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# SCREENING FOR CHRONIC KIDNEY DISEASE

Chronic Kidney Disease (CKD) is a progressive condition that results in significant morbidity and mortality. Because of the important role the kidneys play in maintaining homeostasis, CKD can affect almost every body system. Early recognition and intervention are essential to slowing disease progression, maintaining quality of life, and improving outcomes. Family physicians have the opportunity to screen at-risk patients, identify affected patients, and ameliorate the impact of CKD by initiating early therapy and monitoring disease progression.[1]

The purpose of this case is to create an easy-to-use screening tool to identify patients at risk for CKD. Despite the wide availability and low cost of a test for CKD based on one or more blood samples, studies have shown that many in the at-risk population have not been tested. One reason for this is that awareness of CKD is low. Given the proven benefits of early detection and treatment, the need for some kind of screening tool is clear. Although there is no reason to test everyone, those patients with a high enough probability of having CKD should be tested. The purpose of this case is to see if those high-risk patients can be identified using easily obtainable patient data.

## The Study Population

Since 1975, the National Center for Health Statistics of the Centers for Disease Control and Prevention has conducted nationwide surveys of U.S. adults. Using trained personnel, the center collected a wide variety of demographic and health information using direct interviews, examinations, and blood samples. The data set consists of selected information from 8,819 adults 20 years of age or older taken from the 1999–2000 and 2001–2002 surveys. The sample subjects were randomly divided into two pools: a 6,000-case training set and a 2,819-case validation sample.

[1] Catherine S. Snively, MD, and Cecilia Gutierrez, MD, "Chronic Kidney Disease: Prevention and Treatment of Common Complications," *American Family Physician*, 70 (10), (November 2004).

This case was prepared by Professor Phillip E. Pfeifer and Professor Heejung Bang (Weill Cornell Medical College). It was written as a basis for class discussion rather than to illustrate effective or ineffective handling of an administrative situation. 

A test for CKD was administered to everyone in the study population.[2] The variable of interest is CDK, a 0/1 dummy variable indicating whether or not the subject had CKD. **Exhibit 1** defines the 34 variables in the data set. Notice that variables in columns A through J are demographic in nature, K through V were collected during the physical exam, and W through AH are based, in part, on self-reported health histories.

**The Causes of CKD**[3]

The two main causes of chronic kidney disease are diabetes and high blood pressure, which are responsible for up to two-thirds of the cases. Diabetes happens when your blood sugar is too high, causing damage to many organs in your body, including the kidneys and heart, as well as blood vessels, nerves, and eyes. High blood pressure, or hypertension, occurs when the pressure of your blood against the walls of your blood vessels increases. If uncontrolled, or poorly controlled, high blood pressure can be a leading cause of heart attacks, strokes, and chronic kidney disease. Also, chronic kidney disease can cause high blood pressure.

Other conditions that affect the kidneys are:

- Glomerulonephritis, a group of diseases that cause inflammation and damage to the kidney's filtering units. These disorders are the third most common type of kidney disease.
- Inherited diseases, such as polycystic kidney disease, which causes large cysts to form in the kidneys and damage the surrounding tissue.
- Malformations that occur as a baby develops in its mother's womb. For example, a narrowing may occur that prevents normal outflow of urine and causes urine to flow back up to the kidney. This causes infections and may damage the kidneys.
- Lupus and other diseases that affect the body's immune system.
- Obstructions caused by problems like kidney stones, tumors, or an enlarged prostate gland in men.
- Repeated urinary infections.

[2] The test used a formula to estimate glomerular filtration rate based on measured serum creatinine concentration, age, gender, and race. CKD was defined as estimated filtration rate less than 60 ml/min/1.73 $m^2$. For details, see Heejung Bang, David A. Shoham, Philip J. Klemmer, Ronald J. Falk, Madhu Mazumdar, Debbie Gipson, Romulo E. Colindres, and Abhijit V. Kshirsagar, "SCreening for Occult Renal Disease (SCORED): A Simple Prediction Model for Chronic Kidney Disease," *Archives of Internal Medicine*, 2007.

[3] This section is excerpted from the National Kidney Foundation Web site (www.kidney.org), © 2007, National Kidney Foundation, Inc., 30 East 33rd Street, New York, NY 10016.

**Who Is at Risk?**[4]

While anyone at any age can develop chronic kidney disease (CKD), a number of risk factors have been identified that may lead to possible problems with your kidneys. These include:

- **Diabetes.** Diabetes is the leading cause of CKD. If you have diabetes, talk with your doctor about how to keep your blood glucose as close to normal as possible to ensure your diabetes is under control.
- **Hypertension.** Hypertension, also called high blood pressure, is the second-highest cause of CKD. Keep your blood pressure under control. A number of effective medications are available to help you with this task. Your doctor will help you to determine which medication is right for you.
- **Cardiovascular disease.** In addition to hypertension, other diseases of the heart and blood vessels may increase your risk for kidney disease. People who have had heart attacks or strokes, congestive heart failure, coronary artery disease, or peripheral vascular disease need to be monitored carefully for kidney problems.
- **Family history of kidney disease.** Some kidney diseases are genetic. People with a mother, father, brother, or sister who has had a kidney disease are more likely to develop problems with their kidneys.
- **Age.** People 60 years and older are at a higher risk for developing CKD.
- **Race.** People belonging to certain ethnic groups, such as First Nations (Canadian aboriginal peoples) and Pacific Islanders, are at a higher risk for developing this disease.

