The Johns Hopkins

ACG® SYSTEM

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The Johns Hopkins ACG® System

Excerpt from Version 13.0 Technical Reference Guide

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BLOOMBERG SCHOOL
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Contents

Chapter 1:
Diagnosis-based Markers

The Johns Hopkins ACG® System is a statistically valid, case-mix methodology that allows health care providers, health care organizations, and public-sector agencies to describe or predict a population's past or future health care utilization and costs. The ACG System is also widely used by researchers and analysts to compare various patient populations' prior health resource use, while taking into account morbidity or illness burden.

The ACG System provides a number of markers derived from a patient's diagnosis code history from all encounters during a 12-month period. This chapter provides definition for the ACG System markers derived from diagnosis information.

Morbidity Types – Aggregated Diagnosis Groups (ADGs)

There are thousands of International Classification of Disease (ICD) diagnosis codes that clinicians can use to describe patients' health conditions. The first step of the ACG grouping logic is to assign each diagnosis code to one or more of 32 diagnosis groups referred to as Aggregated Diagnosis Groups, or ADGs. The diagnosis-to-ADG mapping embedded in the ACG System software includes an ADG assignment for all[1] ICD codes. Where a single diagnosis code indicates more than one underlying morbidity type, more than one ADG may be assigned. For example, in ICD-10 the code E11.31 (Type 2 diabetes mellitus with unspecified diabetic retinopathy) would trigger both ADG 18 (Chronic Specialty: Unstable-Eye) and ADG 11 (Chronic Medical: Unstable).

Diagnosis codes within the same ADG are similar in terms of both clinical criteria and expected need for health care resources. Just as individuals may have multiple diagnosis codes, they may have multiple ADGs. The following table lists all ADGs and exemplary diagnosis codes.

ADGs and Common Diagnosis Codes Assigned to Them

ADGs	ICD-10	Diagnosis
1. Time Limited: Minor	K52.9	Noninfectious Gastroentritis
	L22	Diaper or Napkin Rash
2. Time Limited: Minor-Primary Infections	B09	Unspecified Viral Infection
	J05.0	Croup
3. Time Limited: Major	I80.2	Phlebitis of Lower Extremities
	K56.7	Impaction of Intestine
4. Time Limited: Major-Primary Infections	K75.9	Hepatitis, Unspecified
	M00.9	Pyogenic Arthritis

1 *Because they indicate the cause of injury rather than an underlying morbidity, ICD-10 codes beginning V through Y have generally been excluded from the Diagnosis-to-ADG mapping. The source of codes is the Center for Medicare and Medicaid Services (CMS) list of ICD-10-CM codes (available for download at http://www.cms.gov). ICD-10 codes are sourced from the Official ICD-10 Updates published by the World Health Organization (WHO).*

ADGs	ICD-10	Diagnosis
5. Allergies	J30.0	Allergic Rhinitis, Cause Unspecified
	L50.8	Other Urticaria
6. Asthma	J45.0	Extrinsic Asthma
	J45.1	Intrinsic Asthma
7. Likely to Recur: Discrete	M10.9	Gout, Unspecified
	M54.9	Backache, Unspecified
8. Likely to Recur: Discrete-Infection	J35.1	Chronic Tonsillitis
	N39.0	Urinary Tract Infection
9. Likely to Recur: Progressive	E11.1	Adult Onset Type II Diabetes w/Ketoacidosis
	I66.9	Cerebral Thrombosis
10. Chronic Medical: Stable	E10.9	Adult-Onset Type 1 Diabetes
	I10	Essential Hypertension
11. Chronic Medical: Unstable	D57.1	Sickle-Cell Anemia
	E84.0	Cystic Fibrosis
12. Chronic Specialty: Stable-Orthopedic	M48.9	Cervical Spondylosis Without Myelopathy
	M24.9	Other Joint Derangement
13. Chronic Specialty: Stable-Ear, Nose, Throat	H90.5	Central Hearing Loss
	H71	Cholesteatoma
14. Chronic Specialty: Stable-Eye	H52.1	Myopia
	H11.9	Unspecified Disorder of Conjunctiva
16. Chronic Specialty: Unstable-Orthopedic	M48.0	Spinal Stenosis of Lumbar Region
	M92.8	Osteochondritis Dissecans
17. Chronic Specialty: Unstable-Ear, Nose, Throat	H81.0	Meniere's Disease
	H70.1	Chronic Mastoiditis
18. Chronic Specialty: Unstable-Eye	H40.9	Unspecified Glaucoma
	H15.0	Scleritis/Episcleritis
20. Dermatologic	A63.0	Viral Warts
	H61.0	Chondritis of external ear
21. Injuries/Adverse Effects: Minor	S13.4	Neck Sprain
	T09.0	Injury to Trunk

ADGs	ICD-10	Diagnosis
22. Injuries/Adverse Effects: Major	S06	Intracranial Injury
	T46.0	Poisoning by Cardiotonic Glycosides and Similar Drugs
23. Psychosocial: Time Limited, Minor	F12.1	Cannabis Abuse, Unspecified
	F32.0	Brief Depressive Reaction
24. Psychosocial: Recurrent or Persistent, Stable	F41.0	Panic Disorder
	F50.3	Bulimia
25. Psychosocial: Recurrent or Persistent, Unstable	F20.2	Catatonic Schizophrenia
	F10.3	Alcohol Withdrawal Delirium Tremens
26. Signs/Symptoms: Minor	G44.1	Headache
	M79.6	Pain in Limb
27. Signs/Symptoms: Uncertain	M25.4	Effusion of Lower Leg Joint
	R53	Malaise and Fatigue
28. Signs/Symptoms: Major	I51.7	Cardiomegaly
	R55	Syncope and Collapse
29. Discretionary	K40	Inguinal Hernia (NOS)
	L72.1	Sebaceous Cyst
30. See and Reassure	N62	Hypertrophy of Breast
	E65	Localized Adiposity
31. Prevention/Administrative	Z00.1	Routine Infant or Child Health Check
	Z01.4	Gynecological Examination
32. Malignancy	C50	Malignant Neoplasm of Breast (NOS)
	C81.9	Hodgkin's Disease, Unspecified Type
33. Pregnancy	Z33	Pregnant State
	O80.0	Delivery in a Completely Normal Case
34. Dental	K02	Dental Caries
	K05.1	Chronic Gingivitis

Note: Only 32 of the 34 markers are currently in use.

When the *lenient* diagnostic certainty option is applied, any single diagnosis qualifying for an ADG marker will turn the marker on. However, the *stringent* diagnostic certainty option can also be applied. For a subset of chronic diagnoses, there must be more than one diagnosis qualifying for the marker in order for the ADG to be assigned. This was designed to provide greater confidence in the ADGs assigned to a patient. For more information, refer to .

ADGs are distinguished by several clinical characteristics (time limited or not, requiring primary care or specialty care, or addressing physical health or psycho-social needs) and the degree of refinement of the problem (diagnosis or symptom/sign). ADGs are not categorized by organ system or disease. Instead, they are based on clinical dimensions that help explain or predict the need for health care resources over time. The need for health care resources is primarily determined by the likelihood of persistence of problems and their level of severity.

Example

A patient with both Obstructive Chronic Bronchitis (ICD-10 code J44.9) and Congestive Heart Failure (ICD-10 code I50.9) will fall into only one ADG, Chronic Medical: Unstable (ADG-11), while a patient with Candidiasis of Unspecified Site (ICD-10-CM code B37.9) and Acute Upper Respiratory Infections of Unspecified Site (ICD-10-CM code J06.9) will have two ADGs, Likely to Recur: Discrete Infections (ADG-8), and Time Limited: Minor-Primary Infections (ADG-2), respectively.

The criteria for ADG assignment depends on those features of a condition that are most helpful in understanding and predicting the duration and intensity of health care resources. Five clinical criteria guide the assignment of each diagnosis code into an ADG: duration, severity, diagnostic certainty, type of etiology, and expected need for specialty care. The Duration, Severity, Etiology, and Certainty of the ADGs table illustrates how each of these five clinical criteria is applied to the 32 ADGs.

Duration

What is the expected length of time the health condition will last? Acute conditions are time limited and expected to resolve completely. Recurrent conditions occur episodically with intermediate disease-free intervals. Chronic conditions persist and are expected to require long-term management generally longer than one year.

Severity

What is the expected prognosis? How likely is the condition to worsen or lead to impairment, death, or an altered physiologic state? The ADG-taxonomy divides acute conditions into minor and major categories corresponding to low and high severity, respectively. The system divides chronic conditions into stable and unstable based on the expected severity over time. Unstable conditions are more likely to have complications (related co-morbidities) than stable conditions and are expected to require more resources on an ongoing basis (i.e., more likely to need specialty care).

Diagnostic Certainty

Will a diagnostic evaluation be needed or will treatment be the primary focus? Some diagnosis codes are given for signs/symptoms and are associated with diagnostic uncertainty. As such, they may require watchful waiting only or substantial work-up. The three ADGs for signs/symptoms are arranged by expected intensity of diagnostic work-up, from low to intermediate to high.

Etiology

What is the cause of the health condition? Specific causes suggest the likelihood of different treatments. Infectious diseases usually require anti-microbial therapy; injuries may need emergency medical services, surgical management, or rehabilitation; anatomic problems may require surgical intervention; neoplastic diseases could involve surgical care, radiotherapy, chemotherapy; psychosocial problems require mental health services; pregnancy involves obstetric services; and, medical problems may require pharmacologic, rehabilitative, or supportive management.

Expected Need for Specialty Care

Would the majority of patients with this condition be expected to require specialty care management from a non-primary care provider? The routine course of care for some ADG categories implies that specialty care is more likely.

Duration, Severity, Etiology, and Certainty of the ADGs

Note: ADGs 15 and 19 are no longer used.

