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Measuring Hospital Case Mix: Evaluation of Alternative Approaches for the Irish Hospital System

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Abstract: The impetus for this study arose from the need to upgrade the case mix measure of choice in use at the national level in Ireland. Since 1993, various versions of the DRG grouper supported by the Health Care Financing Administration (HCFA) had been in use in Ireland. With improvements in available data, together with developments in the range and quality of alternative groupers available, it was considered timely to test performance of the alternative options on discharge abstract data for Irish hospitals. The groupers selected for testing included four versions of the Australian Refined (AR) DRGs, the AP DRGs (V18.0), CMS DRGs (V20) and IR DRGs (V1.2). Results for the HCFA DRGS (V16.0) were also included for purposes of comparison.

The empirical analysis ranked the AR DRG Groupers highly relative to the alternatives. Additional factors favouring the AR DRG series of Groupers are the fact that they are the more widely used internationally, are updated regularly and supported by Australian government agencies. More support and training opportunities are also available for the use of these Groupers. Given these factors, together with the fact that the ICD-10-AM morbidity coding system is used in Ireland, the AR DRG classification system was recommended as the best option for use at the national level in Ireland.

Keywords: case mix, DRG Groupers, AR DRGs, ICD-10-AM

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Section 1

Introduction

In 1993, the Department of Health and Children began applying a case mix adjustment in the determination of budgets for the largest acute hospitals in Ireland. Since 1990, the Diagnosis Related Group (DRG) system has been the case mix classification system standardised for use in public acute hospitals in Ireland by the Department of Health and Children. Specifically, the DRG version supported by the US Government's Health Care Financing Administration (HCFA)[1] has been the system of choice for the Department of Health and Children since the early 1990's. Three versions of the HCFA DRGs have been in use in Ireland over this period: HCFA DRG V9.0 was in use for 1990-1994, HCFA DRG V12.0 for 1995-1998 and HCFA DRG V16.0 has been used in Ireland since 1999.

Given the rapid rate of development of diagnostic services and treatment interventions, together with improvements in the availability of hospital activity data and advancements in the range and sophistication of case mix classification systems, a review of the options available for updating the case mix measure in place at the national level in Ireland was considered timely. In 2003, therefore, the Department of Health and Children commissioned an evaluation of alternative case mix measures for the Irish hospital system. This evaluation has been undertaken as a collaborative effort between the Economic and Social Research Institute's (ESRI) HIPE & NPRS Unit and Laeta Pty Ltd.

Given that experience of the application of case mix systems in Ireland has been primarily focused on the use of the DRG system, the range of options selected for review was limited to those systems developed within this type of model. This approach was also consistent with the constraints faced in terms of the hospital activity data available. While the coverage and timeliness of these data systems have greatly improved in Ireland in recent years, the scope of the data collected is still somewhat limited. In particular, the clinical data collected consists of principal and secondary diagnoses and procedures performed and does not include any laboratory or pharmaceutical data.

Additional factors guiding the selection of systems for evaluation included the fact that the systems needed to be available and in use internationally, be updated regularly and have available adequate and appropriate support materials that would facilitate the training and education initiatives required if the system was selected for use in Ireland. Given these constraints, therefore, a selection of Australian and US case mix classification systems were evaluated to see which may be most appropriate for use in Irish Hospitals. Where feasible, the most up-to-date version of the classification system available to the study was used. The groupers, together with the version used for the evaluation, are listed here, both with the full name and a common abbreviation used throughout this report:

[1] The Health Care Financing Administration is now known as the Centre for Medical and Medicaid Services (CMS)

Grouper	Abbreviation	Original Health System
AR-DRG V4.0	V40	Australian
AR-DRG V4.1	V41	Australian
AR-DRG V4.2	V42	Australian
AR-DRG V5.0	V50	Australian
AP 18.0 DRG	AP	New York /US
CMS 20	CMS	US Medicare
HCFA 16	HCFA	US Medicare
IR-DRG 1.2	IR	International / US

This project required the hospital activity data to be grouped (with software vendor support) to each of the classification systems listed here. It then required reporting of the case mix information provided by each grouper so that their operational utility could be reviewed. Formalisation of the statistical aspects of the utility review required the development of a methodology to summarise the tabulated case mix information for evaluation at a systems level, and then the implementation of and reporting of the approach developed. The DRG classification schemes evaluated for this study will be described in the next section.

Section 2

Alternative DRG Classification Schemes

Each of the DRG classification schemes evaluated for this study will be described in turn here.

Centre for Medicare and Medicaid Services (CMS) DRGs – Version 20[2]

The Center for Medicare and Medicaid Services (CMS) (formerly the Health Care Financing Administration (HCFA)) at the Department of Health and Human Services in the United States adopted the DRG system in 1983 as the basis of a prospective payment system (PPS) for hospitals within the Medicare programme. One DRG is assigned for each inpatient stay. DRG assignment is based upon the following considerations:

· Principal and secondary diagnoses
· Procedures performed
· Sex
· Age
· Discharge status
· Presence or absence of complications and comorbidities (CCs)
· Birth weight for neonates.

The discharge status variable has the most relevance for the following patient groups: burn patients and newborns transferred to another acute care facility; patients treated for alcoholism or drug abuse who left the hospital against medical advice; and newborns and acute myocardial infarction patients who died.

CMS has developed a standard list of diagnoses that are recognised as complications and comorbidities for the DRGs. DRG assignment for patients may also be influenced by the presence of a secondary condition which, together with a specific principal diagnosis, is considered a substantial complication or comorbidity (CC).

Until version eight of the (HCFA) DRGS, the first step in the determination of the appropriate DRG had been the assignment to the appropriate Major Diagnostic Category (MDC) based on the principal diagnosis. The eighth version of the DRGs constituted a departure from this practice with the initial step in DRG assignment being based on procedure (PRE MDC). This meant that assignment directly to a DRG independently of the MDC of the principle diagnosis took place for patients with the following conditions: heart transplant, liver transplant, bone marrow transplant, tracheostomy, lung transplant, simultaneous pancreas/kidney transplant, or pancreas transplant. The eighth version also created two new MDCs for patients: MDC 24 for multiple traumas and MDC 25 for patients with an HIV infection. Assignment to these two MDCs is based on both principal and secondary diagnoses. There are currently 510 DRGs distributed across 25 Major Diagnostic Categories. An illustration of this system is presented graphically in Figure 1.

[2] Source: Diagnosis Related Groups Version 20.0. Definitions Manual

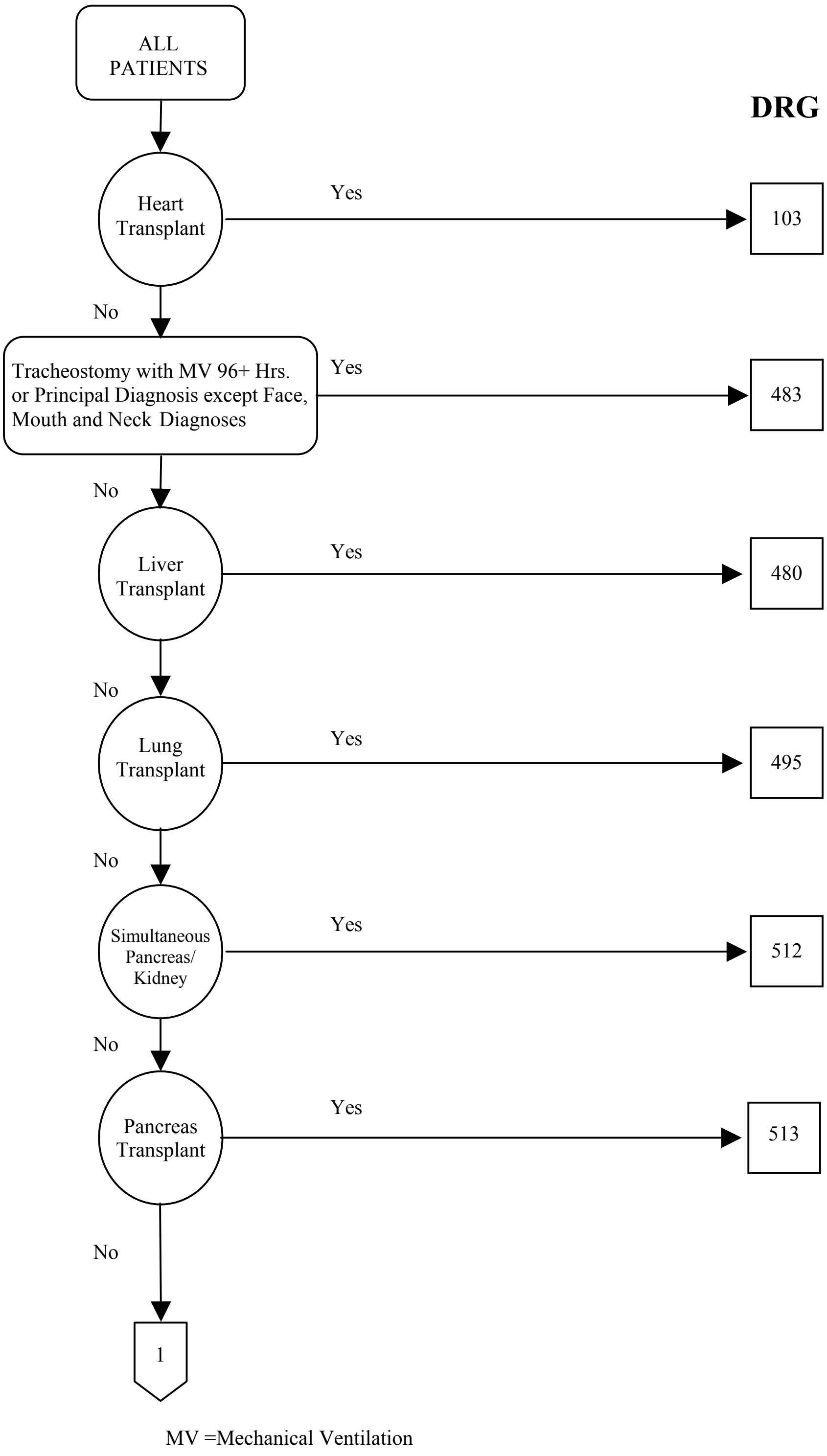


Figure 1 CMS Grouper Version 20.0

Source: Diagnosis Related Groups Version 20.0. Definitions Manual.

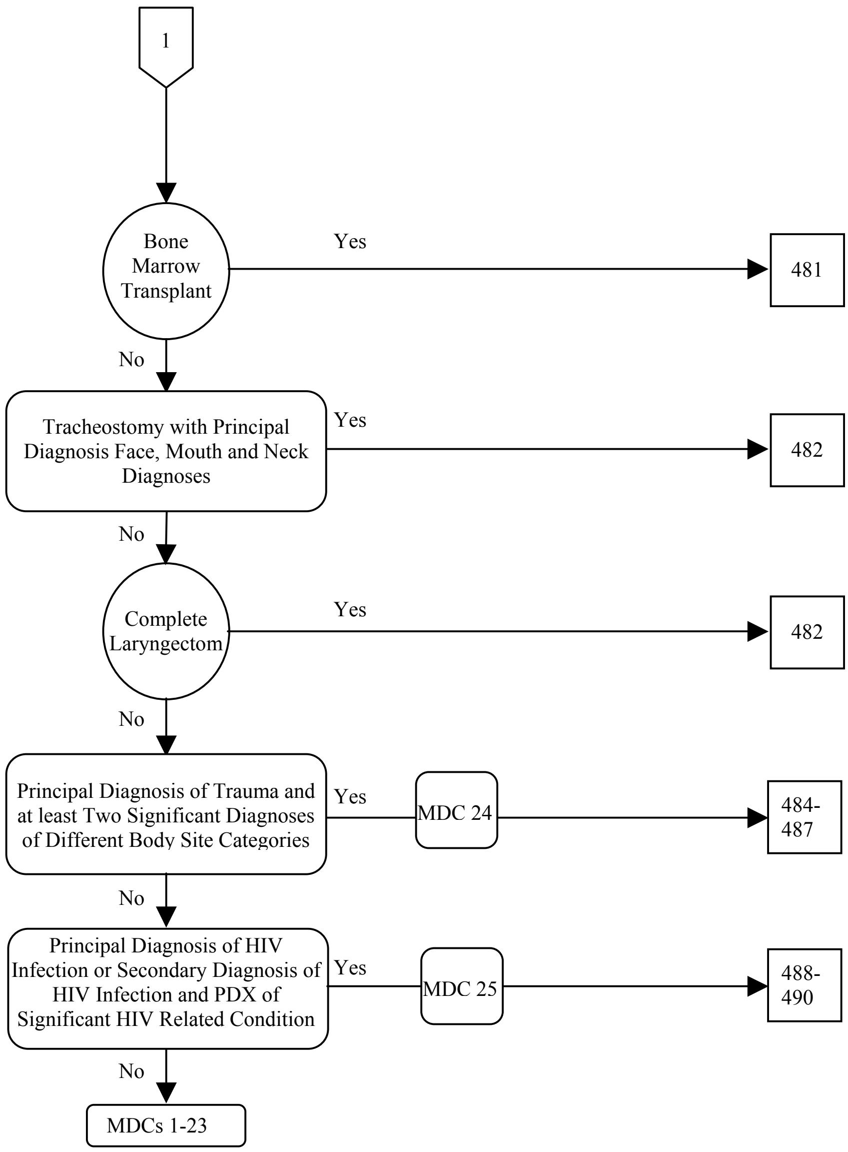


Figure 1 CMS Grouper Version 20.0 (Cont'd.)

Source: Diagnosis Related Groups Version 20.0. Definitions Manual.

Australian Refined DRG's (AR-DRGs) – Version 5[3]

The first Australian DRG classification system (Australian National DRGs (AN-DRGs)) was developed in 1992 based on the use of ICD-9-CM to code diagnoses and procedures. Part of the commitment in the development process pursued at that time was that the classification system would be updated on a regular basis to recognise changes in clinical practice. Since then, the Australian DRG system has been refined over time and in 1996 the Australian National DRG classification evolved into the Australian Refined DRG (AR-DRG) classification based on coding in ICD-10 with Australian modifications (ICD-10-AM). AR-DRG version 5.0 has 665 groups and 25 MDCs. AR-DRG version 5.0 is the result of a comprehensive review of Version 4.2, and was released in September 2002. This version retained the AR-DRG structure of Version 4 classifications, but incorporates major changes to MDC 14 (obstetrics), new same-day DRGs and revised splits in a number of Adjacent DRGs. Version 5.0 uses third edition ICD-10-AM codes and is represented graphically in Figure 2.

The AR-DRG Classification system is based on hierarchies of diagnoses and procedures distributed between surgical, medical and other partitions. The grouping process includes the following tasks in order of presentation:

1. Demographic and clinical edits
2. Major Diagnostic Category (MDC) assignment
3. Pre-MDC processing
4. Adjacent DRG (ADRG) assignment
5. Complication and comorbidity level (CCL) and patient clinical complexity level (PCCL) assignment
6. DRG assignment

[3] Source: AR-DRG v5.0 definitions Manual

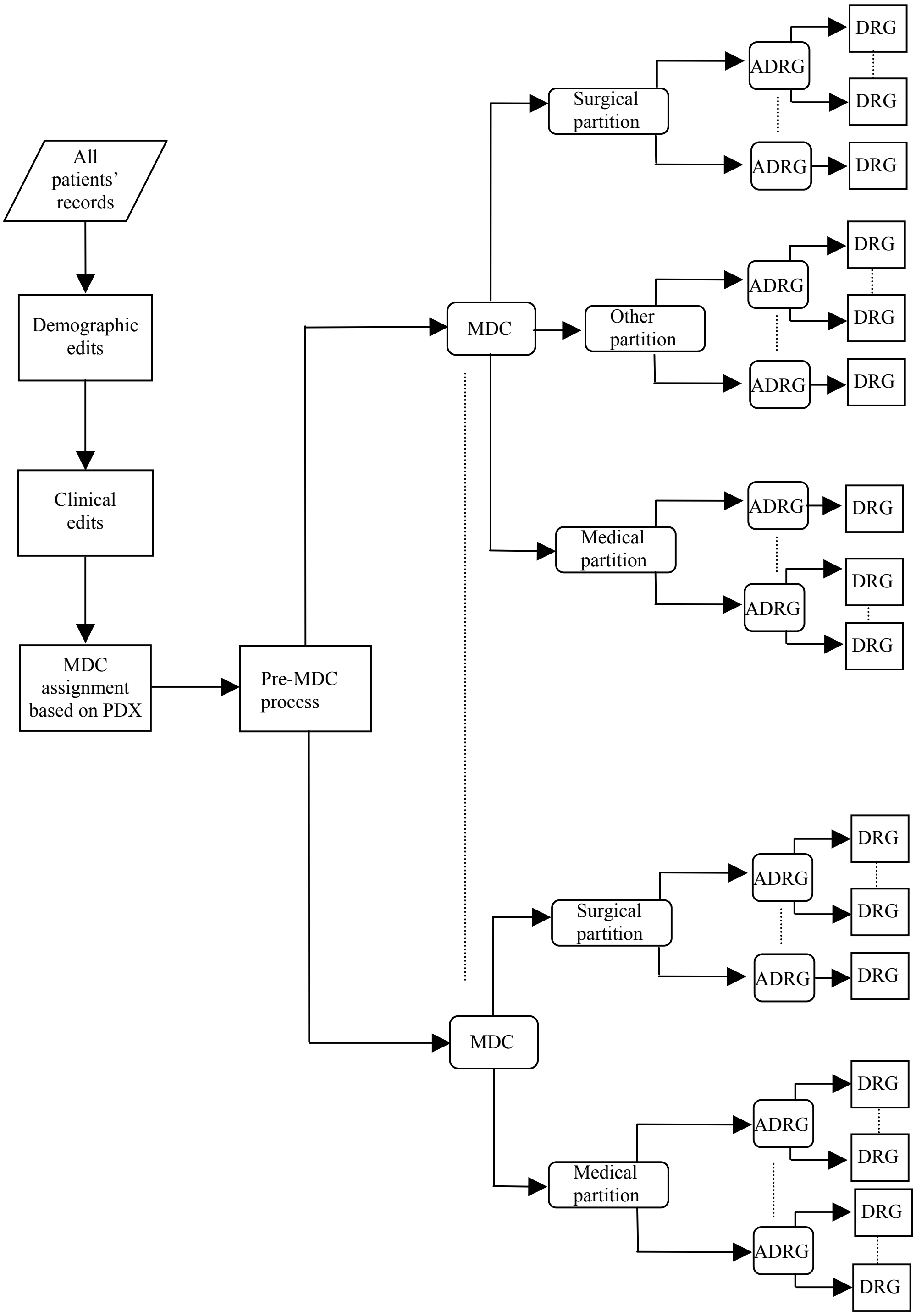


Figure 2 AR-DRG v5: an overview

Surgical, other and medical partitions. MDCs are sub-divided into a maximum of three separate partitions, for surgical, other and medical. The presence or absence of O.R. and NonOR procedures is generally responsible for the assignment of a record to one or other of these partitions

Source: AR-DRG v5.0 definitions Manual

The AR-DRG Numbering System

The numbering system of the AR-DRGs is significantly different to that of the AN-DRGs in that the system itself reveals (1) the broad group (usually the MDC) to which the DRG belongs, (2) The adjacent DRG and (3) the existence/nature of splits based on resource consumption in the DRG.

The format of each AR-DRG consists of four alphanumeric characters organised in terms of **'ADDS'** , where:

- A indicates the broad group to which the DRG belongs
- DD identifies the adjacent DRG within the MDC, and the partition to which the adjacent DRG belongs
- S is a split indicator that ranks DRGs within adjacent DRGs on the basis of their consumption of resources

With regard to the first character, different letters of the alphabet have been used to signify the broad group to which the DRG belongs, with the number '9' being used to identify Error DRGs. For example, the letter A indicates that the first level of assignment is Pre-MDC, B indicates assignment to Diseases and Disorders of the Nervous System, C indicates assignment to Diseases and Disorders of the Eye etc.

The second and third characters of each AR-DRG number - the 'DD' digits - identify the adjacent DRG and the partition to which it belongs. Adjacent DRGs consist of one or more DRGs generally defined by the same diagnosis or procedure code list. DRG numbers that begin with the same letter and share the same middle digits - for example, B69A, B69B, and B69C - may be taken to relate to the same adjacent DRG.

In order that the second and third characters of each AR-DRG number may also be used to identify the partition to which the adjacent DRG belongs, three separate ranges - 01 to 39, 40 to 59 and 60 -99 have been used to indicate the surgical, other and medical partitions respectively. For example, the three AR-DRG numbers P76D, I09B and O40Z reveal that the first is part of a medical partition, the second is part of a surgical partition and the third is part of an 'other' partition.

Finally, the fourth character of each AR-DRG has been used as a split indicator to identify the relative importance of DRGs within an adjacent DRG in terms of resource consumption. Any one of a number of values may be used:

- A highest consumption of resources within the adjacent DRG;
- B second highest consumption of resources;
- C third highest consumption of resources;
- D fourth highest consumption of resources;
- Z no split for adjacent DRG

The classification for Stroke summarised here provides a good illustration of the AR-DRG numbering system:

B70A Stroke W Catastrophic CC

B70B Stroke W Severe CC

B70C Stroke W/O Catastrophic or Severe CC

B70D Stroke, Died or Transferred <5 days

For these AR-DRGs, B indicates that the assignment of discharges, in the first instance, is to the Major Diagnostic Category for Diseases and Disorders of the Nervous System, 70 means that it is a medical condition and the letters A to D rank the groupings (highest to lowest) in order of the level of resource consumption.

Severity of illness

The complications and comorbidity codes (CCs) constitute the severity of illness adjustment applied within the AR-DRGs. Where these codes apply, they are considered likely to result in significantly greater resource consumption. Each diagnosis is assigned a rank, known as a "complication and comorbidity level" (CCL). The value of the rank is between 0-3 for medical episodes and 0-4 for surgical and neonatal episodes. A code of zero indicates that the diagnosis does not represent a complication or comorbidity, forms part of the definition of the Adjacent DRG, is already on the record, or that the complication or comorbidity is closely related to the principal diagnosis. A code of 1 indicates a minor complication or comorbidity, 2 moderate complication or comorbidity, 3 severe complication or comorbidity and 4 catastrophic complication or comorbidity. Each additional diagnosis thus has a complication or comorbidity level assigned to it. Various combinations of these levels can be combined together into a summary patient-level measure, the 'patient clinical complexity level' (PCCL) which takes into account all the additional diagnoses for that admission. In determining the PCCL, a CCL may be reassigned to zero if the complication or comorbidity is closely related to another higher or equivalent level complication or comorbidity on the record. For example, two unrelated diagnosis codes ranked at level 2 are summarised into a single overall PCCL measure of 3. These overall summary measures are then used as part of the splitting procedures for defining individual DRGs.

