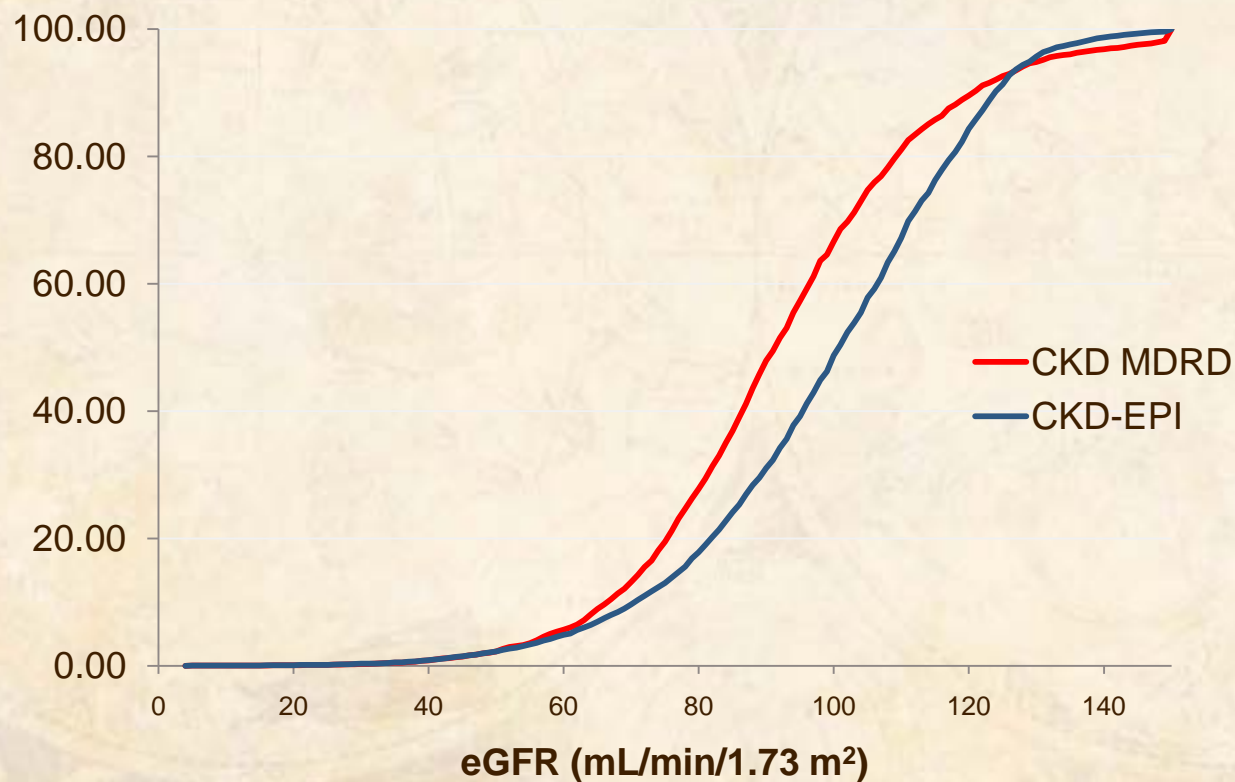


**CKD & outcomes in the
general population:
Which Test, Which Formula?**

Robert N. Foley, MB

USRDS

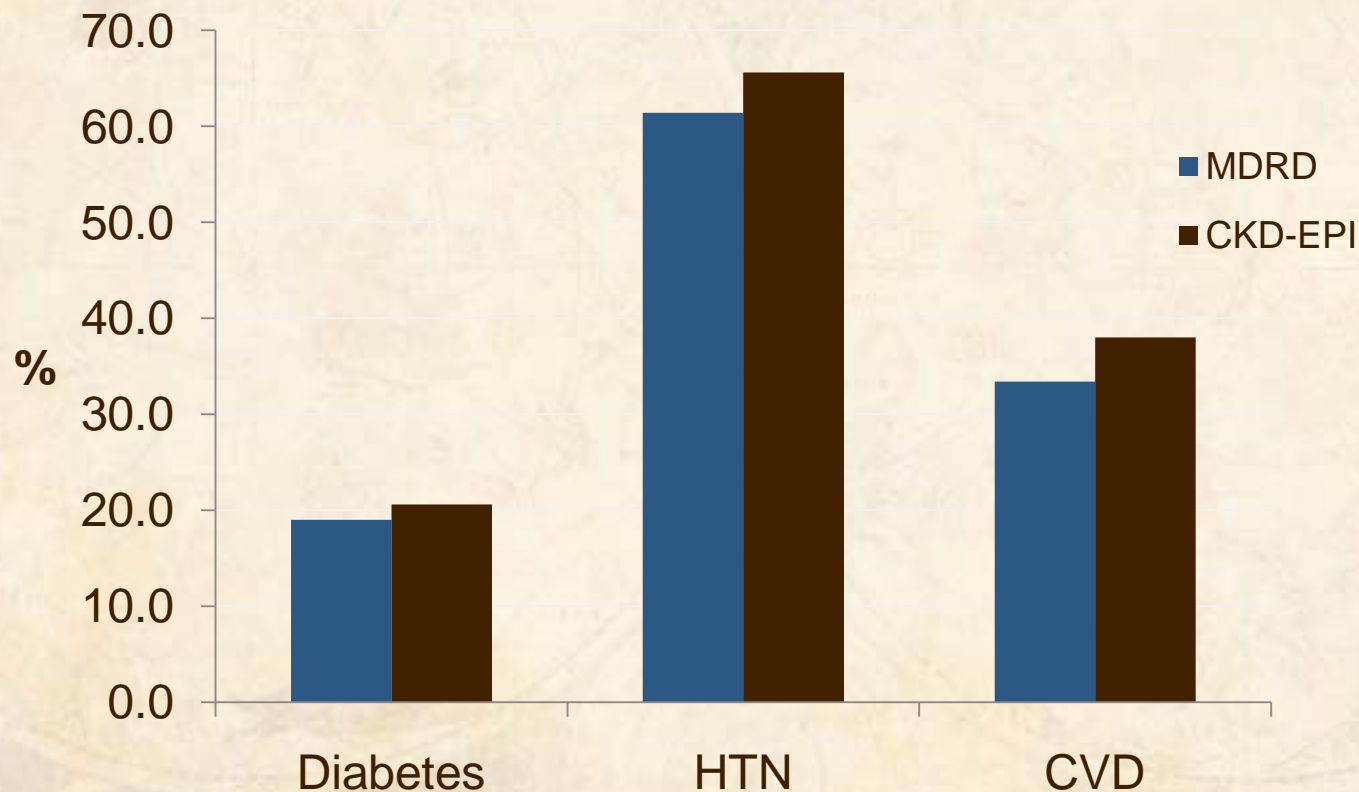
US Adults, NHANES 2003-2006: Cumulative distribution, $eGFR_{CKD-EPI}$ vs. $eGFR_{MDRD}$