ADG	Duration	Severity	Etiology	Diagnostic Certainty	Expected Need for Specialty Care
1. Time Limited: Minor	Acute	Low	Medical, non-infectious	High	Unlikely
2. Time Limited: Minor-Primary Infections	Acute	Low	Medical, infectious	High	Unlikely
3. Time Limited: Major	Acute	High	Medical, non-infectious	High	Likely
4. Time Limited: Major-Primary Infections	Acute	High	Medical, infectious	High	Likely
5. Allergies	Recurrent	Low	Allergy	High	Possibly
6. Asthma	Recurrent or Chronic	Low	Mixed	High	Possibly
7. Likely to Recur: Discrete	Recurrent	Low	Medical, non-infectious	High	Unlikely
8. Likely to Recur: Discrete-Infections	Recurrent	Low	Medical, infectious	High	Unlikely
9. Likely to Recur: Progressive	Recurrent	High	Medical, non-infectious	High	Likely
10. Chronic Medical: Stable	Chronic	Low	Medical, non-infectious	High	Unlikely
11. Chronic Medical: Unstable	Chronic	High	Medical, non-infectious	High	Likely
12. Chronic Specialty: Stable-Orthopedic	Chronic	Low	Anatomic/Musculoskeletal	High	Likely: orthopedics
13. Chronic Specialty: Stable-	Chronic	Low	Anatomic/Ears, Nose, Throat	High	Likely: ENT

ADG	Duration	Severity	Etiology	Diagnostic Certainty	Expected Need for Specialty Care
Ear, Nose, Throat					
14. Chronic Specialty: Stable-Ophthalmology	Chronic	Low	Anatomic/Eye	High	Likely: ophthalmology
16. Chronic Specialty: Unstable-Orthopedics	Chronic	High	Anatomic/Musculoskeletal	High	Likely: orthopedics
17. Chronic Specialty: Unstable-Ear, Nose, Throat	Chronic	High	Anatomic/Ears, Nose, Throat	High	Likely: ENT
18. Chronic Specialty: Unstable-Ophthalmology	Chronic	High	Anatomic/Eye	High	Likely: ophthalmology
20. Dermatologic	Acute, Recurrent	Low to High	Mixed	High	Likely: dermatology
21. Injuries/Adverse Effects: Minor	Acute	Low	Injury	High	Unlikely
22. Injuries/Adverse Effects: Major	Acute	High	Injury	High	Likely
23. Psychosocial: Time Limited, Minor	Acute	Low	Psychosocial	High	Unlikely
24. Psychosocial: Recurrent or Chronic, Stable	Recurrent or Chronic	Low	Psychosocial	High	Likely: mental health
25. Psychosocial: Recurrent or Persistent, Unstable	Recurrent or Chronic	High	Psychosocial	High	Likely: mental health
26. Signs/Symptoms: Minor	Uncertain	Low	Mixed	High	Unlikely
27. Signs/Symptoms: Uncertain	Uncertain	Uncertain	Mixed	High	Uncertain

ADG	Duration	Severity	Etiology	Diagnostic Certainty	Expected Need for Specialty Care
28. Signs/Symptoms: Major	Uncertain	High	Mixed	Low	Likely
29. Discretionary	Acute	Low to High	Anatomic	High	Likely: surgical specialties
30. See and Reassure	Acute	Low	Anatomic	High	Unlikely
31. Prevention/Administrative	N/A	N/A	N/A	N/A	Unlikely
32. Malignancy	Chronic	High	Neoplastic	High	Likely: oncology
33. Pregnancy	Acute	Low	Pregnancy	High	Likely: obstetrics
34. Dental	Acute, Recurrent, Chronic	Low to High	Mixed	High	Likely: dental

Major ADGs

Some ADGs have very high expected resource use and are labeled as Major ADGs. The following table presents major ADGs for adult and pediatric populations.

Major ADGs for Adult and Pediatric Populations

Pediatric Major ADGs (ages 0-17 years)	Adult Major ADGs (ages 18 and up)
3 Time Limited: Major	3 Time Limited: Major
9 Likely to Recur: Progressive	4 Time Limited: Major-Primary Infections
11 Chronic Medical: Unstable	9 Likely to Recur: Progressive
12 Chronic Specialty: Stable-Orthopedic	11 Chronic Medical: Unstable
13 Chronic Specialty: Stable-Ear, Nose, Throat	16 Chronic Specialty: Unstable-Orthopedic
18 Chronic Specialty: Unstable-Eye	22 Injuries/Adverse Effects: Major
25 Psychosocial: Recurrent or Persistent, Unstable	25 Psychosocial: Recurrent or Persistent, Unstable
32 Malignancy	32 Malignancy

While the primary use of ADGs is as a means for collapsing all diagnosis codes into clinically meaningful morbidity types as a first step in the ACG assignment process, ADGs are useful as a risk assessment tool in their own right. There are many examples in the literature of using ADG markers as generic case-mix control variables. The most common application is the introduction of individual ADG-markers as binary flags in a regression model, but something as simple as a count of ADGs or Major ADGs can be a very powerful indicator of need as well.

Relationship Between Number and Major Morbidities in Year 1 and Likelihood of Subsequent High Cost

Number of Year 1 Major Morbidities	Percent of Members	Positive Predictive Value	
		Percent High Cost in Year 2	Percent High Cost in Year 3
0 Major ADGs	77.1%	9.6%	11.0%
1 Major ADG	17.3%	20.9%	21.5%
2 Major ADGs	4.2%	34.7%	34.1%
3 Major ADGs	1.1%	43.6%	45.6%
4+ Major ADGs	0.4%	72.4%	70.1%

Patterns of Morbidity – Adjusted Clinical Groups (ACGs)

Adjusted Clinical Group actuarial cells, or ACGs, are the original building blocks of The Johns Hopkins ACG System methodology. ACG categories are a series of mutually exclusive, health status categories defined by morbidity, age, and sex. They are based on the premise that the level of resources necessary for delivering appropriate health care to a population is correlated with the illness burden of that population. ACG categories are used to determine the morbidity profile of patient populations to more fairly assess provider performance, to reimburse providers based on the health needs of their patients, and to allow for more equitable comparisons of utilization or outcomes across two or more patient or enrollee aggregations.

ACG categories are a person-focused method of categorizing patients' illnesses. Over time, each person develops numerous conditions. Based on the pattern of these morbidities, the ACG System approach assigns each individual to a single ACG category.

The concept of the ACG System grew out of research by Dr. Barbara Starfield and her colleagues in the late 1970s when they examined the relationship between morbidity or illness burden and health care services utilization among children in managed care settings. The research team theorized that the children using the most health care resources were not those with a single chronic illness, but rather were those with multiple, seemingly unrelated conditions. To test their original hypothesis, illnesses found within pediatric health maintenance organization (HMO) populations were grouped into five discrete categories:

1. Minor illnesses that are self-limited if treated appropriately, e.g., the flu or chicken pox.

2. Illnesses that are more severe but also time-limited if treated appropriately, e.g., a broken leg or pneumonia.

3. Medical illnesses that are generally chronic and which remain incurable even with medical therapy, e.g., diabetes or cystic fibrosis.

4. Illnesses resulting from structural problems that are generally not curable even with adequate and appropriate intervention, e.g., cerebral palsy or scoliosis.

5. Psychosocial conditions, e.g., behavior problems or depression.

The Johns Hopkins team's findings supported the hypothesis that clustering of morbidity is a better predictor of health services resource use than the presence of specific diseases. This finding forms the

basis of the current ACG System methodology and remains the fundamental concept that differentiates the ACG System from other case-mix adjustment methodologies.

There are four steps in the ACG category assignment process:

1. Mapping Diagnosis Codes to a Parsimonious Set of Aggregated ADGs

2. Creating a Manageable Number of ADG Subgroups (CADGs)

3. Frequently Occurring Combinations of CADGs (MACs)

4. Forming the Terminal Groups (ACGs)

The first step is described in the preceding section while the remainder are summarized in the following tables and figures depicting the ACG-decision-tree logic.

Creating a Manageable Number of ADG Subgroups (CADGs)

The ultimate goal of the ACG algorithm is to assign each person to a single morbidity group (i.e., an ACG). There are 4.3 billion possible combinations of ADGs, so to create a more manageable number of unique combinations of morbidity groupings, the 32 ADGs are collapsed into 12 CADGs or Collapsed ADGs (presented in the following table). Like ADGs, CADGs are not mutually exclusive in that an individual can be assigned to as few as none or as many as 12.

Although numerous analytic techniques could be used to form CADGs from ADGs, the ACG System has placed the emphasis on clinical cogency. The following three clinical criteria are used:

*   The similarity of *likelihood of persistence or recurrence* of diagnoses within the ADG, i.e., time-limited, likely to recur, or chronic groupings

*   The *severity* of the condition, i.e., minor versus major and stable versus unstable

*   The *types of health care services required* for patient management--medical versus specialty, eye/dental, psychosocial, prevention/administrative, and pregnancy

ADGs and CADGs can be used for various analytic and research applications that do not require mutually exclusive categories such as multivariate predictive or explanatory models.

Collapsed ADG Clusters and the ADGs that Comprise Them

Collapsed ADG (CADG)	ADGs in Each
1. Acute Minor	1 Time Limited: Minor 2 Time Limited: Minor-Primary Infections 21 Injuries/Adverse Events: Minor 26 Signs/Symptoms: Minor
2. Acute Major	3 Time Limited: Major 4 Time Limited: Major-Primary Infections 22 Injuries/Adverse Events: Major 27 Signs/Symptoms: Uncertain 28 Signs/Symptoms: Major
3. Likely to Recur	5 Allergies 7 Likely to Recur: Discrete 8 Likely to Recur: Discrete-Infections 20 Dermatologic 29 Discretionary

Collapsed ADG (CADG)	ADGs in Each
4. Asthma	6 Asthma
5. Chronic Medical: Unstable	9 Likely to Recur: Progressive 11 Chronic Medical: Unstable 32 Malignancy
6. Chronic Medical: Stable	10 Chronic Medical: Stable 30 See and Reassure
7. Chronic Specialty: Stable	12 Chronic Specialty: Stable-Orthopedic 13 Chronic Specialty: Stable-Ear, Nose, Throat
8. Eye/Dental	14 Chronic Specialty: Stable-Eye 34 Dental
9. Chronic Specialty: Unstable	16 Chronic Specialty: Unstable-Orthopedic 17 Chronic Specialty: Unstable-Ear, Nose, Throat 18 Chronic Specialty: Unstable-Eye
10. Psychosocial	23 Psycho-social: Time Limited, Minor 24 Psycho-social: Recurrent or Persistent, Stable 25 Psycho-social: Recurrent or Persistent, Unstable
11. Preventive/Administrative	31 Prevention/Administrative
12. Pregnancy	33 Pregnancy

Frequently Occurring Combinations of CADGs (MACs)

The third step in the ACG categorization methodology assigns individuals into a single, mutually exclusive category called a MAC. This grouping algorithm is based primarily on the pattern of CADGs. The MACs and the Collapsed ADGs Assigned to Them table shows the MACs and the Collapsed ADGs which comprise them.