All Patient DRG's (AP-DRGs) – Version 18[4]

In 1987, the state of New York passed legislation instituting a DRG-based prospective payment system for all non-Medicare patients. The legislation included a requirement that the New York State Department of Health (NYDH) evaluate the applicability of the Medicare DRGs to a non-Medicare population. The legislation required that the DRGs be evaluated with respect to neonates and patients with Human Immunodeficiency Virus (HIV) infections. The evaluation concluded that the Medicare DRGs were not adequate for a non-Medicare population. NYDH entered into an agreement with 3M Health Information Systems (3M HIS) to research and develop all necessary DRG modifications. The DRG definitions developed by NYDH and 3M HIS are referred to as the All Patient DRGs or AP-DRGs. There are 651 DRGs distributed across 25 MDCs. An illustration of the system is presented in Figure 3. AP-DRGs created additional DRG categories for neonates, pediatric patients, and patients with Human Immunodeficiency Virus (HIV). Further refinements to the AP-DRG system also included the addition of the concept of Major Complications and Co-morbidities (MCC).

[4] Source: AP-DRGS Definitions Manual. Version 18.0

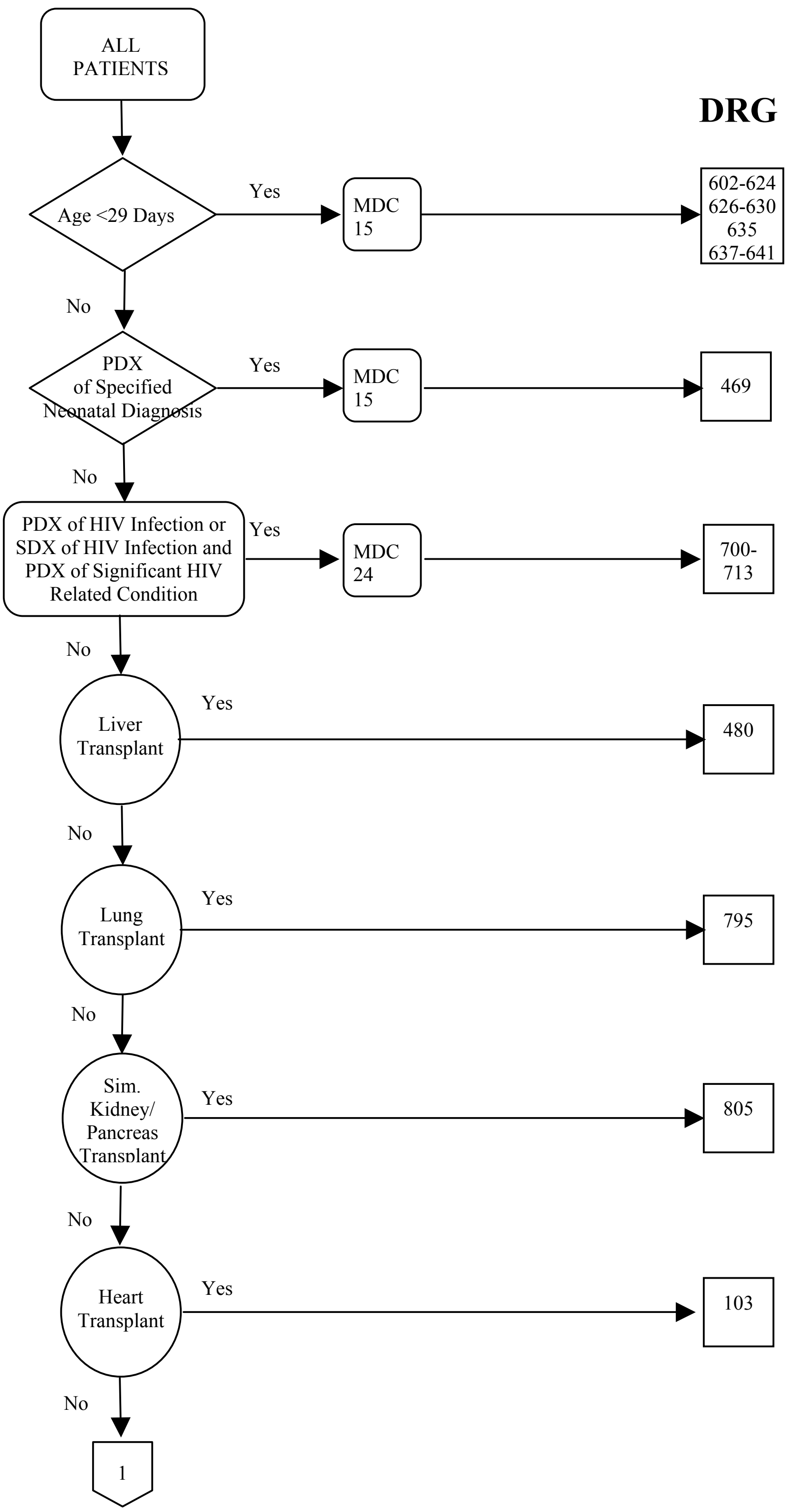


Figure 3 All Patient Diagnosis Related Groups Version 18.0

Source: AP-DRGS Definitions Manual. Version 18.0

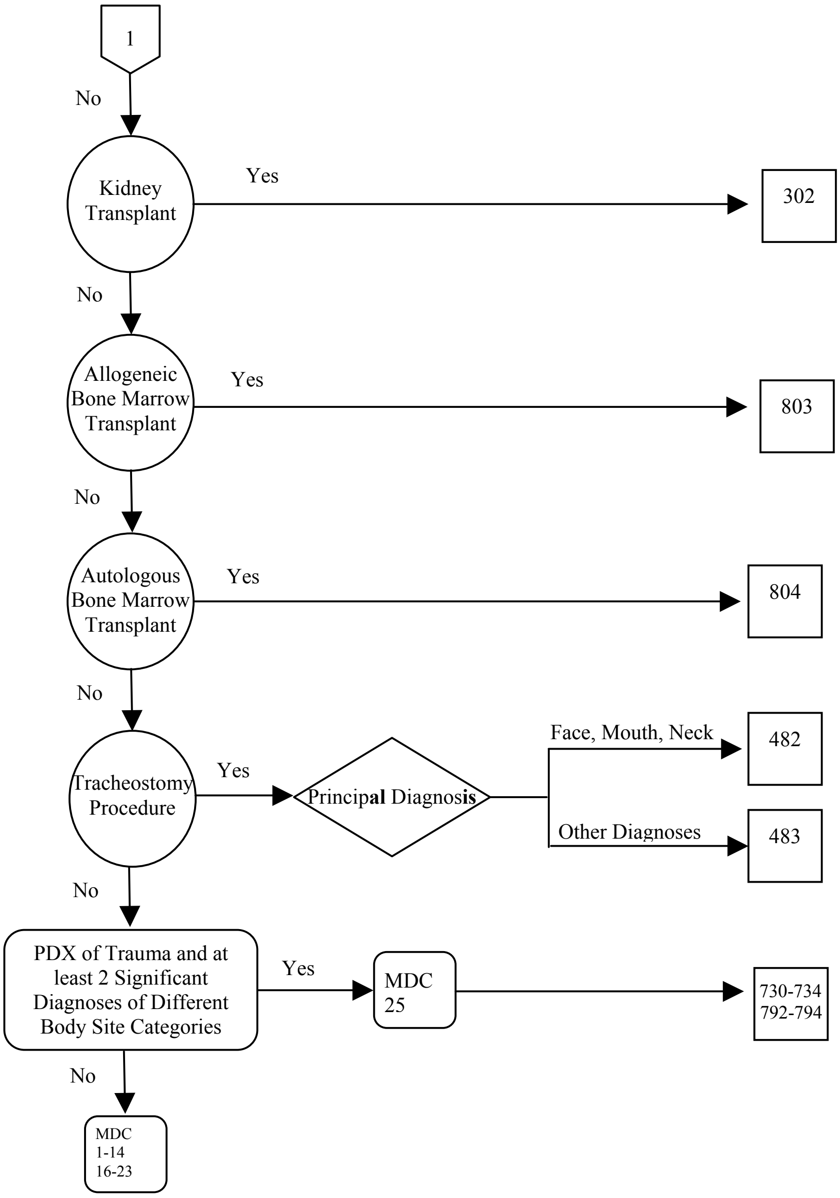


Figure 3 All Patient Diagnosis Related Groups Version 18.0 (Cont'd.)

Source: AP-DRGS Definitions Manual. Version 18.0

Around the same time as the development of the AP-DRG initiative, extensive research had been performed independently by the National Association of Children's Hospitals and Related Institutions (NACHRI) on alternative approaches to improving the DRG categories for neonates and other paediatric patients. The system developed by NACHRI was called the Paediatric Modified Diagnosis Related Groups or PM-DRGs. The PM-DRGs created many additional DRGs specifically for neonatal and pediatric patients. As part of the New York DRG evaluation effort, NYDH and 3M HIS examined the NACHRI neonatal definitions and adopted a modified version of them.

The AP-DRGs use age (<29 days) for assignment to the neonatal MDC in contrast to other DRGs which use principal diagnosis. Irrespective of principal diagnosis therefore, when age at admission is less than 29 days, the AP-DRGs assign the patient to the neonatal MDC. Six birth weight categories, of which there are 34 in total, are used as the primary variable in forming AP-DRGs. The birth weights are defined as follows:

- Less than 750 grams
- 750-999 grams
- 1000-1499 grams
- 1500-1999 grams
- 2000-2499 grams
- Greater than 2499 grams

Within each birth weight category, the neonates are first subdivided on the presence of a significant O.R. procedure and then further subdivided by the presence of multiple major problems, major problems, minor problems, or other problems. The "normal newborn" categories are divided according to birth weights of 2000 to 2499 grams and over 2500 grams.

The majority of hospital databases do not collect information on birth weight.[5] The ICD-9-CM codes have been modified to include a fifth digit specifying the birth weight. As the ICD-9-CM birth weight ranges correspond directly with those used in the AP-DRGs, the neonatal AP-DRGs can be used with databases which do not routinely collect birth weight data.

In addition to the changes for the neonatal AP-DRGs, MDC 24 was created for HIV infection patients. Assignment to MDC 24 is based on principal diagnosis of an HIV infection, or a principal diagnosis of an HIV related complication combined with a secondary diagnosis of an HIV infection. The initial HIV AP-DRG consists of all patients who had a tracheostomy. The presence or absence of an O.R. procedure then determines assignment to the medical and surgical HIV AP-DRGs. Further subdivision is based on the following factors:

- Presence or absence of ventilator support or nutritional support
- Multiple HIV related major infections
- Major HIV related diagnosis

Medical patients are further subdivided according to the following criteria:

[5] HIPE has been collecting birth weight since January 2004. The value collected is the weight in grams on admission and is required for neonates (0-27 days old) and infants up to 1 year of age with admission weight less than 2,500 grams.

- Discharged against medical advice
- Multiple significant HIV related diagnosis
- Presence or absence of Tuberculosis
- Significant HIV related diagnosis
- Other HIV related diagnosis

MDC 25 was added to the AP-DRGs for multiple trauma patients and this was considered highly innovative. In addition, significant modifications have been made for transplants, long-term mechanical ventilation patients, cystic fibrosis, nutritional disorders, high-risk obstetric care, acute leukemia, hemophilia, and sickle cell anemia.

MDC 20 for alcohol and drug abuse was totally modified so that patients were differentiated according to the substance being abused, opiod abuse, alcohol abuse and cocaine and other drug abuse. Each category of substance abuse is further subdivided depending on whether the patient left against medical advice, and the presence of complications and co-morbidities.

Another important development of the AP-DRG system was the development of the list of major (or catastrophic) complications and comorbidities (CCs). This revision was intended to ensure that patients with the most severe secondary diagnoses were assigned to the appropriate classes. The presence of a catastrophic CC is inclined to dominate resource use within an MDC. It was therefore considered appropriate to form a single CC AP-DRG across all surgical patients and a single major CC AP-DRG across surgical patients and single catastrophic CC AP-DRG across all medical patients to produce a total of 56 catastrophic AP-DRGs. Within the AP-DRG system there are non-CCs, CCs and major CCs.

AP-DRGs and the CMS (HCFA) DRGs have a CC exclusion list. The CC exclusion list causes certain CCs not to be considered a CC when the CC occurs with specific principal diagnosis. The AP-DRGs also include a major CC exclusion list. The major CC exclusion list causes some major CCs to be considered only a regular CC when the major CC occurs with specific principal diagnoses. For example, pneumonia is not considered a major CC with a principal diagnosis of chronic bronchitis. The presence of specific non-O.R. procedures, in conjunction with certain CCs, may also cause certain non-major CCs to be considered as major CCs.

International Refined DRGs (IR-DRGs) – Version 1.2[6]

3M Health Information Systems have developed and designed a grouper called the International Refined DRGs (IR-DRGs) to handle variations of coding methods between countries and provide results in classifying patients that are comparable across different countries. The new IR-DRG system builds upon the basic structure of the AP-DRGs, using the concept of the AP-DRGs, refinements to the base DRGs and numerous content modifications in order to reflect modern clinical practice. The IR-DRGs are compatible with both the ICD-9-CM and ICD-10 Diagnosis Coding Systems and ICD-9-CM Procedure Coding Systems.

[6] Source: IR-DRGs International Refined Diagnosis Related Groups. Definitions Manual Version 1.2

Surgical Partitioning

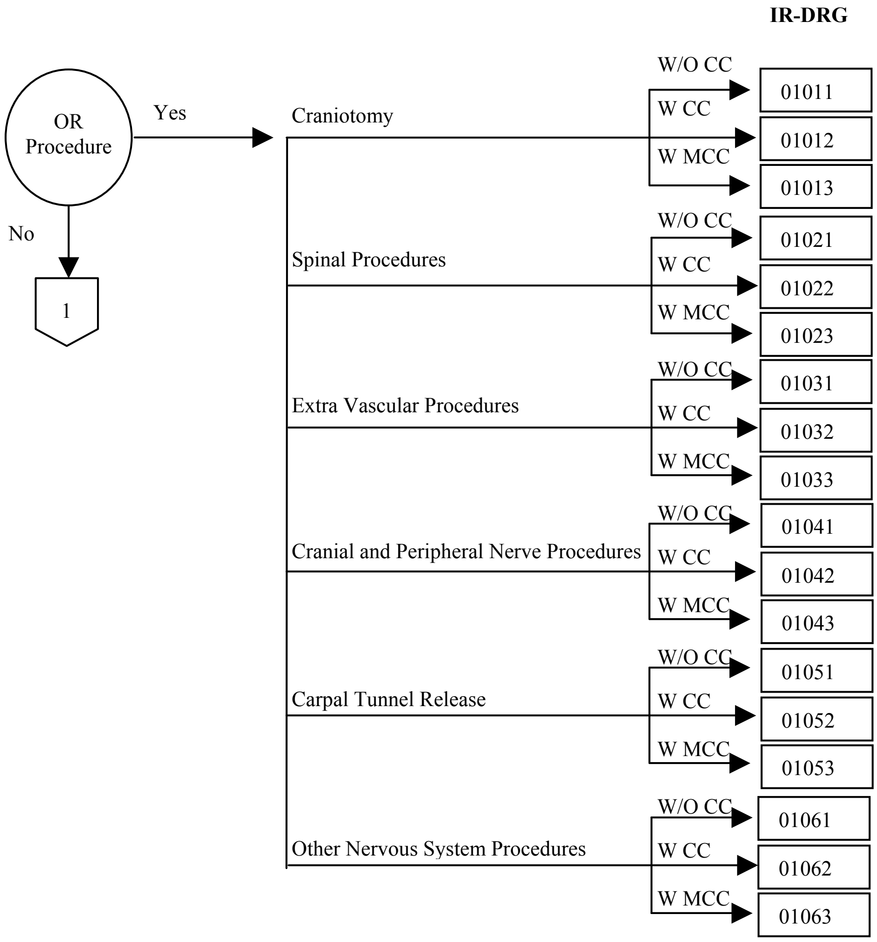


Figure 4 Major Diagnostic Category 1
Disease & Disorders of the Nervous System

Source: IR-DRGs International Refined Diagnosis Related Groups. Definitions Manual Version 1.2

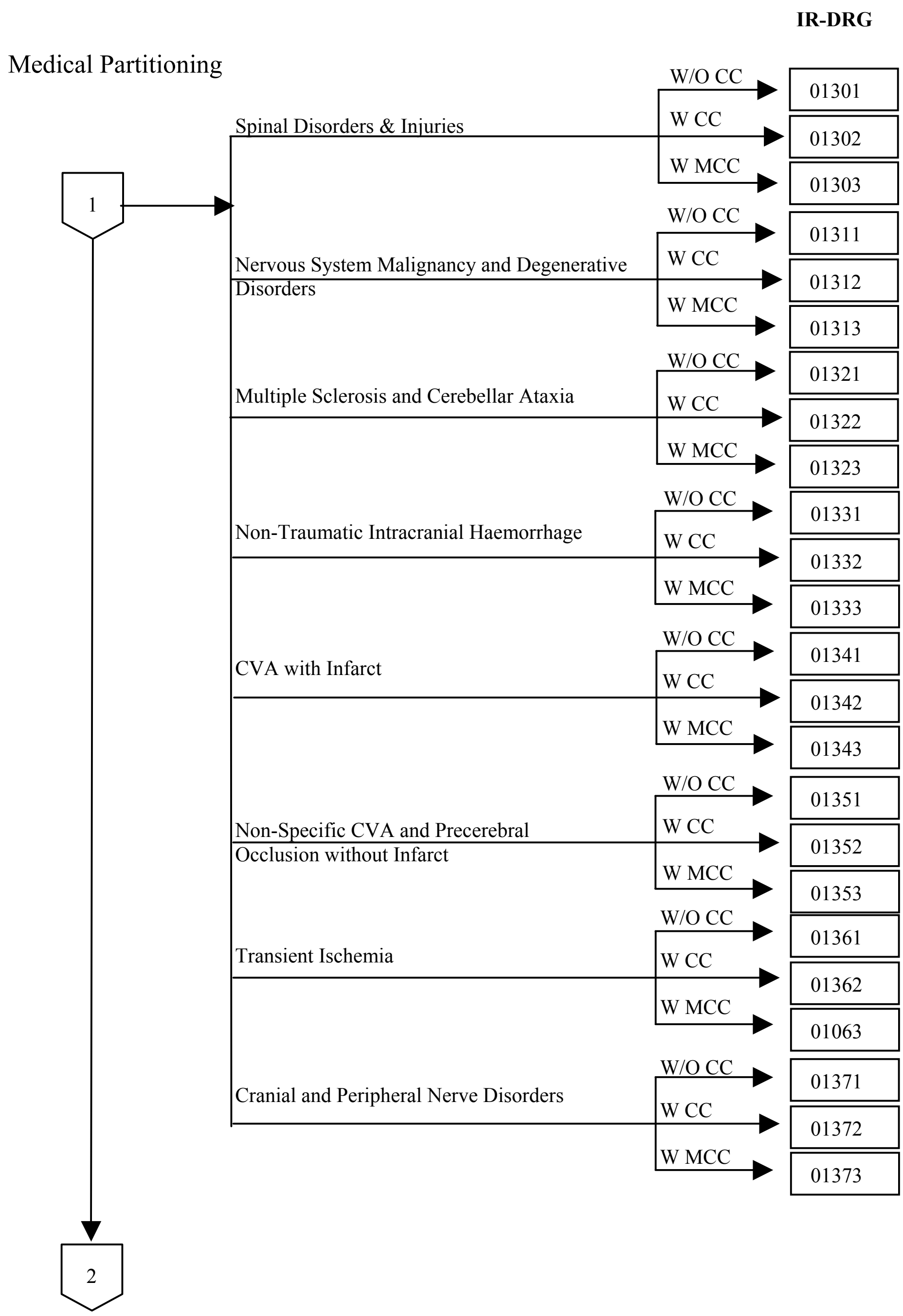


Figure 4 Major Diagnostic Category 1
Disease & Disorders of the Nervous System (Cont'd.)

Source: IR-DRGs International Refined Diagnosis Related Groups. Definitions Manual Version 1.2

Each of the IR-DRGs is defined by a particular set of patient attributes which include principal diagnosis, specific secondary diagnoses, procedures performed, age and sex.

The IR-DRGs consist of 318 base DRGs, 309 of which contain three subclass severity levels, plus two error IR-DRGs for a total of approximately 930 DRGs. The effect of a secondary condition on the principal diagnosis was documented and each secondary diagnosis was assigned to one of three severity levels:

Level 1	No CC
Level 2	CC
Level 3	MCC

All base DRGs, except for nine, are split into three subclasses based on the highest severity of any secondary diagnosis.

Numbering Structure

There are five digits for specification of the IR DRG:

The first two digits indicate the following:

00 indicates Pre-MDC
0-25 indicates MDCs
88 indicates unrelated OR Procedures
99 indicates Error DRGs

The second two digits identify the Base DRG:

10-29 indicates Surgical DRGs
30-59 indicates Medical DRGs
60-86 indicates OB and Neonate DRGs
87-89 indicates Unrelated OR DRGs
98-99 indicates Error DRGs

The last digit identifies the level:

0 indicates no split
1 indicates no CC
2 indicates CC
3 indicates Major CC

Surgical DRGs are numbered in their hierarchical order.

The data sources and method of analysis used to test these DRG classification systems on Irish hospital activity data will be presented in the next section.

Section 3

Data Sources and Method of Analysis

The Data and its Preparation

The Irish health system has a rich data resource, the Hospital Inpatient Enquiry (HIPE), of ICD-9-CM coded medical records covering close to 95 per cent of discharges from acute hospitals in Ireland. Discharge data for the years 1999, 2000 and 2001 were made available to the project, though most of the work concentrated on the discharges occurring in 2000. The data system at that time allowed for the coding of 6 diagnosis codes and 4 procedure codes per record. The diagnosis and procedure codes for all 3 years of data (January 1, 1999-December 31, 2001 inclusive) are coded with the October 1, 1998 version of the ICD-9-CM coding scheme. Appendix 1 outlines the file specification for the HIPE data used for this study and provides the definitions of the relevant variables including dates (of Admission, Separation and Birth), Discharge Mode, Sex and Day-Case Status necessary to group the data. A number of the groupers reviewed might have performed better if precise information about duration of mechanical ventilation and baby birth (or admission) weights had been supplied in the records, however ICD-9-CM codes can and were used to develop proxy data where required. In particular, the neonate codes that allow assessment of birth weight were used in a growth curve to estimate admission weights of babies as required by the Australian Groupers. Other than the development of Admission Weight estimates, therefore, the non-clinical data in the HIPE extract were straightforward to match to the data requirements of each grouper. The medical codes were a bit more problematic.

None of the Australian groupers suited the Irish data as it stood. The significant limitation was the need to map the medical record codes from the ICD-9-CM (1998 Ed.) to the ICD version expected by each AR-DRG Grouper. The maps needed were brought into existence so the project could proceed.

The AR-DRG V4.0 grouper expected medical record coding to conform to the October 1, 1996 version of the (Australian) ICD-9-CMA coding scheme. Similarly, the AR-DRG V4.1 grouper uses the ICD-10-AM (Ed1), AR-DRG V4.2 uses ICD-10-AM (Ed2), and AR-DRG V5.0 uses ICD-10-AM (Ed3)

The first step required to bring the maps into existence was to perform the backward mapping of ICD-9-CM (1998 Ed) to ICD-9-CMA which is based on ICD-9-CM (1996 Ed). Although these ICD-9 versions are not radically different, detailed work was needed to produce a backward mapping. Appendix 2 (Part A, Diagnosis and Part B, Procedures) shows the code mappings that were developed for this project[7].

