The Risk of Infection-Related Hospitalization With Decreased Kidney Function

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Background: Moderate kidney disease may predispose to infection. We sought to determine whether decreased kidney function, estimated by serum cystatin C level, was associated with the risk of infection-related hospitalization in older individuals.

Study Design: Cohort study.

Setting & Participants: 5,142 Cardiovascular Health Study (CHS) participants with measured serum creatinine and cystatin C and without estimated glomerular filtration rate (eGFR) /11021 90 mL/min/1.73 m² at enrollment.

Predictor: The primary exposure of interest was eGFR using serum cystatin C level (eGFRSCysC).

Outcome: Infection-related hospitalizations during a median follow-up of 11.5 years.

Results: In adjusted analyses, eGFRSCysC categories of 60-89, 45-59, and 15-44 mL/min/1.73 m² were associated with 16%, 37%, and 64% greater risk of all-cause infection-related hospitalization, respectively, compared with eGFRSCysC ≥90 mL/min/1.73 m². When cause-specific infection was examined, eGFRSCysC of 15-44 mL/min/1.73 m² was associated with an 80% greater risk of pulmonary and 160% greater risk of genitourinary infection compared with eGFRSCysC ≥90 mL/min/1.73 m².

Limitations: No measures of urinary protein, study limited to principal discharge diagnosis.

Conclusions: Lower kidney function, estimated using cystatin C level, was associated with a linear and graded risk of infection-related hospitalization. These findings highlight that even moderate degrees of decreased kidney function are associated with clinically significant higher risks of serious infection in older individuals.

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Chronic kidney disease (CKD) is a rapidly emerging public health challenge, particularly in older individuals. Moderate to severe CKD is associated strongly with the risk of all-cause hospitalization, with a 10%-50% increase in individuals with stage 3 CKD (estimated glomerular filtration rate [eGFR], 30-59 mL/min/1.73 m²) and a 110% increase in individuals with stage 4 CKD (eGFR, 15-29 mL/min/1.73 m²).1 Complications associated with CKD include both cardiovascular and noncardiovascular disease hospitalizations and death.1-3 Decreased kidney function leads to retention of metabolic waste products and hormonal disturbances that adversely affect multiple target tissues, including blood vessels, bone, and the immune system. Altered immune cell function is a known clinical complication of late-stage kidney disease, shown by markedly high rates of infection and infection-related mortality in people who have end-stage kidney disease receiving dialysis.4,6 However, few studies have sought to determine whether less severely decreased kidney function is associated with infection risk. Existing studies in CKD populations are limited to the evaluation of only specific types of infection, such as bacteremia or pneumonia,7,8 and have relied on serum
creatinine levels to estimate kidney function. Serum cystatin C–based estimates of kidney function may more accurately predict adverse outcomes associated with CKD compared with creatinine-based estimates of kidney function.

In our study, we sought to examine comprehensively the associations of kidney function with risks of infection-related hospitalization in Cardiovascular Health Study (CHS) participants. We estimated kidney function using level of serum cystatin C, an alternate marker of glomerular filtration that does not depend on muscle mass and detects early loss of kidney function more precisely than serum creatinine level.

We also assessed associations with all infection-related hospitalizations and specific infection types.

**METHODS**

**Study Population**

The CHS is a prospective cohort study of community-dwelling adults 65 years or older. Participants were randomly sampled from Health Care Financing Administration Medicare eligibility lists in Sacramento County, CA; Allegheny County, PA; Forsyth County, NC; and Washington County, MD. Participants initially were recruited between 1989 and 1990. Exclusion criteria included inability to provide informed consent or communicate with the interviewer, need of a proxy respondent for baseline examination, institutionalization, being homebound, receipt of hospice care, treatment with radiation or chemotherapy for cancer, or plans to move out of the community within 3 years. An additional 687 African American participants were recruited in 1992-1993. CHS participants were excluded from the present study if they had prevalent end-stage renal disease, eGFR <15 mL/min/1.73 m^2^ based on either creatinine or cystatin C level, or missing baseline serum creatinine or cystatin C measures.

Institutional review board approval for the CHS was obtained from each participating clinical center and the coordinating center at the University of Washington.

