Focus on Heart Attack in Pennsylvania

Research Methods and Results

The Pennsylvania Health Care Cost Containment Council
April 1996

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FOREWORD

The Pennsylvania Health Care Cost Containment Council (PHC4) is preparing its first focused report on heart attack (acute myocardial infarction or "AMI"). AMI was selected by the Council for the focus of this report at the urging of representatives from the Pennsylvania Medical Society, the Hospital Association of Pennsylvania, and the Pennsylvania Osteopathic Medical Association. This topic is of extreme interest to the residents of Pennsylvania because heart disease continues to be the leading cause of death in the Commonwealth. In particular, we hope that this report will encourage the public to be proactive in learning more about heart attack risk and to respond by modifying, when possible, risky behavior. The topic of AMI is also important to health care providers and purchasers because treatment for heart attacks is in a dynamic stage.

The report will use 1993 data and will display (1) risk-adjusted in-hospital mortality outcomes for hospitals, physician practice groups, and payor groups, and (2) risk-adjusted length of stay and case-mix adjusted average charge for hospitals and payor groups.

This document, *Research Methods and Results*, describes the process that the Council used in constructing the models to be used in predicting in-hospital mortality and length of stay and the results of that analysis. The methodology used in determining hospital average charge is discussed as well. In addition to this document, the Council prepared (1) the public report, entitled *Focus on Heart Attack*, which displays heart attack data by three regions in Pennsylvania (Western, Central and Northeastern, and Southeastern) and (2) the *Technical Report*, which provides more detailed data on heart attack patients in 1993 as well as the calculations used in applying the research results to the data in creating the public report.

Throughout this study, the Council made decisions in conjunction with its Technical Advisory Group (a standing committee charged with overseeing all technical and methodological aspects of the Council's research), its Clinical Advisory Panel (an ad hoc committee charged with assisting the Council in clinical and ICD.9.CM coding matters), as well as medical practitioners and researchers.

METHODOLOGY AND RESEARCH - *IN-HOSPITAL MORTALITY*

"Who" Will be Reported

- Hospitals
  (148 acute care hospitals; 41 acute care hospitals with advanced cardiac services)
- Physician practice groups with more than 30 cases
  (Not reported are: practice groups consisting entirely of cardiothoracic surgeons, regardless of number of cases; solo practitioners regardless of number of cases; practice groups with fewer than 30 cases. Individual physicians are not reported.)
- Payor groups
  (6 groups including: Medicaid, Medicare, Blue Cross, Commercial, HMO/PPO, and "Other Payors" which includes self payors (n=517), Health & Welfare Fund (n=26), Workmen's Compensation (n=60), other government programs (n=165), employer (n=60), associations (n=30), auto insurance (n=15).

"What" Will be Reported

- Actual in-hospital mortality
- Expected in-hospital mortality range *(risk-adjusted)*
- Notation if actual is significantly higher or lower than the expected range

(Note: the calculations used to determine the expected range and the test of significance are discussed in the Technical Report. This Research Methods & Results document is intended to provide information on the methodological approach used to determine significant predictors of in-hospital mortality.)

Study Population

Inclusion Criteria. The AMI study population has been defined by ICD.9.CM diagnosis codes and includes those cases meeting the following criteria:

- AMI as the **principal diagnosis and**
- AMI cases in an **initial episode of care**

The ICD.9.CM codes for an AMI as principal diagnosis/initial episode of care are: **410.01** or **410.11** or **410.21** or **410.31** or **410.41** or **410.51** or **410.61** or **410.71** or **410.81** or **410.91.** Cases having one of these codes as a principal diagnosis are included in the study.

Exclusion Criteria. Exclusion criteria were identified two ways. First, with assistance from its advisory groups, the Council identified exclusion criteria. Many of the cases meeting these criteria were automatically excluded from the study based on information contained in the patient record; others required a request and supporting documentation from the hospital or physician. Second, hospitals and physicians were given an opportunity to request that individual cases be excluded. The exclusion criteria are listed below.

- Hospitals which have closed since 1993
- Patients who left against medical advice
- Patients under age 30 and patients over age 99
- Hospitals which treated fewer than 30 AMI cases
- Patients involved in two or more transfers *(i.e., three or more different hospital records for the same episode of care)*
- Patients meeting "clinical complexity" criteria
  - anoxic brain damage upon admission *(request & supporting documentation from hospital/physician required)*
  - significant trauma upon admission *(request and supporting documentation from hospital/physician required)*
  - metastatic cancer *("automatic exclusion" based on the presence of one of the following ICD.9.CM diagnosis codes in the record: 196.x -199.x)*
  - heart transplants *("automatic exclusion" based on the presence of one of the following ICD.9.CM procedure codes in the record: 33.6, 37.5)*

Table 1. Exclusions from analysis

	Cases		Mortality
	number	*percent*	*percent*
Total cases *before* exclusions	40,684	100.0	10.4
Exclusions:			
patients in hospitals which closed since 1993	266	0.7	9.8
patients who left against medical advice/refused treatment	256	0.6	0.8
patients under age 30	67	0.2	3.0
patients over age 99	16	< 0.1	56.3
patients meeting "clinical complexity" criteria	507	1.2	57.2
anoxic brain damage	*(236)*	*(0.6)*	*(89.0)*
metastatic cancer	*(265)*	*(0.6)*	*(29.4)*
significant trauma	*(7)*	*(<0.1)*	*(57.1)*
heart transplants	*(3)*	*(<0.1)*	*(0.0)*
patients where AMI was not principal diagnosis‡	*(7)*	*(<0.1)*	*(85.7)*
patients involved in two or more transfers	123	0.3	3.3
patients in hospitals treating fewer than 30 AMI cases	182	0.4	11.0
Total Exclusions:	1,428	3.5	25.3
Total cases remaining in study	39,256	96.5	9.9

‡ A review of individual requests for exclusions resulted in the decision that these were not AMI cases.

Candidate Variables Tested as Possible Risk-Adjustment Factors to In-hospital Mortality

The candidate variables listed below were tested as possible predictors of in-hospital mortality during the Council's model development research. In identifying possible risk-adjustment factors to in-hospital mortality, the Council considered factors identified in the literature--taking into account the availability and usability of the variables in its data base--and sought advice from its Technical Advisory Group and its Clinical Advisory Panel as well as from the comments received following release of the draft *Research Plan*. In addition to testing MediQual's *Atlas*™ Admission Severity Group as a potential risk-adjustment factor, the Council independently analyzed 19 additional variables separate and apart from MediQual's index. The specific ICD.9.CM codes used to define these conditions are noted in parentheses. All codes are diagnosis codes, unless otherwise stated.

Each of these variables were initially examined at the individual ICD.9.CM code level, and where the number of cases in a particular category was small, categories were collapsed based on similar mortality rates. A final minimum cell size assessment was done prior to building the regression models (discussed later under "Modeling Approach - Data Preparation").

Admission Severity Group

Atlas™ Admission Severity Group (ASG) is *one of 20* candidate variables that the Council tested as possible risk-adjustment factors. It represents a summarization of patient risk based on clinical data found in the medical record. (More detailed information is included in the *Research Plan*.) ASG is defined as:

0 *(no risk of clinical instability)*
1 *(minimal risk of clinical instability)*
2 *(moderate risk of clinical instability)*
3 *(severe risk of clinical instability)*
4 *(maximal risk of clinical instability)*

Admission Source

1 = *physician referral*
2 = *transfer in from general acute care hospital*
3 = *transfer in from skilled nursing facility*
4 = *transfer in from other health care facility (e.g., rehabilitation, psychiatric)*
5 = *emergency room*
6 = *other (clinic referral, HMO referral, court/law enforcement)*

Note: Admission source was not tested for the in-hospital mortality "transfer-in" model, which is described later in this document under "Modeling Approach."

Admission Type

1 = *emergency/urgent*
2 = *elective*

Age

Age was tested as a continuous variable.

Age Squared

In addition to testing age as a possible risk-adjustment factor, the Council tested age squared.

Cardiac Dysrhythmias

0 = *no cardiac dysrhythmias*
1 = *premature beats (427.6)*
2 = *cardiac dysrhythmia, unspecified (427.9)*
3 = *other specified cardiac dysrhythmias (427.8)*
4 = *paroxysmal tachycardia (427.0, 427.1, 427.2)*
5 = *atrial fibrillation and/or flutter (427.3)*
6 = *ventricular fibrillation and/or flutter (427.4)*

Note: Code 427.5 (cardiac arrest) was not tested because coding rules prohibit the capturing of all relevant cases.

Cardiogenic Shock

0 = *no cardiogenic shock*
1 = *cardiogenic shock (785.51)*

Cardiomyopathy

0 = *no cardiomyopathy*
1 = *cardiomyopathy (425.3, 425.4, 425.8, 425.9)*

Conduction Disorders

0 = *no conduction disorders*
1 = *left bundle branch hemiblock /other left bundle branch block (426.2, 426.3)*
2 = *A-V block, other & unspecified (426.1x)*
3 = *right bundle branch block; bundle branch block, other and unspecified; other heart block (426.4, 426.5, 426.6)*
4 = *unspecified conduction disorder (426.9)*
5 = *A-V block, complete (426.0)*
6 = *other specified conduction disorders (426.8)*

Note: Code 426.7 (anomalous atrioventricular excitation) was not tested because there were only a few cases and none died.

Diabetes

0 = *no diabetes*
1 = *diabetes without complications (250.00 - 250.03)*
2 = *diabetes with complications (250.10 - 250.93)*

Note: ICD.9.CM codes for diabetes changed during the fourth quarter of 1993. The above codes reflect that change, and data were verified to be consistent with this change.

Dialysis

0 = *no dialysis*
1 = *dialysis* (procedure codes 39.95 or 54.98 or diagnosis codes v56.0 or v56.8)

Gender

0 = *male*
1 = *female*

Heart Failure

0 = *no heart failure*
1 = *heart failure, including:*
congestive heart failure (398.91, 428.0)
left heart failure (428.1)
unspecified heart failure (428.9)

Note: Following the advice of the Clinical Advisory Panel and in accordance with coding guidelines, for those cases having one of the above heart failure codes ***and*** a hypertension with congestive heart failure code (402.x1, 404.x1, 404.x3) in the record, only the "hypertension" code was used.

Hypertension *with* Complications

0 = *no hypertension with complications*
1 = *hypertension with complications including:*
hyper heart disease w/ chf (402.x1)
hyper renal disease w/ renal failure (403.x1)
hyper heart & renal disease w/ chf (404.x1)
hyper heart & renal disease w/ renal failure (404.x2)
hyper heart & renal disease w/ chf & renal failure (404.x3)
secondary hypertension (405.x)

Hypertension *without* Complications

0 = *no hypertension without complications*
1 = *hypertension without complications including:*
hyper heart disease w/o chf (402.x0)
hyper renal disease w/o renal failure (403.x0)
hyper heart & renal disease w/o chf or renal failure (404.x0)

Infarct Site

The fourth digit of the AMI ICD.9.CM code in the principal diagnosis position (410.**X**x) was used to identify infarct site.