Once a (logical) backward mapping had been developed for the ICD-9-CM codes, the forward mapping tables between ICD-9-CMA and the three versions of ICD-10-AM was relatively straightforward. The Australian Government provides tables for mapping clinical codes used

[7] A detailed exploration of the issues arising with the development of code mapping as applied here is presented in Aisbett, C.W. and Nancy Van Doorn, Evaluating and Refining the Mapping of Clinical Record Codes for AR-DRG Implementation in Ireland: An Exemplar of a Grouper Customisation Process, Laeta Pty Ltd., July 2004.

by its groupers - see http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-casemix-mapdis1.htm).These were applied to the backward mapped ICD-9-CM (1998) data. The final step was to review the backward map (in Appendix 2) to find occasions where qualifying information (4th and 5th digits) lost in the backward mapping was subsequently reflected in ICD-10 codes. Typically, this related to codes that changed between 1996 and 1998 by being extended to 4 or 5 digits and where the extended information was reflected in ICD-10-AM.

The situation with the United States groupers was less complicated and may be summarised as follows:

The HCFA 16.0 grouping did not involve mapping as this DRG classification is designed for the October 1, 1998 coding scheme used to code the diagnoses and procedures.

The CMS 20.0 grouping software, incorporated in 3M Core Grouping Software for Windows Version 2.0, facilitated specifying the version of ICD-9-CM codes used to code the data and the type of mapping to utilise. The data were grouped using Historical and Logical Mapping and the resulting MDC, DRG and mapping indicator values were compared case by case and found to be identical. A total of 61,304 records (7.6%) were mapped.

For the IR-DRG 1.2 grouper the supplier advised that the 3M Casemix Expert Lite is an "all version" grouper which recognises all valid ICD-9-CM diagnosis and procedure codes across different versions and mapping of codes does not occur.

When grouping the data into AP 18.0 DRGs the 3M CME Version 2.0 software facilitated specifying the version of ICD-9-CM codes used to code the data but there were no mapping options to choose and the mapping indicator had the same value (2) in the output file for all cases.

Methodology for Comparing Case Mix Groupers

Application of Case-mix Classification Schemes

Once data are prepared to specification, the mapping of codes and the execution of the grouping software is relatively straightforward, irrespective of the grouper used. Therefore this aspect is not considered in detail here. The way grouped data are used, however, is most relevant to this study.

When case mix classifications are implemented in funding and utilisation tracking systems, their users typically consider subsets of the grouped records, defined not only in terms of their DRG but also by Day Case status and Inlier status.

Day Case status focuses on whether the episode was or was not completed in one calendar day. A Day Case status of “Yes” is generally regarded as a proxy for (planned/deferrable) short stay care of persons not critically ill and as such should exclude episodes discharged dead or to other acute care health facilities. This qualified definition was the one adopted in this evaluation.

Inlier Status is only defined once a grouper and a population of episodes have been selected. Even then, there are choices of statistics to use to identify the DRG specific LOS values that define outliers. A decision made at the outset of this study was that no lower trim point would be set, however separate analyses would be conducted on the data with Day Cases excluded and, further, the data used to calculate the High Trim statistics would exclude these episodes as well.

The actual trimming algorithm used is based on the inter-quartile range of the Day Case Status =”No” (NDC) episodes. The trim point is set as Third Quartile (of the DRG’s NDC LOS distribution) plus 1.5 times the distribution’s inter-quartile range. It is important to note however that:

1) local quadratic interpolations are used if a quartile does not occur as a unique LOS.
2) 1 day is added to the interpolated point
3) the non-integer trim points thus obtained are always rounded up.

For example, if all the observed data have LOS 1 then the quadratic interpolation is reduced to linear yielding a value of 0.5. The number 1 is added, giving the value of 1.5 which is rounded up to 2. The definition of local depends on the spread of the LOS distribution. It requires that each quartile is assessed using the minimum data range that includes 10% of the data and the quartile itself in a central position. Consider estimation of the lower quartile. Linear interpolation based on the nearest days of stay is used to estimate the 20% point of the distribution. The same approach is used to estimate the 30% point. These calculated values define the local range.

Evaluation Criteria

Useful groupers partition the episode population in an informative way. These partitions (DRGs) are designed to carry clinical and statistical information in that knowing the DRG to which an episode belongs tells one something of the clinical inputs required and of the resources that are expected to be consumed. Further, the DRGs should be resource homogeneous in that knowing the average utilisation of episodes in a DRG should provide a reasonable understanding of the likely utilisation of a given episode in that DRG. Beyond these considerations, but secondary to them, is the requirement that the classification does not include numerous DRGs that are often void of episodes or have only a small number of members even in large data sets, such as the HIPE.

The formalisation of these statistical concepts involves a few conceptual steps. The information content (relative to a particular population) is measured using the regression R-Square or Reduction in Variance (RIV). The meaning of this statistic is as follows. If a classification carries information, then knowing the DRG to which a HIPE episode belongs should (in probability) allow more accurate assessment of the resources it consumed (LOS) than if that assessment had to be made in the absence of case-type information. If the penalty for an erroneous assessment is taken to be proportional to the square of the difference between the assessment and the truth, then the RIV measures the expected gain from knowing the DRG. The term expected means the average over all possible choices of episodes about which an assessment can be made.

If the DRG of a particular episode is unspecified, the RIV calculation assumes its LOS to equal to the average LOS (ALOS) of an episode in HIPE. If the DRG of the episode is known, then the RIV calculation assumes its LOS to be the ALOS for episodes in that DRG and HIPE. There is a penalty associated with each of these choices. The RIV is 1minus the ratio of the expected penalty from always choosing the DRG specific ALOS to the expected penalty from always using the overall ALOS.

As its definition exposes, RIV is a function of the HIPE case mix. The case mix changes from year to year hence a measure of variation is required for the RIV. We used re-sampling from HIPE in a simulation trial to obtain standard errors for each RIV value.

The resource homogeneity requirement for DRGs translates into the concept of DRG specific Co-efficient of Stay Variation (CV). This is defined as the Standard Deviation of LOS divided by the average LOS, where the LOS data is drawn from HIPE and the particular DRG in question. This statistic can be provided for each DRG in HIPE. Therefore any episode in HIPE can be assigned a class CV (that of its DRG) and the proportion of episodes in HIPE with class CVs in any specified range can be calculated.

Similarly, the information on which DRGs are void or low or have volume in HIPE can be collated. From this, it is possible to calculate the proportion of episodes in HIPE that are assigned to DRGs with episodes counts in any specified range.

CV, episode count, bed-days and related statistics were estimated on a DRG basis. The methodological challenge was how to present the CV and episode count data in a way relevant to systemic evaluation. The solution was to adopt a "Survival Analysis" approach and provide a graphical analysis which is described here.

Graphical Analysis

As discussed above, groupers fail if a large proportion of the utilisation they are tracking falls into DRGs that have high CV or (as a secondary consideration) low episode counts. It follows that groupers may be compared and evaluated by plotting the cumulative proportion of episodes (or bed-days) they assign to DRGs ranked according to their CVs and/or their episode counts.

To fix this notion, consider just one point on the horizontal axis (an x-value) on a graph comparing CV performance for episodes. If the x-value is 57% say, then the y-value for a grouper shows the proportion of HIPE cases assigned to case-types where the case-type has a CV of 57% or greater. Then, if the y-value for one grouper is larger than the y-value for another grouper, the first grouper has poorer homogeneity (at the specific evaluation threshold of 57%). However, there is no good operational reason to select just one threshold value (57% or otherwise), rather it is appropriate to compare the performance across the whole range of thresholds, e.g. from 500% right down to 0%. This comparison is facilitated by the use of a graph plotting the cumulative proportion of episodes in DRGs that fail the numerical criteria against the value of the criteria. That is, as an x-y plot with x the bounding CV value and y the proportion of HIPE episodes in DRGs with CV's not smaller than the bound.

Similarly, we may produce x-y graphs showing the proportion (y) of HIPE episodes falling to DRGs with less than x episodes in them. If the plots for two different groupers are shown on the same chart, then the grouper with the generally lower curve is better in regard to class size. Better class size performance is only desirable if the grouper also has good RIV performance. That is, given that two groupers have essentially the same RIV, then the grouper with the class size plot generally closer to the x-axis is to be preferred.

Examples of plots of these types appear in Appendix 3 and in the Results section below. The assessment of a grouper on these facets is based on the extent to which the curve for the grouper being tested lies below that of the benchmark grouper. Our method is set up so that a higher y value for a given x value indicates poorer performance.

Of course, unless one grouper clearly dominates the other, it is necessary to calculate the signed area between the two curves with a weighting for low ranked x values. In practice, we did not need to use this refinement.

Trimming Proportion

When case mix classification systems are exploited, LOS inlier populations are usually defined. LOS outlier episodes are atypical (both clinically and statistically) and often require individual record review. A good grouper tends to minimise the proportion of outlier cases it defines. Trimming proportion is therefore one of the evaluation criteria we used. Again, the smaller the trim proportion the better the grouper – all other things being equal. Trimming is appropriate if the removal of a small (clerically feasible) number of records greatly improves the grouper's RIV and DRG specific CV's. For this reason, it is important to evaluate groupers both over all of HIPE (Day-Cases included or excluded) and on the Inlier subsets of HIPE (Day-Cases included or excluded) that they define. The improvements brought about by trimming must be traded off against the increased trimming proportion (and resultant management input) and the decrease size of DRGs. This evaluation considers these aspects, providing evaluation statistics and graphics for Total and Inlier populations.

Section 4

Results and Discussion

Given the analysis undertaken for this study, a very broadranging array of results might be presented here. As our objective in undertaking this study, however, is to make a recommendation regarding the best option available for updating the case mix classification in use at the national level in Ireland, the presentation of results will be limited to those issues considered key to informing this decision. As the groupers being evaluated are being assessed in terms of the stability that might be expected from funding systems based on them, we are interested in such issues as inliers and outliers, day-cases and non-day-cases in the various combinations that may be relevant under the typical funding policy. Such comparisons are also useful in assessing the comparative performance of groupers in their utilisation-tracking role (the other side of the coin so to speak).

In practice, DRGs with few episodes are hard to work with, as utilisation measures obtained for them are subject to relative sample variation not reduced by the Law of Large Numbers. It is especially true of DRGs that are part of the classification system but are seldom populated even in large data sets. Therefore, in Table 1, we compare groupers based on the aggregate episodes and bed-days that fall in "low volume" DRGs. Across all the HIPE data, the IR-DRG system has the largest number of void or low volume DRGs, followed by the AP-DRG system. The AR-DRGs, in general, perform well with AR version 4.1 performing marginally better than the other versions.

Table 1: Void DRGs and Low Volume DRGs for HIPE 2000

Grouper	Number of Void DRGs		DRGs with Less than 5 Episodes	
	All Episodes	Non-Day-Case	All Episodes	Non-Day-Case
AR-DRG V4.0	6	7	12	17
AR-DRG V4.1	5	6	12	16
AR-DRG V4.2	5	6	11	15
AR-DRG V5.0	5	6	9	14
AP 18.0 DRG	13	13	28	29
CMS 20	4	4	7	9
HCFA 16	2	2	8	10
IR-DRG 1.2	30	30	81	82

The classification system of choice will also be required to support reliable estimates of utilisation, given the DRG to which an episode belongs. It would therefore be preferable if the CV of Length of Stay (count of nights stayed) was small as practical while still retaining an appropriate limit to the number of DRGs, and ensured that episodes that occur tend to be in DRGs that are large enough to support analysis. The groupers therefore need to be compared on these issues. Given the complexity of these findings, presentation in graphical form here may be helpful. While graphs developed for the analyses undertaken for all the groupers are presented in Appendix 3, in aiming to achieve clarity, we will limit the presentation here to graphical presentations of the results for AR-DRG V4.1 and IR-DRG 1.2.

The charts presented are of two main types: those assessing the distribution of the size of DRGs the grouper defines (in terms of episodes and bed-days), and those assessing the distribution of the reliability (information content -Coefficient of Variation) of DRGs the grouper defines.

Figure 5 shows, for both theV41 and IR Grouper, the proportion of bed-days associated with episodes that fall in DRGs of less than the Group Size given on the horizontal axis. The proportion (rate per 1000 bed-days) is shown on the vertical axis. There are two curves for each grouper. One provides the analysis of all HIPE episodes, the other of all inlier episodes. The two curves for the IR Grouper are uniformly above the two curves for the V41 grouper. There is little difference between the two curves for the V41 grouper, or between the two curves for the IR Grouper.

These observations translate into the findings that the V41 grouper is markedly superior to the IR Grouper in regard to the distribution of Group Size, and that trimming has little effect on Group Size performance of these groupers.

Figure 5

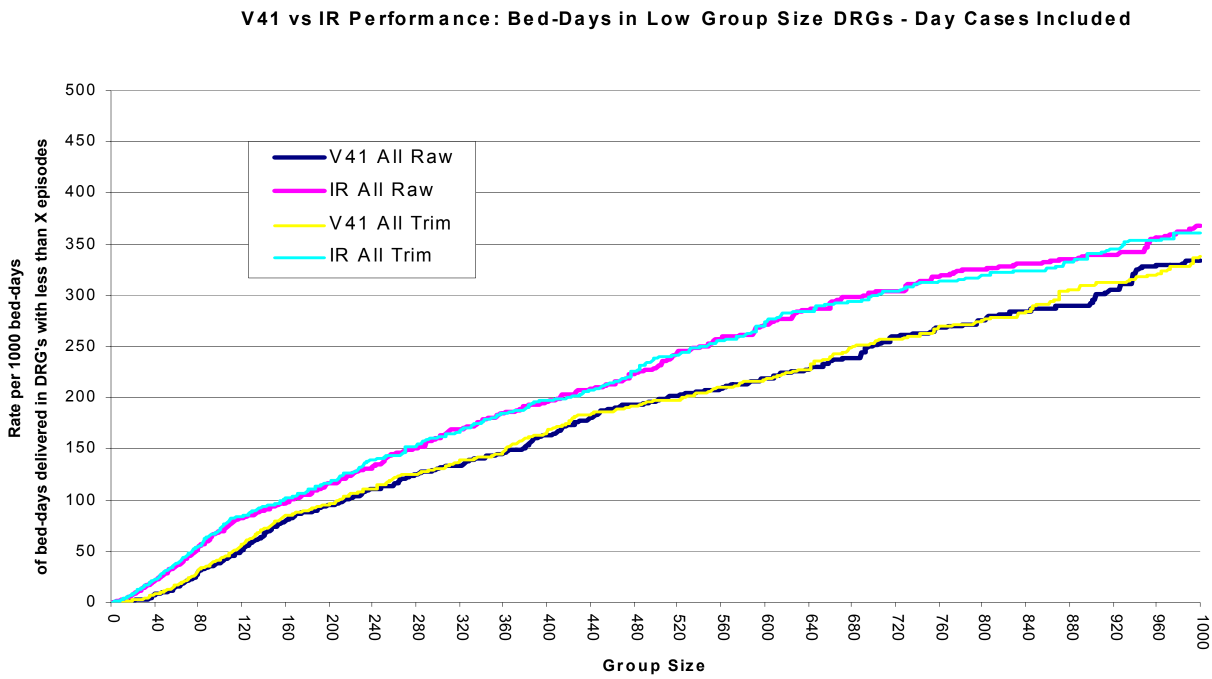


Figure 6 repeats the analysis but with the restriction to HIPE episodes with at least one night of hospital care. The findings are unchanged – V41 is markedly superior even when this data restriction is introduced.

Figure 6

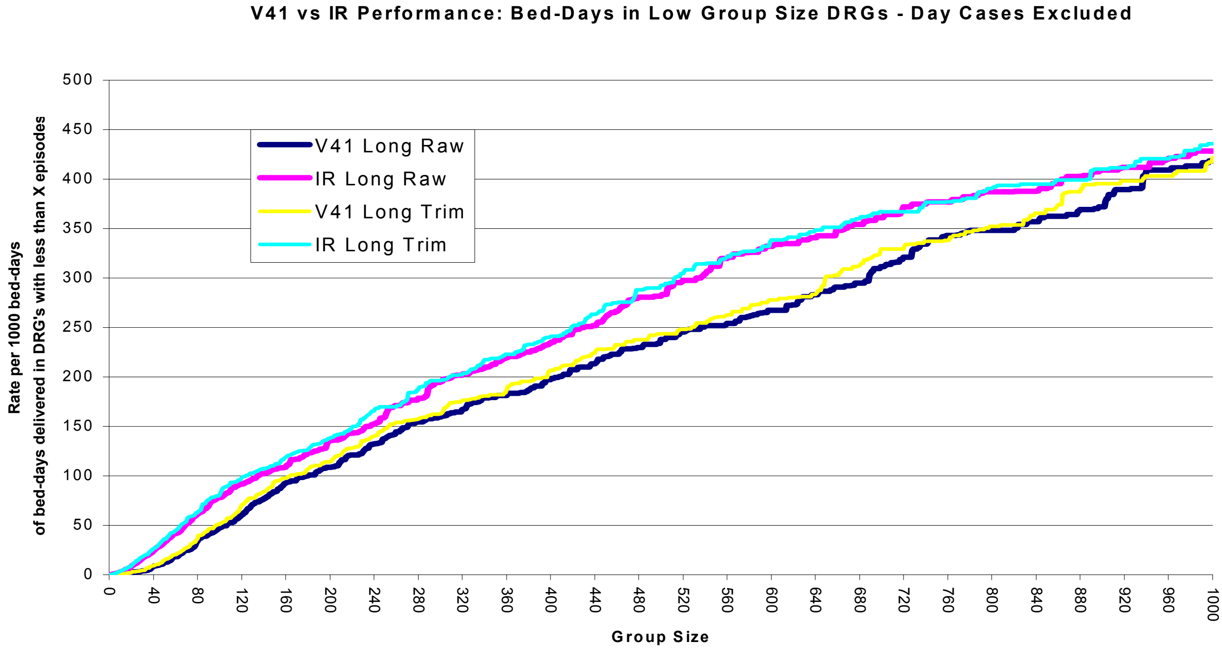
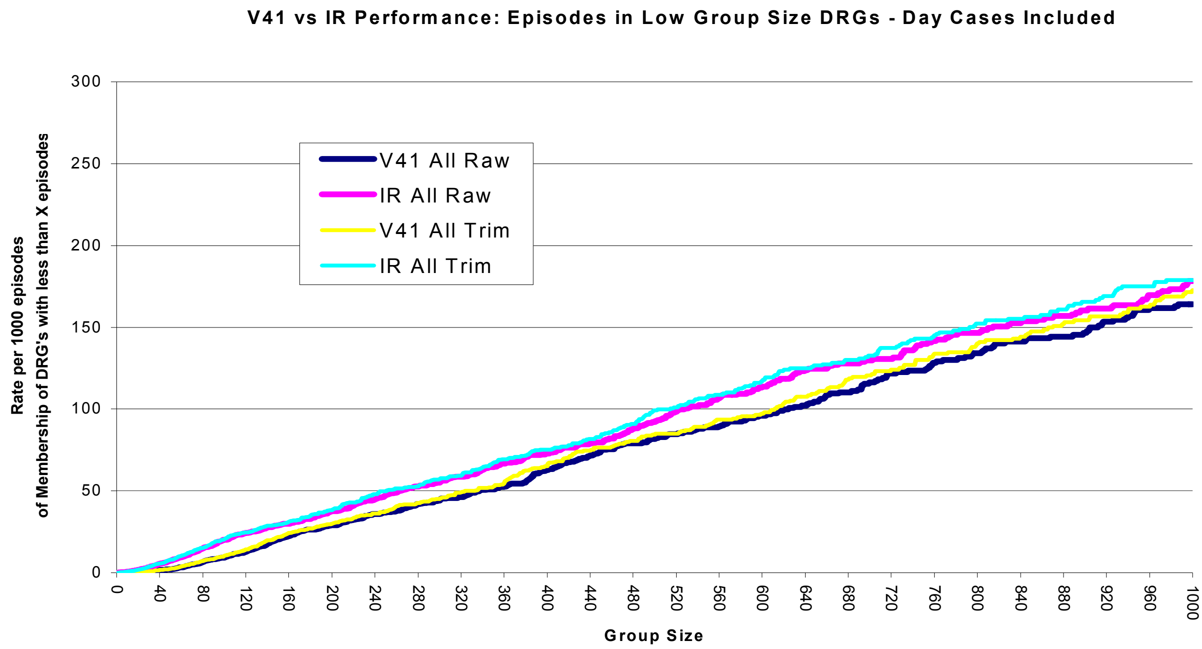


Figure 7 repeats the first graphical analysis, except it analyses episode counts rather than bed-days. That is, it shows the proportion of episodes that fall in DRGs of less than the Group Size given on the horizontal axis. The proportion (rate per 1000 episodes) is shown on the vertical axis for both the V41 and IR groupers. Again, a plot is provided for each grouper for all HIPE data and for the inlier episodes defined by the grouper.

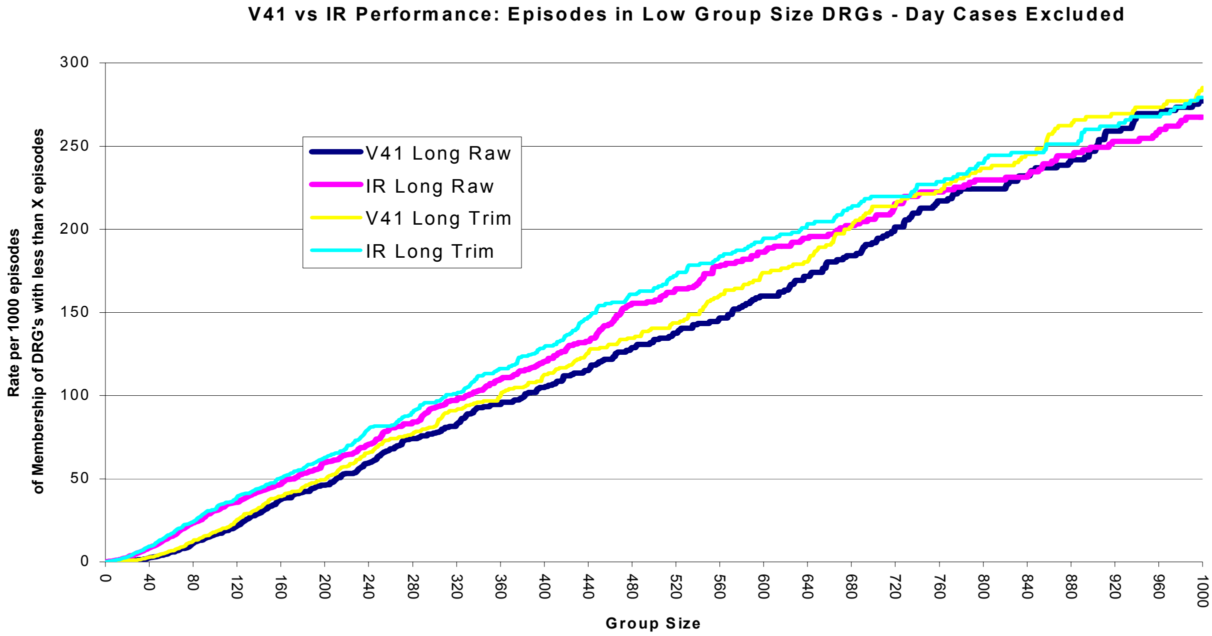
Figure 7



Again, the findings favour V41 and show the similarity of the all cases and inlier results, but the difference between V41 and IR is not as marked.

