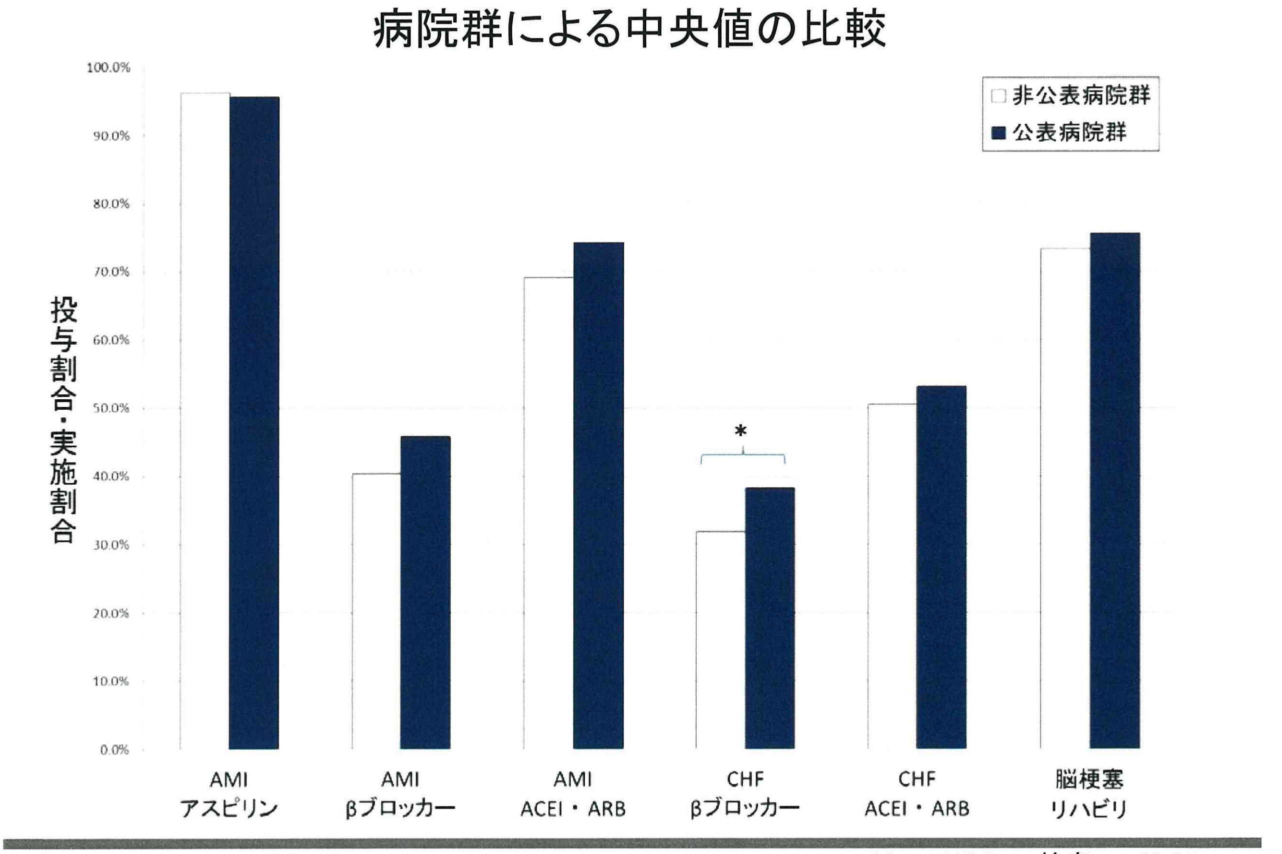
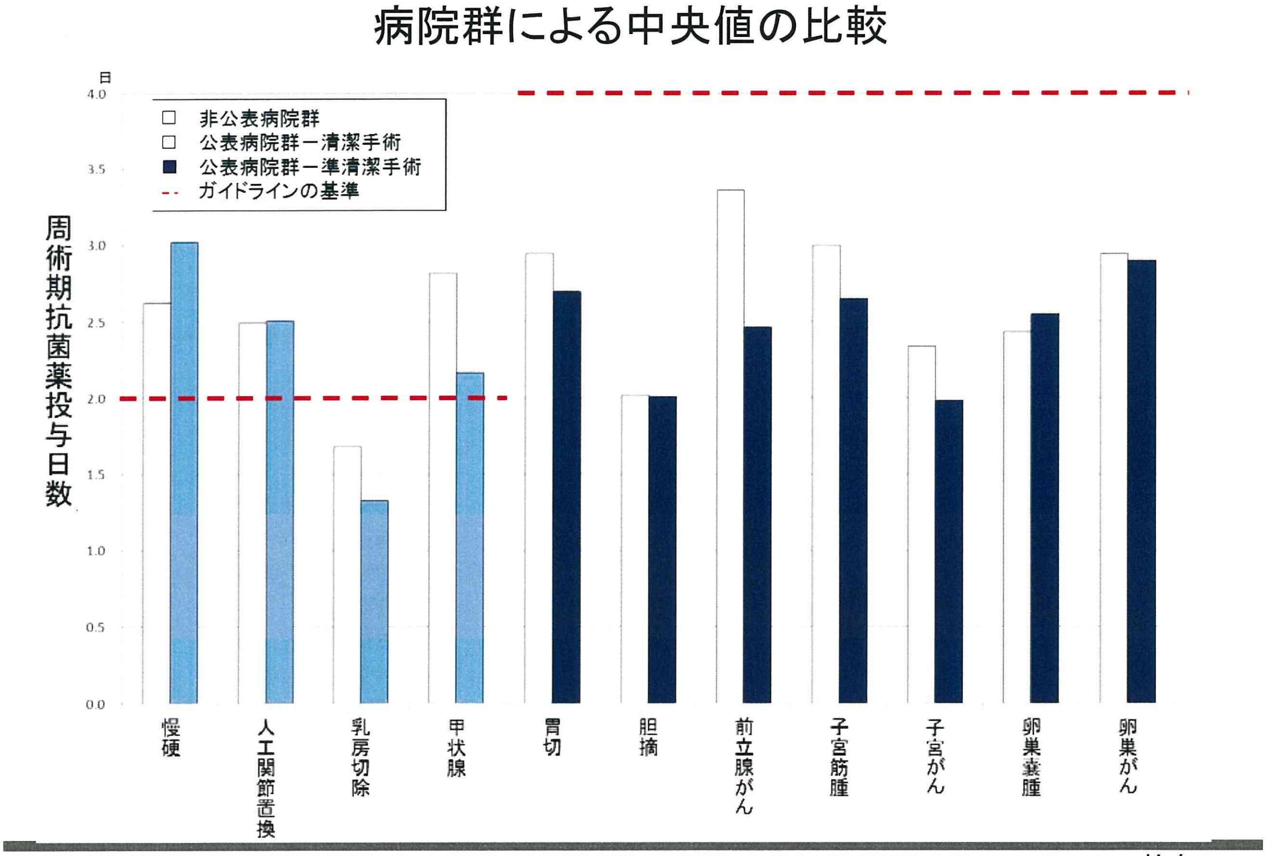
指標別の結果 （2／3）