0 = *anterolateral wall (410.**0**1)*
1 = *other anterior wall (410.**1**1)*
2 = *inferolateral wall* (410.**2**1)
3 = *inferoposterior wall (410.**3**1)*
4 = *other inferior wall (410.**4**1)*
5 = *other lateral wall (410.**5**1)*
6 = *true posterior wall (410.**6**1)*
7 = *subendocardial (non Q-wave) (410.**7**1)*
8 = *other specified sites (410.**8**1)*
9 = *unspecified site (410.**9**1)*

Malignant Neoplasm

Nonmetastatic malignant neoplasm was tested as a potential risk factor. (Metastatic cancer cases were excluded from the study under the rubric of "clinical complexity.")

0 = *no malignant neoplasm*
1 = *malignant neoplasm (140.x - 208.90 except 196.x-199.x)*

Payor

In the absence of data on "social factors," payor was tested as a "surrogate" recognizing its limitations.

1 = *self*
2 = *Medicaid (includes Medicaid HMO)*
3 = *Medicare (includes Medicare HMO)*
4 = *Blue Cross*
5 = *commercial*
6 = *HMO/PPO (including Blue Cross & other)*
7 = *other payors (including Health & Welfare Fund, workmen's compensation, other government program, employer, associations, auto insurance)*

Prior CABG Surgery

0 = *no previous CABG surgery*
1 = *previous CABG surgery (v45.81 or 996.03)*

Renal Failure

0 = *no renal failure*
1 = *chronic renal failure (585.0)*
2 = *unspecified renal failure (586.0)*
3 = *acute renal failure (584.5 - 584.9)*

Modeling Approach

Model Assignment

Transfer cases. The issue of how to handle transfer cases in the 1993 AMI report--both in terms of the research for determining risk factors and in the public reporting of these cases--has received substantial attention by Council staff and Council advisory groups. Because transfer cases comprise a substantial number of all AMI hospitalizations in this study, it was important for the Council to develop an approach that would include transfer cases and yet maintain an accurate portrayal of the care and risk of these patients.

One task that was particularly important to the "transfer" issue is the "linking" of cases that were transferred from one general acute care facility to another. A "link" was determined by an exact match on Social Security Number, gender, birthdate, whether the discharge date of one hospital matched the admit date of a second hospital, and whether the discharge status of the first and the admit source of the second indicated a general acute care transfer. Some flexibility was given to slight birthdate and discharge status/admit source inconsistencies.

Using the AMI data set (a subset of the entire data base), Council staff was able to link approximately 54 percent of the cases that were transferred out to another general acute care facility. Under the assumption that at least a portion of the missing 46 percent were coded as something other than an AMI at the receiving hospital, the entire data base that includes *all hospitalizations* (approximately 2 million records) was searched for these cases. Links were found for an additional 28 percent of the transfer-out cases, resulting in the Council's ability to link--and therefore have outcome information for--a total of approximately 82 percent of the cases that were transferred out. (The discharge status was the only data element verified and used from the linked records found in the "2 million record data base" and it was only used for the county/community analysis). The 18 percent of the transfer out cases that could *not* be "linked" (1,541 cases) likely stem from: transfers to out-of-state hospitals or transfers to VA hospitals (data that are unavailable to the Council), inaccurate coding, or cases that were transferred out in 1993 but not discharged until 1994 (the record for the receiving hospital for such cases would not be in our 1993 data set).

Unit of study. *Hospitalizations* was the unit of study when conducting the research to determine risk factors. Each record was included as a separate entity; i.e., transfer-in/out cases were counted in each of their respective hospitals. The Council originally considered examining "episodes of care" as the unit of study where an episode is defined as the entire course of treatment independent of how often a patient is transferred from one general acute care facility to another. The complexity of such an approach, however, in assigning outcome information to individual hospitals led us to choose hospitalizations as the unit of study. In addition to being able to report outcome information at the individual hospital level, there are several other advantages to using hospitalizations as the unit of study: (1) sending hospitals are given "credit" for keeping their transferred-out patients alive (the average length of stay for these patients is 4.5 days); (2) receiving hospitals with a substantial number of transfer-in cases would not be adversely affected (some of these hospitals transferred-in as much as 80% of their cases); and (3) unlike the "episode" approach where we would have, for transfer patients, two sets of risk factors, looking at hospitalizations as the unit of study allows us to look at only one set of risk factors for each

patient. The disadvantage of using hospitalizations is that we do not know the eventual outcome for the transfer-out patients at the end of their episode of care.

Modeling in-hospital mortality. The Council and its advisory groups struggled with the best way to model in-hospital mortality given the transfer patients in the study. One particular issue involved whether we define patients at their point of entry into an acute care setting (as was done in the two-model approach that was ultimately used and described below) or at the time of discharge (as was done in a three-model approach that the Council originally examined: one for transfer-out cases, one for transfer-in cases, and one for cases that remained in one hospital throughout their entire episode of care.) The two-model approach was ultimately chosen by the Council and its advisory groups because we believed that patients in their initial period of care for a heart attack, as a group, are similar upon entry into an acute care setting (independent of discharge status). Further, this approach more accurately predicted death when death actually occurred.

In-hospital mortality "two-model" approach. The focus of this approach depends on whether the patient is a "direct admit" or a "transfer-in." Two models were built:

- "*Direct admits*." This model included those patients that were in their initial period of care for a heart attack. Direct admits are those patients who were not transferred in from another general acute care facility so they received no prior acute care for their heart attack (although some were transferred from a skilled nursing or other health care facility such as psychiatric or rehabilitation). Some of these patients received all of their care in this initial hospital, while others were transferred out to another general acute care facility. (Although "linking" tells us whether transfer-out cases ultimately died at the second hospital, all transfer-out cases will be counted as lived because we are looking here at individual *hospitalizations*, not entire episodes of care.)
- "*Transfer-ins*." This model included those patients that were "transferred-in" to a general acute care facility (i.e., those who received prior care at an acute care hospital).

There were 492 cases that were not included in the modeling of in-hospital mortality:

354 records in four hospitals that were excluded from the research because of data integrity concerns. The first three hospitals listed below had excessively high numbers of ASG 0 cases with high mortality for these cases. The last one had an excessively high number of left/unspecified heart failure cases with no mortality for these cases (although we did not have corrected data from this hospital in time for modeling, we did receive the corrected data in time for the public report).

- Shamokin Area Community Hospital (n = 97)
- North Philadelphia Health System (n = 50)
- Medical College Hospital/Elkins Park (n=102)
- Brandywine Hospital (n = 105)

138 records that were transferred *in* to a general acute care hospital but for which no first and/or last record could be found. These cases were counted as transfer in cases in the public report

Data Preparation

After cases to be excluded from analysis were removed and after each case was assigned to its appropriate model, the cases for a given model were randomly split into two equal-size samples. Sample I is the development sample; Sample II is the cross validation sample. The number of cases and number of mortalities are shown below.

Table 2. Case counts and mortality by sample

Direct Admit Model			
	Sample I	**Sample II**	**Total**
Number of Cases	15,358	15,357	30,715
Number of Deaths	1,653	1,605	3,258
Mortality Rate	10.8%	10.5%	10.6%
Transfer-in Model			
	Sample I	**Sample II**	**Total**
Number of Cases	4,024	4,025	8,049
Number of Deaths	305	286	591
Mortality Rate	7.6%	7.1%	7.3%

Minimum Cell Size Assessment. The volume of cases in each candidate variable category was examined for minimum cell size assessment. (Five expected cases in the "transfer-in" model was used as a guide; however, if the variable had a large number of categories or if the number of total cases was small, some flexibility was used in determining a cut-off point.) Variable categories that met minimum cell size were considered to have sufficient volume to be considered in the backwards stepwise logistic regression analysis.

If the volume criteria was not met, mortality was evaluated to determine whether the variable (or variable category) should be considered despite its low volume. If a variable (or variable category) appeared to be highly correlated to mortality, it was retained for analysis. If a category of a categorical variable did not meet the volume or mortality criteria, it was combined with another category of similar mortality (based on either the relevant model or the total data) or with the next lowest category in the case of an ordered categorical variable.

Results of Minimum Cell Size Assessment. Following is a list of the variable categories that were collapsed following minimum cell size assessment. Collapses were kept the same across both models so that candidate variable categories would remain constant for each model.

- The "ASG 0" category was collapsed into "ASG 1"
  (Three cases that were missing ASGs were also folded into this category.)

- The "conduction disorder, unspecified" category was collapsed into the "right & other bundle branch block/other heart block category."

- The "left/unspecified heart failure" category was collapsed into the "congestive heart failure" category.

- The "self payor" category was collapsed into the "other payor" category.

- The "unspecified renal failure" category was collapsed into the "acute renal failure" category.

Appendix A contains frequency of occurrence and percent mortality data for each of the candidate variables before minimum cell size assessment (i.e., before variables were collapsed). Appendix A contains two tables: one for the direct admit model and a second for the transfer-in model.

Construction of the Mortality Regression Models

For each of the two models, two backwards stepwise logistic regression models were constructed using Sample I. The p-value needed for a variable to be retained in the model was changed for each regression model (the p-values used were p = 0.05, and p = 0.10), resulting in a total of four models:

- Direct Admit Model p = 0.05 & p = 0.10
- Transfer-in Model p = 0.05 & p = 0.10

All tests of significance were based on the likelihood ratio.

The probability values (p-values) of the variables included in each regression model are shown below. For a variable to be listed, it had to be significant in either model.

Table 3. Probability values for each significant variable by model (Sample I)

	Direct Admits		**Transfer-ins**	
	p = .05 model	p = .10 model	p = .05 model	p = .10 model
Variable	p-value	p-value	p-value	p-value
Atlas™ ASG	.0000	.0000	.0000	.0000
Age	.0000	.0000		
Age Squared			.0003	.0013
Cardiac Dysrhythmias	.0000	.0000	.0000	.0000
Cardiogenic Shock	.0000	.0000	.0000	.0000
Cardiomyopathy	.0157	.0157		
Conduction Disorders	.0000	.0000		
Diabetes	.0119	.0119		
Dialysis	.0047	.0047	.0199	.0223
Gender	.0185	.0185		.0358
Heart Failure				.0954
Infarct Site	.0000	.0000	.0006	.0002
Prior CABG Surgery	.0407	.0407		.0456
Renal Failure	.0000	.0000	.0000	.0000

Blanks indicate that the variable was not significant for that model at the given p-value.

Cross Validation of the Mortality Regression Models

Re-estimation of Coefficients

The first step in the cross validation was to re-estimate the models built in the initial regressions, using only the variables that were significant in Sample I, to determine which factors remain significant (with respect to the p-value used for the model) in Sample II. The result of this step of the cross validation is shown below.