Figure 8 repeats the episode count analysis but with the restriction to "Non-Day-Case" episodes. The V41 grouper out performs the IR grouper, but not uniformly across all group size. However, V41 is superior in the most relevant (smaller) group size range.

Figure 8



Figures 5-8 demonstrate that trimming has only a modest effect on either grouper's group size performance, but that IR is uniformly worse than AR-DRG V41. A similar pattern is found whenever the Australian groupers are compared with the IR grouper.

We now consider the two further charts. Figure 9 includes the "All" episodes and Figure 10 the "Non-Day-Case" episode population. The graphs are set up to show what proportion of the episodes, system-wide, belong in DRGs with CV at least as large as the value given.

Figure 9

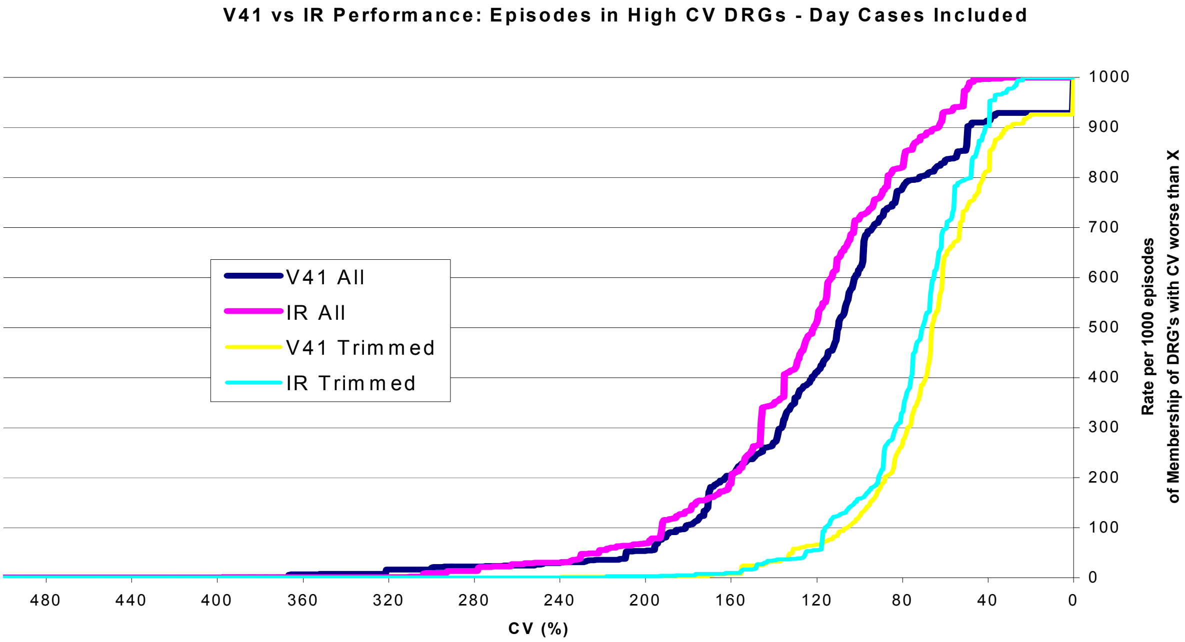
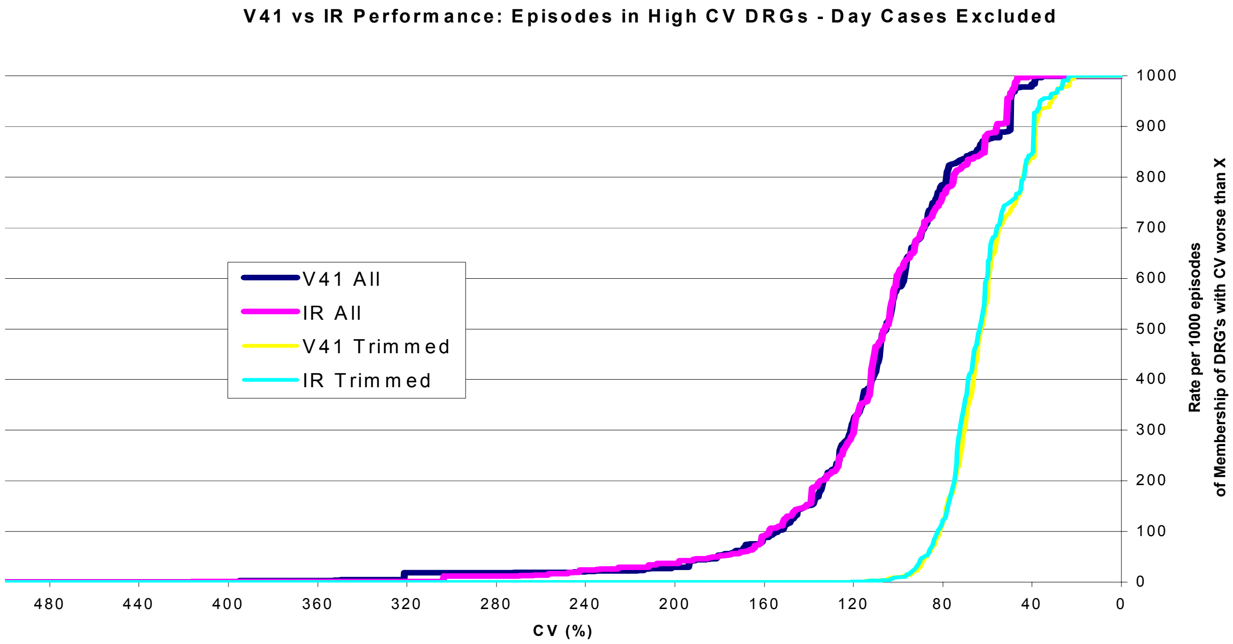


Figure 10



Each of these charts demonstrates that as the CV (%) required of a DRG moves towards zero, the number of episodes that are members of DRGs that have at worst the given CV falls off rapidly. In other words, not much of the data belongs in low CV DRGs, irrespective of the grouper used.

Again, the graphical analyses of CV are set up so that lower values on the vertical axis imply better performance. So one clear finding is the great benefit of trimming, even at quite modest levels. Indeed the percentage of episodes trimmed from the chart data was around 3.4% for the ARDRGs and 3.7% for the IR DRGs for the “All Episodes” graph, while for the “Non-Day-Case” chart, there was 5.7% trimmed for both the AR and IR Groupers. The analyses also show a loss of precision with the wholesale incorporation of day-cases, but in practice the use of designated day-case extensions to the DRGs systems can ameliorate this. Of direct relevance to grouper selection is the finding of AR's superiority when Day-Cases are present but that there is no clear winner when restricted to the non-day-case population.

Table 2 shows the proportion of cases trimmed, with day cases included and excluded, for all evaluated groupers. Lower trimming proportions are favourable to the use of a Grouper (all other things being equal) because there is less need for "exceptional" treatment. AR is better in this regard for the General episodes but a little worse for Non-Day-Case episodes.

Table 2: Trimming Proportions (All Groupers)

GROUPER	Trimming (%) – Day Cases **Included**	Trimming (%) – Day Cases **Excluded**
V40	3.36	5.72
V41	3.37	5.74
V42	3.37	5.70
V50	3.68	5.59
AP	3.75	5.69
CMS	3.92	5.96
HCFA	5.31	8.06
IR	3.74	5.67

Another comparator, related but different from CV performance is Reduction in Variance (RIV), which measures the information gained by using knowledge of a DRG when estimating the stay of an episode chosen at random from the population.

For all groupers tested, together with the two treatment populations (General and Non-Day-Case), the RIVs estimated (together with the Standard Error of RIV) are reported in Table 3.

The SE of RIV entries show the standard error in the estimate RIV values. They are approximate, each being based on 25, 50% re-sampled estimates. A number of important conclusions arise given the data in Table 3 and the previous tables. Firstly, the CMS/HCFA DRG groupers are the worst performers for both treatment populations. While better than the CMS/HCFA groupers, the performance of the AP DRG grouper is worse than any of the Australian groupers or the IR grouper. When the remaining groupers are compared, the IR grouper performs on par with the Australian groupers when outliers are present. Despite its heavier trimming proportion, however, IRDRG 1.2 seems generally less effective than the Australian groupers for the general inlier population.

Table 3: RIV (All Groupers)

Grouper	General		Non-Day-Case	
AR-DRG V40	RIV	SE of RIV	RIV	SE of RIV
All Cases	27.9%	0.3%	25.3%	0.2%
Inliers	50.9%	0.2%	48.9%	0.2%
AR-DRG V41				
All Cases	28.0%	0.3%	25.4%	0.3%
Inliers	51.0%	0.2%	49.0%	0.2%
AR-DRG V42				
All Cases	27.9%	0.2%	25.3%	0.2%
Inliers	51.0%	0.1%	49.0%	0.1%
AR-DRG V50				
All Cases	27.7%	0.2%	24.7%	0.2%
Inliers	50.8%	0.2%	48.3%	0.2%
AP DRG				
All Cases	26.3%	0.2%	24.4%	0.2%
Inliers	48.3%	0.2%	47.5%	0.2%
CMS DRG				
All Cases	23.6%	0.3%	21.8%	0.2%
Inliers	45.3%	0.2%	44.6%	0.2%
HCFA DRG				
All Cases	23.6%	0.2%	21.7%	0.2%
Inliers	43.5%	0.1%	42.1%	0.2%
IR DRG				
All Cases	27.7%	0.2%	25.6%	0.2%
Inliers	49.3%	0.2%	48.3%	0.2%

Section 5

Conclusions and Recommendations

The project reported here is one of the most comprehensive studies of its type undertaken internationally, taking account of the number of case mix groupers tested on a national data set. As such, the findings are not only important in the Irish context but will also be of interest to any investigation focused on assessing performance of a range of case mix measures within a national hospital system.

The impetus for this study arose from the need to upgrade the case mix measure of choice in use at the national level in Ireland. Since a case mix adjustment had first been applied for funding purposes within the Irish hospital system in 1993, some version of the DRG grouper supported by the Health Care Financing Administration (HCFA) had been considered the most appropriate for use, given the hospital activity data available over the period. With improvements in available data, together with developments in the range and quality of groupers available, it was considered timely to test performance of the alternative options in the context of this project. The groupers selected for testing included four versions (V4.0, V4.1, V4.2, V5.0) of the Australian Refined (AR) DRGs, the AP DRGs (V18.0), CMS DRGs (V20) and IR DRGs (V1.2). Results for the HCFA DRGS (V16.0) were also included for purposes of comparison. While the analysis, for the most part, was based on data for the year 2000, discharge data for 1999, 2000 and 2001 were also used by the project. Over this period, data returned to the Hospital Inpatient Enquiry accounted for close to 95 per cent of all discharges from acute hospitals nationally. The data analysed for 2000, included 802,021 discharges.

For the analysis, the performance of the groupers on total discharges and the data set with and without day cases was assessed. In addition, a trimming procedure was applied so that performance before and after the exclusion of outlier cases could be assessed. An important innovation for this project was the use of graphical analysis to show how specific groupers performed relative to the alternatives for given criteria. Finally, a multivariate analysis was applied to show the level of variation explained by each of the groupers tested.

The results of this investigation provide important guidance for the selection of a 'best' alternative DRG grouper, given the activity data currently available for acute hospitals in Ireland. In the first instance, it is important to note that, in general, the worst performing groupers were the HCFA DRGs (V16) and CMS DRGs (V20). The decision to upgrade and change from the use of groupers at this level is therefore supported by the results. The next worst performing grouper, generally, was the AP DRGs (V18.0). The best performing groupers, therefore, were the AR DRG groupers and the IR DRG grouper. For the statistical analyses, the performance of the AR DRGs generally surpassed that of the IR DRG grouper, the notable exception being findings for the non-day-case population where the IR DRG grouper performed marginally better for all cases relative to the AR DRG groupers.

Together with the empirical results found for this study of alternative DRG groupers, a number of additional important factors need to be taken into consideration in finalising a recommendation. Firstly, the fact that a mapping procedure had to be applied to the morbidity codes for use with the AR DRG Groupers would be expected to have had some impact on the performance of these groupers. While the magnitude of this impact is difficult to predict, it seems reasonable to expect that some level of improvement in the performance of these groupers would be in evidence in the absence of a mapping procedure. Following a study of alternative coding schemes for use with morbidity data collected from acute hospitals in Ireland, Murphy et al (2004) recommended the adoption of the Australian developed ICD-10-AM classification system.[8] This recommendation was adopted by the Irish Department of Health & Children and ICD-10-AM was introduced for morbidity coding in all hospitals nationally in January, 2005. This development is obviously an important factor to take into account in the selection of a new grouper for use within the Irish system.

For previous studies of alternative DRG Groupers undertaken in Ireland, additional factors considered important in finalising a decision included whether or not the specific DRG Grouper was in use internationally, whether training and support for the use of the grouper was available, the frequency of updates and whether or not the system was government supported. When these criteria are applied to the AR DRG and IR DRG Groupers, the groupers that yielded the best empirical results when tested on Irish data, the findings are quite straightforward. Relative to the IR DRG Grouper, the AR DRG series of Groupers are the more widely used internationally, are updated regularly and supported by Australian government agencies. In addition, the study found that more support and training opportunities were available for the use of these Groupers. Given these factors, together with the impressive empirical performance of the AR DRG groupers and the fact that the ICD-10-AM morbidity coding system has been adopted for use in Ireland, we conclude by recommending the AR DRG classification system as the best option for use at the national level in Ireland, given the current state of development of the hospital activity data systems. As these systems develop, however, the extent to which updated or newly developed approaches to case mix classification and measurement may substantially improve the performance of such measures within the Irish system should be the subject of ongoing assessment and review.

[8] Murphy, D., M.M. Wiley, A. Clifton, D. McDonagh *Updating Clinical Coding in Ireland: Options and Opportunities*, The Economic and Social Research Institute, Dublin, September 2004.

Appendix 1

File Specification for HIPE Data used for testing DRG Groupers

File Specification

Variable Name	Length	Start	End	Notes
HOSPITAL	3	1	3	
DISDATE	8	4	11	1
CASEREF	7	12	18	
ADMDATE	8	19	26	1
BDATE	8	27	34	2
SEX	1	35	35	3
ACODE	1	36	36	4
EMERGIN	1	37	37	5
DCODE	1	38	38	6
EMERGOUT	1	39	39	5
DIAG1	5	40	44	7
DIAG2	5	45	49	7
DIAG3	5	50	54	7
DIAG4	5	55	59	7
DIAG5	5	60	64	7
DIAG6	5	65	69	7
OP1	5	70	74	7
OP2	5	75	79	7
OP3	5	80	84	7
OP4	5	85	89	7
DAYCASE	1	90	90	8
MDC	2	91	92	9
DRG	3	93	95	9
AGE	3	96	98	
LOS	4	99	102	
DOBIND	1	103	103	10
XTRADMIN	13	104	116	11

Notes

Note	Details
1	The format of the Date of Admission and Date of Discharge date fields are DDMMYYYY.
2	The format of the Date of Birth field is YYYYMMDD
3	The following are the values for the Sex field

Value	Meaning
1	Male
2	Female
3	Unknown (Rare and Unlikely)

4 The ACODE field stores the source of admission code for the episode. The following are the values.

0 Admission deferred at patient's wish or by medical constraints

1 Normal admission from waiting list

2 Planned repeat admission

3 Transfer from other acute hospital
The coder is asked whether the transfer is an emergency or planned for all cases with Source of Admission 3. (See Note 5)

4 Emergency - *Other than transfer*	Deliberate Self-Inflicted injury or poisoning. (Code 4 will only be used if medical staff specifically indicate injury or poisoning as self inflicted).
5 Emergency - *Other than transfer*	Road Traffic Accident (RTA)
6 Emergency - *Other than transfer*	Home Accident (including accidental poisoning)
7 Emergency - *Other than transfer*	Other injury (including accidental poisoning other than in the home)
8 Emergency - *Other than transfer*	Other than injury
9 Emergency - *Other than transfer*	Readmission following previous spell of treatment

5 The Emergency Transfer In Indicator field (EMERGIN) and Emergency Transfer Out Indicator field (EMERGOUT) values are as follows:

Value	Meaning
Blank	Not a transfer case
0	Planned hospital transfer
1	Emergency hospital transfer.

6 The DCODE field stores the discharge code of the episode. The following is a list of the discharge codes.

0 - Self discharge
1 - Home
2 - Convalescent home or long stay accommodation
3 – Transfer to other acute hospital
The coder is asked whether the transfer is an emergency or planned for all cases with Discharge Code 3 (See note 5)

6 - Died - post mortem
7 - Died - No post mortem
8 - Other (e.g. Foster care)

Value	Meaning	Map Code *
0	Self Discharge	06
1	Home	09
2	Convalescent home or long stay accommodation	02
3	Other acute hospital	01
6	Died - post mortem	08
7	Died - No post mortem	08
8	Other (e.g. Foster care)	09

* The map codes are suggested values of Australian separation modes. Please note that we are not familiar with the Australian separation mode values.

7 The diagnosis and procedure codes for all 3 years of data (January 1, 1999- December 31, 2001 inclusive) are coded with the October 1, 1998 version of the ICD9-CM coding scheme which corresponds to HCFA version 16.0.

8 The DAYCASE field stores the daycase status of the case and the values are as follows:

Value	Meaning
0	Not a Daycase (i.e. In-patient)
1	Daycase

9 The DRG and MDC codes were obtained from the HCFA 16 grouper provided by 3M.

10 The DOBIND field indicates whether the Date of Birth is a true date of birth.

If the date of birth is unknown the year must be estimated and entered with the day and month being keyed as 00/00 e.g. 1970 = 00/00/1970. When this occurs the DOBIND field is set to 1 (otherwise it is 0 by default) and the date is actually stored as 01/01/1970.

11 Additional administrative details which are probably not relevant but which can be made available to the study later if required

Appendix 2

Code Mappings for Grouping HIPE Data by AR-DRGs

Part A: Diagnosis Code Map

Dx Code Found	Dx Code Used	Occasions	Dx Code Found	Dx Code Used	Occasions
0312	0318	12	4644	46421	2130
03810	0381	289	46611	4661	1089
03811	0381	668	46619	4661	6750
03819	0381	407	47400	4740	12810
0412	04106	149	47401	4748	1227
0796	07989	65	47402	4748	3018
1700	17002	49	48240	4824	101
2130	21301	66	48241	4824	526
27540	2754	204	48249	4824	13
27541	2754	476	48284	48283	15
27542	2754	1252	4831	4848	5
27549	2754	315	5186	1173	56
2773	27739	335	51883	51881	266
2780	27800	1	51884	51881	452
29181	2918	1096	51900	5190	61
29189	2918	84	51901	5190	36
29384	29389	20	51902	5190	44
2940	29409	42	51909	5190	68
30082	30081	30	53640	9974	102
31532	31539	5	53641	9974	146
3321	33219	272	53642	9974	196
3441	34411	1115	53649	9974	60
41404	41400	118	56481	5648	23
41405	41400	521	56489	5648	337
4380	438	652	56962	56969	296
43810	438	145	57460	57400	112
43811	438	163	57461	57401	68
43812	438	579	57470	57410	102
43819	438	59	57471	57411	137
43820	438	3361	57480	57400	36
43821	438	733	57481	57401	13
43822	438	668	57490	57420	205
43830	438	87	57491	57421	67
43831	438	19	57510	5751	1195
43832	438	30	57511	5751	2706
43840	438	51	57512	5751	484
43841	438	14	585	5859	12880
43842	438	14	65570	65580	1
43850	438	20	65571	65581	1794
43851	438	8	65573	65583	4242
43852	438	4	65971	65631	11848
43853	438	18	65973	65633	219
43881	438	5	68600	6860	11
43882	438	253	68601	6860	85
43889	438	541	68609	6860	14
4389	438	571	7101	71018	558
4588	4589	134	7384	73841	265

Dx Code Found	Dx Code Used	Occasions	Dx Code Found	Dx Code Used	Occasions
75251	7525	2443	94140	94130	6
75252	7525	80	94141	94131	1
75261	7526	1258	94146	94136	2
75262	7526	37	94147	94137	1
75263	7526	91	94148	94138	3
75264	7528	12	94149	94139	2
75265	7528	6	94241	94231	1
75269	7528	80	94242	94232	12
75320	7532	95	94243	94233	3
75321	7532	52	94244	94234	7
75322	7532	118	94245	94235	3
75323	7532	27	94249	94239	3
75329	7532	545	94340	94330	3
7560	75609	636	94341	94331	12
75670	7567	46	94342	94332	1
75671	7567	120	94343	94333	1
75679	7567	156	94345	94335	3
75881	7588	11	94346	94336	1
75889	7589	208	94349	94339	2
76381	7638	4	94440	94430	6
76382	7638	50	94442	94432	2
76383	7638	192	94443	94433	6
76389	7638	255	94444	94434	2
78039	78032	7685	94446	94436	2
78071	7807	287	94447	94437	2
78079	7807	3974	94448	94438	5
78603	78609	762	94540	94530	9
78604	78609	28	94541	94531	1
78605	78609	2304	94542	94532	3
78606	78609	158	94544	94534	4
78607	78609	1603	94545	94535	1
7879	78799	1	94546	94536	10
79094	79099	20	94549	94539	6
7965	7969	2	9464	9463	8
7LNRP		4	9494	9493	1
8500	8509	747	95901	9590	19078
8505	8501	229	95909	9590	1492
85189	85180	3	96561	9656	439
85209	85202	1	96569	9656	224
85229	85222	23	99550	9955	27
85249	85242	1	99551	9955	7
85309	85302	3	99552	9955	18
85409	85400	121	99553	9955	13
85419	85412	3	99554	9955	23
92231	9223	321	99555	9955	8
92232	9223	113	99559	9955	4
92233	9223	2	99580	99581	4

Dx Code Found	Dx Code Used	Occasions	Dx Code Found	Dx Code Used	Occasions
99582	99581	3	V2389	V238	68
99583	99581	12	V240	V2401	527
99584	99581	32	V2651	" "	724
99586	99589	25	V2652	" "	80
99655	99652	7	V293	V298	29
99656	99659	8	V4281	V428	2723
99811	9981	3425	V4282	V428	108
99812	9981	2214	V4283	V428	124
99813	9981	284	V4289	V428	128
99851	9985	236	V4450	V445	104
99859	9985	7471	V4451	V445	33
99883	99889	181	V4452	V445	3
E9224	E9179	18	V4459	V445	69
E9674	E9671	10	V4561	V456	1308
E9675	E9671	6	V4569	V456	98
E9677	E9671	6	V4571	6118	543
E9678	E9671	6	V4572	56989	35
E9686	E9688	7	V4573	59389	943
E9856	E9854	3	V5301	V530	7
V0251	V025	181	V5302	V530	3
V0252	V025	7	V5309	V530	102
V0259	V025	1187	V562	V560	24
V0260	V0261	4	V581	V5811	98285
V0269	V0261	7	V5861	V6751	3492
V1048	V1049	13	V5862	V6751	33
V1240	V124	141	V5869	V6751	299
V1241	V124	222	V6110	V611	107
V1249	V124	452	V6111	V611	9
V1361	V136	8	V6112	V611	2
V1369	V136	225	V6122	V6121	2
V1541	V154	146	V6283	V6549	1
V1542	V154	11	V644	" "	1097
V1549	V154	9	V667	" "	4034
V1586	V1589	5	V7610	V761	12
V1640	V164	20	V7619	V761	5
V1641	V164	372	V7644	V7649	9
V1642	V164	236	V7645	V7649	2
V1643	V164	36			
V1649	V164	221			
V1651	V165	32			
V1659	V165	83			
V1861	V186	24			
V1869	V186	245			
V2381	V238	299			
V2382	V238	1770			
V2383	V238	62			
V2384	V238	4			