**Measurements**

Extensive baseline data were ascertained, including demographics (age, sex, and self-reported race), prevalent disease (coronary heart disease, congestive heart failure, hypertension, chronic obstructive pulmonary disease, stroke, and diabetes), blood pressure, weight, height, laboratory measures (serum creatinine, cystatin C, albumin, C-reactive protein [CRP], and interleukin 6 [IL-6]), medications, tobacco use, and education. The CHS laboratory procedures have been outlined in detail previously. Serum creatinine was measured by a colorimetric method (Ektachem 700; Eastman Kodak, Rochester, NY). Serum cystatin C was measured by particle-enhanced immunonephelometric assay (N Latex Cystatin C; Siemens; www.usa.siemens.com); interassay coefficient of variation of 2.3%-3.1%. CRP was measured by enzyme-linked immunosorbent assay (developed by the CHS central laboratory); coefficient of variation of 8.9%. IL-6 was measured by high sensitivity-enzyme-linked immunosorbent assay (R&D Systems; www.rndsystems.com); coefficient of variation of 6.3%.

The primary exposure of interest was kidney function, measured by serum cystatin C (CysC)-based eGFR (eGFR_{CysC}), at study entry. eGFR_{CysC} was calculated using the following equation: eGFR = 76.7 × CysC^{-1.10} × 1.209 × 0.993^\text{age} × 0.851^\text{sex} (if female) × 1.159 [if black], where \( \text{age} = 0.329 \) for females and 0.411 for males, min indicates the minimum of SCr/\( \kappa \) or 1, and max indicates the maximum of SCr/\( \kappa \) or 1.6

The primary outcome of interest was hospitalization for infection. Infection-related hospitalization was defined as any hospitalization with a principal discharge diagnosis of bacteremia, septicemia, endocarditis, or pulmonary, genitourinary, gastrointestinal, soft tissue, bone, or joint infection. Discharge diagnoses were based on International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes (see Item S1, available as online supplementary material). During follow-up, participants were contacted semiannually to ascertain clinically relevant events, including hospitalization. Contact was by telephone alternating with annual examination visits through 1999 and subsequently by semiannual telephone contact. At the semianual contacts, participants were asked about major illnesses and hospital admissions. Medical records were obtained for all reported hospitalizations. All hospitalizations during follow-up (through June 30, 2007) were examined and included in analyses the protocol discharge diagnosis was an infection of interest. Participants were followed up for infection-related hospitalization until the time of death, loss to follow-up, or study end. Secondary to the very low number of episodes of endocarditis (n = 8) and bone and joint infections (n = 0), these types of infection were not examined further.

**Statistical Analyses**

We analyzed baseline eGFR_{CysC} as a continuous variable and according to categories (15-44, 45-59, 60-89, or ≥90 mL/min/1.73 m^2^). Age-adjusted rates and 95% confidence intervals for all-cause and cause-specific infection-related hospitalizations were calculated by eGFR_{CysC} categories. Poisson regression was used to examine whether kidney function, measured by eGFR_{CysC}, was associated with risk of infection-related hospitalization(s). The first multivariable model included age, sex, race, body mass index, diabetes, coronary heart disease, heart failure, cancer, chronic obstructive pulmonary disease, stroke, tobacco use, and serum albumin level. To examine whether the association between eGFR_{CysC} and infection changed with inclusion of markers of inflammation, CRP and IL-6 levels were added to the second model. We tested for overdispersion and found no such violation in our Poisson model. We also evaluated whether the association between kidney function and risk of all-cause infection was modified by age, sex, or race using interaction terms.

Two sensitivity analyses were conducted to examine whether multiple infection-related hospitalizations in the same individual contributed to the observed findings. In the first sensitivity analysis, any infection-related hospitalizations that occurred within 2 weeks of a previous infection-related hospitalization were excluded. In the second sensitivity analysis, only the first infection-related hospitalization was examined using a Cox proportional hazards model. Associations of eGFR_{CysC} and eGFR_{creatinine} with all-cause infection were compared visually by using splines to assess the functional form. Splines were created using S-Plus (version 8.0; Tibco, www.tibco.com), SPSS statistical software (version 15.0.1.1; SPSS...
RESULTS