Table 4. Probability values for each significant variable by model (Samples I & II)

	Direct Admit				**Transfer-in**			
	p = .05		p = .10		p = .05		p = .10	
Variable	I	II	I	II	I	II	I	II
Atlas™ ASG	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Age	.0000	.0000	.0000	.0000				
Age Squared					.0003	.0000	.0013	.0000
Cardiac Dysrhythmias	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Cardiogenic Shock	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Cardiomyopathy	.0157	.6141	.0157	.6141				
Conduction Disorders	.0000	.0000	.0000	.0000				
Diabetes	.0119	.2436	.0119	.2436				
Dialysis	.0047	.0865	.0047	.0865	.0199	.0103	.0223	.0251
Gender	.0185	.5519	.0185	.5519			.0358	.0430
Heart Failure							.0954	.0008
Infarct Site	.0000	.0000	.0000	.0000	.0006	.1147	.0002	.1484
Prior CABG Surgery	.0407	.0626	.0407	.0626			.0456	.0443
Renal Failure	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

Blanks indicate that the variable was not significant for that model at the given p-value.

Direct Model Summary (from Table 4). Twelve variables were significant in the "Direct Admit" p = .10 and p = .05 models (these two models were identical). Of these 12 variables, five did not cross validate in the p = .05 model (cardiomyopathy, diabetes, dialysis, gender, and prior CABG surgery had p-values less than .05 in Sample I but greater than .05 in Sample II). Three variables did not cross validate in the p = .10 model (the p-values for cardiomyopathy, diabetes, and gender are less than .10 in Sample I but greater than .10 in Sample II).

Transfer-in Model Summary (from Table 4). Seven variables were significant in the "Transfer-in" p = .05 model, and ten variables were significant in the p = .10 model. Of these significant variables, only infarct site did not cross validate (i.e., for the p = .05 model, Sample II p-value of .1147 is greater than .05, and for the p = .10 model, Sample II p-value of .1484 is greater than .10).

Measures of Model Adequacy

For the second step in the cross validation process, the estimated coefficients from Sample I were applied to both Sample I and Sample II. The objective was to evaluate each model's performance in both Sample I and Sample II. The following measures were considered in evaluating a model's performance:

Percentage Explained: This term is used to refer to the percentage of the total (-2 log likelihood) attributable to the estimated model. (The "total" comes from a model containing only a constant and no risk factors.) *Range: 0% to 100%*

R-squared: Coefficient of Determination (R^2) refers to the percentage of the total variability among mortality responses (1 = died, 0 = discharged alive) for the patients in the sample that can be explained by the estimated model involving the specified risk factors. If no risk factors were considered in estimating a patient's probability of death, the overall death rate from the sample would be used to estimate **each** patient's probability of death. (The variability among mortality responses for all patients that remains after adjusting each patient's response by the overall death rate is referred to as the "total variability of mortality responses.") However, if the model including risk factors is used, the estimated probabilities of death for patients would vary according to their risk factors. *Range: 0% to 100%*

ROC Area: The area under the receiver operating characteristic curve measures the tendency of the estimated probabilities of death for patients in the sample that died to be ranked higher than those for patients who were discharged alive. *Range: 50% to 100%*

Table 5. Model adequacy measures by model and by sample

	Direct Admit				Transfer-in			
	p = .05		p = .10		p = .05		p = .10	
Measure	I	II	I	II	I	II	I	II
Percentage Explained	33.4	31.3	33.4	31.3	40.2	35.6	40.6	35.2
R^2	31.0	29.1	31.0	29.1	36.4	32.2	37.2	31.9
ROC Area	88.6	87.5	88.6	87.5	91.2	88.6	91.3	88.4

The above table indicates that the measures of model adequacy exceed expectation for both the "Direct Admit" and "Transfer-in" models. (Compare, for example, the 1993 CABG report where, for the final model, the Percentage Explained was 20.4%, the R^2 was 13.0%, and the ROC was 82.9%.) As expected, the measures of model adequacy are slightly less in the cross validation samples than in the development samples.

Creation of the Final Mortality Models

The p = .10 models were used for reporting 1993 AMI data. The p = .10 model was selected (and, historically, has been selected for the CABG public reports) because it allows the Council to be more liberal in identifying risk factors.

The final coefficients associated with the p = .10 models and their p-values are listed in the tables below. The entire data set is used in creating the final coefficients (i.e., Sample I and Sample II are "recombined" and the coefficients are re-estimated). Accompanying these coefficients is the odds ratio effect for each risk factor or risk factor category. This effect is the change in the odds ratio (probability of death/probability of survival) for a patient with the risk factor category compared to a patient without it.

Table 6. "*Direct Admit*" mortality model p = .10 *(based on all direct admit cases)*

Variable	Coefficient	p-value	Odds Ratio
Constant	- 5.1613	.0000	
Atlas™ ASG		.0000	
ASG missing, 0, 1,	- 1.4071		.24
ASG 2	- .6570		.52
ASG 3	.3139		1.37
ASG 4	1.7502		5.76
Age	.0475	.0000	1.05
Cardiac Dysrhythmias		.0000	
none	- .1132		.89
premature beats	- .8157		.44
unspecified	- .2318		.79
other specified	- .1145		.89
paroxysmal tachycardia	.0494		1.05
atrial fibrillation/flutter	- .0041		1.00
ventricular fibrillation/flutter	1.2299		3.42
Cardiogenic Shock	2.2337	.0000	9.33
Cardiomyopathy	.1813	.1895	1.20
Conduction Disorders		.0000	
none	- .0760		.93
left BBB/hemiblock	- .6588		.52
A-V block (not complete)	- .1340		.87
right BBB/oth heart block/ unspecified cond. disorders	.1018		1.11
A-V block (complete)/other specified cond. disorders	.7670		2.15
Diabetes		.0093	
none	- .0694		.93
without complications	- .1191		.89
with complications	.1885		1.21
Dialysis	.5746	.0011	1.78
Gender *(female)*	.0996	.0324	1.10
Infarct Site		.0000	
anterolateral wall	.1642		1.18
other anterior wall	.0702		1.07
inferolateral wall	- .1078		.90
inferoposterior wall	- .2926		.75
other inferior wall	- .2413		.79
other lateral wall	- .0089		.99
true posterior wall	.3721		1.45
subendocardial	- .8457		.43
other specified sites	.1070		1.11
unspecified site	.7828		2.19
Prior CABG Surgery	.2665	.0074	1.31
Renal Failure		.0000	
none	- .5342		.59
chronic	- .2080		.81
acute/unspecified	.7422		2.10

Table 7. "*Transfer-in*" mortality model p = .10 *(based on all transfer-in cases)*

Variable	Coefficient	p-value	Odds Ratio
Constant	- 3.2765	.0000	
Atlas™ ASG		.0000	
ASG missing, 0, 1,	- 1.4935		.22
ASG 2	- .5791		.56
ASG 3	.4847		1.62
ASG 4	1.5879		4.89
Age Squared	.2528	.0000	1.29
Cardiac Dysrhythmias		.0000	
none	- .3084		.73
premature beats	- 1.0151		.36
unspecified	- .1778		.84
other specified	- .0483		.95
paroxysmal tachycardia	.3021		1.35
atrial fibrillation/flutter	- .2798		.76
ventricular fibrillation/flutter	1.5273		4.61
Cardiogenic Shock	2.2155	.0000	9.17
Dialysis	1.0670	.0008	2.91
Gender *(female)*	.3146	.0050	1.37
Heart Failure	.1382	.2466	1.15
Infarct Site		.0001	
anterolateral wall	- .2302		.79
other anterior wall	- .1514		.86
inferolateral wall	- .4086		.66
inferoposterior wall	- .3824		.68
other inferior wall	- .1793		.84
other lateral wall	- .5832		.56
true posterior wall	.5499		1.73
subendocardial	- .3963		.67
other specified sites	.6847		1.98
unspecified site	1.0968		2.99
Prior CABG Surgery	.4945	.0054	1.64
Renal Failure		.0000	
none	- .6114		.54
chronic	- .2134		.81
acute/unspecified	.8248		2.28

The coefficients from Table 6 suggest the following about the **Direct Admit** model:

- an increase in mortality with severity
- an increase in mortality with age
- an increase in mortality for cases with certain cardiac dysrhythmias: (1) paroxysmal tachycardia or (2) ventricular fibrillation/flutter
- an increase in mortality for cases with cardiogenic shock
- an increase in mortality for cases with cardiomyopathy
- an increase in mortality for cases with certain conduction disorders: (1) right bundle branch block/other heart block/unspecified conduction disorders or (2) complete A-V block/other specified conduction disorders
- an increase in mortality for cases having diabetes with complications
- an increase in mortality for cases on dialysis
- an increase in mortality for females
- an increase in mortality for cases where the infarct site is anterolateral, other anterior, true posterior, other specified site, or an unspecified site
- an increase in mortality for cases with prior CABG surgery
- an increase in mortality for cases with acute or unspecified renal failure

The coefficients from Table 7 suggest the following about the **Transfer-in** model:

- an increase in mortality with severity
- an increase in mortality with age squared
- an increase in mortality for cases with certain cardiac dysrhythmias: (1) paroxysmal tachycardia or (2) ventricular fibrillation/flutter
- an increase in mortality for cases with cardiogenic shock
- an increase in mortality for cases on dialysis
- an increase in mortality for females
- an increase in mortality for cases with heart failure
- an increase in mortality for cases where the infarct site is true posterior, other specified site, or an unspecified site
- an increase in mortality for cases with prior CABG surgery
- an increase in mortality for cases with acute or unspecified renal failure

For categorical variables--ASG, cardiac dysrhythmias, conduction disorders, diabetes, infarct site, and renal failure--some categories were significant predictors of in-hospital mortality while other categories of the same variable were not.

***Atlas*™ Admission Severity Group (ASG).** Being an ordered categorical variable, the coefficients are as expected; that is, the higher levels are associated with an increased risk of in-hospital mortality (for both the "direct admit" and "transfer-in" models).

Cardiac Dysrhythmias. An increased risk of in-hospital mortality was associated with paroxysmal tachycardia and ventricular fibrillation/flutter (but not the other categories) for both the "direct admit" and "transfer-in" models.

Conduction Disorders. An increased risk was associated with the category including right bundle branch block/other heart block/unspecified conduction disorders and with

the category including complete A-V block/other specified conduction disorders for the "direct admit" model. This variable was not significant for the "transfer-in" model.

Diabetes. An increased risk was associated with diabetes *with* complications but not for diabetes *without* complications for the "direct admit" model. This variable was not significant for the "transfer-in" model.

