Departament d'Economia Aplicada. Facultat de Ciències Econòmiques i Empresarials. Universitat Autònoma de Barcelona

Programa de tercer cicle del Departament d'Economia Aplicada de la Universitat Autònoma de Barcelona

Tesis doctoral

Análisis del coste hospitalario.
Información e instrumentos para el ajuste de la función de costes hospitalarios.

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Sabadell, a 31 de Enero de 2001

Agradecimientos y justificaciones personales

Esta tesis se ha realizado en el período 1998-2000 y es fruto del trabajo de investigación realizado a lo largo de los años 1995-2000 por un equipo que ha posibilitado la consecución de los objetivos que se incluyen. Los investigadores que han colaborado en aspectos concretos han sido Marta Riu quien ha aportado su conocimiento en sistemas de case-mix y ha tenido una especial aportación en la definición de una tabla de equivalencia de los GRDs que se relacionan con procedimientos quirúrgicos considerados potencialmente ambulatorizables necesaria para el capítulo 3; Pilar Torre ha asesorado sobre la incorporación de los distintos sistemas de valoración de la severidad utilizados en los capítulos 4 y 5; el Dr. Marc Sáez ha colaborado activamente como asesor para aspectos estadísticos para resolver distintos problemas de esta índole aparecidos en los capítulos 2 i 5; Mercé Comas ha dado soporte al análisis estadístico del capítulo 5; la Dra. Eulàlia Dalmau trabajó activamente en la depuración y consolidación de la base de datos con información económica; David Elvira trabajó activamente en el análisis de la información del capítulo 2 sobre el cálculo de outliers y, por último, Lluc Mercadé quien en su colaboración actual con los proyectos de investigación que llevamos a cabo, ha aportado elementos de discusión sobre los análisis ya realizados, especialmente en lo que se refiere a la utilización de variables ecológicas y al análisis multinivel.

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Los trabajos de encuadernación han sido sufragados por el Institut Municipal d'Investigació Mèdica.

El hecho de realizar esta tesis doctoral responde a razones que normalmente no son las habituales para justificar su realización. No se trata de una carta de presentación ni una demostración de suficiencia investigadora, aunque todo ello sin ser el motivo último, se da por supuesto. Ha sido más bien un proceso de consolidación de un proyecto de investigación que ahora, con esta tesis, permite marcar un punto y aparte. El proceso investigador continuará evolucionando pero a un nivel de análisis más micro, contrastando hipótesis más concretas y mediante procedimientos de recogida de información prospectivos, más asistenciales y menos administrativos. Este nuevo planteamiento demandaba un cierre ordenado de la primera etapa.

Debido a esta motivación, el conjunto de los capítulos centrales se ha redactado en inglés (capítulos 2 a 5) con la intención de conseguir su publicación posterior. El resto de la tesis (Capítulos 1 y 6) se ha traducido del catalán al castellano obedeciendo a la voluntad de poder contar con la presencia de personas del resto del estado español en el tribunal.

A la Valèria i en reconeixement als meus pares.

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Indice.

Capítulo 1.

Introducción al estudio de la variabilidad del coste del paciente ingresado.

Justificación.

Los sistemas sanitarios en el entorno europeo se basan en un predominio de financiación pública con coberturas que tienden a ser universales y con redes de provisión más o menos integradas que suministran los servicios sanitarios a la población. Independientemente de la titularidad de los centros proveedores, la relación entre la administración sanitaria (financiador-comprador) y los centros proveedores se establece en un marco de asignación de recursos públicos con la finalidad de cubrir las necesidades de la población general.

Esta realidad ha significado que el flujo económico entre la administración y los centros proveedores se ha basado en criterios de subsistencia de la red de provisión para que cubra el territorio de manera global y permita la prestación de los servicios demandados por la población. La formulación de los criterios por los cuales un proveedor recibe ingresos económicos por un nivel de actividad se han basado históricamente en criterios de reconocimiento retrospectivo del coste incurrido y el pacto de los niveles de actividad. No ha habido por lo tanto una información subyacente del valor ni del coste de las actividades realizadas.[1]

En el contexto de la atención especializada la red de hospitales supone la existencia de grandes empresas, en ocasiones las mayores empresas del área donde radican. Estos grandes centros de actividad no han valorado históricamente el coste de su actividad y no han podido compararse con el resto de hospitales de su entorno. La consecuencia de esta forma de entender la organización de los sistemas de salud ha provocado un desconocimiento del nivel de eficiencia del sector en general, una desconexión entre el volumen de actividad y su composición respecto de los ingresos económicos y, en definitiva la ausencia de información sobre el coste de la actividad hospitalaria.

Esta situación ha convivido con un largo período de expansión de los sistemas sanitarios que ha superado al crecimiento real de la economía. En España esta realidad ha pervivido hasta la mitad de los años 90 y ha significado que los incrementos de costes en la provisión que se iban produciendo eran absorbidos por el crecimiento del conjunto del gasto sanitario.[2] La necesaria contención de costes del sistema sanitario español se ha trasladado de forma inmediata a la relación de la administración sanitaria con los centros proveedores. Desde mitad de los 90 ha aparecido la necesidad de continuar ofreciendo las misma coberturas, mientras debían ajustarse los recursos destinados a la compra de servicios sanitarios y aparecían innovaciones tecnológicas que multiplicaban la necesidad de recursos, así como la percepción ciudadana de mayor necesidad de atención sanitaria una vez habían cubierto otras necesidades que consideraban prioritarias.

La necesidad de conocer los costes de la actividad realizada para conseguir una mayor eficiencia en el rendimiento de los recursos públicos así como la búsqueda de mecanismos para hacer más transparente la asignación de recursos a cada centro proveedor ha propiciado la necesidad de conocer los costes de la actividad realizada.

Les dificultades para obtener información sobre costes de los centros hospitalarios tienen dos causas principales:

- No existía y no existe actualmente una cultura de análisis del coste por actividad realizada. La gestión de los centros hospitalarios podía realizarse contando únicamente con la contabilización general de los gastos que permitiera justificar su reembolso global por parte de la administración.
- No existe información de precios puesto que la predominancia del sector público impide que haya un mercado que genere información de precios de los distintos productos y servicios relacionados con la prestación de servicios sanitarios
- La dificultad de definir producto en la provisión de servicios sanitarios ha provocado grandes dificultades en los intentos de valoración de la actividad realizada.

Para avanzar en el conocimiento del coste por actividad provocado por la provisión de servicios sanitarios es necesario reconocer la naturaleza multiproducto de la función de producción de un hospital: Hospitalización, Actividad ambulatoria, Urgencias, Docencia e Investigación. Solamente de esta manera se puede concretar el análisis a relaciones abordables entre dispositivos asistenciales y su actividad. El conjunto del estudio que se presenta, se ha concretado en el análisis del coste hospitalario correspondiente a la actividad de internamiento.

El coste del paciente ingresado.

Para superar las dificultades generales que se acaban de expresar sobre el desconocimiento del coste unitario observado de las actividades relacionadas con la atención del paciente ingresado y la dificultad de disponer de una definición de producto hospitalario, en la investigación aplicada se han realizado una serie de avances que serán el punto de partida de este estudio.

- Se han diseñado sistemas de clasificación de pacientes (casemix) que se basan en su agrupación en un reducido número de categorías de producto bajo criterios de consumo de recursos, homogeneidad clínica, o factores pronóstico.

  Para el análisis de costes los sistemas de agrupación de pacientes basados en isoconsumo de recursos son claramente los más adecuados. Los distintos sistemas de salud regionales han optado por distintas versiones de los llamados Grupos relacionados por el Diagnóstico (GRD). El presente estudio se ha basado en los GRD de la Heath Care Financing Administration versión 13 utilizados por el Servei Català de la Salut, aunque se han utilizado también otros sistemas de agrupación para valorar las diferencias en sus posibilidades en el análisis de costes.
- Proyectos de asignación de costes del tipo coste por paciente ingresado (a partir de ahora clinical-cost) basados en técnicas de contabilidad analítica que han permitido repartir el conjunto del coste de un período al nivel de los pacientes ingresados. Para este estudio se ha contado con el coste por paciente observado de 35.262 pacientes pertenecientes a los hospitales públicos del Institut Municipal d'Assistència Sanitària de Barcelona.

Si bien las técnicas de casemix, básicamente los GRD, se han generalizado, el conocimiento del coste por paciente observado es todavía un caso excepcional. Esto ha propiciado que se hayan extendido formas alternativas a la valoración del coste. Obviando la realidad americana de los sistemas de ratios 'charge to cost', en Europa se han generalizado los sistemas de cálculo definidos como 'modelling-cost'.[3] Estos sistemas aproximan un coste medio por categoría de producto GRD sobre la base de distribuir el conjunto del coste de un hospital de forma ponderada a cada paciente según el GRD al que pertenecen. Para ello se han creado escalas de costes relativos (a partir de ahora les llamaremos pesos) que ponderan el coste inter-GRD.

En Cataluña, como en toda España y de forma también mayoritaria en Europa, se utilizan los pesos del sistema Medicare americano. Sobre esta forma de aproximación a coste por producto se han desarrollado sistemas de comparación benchmarking entre hospitales y sobre todo, sistemas de pago a hospitales que han comenzado a utilizarse en años recientes.

El presente estudio pretende valorar los peligros de utilizar estos sistemas de 'cost-modelling' con relación a un estándar como es el coste real observado mediante 'clinical-cost', con el fin de ofrecer evidencia empírica sobre las posibilidades del primero de los métodos y la necesidad de evolucionar hacia criterios que ajusten mejor la variabilidad del coste por paciente ingresado.

La justificación definitiva del presente estudio se resume en la necesidad de pasar de aproximaciones indirectas del coste hospitalario mediante ‘cost-modelling’ al comportamiento del coste por paciente ingresado, definiendo una especificación empírica de función de costes del paciente ingresado (FCPI) y valorando las diferencias que existen entre ambas aproximaciones.

La situación actual en nuestro entorno (desde Cataluña a la mayor parte de países europeos)

Quedan muchas preguntas por responder sobre la capacidad de las técnicas de casemix para el análisis del coste hospitalario. A criterio del autor, se ha producido una instrumentalización de los GRD para el análisis de costes en España sin una validación previa de su utilidad:

- No ha habido ningún estudio que haya valorado la capacidad de los GRD para explicar variabilidad de costes.
- No se ha valorado si los criterios de agrupación de pacientes o bien si los pesos asociados a cada categoría GRD son adecuados a la realidad del sistema sanitario en nuestro entorno.
- No se han valorado las diferencias existentes entre los distintos sistemas de clasificación de pacientes según si incluyen o no valoraciones del nivel de severidad, así como por los criterios utilizados para determinar comorbilidades y complicaciones. Dicho de otra forma, no se ha pasado del criterio de análisis del casemix al de ‘ajuste de riesgos’.
- No se ha realizado ninguna aproximación a la repercusión de los casos extremadamente costosos sobre el valor medio de la categoría GRD a la que han sido asignados. Existen tantos criterios para determinar métodos para aislar los casos extremos como países donde se han implantado estas técnicas con la intención de financiar los hospitales. En este sentido Cataluña y después otros servicios regionales como el de Andalucía, han sido los primeros en utilizar técnicas de casemix para la asignación de recursos sin aislar los casos extremos de coste.

Gran parte de estas cuestiones no han podido tener respuesta por falta de información sobre el coste real por paciente ingresado. La oportunidad del presente estudio es disponer del coste por paciente de una muestra suficiente que podrá ser utilizada como estándar de comparación.

En consecuencia, prácticamente la totalidad de los análisis de eficiencia hospitalaria realizados en nuestro entorno, así como los distintos sistemas de pago a hospitales de última generación, han utilizado definiciones de producto basadas en técnicas de casemix sin haber respondido previamente a las cuestiones pendientes expresadas.

También el uso comercial de instrumentos basados en técnicas de casemix ha sobrevalorado sus posibilidades y capacidad operativa. Se ha extendido la creencia en el sector sanitario que la relación entre producción y costes se puede resolver con un simple algoritmo basado en la imputación de los costes totales de un hospital a cada GRD en función del número de pacientes. Esta creencia supone predeterminar que no existe variabilidad intra-GRD, amén que el algoritmo de cálculo de los GRD y de los pesos asociados sean directamente transportable desde los EEUU a cualquier hospital de nuestro entorno.

Objetivos

Objetivo principal.

Determinar las causas de la variabilidad del coste por paciente hospitalizado, considerando el nivel de variabilidad intra-grupo e inter-grupo del coste por paciente ingresado al utilizar los Grupos Relacionados con el Diagnóstico (GRD) como medida del producto hospitalario.

Objetivos concretos

1. Analizar la variabilidad del coste generada por la existencia de casos extremos (outliers). Definir el método de cálculo de outliers de coste más apropiado para ser utilizado sobre la 'duración de la estancia' entendida como variable proxy del coste. (Capítulo 2)

2. Evaluar las diferencias que existen entre el sistema de pesos asociado a los GRD utilizados por Medicare (programa de cobertura pública para personas mayores de la Health Care Financing Administration- HCFA- en los E.E.U.U.) y los pesos ajustados a nuestra realidad calculados sobre la base de costes por paciente observados. (Capítulo 3)

3. Construcción de un sistema de ajuste de riesgos que maximize la capacidad explicativa de la variabilidad inter e intra GRD, dado el nivel de información existente en cualquier sistema hospitalario europeo. (Capítulo 4)

4. Estimación empírica de la función de costes por paciente ingresado que permita explicar el comportamiento del coste por paciente ingresado así como la causa de este comportamiento. (Capítulo 5)

Antecedentes concretos

Se presenta en este apartado una breve síntesis de la situación actual del análisis y discusión sobre los cuatro objetivos concretos a desarrollar en el presente trabajo.

Variabilidad del coste debida a la existencia de casos extremos (Capítulo 2)

Carter[4], Söderlund[5,6] y Lichtig[7] han aportado múltiples evidencias sobre la importancia de los casos extremos como fuente de variabilidad dentro de cada uno de los grupos de pacientes considerados a priori homogéneos. Los autores citados han utilizado la estancia como aproximación del coste cuando han buscado el método de marcaje de outliers más conveniente a sus necesidades.

Sus soluciones abren un amplio abanico de posibilidades de sistemas de marcaje de casos extremos que van desde sistemas basados en indicadores de tendencia central (Carter), hasta sistemas basados en el rango inter-cuartílico (Söderlund), pasando por sistemas mixtos en los que intervienen las dos propuestas anteriores (Lichtig).

Según Monrad Aas[1], casi todos los países que han utilizado los GRD como instrumento relacionado con la valoración de la actividad realizada en el hospital, reconocen la existencia de los outliers y los tratan de forma diferente al resto de casos, ya que significan más coste que el que refleja el valor medio estandarizado aplicado al GRD correspondiente.

Variabilidad inter-grupo debida a la utilización de pesos relativos estandarizados provenientes de un entorno económico, social y organizativo, distinto. (Capítulo 3)

Los GRD se han construido y han evolucionado en base a las necesidades del mercado Medicare. El sistema de medida de pacientes por GRD pretende dar solución al problema de la definición del producto hospitalario. Los pesos asociados son la valoración que se da a cada grupo de pacientes en el entorno Medicare.

En consecuencia, los GRD son una medida de producto adaptada a la realidad de una población concreta y a unos costes relativos fruto de su sistema de prestación de servicios.

Muchos países de Europa y también en Australia o Canadá, han importado este sistema de definición de producto y valoración del mismo. Ante la duda de la capacidad de estos instrumentos de medida y valoración para adaptarse a la realidad de los sectores de salud pública europeos (con coberturas de 100% de la población), cabe plantearse hasta qué punto es recomendable esta importación directa.

Muchos de estos países han adaptado los GRD a su realidad: Gran Bretaña con los Health-Resource-Groups (HRG)[8] , o bien Australia con los AN-GRD[9,10]. Obviamente, de la adaptación de los GRD sale una nueva valoración del coste relativo estandarizado de los mismos[3].

Otros países han preferido utilizar directamente los GRD y sus pesos originales. Entre estos países destacan Noruega,[11] Portugal[12] y desde 1997, Cataluña.[13]

Cuando se han introducido cambios, estos han sido motivados por la necesidad observada de adaptar los criterios de agrupación a las especificidades del sistema sanitario en cuestión, más que a la constatación de diferencias en las estructuras de costes relativas. En el caso español, Casas[14] validó los GRD como instrumentos de definición de producto desde un punto de vista clínico. Hoy en día, cuando ya forman parte de las normativas habituales de diferentes entes regionales (Xunta de Galicia,[15] Junta de Andalucía,[16]) como instrumentos para la asignación de recursos, no se ha validado si los pesos asociados a los GRD de Medicare se adaptan a la estructura organizativa, el nivel de eficiencia medio, la práctica clínica, o las características socioeconómicas de la población.

Variabilidad intra-grupo debida a errores de medida del propio sistema de agrupación (Capítulo 4)

Existe variabilidad intra-grupo no explicada por los GRD debida al importante número de factores que intervienen en la formación del coste asociado a la atención de cada uno de los pacientes.

Los GRD son un compromiso entre la obtención de una clasificación de productos lo más reducida posible y desagregar la diversidad de los pacientes entre el mayor número posible de tipologías, con la finalidad de que el coste medio de cada grupo presente la menor variabilidad posible. Dicho de otra manera, los GRD buscan la máxima variabilidad inter-grupo y la mínima variabilidad intra-grupo, al mismo tiempo que son una herramienta fácilmente manejable por incorporar un número reducido de grupos y ser útiles para la gestión, para el reembolso, el análisis clínico, el benchmark, o el análisis de costes por producto final. Otras razones que motivan esta variabilidad hacen referencia a las variables utilizadas para la construcción de los GRD, las cuales no son suficientes ni suficientemente buenas[17]. Recordar que el sistema RUG (Resource Utilization Groups) análogo a los GRD para pacientes ingresados sociosanitarios, utiliza un número más elevado de variables para su definición,[18] o bien que considera que en el período inicial de la aplicación de los GRD en EEUU, el incremento de la complejidad medida por los GRD se debía casi en su totalidad a la mejora de la calidad de las variables con las que se construyen estos agrupadores.[19] Este fenómeno puede estar dándose ya en Cataluña tras cuatro años de la utilización de los GRD para la valoración de la actividad hospitalaria pública.[20]

Iezzoni[21] y Elixhauser et al[22] han apostado por medidas que mejoren la capacidad de los GRD para aproximar el coste justificable de los pacientes sobre la base de variables que explican severidad, complicaciones y comorbilidades. Muchas veces, los GRD no recogen estas variables que significan causas sistemáticas de variabilidad.

Epstein[23] y Beaver et al[24] han evidenciado que las diferencias socioeconómicas dan lugar a incrementos en la variabilidad del consumo de recursos.

El comportamiento de la función de costes por paciente. Las causas de la variabilidad del coste por paciente (Capítulo 5)

Diversas han sido las aproximaciones a la función de costes hospitalarios, pero todas ellas tendentes a explicar cómo se comporta el coste total por hospital. A título meramente ilustrativo pueden citarse los trabajos de Breyer[25], Grannemann et al,[26] Butler,[27] Rosko,[28] Söderlund[29] y más cercano a nuestra realidad Wagstaff y López-Casasnovas.[30]

No hay demasiadas experiencias de estudio del comportamiento de la variabilidad del coste por paciente y en este campo las aportaciones son más cercanas al ajuste de riesgos que a una verdadera formulación de función de costes por paciente: Calore y Iezzoni,[31] Thomas y Ashcraft,[32] Söderlund et al[6] o bien aproximaciones a la variabilidad de la duración de la estancia.[24]

La realidad parece ser abrumadora, las aproximaciones al producto hospitalario y a su coste asociado solamente tienen relevancia en tanto que implican decisiones en el marco de la macrogestión, en la asignación de recursos. A este nivel de aproximación la variabilidad de coste entre pacientes no es relevante y la propia definición de los agrupadores de pacientes basta para darle solución.

Los conceptos de calidad y de gestión clínica van muy ligados al conocimiento de lo que se hace y el coste que implica. Teniendo presente que éste es el futuro del análisis del coste en el hospital, la determinación de la función de costes por paciente ingresado (FCPI) es el objetivo último a resolver en este trabajo.

Metodología para el análisis.

Sujeto del estudio.

Los hospitales del Mar y de la Esperança de Barcelona, ambos pertenecientes al 'Institut Municipal d'Assistència Sanitaria'(IMAS). Son hospitales generales de titularidad pública que prestan la mayor parte de su actividad a pacientes de la Seguridad Social y que pertenecen a la red de utilización pública de Cataluña, conocida por XHUP. Se parte de la confección de una base de datos del coste por paciente de 35.262 altas de ambos hospitales correspondientes a los períodos 1995 y 1996. Los costes por paciente de la base de datos son fruto de la aplicación de un modelo de contabilidad analítica basada en actividad sobre costes totales históricos.

El IMAS ha desarrollado en el período 1993-1995 un complejo sistema de contabilidad analítica que permite la asignación a cada paciente del conjunto del coste de hospitalización. La relación del sistema de contabilidad analítica basado en el sistema de 'full costing' aplicado a costes históricos ha demostrado su alta fiabilidad al conseguir mantener una relación exhaustiva con la contabilidad general, de manera que el reparto por cada concepto de coste es siempre el reparto del valor global de dicho concepto y período. Históricamente, el IMAS ha venido generando las herramientas que le permiten en la actualidad disponer de un contrastado sistema de clasificación de pacientes y de un consolidado sistema de asignación de costes.

Clasificación de pacientes.

El producto de los hospitales analizados se ha entendido como la desagregación de la actividad total del hospital entre sus ámbitos de consultas externas, urgencias, hospitalización, docencia e investigación.

Los hospitales del IMAS vienen clasificando sus altas mediante la clasificación ICD-9-CM desde 1984. En el período en que se creó la base de datos del estudio se poseía ya de una serie homogénea agrupada mediante la versión 11 de los Grupos Relacionados por el Diagnóstico (GRD) de la Health Care Financing Administration (HCFA) que correspondía al período 1987-1996.

Sistemas de información y costes.