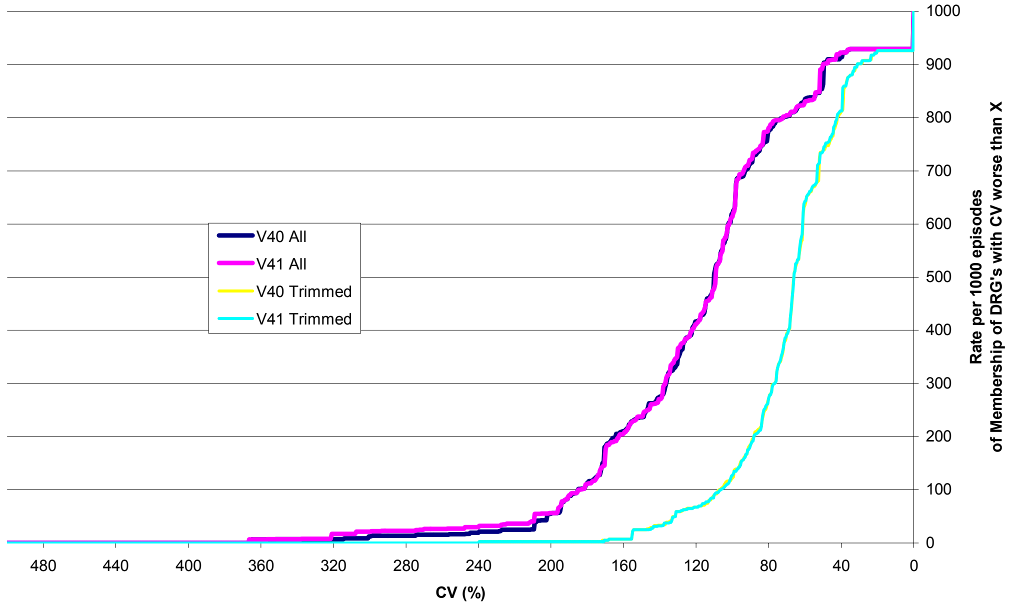
Part B: Map for Procedure Codes

SURG Code Found	SURG Code Used	Occasions	SURG Code Found	SURG Code Used	Occasions
155	1559	1	6564	6562	2
236	2369	26	6574	6571	5
3617	3619	1	6575	6572	3
3639	363	4	6576	6573	3
3735	3733	1	6581	658	478
375	3759	32	6589	658	151
4105	4103	15	6621	662	2878
4106		1	6622	662	838
4701	470	3477	6629	662	2344
4709	470	14787	6631	663	418
4711	471	64	6632	663	415
4719	471	296	6639	663	1812
4836	4542	859	6851	685	202
5121	5122	67	6859	685	2815
5124	5123	154	704	7041	28
5451	545	1709	713	7139	965
5459	545	1721	734	7349	14590
5903	5902	2	740	7401	75
5912	5911	7	741	7411	31094
6029	6021	6028	751	7511	32
6501	650	185	857	8579	244
6509	650	60	8667	8665	5
6513	6512	353	9230	923	22
6514	6519	7	9231	923	169
6531	653	100	9232	923	1
6539	653	599	9233	923	2
6541	654	128	9239	923	2
6549	654	1047	9629	9639	121
6553	6551	49	9910	9929	1827
6554	6552	1	9920	9929	55
6563	6561	84			

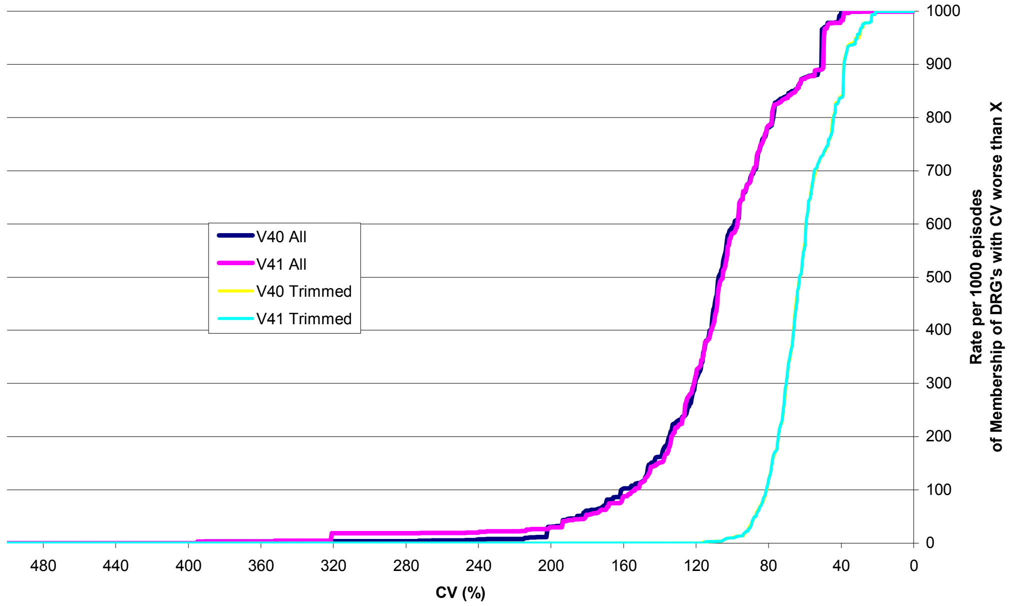
Appendix 3

Graphical Comparisons Assessing Co-Efficient of Variation

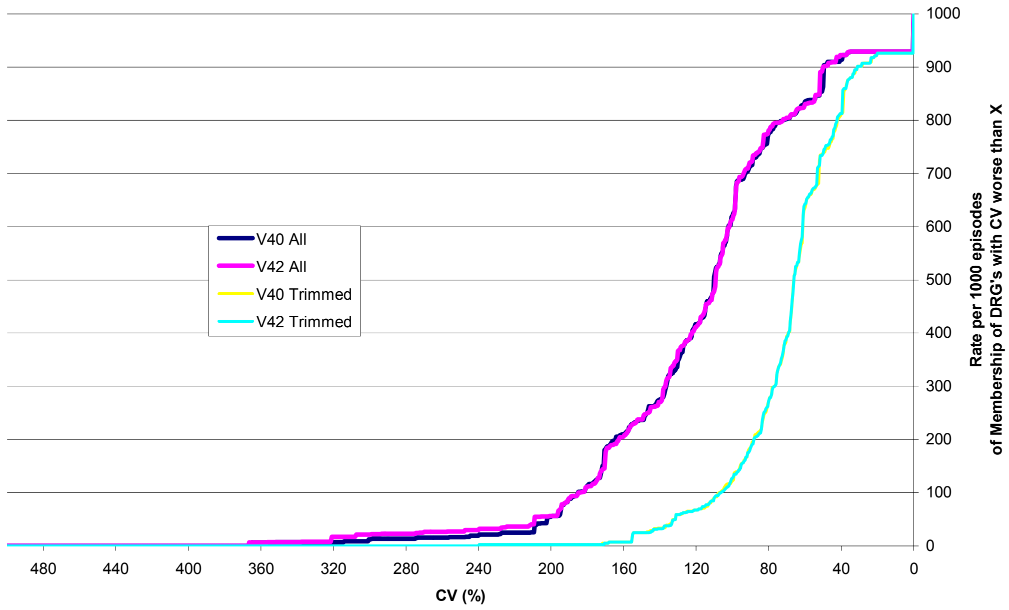
V40 vs V41 Performance: Episodes in High CV DRGs - Day Cases Included



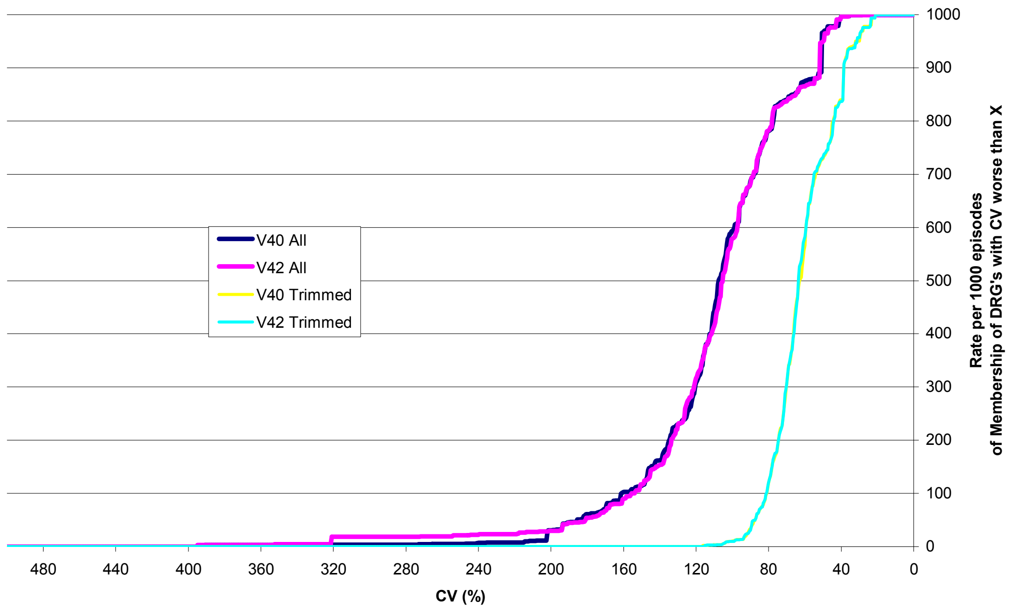
V40 vs V41 Performance: Episodes in High CV DRGs - Day Cases Excluded



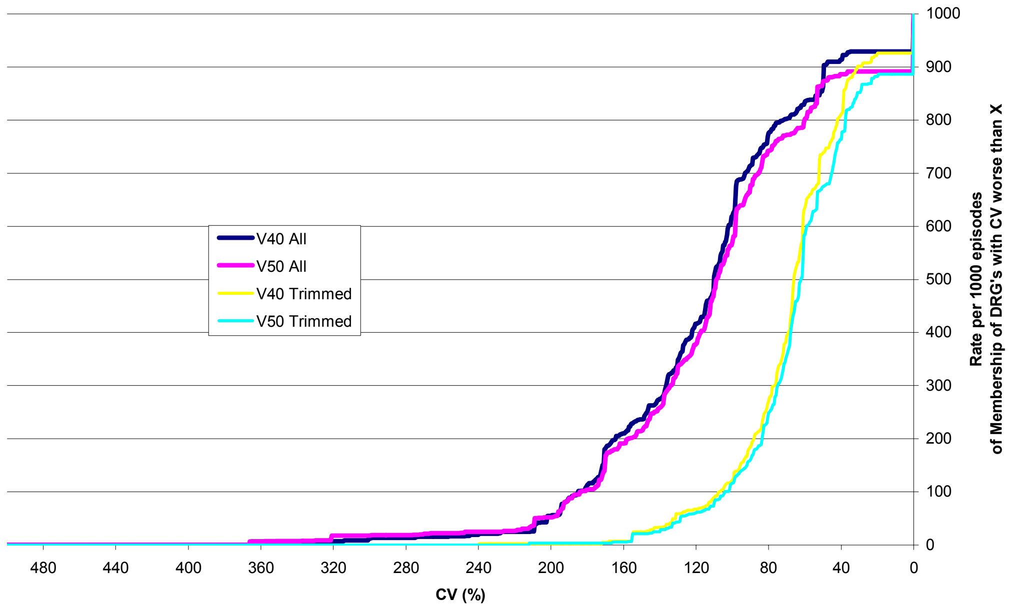
V40 vs V42 Performance: Episodes in High CV DRGs - Day Cases Included



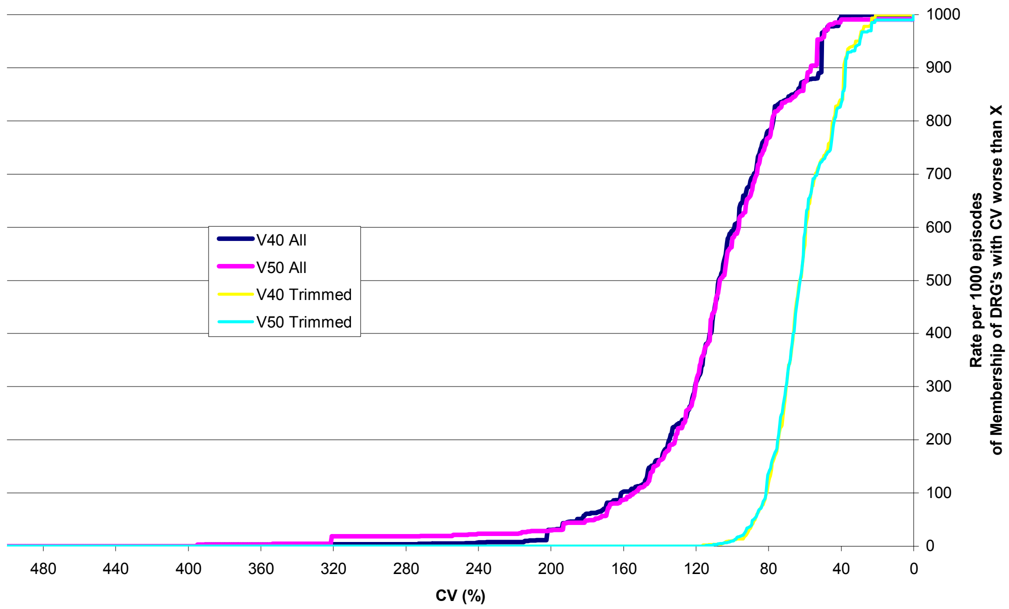
V40 vs V42 Performance: Episodes in High CV DRGs - Day Cases Excluded



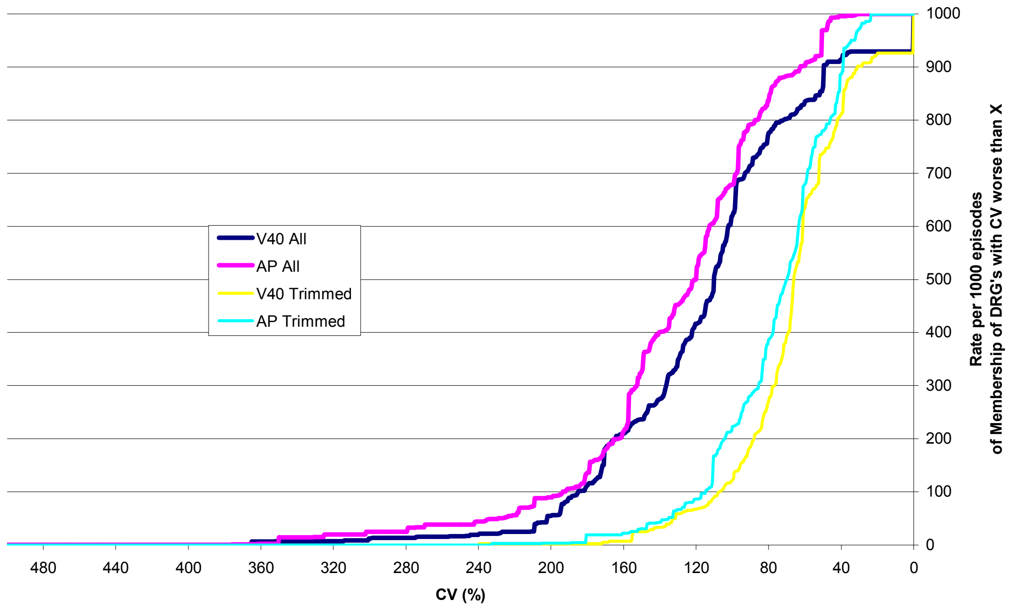
V40 vs V50 Performance: Episodes in High CV DRGs - Day Cases Included



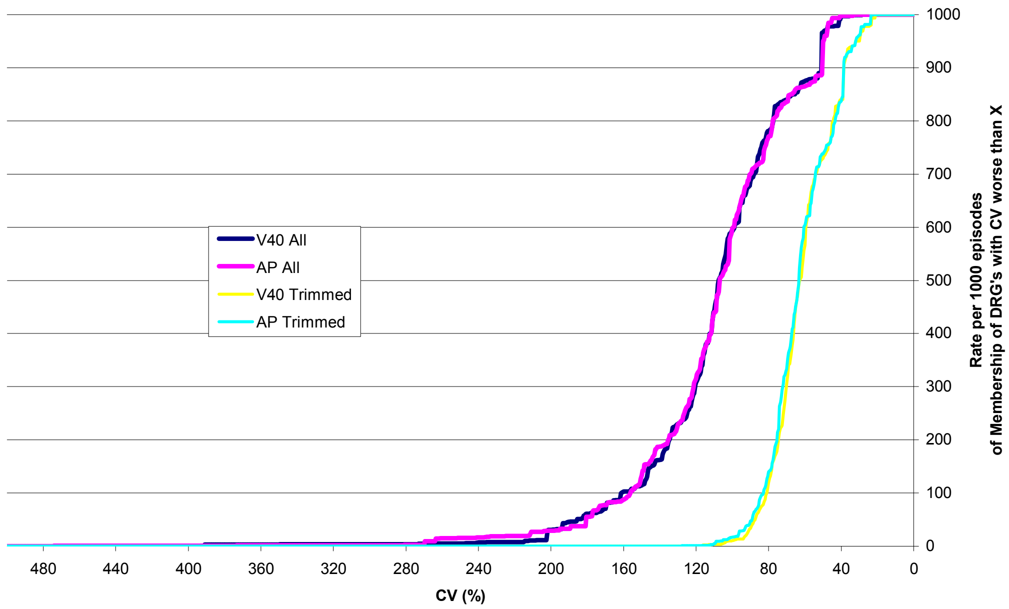
V40 vs V50 Performance: Episodes in High CV DRGs - Day Cases Excluded



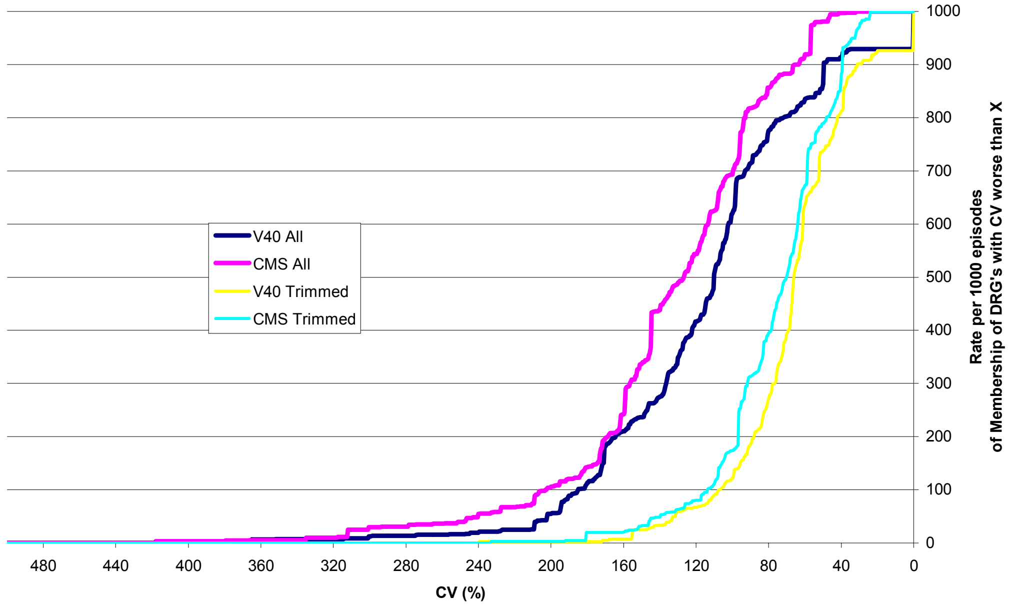
V40 vs AP Performance: Episodes in High CV DRGs - Day Cases Included



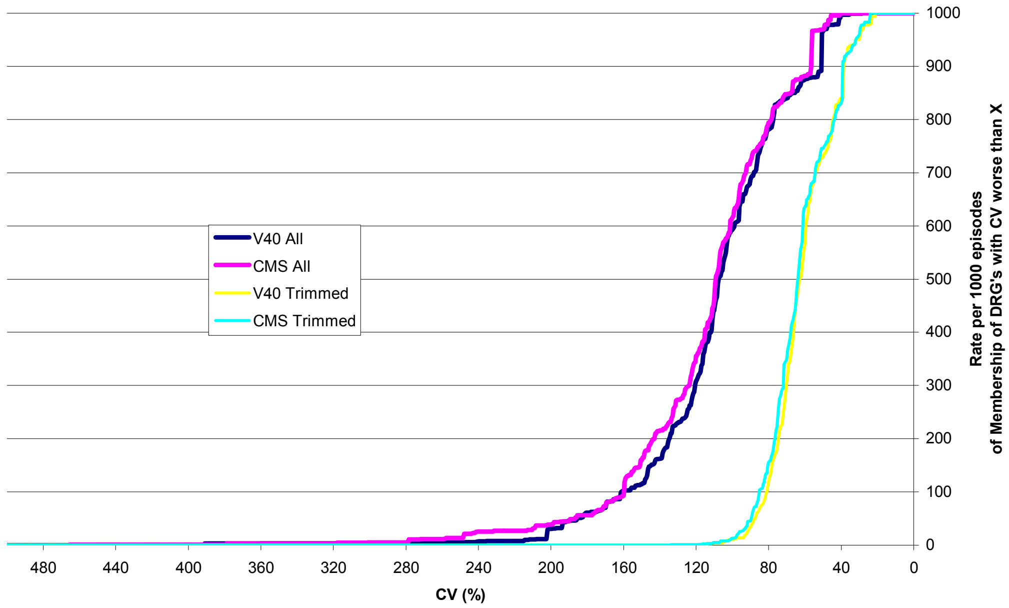
V40 vs AP Performance: Episodes in High CV DRGs - Day Cases Excluded



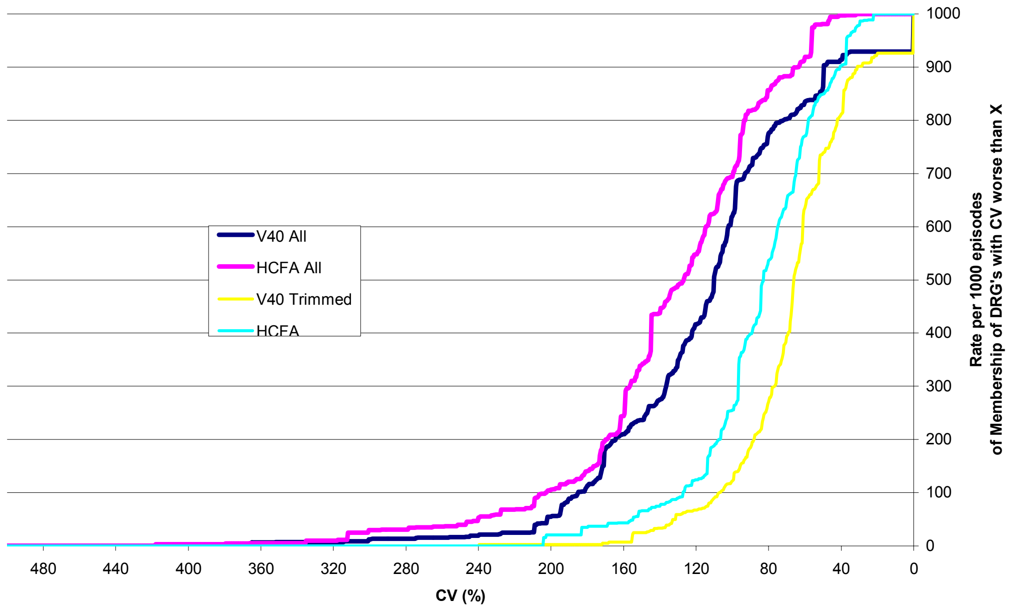
V40 vs CMS Performance: Episodes in High CV DRGs - Day Cases Included