Infarct Site. There was an increased risk of in-hospital mortality for cases where the infarct site was anterolateral, other anterior, true posterior, other specified site, or an unspecified site for the "direct admit" model. For the "transfer-in" model, there was an increased risk for cases where the infarct site was true posterior, other specified site, or an unspecified site.

Renal Failure. An increased risk of in-hospital mortality was associated with acute or unspecified renal failure for both the "direct admit" and "transfer-in" model.

Some variables appear to defy clinical reasoning and require further explanation. Heart failure, for example, was not a significant predictor of in-hospital mortality in the direct admit model. This phenomenon may be the result of these patients having other risk factors (such as cardiogenic shock) that are carrying the weight in the calculation.

Overall, the list of significant risk factors is similar to what we expected, given the literature review and discussions with advisory group.

Summary - In-hospital Mortality Modeling

Table 8. Summary of model development research *(risk factors used in the final in-hospital mortality models are "shaded")*

"Direct Admit" (p = .10) Significant Risk Factors *(shaded)*	***"Transfer-in"*** (p = .10) Significant Risk Factors *(shaded)*
Atlas™ ASG	*Atlas*™ ASG
Admission Source	Admission Source (not tested)
Admission Type	Admission Type
Age	Age
Age Squared	Age Squared
Cardiac Dysrhythmias	Cardiac Dysrhythmias
Cardiogenic Shock	Cardiogenic Shock
Cardiomyopathy	Cardiomyopathy
Conduction Disorders	Conduction Disorders
Diabetes	Diabetes
Dialysis	Dialysis
Gender	Gender
Heart Failure	Heart Failure
Hypertension w/ "Failure"	Hypertension w/ "Failure"
Hypertension w/o "Failure"	Hypertension w/o "Failure"
Infarct Site	Infarct Site
Malignant Neoplasm	Malignant Neoplasm
Payor	Payor
Prior CABG Surgery	Prior CABG Surgery
Renal Failure	Renal Failure

Table 9. Measures of model adequacy *(all data; p = .10)*

	"Direct Admit" Model	**"Transfer-in" Model**
Number of Cases	30,715	8,049
Number of Deaths	3,258	591
Mortality Rate	10.6%	7.3%
Percentage Explained	32.5%	39.0%
R^2	30.2%	34.8%
ROC Area	88.1%	90.8%

METHODOLOGY AND RESEARCH - *LENGTH OF STAY*

"Who" Will be Reported

- Hospitals
- Payor groups

"What" Will be Reported

- Average actual length of stay in days (*geometric* means *not* arithmetic means)
- Expected length of stay range (*geometric* means *not* arithmetic means) *(risk adjusted)*
- Notation if actual is significantly higher or lower than the expected range

(Note: the calculations used to determine the expected range and test of significance are discussed in the AMI Technical Report. This Research Methods & Results document is intended to provide information on the methodological approach used to determine significant predictors of length of stay.)

Study Population

Exclusion Criteria. In addition to the exclusions to the study population noted earlier, other exclusion criteria have been identified for length of stay modeling and analysis:

- Patients who died
  (Given that length of stay will be used as an "efficiency" measure for the patients that survived, patients who died will be excluded from length of stay modeling and analysis.)
- Patients who were "transferred-out
  (Such cases had "truncated" stays.)
- Atypical lengths of stay:
  - those over 40 days *(approximately 0.7% of all cases)*
  - those that were discharged the same day they were admitted *(a small number of transfer-in patients were discharged the same day they were admitted to the second hospital. It is likely that they were admitted specifically to receive a diagnostic catheterization and were subsequently discharged the same day.)*

Table 10. Statewide summary of exclusions from length of stay model

	Cases		Avg. LOS
	number	*percent*	*arithmetic*
Total cases included in the public report mortality analysis	39,256	100%	8.2
Exclusions from length of stay model:			
patients in hospitals excluded due to data integrity[†]	249	0.6%	8.3
patients who were transferred-out	8,476	21.6%	4.6
patients who died	3,855	9.8%	6.7
patients with lengths of stay greater than 40 days	199	0.5%	61.9
patients admitted and discharged the same day	11	< 0.1%	0.0
Total exclusions from length of stay model:	12,790	32.6%	
Total cases *included* in length of stay modeling	26,466	67.4%	9.2

[†]Cases from three hospitals were excluded from length of stay *modeling* because of data integrity concerns: Shamokin Area Community Hospital (n = 97), North Philadelphia Health System (n = 50), Medical College Hospital/Elkins Park (n=102).

When reporting in-hospital mortality outcomes, hospitals with fewer than 30 cases were excluded because mortality is not normally distributed. For length of stay, however, hospitals with any number of cases can be reported because we are starting with a normal distribution. There are 22 hospitals which have fewer than 30 cases after the length of stay exclusions were removed. Length of stay outcomes will be reported for these 22 hospitals.

Candidate Variables Tested as Possible Risk-Adjustment Factors to Length of Stay

The same candidate variables tested as possible risk-adjustment factors to in-hospital mortality were tested for length of stay. In addition, transfer-in status and DRG (diagnosis-related group) were also tested.

Understanding how **payor group** was tested in the length of stay model is especially important. The Council had originally planned to build two length of stay models: one model to use when evaluating hospitals with payor *included* as a candidate variable and a second model to use when evaluating payor groups with payor *excluded* as a candidate variable. First, we tested the set of candidate variables *with payor included*, but it was not a significant predictor of length of stay. Second, we tested the same set of candidate variables *without payor*, and then, after obtaining the results, tested it to see if payor added any significant predictive ability to the model; it did not. In fact, the two final models (one with and one without payor in the original candidate variable list) were identical. Given these results, we went forward with the same length of stay model for both hospital and payor analysis.

Minimum Cell Size Assessment. The same candidate variable "collapsings" used for in-hospital mortality were used for length of stay (see previous discussion on Results of Minimum Cell Size Assessment" under in-hospital mortality section). Since DRG was not tested for in-hospital mortality but was for length of stay, DRG "collapsings" are listed below. DRGs with small numbers were collapsed into other DRGs that were similar both clinically and in length of stay.

DRG 111 (major cardiovascular procedures w/o CC) includes 5 cases from DRG 479 (other vascular procedures w/o CC).

DRG 115 (permanent cardiac pacemaker implant with AMI, heart failure, or shock) includes 2 cases from DRG 118 (cardiac pacemaker device replacement).

DRG 121 (circulatory disorders with AMI and cardiovascular complication, discharged alive) includes 1 case from DRG 123 (circulatory disorders with AMI, expired). (The hospital incorrectly assigned this case to DRG 123. The patient was discharged alive.)

DRG 122 (circulatory disorders with AMI without cardiovascular complication, discharged alive) includes 1 case from DRG 117 (cardiac pacemaker revision except device replacement); 2 cases from DRG 124 (circ disorders except AMI w/ cardiac cath & complex diagnosis); 6 cases from DRG 125 (circ disorders except AMI w/ cardiac cath w/o complex diagnosis), and 1 case from DRG 470 (ungroupable). (DRGs 124 & 125 are incorrect DRG assignments since they are "except" AMI cases.)

DRG 468 includes 1 case from DRG 123 (circulatory disorders with AMI, expired) and 3 cases from DRG 476 (prostatic operating room procedures unrelated to principal diagnosis). (The hospital incorrectly assigned DRG 123 case. The patient was discharged alive.)

DRG 478 includes 2 cases from DRG 114 (upper limb & toe amputation) and 1 case from DRG 119 (vein ligation and stripping).

Appendix B contains frequency of occurrence and average length of stay data *(arithmetic means)* for each of the candidate variables. (The variables are displayed after collapsing, since the decision was made to retain the same variable categories for length of stay as for in-hospital mortality.)

Construction of the Length of Stay Model

While *logistic* regression was used to construct the models for in-hospital mortality, a general *linear* modeling approach was used for length of stay because it is a continuous variable, and unlike in-hospital mortality where two models were built, one model was built for length of stay. (To account for potential differences in lengths of stay due to "transfer-in" status, this variable was tested as a possible predictor for length of stay.) The model building steps were similar to those in the in-hospital mortality model development research. That is, the first task in constructing the length of stay model involved randomly splitting the data set into two, equal-size samples (after cases to be excluded from modeling were removed). One set was used as the development sample (Sample I), and the other set was used as the cross-validation sample (Sample II). The model was constructed using Sample I, after a natural log transformation was done to adjust for skewness in the distribution. All tests of significance were based on general linear model F-tests. Only a $p = .10$ model was built because it allowed the Council to be more liberal in identifying risk factors and that was the p-value chosen for the in-hospital mortality models.

Table 11. Case counts and average length of stay in days

	Sample I	**Sample II**	**Total**
Number of Cases	13,233	13,233	26,466
Average Length of Stay *(arithmetic)*	9.2	9.1	9.2
Average Length of Stay *(geometric)*	7.9	7.8	7.8

Table 12. Candidate variables tested as possible predictors of length of stay *(~~strikethrough~~ indicates non significance (p = .10) and the numbers in parentheses indicate the order in which the variable "fell out" of the model)*

	Variable	**p-value** *(for significant variables only)*
Clinical Variables:	*Atlas*™ ASG	.0001
	Cardiac Dysrhythmias	.0001
	Cardiogenic Shock	.0001
	~~Cardiomyopathy~~ (4)	*NS*
	Conduction Disorders	.0001
	Diabetes	.0001
	~~Dialysis~~ (5)	*NS*
	Heart Failure	.0001
	Hypertension with "Complications"	.0001
	~~Hypertension without "Complications"~~ (3)	*NS*
	Infarct Site	.0001
	Malignant Neoplasm	.0002
	Prior CABG Surgery	.0003
	Renal Failure	.0001
Demographic Variables:	~~Age~~ (1)	*NS*
	~~Age Squared~~ (2)	*NS*
	Gender	.0001
"Process" Variables:	Admission Source	.0001
	Admission Type	.0001
	Transfer-in Status	.0001
	DRG	.0001

Note: NS = not significant at the p = .10 level.

Note that both age and age-squared "fell out" of the model (i.e., were not significant predictors of length of stay). Age was tested as a continuous variable for both in-hospital

mortality and length of stay. However, during preliminary analysis for length of stay, we tested age both as a continuous variable and as a binary variable (up to age 65 versus 65 & over), but it was not a significant predictor of length of stay in either form. When age was the *only* variable tested, it was significant, so it appears that the relationship between length of stay and age *is* being accounted for by the other risk factors retained in the model.

Cross validation of the length of stay model

Re-estimation of Coefficients

The steps in the model cross validation were similar to those used for in-hospital mortality. The first step in the cross validation was to re-estimate the model, using only the variables that were significant in Sample I, to determine which factors remain significant in Sample II.