En el período 1995-1996 las aplicaciones informáticas gestionaban exhaustivamente la información de Laboratorio, Radiología y Medicina Nuclear, Anatomía patológica, Farmacia, Dietas y Prótesis por lo que a consumos directos a paciente se refiere.[33]

La aplicación informática de planificación y control horario de personal permite conocer el tiempo por persona y el centro de coste donde lo desempeña, así como el tiempo destinado a guardias y las libranzas de jornada laboral que ello conlleva. Las aplicaciones de programación de consultas externas, quirófanos, interconsulta y pruebas complementarias permitían conocer el tiempo de dedicación a estas actividades del personal médico y residente. Al tratarse de un sistema de contabilidad de costes históricos totales, el conjunto del tiempo de dedicación registrado se convierte automáticamente en una proporción relativa del tiempo total contratado; dicho de otra manera, el coste que se asigna al paciente incorpora la subactividad y/o falta de productividad.

Como pasos previos a la asignación de costes a cada paciente se trabajó en la confección de parámetros de imputación indirecta (cost-drivers) que son imprescindibles para poder llegar a la imputación 'full costing'. Entre los más novedosos reseñamos los que permiten asignar tiempo destinado a 'investigación' mediante la ponderación del 'factor de impacto' de las publicaciones de cada servicio clínico y usando como referencia el Real decreto 1652/1991 de once de Octubre que en la modificación que hace del RD 1556/1986 de 28 de Junio referente a convenios entre Instituciones Sanitarias y Universidades, el cual asigna cotas máximas a la dedicación investigadora del personal médico de hospitales universitarios. De la misma forma y siguiendo las directrices del RD anterior se imputan los tiempos de dedicación a docencia sobre la base de la aplicación de control y planificación de personal que incorpora la información de horas destinadas a docencia. La formación continuada, la gestión y el control de calidad tienen ya parámetros construidos en base a cálculos de tiempo de dedicación basados en la aplicación de control horario y en estimaciones realizadas ex-proceso.[34]

Una parte sustancial del trabajo realizado previamente a la construcción de la base de datos fue el seguimiento de las aplicaciones informáticas que mantienen los distintos ámbitos de actividad, de manera que la utilización de la información que generan para un uso distinto al de una gestión día a día, no representase dificultades o desviaciones de los valores bajo la perspectiva de la construcción de un sistema de costes exhaustivo.

El sistema de contabilidad analítica.

El sistema de asignación es un sistema 'full costing' de costes históricos que se basa en el enlace entre los centros de coste de la contabilidad general con centros de coste analíticos mediante conversión automática. Se asegura así el reparto de la totalidad de costes referenciados por la contabilidad general a cada paciente como receptor último del reparto. Se asignan la totalidad de costes incurridos para cada hospital a excepción de los costes financieros y de la dotaciones a provisiones por insolvencia.[35-37]

La asignación de costes responde a la imputación del total de costes de los hospitales del estudio y períodos estudiados, a cada paciente y subsiguientemente a cada GRD. La forma de asignación se basa en la imputación directa a cada paciente para: laboratorio, farmacia, radiología, medicina nuclear, anatomía patológica, dietas y prótesis. Los costes directos o indirectos que necesitan de una imputación indirecta entre distintos centros de coste analítico antes de llegar al paciente, se imputan iterativamente entre los distintos centros de coste analíticos hasta llegar al paciente.

El sistema de contabilidad analítica para asignar costes a cada paciente es el enlace de las aplicaciones mecanizadas que gestionan la actividad de los diferentes servicios asistenciales, centrales y de soporte de los hospitales objeto de estudio. En ningún caso, se utilizan fuentes de información que no sean las aportadas por los propios sistemas mecanizados de información que gestionan el conjunto de la actividad asistencial y económica de los centros.

Si bien para la mayoría de asignaciones hay variables intermedias que nos permiten asignar la totalidad del coste de centro de coste analítico indirecto a un centro de coste analítico final y de este al paciente y consecuentemente a GRD, hay una serie de parámetros que revisten una especial dificultad y que son crucialmente importantes: la distribución del tiempo del staff médico de los servicios clínicos que destinan parte de su tiempo a actividad en régimen ambulatorio, guardias de urgencias, pruebas y procesos terapéuticos, actividad quirúrgica, hospitalización e interconsulta (éstas con carácter asistencial) y en lo referente a funciones no asistenciales, docencia, investigación, gestión y control de calidad.[38-40]

Para la mayoría de casos, se conocen los tiempos empleados por paciente, como sucede en la actividad ambulatoria, las pruebas y procesos, la actividad quirúrgica, la interconsulta y sin relación al paciente, el tiempo destinado a guardias. Es en el resto de actividades donde se han construido parámetros de asignación basados en informaciones totalmente objetivables.

La cantidad de información que se va superponiendo en la confección de un sistema mecanizado de asignación de costes ha obligado a realizar la validación y el control de calidad, no tan sólo de la información de base, sino de la traducción y de la adaptación de ésta a las necesidades de la información con cariz económico en que se traduce finalmente.

Métodos específicos de cada objetivo concreto.

Variabilidad intra-grupo generada por la existencia de casos extremos.

Se ha determinado la importancia de su existencia sobre la base de diferentes métodos de marcaje.

Se ha elegido el sistema de marcaje de outliers bajo el criterio de considerar que el mejor sistema es aquél que, aplicado a coste y a duración de la estancia, manifiesta la máxima concordancia en el marcaje de casos extremos.

El método de análisis se ha basado en la valoración del nivel de concordancia entre el hecho de ser o no outlier de coste y estancia al aplicar cada método de marcaje.

Variabilidad inter-grupo debida a la utilización de costes relativos estandarizados de Medicare.

Se han generado dos estructuras de pesos relativos, la de los pesos Medicare y otra basada en los costes observados. Se ha analizado si existen diferencias entre las dos estructuras de pesos y se han contrastado hipótesis sobre diferencias esperadas por diferencias estructurales de ambos sistemas.

El método de análisis se ha basado en la valoración de la correlación entre las dos estructuras de pesos y el análisis de las desviaciones individuales y por agrupaciones de GRD.

Variabilidad intra-grupo debida a error de medida del propio sistema de agrupación GRD. (ajuste de riesgos)

Se ha establecido la capacidad de los pesos Medicare para explicar la variabilidad del coste por paciente. Se ha analizado cómo la utilización de los pesos basados en costes y la depuración de casos extremos permite mejorar la capacidad explicativa de la variabilidad de costes por paciente. Se han elegido aquellos indicadores sintéticos que permiten mejorar aquella parte de la variabilidad intra-grupo no explicada.

El método de análisis se ha basado en estudiar la capacidad de explicación de la variabilidad del coste del paciente ingresado que aporta cada uno de los sistemas de ajuste de riesgos planteado, mediante Regresiones Lineales estimadas por Mínimos Cuadrados Ordinarios.

Propuesta de una función de costes por paciente ingresado (FCPI).

Sobre la base de la información generada en los puntos anteriores, se ha generado una propuesta de función de costes por paciente ingresado capaz de dar luz a las causas que explican la variabilidad del coste por paciente ingresado.

El método de análisis se ha basado en estudiar el comportamiento de la función de costes por paciente ingresado mediante Regresiones Lineales y Modelos Lineales Mixtos.

Capítulo 2

Relevance of outlier cases in case mix systems and evaluation of trimming methods for use in Europe

Introduction

Hospital cost analysis has advanced despite the difficulties of delimiting the product resulting from hospital activity. The total amount of activity, intermediate products and ways of approaching different diseases are interrelated in each hospital patient. Consequently, the associated cost is extremely difficult to evaluate.

At the beginning of the 1980s, systems to define hospital product began to be used which attempted to contain all activities, products and diagnoses in a limited number of groups. The central axis of these systems is the inpatient who is assigned to a product group related to diagnosis and to other criteria concerning severity of illness, complications, comorbidities, or age. To determine the relationship between total hospital cost and total hospital product, a simple linear function is used (equation 1).[27,41]

The main advantage of these patient classification systems is that they eliminate the imprecision inherent in the multiproduct nature of hospitals where collective action in any given patient results in infinite possibilities.[42] In practical terms, this means that these systems are able to establish a dialogue between the provider and the purchaser. The establishment of a purchase-provision relationship for a large number of patients means that inter-patient cost variation can be approached through patient classification systems and that a price can be assigned to each category.[43] Much of the unexplained variability that arises when the care a patient receives is more expensive than the invoice is compensated for by the fact that in another patient the opposite occurs. Similarly, if the whole diagnosis related group (DRG) is under-financed for a given hospital, this is compensated for by the over-financing of another DRG.

$$C_t = \sum_{i=1}^{n} k_i * Y_i \qquad (1)$$

where K_i is the number of cases and Y_i is the value assigned to the product i .

The main limitation of these systems is that they assume that the costs associated with this group are usually the same and therefore, that the activities associated with patients in a particular group are also the same.

Several analyses have found these systems' ability to explain cost variation to be limited.[6,29,31,32] The reduction of the cost of one group of patients to the mean cost of patients belonging to a particular group is a very significant reduction in the complex framework of hospital product.[44]

Little more than half of DRGs, the most commonly used patient classification system, represents more than 90% of the activity of a general hospital.[45] Not more than 250 mean values should explain the cost variation related to 20,000 patients in a particular hospital or to 2,000,000 discharges of a public hospital system.

Another clear limitation of patient classification systems lies in the fragmentation of patient care. These systems include the field of inpatient hospital care, omitting other hospital activities (outpatient, emergency and day-hospital care) because of the added complexity of not having the clear temporal demarcation of patient admission and discharge.

Lognormal cost distribution per hospital patient

When determining the mean cost associated with each DRG in order to take a decision about it, the mean value may not be the most appropriate tool with which to value all the patients in a particular group.

From a mathematical point of view, cost distribution per patient has a minimum value of 0 and a maximum value tending towards the infinite. Patient cost distribution is heavily skewed to the right, signifying a form of cost distribution in which the mean value is subject to tensions which could lead to overvaluation. Consequently, as several authors have pointed out, cost function distribution is lognormal.[7,46]

Financial risk

Patient classification systems have been extensively developed due to their use as an instrument of hospital payment. Obviously, the application of mean values to an entire national health system supposes financial risk for hospitals whose case mix does not fit that of the whole system.[22,47-49] Thus, if the number of patients with a higher cost than the value recognised by the corresponding DRG exceeds that of patients with a lower cost than the standard value, the result will be overall undervaluation of the hospital product.

Outlier cases

DRG groups incorporate patients far removed from the resource use of most patients belonging to the same group.[50] The consequent valuation according to the mean of the patients in the group incorporates the tendency of these outlier cases. This effect, known as masking, leads to the overvaluation of the mean value of this category. On the other hand, the existence of these cases in resource use (length of hospital stay (LOS) or cost) means that, when standard external valuations are used to identify them, their cost is undervalued.

The Medicare system in the United States,[4,51,52] the National Health Service in the United Kingdom[5,8,53] and DRG-based clinical analysis systems[14,54,55] eliminate these values to determine standard mean values, which makes robust inter-hospital and inter-year comparisons possible. Medicare uses a differential payment for these cases.

Determination of outlier cases

To detect outlier cases, several trimming methods can be used which yield different results.[56] [57] Of these methods, two stand out. One group is based on the distribution of the elements which compose the group to be analysed. These methods attempt to make the arithmetic mean more robust. They use a multiple of the standard deviation of normal distribution to designate the trimpoint of outlier cases (equation 2):

$$\text{Trimpoint} = \text{mean} + a * \text{standard deviation} \qquad (2)$$

where 'a' is the parameter that multiplies standard deviation

A second group of trimming methods is based in the inter-quartile range so that a multiple of the range between the 25th and 75th percentiles is added to the 75th percentile.

$$\text{Trimpoint} = \text{75th percentile} + a * \text{inter-quartile range} \qquad (3)$$

In addition to the difference in conception, parametric or non-parametric, these two methods also differ in the parameter used. The parameter is the number of times that either the inter-quartile range is added to the 75th percentile or the standard deviation is added to the mean. If parametric methods are used, the cost per patient distribution for each category must be normal, otherwise the parameters used will be skewed. Because cost function distribution is lognormal, a logarithmic transformation can be performed and subsequently applied to the parametric method used. In this case, once the trimpoint has been found, the transformation obtained reverts to its original value.

In practice, the geometric mean and the standard deviation of the original distribution are used. The geometric mean equals the arithmetic mean calculated over the logarithmic transformation. Thus, the parametric methods used by Medicare until 1997 are given by equation (4):

Trimpoint = geometric mean + a* standard deviation (4)

The aim of this study was to determine the most satisfactory outlier trimming method and to analyse its relevance in the distribution of financial risk among hospitals. The methodology was based on the hypothesis that the most satisfactory trimming method is that which shows the greatest agreement when applied to LOS and to costs. This is a practical hypothesis because resource use in Europe is assimilated by LOS and only rarely is systematic information on cost per patient available in hospital information systems.

This study makes use of per discharge cost information from two public hospitals in Barcelona from 1995 to 1996.

Material and methods

The discharges of patients admitted to the two teaching hospitals during a two-year period between 1995 and 1996 were analyzed. The MHI's hospital cost accounting system based on full costing allocation ensured that the hospitals' total costs were distributed among the patients.

Calculation of trimming methods

A database with costs and LOS for 35,262 patients was constructed. For each DRG the trimpoints for the following equations were calculated both for costs and for LOS:

GM + 2 * SD (referred to hereafter as GM2) (5)

GM + 3 * SD (referred to hereafter as GM3) (6)

75th percentile + 1.5 * IR (referred to hereafter as IQ15) (7)

75th percentile + 2 * IR (referred to hereafter as IQ20) (8)

Where GM is the geometric mean, SD is the standard deviation and IR is the inter-quartile range.

Analysis of agreement

Contingency tables showing four possibilities were constructed: one representing agreement between outlier cases in terms of cost and LOS, one representing agreement between inlier cases and two representing non-agreement (Table 1).

Table 1 2X2 Contingency table

		Length of stay (LOS)		
		inliers	outliers	Total
costs	inliers	inliers (a)	false positives (b)	*(a) + (b)= c1*
	outliers	false negatives (c)	outliers (d)	*(c) + (d)= c2*
	total	*(a) + (c)= e1*	*(b) + (d)= e2*	*(a)+(b)+(c)+(d) =T*

Several “case by case” agreement tests for each method used were applied to these contingency tables.[50,58] These tests measure the proportion of agreement and the level of bias in the cells showing non-agreement**.** We considered cost as the observed variable and LOS as its estimation.

Kappa’s coefficient

This chance-corrected index was used to determine the degree of agreement between the results for LOS and for costs.

$$K = (PO - PC)/(1 - PC) \quad (9)$$

PO = proportion of observed agreement. In Table 1: PO = (a+d)/T

PC = proportion of chance agreement. In Table 1: PC = $(el*cl+e2*c2)/T^2$

The Kappa coefficient oscillates between negative values and 1. If the agreement between observation methods A and B is equal to what could be expected by chance, then K = 0. When PO = 1 (and consequently there is perfect agreement) then K = 1. Landis and Koch suggest an interpretation of this coefficient, classifying agreement into: bad (<0), poor (0-0.20), average (0.21-0.40), moderate (0.41-0.60), substantial (0.60-0.80) and almost perfect (0.81-1). A limitation of the Kappa coefficient is that unequal symmetrical distributions yield low Kappa coefficients despite higher degrees of agreement.

Sensitivity index

The sensitivity index is the proportion of LOS outlier cases detected which agreed with cost outlier cases (standard). The result is expressed in values between 0 and 1

$$Sensitivity = d / c2 \quad (10)$$

Specificity index

The specificity index is the proportion of LOS inlier (not outlier) cases which agreed with cost inlier cases (standard). The result is expressed between 0 and 1:

$$Specificity = a / cl \quad (11)$$

Youden's index

Youden's index includes the sensitivity and specificity indexes. It is given by equation (12).[59] The result is expressed in values between 0 and 1:

$$Y = S + E - 1 \qquad (12)$$

The sensitivity and specificity indexes and Youden's index do not correct for the effect of chance. However, the asymmetry of the contingency table affects the value of the sensitivity and specificity indexes less than that of Kappa's coefficient.

Receiver operating characteristic curve

The receiver operating characteristic (ROC) curve is the relationship established between sensitivity and the complementary specificity.[50] Figure 1 shows that the greater the area below the ROC curve, the greater the agreement on adding higher sensitivity and lower lack of specificity. The area below the ROC curve can be calculated by applying equation (13). The maximum value which can be obtained by this index is 100, equivalent to leaving an area of 100% below the curve:

$$ROC = 1 - U/(c1 * c2) \qquad (13)$$

Where U is the value of the Mann-Whitney non-parametric test for the LOS variable grouped according to the outlier-inlier cost variable and $c1$ and $c2$ are the number of cost inlier cases and cost outlier cases respectively.

The Mann-Whitney non-parametric test relates the continuous value of the explanatory variable with the grouping of the independent variable. The independent variable is whether or not the case is of extremely high cost and the explanatory variable is LOS. However, on identifying outlier cases independently for each DRG, the variable of LOS was reconstructed as the quotient between the LOS of the patient and the average LOS of the DRG to which the patient belonged. Thus, grouping by DRG was incorporated into the variable of LOS.

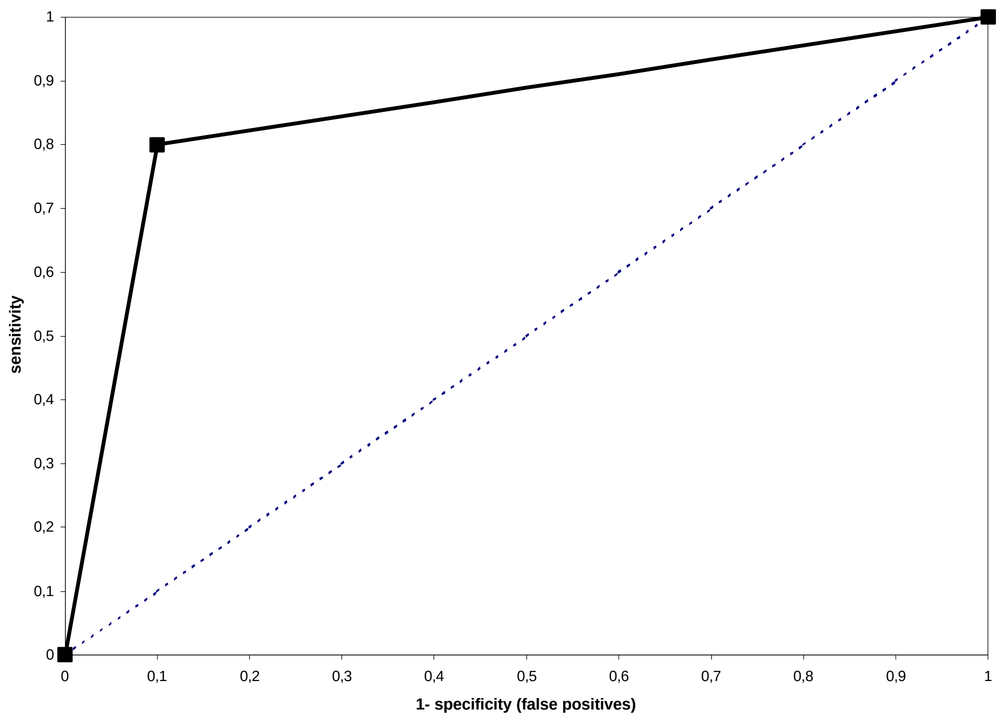
McNemar's test

McNemar's test determines whether there is systematic bias in the cases showing non-agreement, as shown in cells b (false positives) and c (false negatives) in Table 1. Systematic bias exists when one type of error predominates. McNemar´s test statistic is given by:

$$\chi^2 = (b - c)/(b + c) \qquad (14)$$

The critical point of this statistic is $\chi^2_{1,\alpha}$. Above this level, systematic bias at a significance level of α is believed to exist.

Figure 1 ROC curve[1].



Cost associated with outlier cases determined by LOS

The quality of the trimming method should be analysed according to the volume of extreme costs identified by the method when applied to the variable of LOS Independently of the agreement in number of cases, the volume of costs associated with these cases is the most relevant factor to consider when choosing a trimming method.

The quality indicator created enabled calculation of the percentage of outlier costs identified when the trimming method was applied to the variable of LOS.

Results

Table 2 shows the percentage of extreme cost and LOS cases for each of the methods analysed. The percentages of costs and LOS associated with extreme cases are also shown. Between 2% and 6% of cases were cost outliers with an associated cost of between 11% and 20%. The percentage of LOS outliers was between 2% and 7% with associated LOS between 9% and 17% of total LOS. The difference between GM3, used by Medicare, and the other methods was substantial, GM3 being much more conservative and identifying far fewer cases than the other methods. In contrast, IQ15 detected many more cases than the other methods.

The overall distribution of the contingency tables for the four methods is summarised in Tables 3-6. The results of applying the "case by case" agreement tests are presented in Table 7.

Table 2 Outliers determined by different trimming methods.

	cases	costs (MM Pta.)	cases	Length of stay (LOS)
total	35,262	12,794	35,262	312,073
Percentage of outliers:				
	by costs		by LOS	
IQ15[1]	5.90%	20.22%	6.75%	16.29%
IQ20[2]	4.23%	16.50%	4.97%	12.92%
GM2[3]	4.76%	17.91%	4.98%	15.74%
GM3[4]	2.06%	10.56%	2.08%	8.53%

(1) Inter-quartile range with parameter =1.5
(2) Inter-quartile range with parameter =2
(3) Geometric mean plus two standard deviations
(4) Geometric mean plus three standard deviations

Kappa’s coefficient, Youden’s index and the ROC curve analyse the diagonal of the contingency tables. When Kappa’s coefficient and Youden’s index were used, GM2 gave the best valuation and was the second best when the ROC curve was used. When Landis and Koch’s classification of Kappa’s coefficient was used, GM2 and IQ15 showed a substantial degree of agreement. The other methods showed a moderate level of agreement.

