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The Prevalence of Comorbid Chronic Disease in Virginia's Adult Patient Population during the Years 2001 and 2004

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THE PREVALENCE OF COMORBID CHRONIC DISEASE IN VIRGINIA'S ADULT PATIENT POPULATION DURING THE YEARS 2001 AND 2004

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MPH Research Project: EPID 691

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MPH Research Project Agreement Form

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Number of semester hours (3-6): 6 Semester: Fall Year: 2005

A. PROJECT TITLE

The Prevalence of Comorbid Chronic Disease in Virginia's Adult Patient Population During the Years 2001 and 2004

B. PURPOSE

The aim of this study is to determine the prevalence and trends of seven chronic diseases seen in combination among Virginia's 45+ year old hospital discharge population with respect to sex, age, race and location demographics during the period of 2001 (4 quarters) and 2004 (first 3 quarters).

C. SPECIFIC OBJECTIVES

Identify prevalent comorbid chronic disease in Virginia's over 45 discharge population.
Expand on trends in comorbidity data for the 2001- 2004 time period.
Describe prevalence and estimated risk of comorbid diagnoses with respect to patient demographic variables and constituent chronic condition diagnoses.

D. DESCRIPTION OF METHODS

D.1. Identify source(s) of data (eg, existing data set, data collection plans, etc):

As a partner with the AHRQ, Virginia Health Information (VHI) provides "VHI Comorbidity Analysis" data for use on tasks such as the Healthcare Cost and Utilization Project (HCUP). The investigator obtained the information via compact disk from Dr. Kenneth Studer, Policy Analyst and Rural Health Manager, Office of Health Policy and Planning/VDH. He will work with Dr. Studer and Mr. Henry Carretta, who are both familiar with the data.

D.2. State the type of study design (eg, cross-sectional, cohort, case-control, intervention, etc):

Retrospective population-based/Descriptive

D.3. Describe the study population and sample size:

Random selection from the Commonwealth of Virginia hospital discharges: n = 835,053 (2001) and n = 652,104 (2004) before exclusions.

D.4. List variables to be included (If a qualitative study, describe types of information to be collected)

Age, Sex, Race, Location (Health Planning Regions);
Chronic Comorbidities Comorbidities (Cancer, Cardiovascular Disease, Renal Disease, Liver Disease, Diabetes, COPD, and Cerebrovascular Degeneration);
Constituent Conditions (CHF; Valvular, Pulmonary Circulation, Peripheral Vascular, Liver, Peptic Ulcer and Chronic Pulmonary diseases; Paralysis and other Neurological Disorders; Diabetes, Hypothyroidism, Renal Failure, AIDS, Lymphoma, Metastatic Cancer, Tumor, Rheumatoid Arthritis, Coagulopathy, Obesity, Weight Loss, Fluid and Electrolyte disorders, Chronic blood loss anemia, Deficiency anemias, Alcohol abuse, Drug abuse, Psychoses, Depression, and Hypertension)

D.5. Describe methods to be used for data analysis (If a qualitative study, describe general approach to compiling the information collected)

I will use available pertinent statistical software such as SPSS 13.0 for all analysis. The data is most efficiently imported and coded with a specialized SAS package called Comorbidity Software 3.0 from HCUP.

Descriptive analysis: prevalence and means
Chi-square and 95%CI: testing for significant trends from 2001 to 2004
Binary logistic regression: to analyze how certain demographic subcategories and constituent conditions produce risk for comorbid diagnosis

E. ANTICIPATED RESULTS:

Over the period of 1990-2001 Virginia mirrors the rising national prevalence of many chronic conditions, many represented by the a high prevalence in the 45+ demographic.[1,2] Furthermore, it is expected that afflicted seniors more often have multiple chronic conditions (comorbidities) as compared to all other ages. It is also expected that comorbidity will vary by race/ethnicity and sex for different conditions due to existing disparities in prevention, access to and policy for health care.

F. SIGNIFICANCE OF PROJECT TO PUBLIC HEALTH:

Chronic conditions represent a significant number of preventable hospitalizations and huge draw on the U.S. economy. Comorbidity is currently of popularity with the VDH and state government and it is important to analyze yet unstudied perspectives for possible future policy formulation (health insurance, payment and programs). This data set (2001 and 2004) provides the researcher with the very relevant opportunity to investigate current prevalence and trends for common comorbidities in Virginia. As long term care for chronic conditions will continue to heavily impact Virginia and U.S. healthcare, obtaining a grasp of these conditions will be of utmost importance to policy, intervention and prevention programs of the near future.

G. IRB Status:

1) Do you plan to collect data through direct intervention or interaction with human subjects? ___yes __X_no
2) Will you have access to any existing identifiable private information? ___yes __X_no

[1] Kaiser Family Foundation (KFF): State Health Facts: Virginia 2002.
[2] Behavioral Risk Factor Surveillance System Survey (BRFSS) Data, 2002.

If you answered "no" to both of the questions above, IRB review is not required.
Please indicate your IRB status:
_X_ IRB approval not required

H. PROPOSED SCHEDULE: Start Date: 22 APR 2005 End Date: 1 JUL 2005

I. INDICATE WHICH OF THE FOLLOWING AREAS OF PUBLIC HEALTH KNOWLEDGE WILL BE DEMONSTRATED:

1. Biostatistics – collection, storage, retrieval, analysis and interpretation of health data; design and analysis of health-related surveys and experiments; and concepts and practice of statistical data analysis. _X_yes ___no (if yes, briefly describe): This data set will be analyzed in a cross-sectional way for comparing and contrasting trends, rates, ratios, and prevalence among various demographic breakdowns.

2. Epidemiology – distributions and determinants of disease, disabilities and death in human populations; the characteristics and dynamics of human populations; and the natural history of disease and the biologic basis of health. __X_yes ___no (if yes, briefly describe): As this investigation is looking at comorbidities, it is expected that there will be a presentation of morbidity and mortality rates for various chronic conditions as well as there distribution across demographic profiles and background determinants.

3. Environmental Health Sciences – environmental factors including biological, physical and chemical factors which affect the health of a community. ___yes _X_no (if yes, briefly describe):

4. Health Services Administration – planning, organization, administration, management, evaluation and policy analysis of health programs. ___yes _X_no (if yes, briefly describe):

5. Social/Behavioral Sciences – concepts and methods of social and behavioral sciences relevant to the identification and the solution of public health problems. __X_yes ___no (if yes, briefly describe): In so much as social and behavioral epidemiology describe certain prevalence of comorbidities in certain demographics, those will be researched and described.

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Dedication

This paper is dedicated to my parents who have sponsored and guided me through my academic career and who continue to inspire patience and determination in my life.

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Dr. Jack O. Lanier	–	Advisor and Mentor
Dr. Kenneth E. Studer	–	Preceptor
Mr. Henry J. Carretta	–	VCU Dept. of Health Administration Faculty
Ms. Karen Bryant	–	MPH Coordinator

Statement of Purpose

The aim of this study is to categorize the type and prevalence of comorbid chronic disease in Virginia's adult population with respect to the following demographics: sex (Male or Female), age (45 years and older), race (White, Black and Other), and location (five state-defined Health Planning Regions) during the years 2001 (all 4 quarters) and 2004 (first 3 quarters). Due to the lack of state-specific descriptive studies on the interaction of chronic conditions, or chronic comorbidities, the Commonwealth stands to benefit from information that could lead to improvements in public health outcomes.

Abstract

Objective: Chronic disease comorbidities, on the rise in the U.S. and Virginia, represent a new challenge to the way medicine is practiced and prescribed. This descriptive study uses Virginia hospital discharge data to describe the prevalence and trends of chronic disease comorbidities present in the state's over-45 population during the years 2001 and 2004

Methods: Data collected by Virginia Health Information was utilized. Adults over the age of 45 years and who selected for race and location were included in this analysis, with an aggregate sample size of 813,336 (N=458,593 [2001]; N=364,743 [2004]). Pearson chi-square analyses determined significant sample population differences with respect to age, race, sex, location, number of diagnoses (up to 9) and number of chronic comorbid conditions (up to 7). Binary logistic regression predicted odds ratios (ORs) for these comorbid conditions across demographic variables. SPSS 13.0 was used for all analysis.

Results: Chronic comorbidities and their component conditions increased in Virginia's inpatient population from 2001 to 2004. Chronic cardiovascular disease (CCV), chronic liver disease (CLV), chronic renal disease (CRN), chronic pulmonary disease (COP), and cerebrovascular degeneration (CCE) comorbidities all increased in diagnoses prevalence (0.3% - 1.8%), while comorbid cancer (CCA) remained constant at 7.4% and comorbid diabetes (CDI) decreased 0.6%. Mean comorbid diagnoses increased with age. Demographic factors (race, sex, age and location) as well as certain constituent conditions were predictive of one or more comorbidities.