NHANES 2003-2006: eGFR_{CKD-EPI} vs. eGFR_{MDRD}

	MDRD		CKD-EPI	
	eGFR 30-59 (%)	eGFR ≤ 30 (%)	eGFR 30-59 (%)	eGFR ≤ 30 (%)
All adults	7.8	0.5	6.3	0.6
Male	6.0	0.5	5.2	0.6
Female	9.4	0.5	7.4	0.6
White	9.2	0.5	7.4	0.6
African American	4.8	1.1	4.9	1.2

Comorbidity in NHANES 1999–2006, eGFR <60



Claims-based environment: eGFR_{MDRD} <60 vs. eGFR_{CKD-EPI} <60

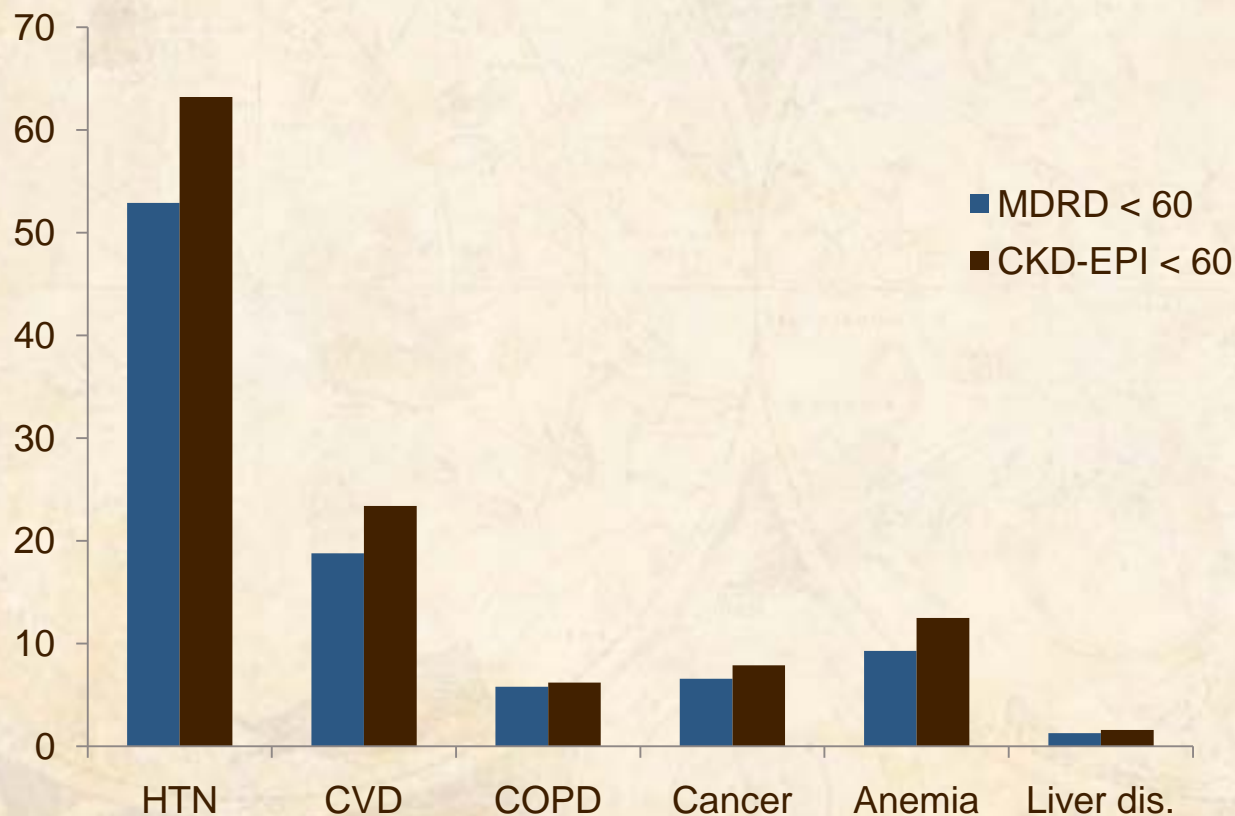
- **Adults <65, mean age 43**
- **Ingenix i3, 2008, N = 724,205**
- **Abnormalities**
 - **Uric acid: 7 mg/dL, male, 6 mg/dL, female**
 - **Hemoglobin: 13 g/dL, male, 12 mg/dL, female**
 - **Others: 5th or 95th percentiles in NHANES**