Table 3 Contingency table: Inter-quartile range with parameter = 1.5 (IQ15)

		Length of stay (LOS)		
		inliers	Outliers	total
costs	inliers	32,299	882	*33,181*
	outliers	645	1,436	*2,081*
	total	*32,944*	*2,318*	*35,262*

Table 4 Contingency table: Inter-quartile range with parameter = 2 (IQ20)

		Length of stay (LOS)		
		inliers	Outliers	total
costs	Inliers	33,011	758	*33,769*
	Outliers	498	995	*1,493*
	total	*33,509*	*1,753*	*35,262*

Table 5 Contingency table: Geometric mean plus two standard deviations (GM2)

		Length of stay (LOS)		
		inliers	Outliers	Total
costs	inliers	32,976	609	*33,585*
	outliers	529	1,148	*1,677*
	total	*33,505*	*1,757*	*35,262*

Table 6 Contingency table: Geometric mean plus three standard deviations (GM3)

		Length of Stay (LOS)		
		inliers	Outliers	Total
costs	inliers	34,235	301	*34,536*
	outliers	293	433	*726*
	total	*34,528*	*734*	*35,262*

When the ROC curve was used, GM3 was the method which left the greatest amount of space below the curve but when other tests were used it gave the lowest values. McNemar's test analyses the symmetry of the contingency table. Only GM3 did not present systematic bias. GM2 presented a value of χ^2 = 5.62, very close to the critical point of this distribution with one degree of freedom and significant at the 5% level which is 3.481. In contrast, the non-parametric methods (IQ15, IQ20) gave values that were both very high and far removed from the critical point.

Table 7 Analysis of agreement by trimming methods

	Kappa	ROC Curve	Youden	Sensitivity	Specificity	McNemar
GM2[1]	0.64	94.5	0.67	0.69	0.98	5.62
GM3[2]	0.58	94.9	0.59	0.60	0.99	0.10
IQ15[3]	0.63	94.4	0.66	0.69	0.97	36.78
IQ20[4]	0.59	94.4	0.64	0.67	0.98	53.82

(1) Geometric mean plus two standard deviations
(2) Geometric mean plus three standard deviations
(3) Inter-quartile range with parameter = 1.5
(4) Inter-quartile range with parameter = 2

The quality of agreement was evaluated by analysis of extreme cost volume associated with LOS outlier cases. Table 8 shows this analysis for the four methods used. The parametric method with two standard deviations (GM2) revealed the highest percentage (68%) of outlier costs when applied to LOS. The remaining methods revealed a lower percentage of costs, although differences were no higher than 7 points. The value of extreme cost of the false positives revealed by LOS approximation represented 20% of total outlier cost according to GM2. Consequently, when GM2 was used the final overall value detected by the LOS trimpoint was 88%. For the other methods, the final percentage was 80% or less.

The results of the tests used demonstrate that GM2 was the trimming method showing the highest level of agreement between cost and LOS variables, both in terms of number of cases and in terms of the cost revealed.

Unlike the non-parametric methods, the parametric methods did not show systematic bias where non-agreement was found (false positives and false negatives).

Table 8 Extreme costs revealed by application of trimming methods over length of stay (LOS)

	MG2[1]	MG3[2]	IQ15[3]	IQ20[4]
Application to costs				
Extreme costs (% total cost) (1)	17.9%	10.6%	20.2%	16.5%
Application to LOS				
Associated costs to agreed cases	12.1%	6.2%	13.2%	10.1%
Associated costs to false positives	3.7%	2.3%	3.1%	2.8%
Extreme costs (% total cost) (2)	15.8%	8.5%	16.3%	12.9%
Percentage of revealed cost (2) / (1)	87.9%	80.8%	80.6%	78.3%

(1) Geometric mean plus two standard deviations
(2) Geometric mean plus three standard deviations
(3) Inter-quartile range with parameter = 1.5
(4) Inter-quartile range with parameter = 2

Discussion

Application of the different trimming methods provides significant information. The correct identification of a small number of cases (between 2% and 5%) would allow the management of between 10% and 20% of resource use.

GM2 was the most satisfactory method used both in the analysis of number of cases and in the analysis of value. When applied to LOS, this method revealed 88% of extreme costs when false positive were included. This is a high figure, allowing effective management of outliers, which grouping of patients into DRGs fails to take into consideration.

GM2 does not reduce the number of extreme cases to the minimum expression and consequently, it may not be the most appropriate method for the complementary funding of these cases. Medicare uses the most conservative trimming method to reduce the percentage of outlier funding to 5% of total expenses for inpatient treatment. Nor is GM2 the method which detects the greatest number of cases and consequently it does not comply with the criteria put forward by Söderlund[5] for choosing IQ15 for the National Health Service in the UK. In this case, the argument for choosing the method which detects the greatest number of cases, costs and LOS is that which makes the resulting mean value for Health Resources Groups more robust.

Therefore, with the hypothesis used in the present study, the most satisfactory method is that which shows the greatest agreement between cost outlier cases and their determination through their application to LOS.

The aim of this type of analysis is to determine cost variability and to identify cases of extreme cost. Thus, it could be argued that:

1. A small number of cases represent an extremely high percentage of the total cost of a given hospital.
2. Criteria for choosing the best LOS trimming method can be established according to its capacity to predict cost outliers.
3. In European environment, the most satisfactory method among those studied was GM2.
4. Trimming methods and their management are necessary to determine hospital cost variability once this has been adjusted for case mix.

The relevance of the correct determination of outliers to the aspect of health policy which concerns cost variation per patient centres on the need of any analysis which attempts to compare inter-hospital costs to correct for outliers, this need being maximal if conclusions about relative efficiency are to be drawn.

Although not the objective of our analysis, if we extend the scope of health policy implications to resource allocation or to hospital services purchasing, our results argue in favour of the measures applied by Medicare’s payment system. This organisation allocates part of its budget to fund the extreme cost observed, but constrains the final amount to a marginal level which does not question its DRG-Prospective Payment System.

A limitation of our analysis is that it is based on data from two hospitals and therefore, the results cannot be generalised. Even so, application of the GM2 trimming method to the total number of discharges from the Catalan Minimum Data Set between 1996 and 1998 revealed that the percentage of LOS outlier cases and their associated LOS was similar. The cases detected represented 4.49%, very similar to the 4.98% revealed by our analysis.

In conclusion, a generalised per-patient cost accounting system in Europe is a utopia which is unlikely to become reality in the short or medium term. Consequently, hospital cost analyses will probably continue to be based on an analysis of LOS consumption adjusted by DRG.[24] Based on the database analysed in the present study, the correlation between costs and LOS is 74%.

Outlier cases lead to overvaluation of the estimated mean cost by DRG due to the lognormal distribution of cost function. For cost analysis, determination of the effect of this overvaluation is indispensable and consequently, the most appropriate trimming method should be used. This is essential because each method yields different results. Thus, criteria for the determination of the most appropriate trimming method have been elaborated and that their use is necessary in order to be able to compare inter-hospital costs, once these have been adjusted by case mix techniques.

Capítulo 3.

Medicare's DRG-weights in a European environment: the Spanish experience.

Introduction

Following the tendency of other European countries, prospective payment systems (PPS) capable of defining and valuing hospital output have recently been introduced in Spain.

At the beginning of the 1980s, Catalonia (Spain) began a process of decentralisation which gave this autonomous region control over its own health system within the_general Spanish context. In the last few years, this system has served as an example for reforms, mainly regarding hospital care, in other regions of Spain as well as in several South-American countries. The Catalan public health sector comprises around 70 general hospitals of which only ten are owned by the regional health service authority, the Catalan Health Service (CHS). The public health sector hospitals, which serve a population with public health insurance (100% of the population), are owned by the municipalities, by non-profit making organisations and by institutions composed of a mixture of these entities and the CHS.

Until recently, a PPS was used which measured and valued inpatient and outpatient hospital activity but which did not distinguish among case-mix categories.[60] Since 1997, hospital output measuring systems have been introduced to allocate resources.[13] Patients have been classified according to the Diagnosis-Related-Groups (DRG)-system used by the US Health Care Financing Administration (HCFA). The HCFA's DRG-weights have been used to weight hospital-wide discharges and to determine how much each hospital should be reimbursed. Unlike a true PPS, the model introduced allocates a fixed budget among hospital-wide activity which is the total of the forecasted activity detailed by each hospital. Thus, priority is given to criteria which tend to reduce the providers' and purchasers' financial risk, as has been explained by Newhause,[47] Magnusen[11] and Ellis[61].

The usefulness of DRGs and their positive results for clinical analysis in Spain and other European countries have been partially validated.[14,55] They have been used on several occasions as a patient classification system for hospital cost analysis.[33,62]
Internationally, this system has been validated and adapted to reimburse hospital output in several countries,[63] such as Portugal,[12] Norway,[11] United Kingdom,[5,6,8,29,64-66] Australia[3,9,10] and Ontario in Canada[67,68] among others. These_countries have modified the patient

classification system and adjusted the DRG-weights to various degrees. As yet, there has been no study of the workings of DRGs and their associated weights in Spain.

There are clear differences between European National Health Services and the US Medicare system. These differences affect the structure of hospital costs and consequently make the transfer of financial tools between systems difficult. As a primary issue, the following differences must be considered:

1. Although the information used to create DRG was the widest possible[69] and based not solely on Medicare patients, the recalibration of weights was based on Medicare's case-mix[52,70] which is very different from the universal health coverage provided by European National Health Services. Within the US system itself, it is questioned whether DRG-weights can be applied to such different hospitals and forms of recalibration.
2. US weights do not incorporate the cost of physicians' fees for which there is a different form of payment,[71] whereas in Europe, physicians are considered integral to the centres' staff and no distinctions are made among the financing of operating costs, whether of staff or of any other type.
3. Because of differences between European systems and the Medicare system, and because output-based payment methods divide up health care without considering it as a whole, the moment in which a patient is admitted to hospital or is discharged may also be different in each system.[72] The reasons for this difference may be due to the structure of the public sector in terms of primary care, long-stay hospitals or nursing homes, to the financial incentives of the alternatives to inpatient care, or to the incentives of the hospital payment system.[73]
4. Ambulatory surgery is performed much more in the US than in Europe;[74-76] in Catalonia it is performed in only a few centres and specialities.[77,78] In the US, ambulatory surgery is financed separately from the general PPS[76,79] while the new model implemented in Catalonia does not distinguish between inpatient and outpatient surgery, reimbursing both through the weight of the corresponding DRG.[13]
5. The cost of prostheses forms part of Medicare's DRG-weights and also of the actual costs of the hospitals analysed. The price of prostheses is much higher in Spain than in the US.

6. Several US health care purchasers who use a DRG-based payment system have decided to apply different forms of payment to certain case-mix categories. This is because of the excessive variability in the types of treatment provided by certain specialities, namely: Rehabilitation, Psychiatry, Drug and Alcohol Abuse, and Transplants.[71,80-82]
7. The deficient classification of secondary diagnoses leads to the undervaluation of the DRG to which the patient is assigned.[83-85] This most likely leads to actual costs being underestimated in European health services where until now there has been no financial incentive to improve the quality of classification.

The aim of this study is to determine whether a positive and sufficient relationship can be established between Medicare's DRG-weights (MW)-structure and the cost-based DRG-weights (CW)-structure determined for the purposes of this study. Our hypothesis is that the seven above-mentioned differences will invalidate the direct importation of MW to Spain. A further aim is to quantify the intensity of these differences and to propose possible adjustments.

The opportunity to carry out this study was provided by exhaustive information on the cost of 35,262 discharges from the hospitals belonging to the Municipal Institute of Health (MIH) in Barcelona from 1995 to 1996. Per discharge cost information in Spanish hospitals is not normally available.

Material and methods

The discharges of patients admitted to the two teaching hospitals during a two-year period between 1995 and 1996 were analysed. The MHI's hospital cost accounting system based on full costing allocation ensured that the hospitals' total costs were distributed among the patients.

Identification of unusually expensive cases

To determine the value of weights based on the average actual cost of each DRG, unusually expensive cases (outliers) must be eliminated. There are several ways of fixing a maximum acceptable cost against which outlier costs can be defined. A trimming method has been chosen which considers the result of adding twice the standard deviation to the geometric mean of the distribution as the trimming point. Several alternative methods have been tested such as the geometric mean plus three standard deviations,[4] the method of interquartile space with parameters 1.5 and 2,[8] which are those normally used in the analyses performed in Spain until now,[86] and the method described by Lichtig.[7] The method finally chosen is that which shows the best statistical correlation between application to costs and to hospital length of stay, which is the proxy variable on which the trimming method is generally applied since it is usually the only variable available.

Determination of a cost-based DRG-structure based on actual average costs

To improve statistical power, DRGs with less than 25 discharges are excluded from our analysis. The net average cost of each DRG was divided by the total average inpatient cost to obtain the CW.

Analysis

A paired t test was used to determine whether the CW of each DRG is statistically different from the MW. The null hypothesis was of equality but, given the economic and organisational differences between health care systems, as well as the differences mentioned in the Introduction, it was expected that it would be rejected. The relation between the two DRG-weight-scales was estimated by a weighted least squares (WLS) regression with CW as dependent variable.

The comparison was based on the adjustment of the MW and the CW according to the number of cases in each DRG; thus the Hospital Production Units (HPU), Medicare's HPU (MHPU) and cost-based HPU (CHPU), respectively, were determined.

$$CHPU_i = CW_i * N_i$$

$$CW_i = \left[{}^{AV\_DRG_i} / {}_{AV\_TOTAL} \right]$$

where:

CW_i is the weight of the DRG_i based on actual cost

AV_DRG_i is the average cost of DRG_i

AV_TOTAL is the average cost of the total number of discharges

N_i is the number of discharges MIH-hospitals belonging to DRG_i

$$MHPU_i = MW_i * N_i$$

where:

MW_i is the Medicare weight associated with the DRG_i

This case-mix adjustment is fundamental because differences in the weight of each DRG are not all equally relevant, depending on the volume of activity they represent[1].

An individual analysis was performed on those DRGs showing deviations predicted by our original hypothesis as well as on unexpected deviations and both sets of deviations were evaluated. To do this, groupings of DRGs must be determined which include the differences mentioned in the Introduction.

1. DRGs with a majority of patients likely to undergo ambulatory surgery were defined according to the criteria laid out by Espinás.[77]
2. DRGs in which prostheses are used were grouped together.
3. DRGs involving specialities excluded from the various DRG-based PPSs were grouped together and were used to analyse the deviation of cost.

[1] For instance, the Uniform Hospital Discharge Data Set (UHDDS) of all the hospitals in the Catalan public sector is composed of a total of 567,825 discharges in 1996. Fifty percent of discharges are grouped into only 54 DRG (11% of which have cases during this period); and 90% of discharges occur in only 51% of the DRG.

During the course of the analysis the importance and cause of any unanticipated deviations which appear were evaluated.

Two sensitivity analyses were performed, one by adjusting the MW of DRGs with systematic deviations detected between CW- and MW- structures. Another was performed by applying MW- and CW-structures to the total number of discharges in the Catalan public sector. The overall deviation between MHPU and CHPU was analysed.

Results

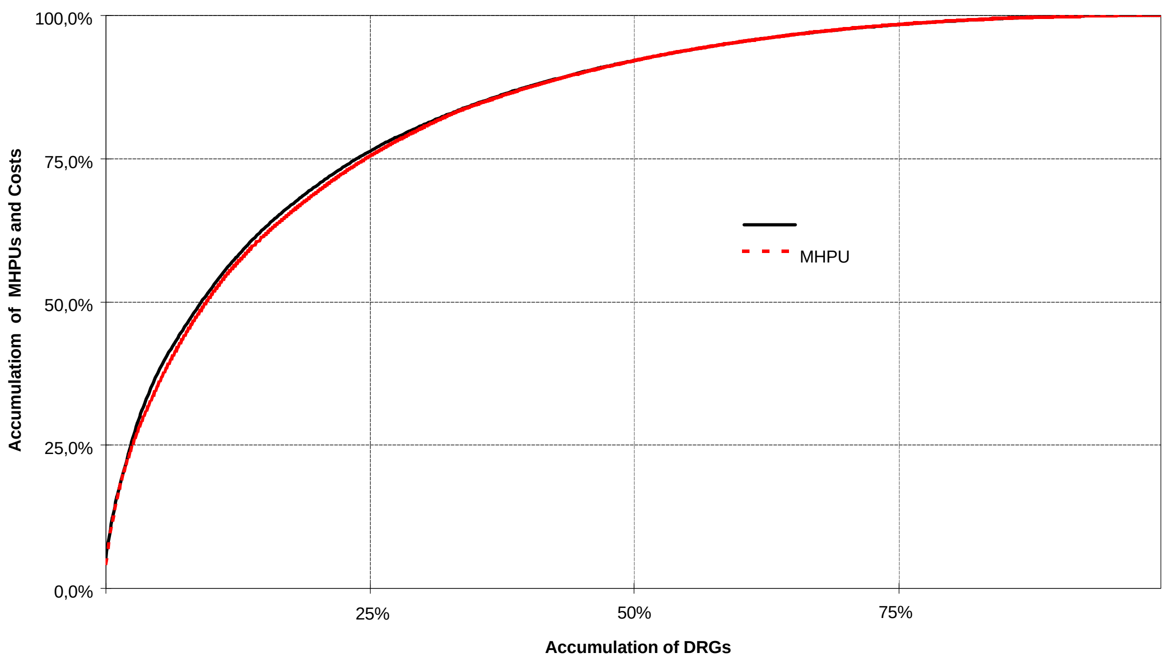
The total number of discharges, total length of stay, and costs used in the analysis are shown in Table 1. The exclusion of outlier costs reduces the number of discharges by 4.8%, the number of hospital stays by 15.4%, and the cost by 17.9%.

The accumulated cost distribution by DRG is practically the same as the accumulated MHPU distribution, as shown in Fig. 1.

Table 1. Description of the data base analysed .

	All cases (1)	Without cost outliers cases (2)	Without cost outliers and DRGs with more than 25 cases (3)	Variation (2) vs. (1)	Variation (3) vs. (1)
Number of DRGs	470	470	267	--	43.2%
Discharges	35 262	33 585	30 773	4.8%	12.7%
Hospital days	312 073	264 990	242 802	15.1%	22.2%
Length of stay	8.85	7.89	7.89	10.8%	10.8%
Cost (million pta.)	12 794	10 502	9 428	17.9%	26.3%

Figure 1. Accumulated costs and MHPUs by DRG.



The determination of MHPU and of CHPU enables the comparison of the two weight-structures. Table 2 shows the DRGs with the highest number of HPUs ordered on the basis of MHPU. The total number of cases analysed, once outlier costs and DRGs with fewer than 25 patients are excluded, is 30,773 (87.3% of the original number), which represents an average cost per discharge of 306,362 pesetas. The net deviation between the two HPUs-scales is only 0.06%, thus the agreement between the two DRG-weight scales is almost perfect.

The correlation between the two DRG-weight-structures, determined by Pearson's correlation index is 85%, by Kendall's correlation is 80%, by Spearman's correlation is 89% and the adjusted R^2 of WLS regression[2] is 95%. The paired t-test reveals no statistically significant deviations between the two DRG-weight structures.

The same results analysed individually for each DRG reveal relevant deviations. Figure 2 shows all the pairs organised in descending order according to their value in terms of MHPU. Figure 2 and Table 3 show DRG-groupings which were expected to cause deviation, organised according to the cause of deviation, such as ambulatory surgery, prostheses, and specialities excluded from existing PPSs. They also show DRGs which led to unexpected systematic deviations revealed by the analysis, such as gynaecology and obstetrics, neonates and, those high-technology procedures for which the patient is temporarily referred to other hospitals. The total deviation for these groupings, which include 25% of the DRGs, represents 38% of discharges, and 51% of the absolute deviation between the two DRG-Weight structures.

[2] WLS Regression corrected problems of heteroscedasticity between the two DRG-weight structures.

Table 2. DRGs with the greatest number of Hospital Production Units based on Medicare-weights (MHPU).

DRG	Description	Cases	Cases without outliers	Average cost	MHPUs	CHPUs	Deviation (%)
209	Major joint & lower limb reattachment procedures	662	638	850 293	1 503.2	1 825.4	21.4%
088	Chronic obstructive pulmonary disease	964	926	249 110	965.7	778.8	-19.4%
489	HIV with major related condition	538	501	474 360	960.7	827.6	-13.8%
014	Specific cerebrovascular disorders except tia	583	559	335 143	703.4	633.6	-9.9%
462	Rehabilitation	476	456	345 787	701.2	533.8	-23.9%
127	Heart failure & shock	626	607	308 978	644.9	627.2	-2.7%
089	Simple pneumonia & pleurisy age >17 w cc	527	500	302 660	590.8	517.3	-12.5%
148	Major small & large bowel procedures w cc	172	163	938 294	572.1	523.4	-8.5%
154	Stomach, esophageal & duodenal procedures age >17 w cc	115	106	1 256 541	484.2	468.6	-3.2%
082	Respiratory neoplasms	330	317	290 279	434.5	310.6	-28.5%
205	Liver disorders except malig, cirr,alc hepa w cc	340	329	157 888	417.4	174.1	-58.3%
039	Lens procedures with or without vitrectomy	773	763	197 208	389.3	494.4	27.0%
211	Hip & femur procedures except major joint age >17 w/o cc	297	283	546 235	382.9	526.1	37.4%
Total for DRGs with more than 25 cases		32 280	30 773	306 362	32 073.3	32 093.1	**0.06%**

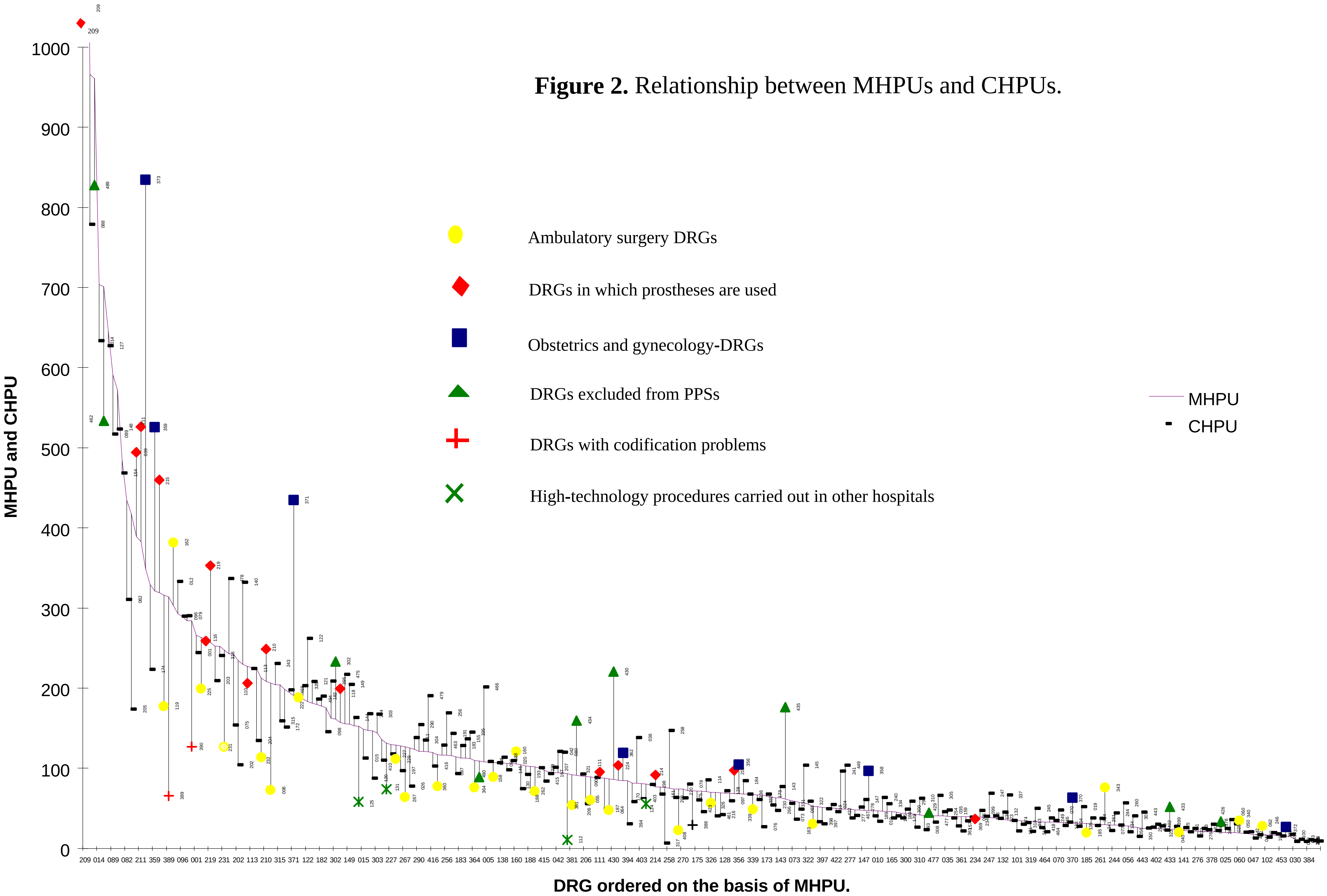


Figure 2. Relationship between MHPUs and CHPUs.