Conclusions: In general, the findings of this report complement current chronic disease monitoring data for the Commonwealth of Virginia. While expected comorbidities did exist (e.g. obesity with diabetes), unpredicted findings such as the highly-comorbid "fluid and electrolyte disorders" or the highly-comorbid "deficiency anemias" were also noted.

Introduction

Chronic comorbidity is the occurrence of ostensibly unrelated chronic diseases and reflects the aggregate effect of all clinical conditions in a given patient.[1,2] Comorbid chronic diseases comprise an increasing number of preventable hospitalizations and a considerable draw on the U.S. economy.[3] Almost every family in the nation is adversely affected by chronic disease, either through the direct burden of the illness or through the indirect hardships of long-term care. Heart disease, cancer, asthma and diabetes are the leading causes of death and disability in the United States, accounting for 70 percent of deaths and affecting the quality of life of 125 million Americans, 65 percent of whom are over 65 years old.[4,5] Medical comorbidity is prognostic of poor rehabilitation in geriatric patients, making this disproportionately affected population ever more dependent on an already strained Medicare system.[6,7,8]

While successful treatments for symptoms exist, chronic conditions are rarely completely cured.[9] A recent study by van Dijk et al[10] documents the predictive nature of chronic conditions in elderly mortality but notes the lack of information on the synergistic effects of these diseases. The simultaneous treatment of multiple chronic conditions and underlying causative factors can be problematical for physicians due to the increased risk of adverse drug interactions during polypharmacy.[11,12,13] For this reason quality of care for chronic illnesses has become a more difficult challenge for physicians, as well as a matter of recent public concern.[14]

According to the Virginia Department of Health (VDH)[15], an accumulation of risk factors and a lack of prevention persist in mature Virginians. Chronic disease risk factors like poor nutrition, physical inactivity, failed prevention and improper care of existing conditions are linked to an increased length of hospital stay, treatment charges and mortality in Virginia.[16,17] Unhealthy diet and sedentary lifestyle are also prevalent in over 70 percent of Virginia's population. Overweight and obesity rates have risen for 15 years and contribute to cardiovascular

disease (CVD), coronary heart disease (CHD), stroke, diabetes, hypertension, arthritis and some cancers.[18,19,20] Twenty-six percent of Virginians are hypertensive and 31 percent have high cholesterol, increasing their risk of stroke, kidney failure, and CHD.[27] Men reported smoking, drinking, and being overweight while women reported a lack of physical activity. Blacks were more often hypertensive, diabetic and obese while Whites more often had high cholesterol.[19] The VDH reports that comorbid cardiovascular disease, cancer, diabetes, renal disease, arthritis and depression are distinct threats to the health of Virginia's elderly.[21]

Cardiovascular disease disproportionately affects Blacks and those over 65.[22] In Virginia, CVD caused over 126,000 hospital admissions and over 35 percent of all deaths in 2002. While precipitating factors remain unknown in more than 40 percent of the cases,[23] studies have found that chronic obstructive pulmonary disease (COPD), diabetes, CHD, hypertension and renal insufficiency are common comorbidities to CVD and each other.[24,25] CHD and hypertension are the most common etiologies in the elderly and often coexist with valvular heart disease, depression and dementia.[13,26]

Cancer has remained the second leading cause of death in Virginia since 1950. Approximately 65,000 Virginians died of cancer from 1997 to 2001.[27] Cancer caused over 27,000 hospitalizations costing $670 million in 2002.[21] Arthritis, diabetes, obesity, hypertension and depression are all well-documented cancer comorbidities.[28]

The national prevalence of diagnosed diabetes, which is expected to double by 2050,[29] increased 47 percent from 1997 to 2002 across all sexes, ages and races. These rates were higher in males and Blacks in every age group.[30] In 2003 diabetes was the seventh leading cause of death in Virginia. Over 385,000 Virginia adults are diabetic, causing over 11,600 hospitalizations in 2002.[21] Seventy percent of diabetes-related deaths are due to a comorbid cause (e.g. CVD, hypertension, obesity and overweight, and renal disease).

Chronic renal disease (CRD) is prevalent in the aging population and is associated with hypertension, smoking, hypercholesterolemia and obesity. Aging, poor nutrition, diabetes and CVD are coexisting predictors for patients with end-stage renal disease (ESRD) and contribute to the increased progression of CRD and its comorbid complications.[31,32] In older CRD patients heart disease risk factors are strongly associated with risk of death from CVD.[33]

Arthritis affects approximately 25 percent of adult Virginians and 55 percent of those over 65.[4] Depression increases the risk of mortality in rheumatoid arthritis (RA).[34] Systemic inflammation due to CHD is the major cause of vascular comorbidity in RA.[35]

Depression is a strong determinant of disability.[36] Up to 65 percent of myocardial infarction patients, 25 percent of cancer patients and 27 percent of stroke patients suffer from depression. Substance abuse disorders are prevalent in depressive patients.[37] It is comorbid with both psychiatric and medical illnesses and is prevalent among diabetics, most often in the presence of comorbidities such as coronary artery disease (CAD), chronic arthritis and stroke.[38]

The literature on chronic disease comorbidity is limited. The numbers and trends reviewed here are helpful in the discussion of singular chronic disease but fall short of a comprehensive description on the state of chronic comorbidity in Virginia. This investigation is designed to analyze current frequencies and trends in order to provide a clearer picture of the prevalence of chronic diseases in Virginia's mature adults.

It is projected that for certain conditions specific demographics, notably age, will be predictive for comorbidity. Findings are expected to confirm the coexistence of previously documented comorbidities (e.g. diabetes with obesity, CVD with hypertension and hypercholesterolemia, cancer with depression, and liver disease with alcohol abuse) as well as less documented comorbidities (e.g. certain conditions with neurodegenerative conditions, psychoses or substance abuse).

Objectives

The primary purpose of this paper is to present prevalence and trend patterns of comorbidities in Virginia's over 45 population utilizing two years (2001 and 2004) of hospital discharge data. The data analysis includes diagnostic results on more than 1.5 million patients, information on the presence of up to seven different chronic comorbidities, and statistics on thirty different chronic conditions that may constitute these seven comorbidities.

Another objective is to report the frequency and location of the outcome variables (seven comorbidities and thirty constituent conditions) in the patient population. As a corollary, this project categorizes the prevalence of chronic disease comorbidity by patient demographics (sex, age, race and location) and presents trends in this data for years 2001 and 2004.

A third objective was to describe any associations of the outcome variables with each other as well as with selected demographic variables.

Methods

Study Population

Patient-level data, obtained from Virginia Health Information (VHI), included every hospital discharge in Virginia during all four quarters of 2001 (835,053 discharges) and for the first three quarters of 2004 (652,104 discharges). After exclusions in the age, race and location categories to remove unknowns and obtain the target population (aged 45 and older), the final sample size was N = 823,336 (n_{2001} = 458,593 and n_{2004} = 364,743).

Study Variables

Demographic variables of interest were analyzed to relate the number and type of diagnoses to gender, age, race and location. The calculation of age in years is based on date of birth and date of hospital admission. The age variable excludes those less than 45 years old and was recoded into decades (45 to 54, 55 to 64, 65 to 74, 75 to 84, and 85 and over) due to previous research that shows chronic conditions tend to increase with age.[4,5,3] Race categories were collapsed into White, Black and Other (comprised of Asians, American Indians and Hispanics) due to relatively lower numbers of these latter groups. Health Planning Regions (Northwestern, Northern, Southwest, Central, and Eastern Virginia) are designated by the Virginia Department of Health. Up to nine diagnoses and up to seven comorbidities per patient were recorded.