Claims-based environment: $eGFR_{MDRD} < 60$ vs. $eGFR_{CKD-EPI} < 60$

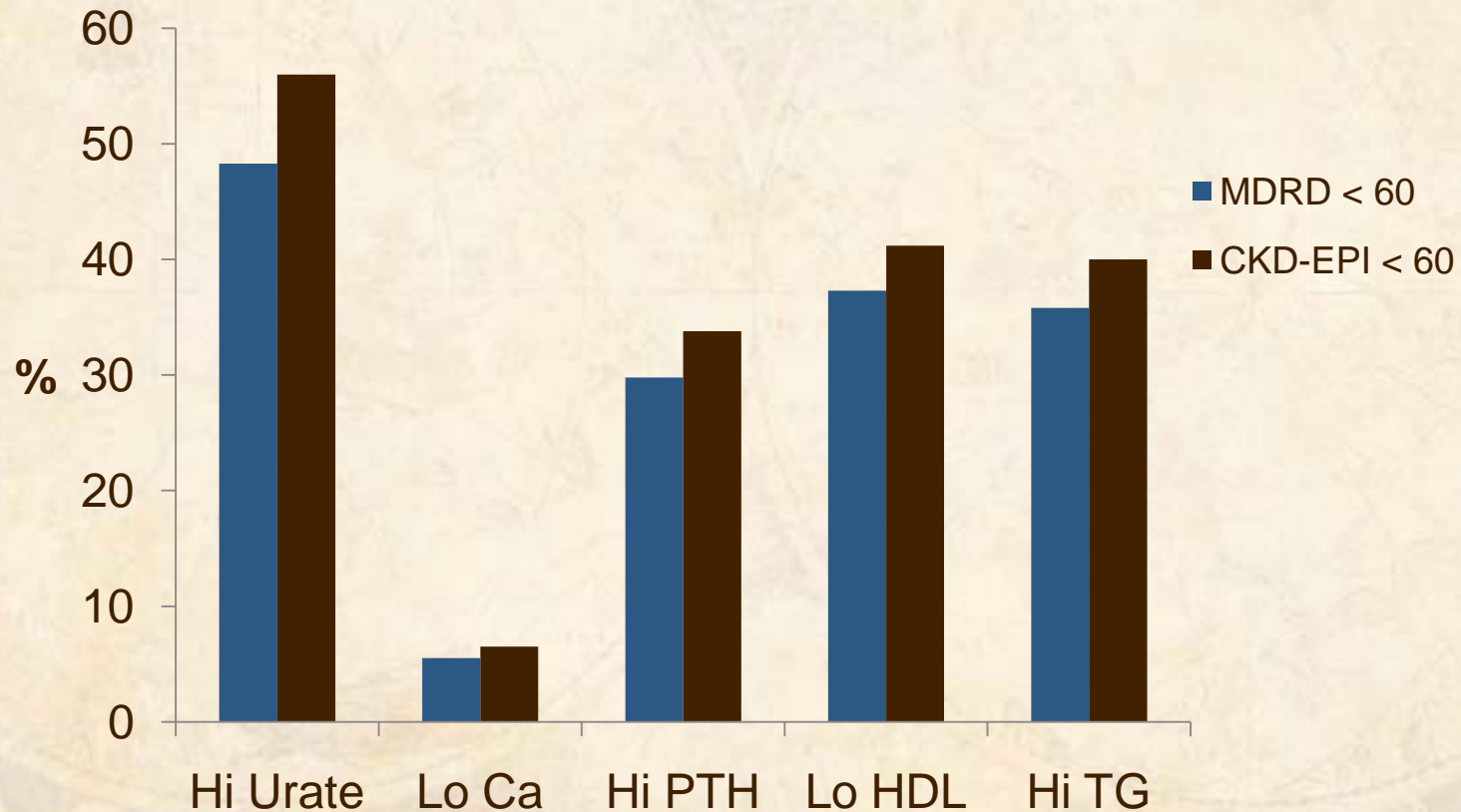
$eGFR_{MDRD} < 60$	8.2%
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$eGFR_{CKD-EPI} < 60$	4.2%
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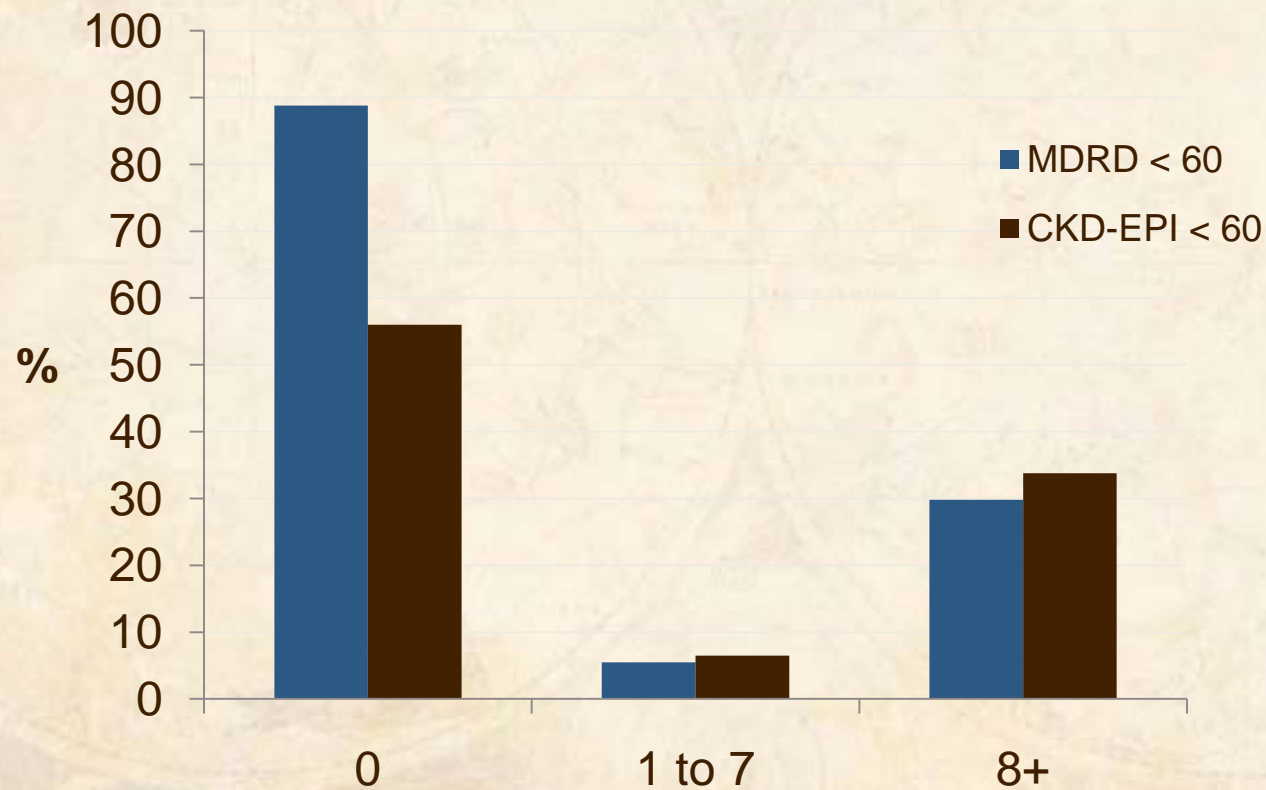
MDRD <60 Vs. CKD-EPI <60 (%)