**The Challenge**

The list of risk factors above is a reflection of the results of several separate studies. What we want to do is figure out how to combine all the possible risk factors to measure the overall risk faced by the study subjects.

The 34 variables in the data set are all easily obtained by a family physician during routine checkups. Only the cholesterol measurements and the hemoglobin count (used to help define anemia) require blood tests. The challenge is to come up with some kind of way to use the first 33 variables to predict the $34^{th}$. The idea would be to create something very simple (like the quizzes you see in popular magazines, for example) that would identify subjects at risk of having CKD. The high-risk subjects would then be encouraged to have their serum creatinine levels checked and/or undergo a complete urinalysis. The challenge here is strictly one of prediction. The variables used need not cause CKD. They need only be indicators of the presence of CKD.

[4] This section was excerpted from the Web site of the government of British Columbia on 18 June 2007. (www.gov.bc.ca), © 2001, Province of British Columbia.

It is also important to note that the study population is not a random sample of U.S. adults. That means that our predictions will not apply directly to the U.S. population and should not be used for actual decision-making.

To get us started, **Exhibit 2** reports summary statistics for the 6,000-subject training set for each of the numerical variables. These statistics are reported for those with and without CKD. A T-statistic to test the equality of the means for the two groups is also reported. Of the 11 numerically scaled variables, age is the most significant predictor of CKD with the average age of those with CKD being 73 compared to 47 for those without CKD.

For categorical variables, a chi-squared test of association is appropriate. **Exhibit 3** reports the cross tabulation counts as well as the calculated chi-squared statistics. Remember, the degrees of freedom associated with each of these chi-squares depend on the number of categories taken on by each variable. Remember also that subjects with missing values have been ignored when constructing **Exhibits 2** and **3**. The most significant predictor of CKD from among the categorical variables is hypertension. Of those with hypertension, 15.5% had CKD compared to 2.7% of those without hypertension. It also appears Hispanics are under-represented in the CKD population and whites are over-represented. It also appears that those who list “noplace” as where they get their health care are very unlikely to have CKD.

Exhibit 1

**SCREENING FOR CHRONIC KIDNEY DISEASE**

Variable Definitions

| *Col.* | *Variable* | *Definition* |
|---|---|---|
| A | ID | Identification number |
| B | Age | Age (years) |
| C | Female | 1 if female |
| D | Racegrp | Self-reported race/ethnic group (white, black, Hispanic, other) |
| E | Educ | 1 if more than high school |
| F | Unmarried | 1 if unmarried |
| G | Income | 1 if household income is above the median |
| H | CareSource | Self-reported source of medical care (Dr./HMO, clinic, noplace, other) |
| I | Insured | 1 if covered by health insurance. |
| J | Weight | Weight (kg) |
| K | Height | Height (cm) |
| L | BMI | Body mass index ($kg/m^2$) |
| M | Obese | 1 if BMI is greater than 30 $kg/m^2$ |
| N | Waist | Waist circumference (cm) |
| O | SBP | Systolic blood pressure (max) |
| P | DBP | Diastolic blood pressure (min) |
| Q | HDL | (mg/dL) the "good" cholesterol |
| R | LDL | (mg/dL) the "bad" cholesterol |
| S | Total Chol | (mg/dL) the sum of good and bad cholesterol |
| T | Dyslipidemia | Too high LDL or too low HDL |
| U | PVD | Peripheral vascular disease reflected by reduced SBP at the leg relative to the arm. |
| V | Activity | Mostly sit (1); stand or walk a lot (2); lift light loads or climb stairs often (3); heavy work and heavy loads (4). |
| W | Poor Vision | Self-reported poor vision |
| X | Smoker | Smoked at least 100 cigarettes. |
| Y | Hypertension | The presence of at least one of four indicators of high blood pressure. |
| Z | Fam Hypertension | Family history of hypertension (high blood pressure) |
| AA | Diabetes | Self-reported physician diagnosed or lab test result |
| AB | Fam Diabetes | Family history of diabetes |
| AC | Stroke | Self-reported response to "Has a doctor ever told you that you had a stroke?" |
| AD | CVD | Response to "Has a doctor ever told you that you had angina pectoris, myocardial infarction, or stroke?" |
| AE | Fam CVD | Family history of cardiovascular disease |
| AF | CHF | Self-reported response to "Has a doctor ever told you that you had congestive heart failure?" |
| AG | Anemia | Treatment for anemia received in past 3 months or hemoglobin at exam lower than 11g/dL |
| AH | CKD | Chronic kidney disease as indicated by measured serum creatinine. |