＊：Mann-Whitney検定 p＜0.05 13

指標別の結果 （3／3）



＊：Mann-Whitney検定 14

考察

- 公表の有無に関する病院規模の違いについて

規模が大きい病院の方が、より地域に対する説明責任の要求や要求に対する責任感が高いことが考えられる。また、公表にかかる事務手続きやその後のモニタリングに要するコストの負担能力が高いことも考えられる。

- 公表病院と非公表病院の指標の値に差がほぼなかったことについて

今回の指標は全てプロセス指標であり、指標の良し悪しを理解するためにある程度の専門知識が必要になる。その為、地域住民に対する説明責任や名声につながりにくく、指標の良し悪しが公表へのインセンティブに結びつきにくかったことが考えられる。

- 公表の一律公表・非公表と部分公表について

公表に際して、指標によって公表、非公表を選ぶ病院よりも、指標の良し悪しに関わらず全ての指標を一律に選ぶ病院が多かった。診療の質の改善や標準化、透明化などの動きに積極的に関わっていく傾向が示唆された。

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本研究の限界と今後の発展

本研究の限界

- 多施設を一律に比較することを優先したため、病院特性の質的な側面については検討していない。
- 対象病院がQIP参加病院に限られるため、母集団に偏りがある可能性が考えられる。

今後の発展

- 考えられる要因の精緻化
- 指標の値や公表に対する態度の経年的な変化

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まとめ

この研究では病院の規模と地域環境因子、臨床指標の良し悪しを臨床指標の公表病院と非公表病院で比較した。

その結果、地域特性や臨床指標の良し悪しは差がなかったが、病院規模では公表病院の方が有意に大きかった。

これらの要因として病院の説明責任の大きさやコスト負担能力、そして指標自体の特性と公表への積極的な姿勢が影響を与えていることが考えられた。

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ご清聴ありがとうございました。

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18

日本医療情報学会

COI開示

筆頭発表者：宇川 直人

演題発表に関連し、開示すべきCOI関係にある企業などはありません。

1

臨床指標値の経年的変化の多施設分析

京都大学大学院医学研究科医療経済学分野
宇川 直人、猪飼 宏、今中 雄一

背景

- 近年、診療の質の改善や標準化、透明化を目的として病院団体等で多施設を対象にした臨床指標の公表事業が行われ始めており、厚生労働省でも昨年度より医療の質の評価・公表等推進事業として政策的な後押しが行われている。

- 当分野のQuality Indicator/Improvement Project(以下QIP)においても2010年度よりDPCデータを用いた臨床指標を算出し、公表している。

↓

本邦においてこうした臨床指標の改善や標準化の実態は十分に明らかになっていない。

3

目的と方法 (1／4)

目的

臨床指標毎の値の変化と、病院毎の値の変化の傾向を明らかにし、設立主体や病床規模別に比較する。

4

目的と方法 （2／4）

方法

- 研究の種類：記述的研究
- 使用データベース：QIPデータベース（DPCデータ）
- 対象臨床指標：急性心筋梗塞（以下AMI）・心不全（HF）の臨床指標
- 対象期間：2007年度から2010年度の4年間
  （但し2010年度は4月から12月までの9ヶ月）
- 対象病院：各年度に対象症例が10症例以上ある117病院

目的と方法 （3／4）

対象となる臨床指標

急性心筋梗塞患者への薬剤投与

- アスピリン投与の割合（以下 AMI-asp）
- βブロッカー投与の割合（ AMI-beta）
- ACE阻害剤orアンギオテンシンⅡ受容体阻害剤投与の割合（AMI-acei・arb)

心不全患者への薬剤投与

- βブロッカー投与の割合（HF-beta）
- ACE阻害剤orアンギオテンシンⅡ受容体阻害剤投与の割合（HF-acei・arb）

対象患者は急性心筋梗塞患者についてはDPC6桁コードと主傷病名ICD-10コード、心不全患者についてはDPC6桁コードを用いて同定。薬剤投与についてはEF統合ファイルを使用。

目的と方法 （4／4）

臨床指標値の変化の傾向により病院を5つにグループ分け

グループ分けの手順	グループ分けの方法	グループ名
指標の値が年度を経るに従って単調に上昇、または下降している	Cochran-armitage検定	• 上昇傾向 • 下降傾向
↓	α=0.025	
指標の値が年度によってばらついている。	カイ2乗検定	• 不安定
↓		
指標の値が比較的良い水準、もしくは悪い水準で安定している。	2007年度の中央値	• 安定-上位 • 安定-下位

7

結果 （1／7）

急性心筋梗塞指標

病院属性

設立主体	病床規模 ＜300	病床規模 300≦
公立	1	17
公的	6	32
民間	8	14

患者属性

	総症例数	平均年齢±SD	男性	女性
2007年	4095	68.0±12.9	2978	1117
2008年	4596	68.2±12.6	3368	1228
2009年	4885	68.3±12.8	3635	1250
2010年	3475	68.3±12.8	2546	929

心不全指標

病院属性

設立主体	病床規模 ＜300	病床規模 300≦
公立	3	19
公的	17	37
民間	20	21

患者属性

	総症例数	平均年齢±SD	男性	女性
2007年	11147	77.0±12.7	5635	5512
2008年	13923	77.0±13.0	7062	6861
2009年	16820	77.4±12.6	8584	8236
2010年	11918	77.8±12.5	6026	5892

