	0.137	0.020	***
JCS Level 100-300 (Grade III)	0.046	0.041	***	0.050	0.043	***
H1	0.121	0.035	***			
H2	0.072	0.045	***			
H3	0.062	0.050	***			
H4	0.038	0.041	***			
H5	0.074	0.039	***			
H6	0.017	0.087				
H7	0.013	0.041				
H8	0.034	0.059	**			
H9	0.030	0.045	**			
H10	0.025	0.076	**			
H11	0.013	0.081				
H12	0.056	0.048	***			
H13	0.010	0.083				
H14	0.030	0.035	**			
H15	0.013	0.075				
H16	-0.006	0.126				
H17	0.009	0.082				
H18	-0.038	0.081	***			
H19	0.058	0.032	***			
H20	-0.059	0.034	***			
H21	0.018	0.044				
H22	-0.063	0.035	***			
H23	-0.020	0.046	*			
H24	0.043	0.045	***			
H25	0.023	0.043	*			
H26	0.043	0.044	***			
H27	-0.005	0.047				
H28	-0.096	0.029	***			
H29	-0.110	0.025	***			
H30	-0.061	0.030	***			
H31	0.004	0.032				
H32	-0.026	0.043	**			
H33	0.005	0.045				
H34	-0.084	0.034	***			
H35	0.023	0.052	*			

* Significance at $p < 0.05$; *** Significance at $p < 0.001$

AUROC: Area Under Receiver Operating Characteristic curve

可視化と医療

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わが国の医療システムにより達成される健康水準は，国際比較においても非常に高い評価を得てきた。一方，国内では医療提供体制の持続可能性について，医療に関わる各ステークホルダーから危ぶむ声が高まっている。そこで，医療提供体制に関する評価を可視化し，ステークホルダー横断的に一層の充実した維持・再構築に向けた議論が望まれる。

これまで，医療システムの評価について，効果，効率，公平性の３要素から検討するというフレームワークが提案されてきた（Aday LA, et al. 1992)。わが国における医療提供体制の現状を鑑みれば，効率ならびに公平性についてより積極的に評価を推進する必要があろう。こうした効率と公平性に関する評価は，国際的にもこれまで軽視されてきた嫌いがあり，例えば英国では 1987 年から 1997 年において学術面では「完全に無視」されてきたという報告があるほどである(Sassi F, et al. 2001)。

本例会においては，救急医療事業における効率と公平性について，特に，コストとアクセスの観点から可視化を試みた実例を紹介した。

まず，多施設におけるコストデータに基づき，病院別救急医療事業の収益性について可視化した例を紹介した。救急医療事業における不採算性については，実務的見地に基づき，広く認識はされている。しかしながら，定量的に可視化した例は少なく，とりわけ単施設での事例に止まるため，議論の一般化可能性に乏しい。今後，病院経営ならびに医療政策の側面からも，こうしたコストを踏まえた効率に繋がる可視化の展開が望まれる。

次に，アクセスについては，利用可能性と実アクセスの観点から可視化した例を紹介した。利用可能性については，救急車搬送受入実績病院までの運転時間アクセス圏と人口の地理的分布の対比によって評価した。実アクセスについては，救急車搬送事案における照会回数４回以上の事案の占める割合と現場滞在時間３０分以上の事案の占める割合によって評価した。

今後，効果，効率，公平性について各々の可視化にとどまらず，いかに各要素のバランスを取るかについて，生じうる対立関係を含めて，ステークホルダー間での調整が望まれる。