Table 3. DRG groupings in which deviations between MHPUs and CHPUs are detected.

Groupings presenting systematic deviation	**number of DRGs (1)**	**Discharges**	**MHPUs**	**CHPUs**	**Net deviation (2)**	**Absolute deviation (3)**	**% of total absolute deviation**
Ambulatory surgery-DRGs	27	4 396	3 227	2 382	-26%	36%	13%
Obstetric and Gynecology-DRGs	8	2 190	1 108	2 206	99%	99%	12%
DRGs in which protheses are used	14	2 971	4 063	4 996	23%	24%	11%
DRGs excluded from PPSs	9	1 641	2 095	2 137	02%	33%	08%
DRGs with codification problems: neonates	3	629	670	222	-67%	67%	05%
High-technology procedures carried out in other hospitals	4	502	458	198	-57%	57%	03%
Total (groupings presenting systematic deviation)	65	12 329	11 621	12 142	04%	40%	51%
Total	267	32 280 (4)	32 073	32 093	0.06%	28%	100%

(1) DRGs with more than 25 cases.

(2) Total deviations between CHPU and MHPU per grouping.

(3) Total absolute deviation between CHPU and MHPU per DRG for each grouping.

(4) Total discharges (inliers and outliers).

Expected deviations

Ambulatory surgery DRG-grouping include 27 DRGs, with a total of 4,396 cases. The net deviation is an overestimation of the actual cost by 26%. The absolute deviation is 36%, given that hernia operations for persons older than 18, tonsillectomies, myringotomies, and circumcisions for persons less than 18 present deviations opposite to the general deviation of the group. This grouping represents 13% of the total absolute deviations between the two MHPU- and CHPU-scales.

Surgical procedures using prostheses involve 14 DRG and 2,971 cases. The net deviation underestimates the cost by 23%. The absolute deviation is 24%. The CW of virtually all the DRGs is higher than the standard value given by Medicare's weights. These DRGs together represent 11% of the total absolute deviation found.

The nine DRGs excluded from PPSs contain 1,641 cases. The absolute deviation is 33%, while the net deviation represents an underestimation of costs by only 2%. These nine DRGs amount to 8% of the total absolute deviation found. The relative cost of Rehabilitation- and AIDS-related-DRGs is much lower than the value assigned by Medicare's weights. On the other hand, Psychiatry-DRGs have much higher cost-based DRG-weights than the value assigned by Medicare's DRG-weights.

Other systematic deviations

Among the groupings of DRGs with systematic deviation revealed by the analysis, gynaecology and obstetrics-DRGs stand out. In these DRGs, the deviation is due to an underestimation of actual costs. This grouping includes eight DRGs with 2,190 cases and represents a deviation of 99% in both net and absolute terms. Because of the intensity of the deviation in this grouping, it accounts for 12% of the total absolute deviation found.

Less important in terms of volume but with important deviations in terms of the overestimation of actual costs, are those DRG-groupings which involve the care of neonates and patients which the two hospitals refer to other centres for high-technology procedures to be carried out.

Sensitivity analyses

When MW-value is adjusted to the CW-value for DRGs which are included in groupings with systematic deviations, the overall deviation between MHPU and CHPU is -1.56%.

Extrapolating MW and CW-structures to the total number of discharges of the Catalan public sector, the deviation between MHPU and CHPU is 1.6%. The same extrapolation made to the previous adjustment reveals a overall deviation of -1.2%.

Discussion

A cost-based DRG-structure has been determined based on information from a hospital cost accounting system which is clearly suitable for the aim of allocating total costs incurred to the patients. Because the majority of procedures are highly automated, costs can be correctly allocated to the patients without any need to use less direct criteria.

In total, 12,700 million pesetas shared among 35,262 discharges have been analysed which represent approximately 6% of the hospital-wide discharges from the Catalan public health sector during a one-year period.[87] Because the MW of the hospitals of the MIH with respect to the MW of the whole public system is 1.14[3], the cost probably represents a greater percentage. This greater percentage could also be due to other factors not included in the case-mix and which correspond to the extra cost of teaching and research,[88] to the higher than average level of technology in these hospitals,[70,83,89] and to the fact that they serve a low-income population[71] and are situated in the most densely populated metropolitan area in the system.[90]

Global Analysis

Cost-based weights have been determined and compared with MW. The analysis has not invalidated the hypothesis of equality between these two structures and the degree of correlation between them is very high.

The final net deviation between the CHPU-structure and the MHPU-structure is only 0.06%. Thus, MW fit well to the cost-structure analysed.

The sensitivity analyses performed reveal that the overall deviation is very slight. If the difficulty of extrapolating the results of the two hospitals to the hospital-wide system is accepted, the deviation is always less than 2%.

Diagnosis-related groups causing systematic deviations

What is undoubtedly of greatest interest is to see how the different DRG-groupings which could explain differences with respect to Medicare's weights-structure behave in the same manner and with the same intensity as our original hypothesis predicted.

[3] This information refers to 1996, according to the CHS.

Thus, adjustments can be made to these weight-structures which could help to reduce the systematic deviations which have appeared. Firstly, for some Ambulatory Surgery-DRGs the adjustment should bear in mind that the deviation disappears in those procedures which are normally carried out on an outpatient basis, such as circumcisions, tonsillectomies, and myringotomies. For the other Ambulatory Surgery-DRGs, incentives to perform procedures on an outpatient basis, in preference to inpatient surgery, should remain until Ambulatory Surgery becomes the norm.

Secondly, the principal negative differences are associated with prostheses. The adjustment should lead to a progressive decrease in their cost but, in the short term, this extra cost to the hospitals should be recognised. Thirdly, a simple adjustment to the weights of those DRG excluded from PPS would not be sufficient to solve the problem. The example of existing PPSs which exclude these DRG should be followed and other forms of payment should be sought. The payment system applied in Catalonia makes these exclusions difficult because it includes these DRGs among "discharges" when calculating the average DRG-weights.

The determination of CW has served to highlight other differences with respect to MW. In certain cases it reveals problems of oversupply in relation to the real demand for certain specialities, as can be seen from the costs of obstetrics and gynaecology-DRGs. Here, MW serve as a reference point and provide invaluable information as far as decision-making is concerned.[91]

In the same way, the cost of DRGs with expensive techniques (angioplasties, cardiac catheterization, arteriographies) is overestimated by MW. The low relative cost is due to the fact that the hospitals studied do not perform these procedures, or perform them only rarely: patients are referred to high-technology centres which perform these procedures and are then referred back to the original hospital until discharged. The codification process incorporates these procedures according to CHS regulations, so that MW recognise them but actual costs do not. These regulations should include a system of inter-hospital billing within the CHS to avoid billing twice but this was unfortunately not the case during the period studied. The new hospital payment system incorporated in Catalonia in 1997 includes an internal billing system which will internalise this deviation.

The sample is not representative of the different hospitals with their structural complexities, catchment areas, relative organisational efficiency and case-mix; consequently, any conclusions which might be drawn cannot be generalised.

Nevertheless, in an urban area with hospitals accredited as highly productive[92] and which carry additional loads such as teaching and research, MW would reimburse 99.94% of the actual cost according to the case-mix studied.

Another limitation of the study is that some DRGs have insufficient cases to be analysed. Nevertheless, the DRGs analysed include more than 91% of inlier cases.

Conclusions

DRG-based financing involves detailed information about one fragment of the health care received by each patient but also involves losing sight of the health care process as a whole. Which part of this process is considered to be a discharge varies, depending on the hospital's organisational structure and its utilisation, on the patient's perception of the effectiveness of each health care centre, and on financial incentives related to the reimbursement of each level of health care (primary care, short-term acute care, long-term care, and so on).[72,75,76,93,94]

With these restrictions in mind, the positive evaluation of Medicare’s DRG-weight system for adjusting the costs incurred by case-mix categories, is based on this system’s ability to adapt to different environments and on how, with sufficient information, it can encourage those policies to which the purchaser gives priority.[74] Because the Catalan hospital payment system is a closed one, with global adjustment rather than rates per DRG, the aggregated adjustment is the most important.

Different hospital activities like an Ambulatory Surgery, Prostheses, Transplants, Rehabilitation, Psychiatry and Drug and Alcohol Abuse are nowadays acquiring more presence in the hospital case-mix and these are precisely the ones that more deviation cause in the standard valuation of hospital product. Therefore, implementation of MW in a European health system makes their adjustment already indispensable and in the future it will be even more necessary.

Because MW are annually recalibrated to adjust to changes the DRG-cost structure, the results of the comparison between the two weight structures would be affected.

To date, there has been no financial incentive to manipulate the information gathered in the UHDDS in order to achieve a higher relative weight for the hospital, or to select patients or changes in the treatment offered to them.[95,96] On the contrary, this situation has produced weight-compression. In future, there may be such perverse incentives but at present the incentive seems to be for better classification.

The definitive aim seems to be to determine a system of case-mix categories adapted to a specific environment, which is what has happened in many countries[63] and then to use these groupings to determine the correct weights. The question is whether effort and scarce existing resources should be devoted toward this aim or whether it would be preferable to adjust the HCFA's DRG-weights given the positive results reported by this study. In the latter case, the adjustment of Medicare's weights has been shown to be essential.

Capítulo 4

Risk adjustment: beyond patient classification systems

Introduction

Considerable information on inpatients is available to those working in hospital management. This information enables definition of hospital product and observation of significant attributes that improve the characterisation of patient profile, the health care process and resource use of the hospital where the patient was treated.[21,48,49,97,98] However, analysis of documentation at the individual patient level provides only partial information, often leading to a superficial description of what has occurred in the health care process. Aggregated analysis is usually more complete, since it can establish a resource use profile based on characteristics that define the level of patients' need for care.

Diagnosis-related groups (DRGs) have become the most commonly used tools for the overall analysis of this information, defining products with a similar resource use and clinical coherence.[63] This classification system attempts to establish criteria for patient grouping based on maximising inter-DRG cost variability and minimising intra-DRG variability. In contrast, the number of groups must be limited to make the classification functional for hospital product management.[42] This was accomplished through different DRG versions with the number of groups ranging from 357 to 641. DRGs were introduced in Spain according to the criteria of Medicare, which uses the Health Care Financing Administration (HCFA) version with 492 groups.

DRGs are useful in patient classification because they establish an invoicing between the purchaser and different providers, and consequently they can be used in price setting. Their capacity, strengths and weakness have been extensively analysed in the literature.[28,61,73,95] However, little in-depth research on the usefulness of DRGs in hospital cost analysis has been published to date. Studies analysing the isocost capacity per category presupposed by the DRG systems [5,6,29,66] have shown their limited ability to reflect resource use variability[31,32]. The lack of information on real cost per patient has made validation of DRGs as predictors of cost variability difficult.

At the same time, the ability of other characteristics of the health care process to explain cost variability has been evaluated. These characteristics include length of stay,[24] aspects related to severity[17,43] comorbidities and complications[22,99-101], characteristics of provider management (efficiency[102] or specialisation[103]), and the patient's socioeconomic status (SES).[23,104,105]

The need to understand DRGs as a valuation method of the activity performed and consequently as a payment system has led to the usefulness of using DRGs as the initial point of hospital cost analysis to be overlooked. In Europe, where there is universal public coverage and where the hospitals obtain their incomes mainly from the public sector, cost and cost variability should be analysed rather than market price.[11] In this setting, competition is not in prices, but in the continued functioning of the hospitals, in patient access equity, and in the optimum allocation of final and overall resources.[1,106]

Thus, an analysis of health care activity cost and of the causes of its variability in Europe is needed. Determination of the characteristics and causes of this cost would allow improvements to be made to payment systems, which should first reflect cost and then the standardisation of reasonable cost. This in turn would enable the creation of adequate incentives to improve allocation of the available economic resources.

In spite of the considerable information available on hospital processes, cost explanation is usually reduced to length of stay or diagnosis. Authors such as Iezzoni,[21] Elixhauser[22] or Peiró[17] have popularised the concept of 'risk adjustment', which refers to variability in the results of the hospital process as a consequence of variability in the hospital process itself and in associated resource use. These authors have advanced the study of the ability of administrative databases to contribute information for use in this adjustment. Information available on the development of hospital activity has enabled patient characterisation based on real resources use.

The aim of this study was to a advance the ability of the available hospital administrative dataset to explain hospital discharge cost variability and specifically, to analyse the extent to which the various DRG patient classification systems used today are able to explain cost variability**.**

A cost database containing information on 35 262 discharges from the two public teaching hospitals owned by the Municipal Institute of Health (MIH) in Barcelona enabled evaluation of a range of information from the Minimum Data Set and other registered data available in their information systems.

The research hypotheses were the following: (i) DRGs provide insufficient information to explain the variability in observed cost; and (ii) use of the information added by the Minimum Data Set substantially improves DRGs' ability to explain cost variability.

Methods

The 35 262 admissions from the MIH hospitals, admitted and discharged between 1995 and 1996, were retrospectively analysed (Table 1).

The relationship between total cost per patient and the variables and indexes extracted from the available information were analysed. The main information sources were the Minimum Data Set, with a maximum of eleven secondary codified diagnoses**,** and the cost accounting system.

Hospital discharge cost is a monetary reflection of a series of activities and resource uses incurred during the course of the patient's treatment. These activities and resource uses differ according to the product, severity of illness, and the patient's other clinical variables, SES characteristics, as well as to the management of the health care process.

Table 1. Baseline.

	H-DRG (1)	A-DRG (2)	APR-DRG (3)
DRG groups	470	313	319
Cases per DRG	71	108	106
Inliers			
total cost	10 501 605 354	10 503 297 026	10 493 333 286
LOS	264 990	265 603	265 140
discharges	33 585	33 718	33 713
Outlier			
total cost	2 291 919 729	2 290 228 057	2 300 191 797
LOS	47 092	46 478	46 942
discharges	1 677	1 544	1 549
Total			
total cost	12 793 525 083	12 793 525 083	12 793 525 083
LOS	312 081	312 081	312 081
discharges	35 262	35 262	35 262
Outlier (%)			
Cost	17.9%	17.9%	18.0%
LOS	15.1%	14.9%	15.0%
Discharges	4.8%	4.4%	4.4%
Average values for inlier cases			
Average discharge cost	312 687	311 504	311 255
Average LOS	7.89	7.88	7.86

(1) HCFA-DRG
(2) Adjacent HCFA-DRG
(3) All Patient refined DRG

Variables

A set of variables associated with causes able to explain cost variability was constructed from the information available. These variables were related to product complexity (DRGs and outliers), disease seriousness (severity, complications, comorbidities), patient characteristics (age, gender, SES characteristics), and management of the health care process (readmission, circumstances on admission and discharge, and surgical procedure).

Cost. The MHI's hospital cost accounting system based on full costing allocation ensured that the hospitals' total costs were distributed among the patients. Consequently, not only is the overall cost per patient known, but also its structure. Thus, costs related to surgical procedures, intensive care unit treatment, pharmacy, radiology, laboratory, prosthesis, and pathologic anatomy can be distinguished from costs related to length of stay (LOS).

Medicare's DRG-weights (MW). Patient classification systems were used to define observed hospital product. As a first step, Medicare's DRG weights were used. This is the weight system used to value hospital activity in several European hospital payment systems and is available only for the HCFA's DRGs.[11,13,15,16,20,63,107]

Cost-based DRG-weights (CW). As an alternative to using Medicare's DRG-weights, each patient was assigned the CW that represents the average cost of all cases within a DRG with respect to the average total cost of the database analysed.[45] The difference in observed cost-based weights between two discharges belonging to two different DRGs is the closest possible approximation to inter-DRG variability. Any unexplained differences must be due to intra-DRG variability not explained by patient classification system.

Three DRG groupings were used in the analysis:

1. HCFA version 11 DRG grouping (H-DRG) which incorporates comorbidities, complications and patient age as a splitting variable between product categories.
2. Adjacent-DRG (A-DRG) which are the H-DRG but regrouping categories in which the difference was due to comorbidities, complications, or age;
3. All Patients Refined (APR)-DRG grouping (version 15)[108], which leaves each patient's severity of illness to a complementary indicator (severity index).

Outlier cases. Medicare considers that product definition based on DRGs must correct for cases of extreme cost compared with the average of cases belonging to a particular group. These cases, although belonging to a specific DRG, imply a much higher expenditure than the average of the specific DRG to which they belong.[4-6,51] The geometric mean plus two standard deviations was used to determine cases of abnormally high cost. This method was applied to each classification system separately, since each DRG category has a different cut-off point.

Severity. The severity of illness associated with each patient was valued using the Disease Staging measurement system.[31,32,109-111] For the APR-DRG classification system, the APR-DRG severity indicator was used.

Comorbidities. Several authors have applied the Charlson[99] Index to reveal comorbidities associated with specific secondary diagnoses and the increased probability of death associated with their presence,[100,101,103,112] after transforming and making it applicable to administrative data (appendix 1). Recently, Elixhauser *et al*.[22] have described a set of 30 groupings of the International Classification of Diseases (ICD-9-MC) diagnoses that imply comorbidity if they occur as secondary diagnoses. However, when the secondary diagnosis giving rise to the comorbidity coincides with a specific DRG they are considered a complication and not a comorbidity (appendix 2). This method is based on administrative data and incorporates individual variability parameters for each comorbidity group with respect to costs. A database with 11 possible codified diagnoses enabled use of the algorithm.

Complications. Complications are processes or events arising from hospitalisation that worsen the patient’s condition. Complications may be general (e.g., urinary infection) or related to the complaint treated. General complications are shown in appendix 3. Diagnoses considered as a complication by the method of Elixhauser *et al*. are included in this variable. A dummy variable distinguishing cases with complications was used.

Both comorbidity and complications indicators were used to complement the information added by the A-DRG.

Readmission . Information both on the discharges during the last three months of 1995 and on those during the first three months of 1997 were added to the 1995 and 1996 databases. This information was then used to calculate the number of readmissions for each patient. In this analysis, an admission was considered as readmission of a particular patient within 90 days of the previous admission. The accumulated number of admissions for each patient gave the value of each patient's readmission variable. The first admission of a readmission process is called the Index admission.

Hospital. The installed supply and the organisation of each hospital were considered to influence cost variability. A dummy variable was used to control for these differences.[89]

Admission circumstance. Emergency admissions may involve more intensive resource use than planned ones. Firstly, emergency admissions are often more complex than planned ones after adjusting for case-mix. Secondly, the cost of the diagnostic tests carried out in emergency admissions belongs to the episode studied, unlike the cost of those carried out before planned admissions.

Exitus. The consequences of a patient dying while hospitalised vary. On the one hand, death may increase cost due to higher treatment intensity, but on the other hand, it may reduce LOS and, consequently, final cost is reduced when the death occurs before the normal LOS of patients in a specific DRG category.

Age. It is generally believed that hospital resource use tends to be concentrated during the last years of a person's life.[113] Therefore, age positively explains part of cost variability, independently of the clinical characteristics of the disease being treated.

Gender. Gender is a patient-defining variable that may add explanatory power to cost evolution after variables related to the product, complexity, severity, and age have been adjusted.

Socioeconomic status (SES). Several studies have supplied information on the effect of low SES on cost.[114] Consequently, the Household Economic Capacity Index (HECI) was used.[115] This index synthesises differences in economic capacity between small areas in a continuous valuation. Although it is an ecological variable, characteristics of these small areas provide information on the SES of patients living in the city of

Barcelona. Among the 35 262 discharges, 26 676 were living in Barcelona City and consequently information on their SES was available.

Surgical procedure. A dummy variable based on whether patients underwent surgical procedures or not was determined using DRG type. Although this variable is incorporated in DRG definition, it is expected that there are characteristics related to hospital structure and organisation that may be captured through this circumstance.

Analysis

In the present study, real discharge cost variability based on a set of variables generated by and available in any European hospital is explained. The sign and the explanatory power of each variable related to discharge cost was evaluated.

Three different approaches to the product were used depending on the DRG grouping system. On the one hand, we used the H-DRG, which already incorporates the components of comorbidity and complications. On the other hand, we used the same DRGs, after eliminating differences in comorbidities, complications, and age (A-DRG). In these cases, the Elixhauser Index (A-DRGE) and the Charlson Index (A-DRGC) were applied. Finally we applied the patient classification system based on APR-DRG where severity definition is determined by the APR-DRG’s grouper severity indicator.