Of the 5,888 original CHS participants, 80 were excluded for missing serum creatinine measurements; 651, for missing cystatin C values; and 15, for eGFR $<15$ mL/min/1.73 m$^2$ or renal replacement therapy, resulting in a final study sample of 5,142. Participants excluded were more likely to be older, men, and nonblack and have prevalent diabetes and cancer and higher hemoglobin, IL-6, serum creatinine, and cystatin C concentrations. Excluded participants had lower body mass index and lower prevalence of coronary heart disease compared with included participants. Of the study participants, 13% had stage 3a CKD (eGFR$\text{SCysC}$, 45-59 mL/min/1.73 m$^2$) and 5% had stage 3b or 4 CKD (eGFR$\text{SCysC}$, 15-44 mL/min/1.73 m$^2$). Participants who had lower eGFR$\text{SCysC}$ values were more likely to be older and men, more likely to smoke, and had higher prevalences of diabetes, hypertension, and cardiovascular disease (Table 1). Lower kidney function also was associated with higher serum levels of the inflammatory markers CRP and IL-6.

Median follow-up was 11.5 years. During follow-up, 20% of the cohort had one infection-related hospitalization and 10% had 2 or more infection-related hospitalizations. Lower estimated kidney function was associated with a significantly greater age-adjusted risk of all infection-related hospitalizations, as well as pulmonary and genitourinary infections (Fig 1). The association of eGFR$\text{SCysC}$ with all infection-related hospitalizations generally was linear across the measured range of kidney function (Fig 2A).

Table 1. Baseline Characteristics of Included CHS Participants by eGFR$\text{SCysC}$ Category

| eGFR$\text{SCysC}$ (mL/min/1.73 m$^2$) | ≥90 (n = 1,279) | 60-89 (n = 2,962) | 45-59 (n = 648) | 15-44 (n = 253) |
|--------------------------------------|----------------|------------------|----------------|----------------|----------------|
| Age (y)                              | 71 ± 4         | 72 ± 5           | 75 ± 6         | 77 ± 7         |
| Men                                  | 377 (30)       | 1,210 (41)       | 298 (46)       | 125 (49)       |
| Black                                | 259 (20)       | 442 (15)         | 90 (14)        | 44 (17)        |
| Smoking history                      |                |                  |                |                |
| Never                                | 609 (48)       | 1,395 (47)       | 274 (42)       | 122 (48)       |
| Former                               | 543 (42)       | 1,201 (41)       | 288 (44)       | 88 (35)        |
| Current                              | 127 (10)       | 366 (12)         | 86 (13)        | 43 (17)        |
| BMI (kg/m$^2$)                       | 25.8 ± 4.2     | 27.0 ± 4.8       | 27.6 ± 5.1     | 27.0 ± 5.2     |
| Diabetes                             | 193 (15)       | 440 (15)         | 124 (19)       | 55 (22)        |
| Hypertension                         | 654 (51)       | 1,704 (58)       | 458 (71)       | 211 (83)       |
| Cancer                               | 145 (11)       | 412 (14)         | 110 (17)       | 45 (18)        |
| CHF                                  | 25 (2)         | 113 (4)          | 54 (8)         | 43 (17)        |
| CHD                                  | 172 (13)       | 589 (20)         | 183 (28)       | 86 (34)        |
| Stroke                               | 22 (2)         | 118 (4)          | 53 (8)         | 34 (13)        |
| COPD                                 | 157 (12)       | 381 (13)         | 85 (13)        | 27 (11)        |
| Albumin (g/dL)                       | 4.0 ± 0.3      | 4.0 ± 0.3        | 4.0 ± 0.3      | 3.9 ± 0.3      |
| Hemoglobin (g/dL)                    | 13.9 ± 1.4     | 14.1 ± 1.3       | 13.8 ± 1.5     | 13.3 ± 1.7     |
| CRP (mg/L)                           | 2.02 (0.98; 3.66) | 2.47 (1.31; 4.33) | 3.45 (1.97; 7.47) | 4.29 (2.52; 9.50) |
| IL-6 (pg/mL)                         | 1.33 (0.95; 2.00) | 1.67 (1.16; 2.50) | 2.28 (1.52; 3.38) | 2.92 (2.02; 3.92) |
| SCr (mg/dL)                          | 0.8 ± 0.2      | 0.9 ± 0.2        | 1.2 ± 0.3      | 1.6 ± 0.5      |
| SCysC (mg/L)                         | 0.8 ± 0.05     | 1.0 ± 0.1        | 1.4 ± 0.1      | 1.9 ± 0.4      |
| eGFR$\text{SCr(CKD-EPI)}$ (mL/min/1.73 m$^2$) | 86 ± 12 | 73 ± 14 | 57 ± 13 | 40 ± 14 |
| eGFR$\text{SCysC}$ (mL/min/1.73 m$^2$) | 103 ± 11 | 76 ± 8 | 54 ± 4 | 37 ± 6 |