Table 13. Probability values for each significant variable (Samples I & II)

Variable	Sample I	Sample II
Atlas™ ASG	.0001	.0001
Cardiac Dysrhythmias	.0001	.0001
Cardiogenic Shock	.0001	.0001
Conduction Disorders	.0001	.0001
Diabetes	.0001	.0015
Heart Failure	.0001	.0001
Hypertension with "Complications"	.0001	.0001
Infarct Site	.0001	.0001
Malignant Neoplasm	.0002	.0085
Prior CABG Surgery	.0003	.0006
Renal Failure	.0001	.0001
Gender	.0001	.0001
Admission Source	.0001	.0001
Admission Type	.0001	.0001
Transfer-in Status	.0001	.0001
DRG	.0001	.0001

Sixteen variables were significant in Sample I. All of these variables cross validated (i.e., the p-values were less than .10 in both Sample I and Sample II).

Measures of Model Adequacy

For the second step in the cross validation process, the estimated coefficients from Sample I were applied to both Sample I and Sample II. The objective was to evaluate the model's performance in both Sample I and Sample II. R-squared was the measure considered in evaluating the model's performance. (See earlier discussion on R-squared).

Table 14. R-squared values by sample

Development	Cross Validation	Total
40.3%	38.8%	39.7%

Methodology used in Determining Average Length of Stay

Each category for each statistically significant clinical or demographic factor is assigned a weight or coefficient. These coefficients are used to compute each individual patient's expected length of stay given the risk factors of the patient. The coefficient for a category represents the estimated difference in mean (log) length of stay for this category versus the last category of that factor. Thus, the coefficient for the last category of a factor is always "0" (zero). When dealing with categorical variables in the length of stay model there is no particular importance to the order of these categories. The constant term in the model represents the predicted value for all factors at the last level. The coefficients for the other levels within a factor represent adjustments to that "baseline." No adjustment is required at the last level for any factor because it is already accounted for in the constant. For example, a patient with an ASG of 4 has a "0" or "baseline" coefficient; while a patient with an ASG of 3 would be adjusted *downward* by .165885583. *(See Table 15, below)*. The order is not important because each ordering scheme would result in different coefficients, but the estimated *difference* between any pairs of levels would be the same (i.e., the *difference* between ASG 4 and ASG 3 would always be .165885583 independent of what the specific coefficients were for each).

Because a natural log transformation was done to adjust for skewness in the distribution, it was necessary to convert the logarithm values back to days when evaluating length of stay. This process results in **geometric means** for length of stay, *not* arithmetic means. Unlike an arithmetic mean that is derived by summing individual values and dividing by the number of observations, a geometric mean is calculated by multiplying the individual values and taking the *n*th root of the product. Geometric means *are averages* and are the natural result when using the log transformation. Geometric means are used in all subsequent calculations for length of stay. A hospital's expected average is determined by averaging the expected lengths of stay for each AMI patient in that hospital. The hospital's expected average will then be compared to its actual average (both will be geometric averages) to determine whether the actual is significantly higher or lower than expected or within the expected range. Outcomes for payor groups will be evaluated in the same way.

Table 15. Coefficients (or "weights") for length of stay model

Variable	Natural Log LOS Coefficient	p-value
Constant	3.751578510	.0001
Atlas™ ASG		.0001
ASG missing, 0, 1,	- 0.455825555	
ASG 2	- 0.303675579	
ASG 3	- 0.165885583	
ASG 4	0	
Admit Source		.0001
physician referral	0.078429665	
transfer from general acute care facility	0.240136429	
transfer from skilled nursing facility	0.099423836	
transfer from other health care facility	0.046011136	
emergency room	0.140136247	
other (clinic or HMO referral, court/law)	0	
Admit Type		.0001
emergency/urgent	0.233329949	
elective	0	
Cardiac Dysrhythmias		.0001
none	- 0.128588256	
premature beats	- 0.093289820	
unspecified	- 0.117950034	
other specified	- 0.107383009	
paroxysmal tachycardia	- 0.009329119	
atrial fibrillation/flutter	0.010257567	
ventricular fibrillation/flutter	0	
Cardiogenic Shock		.0001
no	- 0.167931462	
yes	0	
Conduction Disorders		.0001
none	- 0.131970763	
left BBB/hemiblock	- 0.162247159	
A-V block (not complete)	- 0.074187826	
right BBB/oth heart block/ unspec cond dis	- 0.103649597	
A-V block (complete)/oth specified cond dis	0	
Diabetes		.0001
none	- 0.079740081	
without complications	- 0.074382048	
with complications	0	
Gender		.0001
male	- 0.061026581	
female	0	
Heart Failure		.0001
no	- 0.159998576	
yes	0	
Hypertension with Complications		.0001
no	- 0.118239643	
yes	0	

continued

Variable	Natural Log LOS Coefficient	p-value
Infarct Site		.0001
anterolateral wall	0.142129236	
other anterior wall	0.112086963	
inferolateral wall	0.063018918	
inferoposterior wall	0.100029153	
other inferior wall	0.067724938	
other lateral wall	0.047081688	
true posterior wall	0.033627664	
subendocardial	0.004281533	
other specified sites	0.024944364	
unspecified site	0	
Malignant Neoplasm		.0001
no	- 0.091011018	
yes	0	
Prior CABG Surgery		.0001
no	- 0.053771278	
yes	0	
Renal Failure		.0001
none	- 0.307895886	
chronic	- 0.250684141	
acute/unspecified	0	
Transfer-In Status		.0001
not transferred in	0.432841664	
transferred in	0	
DRG		.0001
104 cardiac valve procedures w/ cardiac cath	- 0.098859298	
105 cardiac valve procedures w/o cardiac cath	- 0.121463607	
106 coronary bypass w/ cardiac cath	- 0.328657284	
107 coronary bypass w/o cardiac cath	- 0.439846758	
108 other cardiothoracic procedures	- 0.250742304	
110 major cardiovascular procedures w/ CC	- 0.628778687	
111 major cardiovascular procedures w/o CC	- 0.843167997	
112 percutaneous cardiovascular procedures	- 1.058472730	
115 perm card pacemaker implant w/AMI,Hrt Fail,Shock	- 0.721891667	
120 other circulatory system operating room proc	- 0.657649623	
121 circ disorders w/ AMI & CC, discharged alive	- 1.087134190	
122 circ disorders w/ AMI w/o CC, discharged alive	- 1.121704326	
144 other circulatory system diagnoses w/ CC	- 1.071542358	
145 other circulatory system diagnoses w/o CC	- 1.292473138	
468 extensive oper room proc unrelated to prin diag	- 0.397739226	
477 nonextensive oper room proc unrelated to prin diag	- 0.744314373	
478 other vascular procedures w/ CC	- 0.572060315	
483 tracheostomy except for face, mouth, & neck diag	0	

CC indicates complication or comorbid condition.

ADJUSTMENTS APPLIED TO *AVERAGE CHARGE*

"Who" Will be Reported

- Hospitals
- Payor groups

"What" Will be Reported

- Average charge per stay for hospitals *(trimmed for outliers and case-mix adjusted)*
- Average charge per stay *(trimmed for outliers and case-mix adjusted)* and average charge per day *(trimmed for outliers)* for payor groups

Determining Average Charge per Stay

Trimming of Charge Outliers

Patient total charges that are atypical were excluded from the calculation of average charge. The methodology to determine these outlier charges was based on the determination of a high and low trim point percentage. Any patient charge that exceeds either trim point is excluded from the calculation for average charge; however, that patient is still included in the other analyses in the report. The first step in trimming charges involved examining DRG frequencies according to whether or not a hospital had the capability to perform advanced cardiac care services. The two hospital "types" were examined separately because charges for the same DRG differ across type of hospital. For the purposes of trimming, DRGs were collapsed into five categories based on MDC5 (major diagnostic category: diseases and disorders of the circulatory system). Both average charge and DRG were examined in making decisions about collapsing DRGs into MDC5 categories (there were too few cases in most DRGs--with the exception of medical DRG--to justify trimming at the DRG level).

Table 16. Frequency of cases by categories used for trimming charges
(Acute care hospitals *without* advanced cardiac services, N = 148)

Category	Number	Percent
MDC5 Open-Heart Surgery *(surgical group)*	1	< 0.1
MDC5 Non-Open Heart Surgery *(surgical group)*	316	1.5
MDC5 Medical *(medical group)*	21,313	98.1
Non-MDC5 *(surgical group)*	58	0.3
Tracheostomy *(surgical group)*	36	0.2

Note: The one cases in MDC5 Surgical (open heart surgery) is from DRG 108. There are a few codes in this DRG that are not considered open heart surgery by the American Heart Association. Obviously, this one cases falls into that category since it is associated with a hospital without advanced cardiac services.

Table 17. Frequency of cases by categories used for trimming charges
(Acute care hospitals *with* advanced cardiac services, N = 41)

Category	Number	Percent
MDC5 Open-Heart Surgery *(surgical group)*	3,325	19.0
MDC5 Non-Open Heart Surgery *(surgical group)*	6,202	35.4
MDC5 Medical *(medical group)*	7,847	44.8
Non-MDC5 *(surgical group)*	42	0.2
Tracheostomy *(surgical group)*	116	0.7

The second step in trimming atypical charges involved an examination of the distribution of cases in each of these categories for both hospital types. This examination suggested that, for the surgical groups, 3 percent of the highest charges be trimmed and 1 percent of the lowest charges be trimmed. For the medical group, 2 percent of the highest charges were trimmed and 1 percent of the lowest charges were trimmed. This trimming approach results in a total of 3.0 percent trimmed for acute care hospitals *without* advanced cardiac services and 3.5 percent trimmed for hospitals *with* advanced cardiac services. While a 4 percent trim might be expected for the hospitals *with* advanced cardiac services (3% of the highest charges and 1% of the lowest charges), the difference can be explained by the distribution of surgical and medical patients.

Table 18. Trimming charge outliers - Summary

Hospital Type	Total Number of Cases	Cases Trimmed		Avg. Charge after Trimming
		N	%	
Hospitals ***without*** Advanced Cardiac Services (N=148)	21,724	653	3.0	$12,847
Hospitals ***with*** Advanced Cardiac Services (N=41)	17,532	619	3.5	$31,160

Case Mix Adjusting Charges

A hospital's (or payor group's) case-mix index is used as a means of adjusting its charges according to the number of patients treated in each DRG and the relative costliness associated with treating patients in that DRG. For case-mix adjusting, DRGs *are not* collapsed into MDC5 categories as was done for *trimming* average charges. Case-mix adjustment of charges should narrow the range of possible explanations for the variability in charges by accounting for the differences in resource consumption due to the treatment received.

The case-mix adjustment is used as an all payor relative weight for each of the DRGs derived from the AMI cases. The first step is to obtain these relative weights for each DRG

for each of the hospital "types" (i.e., relative weights for each DRG were obtained separately for (1) hospitals *without* advanced cardiac services and (2) hospitals *with* advanced cardiac services. Relative weights were obtained for each of these hospital "types" because charges for the same DRG differ dramatically across type of hospital.