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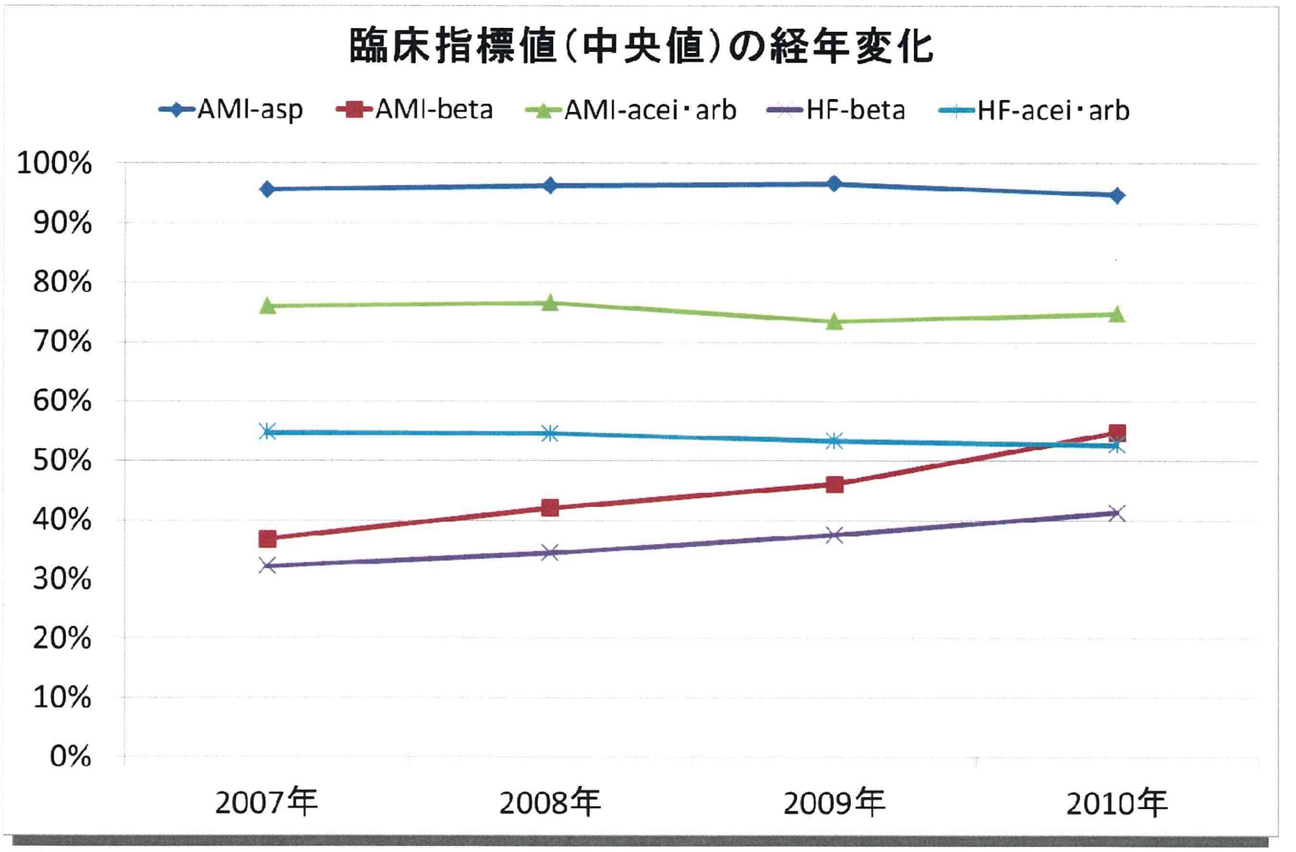
結果 （2／7）



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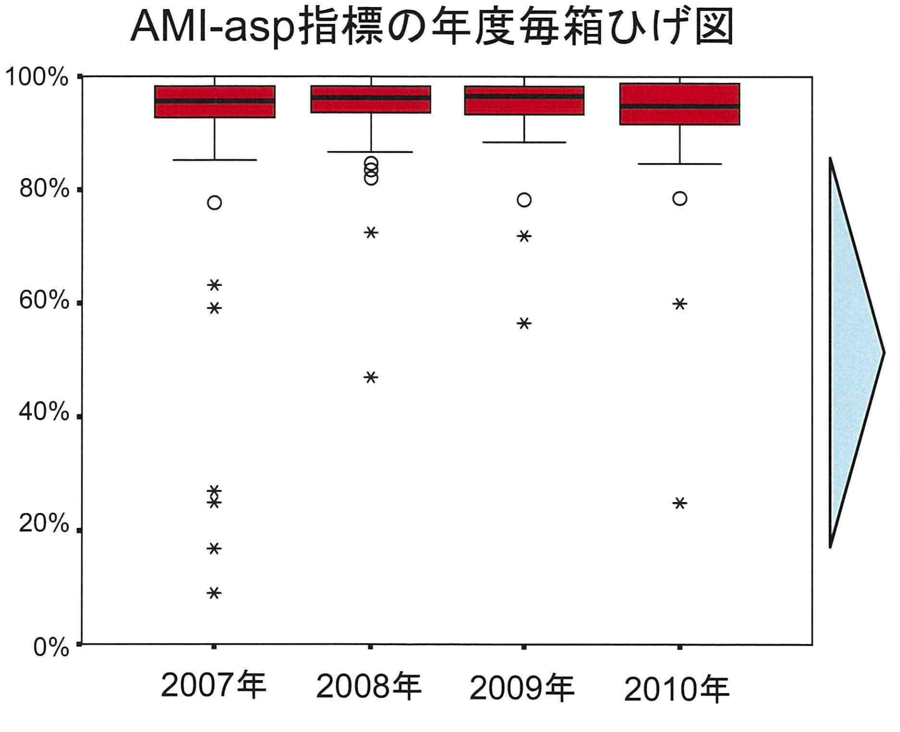
結果 （3／7）



AMI患者に対するアスピリン投与は大部分の病院で上昇の幅がほとんど無いほど実施されている。

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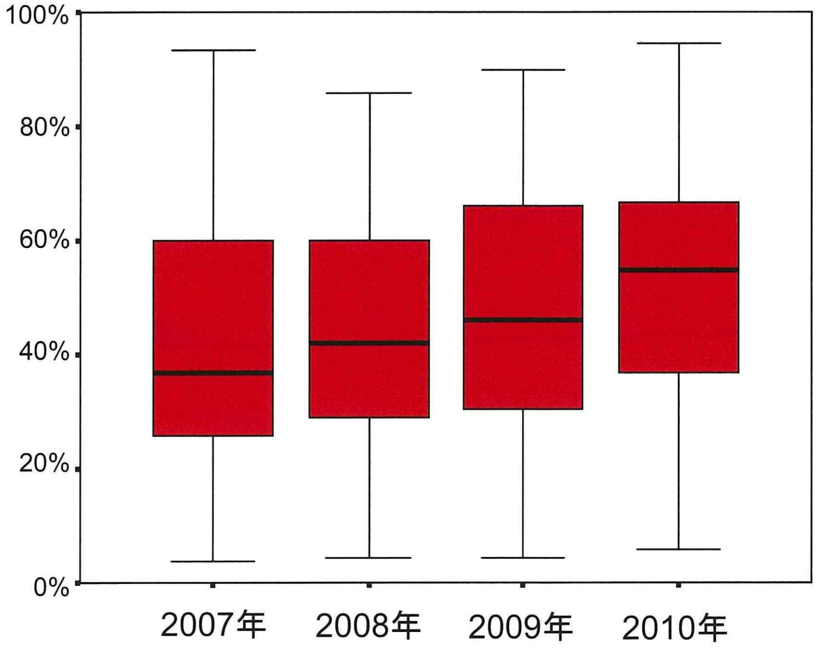
結果（4／7）