There are 23 commonly occurring combinations of CADGs which form MACs 1 through 23:

- The first 11 MACs correspond to presence of a single CADG.
- MAC-12 includes all pregnant women, regardless of their pattern of CADGs.
- MACs 13 through 23 are commonly occurring combinations of CADGs.
- MAC-24 includes all other combinations of CADGs.
- MAC-25 is used for enrollees with no service use or invalid diagnosis input data.
- MAC-26 includes all infants (age <12 months), regardless of the pattern of CADGs.

MACs and the Collapsed ADGs Assigned to Them

MACs	CADGs
1. Acute: Minor	1
2. Acute: Major	2
3. Likely to Recur	3
4. Asthma	4

MACs	CADGs
5. Chronic Medical: Unstable	5
6. Chronic Medical: Stable	6
7. Chronic Specialty: Stable	7
8. Eye/Dental	8
9. Chronic Specialty: Unstable	9
10. Psychosocial	10
11. Prevention/Administrative	11
12. Pregnancy	All CADG combinations that include CADG 12
13. Acute: Minor and Acute: Major	1 and 2
14. Acute: Minor and Likely to Recur	1 and 3
15. Acute: Minor and Chronic Medical: Stable	1 and 6
16. Acute: Minor and Eye/Dental	1 and 8
17. Acute: Minor and Psychosocial	1 and 10
18. Acute: Major and Likely to Recur	2 and 3
19. Acute: Minor and Acute: Major and Likely to Recur	1, 2 and 3
20. Acute: Minor and Likely to Recur and Eye and Dental	1, 3 and 8
21. Acute: Minor and Likely to Recur and Psychosocial	1, 3, and 10
22. Acute: Minor and Major and Likely to Recur and Chronic Medical: Stable	1, 2, 3, and 6
23. Acute: Minor and Major and Likely to Recur and Psychosocial	1, 2, 3, and 10
24. All Other Combinations Not Listed Above	All Other Combinations
25. No Diagnosis or Only Unclassified Diagnosis	No CADGs
26. Infants (age less than one year)	Any CADGs combinations and less than one year old

Forming the Terminal Groups (ACG categories)

MACs form the major branches of the ACG decision tree. The final step in the grouping algorithm divides the MAC branches into terminal groups, the actuarial cells known as ACG categories. The logic used to split MACs into ACG categories includes a combination of statistical considerations and clinical insight. During the ACG System development process, the overarching goal for ACG category assignment was to identify groups of individuals with similar needs for health care resources who also share similar clinical characteristics. Yale University's AUTOGRP software (which performs recursive partitioning) was used to identify subdivisions of patients within a MAC who had similar needs for health care resources based on their overall expenditures. The variables taken into consideration included: age, sex, presence of specific ADGs, number of major ADGs, and total number of ADGs.

Note: Because prevention/administrative needs do not reflect morbidity, ADG 31 is not included in the count of total ADGs[2].

See the Final ACG Categories, Reference ACG Concurrent Risks, and RUBs table on page 31 for a complete listing and description of all ACG categories.

ACG Decision Tree

The ACG Decision Tree figure illustrates the main branches of the ACG decision tree. Some MACs are not subdivided by the characteristics listed above because doing so did not increase the explanatory power of the ACG model. Some include only a single CADG: for instance, MAC-02 is composed of individuals with only acute major conditions. Others, such as MAC-01, acute conditions only, are subdivided into three age groups: ACG 0100 (Age = one year), ACG 0200 (Age = two to five years), and ACG 0300 (six or more years) because resource use differs by age for individuals with this pattern of morbidity. MAC-10, including individuals with psychosocial morbidity only and MAC-17, including individuals with psychosocial and acute minor conditions, are further split by the presence of ADG-24 (recurrent or chronic stable psychosocial conditions) and ADG-25 (recurrent or chronic unstable psychosocial conditions).

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2 *Refer to Weiner (91) and Starfield (91) for more detail on the historical origins of the current system including the original Version 1.0 development process.*
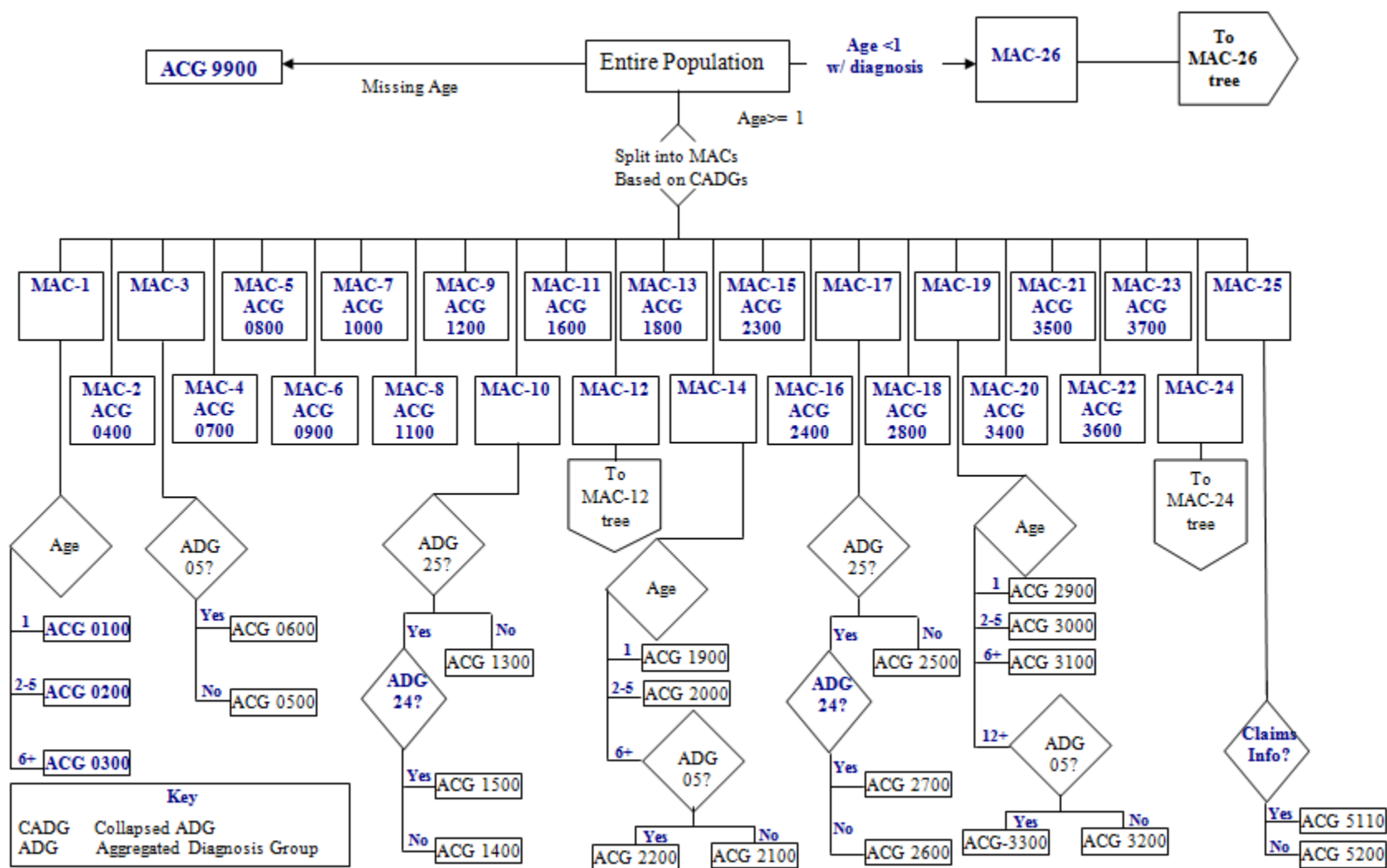
Figure 1. ACG Decision Tree

Decision Tree for MAC-12—Pregnant Women

The Decision Tree for MAC-12—Pregnant Women illustrates the grouping logic for pregnant women. All women with at least one diagnosis code indicating pregnancy are assigned to MAC-12. The ACG catgories for pregnant women are formed with subdivisions first on total number of ADGs (0-1, 2-3, 4-5, 6+) and second, for individuals with two or more ADGs, a split on none versus one or more major ADGs. These two splits yield seven ACG cagtegories for pregnant women.

The standard seven ACG categories for pregnant women can optionally be further subdivided according to whether delivery has occurred during the time period of interest, yielding a total of 14 ACG categories for women with a diagnosis of pregnancy. Either diagnosis codes for delivery or a user-supplied delivery flag can be used to separate pregnant women according to delivery status. Because of the marked differences in resource consumption for women with and without delivery and generally adequate validity of diagnoses associated with delivery, most organizations will find this option desirable to use. By default, the software will use diagnosis codes to subdivide based on delivery status.