The relationship between discharge cost and the variables constructed was established with an unadjusted bivariate correlation. The correlation analysis was performed through Pearson’s lineal correlation for continuous variables and through Spearman’s lineal correlation for dummy variables.

The multivariate analysis was performed through ordinary least squares by relating total discharge cost to explanatory variables. A logarithmic transformation of the variables considered continuous (total cost, SES indicator, comorbidity index and average cost weight) was applied to reduce the magnitude effect, thus avoiding the introduction of a fictitious relationship between variables. Similarly, the logarithmic transformation, which approximates the normal distribution expected for these variables, was applied. This guaranteed the absence of bias in the statistics used to validate the estimation.[25-27,31,41,46]

To obtain more robust cost-based weights, cases belonging to a DRG with less than 37 cases were excluded. A cut-off point was calculated with the aim of including 95% of cases.

To answer the initial hypothesis, the multivariate analysis was performed in various stages:

Equation 1: Analysis of the ability of different DRG patient classification systems using Medicare's weights (MW) and cost-based weights (CW).

Equation 2: The set of variables that provides information to risk adjustment. The variables corresponding to each patient classification system used were introduced. To simplify the analysis, this completed model was applied only to cases not considered outliers.

Results

After exclusion of outliers, the 35 262 discharges were grouped into 313 product categories for the A-DRG with an average of 108 cases. The results for APR-DRG were fairly similar: there were 319 DRGs with an average of 106 cases. In contrast, H-DRG had 470 groups with an average of only 71 patients (Table 1).

Average discharge cost was 362 813 ptas. Average cost, after excluding outliers, oscillated between 311 255 for APR-DRG and 312 687 ptas. for H-DRG. Outlier cases accounted for 4.4% of APR-DRG and 4.8% of H-DRG. However, these cases represented about 15% of stays and 18% of cost, independently of the grouping method.

There was significant gross lineal correlation in all variables except ecological SES. The sign was positive in all variables except readmissions (Table 2).

Table 2. Crude correlation between patient cost and independent variables

Variable		(3)	
product			
Medicare's Weights	continuous	0.4762	*
HCFA-DRG CW (1)	continuous	0.5532	*
Adjacent HCFA-DRG CW (1)	continuous	0.5299	*
APR-DRG CW (1)	continuous	0.5288	*
HCFA-DRG outliers	dummy	0.3091	*
Adjacent HCFA-DRG outliers	dummy	0.3075	*
APR-DRG outliers	dummy	0.3145	*
Elixhauser's comorbidities	continuous	0.1564	*
Elixhauser's complications	dummy	0.1131	*
Charlson	continuous	0.1483	*
APR-DRG severity indicator	categorical	0.2211	*
Disease Staging	categorical	0.1551	*
socioeconomic status			
Age	continuous	0.1369	*
Gender	dummy	0.0165	*
HECI (2)	continuous		ns
hospital process			
Readmission index	dummy	0.0346	*
Readmissions	continuous	-0.0258	*
Hospital	dummy	0.0545	*
Emergency admissions	dummy	0.0996	*
Exitus	dummy	0.1566	*
Surgical procedure	dummy	0.1521	*

*: significance p<0.01; ns: non significance
(1) Cost based DRG-Weights without outlier cases.
(2) Household economic capacity index (HECI)
(3) Pearson's lineal correlation for continuous variables and through Spearman's lineal correlation for dummy variables.

The ability of MWs to explain cost variability estimated through R^2 was 19.3%. CWs completely representative of the sample studied achieved an explanatory power of between 39% and 42%, depending on the patient classification system used. The HCFA's DRG grouping system had slightly greater explanatory power, even though almost 50% more categories were required to achieve this than with other systems (Table 3). When outliers were excluded, the R^2 of the different models increased by 5 points (results not shown).

Table 3. Valuation of patient classification systems' cost variation explanatory power

Dependent variable: Per-Patient cost								
	MW-H-DRG		**CW-H-DRG**		**CW-A-DRG**		**CW-APR-DRG**	
Independent variable	**B**	**SD.**	**B**	**SD.**	**B**	**SD.**	**B**	**SD.**
Weight (1)	0.7267	*0.0091*	0.9827	*0.0070*	0.9907	*0.0075*	1.0136	*0.0079*
Constant	9.1651	*0.0408*	8.0475	*0.0315*	7.9989	*0.0338*	7.8947	*0.0356*
R^2	0.1929		0.4220		0.3924		0.3790	
F	6 374.8		19 476.6		17 231.4		16 280.5	
n (2)	26 670		26 670		26 670		26 670	

(1) Significance at 99% for all variables
(2) Barcelona city residents grouped in significant DRG

Equation 2 incorporates the complete risk adjustment model. The overall model explained up to 50% of cost variability with slight differences among the patient classification systems used. All the variables maintained significance except some severity stages evaluated by Disease Staging. All the variables with greater complexity (DRG weight), seriousness (more comorbidities, complications or severity), process complexity (emergency or surgical admission), or unfavourable SES (greater age or lower economic capacity) resulted in higher cost. Variables interrupting the hospital process (readmissions and death) resulted in lower cost. (Table 4.1 to 4.4)

Table 4.1 Risk adjustment model based on HCFA-DRG (H-DRG)

Dependent variable: Per-patient cost	B	Standard error	T	Significance
Explanatory variables:				
Product				
CW-H-DRG	0.9228	0.0072	128.5890	*
Severity stage 2	0.0182	0.0097	1.8720	***
Severity stage 3	0.0352	0.0115	3.0740	**
Socioeconomic status (SES)				
Age	0.0158	0.0048	3.2630	*
Gender	-0.0205	0.0074	-2.7950	*
Household Economic Capacity Index	-0.0398	0.0131	-3.0430	*
Hospital process				
Readmission index	0.1080	0.0244	4.4433	*
Readmissions	-0.1356	0.0140	-9.7180	*
Hospital	-0.1289	0.0107	-12.0890	*
Emergency admission	0.2418	0.0086	28.0030	*
Exitus	-0.2760	0.0200	-13.7810	*
Surgical procedure	0.1846	0.0092	19.9890	*
Constant	0.1846	0.0092	19.9890	*
R^2	0.5082			
F	2 188.19			
n (1)	25 398			

(1) Barcelona city residents grouped in significant DRGs

* significance at 99%

** significance at 95%

*** non-significant

Table 4.2 Risk adjustment model based on A-DRGE:
Adjacent HCFA-DRG with Elixhauser's comorbidities and complications index.

Dependent variable : Per-patient cost	B	Standard error	T	Significance
Explanatory variables:				
Product				
CW-A-DRGE	0.8961	0.0075	119.8100	*
Elixhauser's comorbidities index	0.1418	0.0072	19.6610	*
Elixhauser's complications index	0.1063	0.0117	9.0770	*
Severity stage 2	0.0216	0.0099	2.1860	**
Severity stage 3	0.0160	0.0119	1.3440	***
Socioeconomic status (SES)				
Age	0.0177	0.0050	3.5500	*
Gender	-0.0380	0.0075	-5.0710	*
Household Economic Capacity Index	-0.0393	0.0133	-2.9680	*
Hospital process				
Readmission index	0.1192	0.0247	4.8200	*
Readmissions	-0.1495	0.0142	-10.5250	*
Hospital	-0.1707	0.0111	-15.4120	*
Emergency admission	0.2499	0.0088	28.4910	*
Exitus	-0.2941	0.0205	-14.3230	*
Surgical procedure	0.2349	0.0094	24.8660	*
Constant	8.3495	0.0725	115.1640	*
R^2	0.4893			
F	1 747.29			
n (1)	25 516			

(1) Barcelona city residents grouped in significant DRGs
* significance at 99%
** significance at 95%
*** non-significant

Table 4.3 Risk adjustment model based on A-DRGC:
Adjacent HCFA-DRG with Charlson's comorbidities index.

Dependent variable : Per-patient cost	**B**	**Standard error**	**T**	**Significance**
Explanatory variables:				
Product				
CW-A-DRGC	0.8987	0.0075	120.0790	*
Charlson's comorbidities index	0.1916	0.0096	19.9480	*
Severity stage 2	0.0219	0.0099	2.2140	*
Severity stage 3	0.0231	0.0117	1.9710	**
Socioeconomic status (SES)				
Age	0.0219	0.0050	4.4090	*
Gender	-0.0396	0.0075	-5.2660	*
Household Economic Capacity Index	-0.0399	0.0133	-3.0090	*
Hospital process				
Readmission index	0.1186	0.0247	4.7910	*
Readmissions	-0.1521	0.0142	-10.6930	*
Hospital	-0.1579	0.0110	-14.3560	*
Emergency admission	0.2570	0.0088	29.3750	*
Exitus	-0.2984	0.0206	-14.4770	*
Surgical procedure	0.2376	0.0095	25.0100	*
Constant	8.3190	0.0725	114.7130	*
R^2	0.4880			
F	1 871.3			
n (1)	25 516			

(1) Barcelona city residents grouped in significant DRG

* significance at 99%

** significance at 95%

*** non-significant

Table 4.4 Risk adjustment model based on All Patient Refined-DRG

Dependent variable: Per-patient cost	**B**	**Standard error**	**T**	**Significance**
Explanatory variables:				
Product				
CW-APR-DRG	0.9259	0.0077	119.513	*
APR-DRG severity index	0.4222	0.0168	25.151	*
Socioeconomic status (SES)				
Age	0.0139	0.0049	2.8290	*
Gender	-0.0357	0.0075	-4.7740	*
Household Economic Capacity Index	-0.0405	0.0133	-3.0490	*
Hospital process				
Readmission index	0.2346	0.0247	9.5130	*
Readmissions	-0.2881	0.0142	-20.3260	*
Hospital	-0.1687	0.0109	-15.5170	*
Emergency admission	0.2270	0.0088	25.7570	*
Exitus	-0.3453	0.0207	-16.6850	*
Surgical procedure	0.2358	0.0094	25.0420	*
Constant	7.9475	0.0726	109.4270	*
R^2	0.4868			
F	2 200.92			
n (1)	25 510			

(1) Barcelona city residents grouped in significant DRGs

* significance at 99%

** significance at 95%

*** non-significant

Discussion

This study shows that the ability of different patient classification systems commonly used in our setting to explain hospital cost variability and to determine resource allocation can be evaluated by using information from a large number of cases on cost per patient. The first issue to take into consideration is that using patient classification systems with imported standardised weights contributes very little to information on cost variability. Twenty percent of the variability is a low percentage but is similar to that obtained in other studies.[31,32]

Normally, the poor ability of DRG-weights to explain cost variability has been attributed to the weight systems used.[45] Using the average value after excluding outliers, based on the observed costs of the database analysed as weight structure, maximises the explanatory power of the classification systems used. Certainly, the doubling of explanatory power after using a completely representative weight structure suggests that the possibility of improving the utilisation of these systems exist. However, 40% is not a high percentage. Furthermore, this percentage is the most satisfactory possible since it was obtained from two hospitals sharing the same management and thus, it does not show either input price differences or inter-hospital variability.

Another possibility for improvement concerns the effect of outliers in blurring the explanatory power of these grouping systems, which use the group mean to characterise all the cases that they incorporate.

Between 4.4% and 4.8% of cases were of extremely high cost. This cost could not be approximated by the mean of the distribution, since it was too far from its distribution core. Their effect in terms of cost was 18%, a figure which led to a displacement of the mean value to higher values, making the mean less representative of all the cases incorporated. Excluding outliers substantially increased the explanatory power of DRGs.

After the increase due to exclusion of outliers was discounted, the set of variables enabling characterisation of patient cost and comparison of resource needs based on different circumstances linked to the patient, process or supply, did not significantly add explanatory power. However, signs and stability of parameters of the different classification systems can add considerable information about the causes of hospital discharge cost variability:

1. DRG systems with few product categories can achieve a similar explanatory power to those that need 50% more categories, when systems to value the seriousness of the disease treated are used.
2. There are few differences between Elixhauser's and Charlson's comorbidities and complications measures. However, the specificity of the former in distinguishing complications and comorbidities should be positively valued.
3. The APR-DRG system is the logical synthesis of the points 1 and 2 that seeks to minimise the number of products and to maximise information about their seriousness.
4. Differentiating between severity, comorbidities and complications is central to an analysis of the different causes of cost variability. The Adjacent-HCFA-DRGs (A-DRG) could provide qualitatively richer information.
5. The simplicity of the Charlson and Elixhauser indexes and their immediate applicability is an advantage, since the severity indicator algorithm of the APR-DRG is much more complicated and less intelligible.

In this study, information on the SES characteristics of 26 676 patients, which is not normally available, was used to evaluate their effect on cost. There was an inverse relation between SES and cost, as in Medicare's payment system, in which serving a population with a lower SES than the average is valued as a justifiable extra cost. This relationship was not captured in the bivariate analysis, but is clearly relevant after adjusting for the variables that define product and other circumstances. Because it is very difficult to collect information on the SES of individual patients in administrative databases, trust will have to be placed in ecological variables, as is the case with the HECI when analysing the effect of SES on hospital resource use.

The remaining adjustment variables behaved in accordance with the initial hypothesis: readmissions resulted in lower average cost per episode while index admissions tended to result in higher costs. Similarly, death reduced the cost of hospital episodes. This was observed only in the multivariate analysis since in the bivariate analysis, death was associated with higher cost.

Even though this study presents the limitation of not representing a sufficiently general setting to enable extrapolation of the conclusions to an entire health care system, the results obtained should be valued as highly relevant as they lead to different health policy implications that should not be ignored:

1. The ability of administrative databases to define product and value its cost does not end in DRG grouping. Many aspects could be improved by using information obtained from administrative databases.
2. The relevance of outliers, because of their intense resource use, should be integrated into activity valuation based on DRG.
3. Adjustment of DRG-weights to the environment in which they are to be used is strongly recommended.
4. Aspects associated with patient characteristics and the hospital process, such as severity, should be valued in order to achieve a good approximation of patient cost.
5. A clear relationship was seen between resource use and the patient SES, which should be integrated into the valuation of cost considered justifiable.

From these five points it can be concluded that a valuation of different hospital activities of a health care system that is based only on DRG-weights can be very inequitable, since these valuation deficiencies may affect some hospitals more deeply than others.

Because only two hospitals sharing the same type of management and following the same guidelines were analysed, these five aspects cannot be associated with structural differences, but must be associated with the activity performed. In other words, they must be related to casemix and not to structural differences. According to this reasoning, any payment system based on activity should include these five causes of cost variability in their method of valuing activity.

This is not the case in the Catalan or Andalusian payment systems mentioned above. These models consider that beyond Medicare’s DRG-weights, no other reason for variability apart from structural differences between centres exists.

Conclusions

Hospital cost can be reasonably well characterised with the available information. DRGs are not questioned as a tool for hospital activity payment when the purpose is to give a price to the provider-purchaser relationship. Until now, the crossed subsidies among cases in the same DRG and across DRGs have been assumed to provide satisfactory overall application. However, the limitations of DRGs to explain resource use variability in cost analysis are clear. Nowadays, the available information permits greater insight into each patient's cost level and thus, resources can be more efficiently allocated.

Explanation of what determines per-patient cost should not be confined to DRGs: all the tools available in hospitals' current information systems should be used in cost and risk adjustment.

Measures that complement the information added by DRGs can easily be applied to administrative databases. Only improvement in the weight system, consideration of outliers, and valuation of seriousness can make the valuation of justifiable cost for different hospitals more objective. Among these variables those that potentially offer greater potential improvement seem to be those that adjust weights to the context in which they are applied and those that correctly identify outliers.

In conclusion, qualitative improvement of the information in the Minimum Data Set should be exploited and would permit a much more accurate characterisation of hospital product and its cost.

Appendix 1. Scoring the Charlson's comorbidity index from secondary diagnoses.

Weights	Conditions	ICD-9-codes
1	Myocardial infarction	410, 411
	Congestive heart failure	398, 402, 428
	Peripheral vascular disease	440-447
	Dementia	290, 291, 294
	Cerebrovascular disease	430-433, 435
	Chronic pulmonary disease	491-493
	Connective tissue disease	710, 714, 725
	Ulcer disease	531-534
	Mild liver disease	571, 573
2	Hemiplegia	342, 434, 436, 437
	Moderate or severe renal disease	403, 404, 580-586
	Diabetes	250
	Any tumour	140-195
	Leukemia	204-208
	Lymphoma	200, 202, 203
3	Moderate or severe liver disease	070, 570, 572
6	Metastatic solid tumor	196-199

Adapted from D'Hoore, 1993.

Appendix 2. Definitions of comorbidities

Comorbidity	ICD-9-CM codes	DRG screen: case does not have the following disorders (DRG)
1.Congestive heart failure	398.91, 402.11, 402.91, 404.11, 404.13, 404.91, 404.93, 428.0-428.9	Cardiac
2. Cardiac arrhythmias	426.10, 426.11, 426.13, 426.2-426.53, 426.6-426.89, 427.0, 427.2, 427.31, 427.6, 427.9, 785.0, v45.0, v53.3	Cardiac
3. Valvular disease	093.20-093.24, 394.0-397.1, 424.0-424.91, 746.3-746.6, v42.2, v43.3	Cardiac
4. Pulmonary circulation disorders	416.0-416.9, 417.9	Cardiac or COPD(88)
5. Peripheral vascular disorders	440.0-440.9, 441.2, 441.4, 441.7, 441.9, 443.1-443.9, 447.1, 557.1, 557.9, v43.4	Peripheral vascular (130-131)
6. Hypertension:		
uncomplicated	401.1, 401.9	Hypertension (134)
complicated	402.10, 402.9, 404.1, 404.90, 405.11, 405.19, 405.91, 405.99	Hypertension (134) or cardiac or renal
7. Paralysis	342.0-342.12, 342.9-344.9	Cerebrovascular (5, 14-17)
8. Other neurological disorders	331.9, 332.0, 333.4, 333.5, 334.0-335.9, 340, 341.1-341.9, 345.00-345.11, 345.40-345.51, 345.80-345.91, 348.1, 348.3, 780.3, 784.3	Nervous system (1-35)
9. Chronic pulmonary disease	490-492.8, 493.00-493.91, 494, 495.0-505, 506.4	COPD (88) or asthma (96-98)

10. Diabetes, uncomplicated (1)	250.00-250.33	Diabetes (294-295)
11. Diabetes, complicated (1)	250.40-250.73, 250.90-250.93	Diabetes (294-295)
12. Hypothyroidism	243-244.2, 244.8, 244.9	Thyroid (290) or endocrine (300-301)
13. Renal failure	403.11, 403.91, 404.12, 404.92, 585, 586, v42.0, v45.1, v56.0, v56.8	Kidney transplant (302) or renal failure / dialysis (316-317)
14. Liver disease	070.32, 070.33, 070.54, 456.0, 456.1, 456.20, 456.21, 571.0, 571.2, 571.3, 571.40-571.49, 571.5, 571.6, 571.8, 571.9, 572.3, 572.8, v42.7	Liver
15. Peptic ulcer disease excluding bleeding	531.70, 531.90, 532.70, 532.90, 533.70, 533.90, 534.70, 534.90, v12.71	GI hemorhage or ulcer (174-178)
16. AIDS	042-044.9	HIV (488-490)
17. Lymphoma	200.00-202.38, 202.50-203.01, 203.8-203.81, 238.6, 273.3, v10.71, v10.72, v10.79	Leukemia/lymphoma
18. Metastatic cancer(2)	196.0-199.1	Cancer
19. Solid tumour without metastasis (2)	140.0-172.9, 174.0-175.9, 179-195.8, v10.00-v10.9	Cancer
20. Rheumatoid arthritis/collagen vascular diseases	701.0, 710.0-710.9, 714.0-714.9, 720.0-720.9, 725	Connective tissue (240-241)
21. Coagulopathy	286.0-286.9, 287.1, 287.3-287.5	Coagulation (397)
22. Obesity	278.0	Obesity procedure (288) or nutrition / metabolic (296-298)
23. Weight loss	260-263.9	Nutrition / metabolic (296-298)
24. Fluid and electrolyte disorders	276.0-276.9	Nutrition / metabolic (296-298)
25. Blood loss anemia	280.0	Anemia (395-396)
26. Deficiency anemias	280.1-281.9, 285.9	Anemia (395-396)
27. Alcohol abuse	291.1, 291.2, 291.5, 291.8, 291.9, 303.90-303.93, 305.00-305.03, v113	Alcohol and drug (433-437)
28. Drug abuse	292.0, 292.82-292.89, 292.9, 304.00-304.93, 305.20-305.93	Alcohol and drug (433-437)
29. Psychoses	295.00-298.9, 299.10-299.11	Psychoses (430)
30. Depression	300.4, 301.12, 309.0, 309.1, 311	Depression (426)

Cardiac: 103-108, 110-112, 115-118, 120-127, 129, 132-133, 135-143;
Renal: 302-305, 315-333; Liver: 199-202, 205-208; Leukemia/Lymphoma: 400-414, 473, 492;
Cancer: 10, 11, 64, 82, 172, 173, 199, 203, 239, 257-260, 274, 275, 303, 318, 319, 338, 344, 346, 347, 354, 355, 357, 363, 366, 367, 406-414.
(1) If complicated diabetes appears, uncomplicated diabetes is not counted. (2) If metastasis appears cancer is not counted.
Adapted from Elixhauser, 1998.