AMI-beta指標の年度毎箱ひげ図



AMI患者に対するβブロッカー投与は病院間のばらつきは大きいものの、全体としては上昇している。

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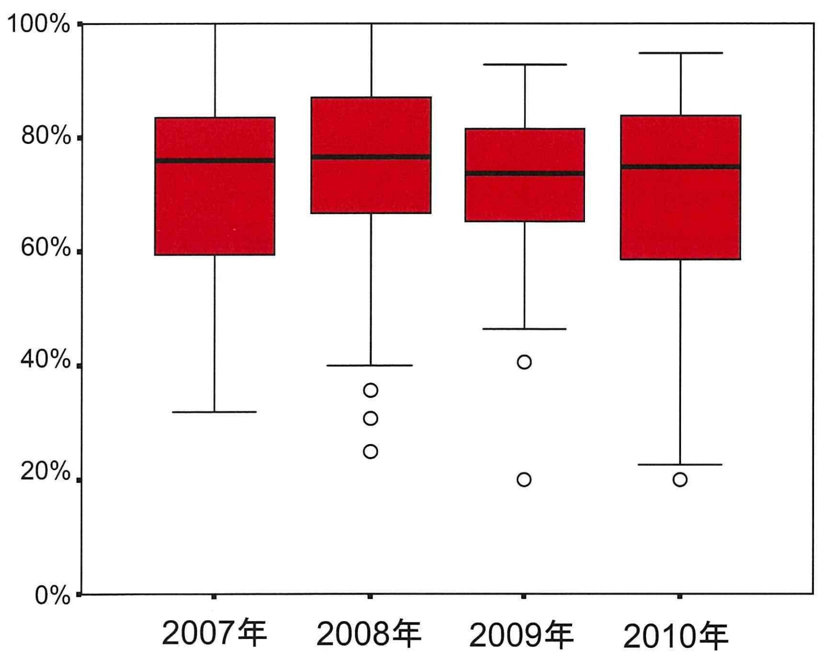
結果（5／7）

AMI-ace･arb指標の年度毎箱ひげ図



AMI患者に対するACEI･ARB投与は病院間のばらつきも大きく、一定の傾向を読み取ることは難しい。

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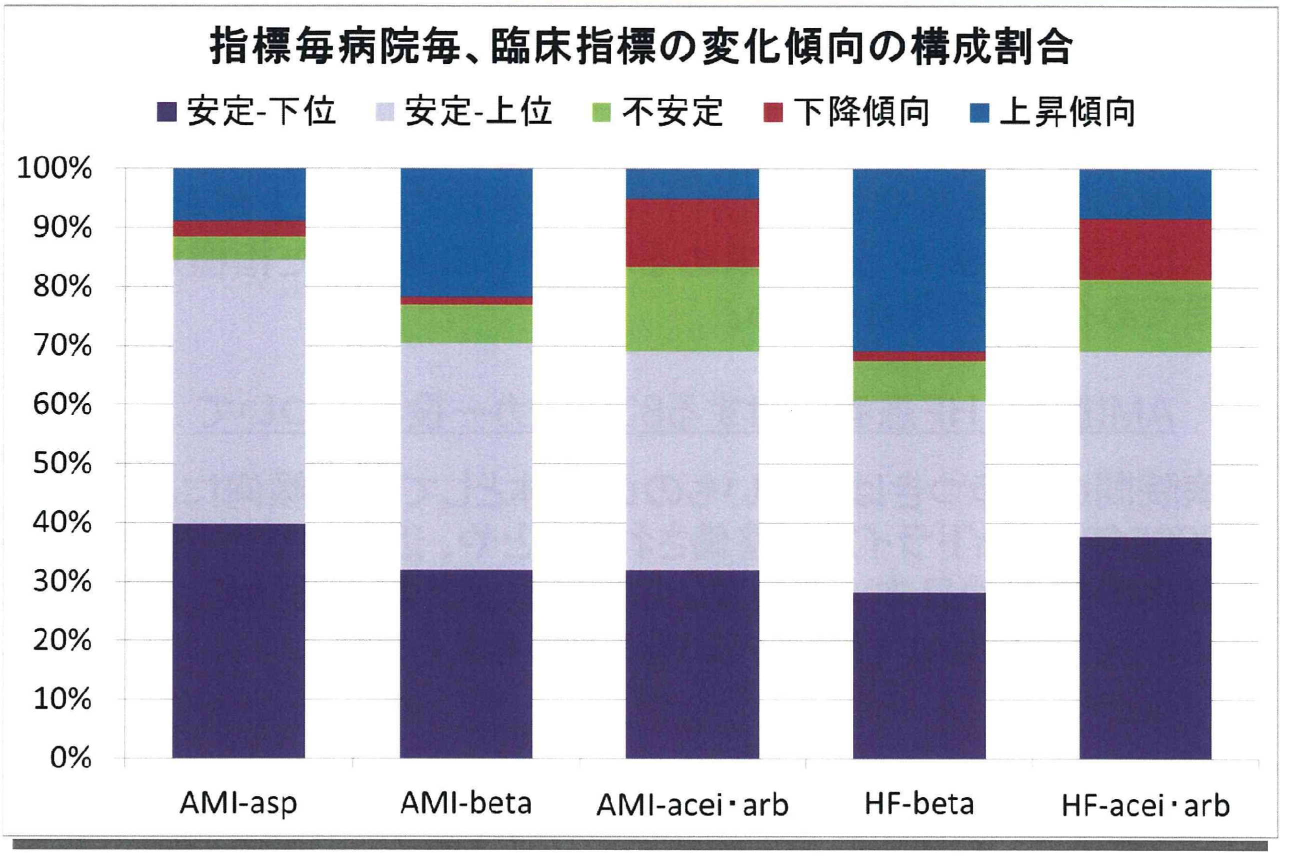
結果（6／7）



結果（7／7）

変化傾向のグループと病院要素によるクロス表

		設立主体			病床規模		症例数		2007年度の値	
		公立	公的	民間	＜300	300≦	上位50%	下位50%	上位50%	下位50%
AMI対象病院		**18**	**38**	**22**	**15**	**63**	**39**	**39**	**39**	**39**
AMI-asp	上昇傾向		6	1	1	6	3	4		7
	下降傾向	1	1			2	1	1	2	
	不安定			3	2	1	2	1	2	1
	安定-上位	8	18	9	7	28	16	19	35	31
	安定-下位	9	13	9	5	26	17	14		
AMI-beta	上昇傾向	1	9	7	2	15	10	7	4	13
	下降傾向	1				1	1		1	
	不安定	1	4			5	4	1	4	1
	安定-上位	10	14	6	5	25	17	13	30	25
	安定-下位	5	11	9	8	17	7	18		
AMI-acei·arb	上昇傾向		2	2	1	3	3	1		4
	下降傾向	5	2	2	1	8	6	3	7	2
	不安定	2	5	4	3	8	6	5	3	8
	安定-上位	4	17	8	5	24	13	16	29	25
	安定-下位	7	12	6	5	20	11	14		
HF対象病院		**22**	**54**	**41**	**40**	**77**	**58**	**59**	**58**	**59**
HF-beta	上昇傾向	7	13	16	12	24	22	14	13	23
	下降傾向		1	1		2	1	1	2	
	不安定	1	6	1	2	6	4	4	6	2
	安定-上位	7	18	13	11	27	24	14	38	
	安定-下位	7	16	10	15	18	7	26		33
HF-acei·arb	上昇傾向	2	6	2	3	7	5	5	2	8
	下降傾向	3	4	5	4	8	4	8	8	4
	不安定	1	8	5		14	9	5	11	3
	安定-上位	7	16	14	12	25	18	19	37	44
	安定-下位	9	20	15	21	23	22	22		