Refer to and for a more detailed discussion of appropriate means of identifying pregnancy and delivery status using user-defined flags.
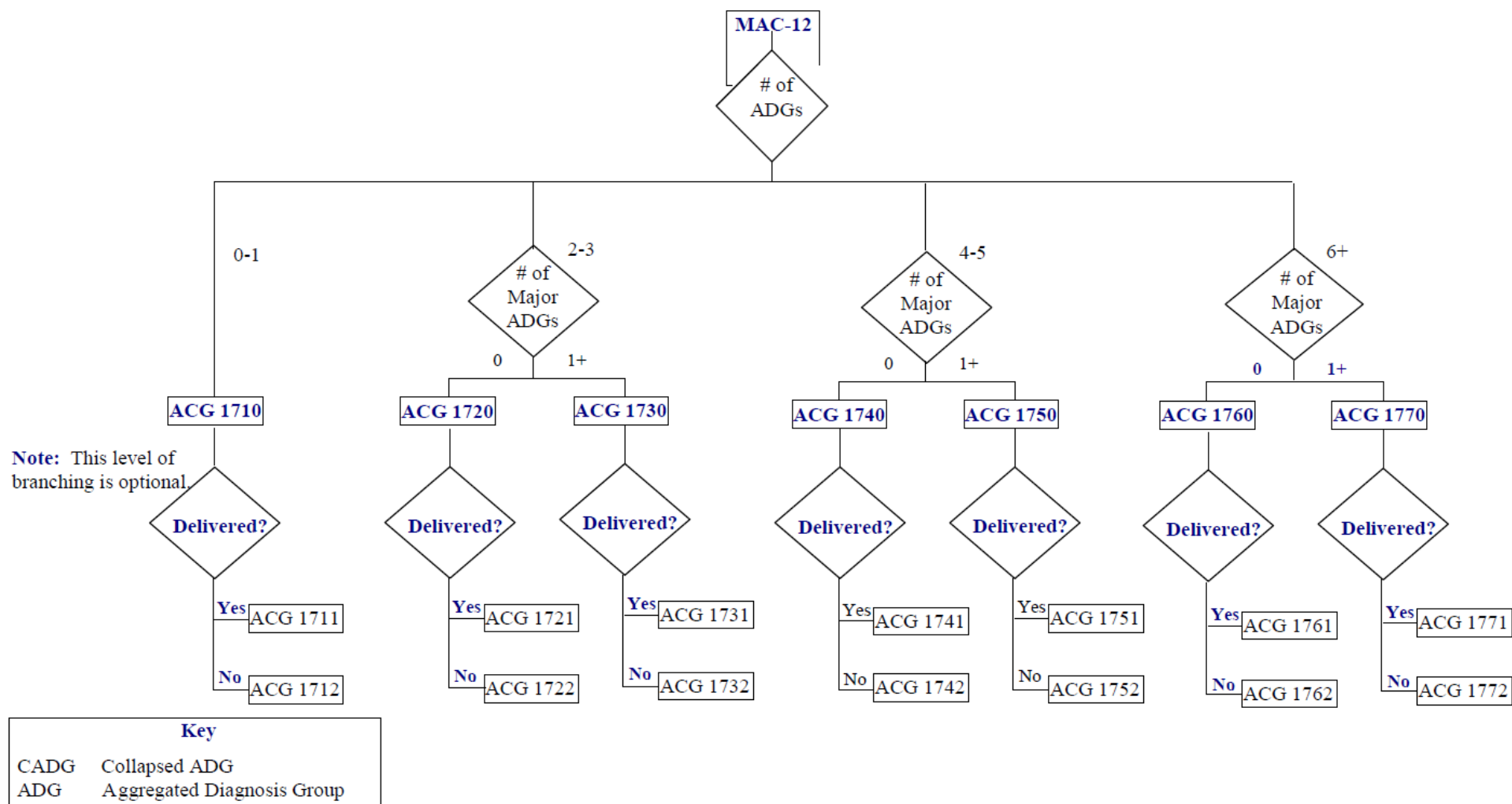
Figure 2. Decision Tree for MAC-12—Pregnant Women

Decision Tree for MAC-26—Infants

The Decision Tree for MAC-26—Infants illustrates the branching algorithm for MAC-26, which includes all infants, regardless of their pattern of CADGs. The first bifurcation is made on the total number of ADGs. Each group is further subdivided by presence of the number of major ADGs. These two splits yield four ACG categories.

For the infant ACG categories, there is an optional additional split on birth weight. If there is accurate birth weight information that can be linked with claims and enrollment files, the four standard infant ACG categories can be further split into low birth weight (<2,500 grams) and normal birth weight (>2,500 grams). Our developmental work suggests that this additional split improves the explanatory power of the ACG System. However, two caveats are important to consider before using this option. First, our research indicates poor validity for existing birth weight diagnosis codes in some administrative data sets. Second, some populations may have such low rates of low birth weight infants that the number of infants grouped into an ACG category may be too small for accurate estimates. In general, we recommend that at least 30 individuals per ACG category are needed to obtain stable estimates of average resource use for that ACG code. By default, the ACG System will divide infants based upon the presence or absence of a diagnosis code indicating low birth weight.

Refer to for a more detailed discussion of appropriate means of identifying low birth weight status using user-defined flags.
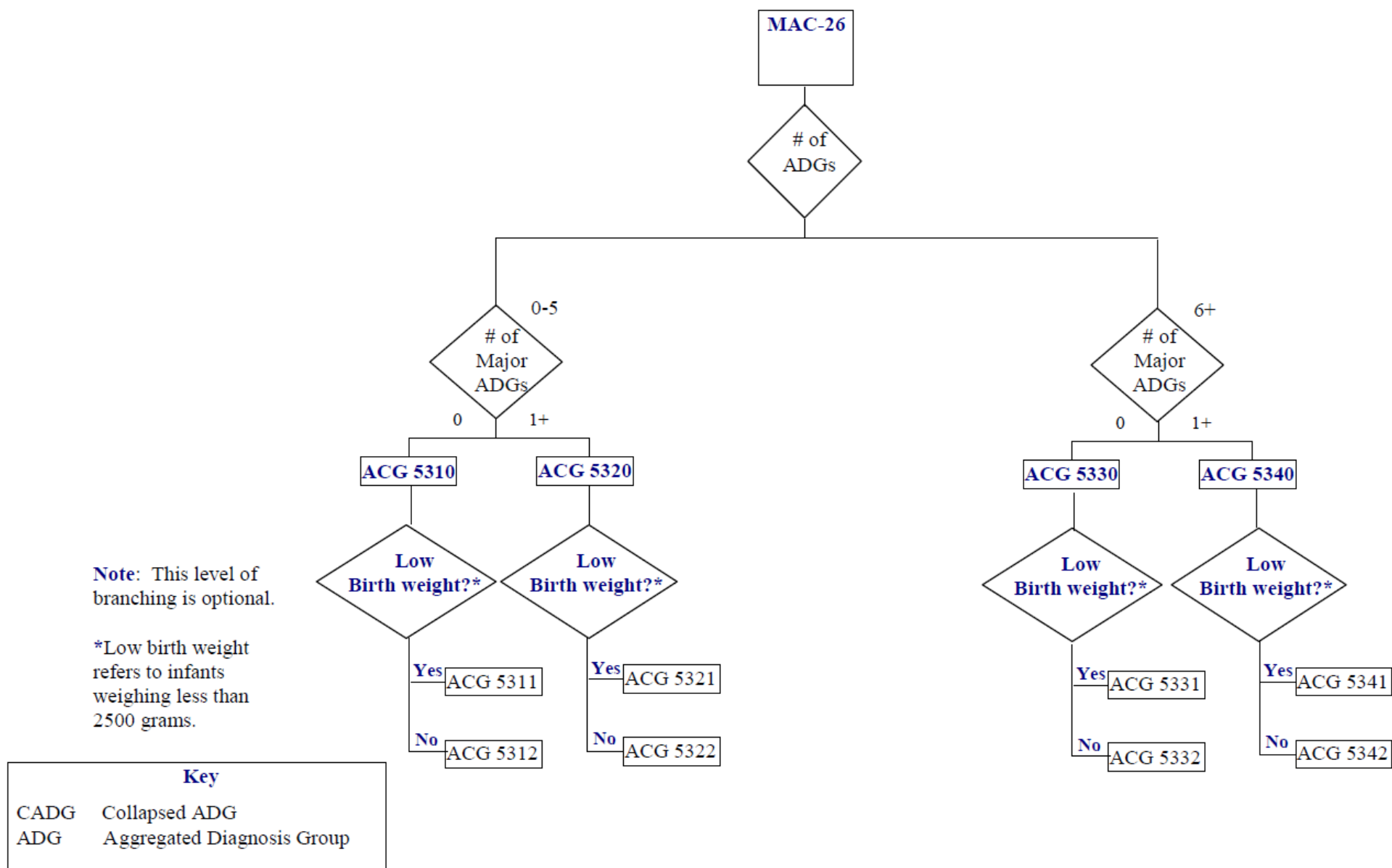
Figure 3. Decision Tree for MAC-26—Infants

Decision Tree for MAC-24—Multiple ADG Categories

The Decision Tree for MAC-24—Multiple ADG Categories illustrates the last branch of the ACG System decision tree, MAC-24, which includes less frequently occurring combinations of CADGs. There are 33 ACG categories within MAC-24. With MAC-24, the first two splits are total number of ADGs (2-3, 4-5, 6-9, and 10+) and then, within each of these four groups, by age. The age splits separate children (1-17 years) from adults (18+), and in some cases further subdivides within these groups. Additional divisions are made on sex and number of major ADGs.
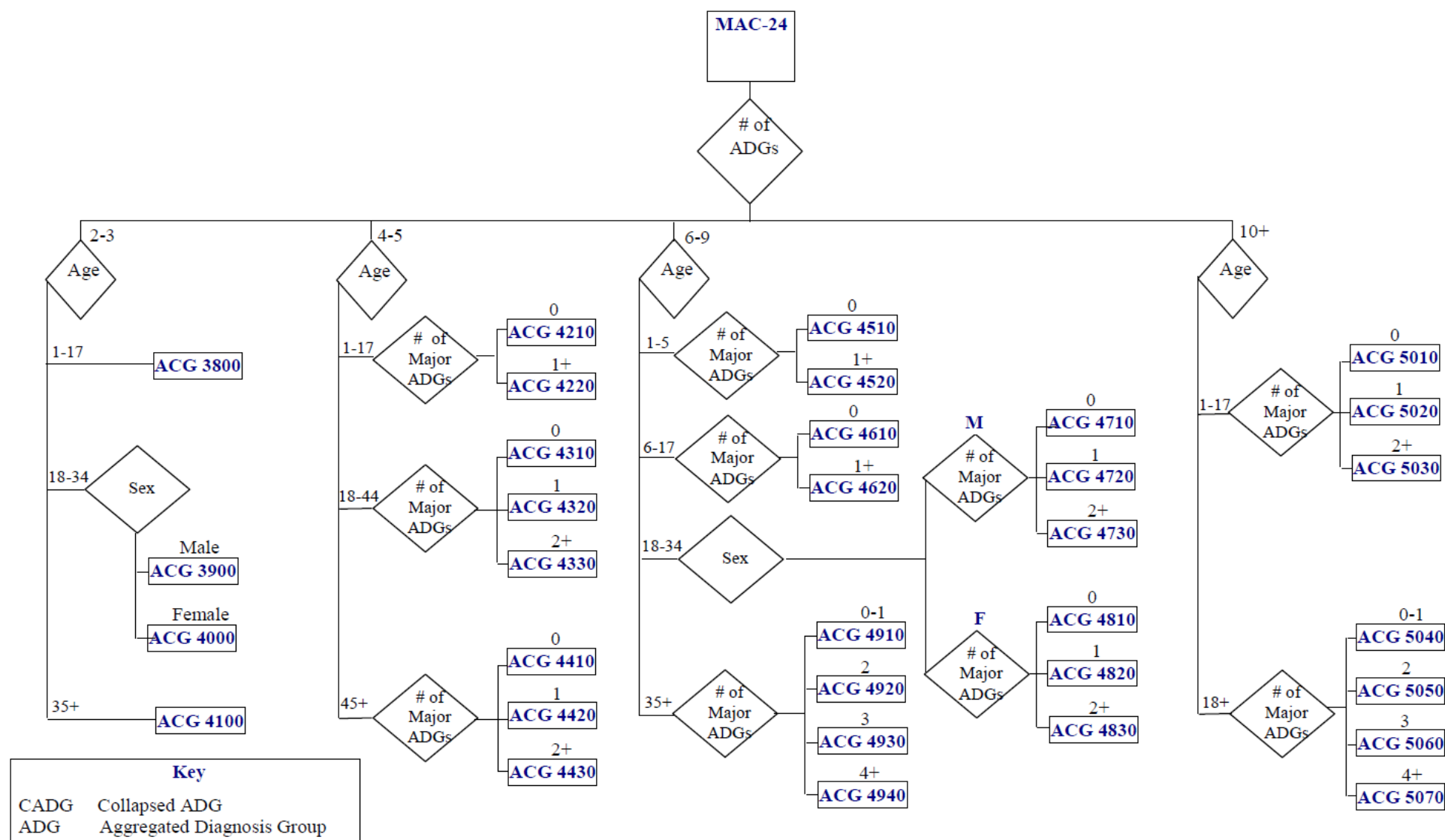
Figure 4. Decision Tree for MAC-24—Multiple ADG Categories

Clinically Oriented Examples of ACG categories

Patients are categorized into an ACG code based on the pattern of ADGs experienced over a predetermined interval and, in some cases, their age and sex. This approach focuses on the totality of diseases experienced by a person rather than any specific disease. Because this method diverges from the traditional biomedical, categorical method of examining morbidity, we show how the ACG System classifies patients with specific types of diseases.