Note: Data are presented as mean ± standard deviation, number (percentage) of participants, or median (25th; 75th percentile). Conversion factors for units: albumin in g/dL to g/L, ×10; SCr in mg/dL to μmol/L, ×88.4; GFR in mL/min/1.73 m$^2$ to mL/s/1.73 m$^2$, ×0.01667; hemoglobin in g/dL to g/L, ×10.

Abbreviations: BMI, body mass index; CHD, coronary heart disease; CHF, congestive heart failure; CHS, Cardiovascular Health Study; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; COPD, chronic obstructive pulmonary disease; CRP, C-reactive protein; eGFR$\text{SCr(CKD-EPI)}$, estimated glomerular filtration rate using the serum creatinine–based CKD-EPI equation; eGFR$\text{SCysC}$, estimated glomerular filtration rate using serum cystatin C level; IL-6, interleukin 6; SCr, serum creatinine; SCysC, serum cystatin C.
stroke, heart failure, diabetes, cancer, chronic obstructive pulmonary disease, and serum albumin level, lower eGFRSCysC categories were associated with significantly greater risks of all-cause, pulmonary, and genitourinary infection–related hospitalizations (Table 2). Further adjustment for serum CRP and IL-6 concentrations did not materially alter these estimates. In contrast, lower estimated kidney function was not associated with gastrointestinal or soft-tissue infections or bacteremia and septicemia. The eGFRSCysC categories of 60-89, 45-59, and 15-44 mL/min/1.73 m² were associated with 16%, 37%, and 64% greater risks of all infection-related hospitalizations compared with eGFRSCysC =90 mL/min/1.73 m². Analyzed as a continuous variable, lower eGFRSCysC was associated with 8%, 7%, and 11% higher adjusted risks of all-cause, pulmonary, and genitourinary infection–related hospitalization. The association between eGFRSCysC and infection was not modified by age, sex, or race. Results did not differ substantively when infection-related hospitalizations that occurred within 2 weeks of a prior infection-related hospitalization were excluded (result not shown). When only the first infection-related hospitalization was examined, findings generally were similar except that statistically significant associations were observed between eGFRSCysC of 45-59 mL/min/1.73 m² and bacteremia/septicemia and pulmonary infection (results not shown).

Given the high rate of pulmonary infections, we also examined rates of vaccination at study entry by eGFR categories. Proportions of participants with influenza vaccination were 43%, 44%, 48%, and 49% for eGFRSCysC categories, whereas proportions with pneumococcal vaccination were 26%, 26%, 27%, and 26% for eGFRSCysC categories.

![Figure 1](image1.png)

**Figure 1.** Age-adjusted rates per 100 person-years of all-cause and cause-specific infection by kidney function (category of serum cystatin C–based estimated glomerular filtration rate [eGFRSCysC; in mL/min/1.73 m²]).

![Figure 2](image2.png)

**Figure 2.** Association between kidney function and risk of infection-related hospitalization. Association between (A) serum cystatin C–based estimated glomerular filtration rate (eGFRSCysC) and risk of all-cause infection-related hospitalization and (B) serum creatinine–based eGFR calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation and risk of all-cause infection-related hospitalization.
In contrast to the linear association between eGFR\textsubscript{SCysC} and infection risk, the association of eGFR\textsubscript{SCR(CKD-EPI)} with all-cause infection-related hospitalization was U-shaped (Fig 2B). A summary of the spline model for eGFR\textsubscript{SCR(CKD-EPI)} showed no significant linear effect (P = 0.4), but showed a marginally significant nonlinear effect (P = 0.05). Because of the U-shaped relation between eGFR\textsubscript{SCR(CKD-EPI)} and infection, eGFR\textsubscript{SCR(CKD-EPI)} was divided into finer categories in the adjusted analyses (≥90, 60-89, 45-59, and 15-44 mL/min/1.73 m\textsuperscript{2}) and eGFR\textsubscript{SCR(CKD-EPI)} of 60-74 mL/min/1.73 m\textsuperscript{2} was selected as the referent group. Compared with eGFR\textsubscript{SCR(CKD-EPI)} of 60-74 mL/min/1.73 m\textsuperscript{2}, participants with eGFR\textsubscript{SCR(CKD-EPI)} of 15-44 mL/min/1.73 m\textsuperscript{2} had 24% higher risk of all-cause infection (P = 0.05) and 54% higher risk of pulmonary infection (P = 0.008). Other ranges of eGFR\textsubscript{SCR(CKD-EPI)} were not associated significantly with risk of infection-related hospitalization (see Table S1).