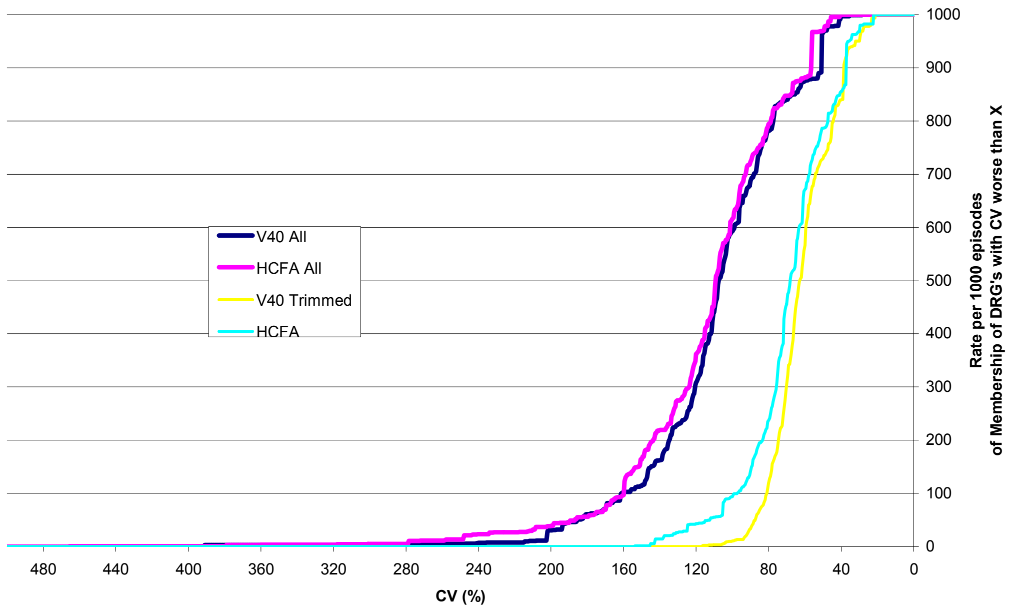
V40 vs CMS Performance: Episodes in High CV DRGs - Day Cases Excluded



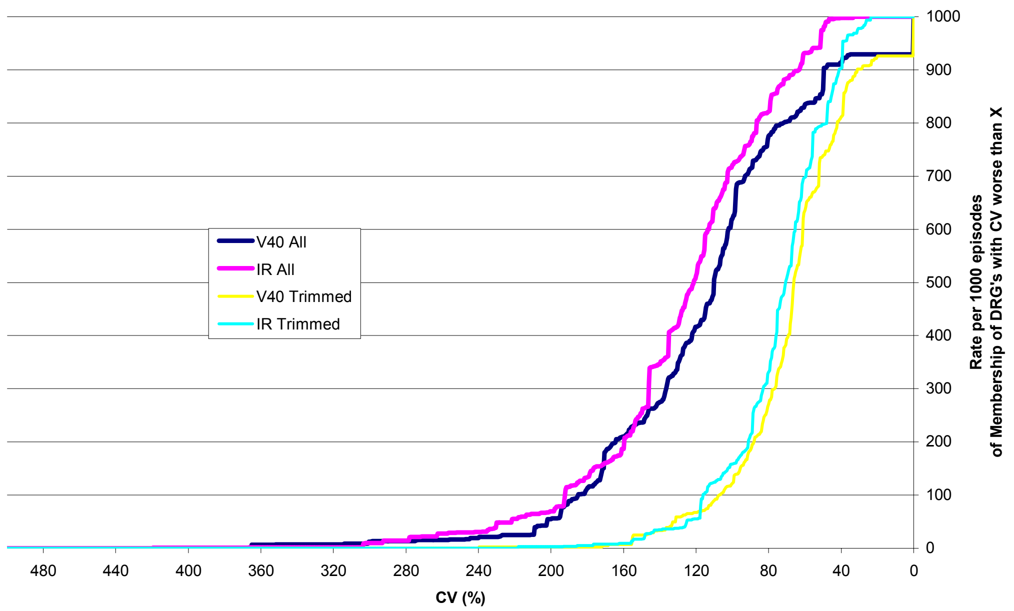
V40 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Included



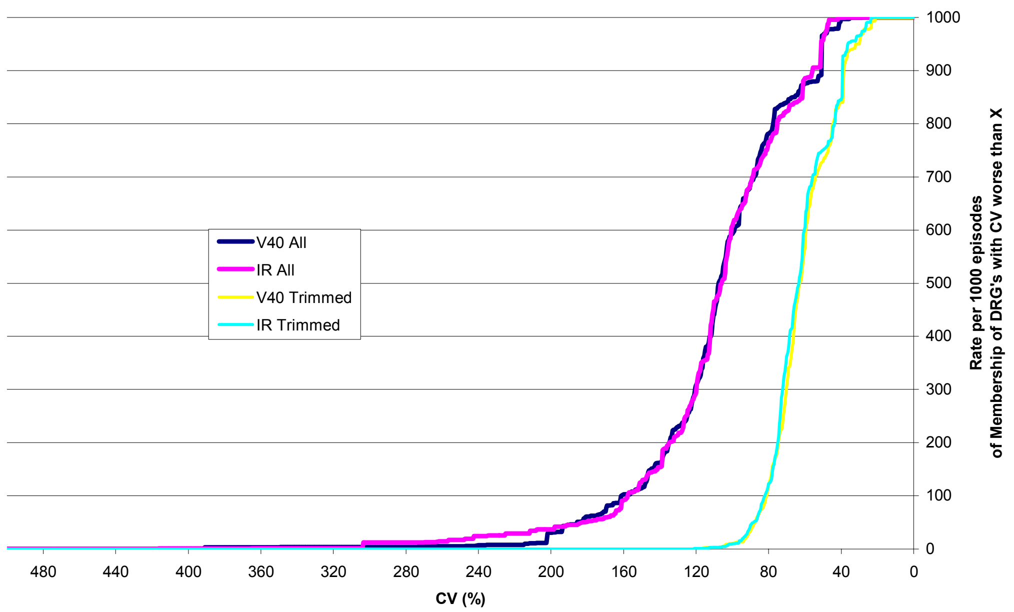
V40 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Excluded



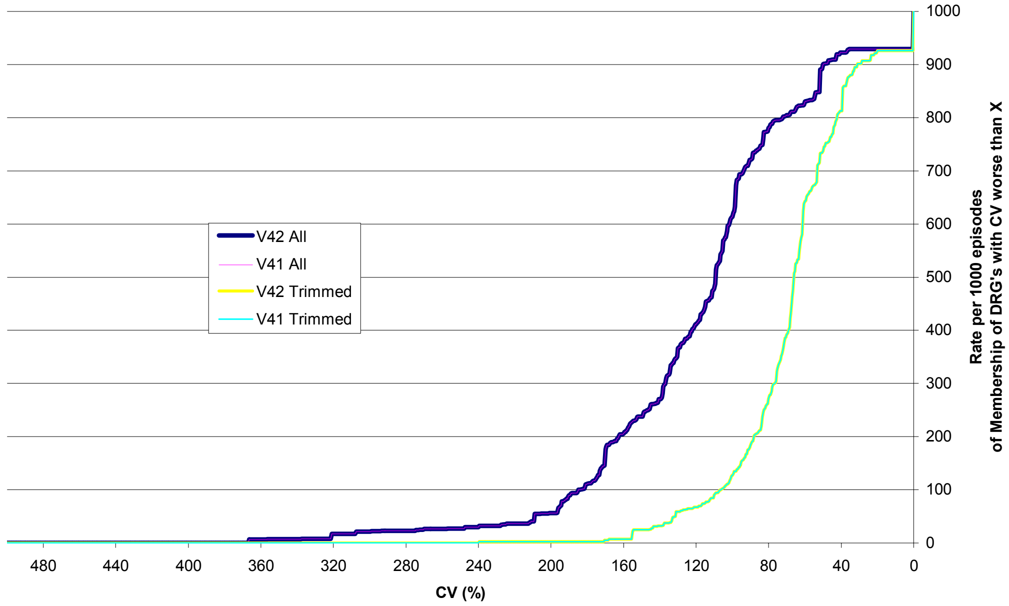
V40 vs IR Performance: Episodes in High CV DRGs - Day Cases Included



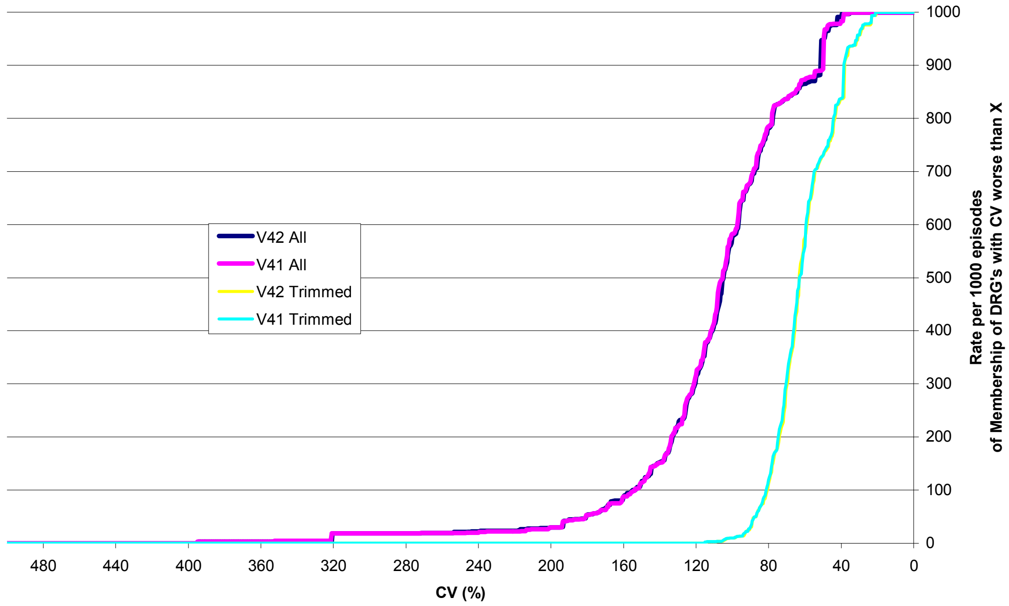
V40 vs IR Performance: Episodes in High CV DRGs - Day Cases Excluded



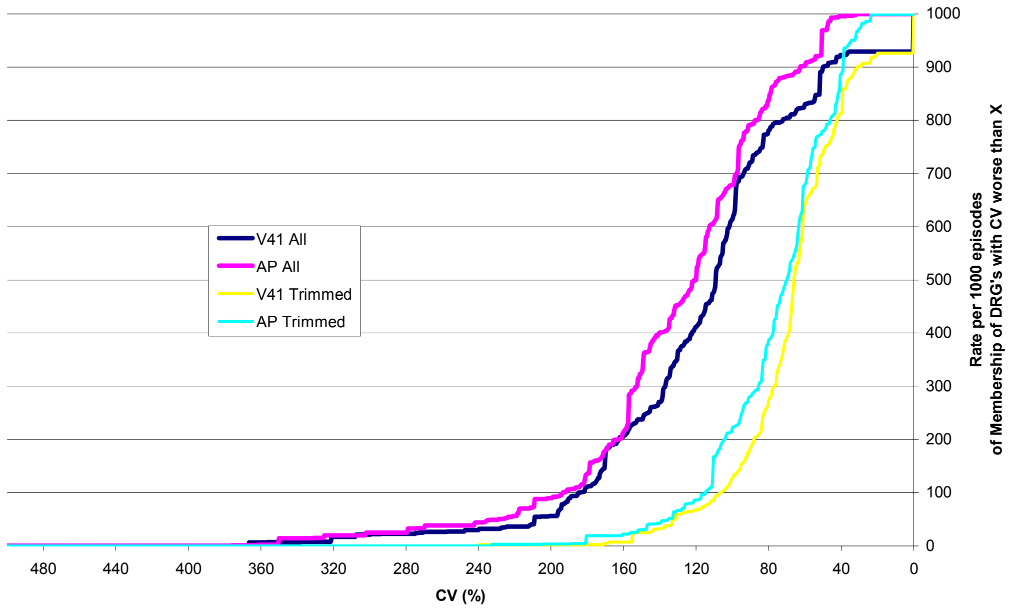
V42 vs V41 Performance: Episodes in High CV DRGs - Day Cases Included



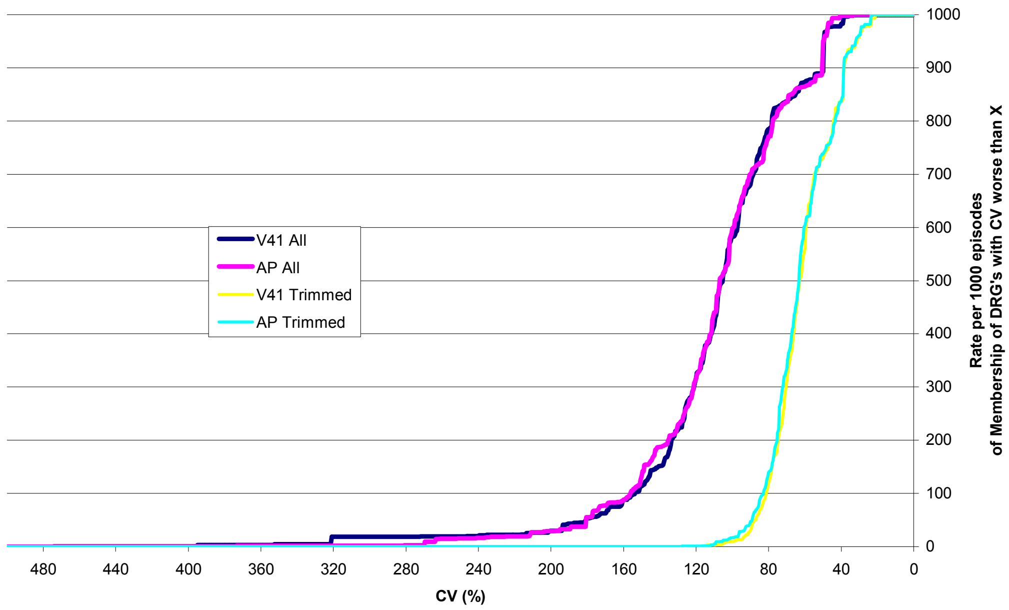
V42 vs V41 Performance: Episodes in High CV DRGs - Day Cases Excluded



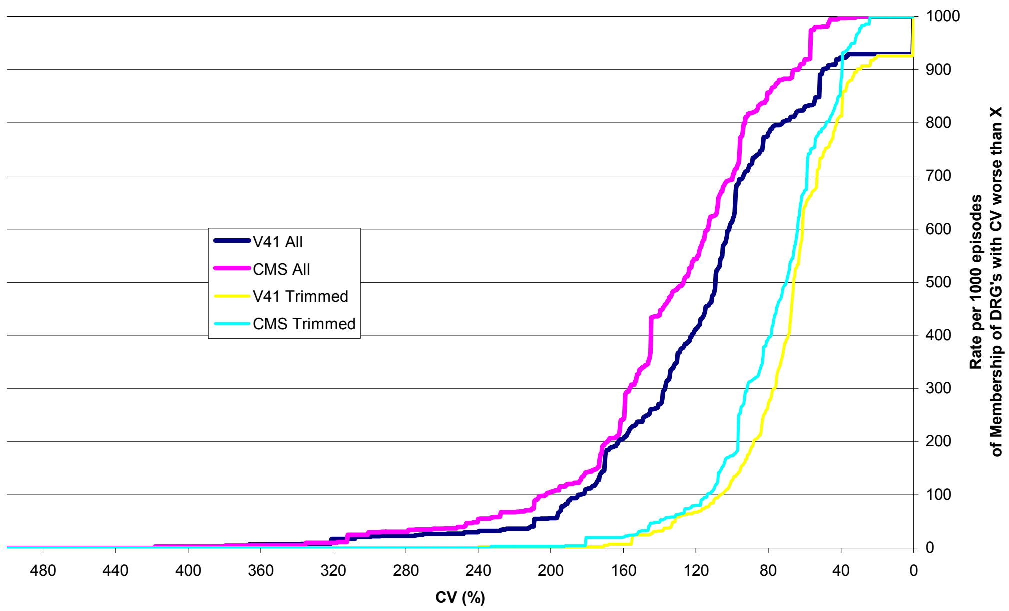
V41 vs AP Performance: Episodes in High CV DRGs - Day Cases Included



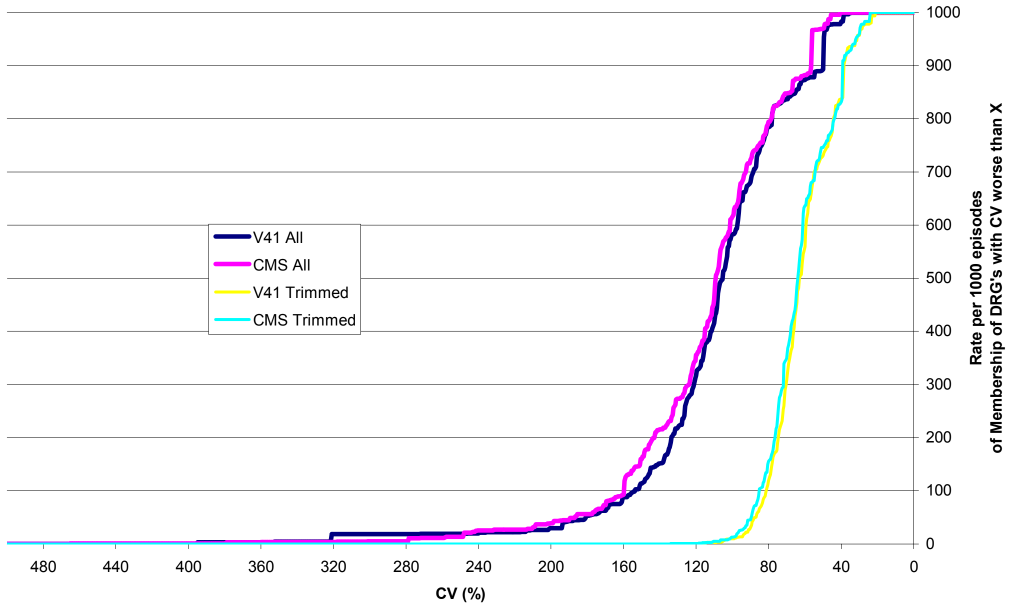
V41vs AP Performance: Episodes in High CV DRGs - Day Cases Excluded



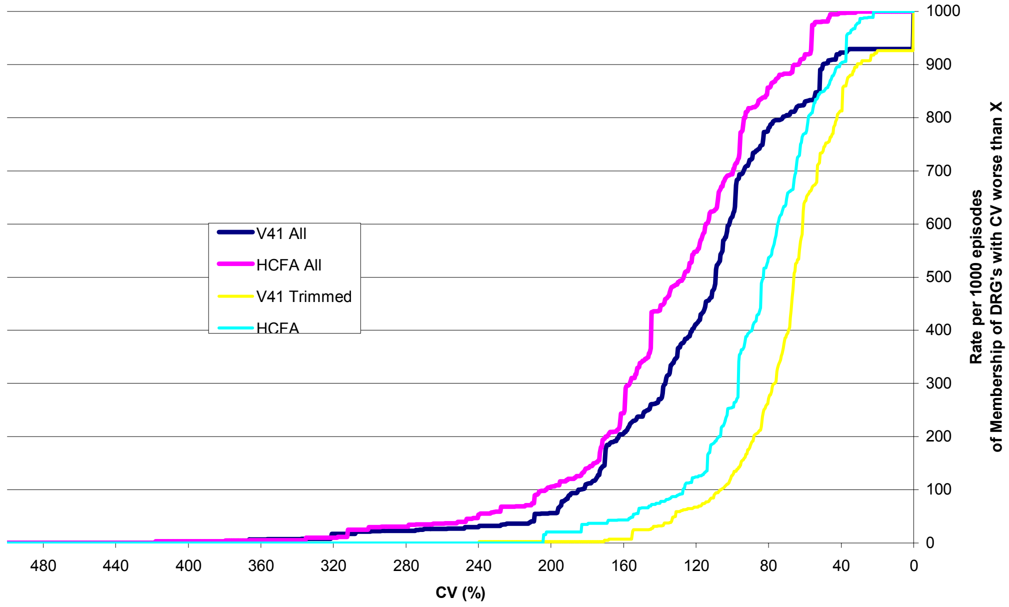
V41 vs CMS Performance: Episodes in High CV DRGs - Day Cases Included



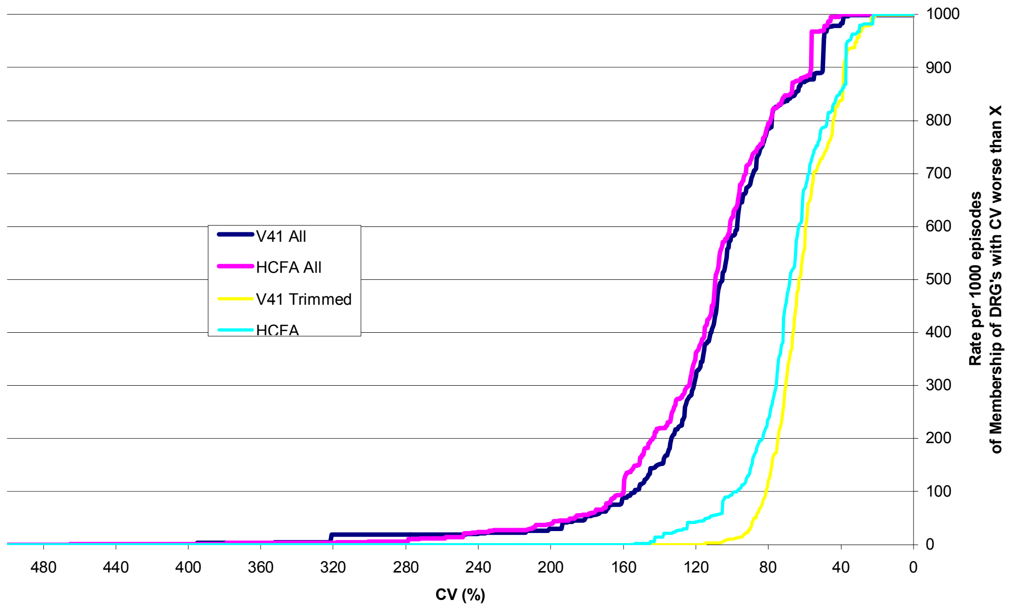
V41 vs CMS Performance: Episodes in High CV DRGs - Day Cases Excluded