In the examples that follow, we categorize patients by choosing a specific clinical feature that they have, such as a disease, pregnancy, or by their age. These examples show how the presence of other diseases or total number of ADGs changes ACG category assignment.

Chronic Illnesses

In the following examples, Example 1: Hypertension presents three patients with hypertension and Example 2: Diabetes Mellitus presents three patients with diabetes. These individuals were actual patients selected from a private health care organization database. The input data used by the ACG System software, the output produced by the software, and the associated resource consumption variables are presented. As these patients demonstrate, there is substantial variability in patterns of morbidity and need for health care for different patients classified by a specific condition such as hypertension or diabetes. Thus, knowing only that a patient has a particular medical problem, even if it is a chronic condition, provides little information about the need for medical services. In general, as the number of different types of morbidities increases, the total number of ambulatory visits increases as does total expenditures. However, the total burden of morbidity as represented by the ACG category – that is, the constellation of ADGs and presence of major ADGs is the most important determinant of resource consumption.

In Example 1: Hypertension, during the assessment period Patient 1 had diagnosis codes given for only hypertension and a routine medical exam and is therefore classified into the ACG category for patients with stable, chronic medical conditions (ACG-0900). In contrast, Patient 3 with hypertension is in an ACG category that branches from MAC-24 (combinations of ADGs not otherwise classified). This occurs because the combinations of ADGs occur too infrequently to merit a separate ACG category. Patients in MAC-24 have both high levels of morbidity and high levels of health need. There is a strong link between the total number of ADGs/major ADGs and resource consumption.

There are two additional ACG categories that describe commonly occurring combinations of morbidity for individuals with stable, chronic medical conditions. ACG-2300 (Chronic Medical--Stable and Acute Minor) is assigned to patients with uncomplicated diabetes, hypertension, or other stable chronic conditions and a minor illness, injury, or symptom. As shown in Patient 2 with Hypertension, individuals in ACG-3600 have four types of morbidities: stable chronic medical conditions (which include the diagnosis of hypertension), acute minor conditions, conditions of low severity likely to reoccur, and acute major conditions.

Example 1: Hypertension

The following patient types demonstrate the levels of hypertension, ADGs, and associated costs.

Patient 1: Low Cost Patient with Hypertension

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 51/Male	ACG-0900: Chronic Medical, Stable	Total Cost: $128 Ambulatory visits: 1 Emergency visits: 0 Hospitalizations: 0
Conditions: Hypertension, General Medical Exam	ADGs: 10 and 31. Chronic Medical: Stable, Prevention/Administrative	

Patient 2: High Cost Patient with Hypertension

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 54/Male	ACG-3600: Acute Minor/Acute Major/Likely Recur/Eye & Dental	Total Cost: $3,268 Ambulatory visits: 1 Emergency visits: 1 Hospitalizations: 0
Conditions: Hypertension, Disorders of Lipid Metabolism, Low Back Pain, Cervical Pain Syndromes, Musculoskeletal Signs and Symptoms	ADGS: 07, 10, 26, and 27 Likely to Recur: Discrete Chronic Medical: Stable Signs/Symptoms: Minor Signs/Symptoms: Uncertain	

Patient 3: Very High Cost Patient with Hypertension

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 52/Male	ACG - 5070: 10+Other ADG Combinations, Age >17, 4+ Major ADGs	Total Cost: $45,937 Ambulatory visits: 17 Emergency visits: 0 Hospitalizations: 1
Conditions: Hypertension, General medical exam, Cardiogenic Shock, Asthma, Low back pain, Peripheral Neuropathy, Anxiety, Depression, COPD, Acute Upper Respiratory Infection, Gastroesophageal Reflux, Iron Deficiency, Cervical Pain Syndromes, Sleep Problems, Obesity, Sinusitis, Joint Pain	ADGs: 02, 03*, 06, 07, 09*, 10, 11*, 16*, 24, 27, 28, and 31. Time Limited: Minor-Primary Infections Time Limited: Major, Asthma Likely to Recur: Discrete Likely to Recur: Progressive Chronic Medical: Stable Chronic Medical: Unstable Chronic Specialty: Unstable-Orthopedic Psychosocial: Recurrent or Persistent Stable Signs/Symptoms: Uncertain Signs/Symptoms: Major, and Prevention/Administrative	

*Major ADG

Example 2: Diabetes Mellitus

The following patient types demonstrate the levels of diabetes mellitus, ADGs, and associated costs.

Patient 1: Low Cost Patient with Diabetes

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 49/Female	ACG-0900: Chronic Medical, Stable	Total Cost: $296 Ambulatory visits: 1 Emergency visits: 0 Hospitalizations: 0
Conditions: Diabetes mellitus	ADGs: 1 0 Chronic Medical: Stable	

Patient 2: High Cost Patient with Diabetes

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 49/Female	ACG-3600: Acute Minor/Acute Major/Likely Recur/Eye & Dental	Total Cost: $1,698 Ambulatory visits: 6 Emergency visits: 1 Hospitalizations: 0
Conditions: Diabetes mellitus, Disorders of Lipid Metabolism, Peripheral Neuropathy, Otitis Media, Gastroesophageal Reflux, Acute sprain, Joint disorder, Bursitis, Arthropathy	ADGS: 01, 07, 08, 10, 22*, 26, and 27 Time Limited: Minor Likely to Recur: Discrete Likely to Recur: Discrete-Infections Chronic Medical: Stable Injuries/Adverse Effects: Major Signs/Symptoms: Minor Signs/Symptoms: Uncertain	

*Major ADG

Patient 3: Very High Cost Patient with Diabetes

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 51/Female	ACG - 5070: 10+Other ADG Combinations, Age >17, 4+ Major ADGs	Total Cost: $33,073 Ambulatory visits: 23 Emergency visits: 2 Hospitalizations: 1
Conditions: Diabetes mellitus, General medical exam, Ischemic Heart Disease, Hypertension, Disorders of Lipid Metabolism,	ADGs: 01, 02, 03*, 04*, 05, 07, 08, 09*, 10, 11*, 12, 16*, 17, 21, 22*, 23, 26, 27, 28, 29, 30, 31 and 34.	

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Low Back Pain, Peripheral Neuropathy, Cerebrovascular Disease, COPD, Acute Lower Respiratory Tract Infection, Allergic Rhinitis, Gingivitis, Otitis Media, Hearing Loss, Chest Pain, Syncope, Chronic Cystic Disease of the Breast, Tobacco Use, Abdominal Pain, Sinusitis, Sleep Apnea, Contusions and Abrasions, Headache, Cough, Fatigue	Time Limited: Minor Time Limited: Minor- Primary Infections Time Limited: Major Time Limited: Major-Primary Infections, Allergies Likely to Recur: Discrete Likely to Recur: Discrete-Infections Likely to Recur: Progressive Chronic Medical: Stable Chronic Medical: Unstable Chronic Specialty: Stable-Orthopedic Chronic Specialty: Unstable-Orthopedic Chronic Specialty: Unstable-Ear, Nose, Throat Injuries/Adverse Effects: Minor Injuries/Adverse Effects: Major Psychosocial: Time Limited, Minor Signs/Symptoms: Minor Signs/Symptoms: Uncertain Major, Discretionary, See/Reassure, and Prevention/Administrative	

*Major ADG

Pregnancy

Using diagnosis codes for pregnancy, the ACG System identifies all women who were pregnant during the assessment period and places them into the pregnancy MAC. ACG categories are formed based on (1) total number of ADGs, (2) presence of complications (i.e., presence of a major ADG), and (3) whether the woman delivered (the default level of assignment can be overridden).

Example 3: Pregnancy/Delivery with Complications shows how the ACG System groups women with a complicated pregnancy/delivery. Both women in the example had diagnosis codes that map to ADG-03 (an acute major morbidity). The salient difference between the two that explains the difference in resource consumption is that Patient 2 had a greater number of ADGs and more major ADGs and thus fits into a more resource intensive ACG category. That is, Patient 2 had a higher level of morbidity than Patient 1, even though both women experienced a complicated pregnancy/delivery.

Example 3: Pregnancy/Delivery with Complications

The following patient types demonstrate the levels of pregnancy and delivery with complications, ADGs, and associated costs.