The VHI data set categorizes seven chronic comorbidities: Cancer (CCA), Cardiovascular Disease (CCV), Liver Disease (CLV), Renal Disease (CRN), Diabetes (CDI), Pulmonary Disease (CPO), and Cerebrovascular Degeneration (CCE). These comorbidities are defined by the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnostic codes and diagnoses related group (DRG) codes. These definitions can be found in Appendix A Table A. If a diagnosis field (primary or secondary) contains a value

falling within the prescribed code ranges, the presence of that chronic comorbidity is indicated by a "1" (its absence is indicated by a "0"), thus allowing analysis of a dichotomous variable.[39]

Since outcomes due to comorbidities vary among patients, simplification into an index of only seven comorbidities could result in loss of information. Thus to control for a broad array of underlying preexisting conditions that comprise these comorbid illnesses, a previous study[16] developed a comprehensive set of 30 comorbidity measures (CHF, Valvular Disease, Pulmonary Circulation Disease, Peripheral Vascular Disease, Liver Disease, Peptic Ulcer Disease, Chronic Pulmonary Disease, Paralysis, Neurological Disorders, Diabetes, Hypothyroidism, Renal Failure, AIDS, Lymphoma, Metastatic Cancer, Tumor, Rheumatoid Arthritis, Coagulopathy, Obesity, Weight Loss, Fluid and Electrolyte Disorders, Chronic Blood Loss Anemia, Deficiency Anemias, Alcohol abuse, Drug abuse, Psychoses, Depression, and Hypertension). These conditions were analyzed in conjunction with the seven comorbidities to find any correlations.

Statistical Analysis

A goal of this study was to describe the prevalence and location of the outcome variables (seven comorbidities and thirty constituent conditions) in the Virginia population. A second goal was to describe any associations of the outcome variables with each other as well as with selected demographic variables.

Comorbidity Software 3.0, obtained from the Agency for Healthcare Research and Quality (AHRQ) and SPSS 13.0 were used to conduct all statistical analyses. Frequencies and proportions were calculated by discharge year for the variables: age, sex, race, health planning region (HPR), number of unspecified diagnoses (0 to 9), the number of comorbidities present (0 to 7), and the thirty constituent conditions developed by Elixhauser et al.[16]

A Pearson chi-square test was performed on the categorical variables (age, sex, race, HPR, number of diagnoses and number of comorbidities) as well as the outcome variables (each

of the seven comorbidities and each of the thirty component conditions) to test whether the observed differences in proportions between the two study groups (2001 and 2004) were statistically different. T-tests compared the mean ages, number of diagnoses and length of hospital stay of the study groups by year. The mean number of comorbidity diagnoses was analyzed over age, race, sex and HPR variables to observe its distribution in the population.

The seven chronic comorbidities were analyzed for changes over time with respect to age, sex, race and HPR. Chi-square analysis was applied to find significant differences in the observations. Binary logistic regression, which included each of the categorical variables (age, sex, race, HPR and year), produced odds ratios (ORs) and 95% Confidence Intervals (CIs) for the description of how each category (e.g. decade bracket) of each demographic variable (e.g. age) contributed to each outcome comorbidity. This method serves to find key contributors while controlling for other confounding demographic variables.

In this study, an OR is the ratio of the odds of a comorbidity's occurrence when a specific risk factor (or demographic category) is present, to the odds of the comorbidity's occurrence when the risk factor is absent. Intra-group comparisons were made by utilizing the lowest average prevalence of all seven comorbidities for a variable to select a reference group (reference OR=1). Any deviation represents an increase (OR>1) or decrease (OR<1) in risk as compared to the reference category. An OR is deemed not significant if its 95% CI contains 1.

The same regression was repeated with the thirty constituent conditions to find which of these conditions contribute to each of the chronic comorbidity outcomes. In conjunction with the prevalence data for these conditions it was hoped to accurately characterize the state of a number of comorbidities in Virginia's patients. Because most diagnosed comorbidities were found to significantly increase from 2001 to 2004 and due to the fact that current data is more useful for policy implications, the year 2004 was chosen for binary regression.

Results

Descriptive Statistics

The distribution of patients in 2001 and 2004 according to the variables of age, sex, race, HPR, number of diagnoses and number of comorbidities are shown in Table 1. For both years, the majority of the patient population was comprised of Virginians aged 65 to 84 (over 47%), females (56%) and Whites (over 77%). Most of the patients in both 2001 and 2004 are from the Southwest and Eastern regions (over 44%), have nine diagnosed conditions (over 32%) and one chronic comorbidity (over 40%). The results of the Pearson chi-square test on these variables are displayed in Table 1 with corresponding p-values. With the exception of sex, chi-square values were large for all study variables, ranging from 81.08 for HPR to 10,510.53 for number of diagnoses. All p-values were significant with the exception of the sex.

Notable differences between the 2001 and 2004 patient populations follow. There was a 1.5% shift of patient discharges from those over 65 to those aged 45 to 64, representing a slight mean age decrease from 68.2 to 67.9 ($p < 0.0001$). The number of Blacks and Others discharged increased slightly. Length of hospital stay increased ($p < 0.0001$). The mean number of diagnoses decreased slightly ($p < 0.0001$) while the mean number of comorbidities increased in every category from 2001 to 2004. There was a consistent increase in mean number of comorbid diagnosis with age, males and Blacks. The western parts of the state had the highest mean diagnoses both years. Table 2 carries data on mean comorbidity diagnoses.

Comorbidity and Constituent Condition Trends

Five of the seven chronic comorbidity diagnoses increased at a significant level from 2001 to 2004 (Table 3). Diagnoses of chronic cardiovascular disease (CCV) had both the largest prevalence (nearly 40% both years) and increased 1.8%. Chronic pulmonary disease (COP) exhibited the second highest prevalence both years, increasing 1.7% to 19.6% in 2004. Chronic

cerebrovascular degeneration (CCE) and chronic liver disease (CLV) both increased 0.3% to 8.2% and 1.9%, respectively, in 2004. Chronic renal disease (CRN) increased almost 1% to 6.7% in 2004. Cancer (CCA) remained constant at 7.4% while chronic diabetes (CDI) decreased from 6.4% to 5.8%.

Twenty-two of the thirty constituent conditions increased at a significant level from 2001 to 2004 (Table 3). The largest increases included hypertension (4.3%), electrolyte disorders (2.2%), fluid and chronic pulmonary disease (1.7%) and depression (1.2%). Diagnoses of liver, pulmonary circulation and peripheral vascular diseases, as well as paralysis, all slightly decreased at a significant level ($p<0.05$). In 2004 the most prevalent diagnoses were hypertension (50%), COPD (20%), diabetes without chronic complications (19%), fluid and electrolyte disorders (19%) deficiency anemias (10%) and CHF (10%). These conditions accounted for the largest increases in the three year period.

Comorbidity Trends by Demographic Variables

Tables 4 to 10 present chi-square analysis on each of the seven diagnosed comorbidities categorized by demographic variables, with notable changes as follows. CCA (Table 4) decreased 0.4% in Blacks ($p=0.0074$) and increased 0.3% in the Southwest HPR ($p=0.0044$). CCV (Table 5) increased significantly across all categories of all demographics ($p<0.0001$), the largest increases being in those aged 85 and over (3.5%), males (2.2%), Blacks (2.5%) and the Central HPR (2.3%). CLV (Table 6) increased mostly in ages 45 to 74 ($p<0.0001$), both sexes, non-Whites and all HPRs except for Central. CRN (Table 7) showed significant increases ($p<0.0001$) in patients aged 65 and older, both sexes, Whites, Blacks, and in all HPRs except for Northwest. CDI (Table 8) decreased approximately 1.0% ($p<0.0001$) in the 55 to 64 age group, females, Blacks and in Central Virginia. COP (Table 9), rose in all demographic groups except Other, increasing approximately 2.0% in the 45 to 54 age group, females, Whites and in

Southwest Virginia ($p<0.0001$). CCE (Table 10) increased less than 1.0% in the 45 to 64 age group, females, Whites, and Northern, Central and Southwest HPRs.

Regression Analysis: Comorbidity and Demographic Categories

Binary logistic regression was used to describe the contribution of the demographic variables (year, age, sex, race and HPR) to each diagnosed comorbidity. The odds ratios (and corresponding 95% CIs) are reported in Table 11. Odds ratios greater than 1.0 indicate a higher risk of a comorbid diagnosis for a certain demographic category.

In reference to 2001, being discharged in 2004 was found to be slightly protective for CCV, CDI, and COP and to increase risk for CLV, CRN and CCE. As compared to the 45 to 54 decade, all ages 55 to 74 showed increased risk for CCA, CRN, CDI, and CCE. The 85 and over age group had a higher risk for CCE diagnosis (OR=5.86, CI: 5.68-6.03).

Males, as compared to females, showed increased risk for CCA (1.39; 1.75-1.85), CLV (1.67; 1.61-1.73) and CRN (1.33; 1.30-1.35), and are most protective for CCV (0.62; 0.61-0.63).

Black and Other groups, as compared to White, showed increased risk for all comorbidities with the exception of CCE and CLV. The highest risks in the race category were seen with CRN: OR=3.13 for Blacks (CI: 3.07-3.20) and OR=2.07 for Other (CI: 1.93-2.21).