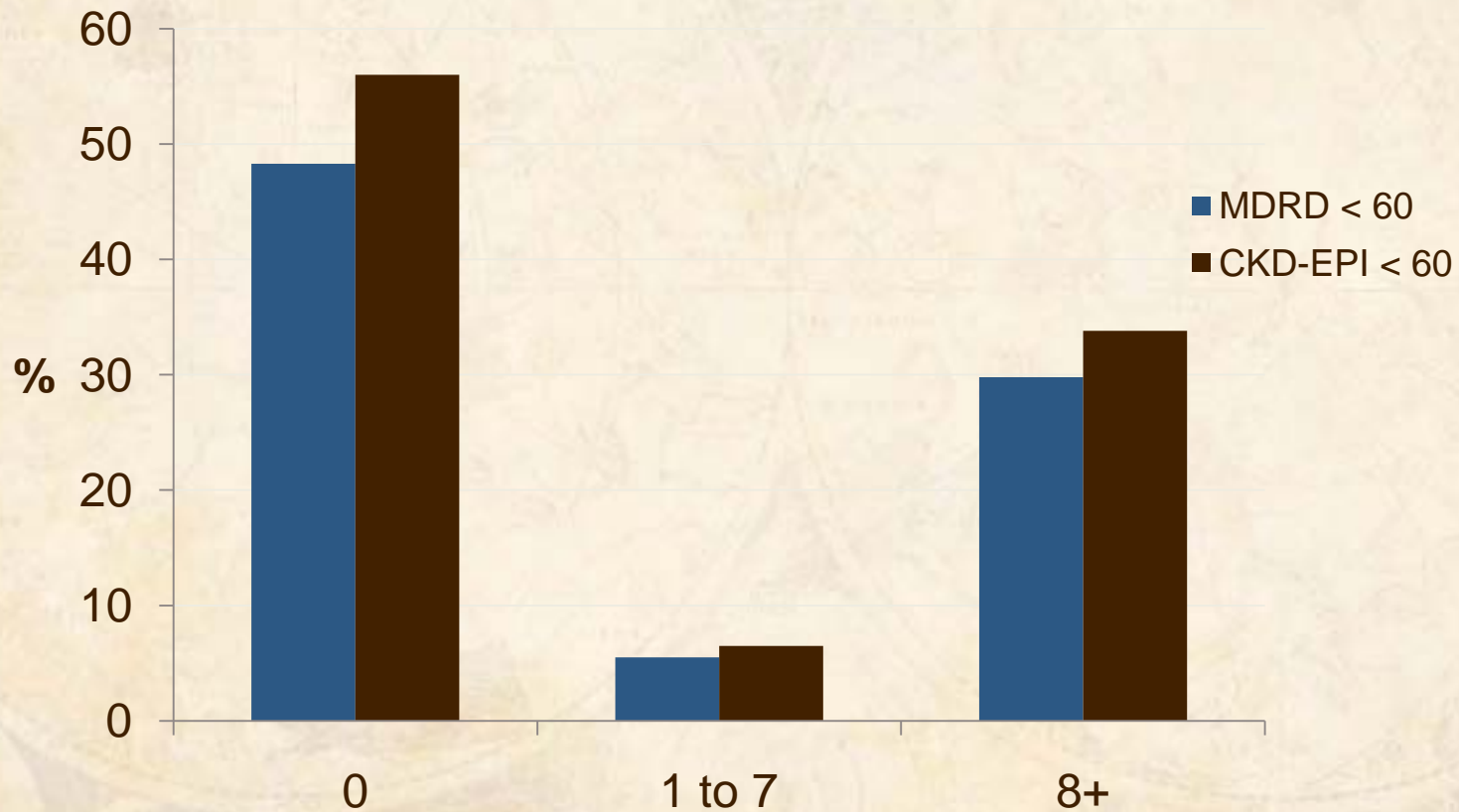
MDRD <60 vs. CKD-EPI <60



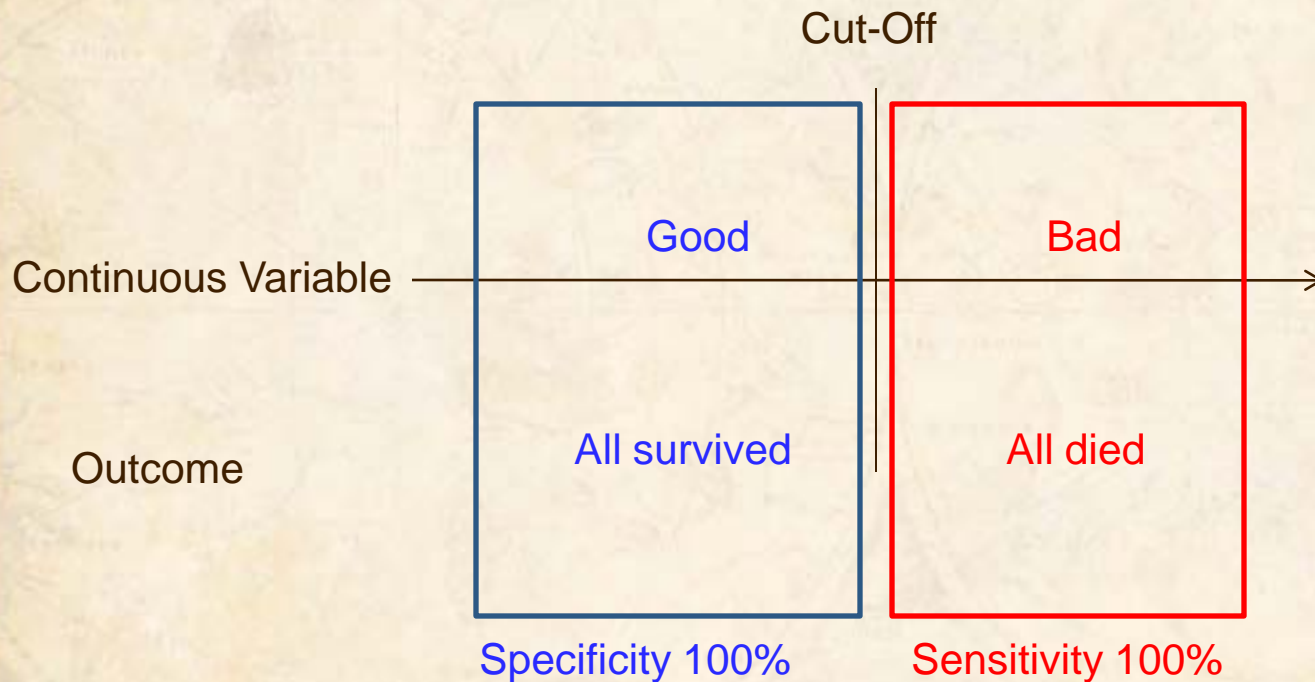
Hospital days



Hospital admissions



Perfect cut-off for discriminating death/survival