Fisher's exact test: $p < 0.05$

結果のまとめと考察

- AMI患者に対するアスピリン投与について

大部分の病院で上昇の幅がほとんど無いほど実施されており、診療の質の改善や標準化が十分になされていることが示唆された。診療の質の改善を求めるにはさらに発展した指標が必要であることが考えられる。

- AMI患者、HF患者に対するβブロッカー投与について

病院間のバラつきは大きいものの全体として上昇傾向にある。2006年にガイドラインが整備されたことや、近年になって保険適応の拡大や日本人を対象とした治験が行われるなど、βブロッカーの再評価が行われていることが考えられた。

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結果のまとめと考察

- AMI患者、HF患者に対するACEI・ARB投与について

一定の経年的な傾向は認めることができず、病院毎でも比較的下降している群や指標の値が不安定な群が多い。現場でコンセンサスが得られていない可能性も否定できないが、指標に改善の余地があることから、指標自体の再検討、精緻化が必要であると考えられた。

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まとめ

この研究では急性心筋梗塞と心不全の臨床指標について、経年的な変化の傾向を明らかにした。

その結果、AMI患者に対するアスピリン投与は大部分の病院で上昇の幅がほとんど無いほど実施されており、標準化もなされていると考えられた。AMI患者やHF患者に対するβブロッカー投与は全体で上昇の途上にあるが、ACEI･ARBの投与は指標の再検討が必要であることが示唆された。

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ご清聴ありがとうございました。

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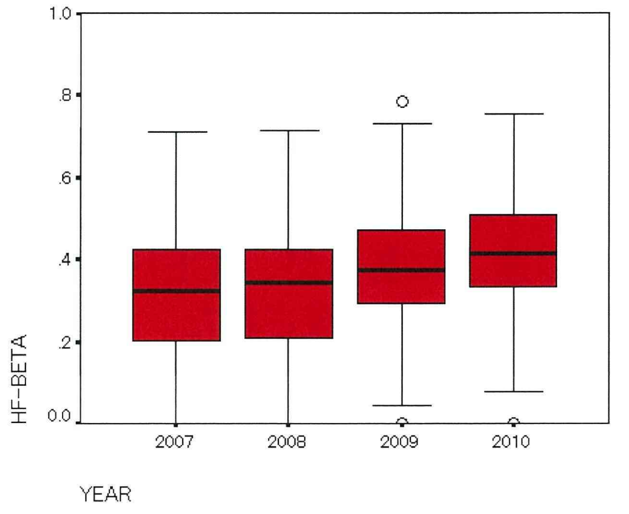

1.0
.8
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HF-BETA
2007
2008
2009
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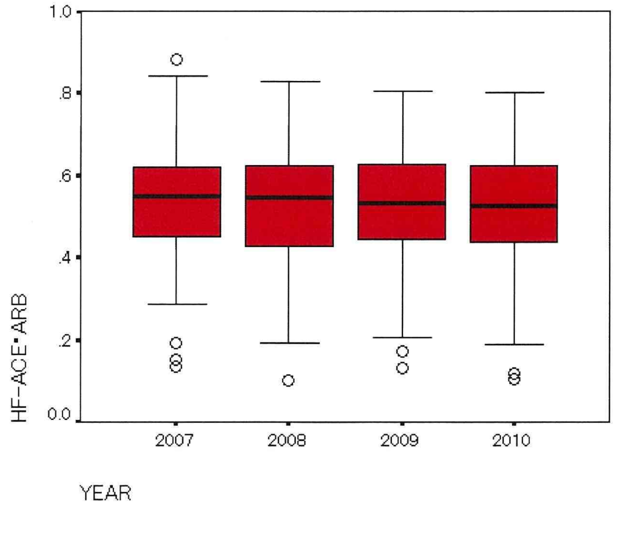
YEAR

19



1.0
.8
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0.0
HF-ACE•ARB
2007
2008
2009
2010
YEAR

20

Title: Multicenter study of trends of quality indicators in Acute Myocardial Infarction and Heart Failure

[Context] In recent years, various organizations such as hospital groups have developed and disclosed performance in quality indicators at a multicenter level. The Quality Indicator/Improvement Project (QIP), which is administrated by our laboratory, had begun the disclosure of hospital performance in process indicators since December 2010. However, the current status of improvement and standardization of performance in these quality indicators remains unclear. **[Objective]** To elucidate the trends of hospital performance in quality process indicators of acute myocardial infarction (AMI) and heart failure (HF), and conduct a comparison of these trends by hospital ownership type, bed capacity, and case volume. **[Methods]** Administrative data were obtained from AMI and HF patients who were discharged from 285 QIP member hospitals during the period of April 2007 to December, 2010. The following 5 quality indicators were evaluated: proportion of AMI patients who were administered (1) aspirin (AMI-asp), (2) beta-blockers (AMI-beta), and (3) angiotensin converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB) (AMI-acei/arb); as well as the proportion of HF patients who were administered (4) beta-blockers (HF-beta) and (5) ACEI or ARB (HF-acei/arb). Hospitals which had less than 10 eligible cases within a year were excluded. The yearly trends of the quality indicators were analyzed stratified at the hospital level, followed by tests of trends and independence. As a result of these tests, hospitals were categorized into the following 4 groups according to their performance in each indicator: upward trend, downward trend, stable and unstable. These results were then compared by hospital ownership type, bed capacity and case volumes. **[Results]** Statistically significant upward trends ($p<0.01$) were observed in AMI-asp, AMI-beta, and HF-beta, while a significant downward trend was observed in AMI-acei/arb (<0.01). While the indicators of AMI-beta and HF-beta exhibited many upward trends, there were many downward trends in AMI-acei/arb and HF-acei/arb. **[Discussion]** The indicators of AMI-beta and HF-beta exists room for improvement. On the other hand, AMI-ACEI/ARB and HF-ACEI/ARB showed many downward trends and instabilities. This may be interpreted as these indicators having little room for improvement, and perhaps highlights the need for reconsideration of the validity of these indicators.

・急性心筋梗塞・心不全における臨床指標値の経年的変化の多施設分析

Multicenter study of trends of quality indicators in Acute Myocardial Infarction and Heart Failure

1. はじめに

1.1 背景

近年、病院団体等で多施設を対象にした臨床指標の開発・公表事業が行われ始めており、厚生労働省でも昨年度より医療の質の評価・公表等推進事業として政策的な後押しが行われている。臨床指標は A.Donabedian による分類でストラクチャー指標、プロセス指標、アウトカム指標に分けられる。当分野の Quality indicator/improvement Project（以下 QIP）においては２０１０年１２月より公開の了承を得た病院のプロセス指標を公表している。プロセス指標はアウトカム指標に比べて指標の算出が容易であり、病院の努力が結果に表れやすい。その反面、プロセスが直接アウトカムに繋がるとは言えないことから、少しでも指標の値が高ければ良い、低ければ良いといったことは言えない。よって、プロセス指標の結果は診療の質の改善や標準化を目的としている。しかし、本邦において、こうした臨床指標の改善や標準化の実態は十分に明らかになっていない。