Results varied by region. As compared to Northern Virginia, all HPRs revealed a slightly increased risk for CLV and, with the exception of the Central region, for CRN and CDI as well . All HPRs except for Central were found mildly protective for CCA, CCV, COP and CCE.

Regression Analysis: Comorbidity and Constituent Conditions

Binary logistic regression was used to describe the individual contribution of each constituent condition to risk of each diagnosed comorbidity. Table 12 reports the prevalence (and corresponding ORs with 95% CIs) of patients in 2004 with a diagnosed comorbidity that are also diagnosed with one or more constituent conditions.

Due to the nature of this comparison, some diagnoses codes coincided (e.g. CDI and diabetes or CLV and liver disease). This occurrence produced very large ORs (italicized in Table 12) as they represent the same diagnosis for both the condition and comorbidity.

CCA coincided with coagulopathy (OR=2.52; 2.28-2.79), weight loss (OR=1.65; 1.46-1.87), deficiency anemias (OR=1.72; 1.60-1.85), and fluid and electrolyte disorders (P=9.6%, OR=1.21; 1.13-1.29).

CCV patients had the highest number of coexisting conditions, as evidenced by a comorbid prevalence range of 20.0% (drug use) to 64.2% (valvular disease). Conditions that increased risk for CCV included peripheral vascular disease (P=58.4%, OR=1.94; 1.88-2.00), valvular disease (P=64.2%, OR=1.58; 1.51-1.65), chronic pulmonary disease (P=51.5%, OR=1.59; 1.56-1.62), diabetes (P=48.9%, OR=1.50; 1.48-1.53), renal failure (P=57.8%, OR=1.50; 1.45-1.55), coagulopathy (P=44.9%, OR=1.26; 1.21-1.32) and hypertension (P=43.6%,OR=1.25; 1.23-1.27).

CLV coincided with diabetes (OR=1.41; 1.29-1.55), weight loss (OR=1.34; 1.14-1.59), fluid and electrolyte disorders (OR=1.60; 1.47-1.73), chronic blood loss anemia (OR=1.41; 1.61-1.70), deficiency anemias (OR=1.13; 1.01-1.27), and alcohol abuse (OR=13.34; 12.14-14.65).

Risk for CRN was increased by valvular disease (P=10.2%, OR=1.16; 1.02-1.32), peripheral vascular disease (P=12.2%, OR=1.32, 1.18-1.48), AIDS (P=14.8%, OR=2.86, 1.54-5.31), lymphoma (P=10.5%, OR=1.73; 1.31-2.28), fluid and electrolyte disorders (P=10.6, OR=2.69; 2.52-2.87), and deficiency anemias (P=14.2%, OR=2.67; 2.48-2.89).

Risk for CDI diagnosis was increased by CHF (P=9.8%, OR=1.33; 1.23-1.44), peripheral vascular disease (P=11.9%, OR=1.25; 1.13-1.37), renal failure (P=23.3%, OR=2.41; 2.22-2.62), liver disease (OR=1.29; 1.09-1.54), obesity (OR=1.10; 1.01-1.21), fluid and electrolyte disorders (OR=1.29; 1.21-1.38), and drug abuse (OR 1.49; 1.16-1.91).

COP was diagnosed with rheumatoid arthritis (P=19.9%, OR=1.36; 1.11-1.16), deficiency anemias, drug abuse and depression.

CCE coincided with neurological disorders (P=29.2%, OR=5.94; 5.69-6.20), hypothyroidism (P=11.3%, OR=1.50; 1.43-1.57), weight loss (OR=1.42; 1.31-1.52), fluid and electrolyte disorders (OR=1.53; 1.48-1.58), chronic blood loss anemia, deficiency anemia, depression (OR=1.37; 1.30-1.44) and hypertension.

Discussion

Descriptive Analysis

Demographic Trends

Fifty-eight percent of Virginia discharges in 2004 had one or two comorbid chronic conditions, with a small increase from 2001. This increase is predicted by previous national and state trends[4,18,19] and highlights the importance of studying comorbidities in depth. In reference to discharges trends (Table 1), fluctuations in age, race and regional demographics were slight and likely due to normal population ebb and flow. Mean comorbidity diagnoses increased by age, as predicted by previous studies.[6,7,8]

Most hospital discharges come from Southwest and Eastern Virginia. These two regions are comprised of many rural and comparatively lower socioeconomic areas of the state. It follows that the Southwest and Eastern HPRs are the first and third ranked regions for mean chronic disease comorbidity diagnoses, respectively. Possible explanations for this result include a lack of access to primary or specialized care, deficiencies in prevention and education and the lack of proper care for chronic conditions.[4] These areas constitute important candidates for continued attention from a health policy standpoint.

Comorbidity Trends

Increases occurred in all comorbidity diagnoses with the exception of cancer (CCA) that stayed constant, and diabetes (CDI) that decreased. While cancer remains a major killer of Virginians, prevention and treatment has been established, if not maximized, over the past fifty years, explaining this constant prevalence.[27] The decrease in CDI could be the result of a recent increase in attention from public and private sector in conjunction with obesity. More extensive trending analysis is required, however we cannot exclude the possibility that Virginia is moving in an unhealthy direction and that preventive medicine strategies still require attention.

Variation existed in the comorbidity analysis with respect to demographics. All with the exception of CCE were found to have a higher prevalence in males. Trending data presented here for CCA, CCV, CRN, COP and CCE support previous findings that these comorbidities increase with age,[4,5] while CLV and CDI revealed just the opposite. Possible explanations include the known linkage between liver disease and diabetes and that diabetes is rapidly increasing in younger ages. Regression analyses agree with these findings (CLV was the least prevalent of all comorbid diagnoses; CDI did not increase in any demographic).

CCV showed expected increases across all demographic variables (almost 2%) due to its multitude of comorbid conditions and pervasive nature in the population. CRN also showed increasing prevalence in most demographics, with larger increases in prevalence seen in Blacks and older age groups. Renal disease is comorbid with hypertension, a prevalent condition in Blacks.[19] CDI only increased in the Other race category, albeit not significantly. However, it should be noted that while diabetes is may be coming under control in Virginia (decreasing across all age groups) it still disproportionately afflicts minority races as compared to Whites.[29] Odds ratios revealed there is a significant increased risk to Blacks for CDI, CRN and CCE.

COP increased in all demographics. Like cardiovascular disease, it is prevalent in all areas. Coexisting diagnoses included arthritis, deficiency anemias, drug abuse and depression. Arthritis and depression are known comorbidities to COPD, but the drug abuse diagnosis is an interesting finding as it is known that greater risks exist for medical comorbidities in persons with addictive disorders.[40]

CCE primarily affected the elderly and females. The slight increase of cerebrovascular degeneration could be a result of the decreasing 85 and over demographic, the category in which it had the highest prevalence. While its prevalence did increase significantly across multiple categories, this condition does not seem to be one that is entirely preventable. Because age is

such a strong predictor (OR=2.76 for patients ages 75 to 84 and OR=5.86 for patients 85 and over), this comorbidity is a good candidate for emphasis on treatment education as part of a regimen for other comorbid conditions that may include depression, hypertension, weight loss, anemias, fluid and electrolyte disorders and hypothyroidism.

Demographic Predictors of Comorbidity Risk

Age is the primary predictor for CCA comorbidity, as revealed by regression analysis. Race groups (Black and Other) are major predictors for CCV, CRN, COP and CDI diagnoses. Sex, race and HPR all contribute to CLV comorbidity. Race and age together predict principally for CRN and CDI comorbidity. Age (specifically those over 75) is a principal predictor of CCE comorbidity. Chronic comorbidities were more often found in the Southwest, Eastern and Northwest regions. This information may be useful in chronic disease prevention strategy. Increasing the accuracy of forecasts of chronic disease comorbidity can help healthcare providers as well as government officials put resources to good use for maximized health outcomes.

It is also interesting that barring the obvious trends, chronic comorbidity affects both sexes, all races and all ages. There were no clear cut findings that support that, for example, Blacks had a much higher prevalence of diabetes or cardiovascular comorbidity. This study expected to find demographics to be more precise predictors of morbidity.

Constituent Predictors of Comorbidity Risk

Table 12 revealed that at least four and as many as eight constituent conditions were co-diagnosed with each chronic comorbidity. CHF, valvular disease, peripheral vascular disease, uncomplicated diabetes, renal failure, AIDS, rheumatoid arthritis, coagulopathy, weight loss, fluid and electrolyte disorders, deficiency and blood loss anemias, drug abuse, depression and hypertension were all diagnosed along with at least two chronic comorbidity diagnoses. Deficiency anemias and fluid and electrolyte disorders were found diagnosed with five of the

chronic comorbidities. This type of analysis is important because it reveals the higher prevalence of specific underlying factors in each comorbidity diagnosis, and thus reveals which conditions deserve more attention from the medical community.