DISCUSSION

When kidney function was assessed by eGFR\textsubscript{SCysC}, we found that it was linearly associated with higher risk of infection-related hospitalization. Compared with participants with eGFR\textsubscript{SCysC} ≥90 mL/min/1.73 m\textsuperscript{2}, participants with stage 3a CKD (eGFR\textsubscript{SCysC}, 45-59 mL/min/1.73 m\textsuperscript{2}) had a nearly 40% increase in risk of infection-related hospitalization, and participants with stages 3b or 4 CKD (eGFR\textsubscript{SCysC}, 15-44 mL/min/1.73 m\textsuperscript{2}) had a 60% increase in risk. These findings highlight that even moderately decreased kidney function is associated with clinically significant greater risks of serious infection.

In contrast to the linear association observed between eGFR\textsubscript{SCysC} and risk of infection, we found a U-shaped relation between eGFR and risk of infection when a creatinine-based measure of eGFR was used.
Only eGFR\(_{\text{Scr(CKD-EPI)}}\) of 15-44 mL/min/1.73 m\(^2\), compared with eGFR\(_{\text{Scr(CKD-EPI)}}\) of 60-74 mL/min/1.73 m\(^2\), was associated with increased risk of infection-related hospitalization. Our findings are similar to other CHS studies that have found cystatin C–based estimates of kidney function to be more strongly and linearly associated with adverse health outcomes compared with creatinine-based estimates.\(^3,18\) Our findings further highlight that cystatin C–based measures of kidney function may more accurately estimate the risks of serious adverse outcomes, such as infection associated with kidney disease.

Interestingly, few studies have examined the risk of infection in individuals who have CKD that does not require dialysis, and the present study is the first to our knowledge that uses cystatin C level to quantify the risks of serious infection in older patients. To date, the largest studies have focused on specific infections, such as bacteremia or pneumonia, and have relied on creatinine-based measures to estimate kidney function. For example, James et al.\(^8\) found that in adults 66 years and older, the risk of bloodstream infections was higher for persons with lower eGFR, finding ~25%, 60%, and 250% higher risk in older persons with eGFR of 45-59, 30-44, and <30 mL/min/1.73 m\(^2\), respectively, compared with persons with eGFR ≥60 mL/min/1.73 m\(^2\). In our study, we did not find a significant increase in risk of bacteremia or sepsis with decreasing levels of kidney function. The discrepancy in findings with our study may be due to key differences in the study by James et al.,\(^7\) including (1) ascertainment of comorbid conditions from administrative data, potentially resulting in residual confounding and higher risk estimates; (2) the combination of all bloodstream infections, including Escherichia coli, Pseudomonas species, and Klebsiella pneumoniae bacteremia, which likely would have been classified as site-specific infection in our study, such as genitourinary or pulmonary; and (3) the inclusion in the James et al.\(^7\) study of predialysis participants with eGFR <15 mL/min/1.73 m\(^2\), a particularly high-risk group. In a separate study of adults, James et al.\(^8\) found that kidney function was associated independently with risk of pneumonia diagnosis during hospitalization and the risk was modified by age. In adults 75 years or older, a significant increase in risk was observed for only eGFR <30 mL/min/1.73 m\(^2\), and these patients had an 80% increase in risk of pneumonia compared with patients with eGFR of 60-104 mL/min/1.73 m\(^2\). Although differences in study design limit direct comparison of findings, participants in our study with eGFR\(_{\text{ScysC}}\) of 15-44 mL/min/1.73 m\(^2\) or eGFR\(_{\text{Scr(CKD-EPI)}}\) of 15-44 mL/min/1.73 m\(^2\) had a significant increase in risk of pulmonary infections, similar to the study by James et al.\(^8\) Importantly, in the study by James et al.,\(^8\) a significant increase in incidence of pneumonia also was observed in participants with eGFR ≥105 mL/min/1.73 m\(^2\); rates of incident pneumonia were similar to or higher than those observed in patients with stage 3b CKD.\(^8\)