Appendix 3. Elixhauser's comorbidity weights

Comorbidity	Coefficients	Weights
1.Congestive heart failure	1.35	3
2. Cardiac arrhythmias	1.13	1
3. Valvular disease	1.06	0
4. Pulmonary circulation disorders	1.48	4
5. Peripheral vascular disorders	1.16	1
6. Hypertension:	1.06	0
7. Paralysis	1.60	5
8. Other neurological disorders	1.27	2
9. Chronic pulmonary disease	1.25	2
10. Diabetes, uncomplicated	1.13	1
11. Diabetes, complicated	1.19	1
12. Hypothyroidism	1.06	0
13. Renal failure	1.12	1
14. Liver disease	1.17	1
15. Peptic ulcer disease excluding bleeding	1.13	1
16. AIDS	1.45	4
17. Lymphoma	1.32	2
18. Metastatic cancer	1.32	2
19. Solid tumour without metastasis	ns	0
20. Rheumatoid arthritis/collagen vascular diseases	1.16	1
21. Coagulopathy	1.75	6
22. Obesity	1.13	1
23. Weight loss	1.70	6
24. Fluid and electrolyte disorders	1.38	3
25. Blood loss anemia	1.22	1
26. Deficiency anemias	1.30	2
27. Alcohol abuse	1.09	0
28. Drug abuse	1.13	1
29. Psychoses	1.14	1
30. Depression	1.17	1

Adapted from: Elixhauser, 1998

Capítulo 5

Constructing inpatient cost function: from risk adjustment to the behaviour of variables defining hospital process

Introduction

Inpatient cost variability has been described as the most serious problem affecting the establishment of cost estimations for contracting and hospital efficiency analysis.[28]
Risk adjustment[21,31] aims to establish and isolate the causes of global variability in per-inpatient cost by constructing instruments that group patients, the most commonly used being the Diagnosis-Related Groups (DRG). Other instruments adjust the characteristics of seriousness, such as comorbidities and complications indicators (the Charlson[99,101] and Elixhauser indexes,[22]) or severity in the case of Disease Staging.[109] Different ways of approaching the patient's socio-economic status have also been studied. These and other instruments have led to the continued improvement of per-patient cost variability adjustment.[23] Most studies have used one or other of these instruments but only a few have used all of them together to construct an overall model of cost function.

The main limitations of these approaches concern the difficulty of determining real per-inpatient cost and consequently of using length of stay (LOS) as a 'proxy' variable.[24,111] Another limitation is that these cost estimations have been used in the global cost valuation of the provider or hospital system.[26,27] Consequently, the point at which the set of characteristics defining patient cost variability outlines a per-patient cost function has not definitively been determined.

Previous analyses have determined the most appropriate tools and the adjustments necessary in a database of per-patient observed costs. With these premises already solved, per-patient cost function should be constructed by determining the most appropriate formulation, taking into account the necessary variables and those that are available.

The aim of this study was to define an ICF that would incorporate the variables that best explain inter-DRG and intra-DRG variability. Above all, we wanted to analyse ICF behaviour and, in particular, the behaviour of the variables that determine intra-GRD variability.

A database containing information on 35 262 patients with per-patient cost and the Minimum Data Set (MDS) information of two public and teaching hospitals owned by Barcelona's Municipal Institute of Health were used to establish the relationship between real observed cost and the variables that explain its variability.

Methodology

Cost function

Hospital cost function (HCF) is a multiproduct function characterised by economies of scale and scope. However, in the short-term, cost variations among products are determined by different relative input needs because the hospital supply remains constant and the spectrum of activities performed by the hospital and its volume does not vary over short periods.

Within hospitals, product definition has historically been reduced to large divisions (inpatients, emergencies, ambulatory processes)[26] and within the inpatient, the most widespread definitions are the patient classification systems, mainly DRGs.[30] A large part of the patient's health care process and consequently of the patient's final cost is determined by the physician's decision. The cost of patients' belonging to the same DRG tends to be the same but differs from the average cost of other DRGs due to differences in care, procedures, diagnostic tests and resource use needs. Thus the HCF is formulated as following:

$$HCF_i = C(Y_i, W_i) + U_i \qquad (1)$$

Where 'i' designates the hospital, 'Y' is the vector that includes the line of product and in the case of inpatients differentiates between casemix (through DRG), 'W' is the input price vector that defines the relationship between the physical need of the input vector and the output cost, and 'U' is the randomly distributed error.

Specification of hospital multiproduct cost function.

Hospital multiproduct cost function has been analysed by several authors,[25,27] but almost all of them have analysed how the output typology could define or justify the cost differences between hospitals. Few of them have analysed the cost variability due to differences within product category that give rise to this variability.

Concerning inter-hospital cost variability, very rudimentary definitions of output have been used due to the limitations of the information systems and because the functional forms permit only a small number of parameters. In 1967 Feldstein was the first to analyse hospital cost function, using a non-flexible cost function with 8 output groups.

[116] In 1983 Conrad and Strauss used translog cost function based on structural form (with only outputs and prices) to analyse three output groups and four input categories.[117] Cowing and Holtmann used the same translog cost function for five outputs and six input categories.[118]

In 1986 Grannemann , Brown and Pauly used a 'hybrid functional form' in which inter-hospital cost variability was explained by the structural regressors, output categories and input prices and by ad-hoc specification variables.[26]

In 1997 Söderlund et al. postulated the following relationship: average cost per inpatient = a function of (average casemix, average long stay days per inpatient (the mean LOS of episodes above the average for their healthcare resource group), percentage of multiple episodes, outpatient attendances per inpatient, accident and emergency visits per inpatient, day visits per inpatient, student teaching units per inpatient, prices of capital items, wage prices, scale of activity, hospital size, degree of specialisation, trust status, competition from other hospitals, and mix of purchasers). These authors postulated a simple linear relationship between average costs per inpatient and the explanatory variables without considering possible interactions between these variables.[119]

All these specifications are hospital cost functions, and all of them establish a trade-off between correct output definition and cost function specification. To answer clinicians' and managers' questions concerning the reasons for patient cost variability, a per-patient cost function in a given hospital with given prices should be constructed that would take into account other restrictions and other aims. In this situation, product definition is the most important issue and neither the number of categories nor the number of variables that define the product for each patient should pose problems.

Only a small number of authors have analysed per-inpatient cost variability more recently. These analyses have outweighed the optimal valuation of hospital product. Calore and Iezzoni (1987),[31] defined a relationship between inpatient cost and an additive and separable cost function which is the log-transformation of a Cobb-Douglas cost function(2):

$$\text{LnCOST}= \alpha_0 + \alpha_1 \ln W + \alpha_2 \text{ DRG}+ \alpha_3 \text{ SEV} +\alpha_4 \text{ AGE}+ \alpha_5 \text{ COMORB} +\alpha_6 \text{ DIED}+ \alpha_7 \text{ TEACH}+ e \qquad (2)$$

Where LnCOST is the natural log of Part-A- inpatient cost in the Medicare system, W is the Health Care Financing Administration's (HCFA) hospital wage index, DRG is a group of dummy variables for each DRG; SEV is a vector of dummy variables for the severity index used (patient management categories or Disease Staging); AGE is a dummy variable for patients over the age of 80 years; COMORB is a dummy variable for patients with unrelated comorbidity; DIED is a dummy variable for patients who died and TEACH is a dummy for teaching hospital.

The aim of this specification was to analyse the marginal increase in explanatory power for the introduction of severity measures over basic product definition based on DRGs. Estimated cost was used as a proxy of observed cost. Very similar analyses were performed by Thomas and Ashcraft (1991)[32], Averill et al. (1992),[120] and Söderlund et al.(1996) [6], but without complementary independent variables (Table 1).

All these authors have tried to value the part of total cost variability explained by DRGs or other patient classification systems and the explanatory power using severity measures that complement the DRG system. Under structural cost function specification these examples would not be considered cost functions because they do not include input prices.

These authors' findings reveal that DRG product classification explains less than 35% of cost variability using trimmed data when global hospital cost is analysed. If the analysis is carried out by splitting categories into DRG groupings, the proportions of cost variability explained tend to be spurious due to the wide range of values.

In 1998 Beaver et al,[24] tried to explain intra-DRG cost variability in the Northern Territory in Australia using an additive and separable functional form that includes ad-hoc variables which the authors thought were the reason for the per-inpatient resource use variability. Socio-economic, demographic and process variables were used to explain unexplained variability after grouping patients by the AN-DRG classification system. Using a logarithm of LOS as a proxy of inpatient cost, the regression model explained 45% of its variability.

Restrictions that should be assumed when proposing a per- inpatient cost function

Product/patient classification systems define a number of categories that impose severe restrictions on the specific definition of cost function. More than 500 groups mean that any formulation based on translog or generalised Leontief cost functions cannot be written because these functional forms create at least [m*(m+1)] /2 parameters if prices are taken; with 500 output groups this would mean 125,250 parameters.[27] As Breyer[25] points out, "It is immediately obvious that the increased flexibility is gained at a cost: the number of parameters to be estimated grows almost proportionately to the square of the number n of original regressors". Because of the need for interactions between each output and other categories to test non-jointness in the production process or the input/output separability, these specifications are non-viable. At the other extreme, patient classification systems have usually been implemented through an implicit functional form that is a simple linear function of the output levels of each product:

$$C = \sum_{i=1}^{n} a_i * y_i \qquad (3)$$

Where 'a_i' is the relative value of product 'i' and 'y_i' is the quantity of product 'i'.

However, to reach this conclusion hard restrictions on cost function should be accepted. The general cost function formulation associated with a multiproduct function (eq. 4) is based on the assumption that inputs can be used for different products (*jointness*), that a combination of outputs can only be obtained with given inputs (*non-input/output separability*) and that a proportional increase in inputs can mean an increase in non-proportional outputs (*non-homogeneity returns to scale*).

Conventional cost function can be represented as:

$$C = f(y, w) \qquad (4)$$

where 'w' represents the vector of input prices and y is the vector of output.

If *non-jointness* in the production process is accepted, each product process can be separated from the others. In a two-product example, cost function can be written as:

$$C = f^{(1)}(y_1, w_1) + f^{(2)}(y_2, w_2) \qquad (5)$$

To impose a new restriction, if *input/output separability* in the production process is accepted, this means that there are no specific interactions between individual inputs and outputs. Costs are now a function of the value of output and of input prices, with relative marginal costs being independent of input prices. Oil-refinery firms, for example, present input/output separability because oil (input) can be refined in different proportions in final products (lead petrol, unleaded petrol, diesel, paraffin, or others). When the input/output separability restriction is incorporated, Equation 5 with can be written as:

$$C= [g^{(1)} (y_1) + g^{(2)} (y_2)] \cdot C (w_1,w_2) \qquad (6)$$

If prices are accepted as given and equal for all hospitals, then cost function can be written as in equation 7. Accepting prices are equal for all units is consistent if cost variability is analysed in the same environment in which there are no differences in input prices.

$$C= g^{(1)} (y_1) + g^{(2)} (y_2) \qquad (7)$$

The difference between (eq. 7) and (eq. 3) now concerns only the relative marginal cost between each product. If it is supposed that $g^{(1)} (y_1) = y^2{}_1$ and $g^{(2)} (y_2) = 3y^2{}_2$, then the marginal cost for each cost function will be $\partial g^1 / \partial y_1 = 2y_1$ and $\partial g^2 / \partial y_2 = 6y_2$ and the relative marginal cost will be $y_1/3y_2$. This relative marginal cost is independent of prices, and thus the final formulation (eq. 3) can be obtained if it is considered that $y_1/3y_2=a_1/a_2$.

However, these restrictions involve denying that common costs exist in a hospital multiproduct cost function. The final product based on the discharge that is defined is the sum of intermediate products. These intermediate products are not related to a single final product and consequently, the imposition of non-jointness is too restrictive to be accepted. If the other restrictions are accepted but if it is also accepted that part of hospital costs are common, then the cost function can be written as follows:

$$C= C(y_1,y_2) + g^{(1)} (y_1) + g^{(2)} (y_2) \qquad (8)$$

Common cost subfunction is the relationship between output and LOS consumed in the process. In the absence of precise cost information, LOS is sometimes used as a proxy of total cost per patient. However LOS is, in fact, part of final per-patient cost and represents the common costs of hospital production function that reverts to each patient through the hospital days consumed. It should be assumed that cost per day of stay is equal for all outputs and for all patients. It should also be assumed that cost per day is equal irrespective of the day in which the stay takes place. These last two restrictions are consistent because common costs for all products are clearly common for each day of stay. However, due to observed intra-DRG variability days of stay can be supposed to vary between patients in the same DRG.

At the same time an equal number of subfunctions and number of products are defined. These specific product cost functions include the costs directly related to the type of product. It should also be assumed that these costs incorporate variability into each product, directly related to treatment and indirectly to LOS.

Figure 1. Day cost vs. total discharge cost.

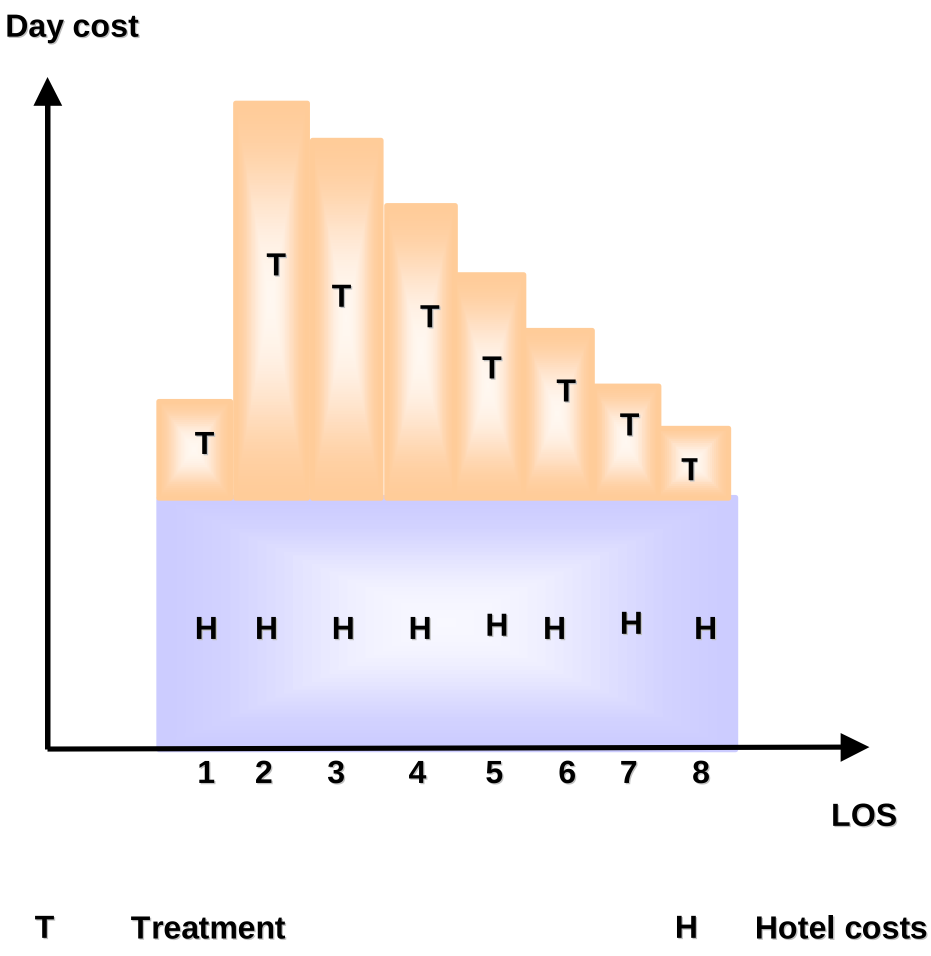


Table 1. Summary of inpatient cost variability studies.

Authors	*Calore, K.A. and Iezzoni, M.D.*	*Thomas, J.W. and Ashcraft, M.L.*	*Averill, R.F. et al.*	*Söderlund, N. et al.*	*Beaver et al.*
Year	1987	1991	1992	1996	1998
Subject	n = 300 122; total cost and DRG/PMC grouping	n = 2 719 cases in selected 11 adjacent-DRGs	n = 76 798	n = 40 000	n = 34 383
Output definition	DRG/PMC clusters and severity scores	A-DRG and severity scores	DRG and Computerised Severity Index	DRG; HRGv1; HRGv2	AN-DRG
Dependent variable	part A estimated inpatient cost	estimated inpatient cost	Estimated inpatient cost	Cost accounting for two hospitals	LOS
Variables	output (dummies for all DRGs), severity of illness, ad-hoc patient and hospital variables and wages without interactions	severity scores	Severity scores	Patient classification systems	output (dummies for all DRGs), ad-hoc patient and hospital variables and socio-economic status without interactions
Specification assumptions	I/O separability, non-jointness, returns of scale	regression for each A-DRG grouping	Analysis of variance	Analysis of variance (RIV)	I/O separability, non-jointness, returns of scale and given prices
Results (DRG-based and trimmed data)	R^2 = 30%	R^2 = 21% with CSI-maximum	Reduction of intra-DRG variability by Computerised Severity Index of 17.4%	RIV = 23.5%	R^2 = 30%

Inpatient cost function

The formulation of total hospital cost function (HCF) is largely based on product definition and consequently, on the variability derived from inter-product differences. However, as mentioned above, the differences within product categories remain unexplained. We have defined these categories as isocost, but in fact they present a high degree of internal variability.[6,31,32]

Inpatient cost function is also based on product definition by DRGs. This grouping of patients into DRGs explains inter-DRG variability. However, from the standardised valuation of the DRGs to observed patient cost, certain factors determine greater more variability, the intra-DRG variability (eq. 9):

$$ICF_i=C(Y_i,W_i, X_i) + U_i \qquad (9)$$

Where ‘i’ identifies each inpatient, ‘Y’ is the product (DRG) vector, ‘W’ the input price, ‘X’ the variables that determine the intra-DRG variability vector and ‘U’ is the randomly distributed error.

Hospital discharge cost is determined by a series of health care processes received by the patient in specialised centres with a highly technological component. According to Butler,[27] discharge cost is determined by the workload and resource use related to the inpatient's stay, the different treatments given to the patient and the fixed costs of admission and discharge. Each day of stay implies a similar patient care cost. Thus, these costs, which include a large part of the nursing costs, hotel and general building infrastructure, should be called fixed. Within a given hospital, cost differences per day of stay will always be insignificant.[121]

Apart from LOS, the different intermediate products received by the patient in relation to the diagnosis and subsequent treatment are what determine variability. Surgical procedures, intensive care unit treatment, radiological and laboratory tests, pathologic anatomy, prosthesis and drugs, as well as other techniques and processes, can be easily recognised. These intermediate products are variable costs in the inpatient hospital process.

Figure 1. shows how the total cost caused by a hospital discharge in relation to LOS is distributed. Its shape is determined by the diagnosis, treatment and recuperation period, which produce the characteristic lognormal distribution.[7] Determination of how each cost component behaves in relation to LOS and discharge enables characterisation of the cost function of the final hospital product.

Using this vision of the composition of hospital discharge cost, the ICF can be redefined by separating two aspects: fixed cost with respect to LOS and the variable cost of treatment (eq.10):

$$ICF_i = \text{Fix C}(LOS_i, W_i, X_i) + \text{Var C}(Y_i, W_i, X_i) + U_i \qquad (10)$$

This equation is almost identical to (eq. 8) with the difference that product definition is not reduced to a single unambiguous label but is composed by several characteristics that explain the different product dimensions.

As can be seen, the most important difference between equations (10) and (8) lies in the consideration that fixed cost depends on LOS and not directly on the product. LOS, however, also depends on the type of product and on the other variables that affect the patient (eq. 11):

$$LOS_i = LOS(Y_i, X_i) + U_i \qquad (11)$$

Empirical formulation

Data

The 35 262 discharges from the hospitals of the Municipal Institute of Health in Barcelona, admitted and discharged during 1995 and 1996, were retrospectively analysed (table 2).

Hospital discharge cost is a monetary reflection of a series of activities and resource uses incurred during the patient's stay. These activities and uses differ according to the product, the severity and the patient's other clinical variables, socio-economic status and the management of the health care process.

The main source of information was the Minimum Data Set with eleven codified secondary diagnoses and the cost accounting system of the hospitals studied.

Table 2. Summary of database

	All patients		**Barcelona city residents**	
	Value	*SD.*	**Value**	*SD.*
All cases	**35 262**		**27 355**	
Length of stay	8.9	*9.8*	9.1	*9.9*
Inpatient average cost	362 813	*501 658*	363 446	*495 285*
% Variable cost	38%		37%	
Without outliers	**33 718**		**26 170**	
Length of stay	7.9	*7.3*	8.1	*7.3*
Inpatient average cost	311 504	*314 368*	312 707	*305 886*
% Variable cost	36%		35%	
% outliers	4.4%		4.3%	
% extreme hospital days	14.9%		14.6%	
% extreme cost	17.9%		17.7%	

Model variables

We differentiated among the variables that shape ICF: those defining product, environmental variables and control variables (table 3). Environmental variables affect the hospital process in terms of the variables defining both LOS and treatment intensity, and also affect the final outcome. The control variables were taken to be those providing indirect information that could not be provided directly. Products were those that were diagnosed and performed during the period of inpatient stay. This group of variables was constructed with the information provided by the International Classification of

Diseases (ICD-9-CM) codes. A-DRG, a synthetic and weighted measure of the comorbidity level, a measure concerning the presence of complications, and a measure related to the severity of the principal diagnosis were obtained from the database.

The environmental variables were those that describe the patient's socio-economic status: age, gender and economic capacity.

Finally, the control variables were focused on the circumstances of admission (whether planned or through the emergency department) and of discharge (whether the patient was discharged from hospital or died). Information on the number of readmissions during the period analysed was also included to incorporate information pertaining to the whole process and not just that provided by admission and discharge.

Table 3. Description of the variables[1]

Variables	
Dependent variables:	
Per-inpatient total cost	Log of per-inpatient cost
Per-inpatient day-hospital cost	Log of per-inpatient day-hospital cost
Per-inpatient quasi-fixed cost	Log of per-inpatient quasi-fixed cost
Per-inpatient variable cost	Log of per-inpatient variable cost
Independent variables:	
Comorbidities according to Elixhauser et al.'s criteria	Log of comorbidity index
Complications according to Elixhauser et al.'s Criteria	1 if complications; 0 for the rest
Average severity of main diagnosis	1 if Disease Staging = 2; 0 for the rest
High severity of main diagnosis	2 if Disease Staging = 3; 0 for the rest
Age	Log of age in years
Sex	1 if female; 0 if male
Family economic capacity	Log of family economic capacity index
Readmission index	1 if the discharge is the first of readmission process; 0 for the remaining
Number of readmissions	0 if no readmissions; 1 for one or two readmissions; 2 for the remaining
Hospital	1 if hospital A; 0 if hospital B
Urgent admission	1 if urgent admission; 0 for the remaining
Exitus	1 if exitus; 0 for the rest

(1) Dummy variables of each DRG are not described.

Cost. The MHI's hospital cost accounting system based on full costing allocation ensured that the hospitals' total costs were distributed among the patients.

Consequently, not only is the overall cost per patient known but also its structure. Total inpatient cost was separated into variable cost and quasi-fixed cost. Variable cost was the total cost of drugs, radiology, laboratory, pathology, prosthesis, operating room and intensive care unit. The remaining cost was considered as a quasi-fixed cost related to LOS.