What is most interesting about this OR data is not the presence or absence of expected comorbidities but the reporting of new or less studied chronic coexistences due to their importance to current and growing comorbid trending.[16] Most notable is the above mentioned fluid and electrolyte disorder, found to be predictive of multiple comorbidities including CRN (OR=2.69), CLV (1.6), CCE (1.53), CDI (1.3) and CCA (1.21). Deficiency anemias predict for CRN (2.67), CCA (1.72), CCE (1.47), and CLV (1.13). Weight loss revealed increased risk for CCA (1.65), CLV (1.34) and CCE (1.42). These common predictive values present another area for future research expanse. The highest correlation in the regression analysis was alcohol use predicting risk for CLV diagnosis at OR=13.34, which is intuitive.

Limitations

This study reports results for hospitalized Virginians only. Multiple discharges of the same patient are inherent to this dataset and thus prevalence data may not be accurate for the patient population. It is not believed that this fact weakens this study, however, because the purpose of this project was to use this population of patients to estimate comorbidity and the occurrence of underlying conditions. Excluding repeated diagnoses or discharges may be useful in a future study. In addition, using the entirety of the 2004 data set and having a larger gap in years in which to study trends would be beneficial.

While reviewers deemed the statistical methods used in this study to be appropriate, other tests may also be suitable. For example, due to the small prevalence of comorbidities and scewness caused by lopsided group proportions, a Poisson regression rather than a logistic regression might be more appropriate. Instead of categorizing age into decades as it was

presented here, the age variable could be left as a continuous variable for regression analysis.

Future studies may see the benefit in the development of comorbidity matrices that take into account multiple confounding conditions as well as allowing for the study of interactions so as to accurately analyze the comorbid risk to certain individuals. If this analysis could be expanded to include behavioral and social risk factors, a powerful predictive model for mortality and morbidity due to chronic comorbid conditions may be feasible.

Conclusion

The results presented in this report concur with VDH data[15] indicating that despite certain improvements, Virginians continue to engage in high-risk behaviors and do not sufficiently employ preventive health practices. This data also supports previously documented correlations between many constituent conditions and chronic comorbidities as well as creates predictions for yet unstudied comorbidities. Innovation in all areas of this disease interaction is significant, not just for improved diagnoses, management or polypharmacy, but in research of new comorbidities and prediction models as well.

Substantial variations in prevalence of chronic comorbidity across all demographic categories indicate a continued need to monitor these factors at the state and local levels. Continued regional-level assessment of progress toward reducing morbidity and mortality due to these conditions is equally important. Certain features in this report have the potential to be helpful indicators for assessing the effectiveness of state and local prevention programs to decrease chronic conditions in the Commonwealth. It is hoped that the comprehensive approach used in the report will be useful in addressing chronic illness in Virginia where Healthy People 2010 goals are still works in progress.[18] Trending results may provide data relevant for health care resource allocation purposes for future medical treatments and physical care. Future identification and classification of chronic risk factors will lead to insightful pathophysiology, help to direct prevention and increase the accuracy of individualized treatment models.

The long-term care and cost required by chronic conditions continues to heavily impact health care in Virginia and the United States. Obtaining accurate information on how chronic comorbidities are influenced by demographic and disease risk factors should remain a high priority in policy, intervention and prevention arenas.

Tables

Table 1. Hospital Discharge Characteristics by Year

Variable	2001		2004		Difference	X2	p-value
	N	%	N	%	(%)		
TOTAL	458593	100.0	364743	100.0			
Age							
45-54	91569	20.0	73904	20.3	0.3	316.35	<0.0001
55-64	91031	19.9	77165	21.2	1.3		
65-74	111756	24.4	84834	23.3	-1.1		
75-84	113333	24.7	87929	24.1	-0.6		
85+	50904	11.1	40911	11.2	0.1		
Sex							
Male	202087	44.1	160707	44.1	0.0	0.01	0.942
Female	256476	55.9	204025	55.9	0.0		
Race							
White	342670	78.4	273504	77.2	-1.2	367.43	<0.0001
Black	88499	20.2	74435	21.0	0.8		
Other	6022	1.4	6559	1.9	0.5		
Health Planning Region							
Northwestern	72544	15.8	56973	15.6	-0.2	81.08	<0.0001
Northern	65467	14.3	53188	14.6	0.3		
Southwest	102790	22.4	81094	22.2	-0.2		
Central	89805	19.6	69526	19.1	-0.5		
Eastern	102886	22.4	83985	23.0	0.6		
Number of Diagnoses							
1	13893	3.0	7504	2.1	-1.0	10510.5	<0.0001
2	24360	5.3	13422	3.7	-1.6		
3	36142	7.9	21131	5.8	-2.1		
4	45433	9.9	28447	7.8	-2.1		
5	50037	10.9	32827	9.0	-1.9		
6	49131	10.7	34185	9.4	-1.3		
7	46303	10.1	35242	9.7	-0.4		
8	44716	9.8	39320	10.8	1.0		
9	148578	32.4	152665	41.9	9.5		
Number of Chronic Comorbidities							
0	179912	39.2	135397	37.1	-2.1	574.653	<0.0001
1	183566	40.0	147070	40.3	0.3		
2	77764	17.0	66853	18.3	1.4		
3	15923	3.5	13981	3.8	0.4		
4	1394	0.3	1396	0.4	0.1		
5	34	0.01	45	0.01	0.0		
6	0	0.0	1	0.0003	0.0		

Table 2. Mean Comorbidity Diagnoses by Year

Variable	2001			2004		
	Mean	N	SD	Mean	N	SD
Age						
45-54	0.50	91569	0.71	0.55	73904	0.74
55-64	0.75	91031	0.83	0.79	77165	0.83
65-74	0.94	111756	0.86	0.98	84834	0.88
75-84	1.04	113333	0.85	1.10	87929	0.86
85+	1.09	50904	0.82	1.15	40911	0.82
Sex						
Male	0.92	202087	0.85	0.97	160707	0.87
Female	0.80	256476	0.83	0.85	204025	0.84
Race						
White	0.87	342670	0.84	0.91	273504	0.85
Black	0.88	88499	0.87	0.92	74435	0.89
Other	0.67	6022	0.80	0.71	6559	0.80
Health Planning Region						
Northwestern	0.87	72544	0.85	0.91	56973	0.86
Northern	0.76	65467	0.82	0.82	53188	0.84
Southwest	0.91	102790	0.85	0.97	81094	0.87
Central	0.84	89805	0.83	0.89	69526	0.85
Eastern	0.87	102886	0.85	0.90	83985	0.86