1.2 目的

急性心筋梗塞（以下 AMI）・心不全（HF）の臨床指標を対象に臨床指標毎の値の変化と、病院毎の値の変化の傾向を明らかにし、設立主体や病床規模別に比較する。

2 方法

2.1 使用データベースと対象の臨床指標

QIP 参加病院の 2007 年 4 月から 2010 年 12 月までにデータ提出のある 285 病院の退院症例 DPC データを使用した。対象の臨床指標は各年度の急性心筋梗塞患者へのアスピリン投与の割合（AMI-asp）、同 β ブロッカー投与の割合（AMI-beta）、同 ACE 阻害剤もしくはアンギオテンシンⅡ受容体拮抗剤（ACEI・ARB）投与の割合（AMI-acei・arb、心不全（HF）患者への β ブロッカー投与の割合（HF-beta）、同 ACEI・ARB 投与の割合（HF-acei・arb）の計 5 指標とした。

2.2 解析方法

それぞれについて 2007 年度から 2010 年度までの各年度 10 症例以上ある病院のみを分析の対象とし、病院で層別化した年度に関する指標値の傾向検定を行った。続いて各指標で病院毎に年度に対する指標値の傾向性検定を行い、上昇傾向にある病院と下降傾向にある病院を特定し、傾向が認められなかった病院については独立性検定を行い、指標が安定している病院と不安定な病院の４つのグループにわけた。そしてそれらが病床数（200 床未満・200 床以上 500 床未満・500 床以上）、症例数（三分位毎）、設立主体（公立・公的・民間）、2007 年度の指標値（三分位毎）によって違いがあるかどうかを検定した。統計分析には SAS Var9.2 を使用した。

3 結果

AMI の 3 指標はそれぞれ 78 病院、17051 ケース、HF の 2 指標ではそれぞれ 118 病院、53808 ケースが対象となった。

指標値の中央値の変化は AMI-asp : 95.6%（2007 年度）-94.8%（2010 年度）、AMI-beta : 36.8%-54.7%、AMI-acei・arb : 76.1%-74.8%、HF-beta : 32.2%-41.3%、HF-acei・arb : 54.8%-52.6%であった。これらの傾向性検定では AMI-asp と AMI-beta、HF-beta では有意（$p<0.01$）に上昇傾向が見られたが、AMI-acei・arb では有意（<0.01）に下降傾向が見られた。HF-acei・arb は有意ではなかった（0.37）。

病院毎の変化傾向は指標ごとに有意（<0.01）に構成割合が違っていた。AMI-beta と HF-beta では上昇病院が多かったが、AMI-acei・arb と HF-acei・arb では下降傾向が多かった。

設立主体による構成割合の違いでは AMI-asp と AMI-beta において有意（<0.05）であり、AMI-asp では公立病院で上昇傾向が少なく、民間病院で不安定が多く、また、AMI-beta では公立病院で上昇傾向が少なく、民間病院で多かった。2007 年度の指標値による構成割合の違いでは AMI-asp（<0.01）と AMI-acei・arb（<0.05）、HF-acei・arb（<0.01）で有意であり、いずれも 2007 年度の指標が良いほど下降傾向が多く、悪いほど上昇傾向が多かった。病床数、症例数による構成割合の違いは有意ではなかった。

4 考察

4.1 結果の解釈

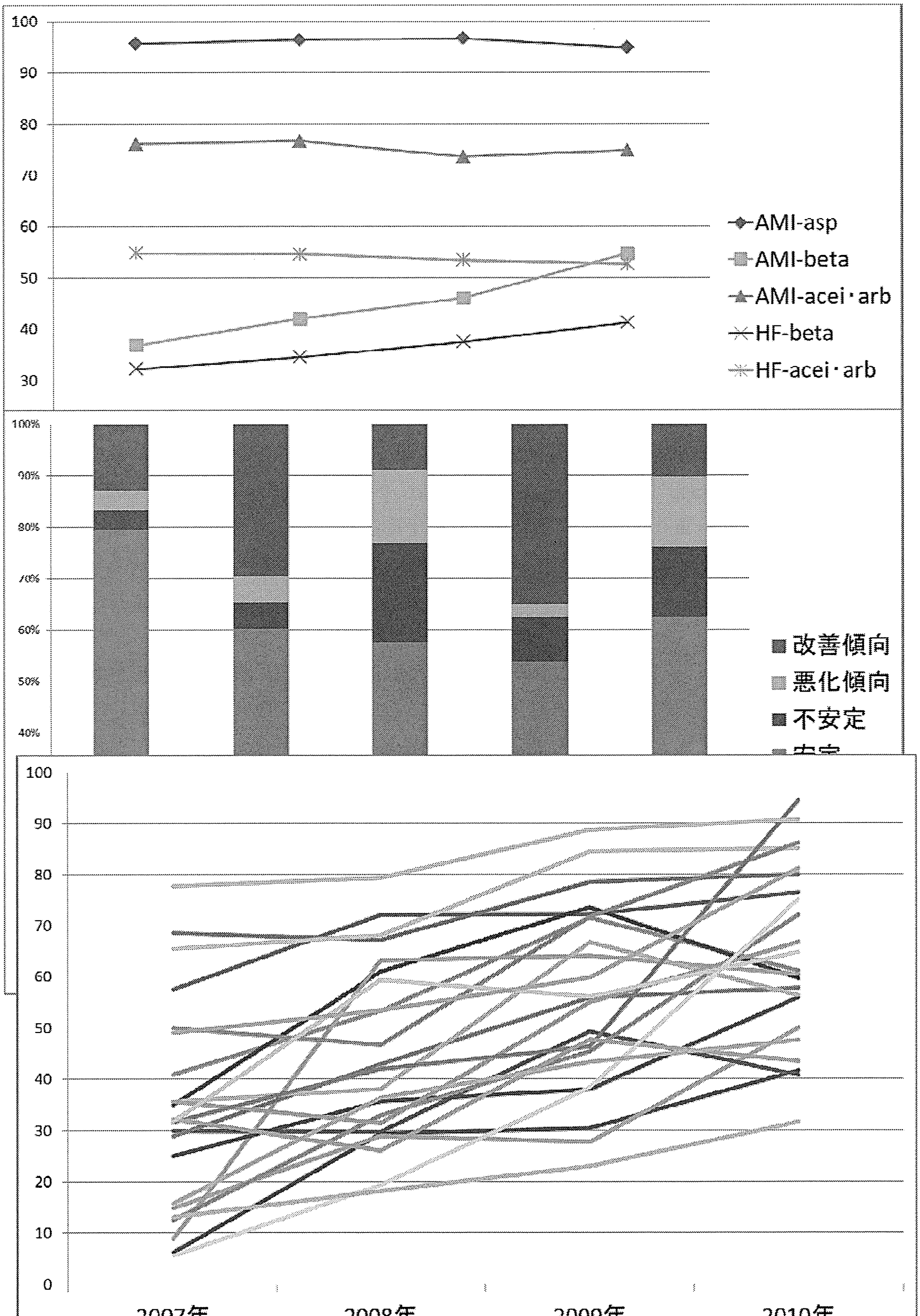
AMI-asp は全体の上昇傾向、設立主体や 2007 年度の指標による変化傾向の構成割合が違っていたが、指標の絶対値としては中央値が 95%にあり、上昇の幅がほとんどないことから実質的な意味はほとんどないものと思われる。AMI-beta と HF-beta については全体でも病院毎の構成割合でも上昇傾向にあり、まだ十分に改善の余地があることが示唆された。逆に、AMI-acei・arb と HF-acei・arb については上昇傾向は支配的ではなく、逆に下降傾向や不安定な病院の割合が比較的高かったことから、あまり上昇の余地がないことも考えられ、一定の価値判断は難しい。より精緻な指標の開発が必要であることが示唆された。