Table 4. Summary of statistics for variables[1] in the inpatient cost function models (n=24 302)

Variables	Mean sample	Standard deviation	Minimum	Maximum
Dependent variables:				
Per-inpatient total cost	305 771	266 088	10 859	4 559 969
Per-inpatient day-hospital cost	47 159	35 749	10 859	2 078 723
Per-inpatient quasi-fixed cost	201 376	170 525	10 859	2 379 234
Per-inpatient variable cost	104 395	166 997	0	3 665 549
Independent variables:				
Comorbidities according to Elixhauser et al.'s criteria	0.79	1.44	0.00	13.00
Complications according to Elixhauser et al.'s criteria	0.13	0.34	0.00	1.00
Average severity of main diagnosis	0.20	0.40	0.00	1.00
High severity of main diagnosis	0.16	0.36	0.00	1.00
Age	57.47	23.90	0.00	109.00
Sex	0.51	0.50	0.00	1.00
Family economic capacity	125.20	36.68	45.46	463.66
Readmission index	0.04	0.19	0.00	1.00
Number of readmissions	0.13	0.81	0.00	16.00
Hospital	0.82	0.38	0.00	1.00
Urgent admission	0.55	0.50	0.00	1.00
Exitus	0.04	0.19	0.00	1.00

(1) Dummy variables of each DRG are not described.

Product variables. The DRG grouping was carried out through HCFA version 13, but without differences between categories due to age, complications and comorbidities. The result was the Adjacent-DRG (ADRG). The indicators of comorbidities and complications levels were constructed by using the indexes defined by Elixhauser.[22,122] Finally, severity was introduced by applying Disease Staging to the whole database.[110]

Environmental variables. Age and gender incorporate information concerning patients' sociodemographic characteristics. Information on economic capacity was approximated through the ecological information at the census section level obtained from the Household Economic Capacity Index (HECI).[115] Use of this variable reduced the size of the database analysed because some of the patients treated did not belong to the city of Barcelona.

Control variables. Control variables were those that distinguish the two hospitals studied, those that described whether the patient died while in hospital, and those that determine whether the admission was planned or through the emergency department. Readmission was also considered a control variable. The first admission in a series was characterised as a dummy control variable.

The ICF to be estimated

Because the ICF specification was restricted in order to be additive and separable and because nearly all variables were dummies, the most appropriate formulation was, in this case, a functional formulation of the Cobb-Douglas type (eq. 12).

$$\log\left(IC_i\right) = b_0 + \sum_{j=1}^{187} b_j Y_{ij\,i} + \sum_{k=1}^{12} c_k X_{ik} + U_i \quad (12)$$

A logarithmic transformation of all the continuous variables was performed (table 4). ‘i’ identifies each patient, while ‘j’ and ‘k’ refer to each variable introduced. ‘IC’ is the inpatient cost, the vector ‘Y’ represents the different DRGs and the vector ‘X’ the variables explaining intra-DRG’s cost variability. ‘β’ and ‘χ’ are the estimated parameters for the different variables.

The model to be estimated does not incorporate any reference to input prices because the two hospitals studied are in fact a functional unit with the same management and the period analysed was short enough not to include differences due to price variations.

Because outliers are too far from the core of the distribution where they are grouped, they were excluded from the analysis of the database to reduce the intra-DRG variability.

Because the incorporation of information on patients’ socio-economic status was of special interest and because the information was from the 1996 HECI, which refers to Barcelona City, the estimations were performed using only information on patients from the database who were residents in Barcelona.

Table 5. Correlation between inpatient cost and independent variables (1) (n=24 302)

Variable	Type of variable	total cost	Variable cost	quasi-fixed cost
Product				
Aggregated-DRG-HCFA outliers	dummy	0.308 *	0.216 *	0.280 *
Comorbidities (2)	continuous	0.156 *	0.067 *	0.226 *
Complications (2)	dummy	0.113 *	-0.022 *	0.176 *
Severity (Disease Staging)	categorical	0.155 *	-0.087 *	0.259 *
Socio-economic status				
Age	continuous	0.137 *	0.075 *	0.174 *
Sex	dummy	-0.033 *	-0.048 *	ns
Family economic capacity	Continuous	ns	ns	ns
Process management				
Readmission index	dummy	0.043 *	ns	0.050 *
Readmission	Continuous	-0.026 *	-0.021 *	-0.024 *
Hospital	dummy	-0.013 **	-0.084 *	0.091 *
Urgent admission	dummy	0.179 *	-0.144 *	0.360 *
Exitus	dummy	0.055 *	0.021 *	0.069 *
Length of stay	continuous	0.748 *	0.4 *	0.967 *

*: significant p<0.01; **: significant p<0.05; ns: non-significant
(1) Pearson's lineal correlation for continuous variables and Spearman's correlation for dummy and categorical variables.
(2) Variables based on Elixhauser et al.'s criteria.

Model 1. Cost function was estimated through Ordinary Least Squares (OLS) to observe the degree of adjustment and the signs of the various variables incorporated. Cost variable followed normal distribution due to logarithmic transformation. However, because of problems of heteroscedasticity, cost function was modelled through a Poisson distribution and estimated through Generalised Lineal Models (GLM). The consistency of the results obtained through OLS did not vary after the new formulation; for this reason and because OLS outputs are more easily interpreted, the results are presented through this method. No significant problems of multicollinearity between the independent variables were observed.

Apart from heteroscedasticity, estimation of the empirical formulation of ICF though OLS poses serious problems of consistency of the parameters due to the incidental parameter, defined by Neyman[123] and recently updated by Lancaster.[124] This effect is produced when there is a finite number of groups with an unusually high number of cases – as was the case in our formulation. The variance of the different variables for each group may vary, thus affecting the stability of the overall estimation of the parameters. This problem may be overcome either by introducing interactions or by using a mixed model. Because of the number of variables and because they were dummies, the first option was not viable. Instead, a mixed model was used in which level 1 refers to intra-DRG variability which represents all the variables apart from DRGs; while level 2 refers to inter-DRG variability incorporated into the DRG itself. A mixed lineal model (MLM) was estimated assuming that the response variable was normal.[125,126] The mixed model was estimated through Maximum Likelihood and the results were compared with those of the model estimated by OLS. The consistency of the estimators was nearly total and consequently the results are presented according to two methods (OLS and MLM) since the value and tendency of the parameters is almost identical.[127]

Model 2. The same function was estimated to explain inpatient day cost. Thus, the behaviour of the incorporated variables could be observed more in relation to the LOS than in relation to the whole discharge, which provided an approximation of the structure of per day cost of stay.

Models 3 and 4. The cost functions were estimated by distinguishing between quasi-fixed cost, and variable cost.

To perform the multivariate analysis, DRGs with less than 37 cases were excluded by using a cut-off point that incorporated 95% of the cases in the database. These cases were eliminated, since the introduction of the DRGs as a dummy adjustment variable would have incorporate too much significance due to an excessive identification with the dependent variable. A total of 187 DRG groups remained.

Results

The 35 262 cases had an average cost of 362 813 pesetas. After excluding outliers, the average cost was 311 504. The percentage of outliers was 4.4%. LOS associated with these cases accounted for 14.9% and associated costs accounted for 17.9%. These relative figures remained almost the same when analysing only Barcelona City residents (table 2). 24 032 cases were analysed when non-significant DRG were excluded.

All the variables showed a significant bivariant relationship with cost except the ecological socio-economic variable (table 5). Concerning total cost, all significant variables showed a gross positive relationship except readmission and the dummy variables that corresponded to hospital and gender. When analysing fixed cost, we obtained a pattern almost identical to that of total cost. The sign variations for variable cost were significant; thus variables such as principal diagnostic severity or admission through the emergency department showed a negative relationship with respect to variable cost.

Inpatient cost function

Estimation of cost function through a multivariate OLS model explained up to 51% of the total cost variation. The residuals of the MLM estimation rose to 0.53. Tables 6.1 and 6.2 show how the different variables considered for OLS and MLM respectively, were related in the expected way to total cost. The dummy variables representing each DRG are not shown, since they only served the function of adjusting the resulting product in each discharge. In the Cobb-Douglas inpatient cost function parameters represent cost elasticities. It is important to note the significance and the positive signs of all the variables defining product, such as comorbidities (+0.16), complications (+0.14) and age (+0.09); as well as that of those controlling aspects related to the complexity of the health care process, such as admissions to the emergency department (+0.36) or the index admission in a series of later readmission (+0.15). Readmission (-0.16) and death (-0.30) showed high negative sings. Variables that defining socio-economic status as economic status showed the expected sign, negatively relating level of wealth to the cost of hospitalisation (-0.04).

Table 6.1
Inpatient cost function. Total cost. OLS linear regression

Dependent variable: Inpatient total cost Dependent variables	B	Standard error	β	t-ratio	
Product					
Comorbidities	0.1582	0.0076	0.1118	20.904	*
Complications	0.1400	0.0144	0.0580	9.7410	*
Severity: average stage	0.0938	0.0120	0.0462	7.7880	*
Severity: high stage	0.0836	0.0158	0.0372	5.3060	*
Socio-economic status					
Age	0.0845	0.0070	0.0853	12.070	*
Sex	-0.0064	0.0084	-0.0039	-0.7600	ns
Family economic capacity	-0.0323	0.0134	-0.0112	-2.4130	**
Process management					
Readmission index	0.1451	0.0256	0.0332	5.6690	*
Readmissions	-0.1607	0.0157	-0.0646	-10.221	*
Hospital	-0.1244	0.0146	-0.0587	-8.540	*
Emergency admission	0.3581	0.0110	0.2188	32.467	*
Exitus	-0.2975	0.0212	-0.0677	-14.057	*
Constant	11 7096	0.0768		152.509	*
R^2	0.5066				
F	127.03				
n (1)	24 302				

(1) Inlier cases living in Barcelona grouped in significant DRG.
* significant at 99%
** significant at 95%
ns non-significant

Inpatient day cost analysis

When the multivariate OLS model was analysed with respect to average inpatient day cost (table 6.3), the variability explained increased to R^2 of 69%. The set of variables determining intra-DRG variability did not behave in the same way as when used to explain total cost per patient. Some explanatory variables changed the sign, making it negative in relation with patient day cost. These variables belonged to those approximating the seriousness of patient status (comorbidity (-0.02), complexity (-0.02) and age (-0.12)), and to the seriousness of the health care process (emergency admission (-0.03)). Death (+0.14) and socio-economic status (+0.03) also changed the sign, making it positive in relation to day cost.

Table 6.2
Inpatient cost function. Total cost. Mixed linear model

Fixed effects				
Dependent variable: inpatient total cost	**B**	**Standard error**	**t-ratio**	
Dependent variables				
Product				
Comorbidities	0.1566	0.0128	12.2231	*
Complications	0.1864	0.0286	6.3512	*
Severity: average stage	0.0887	0.0122	7.2936	*
Severity: high stage	0.0883	0.0163	5.3936	*
Socio-economic status				
Age	0.1183	0.0204	5.4338	*
Sex	-0.0054	0.0084	-0.6427	ns
Family economic capacity	-0.0329	0.0132	-2.4916	**
Process management				
Readmission index	0.0728	0.0126	5.7747	*
Readmissions	-0.1656	0.0155	-10.6777	*
Hospital	-0.0567	0.0074	-7.6592	*
Emergency admission	0.3542	0.0111	32.0239	*
Exitus	-0.3057	0.0211	-14.5206	*
Constant	11.8888	0.1148	103.5366	*
AIC	42 226.95			
BIC	41 421.30			
Number of observations (1)	24 302			
Number of groups	187			
Random effects				
		Standard error		
Comorbidities		0.1147954		
Complications		0.2178874		
Age		0.2137135		

(1) Inlier cases living in Barcelona with significant DRG.
* significant at 99%
** significant at 95%
ns non-significant

Differentiation between variable cost and quasi-fixed cost

The partial cost analysis of the variable costs (table 6.4) showed the same signs of the main explanatory variables as did the general model for whole costs. However, some variables lost significance. The power (R^2) of the estimation to explain variable cost variability was 48%, only three points below the estimation for total cost.

Fixed costs were explained in a very similar way to the total cost per patient, with no significant differences (table 6.5).

Table 6.3
Inpatient cost function. Total day-cost. OLS linear regression

Dependent variable: Inpatient total day cost	B	Standard error	β	t-ratio	
Dependent variables					
Product					
Comorbidities	-0.0208	0.0038	-0.0234	-5.520	*
Complications	-0.0160	0.0072	-0.0105	-2.2330	**
Severity: average stage	0.0143	0.0060	0.0112	2.3870	**
Severity: high stage	0.0040	0.0079	0.0029	0.5150	ns
Socio-economic status					
Age	-0.1236	0.0035	-0.1980	-35.388	*
Sex	0.0280	0.0042	0.0273	6.6670	*
Family economic capacity	0.0278	0.0067	0.0153	4.1660	*
Process management					
Readmission index	0.0057	0.0128	0.0021	0.4470	ns
Readmissions	-0.0299	0.0078	-0.0190	-3.810	*
Hospital	-0.0189	0.0073	-0.0142	-2.606	*
Emergency admission	-0.1136	0.0055	-0.1102	-20.660	*
Exitus	0.1415	0.0106	0.0511	13.402	*
Constant	10.6725	0.0383		278.671	*
R^2	0.6936				
F	275.50				
n (1)	24 302				

(1) Inlier cases living in Barcelona grouped in significant DRG.
* significant at 99%
** significant at 95%
ns non-significant

Table 6.4
Inpatient cost function. Variable cost. OLS linear regression

Dependent variable: variable cost Dependent variables	B	Standard error	β	t-ratio	
Product					
Comorbidities	0.2788	0.0254	0.0602	10.985	*
Complications	0.2053	0.0482	0.0260	4.2580	*
Severity: average stage	0.0212	0.0404	0.0032	0.5240	ns
Severity: high stage	-0.0161	0.0528	-0.0022	-0.3050	ns
Socio-economic status					
Age	5.8688	0.0235	0.1812	24.997	*
Sex	0.0506	0.0282	0.0095	1.7930	ns
Family economic capacity	0.0535	0.0448	0.0057	1.1930	ns
Process management					
Readmission index	0.3742	0.0858	0.0262	4.3590	*
Readmissions	-0.4610	0.0527	-0.0566	-8.742	*
Hospital	0.0103	0.0488	0.0015	0.211	ns
Emergency admission	0.5739	0.0370	0.1072	15.517	*
Exitus	-0.4843	0.0710	-0.0337	-6.822	*
Constant	6.2454	0.2575		24.252	*
R^2	0.4814				
F	114.94				
n (1)	24 302				

(1) Inlier cases living in Barcelona grouped in significant DRGs.
* significant at 99%
** significant at 95%
ns non-significant

Table 6.5
Inpatient cost function. Quasi-fixed cost. OLS linear regression

Dependent variable: quasi-fixed cost Dependent variables	B	Standard error	β	t-ratio	
Product					
Comorbidities	0.1792	0.0079	0.1211	22.809	*
Complications	0.1676	0.0149	0.0663	11.233	*
Severity: average stage	0.0698	0.0125	0.0328	5.577	*
Severity: high stage	0.0626	0.0164	0.0268	3.829	*
Socio-economic status					
Age	0.0755	0.0073	0.0730	10.395	*
Sex	-0.0413	0.0087	-0.0243	-4.725	*
Family economic capacity	-0.0550	0.0139	-0.0183	-3.962	*
Process management					
Readmission index	-0.1381	0.0266	0.0302	5.196	*
Readmissions	-0.1406	0.0163	-0.0540	-8.611	*
Hospital	-0.1706	0.0151	-0.0770	-11.285	*
Emergency admission	0.4644	0.0114	0.2712	40.562	*
Exitus	-0.4173	0.0220	-0.0907	-18.990	*
Constant	11.7253	0.0797		147.089	*
R^2	0.5141				
F	130.86				
n (1)	24 302				

(1) Inlier cases living in Barcelona grouped insignificant DRG.
* significant at 99%
** significant at 95%
ns non-significant

Discussion

Analysis of ICF was based on a database containing information on real observed costs per-patient and a series of characteristics that defines the patient, the disease, the circumstances related to admission and discharge and other related hospital episodes. The model used differentiates between two groups of variables. Firstly, the DRGs used to adjust the inter-DRG variability were employed. Because 187 groups were introduced as a dummy variable in the OLS model or as a group label in MLM, their parameters were not systematically analysed. On the other hand, 187 DRG groups is a relatively small number with which to define the entire activity of two general hospitals with a total of 24 302 discharges. Reducing DRG groups to adjacent-DRGs by not distinguishing between complications, comorbidities and age produced an advantageous definition of product line especially because the reduction in groups did not lead to a reduction in explanatory power. The second group of variables explained intra-DRG variability.

The behaviour of these variables can only be given a more in-depth analysis when different aspects of patient cost such as total cost, patient day cost, quasi-fixed cost and variable cost have been explained. The following three points should be emphasised:

a) Patient seriousness signifies positive intra-DRG cost variability that is lower than LOS variability.

The relationship established between variables related to seriousness when these variables explain total inpatient cost compared with when they explain inpatient day cost is highly significant. The circumstances defining the patient and the complexity of the hospital process are clearly associated with a higher total cost per patient[22,31,32] but are also clearly related to a lower cost per stay. Turning back to figure 1 and considering that adjustment is through product (by DRG), the comparison between the two estimations shows that higher seriousness during hospital stay signifies a prolongation that follows the pattern outlined, in which the variable day cost decreases and fixed cost remains constant, which implies that the marginal cost of an increase in LOS is lower than the average inpatient day cost. This demonstrates that, even though the greater the seriousness the higher the resource use, the higher cost is still lower than the average inpatient day cost[4,25,27,51] and tends to coincide with the fixed cost.

b) Death during hospital stay implies a lower final cost per patient, but also greater therapeutic intensity during the days of stay

Another important consideration is what happens when the patient dies in hospital. The different estimations serve to confirm the hypothesis that although death implies a lower total cost because it truncates the health care process, resource use intensity during the admission period is higher compared with that of patients who are discharged. These two results are not incompatible and confirm the hypothesis previous to the analysis.

c) Lower socio-economic status measured ecologically explains positive intra-DRG variability

The information added through the community variable of the socio-economic status must be mentioned. Lower socio-economic status is related to higher cost,[23,105] but the analysis also clearly reveals that the inpatient day cost of patients with a higher socio-economic status is also higher. The absolute relationship between socio-economic status and overall cost when adjusting by casemix is not surprising and it seems that it is due to a higher LOS because of a slower recovery. On the other hand, the behaviour of resource use per day is more difficult to explain. No hypotheses on the influence of socio-economic status on inpatient day cost can be formed until direct information on the socio-economic status per patient is available. The results obtained from using aggregate variables as a proxy of individual variables must be interpreted carefully as Robinson[128] pointed out with the called ecological fallacy, the effect found at the aggregate level may not occur at the individual level.

Because this study analyses only two hospitals, the results cannot be generalised. However, our objective was to develop an ICF and to observe the main tendencies in the behaviour of the variables considered. Another limitation of the study is that the type of cost accounting system used does not allow fixed costs to be clearly differentiated from variable costs, since this was not an aim when the system was designed.

Conclusions

A definition of hospital cost function can be formulated using current information systems. The multiproduct nature of production function, as well as the difficulties of characterising the resulting product of the health care process, can be overcome by optimising all the instruments that have been perfected during the last few years.

Determination of the behaviour of inpatient cost is essential to establish an accurate results measure, payment system or cost analysis. Consequently, we emphasise that:

- Higher hospital resource use can be explained using the explanatory variables that complement product complexity described per DRG. Consequently, they should be considered when defining justifiable hospital cost.
- Among the variables that can lead to a better definition of justifiable cost, some, such as circumstance of admission or age, are purely administrative and others, such as comorbidities and complications indicators, can be easily constructed.
- Patient seriousness contributes to an increase in total cost, but the marginal increase is lower than the average inpatient day cost.
- Inpatient cost increases when the patient's socio-economic status is lower because LOS increases, but higher socio-economic status led to increased treatment intensity.

This analysis leaves certain questions unresolved. A more detailed determination of personal socio-economic status information and a knowledge of its importance than that allowed by the outline obtained through the ecological approach is needed.

In conclusion, by considering product definition such as that performed in this study and by observing the results obtained, a solid basis for hospital efficiency analysis can be obtained.

Capítulo 6.

Conclusiones.

Resumen por objetivos

Objetivo 1.

Analizar la variabilidad del coste generada por la existencia de casos extremos (outliers). Definir el método de cálculo de outliers de coste más apropiado para ser utilizado sobre la 'duración de la estancia' entendida como variable proxy del coste.

Inherente a la definición de un sistema de agrupación de pacientes que agrupa a todos los casos en un número limitado de categorías es la existencia de casos que difieren en gran medida en el consumo de recursos ya sean costes o duración de la estancia.

Se han analizado dos tipologías de criterios para la determinación de casos extremos. Los métodos paramétricos basados en robustecer los estimadores de tendencia central de la distribución y aquellos métodos no paramétricos basados en eliminar la cola de la distribución mediante distancias intercuartílicas.

Todos los métodos analizados han aportado un resultado muy importante: los casos considerados extremos (outliers) incorporan un nivel de coste o duración de la estancia cuatro veces superior a la media de los casos.

El método que mejor concordancia ha demostrado entre la determinación de outliers por estancia y coste ha sido el que se basa en marcar el punto de corte como resultado de sumar dos desviaciones estándar a la media geométrica. Este método consigue la mayor concordancia en número de casos considerados outliers según el criterio del coeficiente de Kappa, mejor relación entre especificidad y sensibilidad y sobretodo, mayor capacidad para aproximar costes extremos mediante su aplicación a estancias. En general, los métodos paramétricos presentan también menor sesgo en los errores cometidos, es decir, entre falsos positivos y falsos negativos.

Mediante este método de determinación de casos extremos se consideran outliers el 4,76% de los casos y el 19,91% de los costes. No debe considerarse solamente un criterio para la depuración de las bases de datos para tener unos estimadores de la tendencia central más robustos, sino que también debe considerarse un resultado importante en sí mismo. No hay ninguna categoría de producto en la base de datos utilizada ni en la del SCS que concentre tantos casos y sobretodo, tanto consumo de recursos. Esta es sin duda una de las limitaciones que deben ser tenidas en cuenta cuando se utilizan los GRD como método de clasificación y/o de financiación de producto hospitalario.