Table 3. Prevalence of Comorbidities and Constituent Conditions

Variable	2001		2004		Diff.	X^2	p-value
	N	%	N	%	(%)		
TOTAL	458593	100.0	364743	100.0			
Chronic Comorbidities							
Cancer (CCA)	33716	7.4	26983	7.4	0.0	0.62	0.4300
Chronic Cardiovascular (CCV)	177459	38.7	147881	40.5	1.8	290.13	<0.0001
Chronic Liver (CLV)	7488	1.6	7044	1.9	0.3	104.33	<0.0001
Chronic Renal (CRN)	26801	5.8	24303	6.7	0.8	234.00	<0.0001
Chronic Diabetes (CDI)	29309	6.4	21112	5.8	-0.6	128.45	<0.0001
Chronic Pulmonary Dz (COP)	81884	17.9	71451	19.6	1.7	403.03	<0.0001
Cerebrovascular Deg. (CCE)	35952	7.8	29760	8.2	0.3	28.24	<0.0001
Constituent Conditions							
Congestive heart failure	40870	8.9	35785	9.8	0.9	194.45	<0.0001
Valvular disease	15661	3.4	14245	3.9	0.5	139.63	<0.0001
Pulmonary circulation dz.	4471	1.0	3362	0.9	-0.1	6.10	0.0135
Peripheral vascular disease	25372	5.5	19431	5.3	-0.2	16.64	<0.0001
Paralysis	13624	3.0	9376	2.6	-0.4	119.85	<0.0001
Other neurological disorders	17601	3.8	14188	3.9	0.1	1.47	0.2254
Chronic pulmonary disease	85561	18.7	74351	20.4	1.7	387.26	<0.0001
Diabetes w/o chronic compl.	85492	18.6	70772	19.4	0.8	76.51	<0.0001
Diabetes w/ chronic compl.	19883	4.3	16010	4.4	0.1	1.41	0.2355
Hypothyroidism	35606	7.8	30918	8.5	0.7	138.85	<0.0001
Renal failure	22974	5.0	21215	5.8	0.8	260.34	<0.0001
Liver disease	6531	1.4	2769	0.8	-0.7	249.16	<0.0001
Peptic ulcer Disease	357	0.1	195	0.1	0.0	18.03	<0.0001
AIDS	359	0.1	432	0.1	0.0	34.13	<0.0001
Lymphoma	3284	0.7	2769	0.8	0.0	5.16	0.0231
Metastatic cancer	12828	2.8	10345	2.8	0.0	1.13	0.2879
Solid tumor w/out metastasis	10393	2.3	8305	2.3	0.0	0.10	0.7469
Rheumatoid arthritis	10207	2.2	8623	2.4	0.1	17.42	<0.0001
Coagulopathy	11106	2.4	10803	3.0	0.5	228.76	<0.0001
Obesity	21156	4.6	20268	5.6	0.9	378.54	<0.0001
Weight loss	11935	2.6	9890	2.7	0.1	9.35	0.0022
Fluid & electrolyte disorders	77167	16.8	69421	19.0	2.2	675.55	<0.0001
Chronic blood loss anemia	9760	2.1	8092	2.2	0.1	7.81	0.0052
Deficiency Anemias	43932	9.6	36673	10.1	0.5	51.85	<0.0001
Alcohol abuse	13735	3.0	12236	3.4	0.4	86.03	<0.0001
Drug abuse	3690	0.8	4500	1.2	0.4	379.85	<0.0001
Psychoses	9934	2.2	8690	2.4	0.2	43.00	<0.0001
Depression	25588	5.6	24673	6.8	1.2	497.55	<0.0001
Hypertension	208416	45.4	181508	49.8	4.3	1518.30	<0.0001

Table 4. Cancer (CCA) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	4733	5.2	3847	5.2	0.0	0.11	0.7384
55-64	7215	7.9	6273	8.1	0.2	2.34	0.1258
65-74	9916	8.9	7626	9.0	0.1	0.80	0.3698
75-84	8971	7.9	6914	7.9	-0.1	0.19	0.6651
85+	2881	5.7	2323	5.7	0.0	0.01	0.9041
Sex							
Male	17285	8.6	13933	8.7	0.1	1.55	0.2136
Female	16430	6.4	13050	6.4	0.0	0.02	0.8928
Race							
White	25272	7.4	20462	7.5	0.1	2.51	0.1134
Black	6806	7.7	5463	7.3	-0.4	7.16	0.0074
Other	426	7.1	481	7.3	0.3	0.32	0.5742
Health Planning Region							
Northwestern	5488	7.6	4303	7.6	0.0	0.01	0.9334
Northern	4874	7.4	4023	7.6	0.1	0.60	0.4398
Southwest	6851	6.7	5678	7.0	0.3	8.09	0.0044
Central	7140	8.0	5455	7.8	-0.1	0.59	0.4429
Eastern	7846	7.6	6188	7.4	-0.3	4.43	0.0353

Table 5. Chronic Cardiovascular Disease (CCV) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	15859	17.3	13746	18.6	1.3	45.66	<0.0001
55-64	28033	30.8	24952	32.3	1.5	45.95	<0.0001
65-74	47525	42.5	37737	44.5	2.0	75.25	<0.0001
75-84	57866	51.1	47380	53.9	2.8	158.51	<0.0001
85+	28176	55.4	24066	58.8	3.5	111.62	<0.0001
Sex							
Male	87120	43.1	72810	45.3	2.2	175.12	<0.0001
Female	90335	35.2	75065	36.8	1.6	121.76	<0.0001
Race							
White	139201	40.6	115516	42.2	1.6	163.21	<0.0001
Black	29700	33.6	26837	36.1	2.5	111.03	<0.0001
Other	1784	29.6	2008	30.6	1.0	1.46	<0.0001
Health Planning Region							
Northwestern	29153	40.2	23726	41.6	1.5	28.07	<0.0001
Northern	23296	35.6	19966	37.5	2.0	48.38	<0.0001
Southwest	42771	41.6	35428	43.7	2.1	80.05	<0.0001
Central	32489	36.2	26732	38.4	2.3	86.59	<0.0001
Eastern	39793	38.7	33703	40.1	1.5	40.91	<0.0001

Table 6. Chronic Liver Disease (CLV) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	2792	3.0	2684	3.6	0.6	43.39	<0.0001
55-64	1913	2.1	1922	2.5	0.4	28.41	<0.0001
65-74	1587	1.4	1464	1.7	0.3	29.49	<0.0001
75-84	995	0.9	810	0.9	0.0	1.04	0.3073
85+	201	0.4	164	0.4	0.0	0.02	0.8856
Sex							
Male	4420	2.2	4054	2.5	0.3	44.15	<0.0001
Female	3068	1.2	2990	1.5	0.3	63.48	<0.0001
Race							
White	5496	1.6	5211	1.9	0.3	80.92	<0.0001
Black	1547	1.7	1428	1.9	0.2	6.55	0.0105
Other	145	2.4	248	3.8	1.4	19.56	<0.0001
Health Planning Region							
Northwestern	1196	1.6	1174	2.1	0.4	30.15	<0.0001
Northern	968	1.5	985	1.9	0.4	25.26	<0.0001
Southwest	1681	1.6	1566	1.9	0.3	22.85	<0.0001
Central	1458	1.6	1196	1.7	0.1	2.24	0.1347
Eastern	1765	1.7	1743	2.1	0.4	32.51	<0.0001

Table 7. Chronic Renal Disease (CRN) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	4143	4.5	3566	4.8	0.3	8.33	0.0039
55-64	5542	6.1	4909	6.4	0.3	5.37	0.0205
65-74	7315	6.5	6558	7.7	1.2	103.23	<0.0001
75-84	7081	6.2	6593	7.5	1.3	122.20	<0.0001
85+	2720	5.3	2677	6.5	1.2	59.04	<0.0001
Sex							
Male	13161	6.5	12193	7.6	1.1	159.02	<0.0001
Female	13640	5.3	12110	5.9	0.6	82.03	<0.0001
Race							
White	15121	4.4	13670	5.0	0.6	117.02	<0.0001
Black	10397	11.7	9595	12.9	1.1	49.01	<0.0001
Other	471	7.8	574	8.8	0.9	3.57	0.0590
Health Planning Region							
Northwestern	4139	5.7	3516	6.2	0.5	12.45	0.0004
Northern	3295	5.0	3111	5.8	0.8	38.26	<0.0001
Southwest	5716	5.6	5142	6.3	0.8	49.63	<0.0001
Central	5692	6.3	5178	7.4	1.1	75.87	<0.0001
Eastern	6814	6.6	6388	7.6	1.0	68.09	<0.0001

Table 8. Chronic Diabetes (CDI) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	5269	5.8	4010	5.4	-0.3	8.32	0.0039
55-64	7351	8.1	5499	7.1	-0.9	53.30	<0.0001
65-74	8789	7.9	6041	7.1	-0.7	38.22	<0.0001
75-84	6456	5.7	4423	5.0	-0.7	42.99	<0.0001
85+	1444	2.8	1139	2.8	-0.1	0.23	0.6317
Sex							
Male	12695	6.3	9585	6.0	-0.3	15.67	<0.0001
Female	16614	6.5	11527	5.6	-0.8	135.78	<0.0001
Race							
White	19127	5.6	13532	4.9	-0.6	121.85	<0.0001
Black	8835	10.0	6675	9.0	-1.0	48.42	<0.0001
Other	389	6.5	438	6.7	0.2	0.24	0.6218
Health Planning Region							
Northwestern	4367	6.0	3107	5.5	-0.6	18.82	<0.0001
Northern	3615	5.5	2871	5.4	-0.1	0.87	0.3499
Southwest	7029	6.8	5072	6.3	-0.6	25.13	<0.0001
Central	5788	6.4	3774	5.4	-1.0	71.83	<0.0001
Eastern	7100	6.9	5357	6.4	-0.5	20.28	<0.0001