4.2 今後の発展

今回の研究では AMI と HF の指標のみであったので他の臨床指標にも拡大し、指標の精緻化を進めつつ、より長期的な動向も含めて検討を深めていきたい。

5 結語

AMI 患者に対するアスピリン投与は大部分の病院で上昇の幅がほとんど無いほど実施されており、標準化もなされていると考えられる。AMI 患者や HF 患者に対する β ブロッカー投与は全体で上昇の途上にあるが、ACEI・ARB の投与は指標の再検討が必要であることが示唆された。


100
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AMI-asp
AMI-beta
AMI-acei・arb
HF-beta
HF-acei・arb
100%
90%
80%
70%
60%
50%
40%
改善傾向
悪化傾向
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100
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Development of efficiency indicators of operating room management for multi-institutional comparisons

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Keywords
administrative data, assessment of performance, efficiency indicators, improvement, multi-institutional comparison, operating room management

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Abstract

Objectives The efficiency of a hospital's operating room (OR) management can affect its overall profitability. However, existing indicators that assess OR management efficiency do not take into account differences in hospital size, manpower and functional characteristics, thereby rendering them unsuitable for multi-institutional comparisons. The aim of this study was to develop indicators of OR management efficiency that would take into account differences in hospital size and manpower, which may then be applied to multi-institutional comparisons.

Methods Using administrative data from 224 hospitals in Japan from 2008 to 2010, we performed four multiple linear regression analyses at the hospital level, in which the dependent variables were the number of operations per OR per month, procedural fees per OR per month, total utilization times per OR per month and total fees per OR per month for each of the models.

Results The expected values of these four indicators were produced using multiple regression analysis results, adjusting for differences in hospital size and manpower, which are beyond the control of process owners' management. However, more than half of the variations in three of these four indicators were shown to be explained by differences in hospital size and manpower.

Conclusion Using the ratio of observed to expected values (OE ratio), as well as the difference between the two values (OE difference) allows hospitals to identify weaknesses in efficiency with more validity when compared to unadjusted indicators. The new indicators may support the improvement and sustainment of a high-quality health care system.

Introduction

Hospital managers, doctors, nurses, medical support staff, administrative clerks and other support staff all play roles in carrying out improvements in management efficiency [1]. The assessment of individual hospitals' performance in management efficiency is an important step towards these improvements. Tools such as Total Quality Management and Balanced Score Cards have been introduced to evaluate and improve the efficiency of individual hospital departments, as well as total hospital management [2]. In particular, the management of hospitals' operating rooms (ORs) has been the focus of recent attention [3–7]. Previous studies showing a high correlation between the total number of operations in an OR and overall hospitalization fees [7,8], while our analysis of data from 153 Japanese hospitals during the period of April to September 2009 revealed that surgery and anaesthetizations fees comprised 28.1% of all hospitalization fees (data not shown). This highlights the substantial contribution of surgeries to the overall income of a hospital.

Several studies have emphasized the need for evaluations of OR management efficiency [4–6,8–15]. The assessment of OR performance has been previously conducted using indicators such as the number of operations, the procedural fees per OR, the total utilization times per OR and the total fees per OR. However, such assessments tend to be conducted at an individual hospital level, and such indicators are unable to take into account differences in hospital size, manpower and functional characteristics, such as differences in the number of surgeons, anaesthesiologists and nurses per OR; or the average length of stay (LOS) for each hospital [7,10–15]. There is therefore a necessity for assessment indicators that can adjust for differences in structural factors such as hospital size and manpower, which are beyond control of owners' hospital management, thereby allowing their applications in multi-hospital comparisons.

The aim of this study was to develop indicators of OR management efficiency that would take into account differences in hospital size and manpower, which may then be applied to multi-institutional comparisons.

Methods

Data sources

Data were obtained from the Quality Indicator/Improvement Project (QIP), which is a programme administrated by the Department of Healthcare Economics and Quality Management in Kyoto University. In this programme, member hospitals from all regions of Japan voluntarily provide administrative claims data for analysis. The objectives of the QIP are (1) to measure objective numeric indicators (performance indicators) in which the process, outcome and economy of diagnoses and treatments can be evaluated; (2) to provide feedback of these findings to the participant hospitals on a regular basis; and (3) to contribute to the improvement of the quality of health care in hospitals.

The administrative data used were based on the Diagnosis Procedure Combination system, which is a standardized per-diem patient classification system for the purpose of hospital reimbursement in Japan. Specifically, data were obtained from the E and F files from the database, which contain detailed information such as general anaesthesia duration and dosages for all prescribed medications on a daily basis. In this study, we utilized data from patients that were admitted to 224 hospitals from April 2008 to March 2010.

Information regarding the number of beds, number of staff, average LOS and the number of ORs in each individual situation were obtained from a yearly survey conducted on all QIP member hospitals. Data on the operation durations were obtained from the Confederation of Social Insurance Committees of Surgical Societies (*Gaihoren*) [16].

Indicator development and analysis

We focused on existing indicators of OR management efficiency that are currently utilized: number of operations per OR per month, procedural fees per OR per month, total utilization times per OR per month and total fees per OR per month [7,8,11,14]. These unadjusted rates of each of the indicators were calculated using data from the QIP database. Operations performed in each OR were identified on the basis of operation records of the past 3 years in the OR and the judgment of specialists from each department. Anaesthesia utilization duration was used as a proxy for OR utilization time, with data for epidural anaesthesia, intrathecal anaesthesia, intravenous anaesthesia or local anaesthesia calculated using *Gaihoren* data. The associations of indicators of OR management efficiency with hospital size and characteristics were analyzed using Pearson's correlation coefficient.

The 224 hospitals in the sample were randomly divided into two groups: one group served as the sample for indicator development, and the other was used for verification purposes [17]. To take into account inter-hospital variations, we performed four multiple linear regression analyses at the hospital level using a stepwise procedure, in which the dependent variables were (1) the number of operations per OR per month, (2) procedural fees per OR per month, (3) total utilization times per OR per month and (4) total fees per OR per month for each of the models. Independent variables in the regression models were factors related to hospital size and characteristics, namely the total number of beds, average LOS, number of nurses per OR, number of ORs, number of surgeons per OR, number of anaesthesiologists per OR and number of emergency patients. The validity of the models was verified using the verification sample group [17].