$$(\text{Sensitivity } (\%)) + \text{Specificity } (\%) = 200$$

General Case for Threshold X

Specificity = Proportion of Survivors with Level Below X

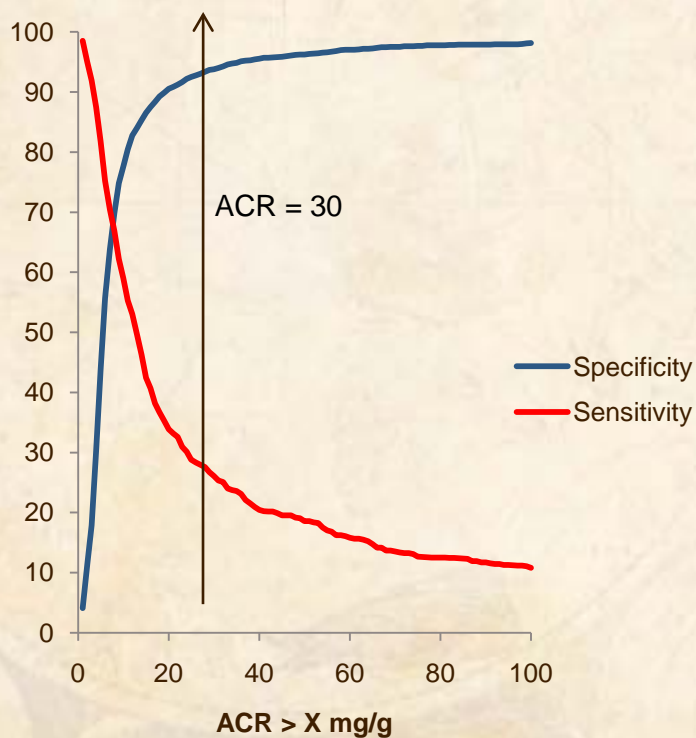
Sensitivity = Proportion of Deaths with Level Above X