Exhibit 2

**SCREENING FOR CHRONIC KIDNEY DISEASE**

Descriptive Statistics for Numerically Scaled Variables
(training-set data broken out by CKD groups)

| | CKD=0 | | | CKD=1 | | | |
|---|---|---|---|---|---|---|---|
| | Average | Std Dev | Count | Average | Std Dev | Count | T-stat |
| **Age** | 47.15 | 17.90 | 5536 | 73.05 | 11.71 | 464 | -43.56 |
| **Weight** | 79.17 | 19.60 | 5432 | 77.74 | 19.25 | 435 | 1.49 |
| **Height** | 167.25 | 10.12 | 5433 | 165.29 | 10.41 | 428 | 3.77 |
| **BMI** | 28.24 | 6.22 | 5377 | 28.35 | 5.98 | 417 | -0.36 |
| **Waist** | 96.54 | 15.24 | 5365 | 100.10 | 14.44 | 420 | -4.85 |
| **SBP** | 124.27 | 20.14 | 5352 | 141.47 | 25.28 | 442 | -13.94 |
| **DBP** | 71.86 | 12.24 | 5318 | 67.73 | 14.28 | 430 | 5.83 |
| **HDL** | 51.97 | 15.79 | 5529 | 50.08 | 16.18 | 463 | 2.41 |
| **LDL** | 151.85 | 42.46 | 5529 | 157.20 | 44.02 | 463 | -2.52 |
| **Total Chol** | 203.82 | 42.04 | 5531 | 207.28 | 44.98 | 463 | -1.60 |
| **Activity** | 2.06 | 0.82 | 5530 | 1.69 | 0.67 | 462 | 11.11 |

Exhibit 3

**SCREENING FOR CHRONIC KIDNEY DISEASE**

CrossTabs for Categorical Variables
Training Set Data

| | *Variable=0* | | | *Variable=1* | | | |
|---|---|---|---|---|---|---|---|
| **Variable** | **CKD=0** | **CKD=1** | **%1s** | **CKD=0** | **CKD=1** | **%1s** | **Chi-square** |
| Female | 2655 | 210 | 7.3%* | 2881 | 254 | 8.1% | 1.3 |
| Educ | 3064 | 308 | 9.1% | 2458 | 155 | 5.9% | 21.1 |
| Unmarried | 3335 | 227 | 6.4% | 1926 | 211 | 9.9% | 23.1 |
| Income | 2723 | 293 | 9.7% | 2088 | 104 | 4.7% | 44.5 |
| Insured | 1137 | 17 | 1.5% | 4329 | 439 | 9.2% | 78.2 |
| Obese | 3708 | 281 | 7.0% | 1669 | 136 | 7.5% | 0.4 |
| Dyslipidemia | 4951 | 414 | 7.7% | 585 | 50 | 7.9% | 0.0 |
| PVD | 5379 | 395 | 6.8% | 157 | 69 | 30.5% | 171.1 |
| Poor Vision | 4932 | 355 | 6.7% | 277 | 60 | 17.8% | 57.0 |
| Smoker | 3902 | 273 | 6.5% | 1634 | 191 | 10.5% | 27.4 |
| Hypertension | 3476 | 97 | 2.7% | 2007 | 367 | 15.5% | 322.0 |
| Fam Hypertension | 4231 | 388 | 8.4% | 1305 | 76 | 5.5% | 12.5 |
| Diabetes | 4998 | 334 | 6.3% | 537 | 130 | 19.5% | 145.3 |
| Fam Diabetes | 3829 | 307 | 7.4% | 1707 | 157 | 8.4% | 1.8 |
| Stroke | 5403 | 404 | 7.0% | 128 | 59 | 31.6% | 153.7 |
| CVD | 5249 | 348 | 6.2% | 275 | 115 | 29.5% | 276.7 |
| Fam CVD | 3469 | 306 | 8.1% | 1824 | 118 | 6.1% | 7.7 |
| CHF | 5401 | 404 | 7.0% | 113 | 56 | 33.1% | 158.3 |
| Anemia | 5434 | 442 | 7.5% | 99 | 22 | 18.2% | 18.9 |

*Read: Of the subjects who were not female, 7.3% (210) had CKD. Of the females, 8.1% (254) had CKD.

| Racegrp | CKD=0 | CKD=1 | Total |
|---|---|---|---|
| Black | 1001 | 77 | **1078** |
| Hispa | 1688 | 70 | **1758** |
| Other | 184 | 6 | **190** |
| White | 2663 | 311 | **2974** |
| **Total** | **5536** | **464** | **6000** |
| Chi-square | | | 71.7 |

| CareSource | CKD=0 | CKD=1 | Total |
|---|---|---|---|
| Vlinhth | 1169 | 100 | **1269** |
| Dr./HMO | 3156 | 326 | **3482** |
| Noplace | 911 | 14 | **925** |
| Other | 298 | 24 | **322** |
| **Total** | **5534** | **464** | **5998** |
| Chi-Square | | | 63.2 |