Table 9. Chronic Pulmonary Disease (COP) Trends

Variable	2001		2004		Difference	X^2	p-value
	N	%	N	%	(%)		
Age							
45-54	9610	10.5	9187	12.4	1.9	152.2595	<0.0001
55-64	15301	16.8	14194	18.4	1.6	72.62543	<0.0001
65-74	23952	21.4	19796	23.3	1.9	100.8988	<0.0001
75-84	24175	21.3	20472	23.3	2.0	109.2323	<0.0001
85+	8846	17.4	7802	19.1	1.7	43.78815	<0.0001
Sex							
Male	38630	19.1	32861	20.4	1.3	100.4161	<0.0001
Female	43252	16.9	38585	18.9	2.0	326.1311	<0.0001
Race							
White	65789	19.2	57743	21.1	1.9	347.3994	<0.0001
Black	12707	14.4	11908	16.0	1.6	84.73569	<0.0001
Other	541	9.0	608	9.3	0.3	0.3094	0.5780
Health Planning Region							
Northwestern	12970	17.9	11237	19.7	1.8	71.4461	<0.0001
Northern	9004	13.8	8300	15.6	1.9	80.76234	<0.0001
Southwest	21407	20.8	18747	23.1	2.3	139.4787	<0.0001
Central	15744	17.5	13555	19.5	2.0	100.824	<0.0001
Eastern	18473	18.0	15855	18.9	0.9	26.30132	<0.0001

Table 10. Chronic Cerebrovascular Degeneration (CCE) Trends

Variable	2001		2004		Difference (%)	X^2	p-value
	N	%	N	%			
Age							
45-54	3688	4.0	3596	4.9	0.8	68.28	<0.0001
55-64	3135	3.4	3045	3.9	0.5	29.76	<0.0001
65-74	5512	4.9	4241	5.0	0.1	0.46	0.4980
75-84	12570	11.1	9994	11.4	0.3	3.76	0.0526
85+	11047	21.7	8884	21.7	0.0	0.00	0.9598
Sex							
Male	12948	6.4	10503	6.5	0.1	2.44	0.1183
Female	23002	9.0	19257	9.4	0.5	30.13	<0.0001
Race							
White	26463	7.7	22304	8.2	0.4	39.01	<0.0001
Black	7543	8.5	6460	8.7	0.2	1.24	0.2648
Other	290	4.8	304	4.6	-0.2	0.23	0.6329
Health Planning Region							
Northwestern	5850	8.1	4673	8.2	0.1	0.81	0.3667
Northern	4938	7.5	4387	8.2	0.7	20.16	<0.0001
Southwest	8278	8.1	6970	8.6	0.5	17.49	<0.0001
Central	7434	8.3	6030	8.7	0.4	7.91	0.0049
Eastern	8156	7.9	6636	7.9	0.0	0.04	0.8371

Table 11. Comorbidities Predicted by Demographic Variables

Variable	CCA			CCV			CLV			CRN			CDI			COP			CCE		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Year																					
2001	1.00			1.00			1.00			1.00			1.00			1.00			1.00		
2004	1.00	0.98	1.02	0.91	0.90	0.92	1.18	1.14	1.22	1.14	1.12	1.16	0.89	0.87	0.91	0.88	0.87	0.89	1.06	1.04	1.08
Age																					
45-54	1.00						1.00			1.00			1.00			1.00			1.00		
55-65	1.57	1.53	1.62	0.48	0.47	0.49	0.66	0.64	0.69	1.43	1.39	1.48	1.43	1.39	1.47	0.62	0.61	0.63	0.84	0.81	0.88
65-74	1.80	1.75	1.85	0.28	0.28	0.29	0.45	0.43	0.47	1.73	1.68	1.78	1.43	1.39	1.47	0.47	0.46	0.47	1.15	1.12	1.19
75-84	1.59	1.55	1.64	0.19	0.19	0.19	0.27	0.26	0.29	1.77	1.72	1.83	1.02	0.99	1.05	0.47	0.46	0.48	2.76	2.68	2.84
85+	1.15	1.10	1.19	0.15	0.15	0.15	0.12	0.11	0.13	1.56	1.50	1.62	0.52	0.49	0.54	0.61	0.59	0.62	5.86	5.68	6.03
Sex																					
Male	1.39	1.36	1.41	0.62	0.61	0.63	1.67	1.61	1.73	1.33	1.30	1.35	0.96	0.95	0.98	0.86	0.85	0.87	0.82	0.81	0.84
Female	1.00			1.00			1.00			1.00			1.00			1.00			1.00		
Race																					
White	1.00			1.00			1.00			1.00			1.00			1.00			1.00		
Black	1.02	1.00	1.05	1.08	1.07	1.10	0.91	0.87	0.95	3.13	3.07	3.20	1.93	1.89	1.98	1.32	1.30	1.34	1.31	1.28	1.33
Other	0.96	0.89	1.03	1.28	1.23	1.33	1.64	1.47	1.83	2.07	1.93	2.21	1.30	1.20	1.40	2.05	1.92	2.18	0.70	0.64	0.76
HPR																					
Northwestern	0.96	0.93	0.99	0.89	0.88	0.91	1.17	1.10	1.25	1.13	1.09	1.18	1.05	1.01	1.09	0.84	0.82	0.86	0.98	0.95	1.01
Northern	1.00			1.00			1.00			1.00			1.00			1.00			1.00		
Southwest	0.85	0.83	0.88	0.84	0.83	0.86	1.17	1.10	1.24	1.13	1.09	1.17	1.21	1.17	1.25	0.69	0.67	0.70	0.96	0.93	0.98
Central	1.02	0.99	1.05	1.00	0.98	1.02	1.08	1.01	1.15	0.96	0.93	0.99	0.91	0.88	0.94	0.79	0.77	0.81	0.94	0.91	0.97
Eastern	0.95	0.92	0.98	0.92	0.90	0.94	1.20	1.13	1.28	1.00	0.97	1.04	1.03	0.99	1.06	0.80	0.78	0.82	0.91	0.88	0.94

Table 12. 2004 Comorbidities Predicted by Constituent Conditions

Condition	Cancer (CCA)				Cardiovascular Disease (CCV)				Liver Disease (CLV)			
	Prev	OR	95% CI		Prev	OR	95% CI		Prev	OR	95% CI	
Congestive heart failure	6.5	0.76	0.69	0.84	*99.3*	*282*	--	--	1.70	0.96	0.85	1.09
Valvular disease	6.6	0.71	0.60	0.82	64.2	1.58	1.51	1.65	1.60	0.74	0.61	0.91
Pulmonary circulation disease	4.4	0.57	0.39	0.82	61.6	1.04	0.95	1.14	2.10	1.31	0.91	1.88
Peripheral vascular disease	4.2	0.50	0.43	0.59	58.4	1.94	1.88	2.00	0.70	0.53	0.42	0.66
Paralysis	5.5	0.49	0.39	0.62	38.5	0.89	0.85	0.93	0.60	0.42	0.30	0.59
Other neurological disorders	6.3	0.32	0.26	0.40	34.7	0.68	0.65	0.70	1.60	0.72	0.59	0.87
Chronic pulmonary disease	8.0	0.64	0.60	0.69	51.5	1.59	1.56	1.62	1.60	0.73	0.67	0.80
Diabetes w/o chronic compl.	5.5	0.80	0.75	0.86	48.9	1.50	1.48	1.53	2.00	1.41	1.29	1.55
Diabetes w/ chronic compl.	3.3	0.45	0.37	0.54	51.0	1.24	1.19	1.29	1.80	1.09	0.92	1.31
Hypothyroidism	5.1	0.73	0.66	0.82	40.3	1.01	0.99	1.04	1.20	0.91	0.78	1.05
Renal failure	5.0	0.56	0.48	0.65	57.8	1.50	1.45	1.55	2.20	0.85	0.74	0.99
Liver disease	6.7	0.89	0.74	1.07	26.2	0.50	0.46	0.53	*72.10*	*483.4*	--	--
Peptic ulcer Disease	6.7	0.82	0.27	2.56	35.9	0.77	0.55	1.07	3.60	1.53	0.50	4.72
AIDS	7.6	1.50[a]	0.83	2.72	22.0	0.54	0.42	0.70	5.30	0.10	0.05	0.17
Lymphoma	*97.8*[b]	*2813*	--	--	38.2	0.86	0.78	0.93	1.60	0.53	0.35	0.82
Metastatic cancer	*100.0*	*9E+10*	--	--	26.0	0.49	0.47	0.52	1.50	0.80	0.65	1.00
Solid tumor w/out metastasis	*99.1*	*7924*	--	--	36.1	0.77	0.74	0.81	2.00	1.11	0.88	1.39
Rheumatoid arthritis	5.1	0.66	0.55	0.81	37.3	0.82	0.78	0.86	1.00	0.67	0.51	0.89
Coagulopathy	14.1	2.52	2.28	2.79	44.9	1.26	1.21	1.32	13.70	6.91	6.22	7.67
Obesity	2.4	0.47	0.40	0.55	36.2	0.75	0.73	0.78	1.30	0.92	0.77	1.10
Weight loss	13.8	1.65	1.46	1.87	38.3	0.74	0.70	0.77	3.60	1.34	1.14	1.59
Fluid & electrolyte disorders	9.6	1.21	1.13	1.29	42.5	0.94	0.92	0.96	3.00	1.60	1.47	1.73
Chronic blood loss anemia	8.7	1.13	0.96	1.32	43.2	0.90	0.85	0.95	4.20	1.41	1.16	1.70
Deficiency Anemias	10.9	1.72	1.60	1.85	40.6	0.90	0.87	0.92	2.20	1.13	1.01	1.27
Alcohol abuse	4.1	0.35	0.28	0.43	25.1	0.59	0.56	0.62	16.00	13.34	12.14	14.65
Drug abuse	2.4	0.33	0.22	0.48	20.0	0.48	0.44	0.52	4.30	0.14	0.11	0.17
Psychoses	4.6	0.65	0.53	0.79	27.2	0.55	0.52	0.58	2.00	0.83	0.67	1.04
Depression	5.0	0.57	0.50	0.65	31.0	0.66	0.64	0.68	1.60	1.04	0.90	1.20
Hypertension	5.3	0.58	0.55	0.61	43.6	1.25	1.23	1.27	1.2	0.55	0.51	0.59

