

Methodological Comparison of Categorized Versus Continuous Decline in Kidney Function: Insights from the CKD Care Model

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Introduction

- Decision analysts evaluating the economic impact of survival-improving health technologies typically rely on lifetime models that use biomarkers – such as estimated glomerular filtration rate (eGFR) in chronic kidney disease (CKD), cholesterol in cardiovascular disease, or CD4 counts in HIV – to predict the risk of adverse health outcomes.
- In standard state transition models, these biomarkers are represented as ordinal categories, requiring the discretization of inherently continuous data. This introduces a structural simplification.
- Although many chronic diseases progress continuously over time, individuals grouped within a given health state are assumed to share identical risks of disease progression or clinical events.
- Here, we examine the implications of this assumption by comparing the effects on costs and quality adjusted life years (QALYs) of modelling a biomarker as categorical (ordinal) versus continuous within a published economic model of CKD.¹

Objective

- The objective was to compare the modeled QALYs and lifetime costs between categorical and continuous versions of eGFR decline in the same model, holding other factors constant.

Methods

- The CKD Care Model is a flexible, transparent decision analytical model for projecting the impact of eGFR decline on clinical outcomes and evaluating management strategies for CKD.¹
- The model tracks progressive declines in eGFR and increases in albuminuria on the occurrence of cardiovascular events or kidney failure in a hypothetical cohort of patients with CKD.
- Clinically, CKD is defined by reduced eGFR (<60 mL/min/1.73 m²) or elevated albuminuria (urine albumin creatinine ratio [uACR] >30 mg/g) and, grouped according to the five-level ordinal scale defined by the Kidney Disease | Improving Global Outcomes (KDIGO).
- Keeping all inputs the same, we compared the costs and QALYs between a categorical version using KDIGO categories and a continuous version that uses continuous function of eGFR.
- Cost data were drawn from the Optum Market Clarity database, which links electronic health records to inpatient, outpatient, and pharmacy claims for over 102 million patients across diverse US care settings.
- Costs were measured from the first recorded CKD diagnosis following confirmed physiological evidence (two eGFR values <60 mL/min/1.73 m² at least 90 days apart) until censoring (earliest of death, end of study, or last recorded encounter).
- Event-specific costs were estimated for heart failure (HF), myocardial infarction (MI), stroke, and kidney failure, alongside costs for patients without these events.
- To reflect acute and ongoing management, costs were: partitioned into first and subsequent years of follow-up; and stratified by age (<65 vs ≥65 y) and type 2 diabetes (T2D) status to capture variation in healthcare utilization and pricing.
- For the continuous version, eGFR- and albuminuria-specific event risks and costs were obtained by smoothing across published KDIGO categories using a cubic spline function.

Results

- Population characteristics were derived the Chronic Renal Insufficiency Cohort Study (CRIC),² with mean age of 58 years, 41% female; mean eGFR 52 mL/min/1.73m², prevalence of T2D 41% and prevalence of hypertension 86%.
- Cumulative incidence plots in the **FIGURE 1** show the smoothing of the cumulative incidence for the continuous model compared to the discrete, categorical model (KDIGO category G3a / A1).
- Comparison of lifetime costs and QALYs in **TABLE 1** are shown by eGFR category.

FIGURE 1. Cumulative incidence of first events for (A) Categorical and (B) Continuous versions of the model (KDIGO category G3a / A1).

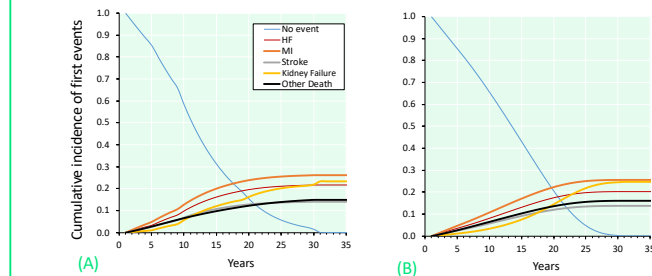


TABLE 1. Comparison of lifetime costs and QALYs per person diagnosed with chronic kidney disease (CKD) between categorical and continuous event risks and costs across KDIGO categories (albuminuria categories combined).

KDIGO category	Costs			QALYs		
	Categorical	Continuous	Difference	Categorical	Continuous	Difference
G3a	\$421,987	\$431,374	2.2%	10.4	10.5	0.9%
G3b	\$548,843	\$550,287	0.3%	9.4	9.4	0.2%
G4	\$775,412	\$797,365	2.8%	7.6	7.7	1.3%

QALYs = quality adjusted life years; KDIGO = Kidney Disease Improving Global Outcomes; eGFR = estimated glomerular filtration rate

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Results (continued)

- TABLE 1** shows that for CKD patients in KDIGO G3a, G3b, and G4, respectively, the categorical model projected lifetime QALYs of 10.4, 9.4, and 7.6, and the lifetime costs were approximately \$421,000, \$548,000, and \$775,000.
- Projected QALYs were within 1% of the value projected between the continuous and categorical versions and lifetime costs in the continuous version were 2%, <1% and 3% higher than the projections using a categorical model.

Conclusions

- While inconsistencies were noted between continuous and categorical functions over shorter time frames (data not shown), differences in the CKD Care Model between continuous and categorical eGFR using the same input parameters led to only small differences in lifetime QALYs and costs.
- The finding of only small changes in a real-world population is consistent with the findings that showed less than 4% difference in QALYs between categorical and continuous versions of a fully hypothetical simulation.³
- As a first approximation, the results indicate that categorizing eGFR in models of CKD progression leads to only small differences in costs and QALYs.
- Such information may be useful for analysts modeling continuous physiologic parameters and informing the time frame for the analysis.

Limitations

- The model relies on evidence from a single cohort study – this warrants a cautious approach to generalization.
- Only aggregate risk tables are available from the published sources when multivariable risk equations would allow greater granularity for the modeling.
- Other data sources are obtained from literature and their use in the model involves extrapolation from the original population-based studies.
- Other limitations of the CKD Care Model are also applicable.

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