Patient 1: Pregnancy/Delivery with Complications, Low Morbidity

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 32/Female	ACG-1731: 2-3 ADGs, 1+ Major ADGs, Delivered	Total Cost: $8,406 Ambulatory visits: 3
Conditions: General medical exam, Pregnancy and delivery - uncomplicated and Pregnancy and delivery - with complications.	ADGs: 01, 03*, 31, and 33. Time Limited: Minor Time Limited: Major Prevention/Administrative, and Pregnancy	Emergency visits: 0 Hospitalizations: 1

*Major ADG

Patient 2: Pregnancy/Delivery with Complications, High Morbidity

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 36/Female	ACG-1771: 6+ ADGs, 1+ Major ADGs, Delivered	Total Cost: $19,714 Ambulatory visits: 13
Conditions: General medical exam Hypertension, Low Back Pain, Urinary tract infection, Renal Calculi, Cervical Pain Syndromes, Joint disorder, Pregnancy and delivery-with complications.	ADGs: 03*, 07, 08, 10, 11*, 21, 22*, 28, 31, and 33. Time Limited: Major Likely to Recur: Discrete Likely to Recur: Discrete-infections Chronic Medical: Stable Chronic Medical: Unstable Injuries/Adverse Effects: Minor Injuries/Adverse Effects: Major Signs/Symptoms: Major Prevention/Administrative, and Pregnancy	Emergency visits: 2 Hospitalizations: 1

*Major ADG

The Clinical Classification of Pregnancy/Delivery ACG categories table presents an alternative clinical categorization of the pregnancy/delivery ACG categories. Three dimensions are used to classify the ACG code – number of ADGs, presence of major ADGs, and whether the women delivered during the assessment period. Resource consumption increases along each of the three axes: presence of delivery, presence of a major ADG, and number of ADGs. Using various combinations of these ACG categories, a clinician, or manager can determine the proportion of women with complicated pregnancies and deliveries overall, and with different levels of morbidity. The need for specialty services will be greatest for those women with higher levels of morbidity and complications as defined by presence of a major ADG.

Clinical Classification of Pregnancy/Delivery ACG Categories

ACG Categories	Pregnancy Only		Delivered	
Morbidity Level	Uncomplicated (No Major ADGs)	Complicated (1+ Major ADGs)	Uncomplicated (No Major ADGs)	Complicated (1+ Major ADGs)
Low (1-3 ADGs)	1712, 1722	1732	1711, 1721	1731
Mid (4-5 ADGs)	1742	1752	1741	1751
High (6+ ADGs)	1762	1772	1761	1771

Pregnant

Pregnancy status is a key differentiator for the ACG decision tree. The ACG System software will use the diagnoses provided in the medical services file to identify pregnancy as follows:

- ICD-10: O00.x-O99.x, O9A.x, Z33.x-Z37.x, Z39.x, Z3A.x

It is possible for analysts to provide the software with a flag indicating that a woman is pregnant. The rationale for including this option is that, in some plans, it is not uncommon for the charges associated with a woman's pregnancy and subsequent delivery to be reimbursed as a global or fixed payment at the time of delivery. In this reimbursement scenario, a woman's claims history may not include a pregnancy diagnosis until she actually delivers. However, given the importance of this information, the plan often does know that the woman is pregnant, despite this lack of related diagnosis codes during the prenatal care period. In cases where the plan wishes to supplement the standard claims data (i.e., if a pregnancy registry is believed to be more accurate than standard claims data), the user may submit a special pregnancy flag that can supplement the standard diagnosis stream. Refer to Patient Data Format on page for a discussion on implementing this approach.

Delivered

Delivery status is an important branch for pregnancy in the ACG Decision tree.

Each ACG from 1710 through 1770 is split into two categories (1711, 1712 through 1771, 1772) based on whether or not the women within these categories have delivered during the period of analysis. After extensive testing, the ACG System development team at Johns Hopkins is confident the standard diagnosis codes used by the software for identifying deliveries are effective with positive predictive accuracy (that is, the women did actually deliver) averaging greater than 96% among all plans tested. However, for a variety of reasons diagnosis codes for delivery may not appear in a woman's claim history even though she did in fact deliver. For example, the delivery may have occurred in an outpatient birthing center or other non-traditional venue, and claims were never submitted containing any delivery codes. Also, if an analyst is using only ambulatory data (not generally recommended) where the delivery diagnosis codes are not available, it is suggested that the user provide a delivered flag in the input data stream. Refer to Patient Data Format on page for a discussion on implementing this approach.

Pregnancy without Delivery

Pregnancy without delivery is an important condition for predicting future resource use and is a marker used by the ACG Predictive Models. If date of service is not available, this marker will be set to Y when the ACG assignment does not indicate delivery: 1712, 1722, 1732, 1742, 1752, 1762 or

1772. If date of service is available, this marker will consider the order of events to capture the latest pregnancy status during the observation period in the event that a pregnancy does not continue to delivery or the patient experiences multiple pregnancies during the year.

- If the patient delivered during the year, but there are additional pregnancy diagnoses more than six weeks after the latest delivery diagnosis, the pregnancy without delivery marker will be set to Y.

- If the patient was pregnant during the year, but the pregnancy terminated, the pregnancy without delivery marker will be set to N. If a subsequent pregnancy is identified more than six weeks after the latest termination diagnosis, the pregnancy without delivery marker will be set to Y.

Infants

The ACG System places all infants into an infant MAC. By definition, all had at least one hospitalization (at time of delivery). ACG groups are formed based on total number of ADGs and the presence of a complication or major ADG. Example 4: Infants compares an infant in the low morbidity/no complications ACG (5310, the most frequently assigned infant ACG) to an infant in the higher morbidity/with complications ACG (5340, the most resource intensive infant ACG). Infant 1 had a typical course: hospitalization at birth, routine check-ups, and illness management for upper respiratory tract infection and otitis media. Infant 2 presents a completely different picture in terms of pattern of morbidity and resource consumption, both of which are substantially greater in comparison with Infant 1.

Example 4: Infants

The following patient types demonstrate the levels of infants with complications, ADGs, and associated costs.

Patient 1: Infant with Low Morbidity, Normal Birthweight

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 0/Female	ACG 5312: 0-5 ADGs, No Major ADGs, Normal Birthweight,	Total Cost: $3,208 Ambulatory visits: 17 Emergency visits: 0 Hospitalizations: 1
Conditions: General medical exam Otitis media, Acute upper respiratory tract infection, Fungal infection and Gastroesophageal Reflux	ADGs: 02, 08, 26, and 31 Time Limited: Minor Likely to Recur: Discrete-Infections Signs/Symptoms: Minor, and Prevention/Administration	

Patient 2: Infant with High Morbidity, Low Birthweight

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Age/Sex: 0/Male	ACG 5341: 6+ ADGs, 1+ Major ADGs, Low Birthweight	Total Cost: $165,142 Ambulatory visits: 19 Emergency visits: 0 Hospitalizations: 1
Conditions: General medical exam, Respiratory symptoms	ADGs: 03*, 04, 07 , 10, 11*, 22, 26, 27, 28, and 31	

Input Data/Patient Characteristics	ACG Output	Resource Consumption Variables
Congenital Heart Disease, Cardiac Arrhythmia, Septicemia, Nausea, vomiting, Gastroesophageal Reflux, Neonatal Jaundice, Renal Disorders, Endocrine disorders, Vesicouretal reflux	Time Limited: Major Time Limited: Major-Primary Infections Likely to Recur: Discrete Chronic Medical: Stable, Chronic Medical: Unstable Injuries/Adverse Effects: Major Signs/Symptoms: Minor Signs/Symptoms: Uncertain Signs/Symptoms: Major, Discretionary, and Prevention/Administrative	

*Major ADG

The Clinical Classification of Infant ACG Categories table provides a clinical classification of the infant ACG categories.

Clinical Classification of Infant ACG Categories

| Morbidity Level | Low Birthweight | | Normal Birthweight | |
	No Complications (no Major ADGs)	Complication (1+ Major ADGs)	No Complications (no Major ADGs)	Complication (1+ Major ADGs)
Low (0-5 ADGs)	5311	5321	5312	5322
Mid (6+ ADGs)	5331	5341	5332	5342

Low Birth Weight (Less than 2500 Grams)

Because low birth weight is a significant predictor of resource use, diagnosis can be used to identify low birth weight newborns when available. The ACG System software uses the following list of codes to identify low birthweight newborns:

- ICD-10: P05.0x, P05.1x, P07.0x, P07.1x

In a manner similar to the way pregnant women are subdivided by delivery status, infants can be subdivided into subcategories based on their birth weight. Diagnosis codes allow for identification of low or normal birth weights among neonates. Historically, validation analysis across a variety of health care organizations indicated that within most plans 2% to 5% of infants were identified as low birth weight.

Based on vital records and other sources, the actual percentage should be somewhere between 6% and 9%. If diagnoses do not seem to be a reliable source of the recording of birth weight, analysts may wish to take advantage of this feature to appropriately categorize low birth weight infants. Analysts can flag such infants before passing the data to the ACG System software. Refer to Patient Data Format on page for a discussion on implementing this approach.

Resource Utilization Bands (RUBs)

ACG categories were designed to represent clinically logical categories for persons expected to require similar levels of health care resources (i.e., resource groups). However, enrollees with similar overall

utilization may be assigned different ACG categories because they have different epidemiological patterns of morbidity. For example, a pregnant woman with significant morbidity, an individual with a serious psychological condition, or someone with two chronic medical conditions may all be expected to use approximately the same level of resources even though they each fall into different ACG categories. In many instances it may be useful to collapse the full set of ACG codes into fewer categories, particularly where resource use similarity is a desired objective.

ACG categories are collapsed according to a combination of concurrent relative resource use and number of comorbidities in the creation of Resource Utilization Bands (RUBs). For clinical cogency and consistency across age groups, the count of morbidity types (ADGs) may influence the final determination of RUB in addition to the concurrent relative resource use. The software automatically assigns six RUB classes:

- 0 - No or Only Invalid Dx
- 1 - Healthy Users
- 2 - Low
- 3 - Moderate
- 4 - High
- 5 - Very High

The relationship between ACG categories and RUBs is defined in the following table

Final ACG Categories, Reference ACG Concurrent Risks, and RUBs

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
0100	Acute Minor, Age 1	0.306	N/A	N/A	2
0200	Acute Minor, Age 2 to 5	0.119	N/A	N/A	1
0300	Acute Minor, Age > 5	0.095	0.117	0.209	1
0400	Acute Major	0.201	0.231	0.343	2
0500	Likely to Recur, w/o Allergies	0.130	0.186	0.198	2
0600	Likely to Recur, with Allergies	0.124	0.202	0.249	2
0700	Asthma	0.128	0.181	0.265	2
0800	Chronic Medical, Unstable	0.872	1.424	1.096	3
0900	Chronic Medical, Stable	0.278	0.257	0.297	2
1000	Chronic Specialty, Stable	0.167	0.168	0.355	2
1100	Eye/Dental	0.087	0.109	0.174	1
1200	Chronic Specialty, Unstable	0.097	0.159	0.363	2
1300	Psychosocial, w/o Psych Unstable	0.257	0.233	0.304	2
1400	Psychosocial, with Psych Unstable, w/o Psych Stable	0.568	0.615	0.391	3