[a] Boxes represent statistically significant results

[b] Italicized results have high ORs due to overlapping or identical ICD-9-CM diagnosis definitions for both Comorbidity and Condition

Table 12. Cont'd. 2004 Comorbidities Predicted by Constituent Conditions

Condition	Renal Disease (CRN)				Diabetes (CDI)			
	Prev	OR	95% CI		Prev	OR	95% CI	
Congestive heart failure	15.20	2.86	2.66	3.09	9.8	1.3	1.23	1.44
Valvular disease	10.20	1.16	1.02	1.32	5.4	1.1	0.91	1.22
Pulmonary circulation disease	8.50	1.10	0.84	1.43	5.0	0.6	0.44	0.82
Peripheral vascular disease	12.20	1.32	1.18	1.48	11.9	1.2	1.13	1.37
Paralysis	5.10	0.82	0.66	1.02	5.8	1.0	0.88	1.20
Other neurological disorders	5.10	0.42	0.35	0.51	3.9	0.8	0.70	0.97
Chronic pulmonary disease	7.00	0.90	0.84	0.97	5.3	0.8	0.79	0.90
Diabetes w/o chronic compl.	6.80	1.02	0.94	1.12	7.1	*39.6*	*36.27*	*43.34*
Diabetes w/ chronic compl.	35.90	16.69	15.50	17.98	*96.9*	*14472*	--	--
Hypothyroidism	4.60	0.94	0.83	1.06	4.6	0.9	0.86	1.04
Renal failure	*96.6*	*6E+03*	--	--	23.3	2.4	2.22	2.62
Liver disease	9.90	0.95	0.77	1.17	6.6	1.3	1.09	1.54
Peptic ulcer Disease	5.60	0.96	0.25	3.68	5.1	0.5	0.12	2.07
AIDS	14.80	2.86	1.54	5.31	3.9	0.9	0.40	2.19
Lymphoma	10.50	1.73	1.31	2.28	3.8	0.8	0.56	1.14
Metastatic cancer	3.70	0.67	0.54	0.82	2.4	0.8	0.61	0.94
Solid tumor w/out metastasis	4.90	0.89	0.72	1.11	3.0	0.8	0.68	1.03
Rheumatoid arthritis	5.50	1.21	1.00	1.48	3.7	0.9	0.75	1.10
Coagulopathy	10.20	1.10	0.95	1.29	5.2	1.1	0.96	1.33
Obesity	4.30	0.98	0.85	1.14	7.5	1.1	1.01	1.21
Weight loss	12.90	1.16	1.00	1.35	5.0	0.8	0.63	0.96
Fluid & electrolyte disorders	10.60	2.69	2.52	2.87	6.9	1.3	1.21	1.38
Chronic blood loss anemia	8.30	1.02	0.84	1.24	5.3	0.8	0.67	0.99
Deficiency Anemias	14.20	2.67	2.48	2.89	7.8	0.9	0.84	0.99
Alcohol abuse	2.90	0.64	0.51	0.79	2.8	0.9	0.77	1.11
Drug abuse	4.80	0.75	0.54	1.04	4.2	1.5	1.16	1.91
Psychoses	4.40	0.81	0.65	1.01	5.0	1.0	0.86	1.21
Depression	2.90	0.65	0.55	0.76	4.2	1.0	0.93	1.15
Hypertension	9.5	0.39	0.36	0.42	6.6	0.7	0.66	0.74

Table 12. Cont'd. 2004 Comorbidities Predicted by Constituent Conditions

Condition	Pulmonary Disease (COP)				Cerebrovascular Degen. (CCE)			
	Prev	OR	95% CI		Prev	OR	95% CI	
Congestive heart failure	32.4	0.60	0.53	0.68	8.9	1.25	1.20	1.31
Valvular disease	22.7	1.00	0.82	1.21	7.2	0.89	0.82	0.96
Pulmonary circulation disease	41.2	0.92	0.68	1.23	5.8	0.66	0.55	0.79
Peripheral vascular disease	25.4	0.59	0.49	0.71	6.5	0.95	0.89	1.02
Paralysis	14.4	0.84	0.63	1.12	10.3	0.95	0.88	1.03
Other neurological disorders	8.4	1.16	0.96	1.40	29.2	5.94	5.69	6.20
Chronic pulmonary disease	*96.1*	*5E-12*	--	--	7.6	0.79	0.76	0.82
Diabetes w/o chronic compl.	19.5	0.98	0.89	1.08	7.6	0.91	0.87	0.94
Diabetes w/ chronic compl.	18.1	1.06	0.87	1.29	5.3	0.57	0.52	0.62
Hypothyroidism	18.4	0.93	0.81	1.07	11.3	1.50	1.43	1.57
Renal failure	20.8	0.65	0.53	0.79	6.0	0.69	0.64	0.74
Liver disease	17.6	0.90	0.66	1.25	4.7	0.34	0.29	0.41
Peptic ulcer Disease	20.0	0.00	0.00	0.60	6.2	0.61	0.28	1.30
AIDS	17.6	0.66	0.16	1.00	10.4	0.97	0.61	1.55
Lymphoma	16.4	1.78	1.25	0.92	4.7	0.49	0.39	0.61
Metastatic cancer	22.7	0.69	0.54	0.59	2.9	0.24	0.21	0.28
Solid tumor w/out metastasis	26.5	0.80	0.63	0.84	5.9	0.63	0.57	0.71
Rheumatoid arthritis	19.9	1.36	1.11	1.16	5.5	0.62	0.56	0.70
Coagulopathy	20.0	0.78	0.61	0.00	5.2	0.56	0.50	0.62
Obesity	20.9	0.80	0.68	0.98	4.4	0.30	0.27	0.34
Weight loss	36.0	0.74	0.59	1.06	11.5	1.42	1.31	1.52
Fluid & electrolyte disorders	21.9	0.95	0.87	0.93	10.9	1.53	1.48	1.58
Chronic blood loss anemia	20.4	0.46	0.32	0.65	7.3	1.17	1.06	1.28
Deficiency Anemias	19.5	1.04	0.92	0.90	10.0	1.47	1.41	1.54
Alcohol abuse	23.2	0.60	0.47	0.00	7.4	0.60	0.54	0.66
Drug abuse	19.3	1.15	0.83	0.66	11.1	0.76	0.65	0.90
Psychoses	23.3	0.72	0.56	1.78	*100.0*	*3E+10*	--	--.
Depression	20.9	1.08	0.94	0.69	10.7	1.37	1.30	1.44
Hypertension	18.4	0.99	0.91	0.80	8.0	1.12	1.09	1.15

Appendix A

Table 13. Comorbidity Diagnoses Codes

Chronic Comorbidity	ICD-9-CM Diagnosis Field Values and Ranges
Cancer (CCA)	141.0 to 160.9; 162.0 to 172.9; 174.0 to 208.91
Cardiovascular Disease (CCV)	412.0 to 414.9; 426.0 to 429.1
Liver Disease (CLV)	571.0 to 572.8
Renal Disease (CRN)	582.0 to 583.9; 585.0 to 587.0; 403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92 or 404.93
Diabetes (CDI)	250.01; 250.1 to 250.91
Pulmonary Disease (CPO)	496.0; 491.0 to 493.91
Cerebrovascular Degeneration (CCE)	290.0 to 290.9; 294.0 to 299.9

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