Case-mix Adjustment Steps:

1. compute all payor relative weights for the relevant DRGs
2. calculate each hospital's (or payor group's) case-mix index
3. apply that case-mix index to its trimmed average charge

Step 1: Computation of All Payor Relative Weight (RW):

Based on 1993 Pennsylvania AMI Data:

- Exclude all outlier patient charges.

- Calculate statewide average charge for all relevant DRGs together (average for all DRGs, combined).

- Calculate statewide average charge of cases assigned to each relevant DRG (average for each DRG)

  Relative Weight DRG 121 (for example) = average DRG 121/average all
  Relative Weight DRG 122 (for example) = average DRG 122/average all

  (Relative Weights for each of the relevant DRGs were calculated as above. There were 30 different DRGs derived from the 1993 AMI cases. There was one case in DRG 470; it was collapsed into DRG 122).

Table 19. Statewide average charge by DRG and associated relative weights
(Acute care hospitals *without* advanced cardiac services, N = 148)

DRG	Average Statewide Charge	Relative Weight
108	$ 31,171	2.426213
110	$ 25,114	1.954764
111	$ 11,631	0.905301
112	$ 30,011	2.335947
113	$ 52,311	4.071738
114	$ 35,760	2.783418
115	$ 36,954	2.876405
117	$ 16,570	1.289756
118	$ 32,692	2.544611
120	$ 33,295	2.591557
121	$ 13,869	1.079509
122	$ 10,791	0.839923
123	$ 11,128	0.866190
125	$ 4,858	0.378131
144	$ 11,674	0.908630
145	$ 8,847	0.688605
468	$ 32,768	2.550583
476	$ 21,941	1.707785
477	$ 19,690	1.532588
478	$ 39,611	3.083168
483	$124,165	9.664631
All Cases	$ 12,847	———

Table 20. Statewide average charge by DRG and associated relative weights
(Acute care hospitals *with* advanced cardiac services, N = 41)

DRG	Average Statewide Charge	Relative Weight
104	$ 97,768	3.137637
105	$ 83,476	2.678981
106	$ 63,835	2.048659
107	$ 56,263	1.805631
108	$ 73,841	2.369766
110	$ 41,730	1.339228
111	$ 31,751	1.018963
112	$ 24,651	0.791131
113	$ 85,164	2.733150
115	$ 40,237	1.291302
118	$ 72,354	2.322029
119	$ 44,781	1.437147
120	$ 44,051	1.413718
121	$ 19,150	0.614570
122	$ 14,077	0.451785
123	$ 15,740	0.505150
124	$ 9,535	0.306012
125	$ 10,038	0.322143
144	$ 9,632	0.309120
145	$ 11,570	0.371317
397	$ 23,175	0.743734
468	$ 48,905	1.569494
476	$ 21,508	0.690252
477	$ 34,196	1.097456
478	$ 38,577	1.238030
479	$ 27,210	0.873249
483	$276,184	8.863515
All Cases	$ 31,160	———

Step 2: Example of Calculation of Case-mix Index:

The first step is to determine a DRG-specific case-mix index for each DRG within each hospital (or payor group):

For example, for Hospital "A" in DRG 121:

DRG-specific Case Mix = R.W. x N

where,

R.W. = **All Payor Relative Weight** associated with DRG 121
N = Number of cases treated for DRG 121 by Hospital "A" (after outliers are deleted)

After a DRG-specific case-mix product has been calculated for each DRG, a hospital-specific sum is computed. Each hospital's total patients (N) are also summed across the reported DRGs. These two values (N and DRG case-mix product total) are used to determine each hospital's index or the relative costliness of treating patients for the DRGs at each hospital.

Thus, the case-mix index for Hospital "A" is

$$Hospital\ \ Case\text{-}Mix\ Index \quad = \quad \frac{\sum(DRG\ Case\text{-}Mix)}{N}$$

After a case-mix index is computed for each hospital, these indices will be used to calculate each hospital's adjusted charge. The formula to calculate adjusted charge is as follows:

Step 3: Calculation of Case-mix Adjusted Average Charge:

$$\text{adjusted charge} = \frac{\text{average charge}}{\text{hospital case-mix index}}$$

Since each hospital's case-mix index is derived from the relative weight of each DRG and the number of patients treated within each DRG, the case-mix index is representative of an "average relative weight" of the hospital's intensity of high charge services for the DRGs encompassing cases in the AMI Report. Because heavier DRG weights imply greater resource consumption, it follows that a hospital with a high case-mix index, relative to other hospitals, would have higher average charges. This effect is accounted for in the average charge by dividing out the index, therefore, providing for a more accurate reflection of resource use not related to differences in services received.

Determining Average Charge per Day

Average charge per day will be reported for payor groups but not for hospitals. Average charge per day is calculated by adding the total charges for each patient and dividing by the length of stay (in days). Average charges included in this calculation are *trimmed* but are not case-mix adjusted. This approach accounts for the differences in average charge explained by longer lengths of stay.

COUNTY & COMMUNITY DATA

"Why" Report County and Community Data

County and community level AMI hospitalization rates and in-hospital mortality rates were examined using small area analysis. Small area analysis documents county and community-level variations in the use of inpatient health care services. This information may help in targeting areas that would benefit from increased prevention and health education efforts or may pinpoint important issues in the health care delivery system. Previous Council reports have focused on hospital-specific data and to a limited degree physician-specific data. In examining a disease such as heart attack, however, there may be other factors, outside of the direct control of hospitals and physicians, contributing to the survival and mortality rates of patients. Community factors--residents' health status, geographic access to medical facilities, socioeconomic and other factors--have been demonstrated to contribute to who will suffer a heart attack, as well as the odds of surviving one.

"Who" Will be Reported

- Pennsylvania residents admitted to Pennsylvania hospitals in 1993 with heart attack as the principal diagnosis were included in the county/community analysis. Because this information is population based, in-patient heart attack *occurrences* (not hospitalizations) were examined in this section.

"What" Will be Reported

- Age- and sex-adjusted inpatient hospitalization rates for heart attack and associated mortality rates for Pennsylvania counties and communities will be reported. (Age is adjusted in five year intervals up to age 84, with ages 85 and over considered as a single interval.) (Population information is based on 1992 population estimates.)

    - When multiple admissions were involved in an episode of care (i.e., a patient was transferred from one general acute care facility to another), only one hospital admission was counted (giving a count of heart attack *occurrences*, not hospitalizations). The last record in the episode was used to identify whether the patient lived or died.

    - County and community information will be reported by region (Western Pennsylvania, Central & Northeastern Pennsylvania, and Southeastern Pennsylvania).

    - Information for each *county* in a given region will be reported, but only those communities with statistically significant high/low hospitalization rates for AMI and/or statistically significant high/low in-hospital mortality rates for AMI will be displayed in the public report.

- There are 67 counties and 198 communities. Western Pennsylvania Area includes 22 counties, Central and Northeastern Pennsylvania Area includes 35 counties, and Southeastern Pennsylvania Area includes 10 counties. (Counties and communities do not follow strict municipal lines. Zip codes that cross county lines are considered to be part of the county where the majority of residents with that zip code reside.)

- Heart attack mortality data from the Department of Health will also be reported. Using data provided by the Pennsylvania Department of Health, the Council is able to report the ***total*** number of heart attack deaths for residents of each county (not just in-hospital heart attack deaths). When examining Department of Health mortality statistics and PHC4 statistics, it is important to remember that there are differences between the two study populations:

  - The Department of Health data are age-adjusted to the 1940 standard million U.S. population. They are not adjusted for sex as are the Council's county/community data.

  - The ICD.9.CM diagnosis codes used by the Department of Health include all 410.xx codes in the principal diagnosis position (i.e., 410.x0, 410.x1, and 410.x2). The Council used only 410.x1 (initial episode of care) in the principal diagnosis position.

  - The Department of Health data reflect cause of death, while the Council's data reflect the principal reason for hospital admission.

  - The Department of Health used all Pennsylvania residents including those that died out of state. The Council used all Pennsylvania residents hospitalized in Pennsylvania for heart attack.

Exclusions to County/Community Analysis

The focus here was on Pennsylvania *residents*, so heart attack *occurrences* (not hospitalizations) were examined. Because it was less important in this section to exclude "outliers," the exclusions to the study population noted in Table 1 are ***included*** in this analysis.

Table 21. Summary of exclusions from county and community analysis

	Cases	
	number	*percent*
Total number of heart attack occurrences	35,893	100%
Exclusions from county/community analysis:		
patients who were non-Pennsylvania residents	2,141	6.0%
patients missing critical data fields	34	0.1%
Total exclusions from county/community analysis:	2,175	6.1%
Total cases *included* in county/community analysis	33,718[†]	93.9%

[†]The Council estimates that this figure accounts for about 85% of total heart attack occurrences statewide.

While not excluded from analysis, in-hospital mortality data for four counties were "suppressed" because they had fewer than six expected deaths: Cameron, Forest, Fulton, and Sullivan counties.

Appendix A

Table A-1. Candidate variable frequency & percent mortality - "**Direct Admit**" model *(before collapsing cells)*

Variable and ICD.9.CM Codes	*Number of Cases*			*Percent Mortality*		
	Sample I (n=15,358)	Sample II (n=15,357)	Total (n=30,715)	Sample I (10.8%)	Sample II (10.5%)	Total (10.6%)
Atlas™ Admission Severity Group (ASG)						
0	18	26	44	0.0	3.8	2.3
1	2,594	2,548	5,142	0.8	0.8	0.8
2	6,771	6,925	13,696	3.9	4.2	4.0
3	5,165	5,072	10,237	17.2	16.5	16.9
4	810	784	1,594	59.1	58.2	58.7
missing	0	2	2	—	50.0	50.0
Admission Source						
physician referral	1,638	1,633	3,271	8.4	9.1	8.7
transfer from general acute care facility	*(all of these cases were direct admits)*					
transfer from skilled nursing facility	122	129	251	26.2	24.0	25.1
transfer from other health care facility	82	81	163	17.1	23.5	20.2
emergency room	13,372	13,396	26,768	10.9	10.4	10.7
other (clinic/HMO referral, court/law enforcement)	144	118	262	7.6	7.6	7.6
Admission Type						
emergency/urgent	15,218	15,204	30,422	10.8	10.5	10.6
elective	140	153	293	7.1	5.9	6.5
Age (tested as a continuous variable)						
30-39 years	223	233	456	0.9	1.3	1.1
40-49 years	1,235	1,188	2,423	1.9	1.5	1.7
50-59 years	2,119	2,219	4,338	2.7	3.3	3.0
60-69 years	3,919	3,808	7,727	7.2	6.8	7.0
70-79 years	4,646	4,693	9,339	13.0	11.7	12.3
80-89 years	2,794	2,757	5,551	20.3	21.0	20.6
90-99 years	422	459	881	28.2	27.0	27.6
Cardiac Dysrhythmias						
none	10,154	10,229	20,383	9.1	8.6	8.8
premature beats (427.6x)	381	360	741	5.5	4.7	5.1
cardiac dysrhythmia, unspecified (427.9x)	142	152	294	8.5	10.5	9.5
other specified cardiac dysrhythmias (427.8x)	866	887	1,753	9.7	10.7	10.2
paroxysmal tachycardia (427.0-427.2)	1,271	1,246	2,517	10.8	11.0	10.9
atrial fibrillation and/or flutter (427.3x)	2,144	2,127	4,271	15.8	16.3	16.0
ventricular fibrillation and/or flutter (427.4x)	400	356	756	34.3	32.0	33.2
Cardiogenic Shock						
no	14,627	14,715	29,342	8.0	8.1	8.1
yes (785.51)	731	642	1,373	65.3	64.3	64.8
Cardiomyopathy						
no	15,057	15,024	30,081	10.6	10.4	10.5
yes (425.3, 425.4, 425.8, 425.9)	301	333	634	17.6	13.2	15.3