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
1500	Psychosocial, with Psych Unstable, w/ Psych Stable	0.994	1.034	0.603	3
1600	Preventive/Administrative	0.064	0.101	0.123	1
1710	Pregnancy: 0-1 ADGs	0.705	1.354	N/A	3
1711	Pregnancy: 0-1 ADGs, delivered	1.897	2.154	N/A	4
1712	Pregnancy: 0-1 ADGs, not delivered	0.140	0.312	N/A	2
1720	Pregnancy: 2-3 ADGs, no Major ADGs	1.238	1.668	N/A	3
1721	Pregnancy: 2-3 ADGs, no Major ADGs, delivered	2.184	2.537	N/A	4
1722	Pregnancy: 2-3 ADGs, no Major ADGs, not delivered	0.490	0.520	N/A	3
1730	Pregnancy: 2-3 ADGs, 1+ Major ADGs	1.238	2.282	N/A	4
1731	Pregnancy: 2-3 ADGs, 1+ Major ADGs, delivered	2.184	2.856	N/A	4
1732	Pregnancy: 2-3 ADGs, 1+ Major ADGs, not delivered	0.490	0.805	N/A	3
1740	Pregnancy: 4-5 ADGs, no Major ADGs	1.210	1.902	N/A	4
1741	Pregnancy: 4-5 ADGs, no Major ADGs, delivered	2.502	2.865	N/A	4
1742	Pregnancy: 4-5 ADGs, no Major ADGs, not delivered	0.553	0.791	N/A	3
1750	Pregnancy: 4-5 ADGs, 1+ Major ADGs	1.210	2.650	N/A	4
1751	Pregnancy: 4-5 ADGs, 1+ Major ADGs, delivered	2.502	3.372	N/A	4
1752	Pregnancy: 4-5 ADGs, 1+ Major ADGs, not delivered	0.553	1.218	N/A	3
1760	Pregnancy: 6+ ADGs, no Major ADGs	1.548	2.195	N/A	4
1761	Pregnancy: 6+ ADGs, no Major ADGs, delivered	2.999	3.300	N/A	4
1762	Pregnancy: 6+ ADGs, no Major ADGs, not delivered	1.064	1.256	N/A	3

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
1770	Pregnancy: 6+ ADGs, 1+ Major ADGs	3.963	3.757	N/A	4
1771	Pregnancy: 6+ ADGs, 1+ Major ADGs, delivered	5.083	4.607	N/A	4
1772	Pregnancy: 6+ ADGs, 1+ Major ADGs, not delivered	3.429	2.668	N/A	4
1800	Acute Minor and Acute Major	0.328	0.364	0.396	2
1900	Acute Minor and Likely to Recur, Age 1	0.441	N/A	N/A	2
2000	Acute Minor and Likely to Recur, Age 2 to 5	0.204	N/A	N/A	2
2100	Acute Minor and Likely to Recur, Age > 5, w/o Allergy	0.178	0.235	0.277	2
2200	Acute Minor and Likely to Recur, Age > 5, with Allergy	0.198	0.258	0.300	2
2300	Acute Minor and Chronic Medical: Stable	0.295	0.294	0.350	2
2400	Acute Minor and Eye/Dental	0.155	0.181	0.361	2
2500	Acute Minor and Psychosocial, w/o Psych Unstable	0.339	0.281	0.238	2
2600	Acute Minor and Psychosocial, with Psych Unstable, w/o Psych Stable	0.670	0.862	0.434	3
2700	Acute Minor and Psychosocial, with Psych Unstable and Psych Stable	1.145	1.170	0.434	3
2800	Acute Minor and Likely to Recur	0.326	0.394	0.394	3
2900	Acute Minor/Acute Major/Likely to Recur, Age 1	0.816	N/A	N/A	3
3000	Acute Minor/Acute Major/Likely to Recur, Age 2 to 5	0.448	N/A	N/A	3
3100	Acute Minor/Acute Major/Likely to Recur, Age 6 to 11	0.389	N/A	N/A	3
3200	Acute Minor/Acute Major/Likely to Recur, Age > 11, w/o Allergy	0.540	0.578	0.639	3
3300	Acute Minor/Acute Major/Likely to Recur, Age > 11, with Allergy	0.530	0.576	0.579	3
3400	Acute Minor/Likely to Recur/Eye & Dental	0.254	0.329	0.437	2

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
3500	Acute Minor/Likely to Recur/Psychosocial	0.471	0.493	0.451	3
3600	Acute Minor/Acute Major/Likely Recur/Eye & Dental	0.942	1.030	1.051	3
3700	Acute Minor/Acute Major/Likely Recur/Psychosocial	0.898	0.998	1.114	3
3800	2-3 Other ADG Combinations, Age < 18	0.378	N/A	N/A	2
3900	2-3 Other ADG Combinations, Males Age 18 to 34	N/A	0.488	N/A	3
4000	2-3 Other ADG Combinations, Females Age 18 to 34	N/A	0.414	N/A	3
4100	2-3 Other ADG Combinations, Age > 34	N/A	0.537	0.605	3
4210	4-5 Other ADG Combinations, Age < 18, no Major ADGs	0.502	N/A	N/A	3
4220	4-5 Other ADG Combinations, Age < 18, 1+ Major ADGs	1.020	N/A	N/A	3
4310	4-5 Other ADG Combinations, Age 18 to 44, no Major ADGs	N/A	0.519	N/A	3
4320	4-5 Other ADG Combinations, Age 18 to 44, 1+ Major ADGs	N/A	1.174	N/A	3
4330	4-5 Other ADG Combinations, Age 18 to 44, 2+ Major ADGs	N/A	2.049	N/A	4
4410	4-5 Other ADG Combinations, Age > 44, no Major ADGs	N/A	0.653	0.674	3
4420	4-5 Other ADG Combinations, Age > 44, 1+ Major ADGs	N/A	1.272	1.201	3
4430	4-5 Other ADG Combinations, Age > 44, 2+ Major ADGs	N/A	2.363	2.016	4
4510	6-9 Other ADG Combinations, Age < 6, no Major ADGs	0.852	N/A	N/A	3
4520	6-9 Other ADG Combinations, Age < 6, 1+ Major ADGs	1.722	N/A	N/A	4
4610	6-9 Other ADG Combinations, Age 6 to 17, no Major ADGs	0.835	N/A	N/A	3
4620	6-9 Other ADG Combinations, Age 6 to 17, 1+ Major ADGs	2.075	N/A	N/A	4

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
4710	6-9 Other ADG Combinations, Males, Age 18 to 34, no Major ADGs	N/A	0.857	N/A	3
4720	6-9 Other ADG Combinations, Males, Age 18 to 34, 1+ Major ADGs	N/A	1.645	N/A	3
4730	6-9 Other ADG Combinations, Males, Age 18 to 34, 2+ Major ADGs	N/A	3.556	N/A	4
4810	6-9 Other ADG Combinations, Females, Age 18 to 34, no Major ADGs	N/A	0.886	N/A	3
4820	6-9 Other ADG Combinations, Females, Age 18 to 34, 1+ Major ADGs	N/A	1.536	N/A	3
4830	6-9 Other ADG Combinations, Females, Age 18 to 34, 2+ Major ADGs	N/A	2.937	N/A	4
4910	6-9 Other ADG Combinations, Age > 34, 0-1 Major ADGs	N/A	1.529	1.510	3
4920	6-9 Other ADG Combinations, Age > 34, 2 Major ADGs	N/A	3.069	2.759	4
4930	6-9 Other ADG Combinations, Age > 34, 3 Major ADGs	N/A	5.515	4.845	5
4940	6-9 Other ADG Combinations, Age > 34, 4+ Major ADGs	N/A	10.657	7.924	5
5010	10+ Other ADG Combinations, Age 1 to 17, no Major ADGs	1.620	N/A	N/A	3
5020	10+ Other ADG Combinations, Age 1 to 17, 1 Major ADGs	3.239	N/A	N/A	4
5030	10+ Other ADG Combinations, Age 1 to 17, 2 Major ADGs	10.686	N/A	N/A	5
5040	10+ Other ADG Combinations, Age > 17, 0-1 Major ADGs	N/A	2.383	2.292	4
5050	10+ Other ADG Combinations, Age > 17, 2 Major ADGs	N/A	3.992	3.629	4
5060	10+ Other ADG Combinations, Age > 17, 3 Major ADGs	N/A	6.370	5.506	5
5070	10+ Other ADG Combinations, Age > 17, 4+ Major ADGs	N/A	16.140	11.176	5

ACG	Description	Pediatric (0-17 Years)	Adult (18-64)	Elderly (65 Years and Older)	Rub
5110	No Diagnosis or Only Unclassified Diagnosis (2 input files)	0.061	0.108	0.462	1
5200	Non-Users (2 input files)	0.000	0.000	0.000	0
5310	Infants: 0-5 ADGs, no Major ADGs	0.810	N/A	N/A	3
5311	Infants: 0-5 ADGs, no Major ADGs, low birth weight	2.904	N/A	N/A	4
5312	Infants: 0-5 ADGs, no Major ADGs, normal birth weight	0.786	N/A	N/A	3
5320	Infants: 0-5 ADGs, 1+ Major ADGs	2.997	N/A	N/A	4
5321	Infants: 0-5 ADGs, 1+ Major ADGs, low birth weight	11.865	N/A	N/A	5
5322	Infants: 0-5 ADGs, 1+ Major ADGs, normal birth weight	1.907	N/A	N/A	4
5330	Infants: 6+ ADGs, no Major ADGs	1.410	N/A	N/A	3
5331	Infants: 6+ ADGs, no Major ADGs, low birth weight	3.372	N/A	N/A	4
5332	Infants: 6+ ADGs, no Major ADGs, normal birth weight	1.357	N/A	N/A	3
5340	Infants: 6+ ADGs, 1+ Major ADGs	9.913	N/A	N/A	5
5341	Infants: 6+ ADGs, 1+ Major ADGs, low birth weight	26.966	N/A	N/A	5
5342	Infants: 6+ ADGs, 1+ Major ADGs, normal birth weight	5.807	N/A	N/A	5
9900	Invalid age or date of birth	0.000	0.000	0.000	0

Source: IQVIA, formerly QuintilesIMS, One IMS Drive, Plymouth Meeting, PA 19462; Subset of the Legacy PharMetrics Adjudicated Claims Database containing a national cross-section of managed care plans; population of 3,306,768 Commercial beneficiaries (age under 65 years), 2013-15. These weights represent the content of the US-All Age Risk Assessment Variables which expresses risk relative to an adult population mean. Risk scores will vary by population represented by the user's selection of Risk Assessment Variables.