ACR and creatinine-based eGFR and death or survival

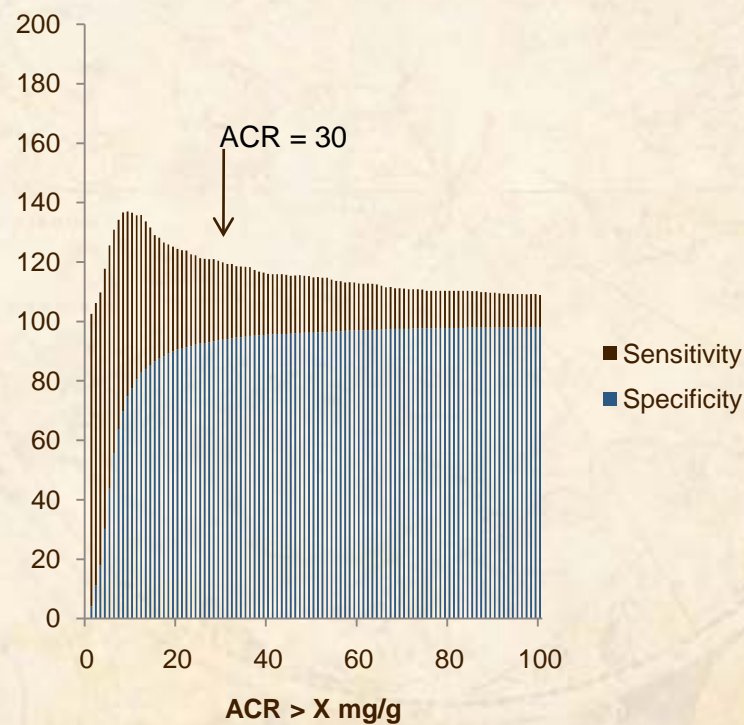
- **Adults ≥ 20 years, NHANES 1988-1994**
- **Survey methodology, representative of non-institutionalized US population**
- **Vital status known through 2006**