We found a similar U-shaped risk when creatinine-based measures of eGFR (eGFR\(_{\text{Scr(CKD-EPI)}}\)) were used to examine the relationship between kidney function and infection risk. Of interest, the proportion of CHS participants that reported influenza vaccination at study entry was highest in the lowest eGFR\(_{\text{ScysC}}\) categories, whereas pneumococcal vaccination overall was similar across eGFR categories.

The observed association between kidney function and infection-related hospitalization may be due to increased susceptibility to infection and/or increased severity of infection in older patients with CKD. Biologically, kidney disease is a metabolic disorder and is associated with numerous alterations in immune function. Although not well studied in predialysis CKD, end-stage renal disease and its associated metabolic consequences result in an acquired immuno-deficiency with numerous alterations in immune function. Findings include (1) impaired polymorphonuclear chemotaxis, phagocytosis, oxidative metabolism, and intracellular killing\(^19-21\); and (2) inadequate costimulation of T cells by antigen-presenting cells, resulting in impaired activation of helper T cells.\(^22\) Furthermore, the observed immune dysfunction can result in vaccine hyporesponsiveness.\(^21,23\) Kidney disease is a continuum, and alterations in immune cellular function may develop well before end-stage renal disease, similar to other metabolic abnormalities associated with kidney disease.

Our study contributes to the current literature in several important ways. First, we estimated kidney function using cystatin C level, allowing us to examine more directly the association between kidney function and infection. In contrast to creatinine, cystatin C is produced by all nucleated cells and is not correlated with muscle mass,\(^24\) a particular concern in older populations that may have low serum creatinine levels secondary to low muscle mass or malnutrition. Biologically, it is unlikely that normal kidney function increases the risk of infection-related hospitalization, and the apparent U-shaped relation between creatinine-based measures of kidney function and infection observed in our study and others\(^8\) likely is secondary to misclassification of kidney function when using creatinine-based estimates. Second, our study included comprehensive ascertainment of important comorbid conditions and health behaviors, reducing the likelihood of residual confounding and allowing for more precise estimates of the excess infection risk associated with kidney disease. Third, our study examined a
broad range of infections and found that multiple types of infections contributed to the overall risk of infection-related hospitalization.

Our study has several limitations. First, CHS participants were 65 years or older at study entry; thus, our findings are applicable to only older patients with kidney disease. However, CKD is most common in this age group and these findings in the elderly therefore are important. Second, we examined only principal discharge diagnoses; thus, our study likely underestimates the true burden of infection in older patients with CKD. Third, we did not have measures of proteinuria and therefore cannot draw conclusions regarding the impact of proteinuria on the observed findings. Fourth, we cannot exclude that residual confounding contributed to some of the observed association between decreased kidney function and infection. Fifth, we examined kidney function at only study entry and therefore cannot determine whether progression of kidney disease influenced the risk of infection. Sixth, we used ICD-9-CM codes to identify infections of interest as opposed to validated clinical criteria for specific types of infection, potentially resulting in misclassification. Finally, given the low number of specific types of infection (e.g., soft tissue, gastrointestinal, and sepsis) and the limited number of participants with severe CKD, our study may not be able to detect important differences in the risk of certain types of infections with respect to decreased kidney function. Despite these limitations, our study has important implications for the care of older patients with kidney disease.

In summary, lower levels of kidney function are associated with higher risk of infection, including even moderately decreased kidney function. Future studies are needed to understand the factors that contribute to this observed risk. Important areas in need of further research include the effect of moderately decreased kidney function on immune cell function, vaccine responsiveness in older patients with kidney disease, and the short- and long-term outcomes of serious infections in persons with CKD.

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Financial Disclosure: The authors declare that they have no other relevant financial interests.

SUPPLEMENTARY MATERIAL

Table S1: Association of all-cause and cause-specific infection-related hospitalizations with eGFR\textsubscript{MED,Ckd,Epity}. Note: The supplementary material accompanying this article (doi:10.1053/j.ajkd.2011.07.012) is available at www.ajkd.org

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