Note: The default is to subdivide these groups* on delivery or low birth weight status. Grouping the ACG categories without these divisions is optional and must be turned on in order to be used.

ACG Concurrent Risk

An ACG concurrent risk is an assessment of the relative resource use for individuals in the ACG category applying an actuarial cell approach. The ACG concurrent risk is calculated as the mean cost of all patients in an ACG category divided by the mean cost of all patients in the population. A fixed set of ACG concurrent risk weights derived from external reference data is available in the software output file as Reference ACG Concurrent Risk.

Separate sets of weights exist for under 65 working age populations, over age 65 Medicare eligible populations (United States federal program that pays for certain health care expenses for people aged 65 or older), and all age populations. The weights used are determined by the Risk Assessment Variables selected during processing. The weights produced by the software are relative weights, i.e., relative to a population mean, and are standardized to a mean of 1.0. An individual weight is associated with each ACG and all individuals assigned the same ACG category will have the same ACG Concurrent Risk. In the case of an elderly reference set, the weights of some ACG categories (e.g., those associated with pediatrics, pregnancy or newborns) may be extrapolated from an under 65 population. If the all age reference is selected, different weights will be applied to children (0-17), adults (18-64) and elderly (65+)[3]. The software-supplied weights may be considered a national reference or benchmark for comparisons with locally calibrated ACG-weights. In some instances (e.g., for those with limited or no cost data), these weights may also be used as a reasonable proxy for local cost data.

The software-supplied Reference ACG Concurrent Risk is supplied in two forms: unscaled and rescaled. Unscaled Reference ACG Concurrent Risk represents the values of the Reference ACG Concurrent Risk applied to a population of interest. If the mean of the Unscaled ACG Concurrent Risk is greater than 1.0 it indicates the rating population (the population to which the weights are being applied) is sicker than the reference population (the national reference database). If the mean is less than 1.0, it indicates the rating population is healthier. To ensure that dollars in the system are not over-estimated or under-estimated, the ACG System also makes available a Rescaled Reference ACG Concurrent Risk that mathematically manipulates the Unscaled Reference ACG Concurrent Risk to have a mean of 1.0 in the local population. The steps for performing this manually are discussed in the following "Rescale and Assign Monetary Values Process" section.

Our experience indicates that ACG concurrent risk weights, especially when expressed as relative values, have remarkable stability. Where differences in ACG concurrent risk are present across health care organizations, it is almost universally attributable to differences in covered services reflected by different benefit levels and cost structures.

If local cost data are available, the ACG System software also calculates Local ACG Concurrent Risk. These local weights more accurately reflect local benefit levels and area practice patterns. If any ACG category contains fewer than 30 patients then ACG concurrent risk will be calculated by pooling cells common to RUB categories and the aggregate score for the RUB shall be applied. In general it is recommended that the reference population (on which the weights are developed) should be as similar as possible to the assessment population to which the weights are applied.

Rescale and Assign Monetary Values Process

The rescaling process consists of the following steps:

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3 *All age modeling does not apply to rank probability scores, the persistent high users, unexpected high pharmacy cost, or hospitalization models. For these models a single calibration to the entire population is performed.*

Step 1: Compute population mean risk Compute a separate grand mean for each of the weights (either concurrent or predicted risk) generated for the client's population (the observations represent individuals). The mean for this example is shown at the bottom of Column B in the table following.

Step 2: Apply weighting factor Divide each individual's risk by the rescaling factor (i.e., the mean) computed in Step 1. The result is the rescaled relative risk (Column C).

Step 3: Compute population mean cost For the same population on which the weights were based, compute the mean cost for the current data year. For this example, the mean cost was 1,265.11.

Step 4: Compute cost Multiply the rescaled relative weights generated for each member of the population (Column C) by the average population cost generated from Step 3 to calculate an estimated individual cost (Column D).

A Member	B Relative Weight	C Rescaled Weight	D Estimated Cost
1	0.185	0.171	216.36
2	0.291	0.268	339.61
3	0.387	0.357	451.64
4	0.457	0.422	533.33
5	0.541	0.499	631.33
6	0.609	0.562	711.58
7	0.696	0.642	812.58
8	0.842	0.777	982.84
9	1.025	0.946	1,196.68
10	1.293	1.194	1,510.19
11	1.892	1.746	2,209.38
12	4.783	4.415	5,585.78
Mean	*1.083*	*1.000*	*1,265.11*

The rescaling factor functions as a summary case-mix index for understanding how the rating population (e.g., local population) compares to the reference population. The interpretation of this factor is analogous to how one interprets both relative risks and profiling indicators. If the rescaling factor is greater than 1.0 (as it was in the example), then the client's population is sicker. If the factor is less than 1.0, then the client's population is healthier than the reference population.

Concurrent Model Performance Assessment and Validation

In creating regression models it is customary to divide the data randomly into two parts, a test dataset and a validation dataset. The models are designed using the test dataset, and then validated on the other dataset to avoid statistical over-fitting of the model. The typical statistics used to validate concurrent cost models are Adjusted R-Squared as a measure of individual variation explained and Expected to Actual ratios as a measure of population variation explained.

R-Squared

The conventional measure of model performance is the R-Squared statistic. This statistic measures how well the model fits the data and has become a standard measure of performance, especially among underwriters and actuaries who must price products across a range of populations. The R-squared value, expressed as a decimal number between 0 and 1, is interpreted as how much variance around the mean is explained by the model. A perfect model would explain all the variation and the R-squared would be 1. This, of course, is a rare occurrence and, in fact, suggests that there might be some design defect in the model. Outlier values can diminish the R-squared performance and are sometimes truncated. Model performance can also be improved by focusing only on those persons who have high values of the modeled outcome where variation is also high. A good fit will occur although the model may actually not work as well for persons who are not in the highest group.

The following table provides the R-squared values for various concurrent model options presented in the ACG System using the all age reference population.

R-Squared Performance for ACG System Concurrent Risk Models

	R-Squared Modeling Total Cost without Truncation	R-Squared Modeling Total Cost Truncated at $250,000
Local Age-Sex Risk	0.035	0.056
Local ACG Concurrent Risk	0.229	0.332
Reference ACG Concurrent Risk	0.231	0.333
Concurrent Risk (regression-based)	0.428	0.536

Source: IQVIA, formerly Quintiles/IMS, One IMS Drive, Plymouth Meeting, PA 19462; Subset of the Legacy PharMetrics Adjudicated Claims Database containing a national cross-section of managed care plans; population of 3,306,768 Commercial beneficiaries (age under 65 years), 2013-15.

Expected to Actual Cost Ratios

The credibility of models does not solely rest on regression fit, which is a measure of performance at the individual level. To determine how well models perform at estimating cost across the full range of risk, we also recommend looking at persons in different cost cohorts (we use quintiles).

Expected to Actual Cost Ratios are another means for assessing risk models. The ratio represents the expected cost derived from the risk model divided by the actual cost for a given sub-population. In the case of costs, one might array the population into different cost quintiles and consider the expected to actual cost ratios for each of these quintiles. The goal is to approach 1.0 as closely as possible, especially in the high cost quintile. Ratios less than 1.0 mean that the model under-estimates costs while ratios over 1.0 suggest that the model is over-estimating costs.

The following table shows these ratios for the various concurrent model options presented in the ACG System using the all age reference population.

Expected to Actual Cost Ratios by Cost Quintile for ACG System Concurrent Risk Models

	Local Age-Sex Risk Cost Ratio	Local ACG Concurrent Risk Cost Ratio	Reference ACG Concurrent Risk Cost Ratio	Concurrent Risk (regression-based) Cost Ratio
Top 1%	0.05	0.30	0.30	0.53

	Local Age-Sex Risk Cost Ratio	Local ACG Concurrent Risk Cost Ratio	Reference ACG Concurrent Risk Cost Ratio	Concurrent Risk (regression-based) Cost Ratio
Top 5%	0.13	0.46	0.46	0.64
Top 20%	0.31	0.71	0.71	0.81
Mid-High	1.85	1.89	1.89	1.57
Mid	4.43	2.77	2.79	2.07
Low-Mid	11.09	4.22	4.46	3.05
Bottom 20%	271.92	14.73	14.76	21.85

Source: IQVIA, formerly Quintiles/IMS, One IMS Drive, Plymouth Meeting, PA 19462; Subset of the Legacy PharMetrics Adjudicated Claims Database containing a national cross-section of managed care plans; population of 3,306,768 Commercial beneficiaries (age under 65 years), 2013-15.

There is a tendency for all of the models to somewhat overestimate costs among the lowest cost quintile and somewhat underestimate costs in the highest cost quintile. This effect is most pronounced in the age and sex model. The various morbidity-based ACG System concurrent models all substantially outperform age and sex.

Index

A

ACG
chronic illness examples *23*
clinical classification of pregnancy/delivery *27*
clinically-oriented examples *23, 26*
decision tree *15*
delivery *27*
diabetes example *25*
hypertension example *23*
infants clinical classification *30*
infants examples *29*
pregnancy *27*
pregnancy/delivery with complications example *26*
RUB categories *31*
terminal groups formation *14*
ADG
clusters *12*
collapsed *12, 13*
diagnostic certainty *8*
duration *8*
etiology *8*
expected need for specialty care *8*
major *10*
severity *8*
subgroups *12*
applications *11*

B

birth weight *30*

C

CADG
collapsed *12*
combinations *13*
MAC assignments *13*
chronic illness
diabetes example *25*
examples *23*
hypertension example *23*
clinical aspects
duration *7*
etiology *7*
expected need for specialty care *8*
severity *7*

clinically-oriented pregnancy example *26*
collapsed ADG *12*
cost models
ACG concurrent risk *37*

D

decision tree
ACG *15*
MAC-12 pregnant women *17*
MAC-24 multiple ADG categories *21*
MAC-26 infants *19*
delivered *28*
delivery ACGs *27*
diagnostic certainty *8*
duration *7, 8*

E

etiology *7, 8*
expected need for speciality care *8*
expected need for specialty care *8*

I

ICD mapping to ADG group *4*
infants
ACG *30*
examples *29*
infants decision tree *19*

L

low birth weight *30*

M

MAC
assigned collapsed ADG *13*
combinations *13*
MAC-12 *17*
MAC-24 *21*
MAC-26 *19*
major ADG *10*
mapping ICD to ADG set *4*
markers
diagnosis-based *4*
multiple ADG categories decision tree *21*