In order to develop indicators of OR management efficiency that took into account variations in hospital size and characteristics, we utilized the abovementioned regression models to calculate expected values of the number of operations per OR per month, procedural fees per OR per month, total utilization times of per OR per month and total fees per OR per month. We then calculated the ratio between the observed and expected values (OE ratio) and the difference between the observed and expected values (OE difference) to be used as new indicators [18,19]. An OE ratio greater than one indicates that the observed value has exceeded the expected value after taking into account inter-hospital variations, while the ratio less than one indicates that the expected value has exceeded the observed value. An OE difference less than zero indicates that the expected value has exceeded the observed value after taking into account inter-hospital variations, while the difference greater than zero indicates that the observed value has exceeded the expected value. Statistical analyses were conducted using Dr. SPSS II, and statistical significance was set at $P < 0.05$. All fees were expressed as US dollars using the purchasing power parity rate for Japanese yen to US dollars in 2010 (¥111 = $1), as stipulated by the Organization for Economic Cooperation and Development National Account database.

Results

A preliminary analysis revealed a large degree of inter-hospital variations in the general indicators of OR management efficiency, hospital size and characteristics (Table 1). The mean of procedural fees per OR per month was $67 492 [standard deviation (SD): $33 712], and mean of number of operations per OR per month was 42 (SD: 16 operations).

Table 2 shows the associations of indicators of OR management efficiency with hospital size and characteristics using Pearson's correlation. The four performance indicators were found to be significantly associated with hospital size and characteristics ($r = 0.277$~0.863; $P < 0.01$). The number of operations showed positive correlations with the number of surgeons per OR, number of nurses per OR, total number of beds, number of ORs, number of anaesthesiologist per OR and number of emergency patients ($r = 0.332$~0.628; $P < 0.01$); and negative correlations with the average LOS($r = -0.417$; $P < 0.01$). Procedural fees per OR per month were significantly associated with hospital size and characteristics, showing positive correlations with the number of surgeons per OR, number of nurses per OR, total number of beds, number of ORs, number of anaesthesiologist per OR and number of emergency patients ($r = 0.451$~0.863; $P < 0.01$) negative correlations with the average LOS ($r = -0.329$; $P < 0.01$).

The results of the multiple linear regression analyses are presented in Table 3. The number of number of surgeons per OR, total number of beds, number of anaesthesiologists per OR and number of nurses per OR showed significant association with the number

Table 1 Descriptive statistics of indicators for OR management efficiency and hospital size and characteristics

	Mean	Median	SD	Min	Max	*n*
Number of operations per OR per month	41.6	41.1	15.7	10.6	84.6	224
Procedural fee per OR per month ($)	67 492	62 366	33 712	13 949	195 389	224
Total utilization time per OR per month(hours)	60.2	57.5	29.6	3.8	160.8	209
Total fees per OR per month ($)	111 740	96 986	72 034	15 584	461 148	224
Total number of beds	343.7	314	188.9	43	1 118	224
Average length of stay	15.1	15	2.6	9.2	34.1	219
Number of ORs	5.9	5	3.1	1	20	224
Number of surgeons per OR	4.7	4.5	1.6	1	11	214
Number of anaesthesiologist per OR	0.6	0.6	0.3	0	1.5	178
Number of nurses per OR	3	2.9	1	0.6	8	184
Number of emergency patients per year	2 088	1 719	1 767	2	11 211	219

OR, operating room.

of operations per OR per month. The regression model showed that these four variables were able to account for 63% of the observed inter-hospital variations in the number of operations per month. When the dependent variable was the procedural fees per OR per month, significant associations were found with the number of surgeons per OR, total number of beds, number of anaesthesiologists per OR and number of nurses per OR. These variables were able to account for 56% of the observed inter-hospital variations. When the dependent variable was the total utilization time per OR per month, significant associations were found with the number of anaesthesiologists per OR, number of ORs and number of nurses per OR. These variables explained 64% of the observed inter-hospital variations. When the dependent variable was the total fees per OR per month, significant associations were found with the number of nurses per OR, total number of beds and number of anaesthesiologists per OR. These variables explained 33.8% of the observed inter-hospital variations.

To verify the stability of the four multiple linear regression models, we generated R^2 values for similar models using the verification group. In this sample, the R^2 values showed that the models were able to account for 50%, 48%, 47% and 34.1% of variations for the number of operations per OR per month, procedural fees per OR per month, total utilization times per OR per month and total fees per OR per month, respectively.

As novel indicators of OR management efficiency, the OE ratio and OE difference were calculated for each dependent variable (number of operations per OR per month, procedural fees per operation per month, total utilization time per OR per month, total fees per OR per month) using the expected values from the regression models, and the results for number of operations per OR per month, procedural fees per OR per month, total utilization time per OR per month and total fees per OR per month are shown in Figures 1 and 2. Figure 1 showed that the OE ratio of: the number of operation per OR per month ranged from 0.29 to 1.93; procedural fees per OR per month ranged from 0.25 to 3.1; total utilization time per OR per month ranged from 0.18 to 2.08; the total fees per OR per month ranged from 0.28 to 4.5. Figure 2 showed that the OE difference of the number of operation per OR per month ranged from −39.4 to 38.8; procedural fees per OR per month ranged from $−68 818 to $132 530; total utilization time per OR per month ranged from −81.62 hours to 62.8 hours; total fees per OR per month ranged from $−133 677 to $304 851.

Discussion

In this study, we have developed new indicators to assess OR management efficiency that takes into account variations in hospital size and characteristics suitable for multi-institutional comparisons, and used these indicators to conduct such a comparison using administrative data from multiple hospitals in Japan.

As shown in Table 2, we found that existing unadjusted OR performance indicators (number of operations per OR per month, procedural fees per OR per month, total utilization times per OR per month and total fees per OR per month) showed significant correlations to hospital size and characteristics (the numbers of surgeons, anaesthesiologists and nurses per OR, the total number of beds and the average LOS of each hospital) using multi-institutional data. Furthermore, the R^2 values were 0.63, 0.56, 0.64 and 0.338 for the number of operations per OR per month, procedural fees per OR per month, total utilization times per OR per month and total fees per OR per month, respectively, providing satisfactory explanatory power for all four dependent variables. We then calculated the OE ratio and OE difference using these models, and compared the results between multiple hospitals. These results were a more meaningful comparison of efficiency, as they allow for the adjustment of hospital size and manpower.

Figures 1 and 2 showed the application of the new indicators of OE ratio and OE difference for the number of operations per OR per month, procedural fees per OR per month, total utilization time per OR per month and total fees per OR per month. Using the OE ratio and OE difference, each individual hospital can assess the efficiency of their OR when compared to the results of other hospitals. A hospital with an OE ratio above one or an OE difference above zero indicates a higher efficiency than expected after taking into account variations in hospital characteristics, while a hospital with an OE ratio below one or an OE difference below zero indicates a lower efficiency than expected. As these indicators take into account the variations in hospital size and characteristics, inter-hospital comparisons become more meaningful. Such benchmarking among multiple facilities and working based on the best practice for achieving objectives are thought to be important in organizational management, with benefits including the clarification of strengths and weaknesses, knowledge of multiple positions and reference to the best practice [20]. The