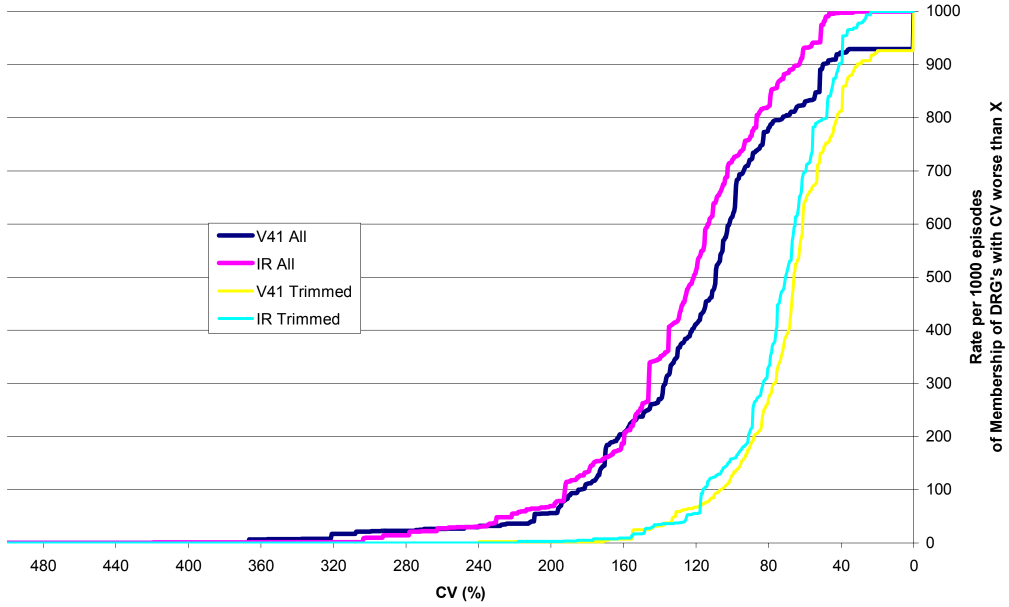
V41 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Included



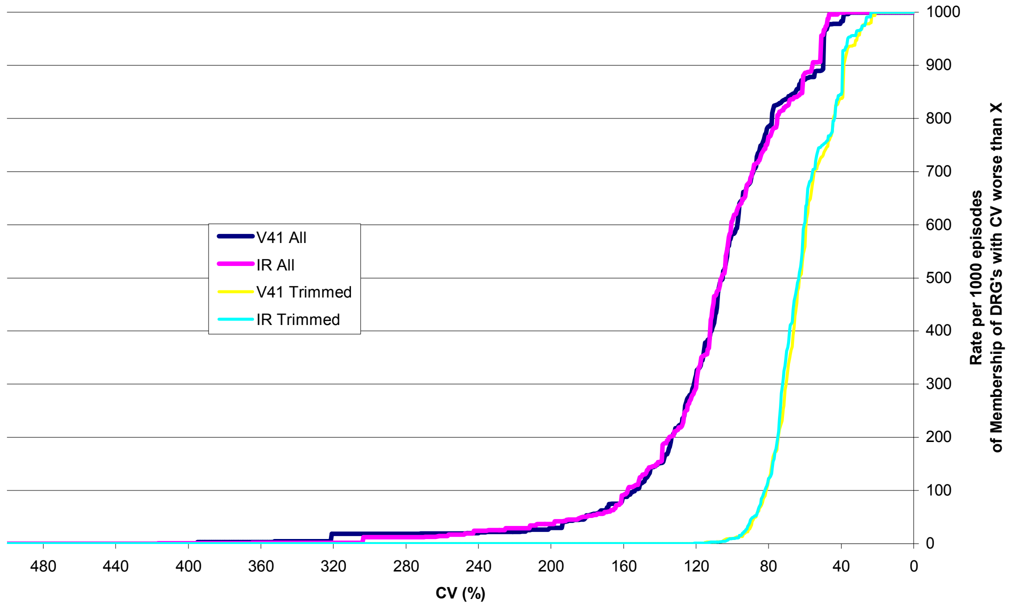
V41 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Excluded



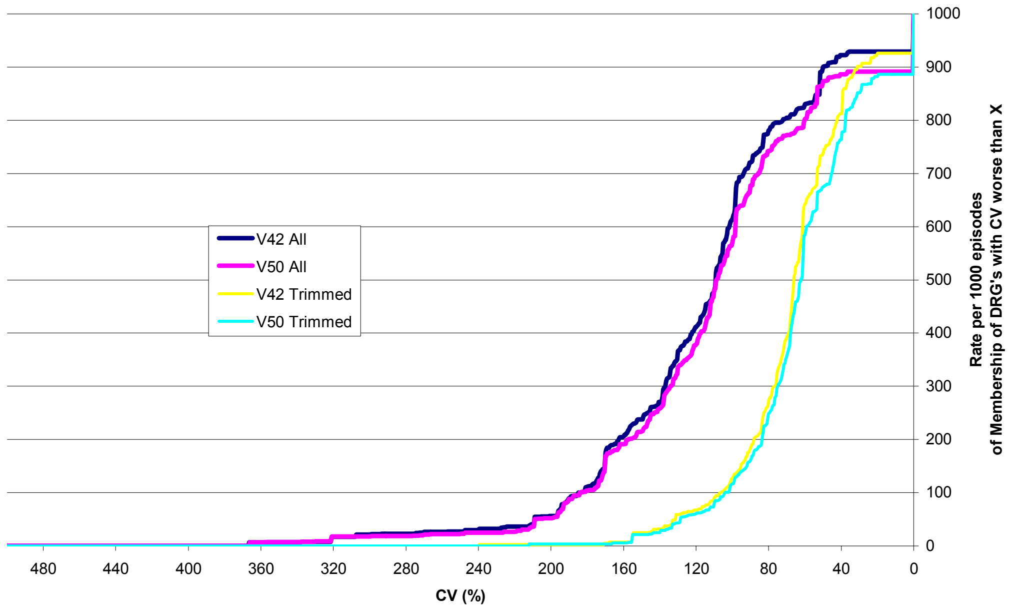
V41 vs IR Performance: Episodes in High CV DRGs - Day Cases Included



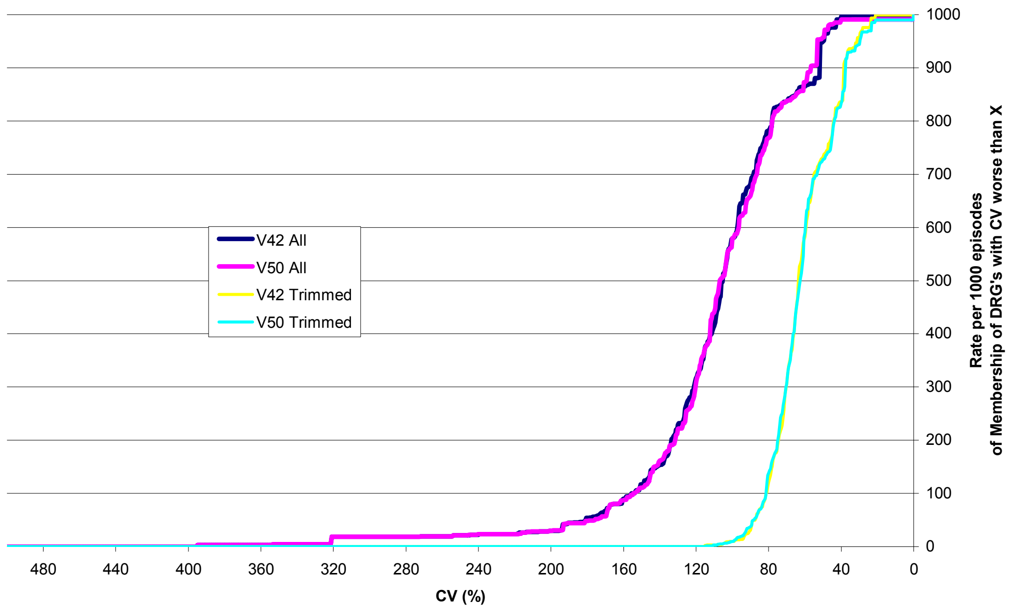
V41 vs IR Performance: Episodes in High CV DRGs - Day Cases Excluded



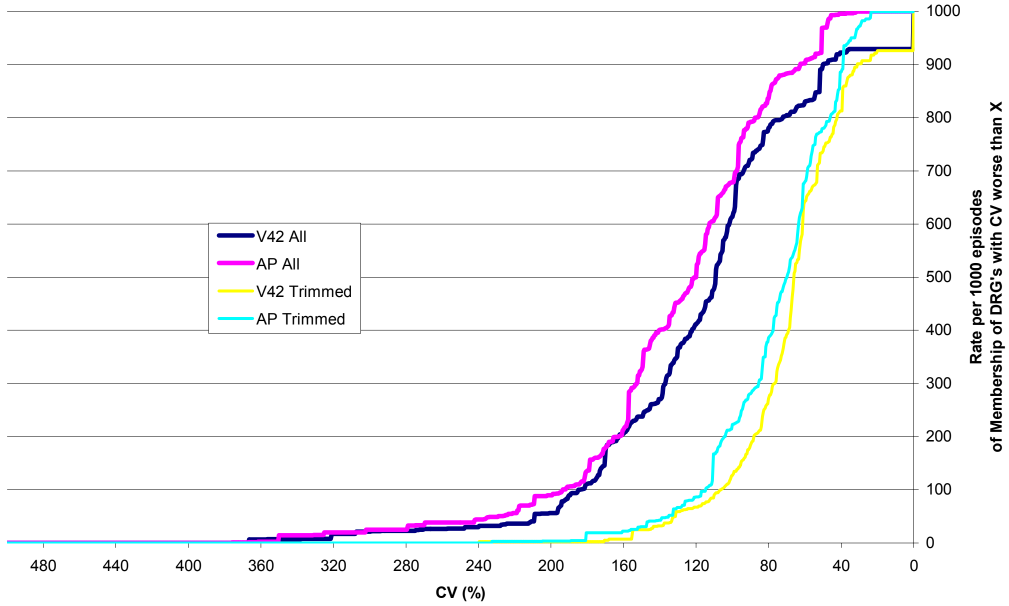
V42 vs V50 Performance: Episodes in High CV DRGs - Day Cases Included



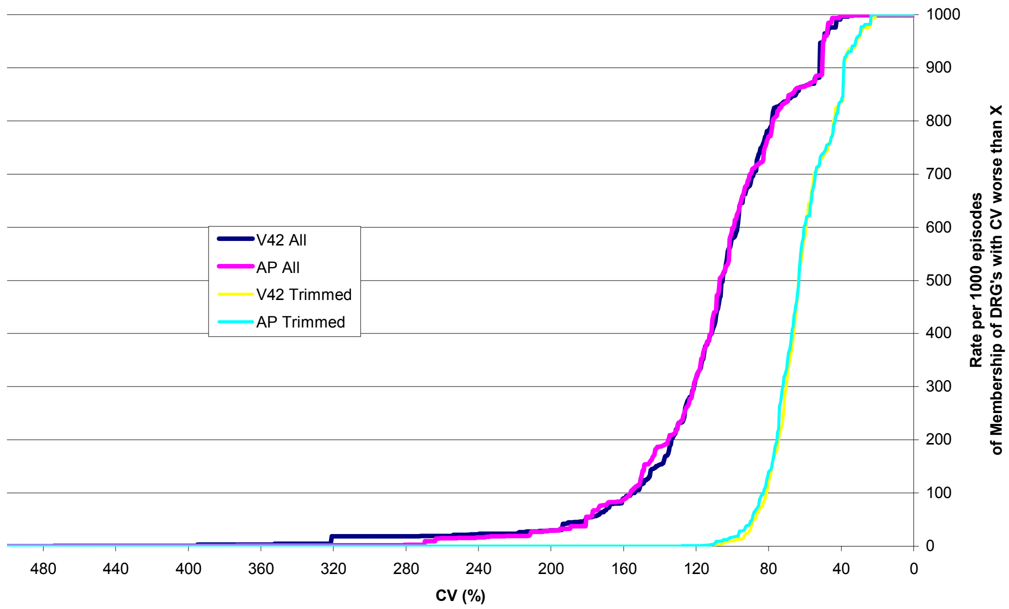
V42 vs V50 Performance: Episodes in High CV DRGs - Day Cases Excluded



V42 vs AP Performance: Episodes in High CV DRGs - Day Cases Included



V42 vs AP Performance: Episodes in High CV DRGs - Day Cases Excluded



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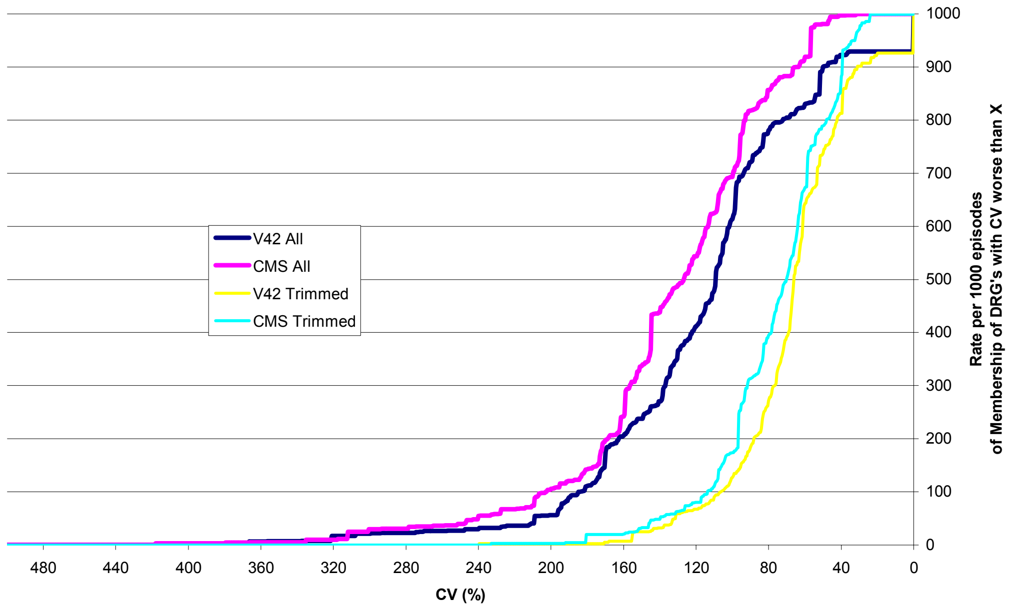
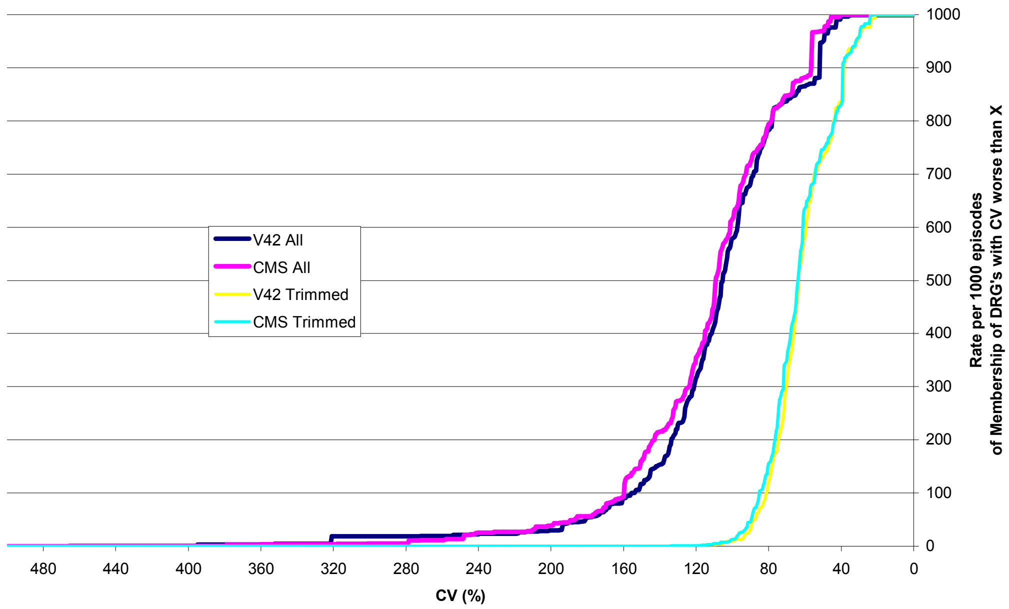
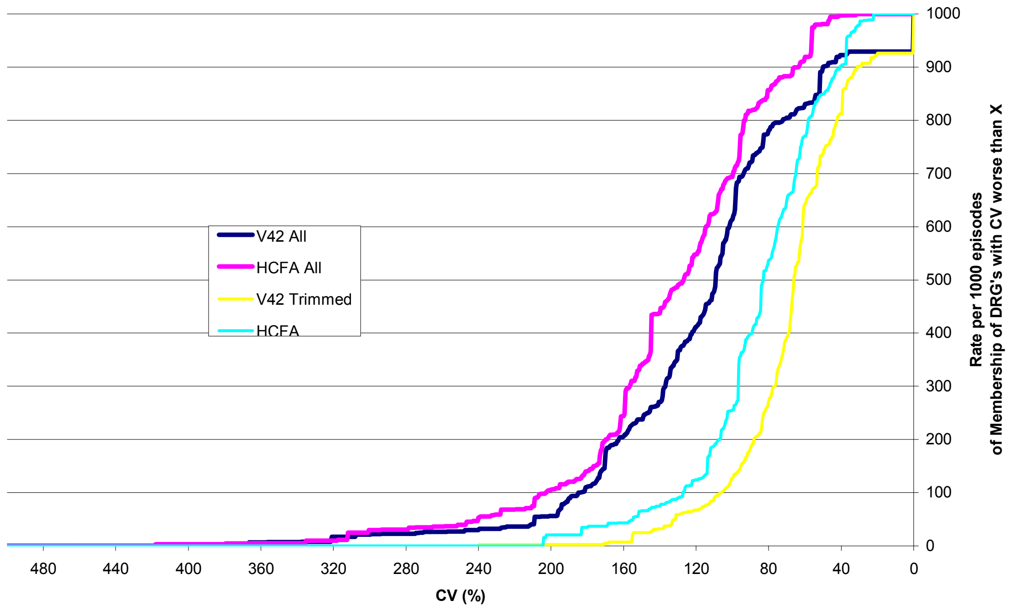


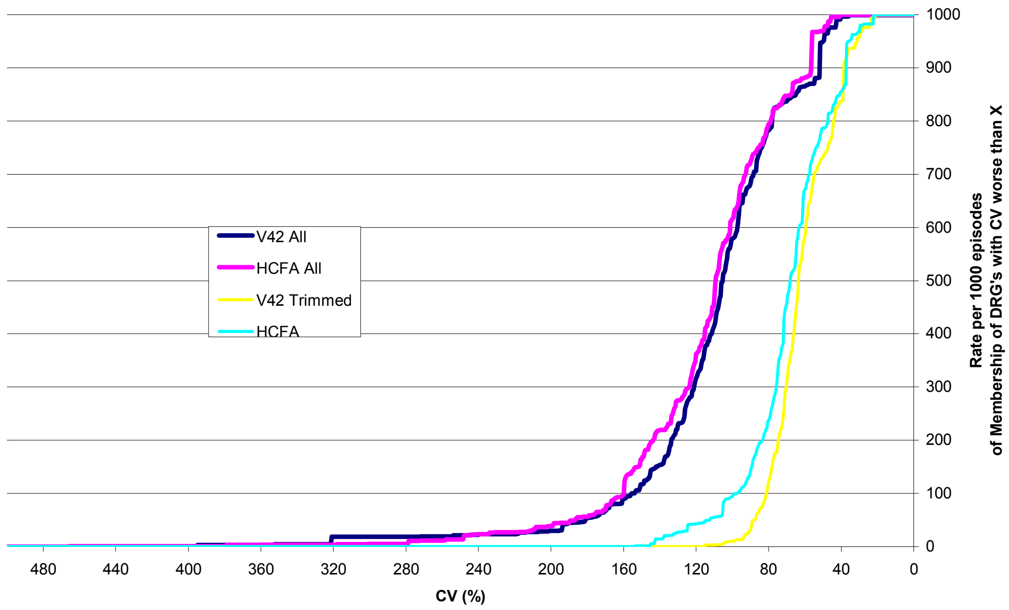
V42 vs CMS Performance: Episodes in High CV DRGs - Day Cases Excluded



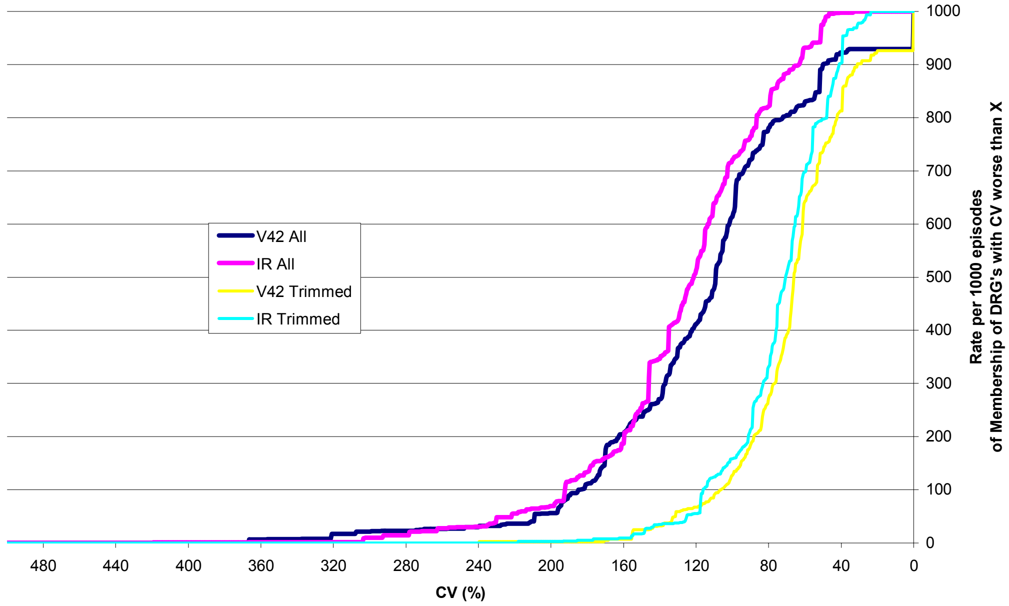
V42 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Included