Urinary ACR

Sensitivity, Specificity

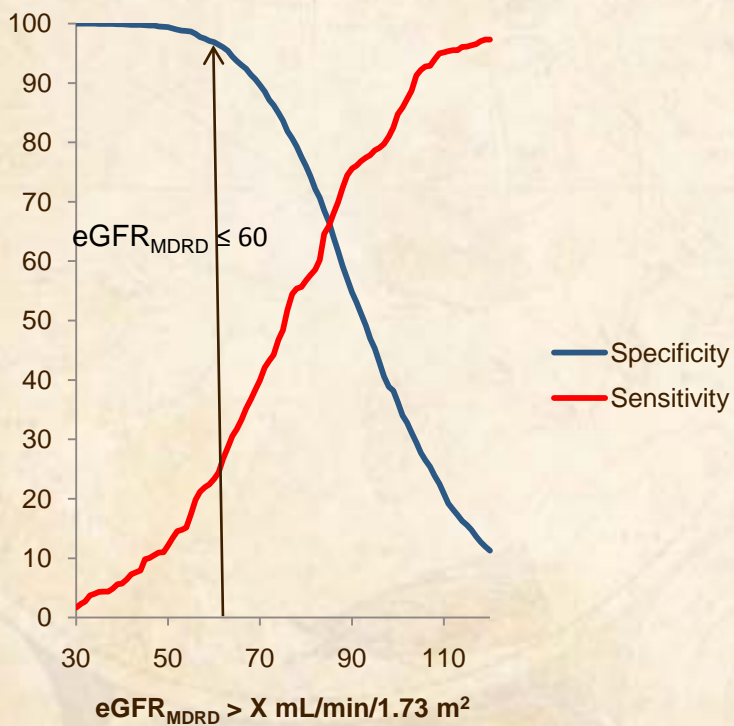


Sensitivity + Specificity

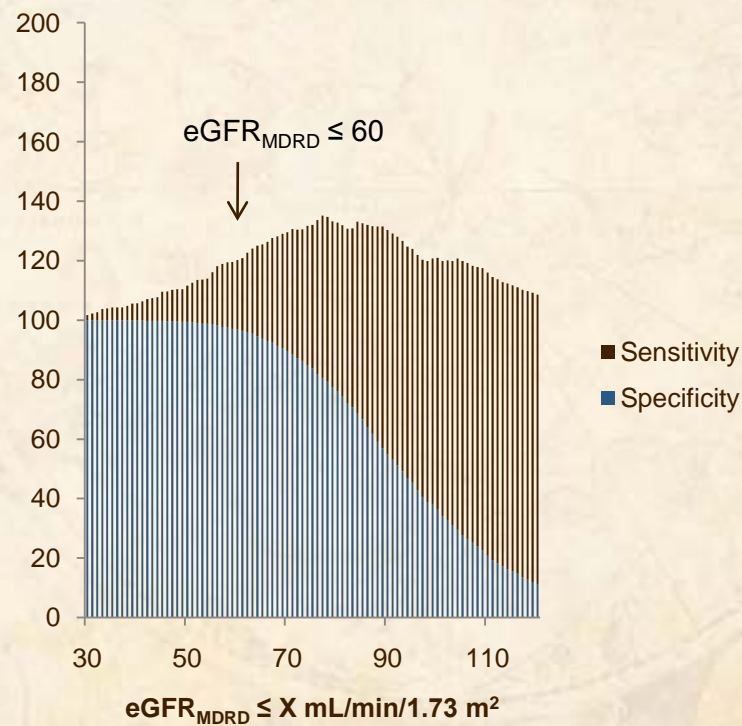


eGFR_{MDRD}

Sensitivity, Specificity

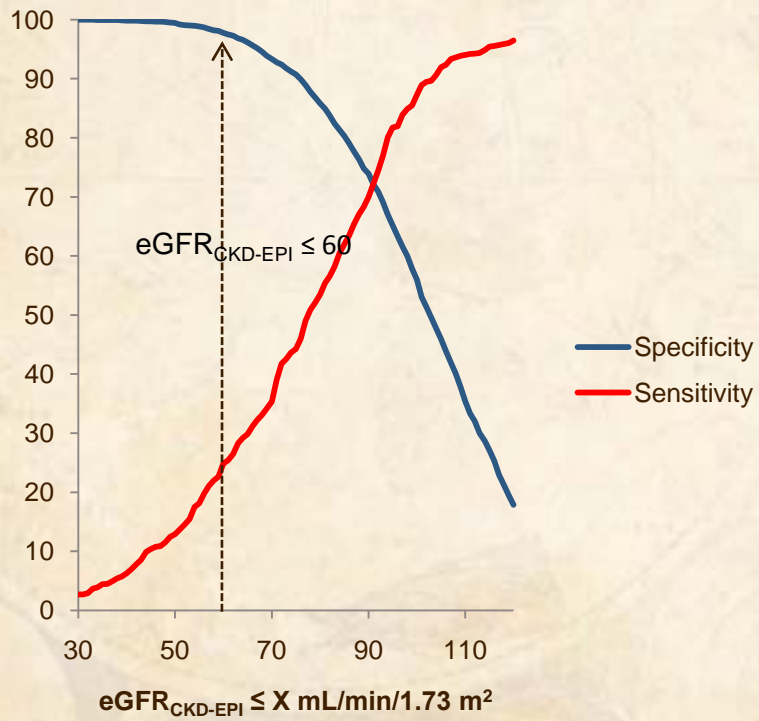


Sensitivity + Specificity

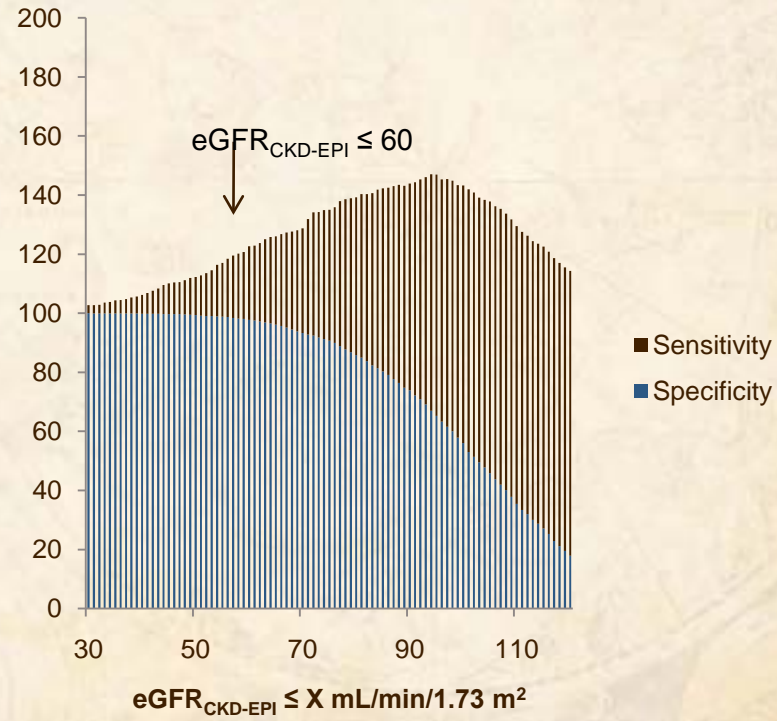


eGFR_{CKD-EPI}

Sensitivity, Specificity



Sensitivity + Specificity



ACR, Cr, eGFR_{Cr}, Cystatin C, classic risk factors: Comparison of best thresholds

	Mean (SE) or Median [IQR]
Cystatin C, mg/L	0.90
Creatinine, mg/dL	0.84
eGFR _{CKD-EPI} , mL/min/1.73 m ²	99.5 (0.8)
ACR, mg/g	5.7 [3.6-10.3]
Age, years	44.6

Mortality discrimination, all adults: Ranking of best thresholds

Rank	Risk Factor	Prevalence	Sensitivity/Specificity
1	Age >58	22.9	0.73/0.87
2	eGFR_{CKD-EPI} ≤92	32.3	0.71/0.75
3	Systolic BP > 127	31.0	0.66/0.76
4	Cystatin C >0.94	28.5	0.64/0.78
5	ACR >11	24.0	0.51/0.81
6	Hypertension	23.9	0.44/0.80
7	Cholesterol >204	47.1	0.62/0.56
8	CVD	4.8	0.19/0.98
9	Creatinine >0.97	14.7	0.28/0.88
10	Diabetes	5.0	0.14/0.97
11	BMI >27	39.4	0.46/0.62
12	HDL ≤40	26.4	0.30/0.74