日本医療・病院管理学会　第278回例会

『医療制度再構築への学際的アプローチ』

1. 可視化と医療
救急医療事業にまつわるコストとアクセス

平成21年9月19日

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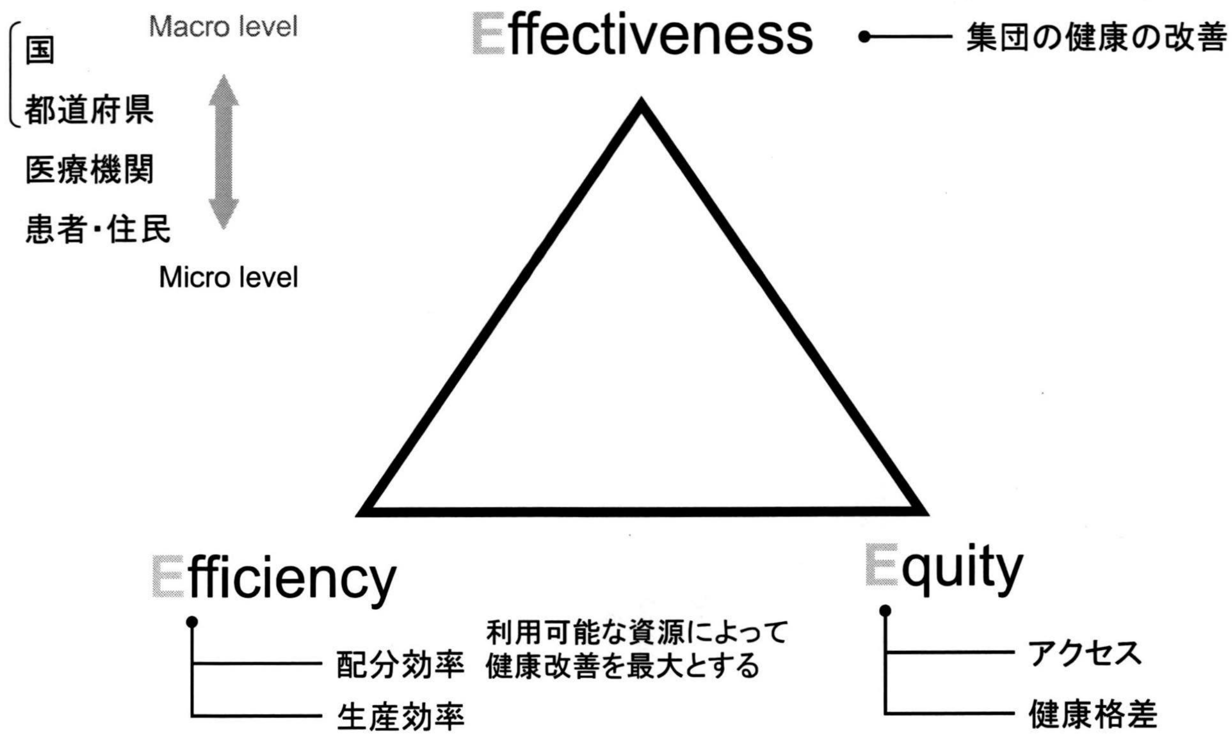
医療提供体制の評価の必要性

- わが国の医療提供体制は，国際的にも優れたパフォーマンスを発揮していると評価されてきた
  (World Health Organization)
- 改革なしには，20年後にわが国のGNPあたり医療費は2倍に膨れ上がると懸念されている
  (Hagist C and Kotlikoff LJ, 2005)
- 持続可能な医療提供体制の構築・維持に向けて，各ステークホルダーによる評価は必要不可欠である
  - 特に近年，各都道府県において医療計画の策定が継続的課題である

医療提供体制評価の3基準



Mooney G (1989)
Aday LA, Begley CE, Lairson DR, and Slater CH (1998)

評価指標 –Macro level

- Effectiveness
  - 再発率，職場復帰率，精神健康状態回復率　など
- Efficiency
  - 生産関数
  - 費用対効果，費用対便益，費用対効用
- Equity
  - 利用可能性：医療機関・医療職者の分布，
    サービス選択の自由（提供者，支払者）
  - 実アクセス：提供されたサービス類型・量，満足度
    など

Aday LA, Begley CE, Lairson DR, and Slater CH (1998)

対象とする医療事業

4疾病5事業および懸案事項

1. がん
2. 脳卒中
3. 急性心筋梗塞
4. 糖尿病

1. 救急医療
2. 災害時における医療
3. へき地の医療
4. 周産期医療
5. 小児医療

1. 精神保健医療対策
2. 障害保健対策
3. 認知症対策
4. 結核・感染症対策
5. 臓器移殖対策
6. 難病等対策
7. 歯科保健医療対策
8. 血液の確保・適正使用対策
9. 医薬品等の適正使用対策
10. 医療に関する情報化
11. 保健・医療・介護(福祉)の総合的な取組

本講演の目的

医療提供体制における評価方法・適用例の紹介

- アクセス
  救急搬送受入状況について可視化
  - 利用可能性評価:地理的網羅性
  - 実アクセス評価:受入照会回数,現場滞在時間
- コスト
  病院別救急医療事業の収益性について可視化
  - 多施設におけるコストデータに基づく収支,収益率

アクセス

アクセスの評価内容とその方法

1. 利用可能性 (Planned System)
   - 地理的網羅性

2. 実アクセス　(Realized Access)
   - 受入照会回数，現場滞在時間