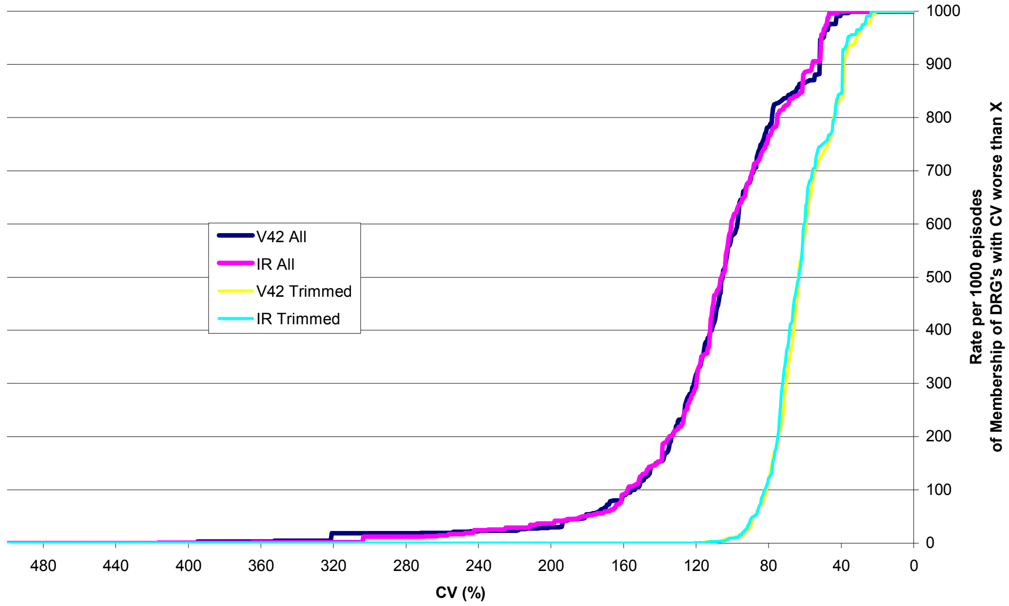
V42 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Excluded



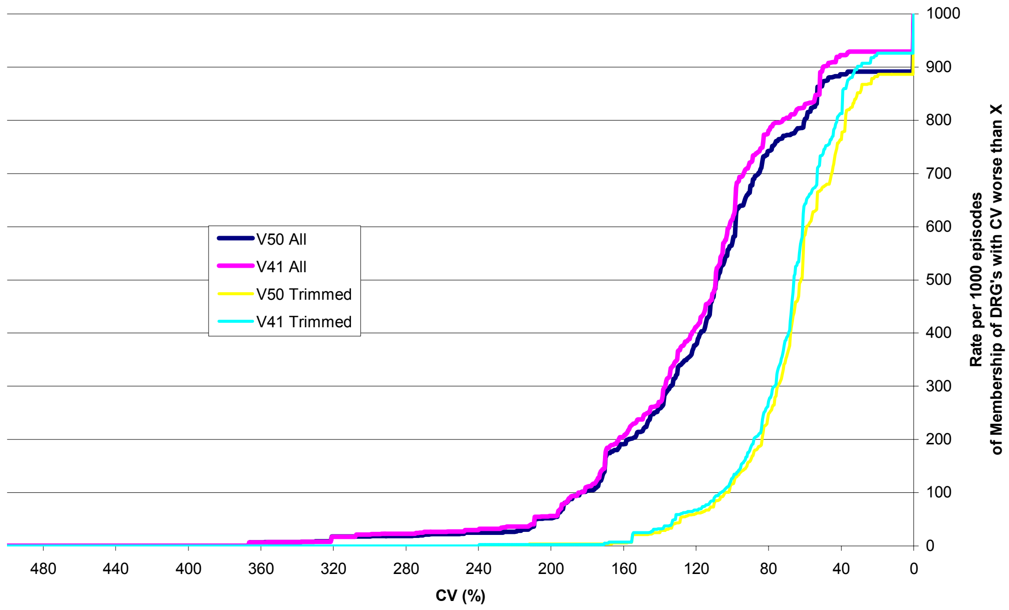
V42 vs IR Performance: Episodes in High CV DRGs - Day Cases Included



V42 vs IR Performance: Episodes in High CV DRGs - Day Cases Excluded



V50 vs V41 Performance: Episodes in High CV DRGs - Day Cases Included



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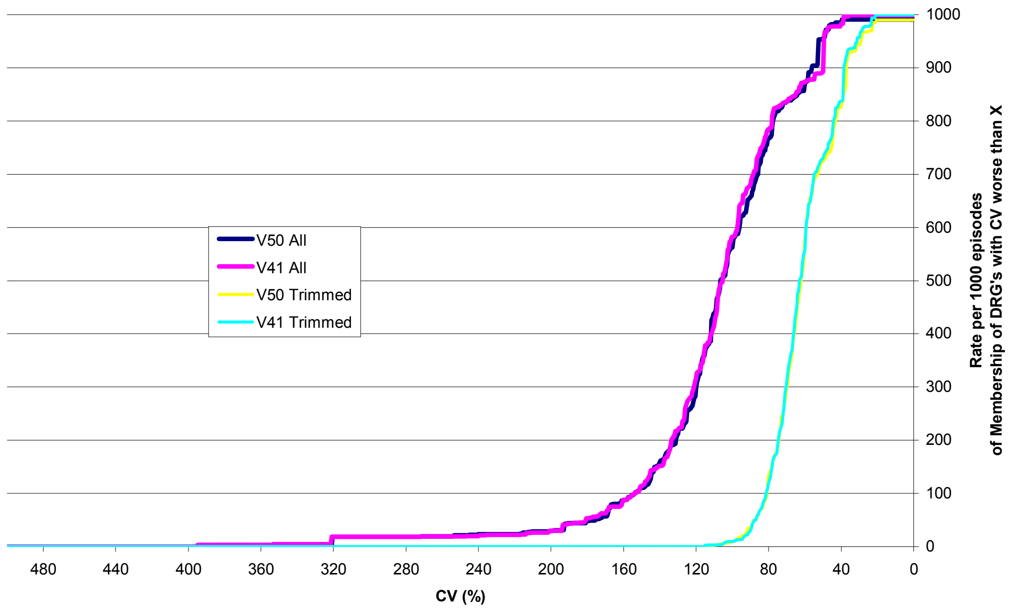
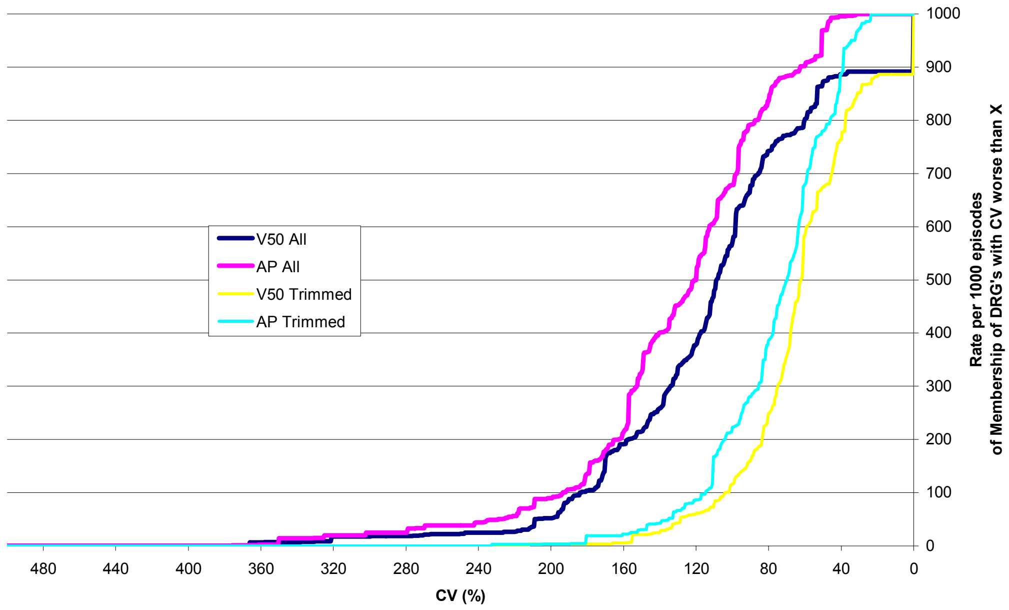


V50 vs AP Performance: Episodes in High CV DRGs - Day Cases Included



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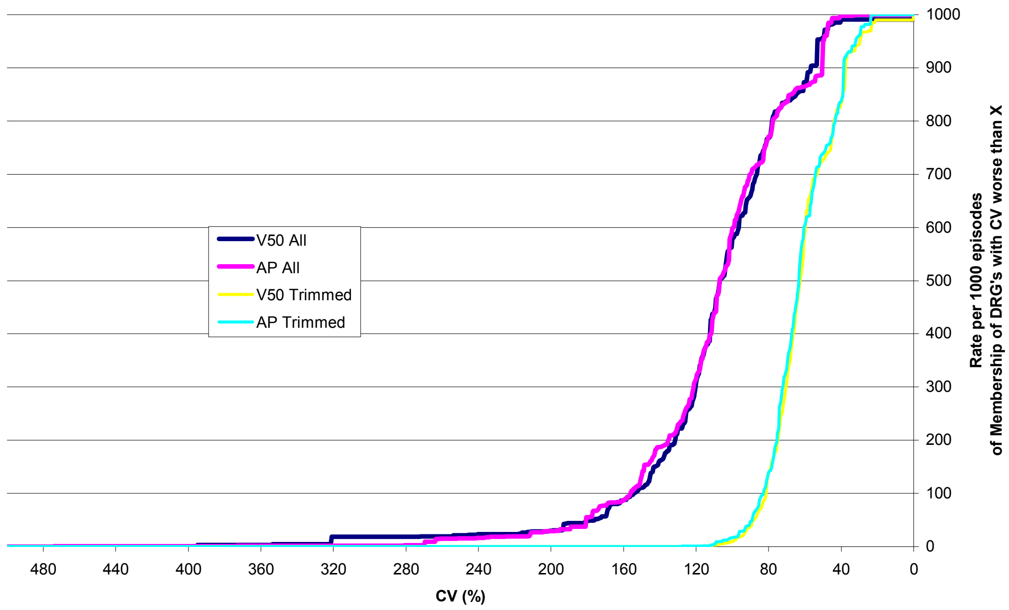
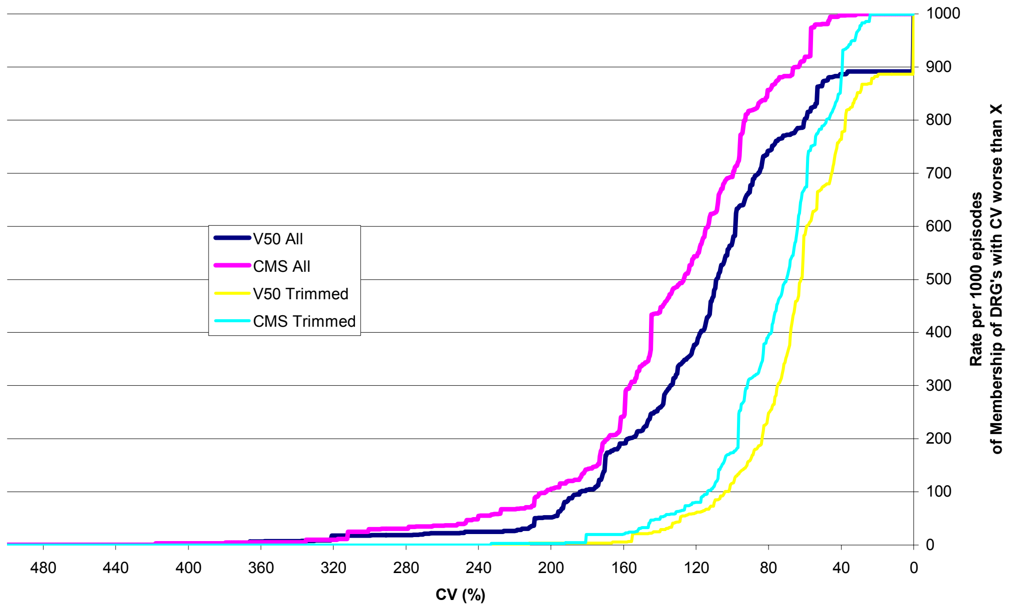


V50 vs CMS Performance: Episodes in High CV DRGs - Day Cases Included



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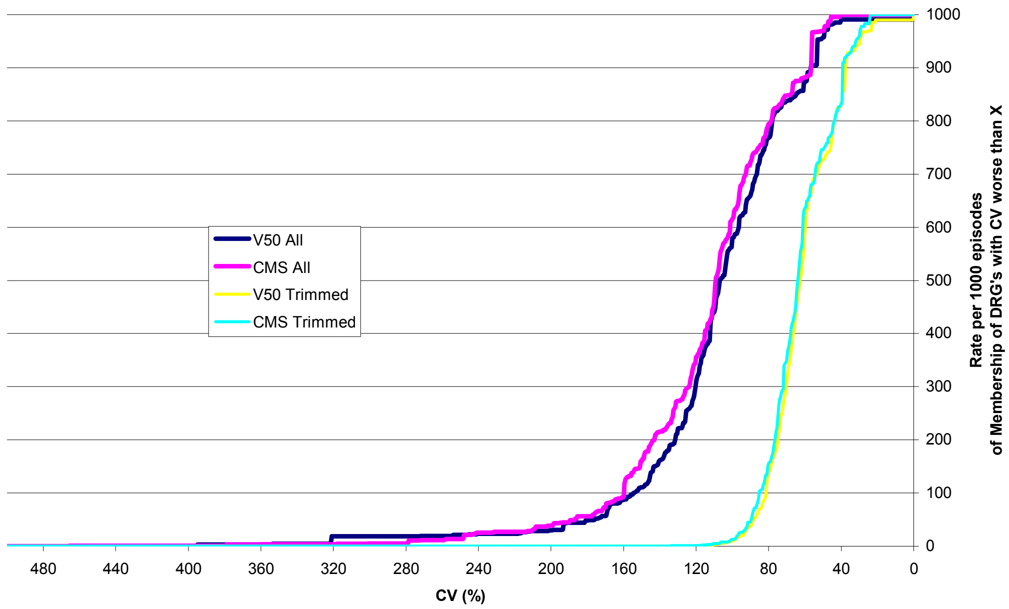
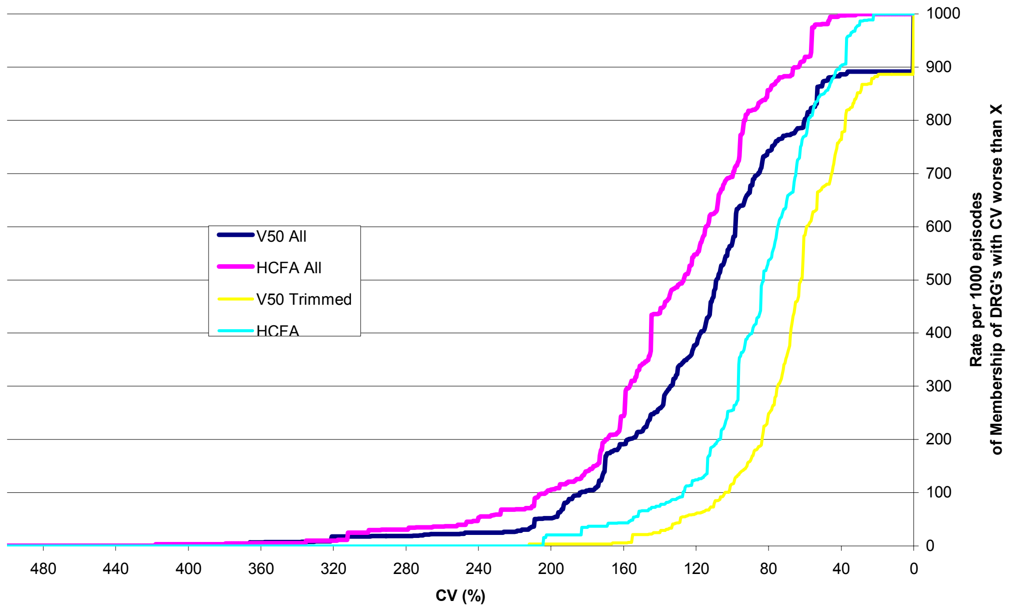


V50 vs HCFA Performance: Episodes in High CV DRGs - Day Cases Included



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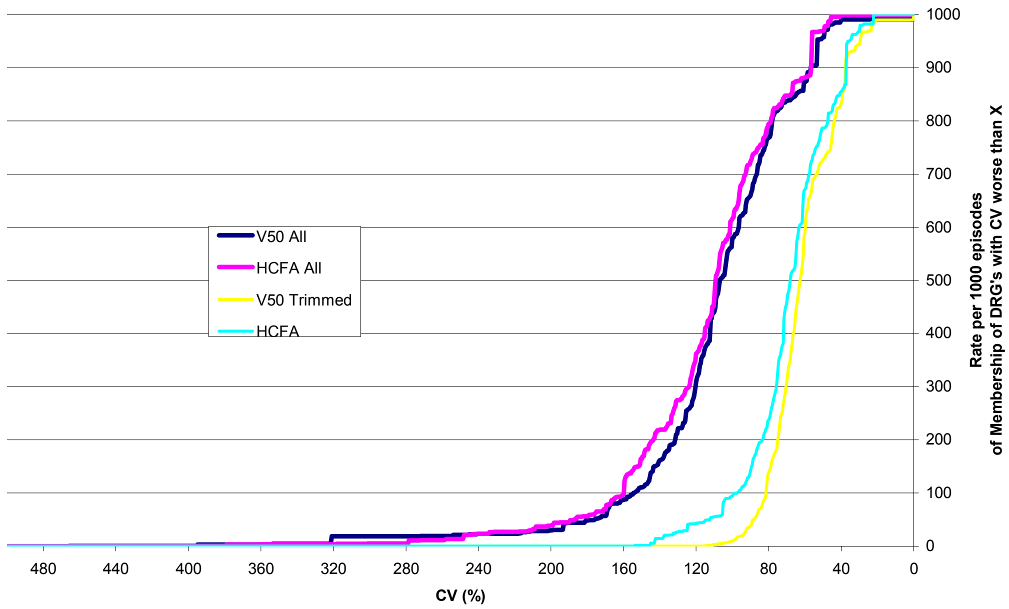
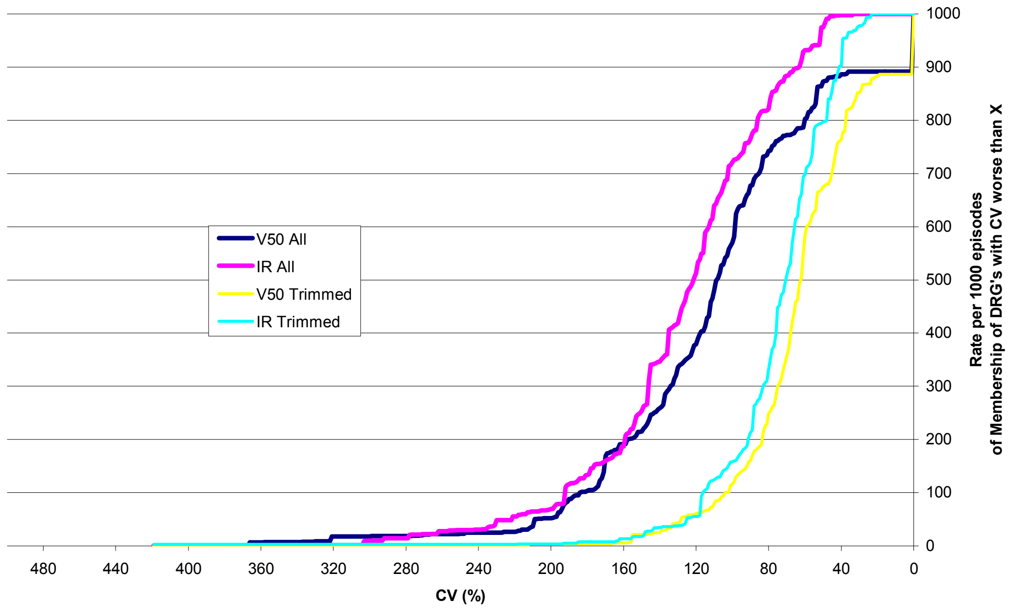
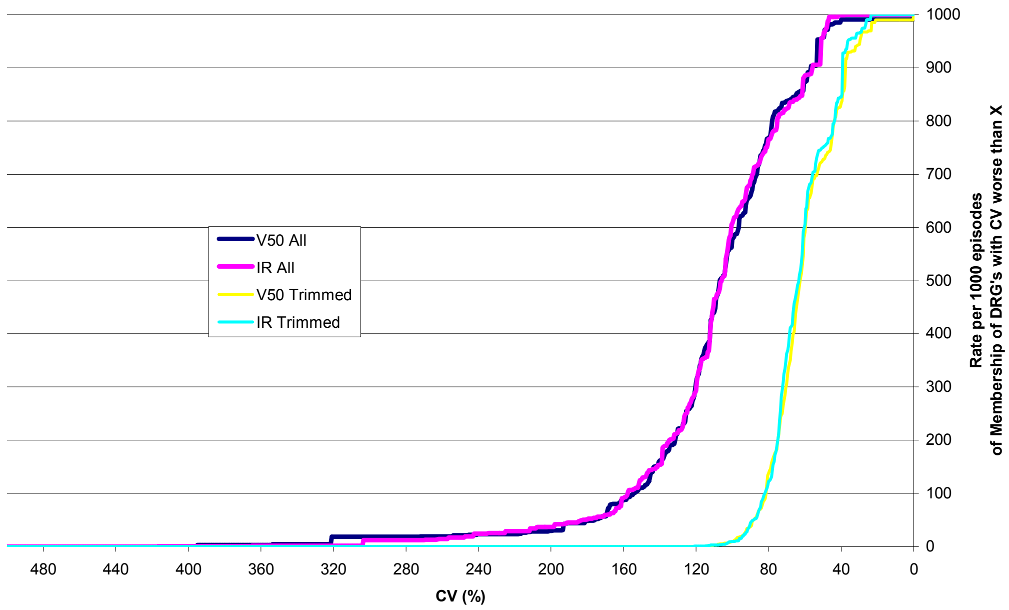


V50 vs IR Performance: Epidsodes in High CV DRGs - Day Cases Included



V50 vs IR Performance: Episodes in High CV DRGs - Day Cases Excluded



Year	Number	Title/Author(s) *ESRI Authors/Co-authors Italicised*
2007	191	The Impact of the EU-US Open Skies Agreement on International Travel and Carbon Dioxide Emissions *Karen Mayor* and *Richard S.J. Tol*
	190	Comparing the Travel Cost Method and the Contingent Valuation Method – An Application of Convergent Validity Theory to the Recreational Value of Irish Forests *Karen Mayor, Sue Scott, Richard S.J. Tol*
	189	The Impact of Flexible Working Arrangements on Work-Life Conflict and Work Pressure in Ireland *Helen Russell, Philip J. O'Connell* and *Frances McGinnity*
	188	The Housing Tenure of Immigrants in Ireland: Some Preliminary Analysis *David Duffy*
	187	The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers *Karen Mayor* and *Richard S.J. Tol*
	186	*Irish Sustainable Development Model (ISus)* Literature Review, Data Availability and Model Design *Joe O'Doherty, Karen Mayor, Richard S.J. Tol*
	185	Managing Term-Time Employment and Study in Ireland *Merike Darmody* and *Emer Smyth*
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	183	Real Interest Parity in the EU and the Consequences for Euro Area Membership: Panel Data Evidence, 1979-2005 *Martin O'Brien*
	182	Can Small Firms' Perceived Constraints Help Explain Survival Rates? *Seán Lyons*

181 Understanding the Implications of Choice of Deprivation Index for Measuring Consistent Poverty in Ireland
Christopher T. Whelan

180 Economics in Ireland
Frances Ruane and *Richard S.J. Tol*

179 Airline Emissions of Carbon Dioxide in the European Trading System
John Fitz Gerald and *Richard S.J. Tol*

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