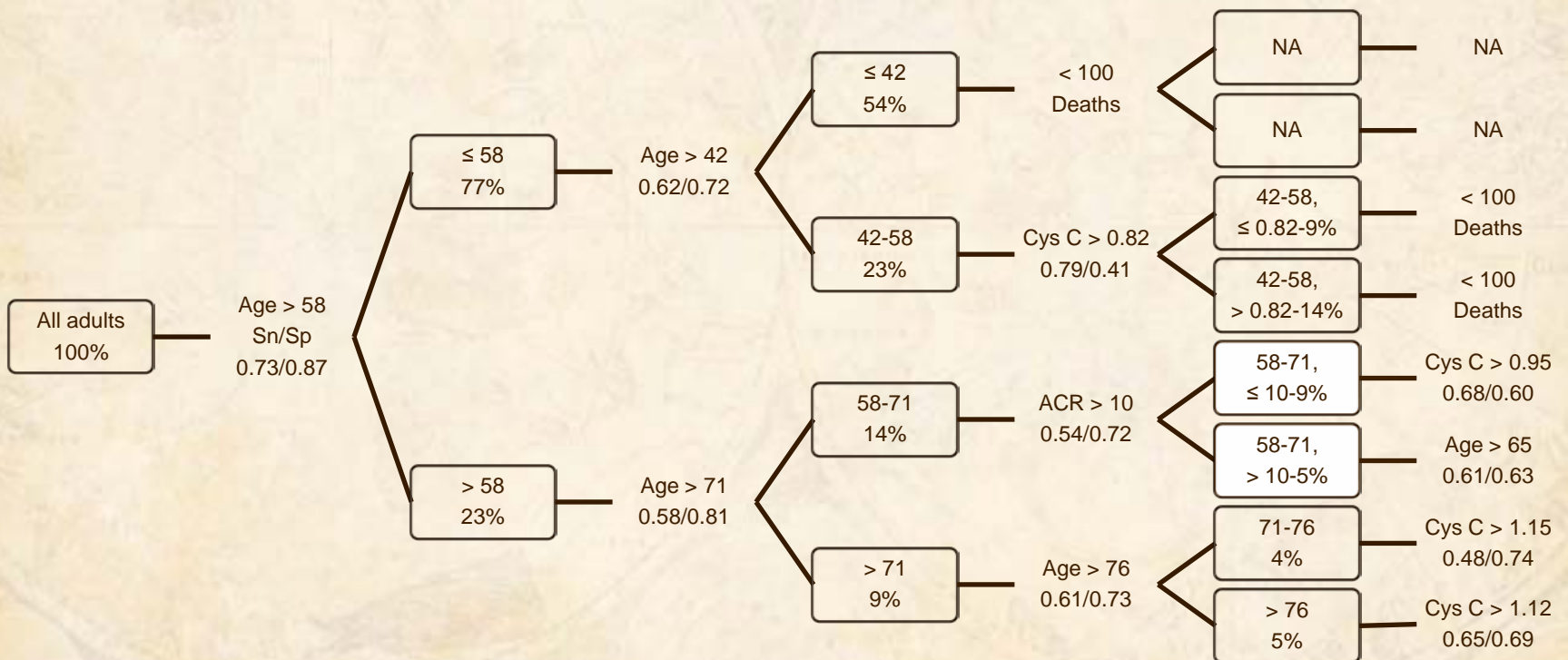
Mortality discrimination, adults ≤ 58 : Ranking of best thresholds

Rank	Risk Factor	Prevalence	Sensitivity/Specificity
1	Age >42	29.9	0.62/0.72
2	Systolic BP >125	23.4	0.43/0.78
3	Cystatin C >0.82	48.1	0.68/0.53
4	BMI >27	37.8	0.56/0.63
5	ACR >11	18.4	0.36/0.83
6	Smoking	32.9	0.49/0.68
7	Cholesterol >239	14.4	0.29/0.86
8	Hypertension	17.8	0.32/0.83
9	Diabetes	3.3	0.11/0.97
10	CVD	1.4	0.07/0.99
11	African American	11.6	0.17/0.89
12	Creatinine >1.17	1.5	0.05/0.99

Mortality discrimination, adults >58: Ranking of best thresholds

Rank	Risk Factor	Prevalence	Sensitivity/Specificity
1	Age > 71	39.2	0.58/0.81
2	Cystatin C ≤ 1.15	32.2	0.47/0.84
3	ACR >12	40.1	0.54/0.74
4	eGFR_{CKD-EPI} ≤ 68	30.9	0.42/0.81
5	Systolic BP >135	52.8	0.62/0.57
6	CVD	16.3	0.23/0.91
7	Creatinine >0.88	42.7	0.5/0.65
7	Hypertension	44.3	0.49/0.61
8	Diabetes	10.6	0.15/0.94
9	HDL ≤ 44	38.2	0.42/0.66
10	Men	43.1	0.47/0.61
11	Smoking	15.2	0.18/0.88

Survival/Death: Classification tree



Conclusions

- **CKD-EPI formula seems to identify fewer cases than MDRD formula when threshold is 60 mL/min/1.73 m².**
 - **More comorbidity, worse outcomes**
 - In representative adults.
 - With large claims-based data.
- **Optimal thresholds for discriminating death from survival much closer to 'normal' than recognized in current classification systems.**
 - **Optimal thresholds with CKD-EPI formula and cystatin C appear to perform better.**
 - **ACR and GFR thresholds have additive discrimination.**