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table A-1. "**Direct Admit**" Model - *cont.*

Variable and ICD.9.CM Codes	Number of Cases			Percent Mortality		
	Sample I (n=15,358)	Sample II (n=15,357)	Total (n=30,715)	Sample I (10.8%)	Sample II (10.5%)	Total (10.6%)
Conduction Disorders						
none	13,418	13,382	26,800	9.7	9.5	9.6
left BBB / hemiblk (426.2, 426.3)	455	465	920	11.9	9.9	10.9
A-V block, other & unspecified (426.1x)	485	517	1,002	13.2	11.0	12.1
right & other BBB / other heart blk (426.4-426.6)	444	461	905	16.2	16.5	16.4
unspecified conduction disorder (426.9)	97	76	173	15.5	15.8	15.6
A-V block complete (426.0)	369	369	738	31.2	31.4	31.3
other specified conduction disorders (426.8x)	90	87	177	37.8	32.2	35.0
Diabetes						
none	11,120	11,103	22,223	10.3	10.0	10.1
diabetes without complication (250.0x)	3,465	3,522	6,987	10.9	11.1	11.0
diabetes with complication (250.1x - 250.9x)	773	732	1,505	16.7	14.6	15.7
Dialysis						
no	15,197	15,194	30,391	10.6	10.3	10.4
yes (39.95, 54.98, v56.0, v56.8)	161	163	324	29.8	26.4	28.1
Gender						
male	8,876	8,904	17,780	8.6	8.7	8.6
female	6,482	6,453	12,935	13.8	12.8	13.3
Heart Failure						
no	10,133	10,169	20,302	7.7	7.4	7.6
left/unspecified heart failure (428.1, 428.9)	164	168	332	14.6	15.5	15.1
congestive heart failure 398.91, 428.0)	5,061	5,020	10,081	16.7	16.4	16.5
Hypertension with Complications						
no	14,922	14,932	29,854	10.6	10.3	10.5
yes (402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.x)	436	425	861	15.8	15.1	15.4
Hypertension without Complications						
no	15,049	15,025	30,074	10.8	10.5	10.6
yes (402.x0, 403.x0, 404.x0)	309	332	641	9.1	8.7	8.9
Infarct Site - Principal Diagnosis						
anterolateral wall (410.01)	744	760	1,504	14.9	16.7	15.8
other anterior wall (410.11)	2,893	2,853	5,746	14.3	14.0	14.1
inferolateral wall (410.21)	552	553	1,105	11.8	11.2	11.5
inferoposterior wall (410.31)	468	455	923	12.0	9.2	10.6
other inferior wall (410.41)	3,417	3,442	6,859	9.1	8.9	9.0
other lateral wall (410.51)	403	425	828	11.4	9.6	10.5
true posterior wall (410.61)	147	149	296	12.9	10.7	11.8
subendocardial (non Q-wave) (410.71)	5,154	5,149	10,303	5.2	4.8	5.0
other specified sites (410.81)	459	419	878	15.3	15.8	15.5
unspecified site (410.91)	1,121	1,152	2,273	26.0	25.9	26.0

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table A-1. "**Direct Admit**" Model - *cont.*

Variable and ICD.9.CM Codes	*Number of Cases*			*Percent Mortality*		
	Sample I (n=15,358)	Sample II (n=15,357)	Total (n=30,715)	Sample I (10.8%)	Sample II (10.5%)	Total (10.6%)
Malignant neoplasms (non-metastatic) Note: metastatic cancer cases were excluded from public report analysis.						
no	15,069	15,046	30,115	10.7	10.3	10.5
yes (140.x - 208.90 except 196.x - 199.x)	289	311	600	14.9	16.4	15.7
Payor						
self	177	223	400	4.0	6.7	5.5
Medicaid	747	713	1,460	5.0	5.2	5.1
Medicare	9,972	10,018	19,990	14.5	13.9	14.2
Blue Cross	2,552	2,498	5,050	3.6	3.6	3.6
commercial	981	1,002	1,983	2.4	2.7	2.6
HMO/PPO (Blue Cross & Other)	776	790	1,566	4.4	4.1	4.2
other (*Health & Welfare Fund, Workmen's Comp, other gov. programs, employers, associations, auto insurance*)	153	113	266	8.5	9.7	9.0
Prior CABG Surgery						
no	14,359	14,317	28,676	10.9	10.5	10.7
yes (v45.81 or 996.03)	999	1,040	2,039	9.4	9.1	9.3
Renal Failure						
none	14,533	14,493	29,026	9.2	8.9	9.1
chronic renal failure (585)	324	333	657	21.0	18.0	19.5
unspecified renal failure (586)	105	121	226	42.9	40.5	41.6
acute renal failure (584.5-584.9)	396	410	806	50.3	51.2	50.7
Mean Age			68.6			
Mean Age (females)			72.8			
Mean Age (males)			65.5			

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table A-2. Candidate variable frequency & percent mortality - "**Transfer-in**" model *(before collapsing cells)*

	Number of Cases			*Percent Mortality*		
	Sample I (n=4,024)	Sample II (n=4,025)	Total (n=8,049)	Sample I (7.6%)	Sample II (7.1%)	Total (7.3%)
***Atlas*™ Admission Severity Group (ASG)**						
0	8	13	21	0.0	0.0	0.0
1	1,461	1,448	2,909	1.2	0.6	0.9
2	1,868	1,899	3,767	4.0	4.9	4.5
3	582	579	1,161	23.7	22.3	23.0
4	105	85	190	70.5	64.7	67.9
missing	0	1	1	—	0.0	0.0
Admission Source (not tested for transfer-in model)						
Admission Type						
emergency/urgent	3,649	3,669	7,318	8.0	7.5	7.7
elective	375	356	731	3.5	3.1	3.3
Age (tested as a continuous variable)						
30-39 years	106	113	219	0.9	2.7	1.8
40-49 years	501	507	1,008	3.0	1.0	2.0
50-59 years	851	845	1,696	2.9	2.4	2.7
60-69 years	1,234	1,217	2,451	7.4	7.5	7.4
70-79 years	1,082	1,120	2,202	11.8	10.8	11.3
80-89 years	242	218	460	16.9	21.1	18.9
90-99 years	8	5	13	50.0	0.0	30.8
Cardiac Dysrhythmias						
none	2,909	2,960	5,869	5.2	4.6	4.9
premature beats (427.6x)	66	42	108	4.5	2.4	3.7
cardiac dysrhythmia, unspecified (427.9x)	27	16	43	18.5	0.0	11.6
other specified cardiac dysrhythmias (427.8x)	156	150	306	9.6	7.3	8.5
paroxysmal tachycardia (427.0-427.2)	233	247	480	18.9	13.0	15.8
atrial fibrillation and/or flutter (427.3x)	528	508	1,036	10.8	13.2	12.0
ventricular fibrillation and/or flutter (427.4x)	105	102	207	28.6	38.2	33.3
Cardiogenic Shock						
no	3,748	3,759	7,507	4.1	3.9	4.0
yes (785.51)	276	266	542	55.1	52.3	53.7
Cardiomyopathy						
no	3,963	3,962	7,925	7.5	7.0	7.2
yes (425.x)	61	63	124	13.1	14.3	13.7
Conduction Disorders						
none	3,647	3,627	7,274	6.5	6.0	6.3
left BBB /hemiblk (426.2, 426.3)	59	78	137	15.3	12.8	13.9
A-V block, other & unspecified (426.1x)	90	88	178	7.8	13.6	10.7
right & oth BBB/oth heart blk (426.4-426.6)	95	91	186	12.6	9.9	11.3
conduction disorder, unspecified (426.9)	15	15	30	20.0	13.3	16.7
A-V block complete (426.0)	102	101	203	31.4	26.7	29.1
other specified conduction disorders (426.8x)	16	25	41	25.0	32.0	29.3

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table A-2. "**Transfer-in**" Model - *cont*

	Number of Cases			*Percent Mortality*		
	Sample I (n=4,024)	Sample II (n=4,025)	Total (n=8,049)	Sample I (7.6%)	Sample II (7.1%)	Total (7.3%)
Diabetes						
none	3,083	3,062	6,145	6.9	6.4	6.7
diabetes without complication (250.0x)	810	840	1,650	9.0	8.9	9.0
diabetes with complication (250.1x - 250.9x)	131	123	254	13.7	13.0	13.4
Dialysis						
no	3,980	3,983	7,963	7.2	6.6	6.9
yes (39.95, 54.98, v56.0, v56.8)	44	42	86	38.6	54.8	46.5
Gender						
male	2,596	2,623	5,219	6.3	5.6	5.9
female	1,428	1,402	2,830	9.9	9.9	9.9
Heart Failure						
none	3,138	3,135	6,273	5.2	4.0	4.6
left /unspecified heart failure (428.1, 428.9)	40	56	96	12.5	12.5	12.5
congestive heart failure (398.91, 428.0)	846	834	1,680	16.1	18.5	17.3
Hypertension with Complications						
no	3,962	3,962	7,924	7.4	6.8	7.1
yes (402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.x)	62	63	125	17.7	27.0	22.4
Hypertension without Complications						
no	3,983	3,994	7,977	7.6	7.2	7.4
yes (402.x0, 403.x0, 404.x0)	41	31	72	4.9	0.0	2.8
Infarct Site - Principal Diagnosis						
anterolateral wall (410.01)	191	183	374	8.9	10.9	9.9
other anterior wall (410.11)	921	957	1,878	10.9	7.9	9.4
inferolateral wall (410.21)	147	156	303	6.1	9.6	7.9
inferoposterior wall (410.31)	129	129	258	14.0	10.1	12.0
other inferior wall (410.41)	1,079	1,171	2,250	7.1	6.2	6.7
other lateral wall (410.51)	116	99	215	6.0	6.1	6.0
true posterior wall infarction (410.61)	40	35	75	7.5	11.4	9.3
subendocardial infarction (non Q-wave) (410.71)	1,279	1,155	2,434	3.7	5.1	4.4
other specified sites (410.81)	60	59	119	23.3	11.9	17.6
unspecified site (410.91)	62	81	143	21.0	16.0	18.2