Objetivo 2.

Evaluar las diferencias que existen entre el sistema de pesos asociado a los GRD utilizados por Medicare (programa de cobertura pública para personas mayores de la Health Care Financing Administration- H.C.F.A.- en los E.E.U.U.) y los pesos ajustados a nuestra realidad calculados sobre la base de costes por paciente observados.

La estructura de pesos utilizada por Medicare consigue una buena correlación con la estructura de pesos relativos generada a partir de los costes por paciente de los hospitales del Institut Municipal d’Assistència Sanitària de Barcelona. Concretamente, la correlación basada en Mínimos Cuadrados Ponderados alcanza el 95%. Otras valoraciones del nivel de acuerdo entre las dos estructuras de pesos basadas en medidas de correlación no paramétrica de variables ordinales como Tau B de Kendall proporcionan niveles de acuerdo muy elevados (80%), mientras que la correlación de Pearson es del 85%.

Sin embargo, las diferencias entre GRDs concretos pueden ser muy elevadas. Las hipótesis de partida sostenían que las dos estructuras debían presentar desviaciones sistemáticas debidas a diferencias de tipo organizativo (pago de los médicos), de práctica clínica y de estructura de los hospitales del estudio, de población sobre la base de la cual se recalibraban anualmente (población Medicare frente a población general), de incentivos por sistemas de financiación distintos (CMA y patologías que presentan gran variabilidad de intensidad terapéutica), por diferencias entre la relación de los niveles asistenciales o bien por imperfección de los mecanismos de mercado (precio de las prótesis).

Todas estas hipótesis resultaron claramente refrendadas por los resultados, de manera que en los GRD que utilizaban prótesis existía una desviación positiva del 23%, los procedimientos susceptibles de ser realizados en CMA presentaban una desviación negativa del 26%, también aquellas patologías excluidas de diversos sistemas de pago prospectivo en E.E.U.U. como abuso de drogas y alcohol, transplantes y problemas psiquiátricos, presentan desviaciones muy importantes de signo diverso. También se pudieron establecer grupos de desviación sistemática debidas a problemas de oferta de los hospitales de estudio y a los sistemas de pago vigentes en el momento del estudio. En total, 65 grupos GRD de los 267 analizados, explicaban el 51% de la variabilidad total.

Como se ha estudiado ampliamente en la literatura, las desviaciones entre diferentes grupos tienden a compensarse, pero ello no es obstáculo para poder establecer causas objetivas que provocan desviaciones claras que se deben a diferencias del contexto europeo respecto al de origen de los pesos Medicare. La utilización de estructuras de pesos estandarizadas para otros contextos organizativos, culturales y socioeconómicos debe estar precedida de un proceso de reajuste que reduzca las desviaciones más evidentes, con lo que se reduciría sustancialmente el volumen de la desviación entre las dos estructuras de pesos.

Objetivo 3.

Construcción de un sistema de ajuste de riesgos que maximize la capacidad explicativa de la variabilidad inter e intra-GRD, dado el nivel de información existente en cualquier sistema hospitalario europeo.

La información generada en los hospitales del estudio permite construir las variables suficientes para alcanzar la misma o superior capacidad explicativa de la variabilidad del coste por paciente que la que se pueda conseguir en cualquier sistema hospitalario avanzado. Con la información del Conjunto Mínimo Básico de Datos, una contabilidad analítica estándar basada en buenos sistemas de información e información ecológica -comunitaria- del nivel socioeconómico de la población atendida se puede conseguir un modelo de Ajuste de Riesgo que supera el 50% de capacidad explicativa de la variabilidad del coste de paciente ingresado.

La conceptualización del coste del producto hospitalario como una realidad poliédrica permite construir las variables que explican de forma específica cada una de las aristas que componen el coste de la atención del paciente hospitalizado. La complejidad de la patología la representa el GRD mediante los pesos basados en coste real observado una vez excluidos los casos extremos, la comorbilidad y complicaciones son explicadas por índices basados en los diagnósticos secundarios, la severidad del diagnóstico principal la explica el Disease Staging, las características socioeconómicas las explica la edad y el

sexo y, finalmente, las características del proceso asistencial se explican por variables de control como los reingresos o bien la admisión urgente.
Segmentar la explicación del coste entre distintas variables ajustadas a cada una de las causas que lo explican, permite reducir el número de grupos GRD substancialmente sin reducir la capacidad explicativa global.

Lejos de la tendencia de aumentar el número de categorías para reducir así la variabilidad intra-grupo, se pueden utilizar adaptaciones reducidas que sean mucho más manejables y que cumplan a la perfección la función de explicar la complejidad de la patología, dejando en manos de distintas variables asociadas otras facetas del coste del producto hospitalario.

Los GRD de la HCFA con sus pesos originales no explican más del 19% de la variabilidad total y ante esta modesta aportación, existe la posibilidad de llegar al 50% utilizando la información que es requerida por cualquier servicio de salud a sus hospitales desde hace más de una década. La diferenciación de las causas de la variabilidad del coste del paciente entre distintas variables específicas con bajos niveles de correlación entre ellas, permite conocer las causa reales de la variabilidad del coste y su importancia real. Las potencialidades de este nivel de ajuste del riesgo financiero pueden ser utilizadas para mejorar los actuales mecanismos de pago de la actividad hospitalaria, así como para justificar las diferencias del coste incurrido entre distintos hospitales, ahora reducidas a causas estructurales.

Objetivo 4.

Formulación de la Función de Costes por Paciente Ingresado que permita explicar el comportamiento del coste del paciente ingresado así como la causa de este comportamiento.

Este es el cuarto objetivo concreto final que incorpora información de los demás objetivos alcanzados y los internaliza para poder llegar a la construcción de una función que explique el comportamiento del coste de paciente hospitalario ingresado. Partiendo de una información de coste basada en modelos de contabilidad analítica que se centran en actividad, alimentados por conductores de coste sustentados en sistemas de información mecanizados, se han podido asumir los distintos objetivos previos. Una vez determinados los casos considerados extremos bajo un criterio operativo (objetivo 1), analizada la capacidad de los sistemas de clasificación de pacientes y de los pesos asociados que se están utilizando ampliamente en nuestro país para el ajuste del producto hospitalario (objetivo 2) y creadas las variables que permiten el ajuste del riesgo generado por la variabilidad del coste por paciente (objetivo 3), es posible afrontar la formulación de una función empírica que explique el comportamiento de los costes por paciente ingresado.

La función de costes hospitalarios por paciente ingresado FCPI propuesta tiene dos características principales:

1ª. El coste de la atención al paciente hospitalizado es la suma de un coste fijo por día de estancia más un coste variable de tratamiento respecto del alta (del producto). Aunque no son independientes entre ellos se pueden separar conceptualmente pues responden a generadores de coste bastante distintos. El coste fijo por día de estancia se relaciona con las cargas habituales de enfermería en planta y aspectos hoteleros que son los que definen el concepto de ingreso hospitalario. Por su parte el coste variable de diagnóstico y tratamiento se relaciona con una determinada patología o proceso, es decir con el conjunto del alta.

2ª. La utilización de técnicas de casemix absorbe una parte relevante de la variabilidad de coste que existe entre los distintos grupos o categorías de producto: la variabilidad inter-producto (inter-GRD), si se usan los valores relativos adecuados (objetivo 2). La gran variabilidad intraGRD que subyace al utilizar estas técnicas de agrupación de productos, demostrada al analizar los objetivos anteriores por la existencia de outliers (objetivo 1) y causas relacionadas con características del paciente (objetivo 3), queda sin resolver mediante el vector de variables que definen producto.

Sobre la base de ello se define una función de coste por paciente ingresado en la que se supone separabilidad entre los aspectos de coste fijo por estancia y coste variable por producto.

$$FCPI_i = C\ fix(E_i, W_i, X_i) + C\ var(Y_i, W_i, X_i) + U_i$$

Donde i es el paciente, E es la duración de la estancia, Y el producto definido por GRD, X el vector de variables que explican características diferenciadoras entre pacientes y U es el error aleatoriamente repartido. W representa el vector de precios no relevante en este caso porque la base de datos utilizada obedece a un único conjunto de gestión y temporal.

La formulación empírica internaliza los conceptos de variabilidad inter-GRD e intra-GRD con dos grupos de variables claramente diferenciados, mientras que las diferencias entre coste fijo y coste variable, así como el comportamiento del coste en relación con la duración de la estancia se han analizado mediante la transformación de la variable dependiente. La especificación funcional de la función de costes se basa en una función de tipo Cobb-Douglas:

$$\log(CP_i) = b_0 + \sum_{j=1}^{187} b_j Y_{ij^i} + \sum_{k=1}^{12} c_k X_{ik} + U_i$$

El conjunto de variables dicotómicas que explican variabilidad inter-GRD se reduce a 187 gracias a la transformación de los GRD HCFA v13 originales, y las variables que explican las características del paciente se elevan hasta 12 teniendo la mayor parte de ellas la función de explicar alguna de las aristas de la compleja formación del coste por paciente.

Es destacable que cada una de las variables utilizadas para explicar comorbilidades, complicaciones, severidad, situación socioeconómica y de proceso asistencial, toman un signo y significatividad que concuerda con lo esperado con relación al coste final por paciente.

También es muy destacable que las variables que explican circunstancias agravantes del estado del paciente (comorbilidades, complicaciones, edad y admisión urgente) comportan un coste marginal inferior al coste medio por estancia una vez ajustado el producto. Esto nos permite concluir que el agravamiento de las circunstancias del paciente se corresponde con un incremento de los días de estancia (coste fijo por estancia) pero con un coste variable por alta muy inelástico al incremento de días de estancia. Estos argumentos son claramente compatibles con la independencia del coste de quirófano para los pacientes quirúrgicos o del coste diagnóstico en el conjunto de pacientes, respecto de la duración de la estancia para la recuperación completa del enfermo.

Limitaciones generales a los resultados obtenidos para obtención de los objetivos planteados.

El uso de una base de datos que se refiere solamente a dos hospitales se debe considerar una limitación para la extrapolación de las conclusiones obtenidas. Sin embargo las características de los dos hospitales responden a las de hospitales generales, urbanos, completamente homogéneos entre ellos puesto que pertenecen a una misma organización pública y atienden a una diversidad muy elevada de clases sociales de población. Sus niveles de productividad son de los más elevados del conjunto de la red pública catalana y los informes de benchmark sobre la calidad de la información generada para la obtención de una buena clasificación GRD han sido siempre muy favorables a estos hospitales, así como su tradición en el manejo de técnicas de casemix los ha convertido en pioneros en este ámbito.

Con relación a la información sobre costes, cabe citar que la dificultad extrema en la comparabilidad de información de esta índole entre distintos hospitales es también un argumento para pensar que ampliar la información a otros hospitales hubiera introducido también un gran número de limitaciones a los resultados. Este último extremo sólo se hubiera podido dar en el caso que hubiera existido información de coste por paciente en otros hospitales.

Discusión general.

El conjunto de capítulos que componen la tesis mantienen una relación entre ellos y con el objetivo final que quisiera resaltar especialmente en este apartado de discusión general, puesto que las discusiones de cada capítulo y el resumen por objetivos ya recogen el conjunto de los resultados obtenidos.

El hilo común que relaciona el conjunto de este trabajo es el análisis de todos aquellos factores que determinan variabilidad del coste por paciente ingresado sobre la base de la aproximación a producto hospitalario existente más utilizada en nuestro país y en general en todos, que son los Grupos Relacionados por el Diagnóstico (GRD).

Los GRD, en su formulación en los E.E.U.U. y con sus valoraciones relativas correspondientes (pesos), se han incorporado a nuestro entorno sin una evaluación previa de su capacidad operativa real para explicar la variabilidad de costes entre pacientes. De la revisión de la literatura se desprenden diversas razones para poner en duda que la valoración del coste justificable de un hospital sea una formulación lineal aditiva del estilo:

$$C_t = \sum_{i=1}^{n} k_i * Y_i$$

donde un peso K estandarizado para otro entorno organizativo, cultural y poblacional, multiplica al número de casos incluidos en cada grupo de pacientes Y.

En primer lugar encontramos la existencia de outliers que debe ser tenida en cuenta puesto que la construcción de los valores medios por grupo viene sobrevalorada por la existencia de casos extremadamente más costosos que la mayoría de los pacientes agrupados en un GRD. La casuística de los métodos utilizados para robustecer los valores medios de cada grupo sobre la base de neutralizar el impacto de los casos extremos ha sido tan diversa como países lo han intentado. Por este motivo no se trataba solamente de introducir un método cualquiera de marcaje de casos extremos sino de establecer un criterio que permitiera elegir uno entre los más empleados. Este criterio venía impuesto por la realidad del entorno europeo donde no existe información de costes generados bajo modelos de coste por paciente. Por este motivo el criterio ha sido el de seleccionar un método que aplicado a la variable proxy duración de la estancia, fuera el que seleccionaría los mismos casos que cuando se aplica al coste. En definitiva se trataba de eliminar variabilidad intra-grupo (intra-GRD).

En segundo lugar, existía evidencia de los problemas que generaba la propia construcción de los pesos asociados a los GRD de Medicare (los únicos realmente operativos y utilizados para la contratación de servicios). Debía ponerse en duda su validez para el entorno europeo en general y en partícular para el caso catalán, puesto que la mayoría de países que han utilizado estas técnicas de casemix para valorar su actividad, han recalibrado los pesos según diversidad de técnicas que pretendían que los pesos utilizados fueran reflejo de su realidad. En este caso la reducción de la variabilidad inter-GRD que se puede explicar es máxima puesto que se han construido pesos basados en costes observados por paciente. Al analizar solamente dos hospitales la aproximación al valor medio real era muy elevada, máxime habiendo eliminado los casos extremos para la elaboración de este valor medio. Ante este resultado, la reflexión que tiene una aplicación clara en política sanitaria es que las desviaciones globales respecto de los pesos Medicare han sido realmente pequeñas pero que para agrupaciones de GRD con características concretas, estas desviaciones se han manifestado muy elevadas y por ello deben ser recalibradas y adaptadas a nuestro entorno.

En tercer lugar, desde el inicio de la implantación de los GRD en 1983 en Medicare, se han destacado las limitaciones de estos sistemas para absorber la variabilidad intra-GRD. Las técnicas englobadas bajo el concepto de ajuste de riesgos han ido conceptualizando causas que determinan esta variabilidad intra-grupo. Esta variabilidad se ha demostrado que puede ser reducida empleando diversos indicadores sintéticos que utilizan la información administrativa existente. Basándonos en diversos intentos descritos en al literatura, se ha hecho una selección de aquellos indicadores que mejor podían explicar cada una de las dimensiones de la variabilidad intra-grupo con la característica de que fueran lo más estancas posible entre ellas. Este criterio ha servido para reducir el solapamiento en lo que explicaba cada variable y poderlas considerar complementarias, rompiendo la tendencia de la literatura de contraponer elementos para elegir entre diversos uno único que fuera complemento de los GRD o incluso substitutivo. El resultado de la suma de los tres análisis anteriores es la aplicación de un modelo de ajuste de riesgos que es capaz de explicar el 51% de la variabilidad del coste por paciente y contraponerlo con el 19% que la utilización de los GRD permite en nuestro entorno.

En cuarto y último lugar, se ha pretendido superar la tendencia a la reducción de la utilización de los GRD para determinar el coste justificable global de un hospital básicamente por razones estratégicas de asignación de recursos, sin atender a la necesidad de conocer el coste real por paciente y las distorsiones que ello crea en la valoración global. La justificación expresada ampliamente de que las diferencias dentro de cada grupo se compensan de la misma forma que las diferencias entre grupos para acabar dando una valoración final correcta por hospital, solo es válida para asignar recursos a grandes hospitales que presentan gran variedad de casos por GRD y la mayor parte de los GRD. No es así para la gestión clínica, ni para el análisis de eficiencia.

Los diversos argumentos analizados que ponen en duda la forma en que se están utilizando los GRD en nuestro país son los que se han tratado de resolver con los distintos capítulos de este trabajo. Por este motivo consideraba que una forma de resumir la información analizada era mediante la construcción de una Función de Coste por Paciente Ingresado (FCPI) que permitiera el análisis del comportamiento de la variabilidad de dicho coste.

Una función de costes que incorpora la agrupación GRD, que explica más variabilidad con menos categorías para explicar variabilidad inter-GRD, que reduce la variabilidad intra-GRD mediante la eliminación de casos extremos y mediante la utilización de los índices construidos para explicar comorbilidades, complicaciones, severidad, características socioeconómicas y sociodemográficas, así como características del proceso asistencial. En definitiva una función que incorpora todas las causas medibles de variabilidad de coste por paciente dentro de un hospital.

Implicaciones políticas y agenda de investigación futura.

El futuro de los sistemas de clasificación en España.

Ajustar los Grupos Relacionados por el Diagnóstico a nuestra realidad como lo han hecho canadienses, australianos e ingleses entre otros, es un objetivo que debería plantearse en un futuro no muy lejano puesto que de ello depende en gran medida la credibilidad de este tipo de agrupación por parte de los clínicos, los cuales serán los grandes destinatarios de estos instrumentos para poder implementar estrategias de gestión clínica. Por otra parte esta política evitaría la atomización de versiones de GRD utilizadas por los distintos entes regionales. La decisión del INSALUD de utilizar la versión All Patient GRD ha llevado a que muchas comunidades con transferencias en sanidad hayan hecho la misma migración. La filosofía AP GRD es totalmente contraria a los resultados establecidos en nuestro estudio, según los cuales se ha podido establecer que con un número muy reducido de categorías se puede mantener la capacidad explicativa de la variabilidad del coste y a la vez se hace mucho más operativa su utilización como herramienta de dialogo entre comprador y proveedor o bien, clínico y gerente. La relación del número de categorías es de ‘dos a uno’ entre el método AP GRD y los GRD agrupados utilizados en nuestro estudio. Además, los pesos asociados a Medicare se utilizan para pagar y son de conocimiento público, mientras que los AP GRD no se han experimentado en la práctica de la contratación y además tienen un coste elevado que el sistema público de salud debe satisfacer para poder utilizarlos.

El ajuste de los pesos correspondientes a cada grupo debe realizarse tanto si se redefine la clasificación de productos como si se renuncia a esta opción.

El conocimiento del coste por paciente.

Los últimos años se ha puesto sobre la mesa la necesidad de valorar la actividad que realizan los hospitales con relación al coste justificable en que incurren. Diversas acciones como el proyecto SIGNO a nivel INSALUD, el COHAN en el ámbito de la Junta de Andalucía, el SIE en el Comunidad Valenciana, y también la Central de Balanços han pretendido conocer el coste de la actividad de los hospitales españoles. Las experiencias en el ámbito de un hospital concreto también han existido basándose en muchas ocasiones en refinamientos de los proyectos al nivel de servicios de salud antes mencionados. De todas formas no son suficientes las experiencias de contabilidades de costes por paciente para poder utilizarlas como base para el recalibrado de los pesos GRD al estilo del Estado de Victoria en Australia, por ejemplo.

Se ha confundido en demasiadas ocasiones el cost-modelling con el coste por paciente (clinical-cost) y se ha llegado a considerar que con un algoritmo GRD, sus pesos y una contabilidad general o incluso pública, ya se podía obtener un coste por paciente que permitiera la gestión clínica, el benchmark, la contratación, la planificación estratégica y los análisis de eficiencia del sector hospitalario. No es así de ninguna forma y es del todo necesario conseguir más ejemplos como el de la contabilidad analítica del IMAS basado en el sistema de información económica y asistencial IMASIS para poder extrapolar sus resultados a la categoría de estándares que permitan disponer de una verdadera estructura de pesos estandarizada del coste justificable para los hospitales catalanes, los españoles e incluso que pueda existir una generalización en el ámbito europeo.

Este reto de conseguir una red de hospitales con sistemas de coste por paciente basados en actividad y sistemas de información que alimenten los conductores de coste, topará con otro problema que deberá resolverse en su momento y que no es otro que la variabilidad de coste interhospitalaria no explicable por ninguna de las causas estudiadas en el presente proyecto. La importancia de desmitificar el supuesto coste justificable con relación al coste de la docencia, la investigación, la super-especialización como explicación de cualquier coste diferencial es también esencial para poder conocer el coste justificable de la atención hospitalaria.

La mejora de calidad de la información de los informes de alta.

La información contenida en los informes de alta que realizan los clínicos es la base del conjunto de la información relacionada con el producto hospitalario en que se ha basado el proyecto realizado. La mejora de la información que contiene es absolutamente necesaria para que la información sintética resultante sea cada vez mejor. Hay diversas causas que la pueden mejorar: Una de ellas es su utilización como información que valora la actividad del hospital que ya es una realidad en la Xarxa d’Hospitals d’Utilització Pública de Catalunya (XHUPC). La segunda es la mejora en el número de diagnósticos codificados. La tercera es el aumento del peso medio global del sistema que debe apuntarse en buena medida, a las consecuencias reales que esta información tiene sobre la contratación de servicios. Pero esta mejora debe buscarse en el trabajo de los expertos en codificación que responden a los estímulos de la dirección en este sentido, mientras que el papel en la mejora de la información aportada por los clínicos es muy reducida puesto que su marginación de la capacidad de gestión les hace refractarios a esta nueva situación. La mejora de la información tendrá un salto cualitativo espectacular cuando la cultura de la gestión clínica se introduzca de forma efectiva, puesto que la información sobre el producto hospitalario conseguirá ser en ese momento el nexo de unión entre toda la cadena de gestión: de la micro gestión (gestión clínica) a la meso-gestión (gestión de centros) y por último llegando a la macro-gestión (de los servicios nacionales de salud).

La mejora en la información socioeconómica del paciente.

La información socioeconómica es una parte fundamental de la variabilidad de coste por paciente y es sin duda la que menos disponible se encuentra en las bases de datos administrativas que se manejan para la construcción de una buena función de costes por paciente. Teniendo en cuenta los problemas debidos a la confidencialidad de algunas de estas informaciones, su uso para la determinación del coste por paciente es del todo posible gracias a los actuales sistemas de información existentes. Solamente la existencia de un código identificador único por habitante que estuviera en todas y cada una de las bases de datos que se manejan en el ámbito público, mejoraría la capacidad de conocer el impacto del factor socioeconómico en el coste justificable del paciente atendido.

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