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table A-2. "**Transfer-in**" Model - *cont*

	Number of Cases			*Percent Mortality*		
	Sample I (n=4,024)	Sample II (n=4,025)	Total (n=8,049)	Sample I (7.6%)	Sample II (7.1%)	Total (7.3%)
Malignant neoplasms (non-metastatic) Note: metastatic cancer cases were excluded from public report analysis.						
no	3,988	3,984	7,972	7.6	7.1	7.4
yes (140.x - 208.90 except 196.x - 199.x)	36	41	77	8.3	4.9	6.5
Payor						
self	55	56	111	5.5	5.4	5.4
Medicaid	213	212	425	5.2	4.2	4.7
Medicare	2,016	2,019	4,035	11.6	10.8	11.2
Blue Cross/Blue Shield	1,005	967	1,972	3.2	3.0	3.1
commercial	436	454	890	2.3	3.5	2.9
HMO/PPO (BC/BS & other)	262	288	550	4.6	3.5	4.0
other payors *(Health & Welfare Fund, Workmen's Comp, other gov. programs, employers, associations, auto insurance)*	37	29	66	8.1	0.0	4.5
Prior CABG Surgery						
no	3,709	3,698	7,407	7.3	6.8	7.0
yes (v45.81 or 996.03)	315	327	642	10.8	11.0	10.9
Renal Failure						
none	3,823	3,851	7,674	5.8	5.5	5.6
chronic renal failure (585)	45	36	81	20.0	25.0	22.2
unspecified renal failure (586)	6	9	15	33.3	55.6	46.7
acute renal failure (584)	150	129	279	48.0	47.3	47.7
Mean Age			63.0			
Mean Age (females)			60.9			
Mean Age (males)			66.9			

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Appendix B

Table B-1. Candidate variables frequency & arithmetic average length of stay *(after collapsing cells)*

	Number of Cases			*Average LOS (arithmetic)*		
	Sample I (n=13,233)	Sample II (n=13,233)	Total (n=26,466)	Sample I (%)	Sample II (%)	Total (%)
Atlas™ Admission Severity Group (ASG)						
0 , 1, missing	2,981	3,005	5,986	6.8	6.8	6.8
2	6,298	6,172	12,470	8.9	8.7	8.8
3	3,676	3,771	7,447	11.2	11.0	11.1
4	278	285	563	15.3	14.8	15.1
Admission Source						
physician referral	1,264	1,255	2,519	8.9	8.7	8.8
transfer from general acute care facility	3,374	3,489	6,863	8.3	8.1	8.2
transfer from skilled nursing facility	93	90	183	10.9	9.7	10.3
transfer from other health care facility	83	80	163	9.0	10.0	9.5
emergency room	8,281	8,191	16,472	9.7	9.6	9.6
other (clinic/HMO referral, court/law enforcement)	138	128	266	8.6	8.0	8.3
Admission Type						
emergency/urgent	12,775	12,759	25,534	9.3	9.2	9.2
elective	458	474	932	7.1	6.8	6.9
Age						
30-39 years	210	248	458	6.7	6.6	6.6
40-49 years	1,217	1,132	2,349	7.4	7.0	7.2
50-59 years	2,086	2,076	4,162	7.9	7.9	7.9
60-69 years	3,461	3,389	6,850	9.3	8.8	9.1
70-79 years	3,852	3,904	7,756	9.9	9.9	9.9
80-89 years	2,104	2,158	4,262	10.4	10.3	10.3
90-99 years	303	326	629	10.4	10.3	10.4
Cardiac Dysrhythmias						
none	9,029	9,070	18,099	8.5	8.4	8.4
premature beats (427.6x)	322	311	633	9.1	9.1	9.1
cardiac dysrhythmia, unspecified (427.9x)	108	118	226	9.0	8.9	8.9
other specified cardiac dysrhythmias (427.8x)	716	695	1,411	9.0	9.1	9.0
paroxysmal tachycardia (427.0-427.2)	911	942	1,853	10.2	9.9	10.0
atrial fibrillation and/or flutter (427.3x)	1,910	1,888	3,798	12.0	11.7	11.9
ventricular fibrillation and/or flutter (427.4x)	237	209	446	11.8	11.2	11.5
Cardiogenic Shock						
no	12,991	12,968	25,959	9.1	9.0	9.0
yes (785.51)	242	265	507	16.7	14.5	15.5
Cardiomyopathy						
no	12,958	12,957	25,915	9.2	9.1	9.1
yes (425.x)	275	276	551	10.2	10.4	10.3

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table B-1. - *cont.*

	Number of Cases			*Average LOS (arithmetic)*		
	Sample I (n=13,233)	Sample II (n=13,233)	Total (n=26,466)	Sample I (%)	Sample II (%)	Total (%)
Conduction Disorders						
none	11,709	11,696	23,405	9.1	8.9	9.0
left BBB / hemiblk (426.2, 426.3)	379	369	748	9.2	9.3	9.2
A-V block, other & unspecified (426.1x)	419	416	835	10.0	10.1	10.1
right & oth BBB/oth heart blk (426.4-426.6)	432	460	892	9.9	10.3	10.1
conduction disorder, unspecified (426.9)						
A-V block complete (426.0)	294	292	586	12.8	11.8	12.3
other specified conduction disorders (426.8x)						
Diabetes						
none	9,641	9,620	19,261	9.0	8.8	8.9
diabetes without complication (250.0x)	3,007	3,021	6,028	9.6	9.5	9.5
diabetes with complication (250.1x - 250.9x)	585	592	1,177	11.4	11.0	11.2
Dialysis						
no	13,123	13,100	26,223	9.2	9.0	9.1
yes (39.95, 54.98, v56.0, v56.8)	110	133	243	14.3	12.4	13.3
Gender						
male	7,857	7,770	15,627	8.8	8.7	8.8
female	5,376	5,463	10,839	9.8	9.6	9.7
Heart Failure						
no	9,090	9,052	18,142	8.1	8.0	8.1
yes	4,143	4,181	8,324	11.6	11.3	11.5
Hypertension with Complications						
no	12,887	12,871	25,758	9.1	9.0	9.1
yes (402.x1, 403.x1, 404.x1, 404.x2, 404.x3, 405.x)	346	362	708	12.4	11.0	11.7
Hypertension without Complications						
no	12,992	13,000	25,992	9.2	9.1	9.2
yes (402.x0, 403.x0, 404.x0)	241	233	474	9.1	9.2	9.1
Infarct Site - Principal Diagnosis						
anterolateral wall (410.01)	563	591	1,154	10.6	9.9	10.2
other anterior wall (410.11)	2,469	2,442	4,911	9.8	9.7	9.7
inferolateral wall (410.21)	452	470	922	9.5	9.0	9.2
inferoposterior wall (410.31)	362	413	775	9.4	9.4	9.4
other inferior wall (410.41)	3,097	3,025	6,122	8.9	8.7	8.8
other lateral wall (410.51)	358	383	741	8.5	8.9	8.7
true posterior wall (410.61)	123	122	245	8.9	9.0	8.9
subendocardial (non Q-wave) (410.71)	4,849	4,753	9,602	8.9	8.9	8.9
other specified sites (410.81)	292	326	618	9.5	9.6	9.5
unspecified site (410.91)	668	708	1,376	9.7	9.2	9.4

continued

Source: PA Health Care Cost Containment Council 1993 AMI Data Set

Table B-1. - *cont.*

	Number of Cases			*Average LOS (arithmetic)*		
	Sample I (n=13,233)	Sample II (n=13,233)	Total (n=26,466)	Sample I (%)	Sample II (%)	Total (%)
Malignant neoplasm (non-secondary) Note: metastatic cancer cases were excluded from public report analysis.						
no	12,996	12,971	25,967	9.2	9.0	9.1
yes (140.x - 208.90 except 196.x - 199.x)	237	262	499	11.5	10.6	11.0
Prior CABG Surgery						
no	12,231	12,278	24,509	9.2	9.1	9.1
yes (v45.81 or 996.03)	1,002	955	1,957	9.3	9.1	9.2
Renal Failure						
none	12,687	12,692	25,379	9.0	8.9	9.0
chronic renal failure (585)	254	262	516	11.1	10.9	11.0
acute/unsp. renal failure (584 & 586)	292	279	571	16.3	15.7	16.0
Diagnosis Related Group (DRG)						
104 - Cardiac Valve Procedures w/ Cardiac Cath	66	57	123	22.6	18.9	20.9
105 - Cardiac Valve Procedures w/o Cardiac Cath	8	9	17	19.6	16.0	17.7
106 - Coronary Bypass w/ Cardiac Cath	1,261	1,183	2,444	14.4	14.4	14.4
107 - Coronary Bypass w/o Cardiac Cath	195	192	387	12.1	10.7	11.4
108 - Other Cardiothoracic Procedures	45	37	82	15.0	17.9	16.3
110 - Major Cardiovascular Procedures w/ CC	217	213	430	14.1	12.4	13.3
111 - Major Cardiovascular Procedures w/o CC	32	31	63	7.1	7.3	7.2
112 - Percutaneous Cardiovascular Procedures	2,501	2,544	5,045	6.7	6.8	6.8
115 - Perm Card Pacemkr Imp w/AMI, Hrt Fail, Shock	107	88	195	14.2	14.1	14.2
120 - Other Circ System Operating Room Procedures	30	27	57	16.7	14.7	15.8
121 - Circ Dis w/AMI & Cardiovas Comp, Disch Alive	4,977	5,048	10,025	10.0	9.8	9.9
122 - Circ Dis w/AMI w/o Cardiovas Comp, Disch Alive	3,670	3,681	7,351	7.0	7.0	7.0
144 - Other Circulatory System Diagnoses w/ CC	7	9	16	13.0	7.2	9.8
145 - Other Circulatory System Diagnoses w/o CC	6	5	11	5.5	6.6	6.0
468 - Extensive OR Proc Unrelated to Princ Diag	26	21	47	16.1	18.4	17.1
477 - Nonextensive OR Proc Unrelated to Princ Diag	16	17	33	14.3	13.1	13.7
478 - Other Vascular Procedures with CC	59	60	119	14.1	14.1	14.1
483 - Tracheostomy Except Face, Mouth & Neck Diag	10	11	21	27.6	31.2	29.5
Transfer-in Status						
not transferred-in	9,603	9,477	19,080	9.6	9.5	9.6
transferred-in	3,630	3,756	7,386	8.2	8.0	8.1

Source: PA Health Care Cost Containment Council 1993 AMI Data Set