The Best Predictors of Survival: Do They Vary by Age, Sex, and Race?

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Introduction

• Myriad factors have been linked to human survival: social factors, health conditions, biological markers.

• Prognosis: Strongest predictors of survival of older adults are similar across countries with comparable life expectancy.

• Do the best predictors of survival differ across demographic subgroups?
Data

- 1999-2006 NHANES (U.S.), ages 20+
- Household interview and physical examination
- \( N=18,027 \) who provided a blood sample & for whom vital status could be verified
- Outcome: Mortality \( \leq 5 \) years post-exam
- Gompertz hazard model with age as the metric for time (age-specific mortality)
Modeling Strategy

• Stratified:
  – By Age group (20-64, 65-79, 80+)*
  – Within each age group
    • By Sex
    • By Race/ethnicity (non-Latino whites, non-Latino blacks, Latinos)*

• 30 predictors, each tested individually

• Non-proportional hazards: if age interaction significant for any subgroups, included for all 8 subgroups

* Controlling for sex
## Predictors of Mortality

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Illness-related</th>
<th>Biomarkers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (the “clock”)</td>
<td>History of diabetes</td>
<td>SBP</td>
</tr>
<tr>
<td>Sex</td>
<td>History of cancer</td>
<td>DBP</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td>History of stroke</td>
<td>Resting pulse</td>
</tr>
<tr>
<td>Social factors</td>
<td>History of heart disease</td>
<td>Total cholesterol (TC)</td>
</tr>
<tr>
<td>Marital status</td>
<td>Hospital stays</td>
<td>HDL cholesterol</td>
</tr>
<tr>
<td>Education</td>
<td>5+ medications</td>
<td>Ratio of TC/HDL</td>
</tr>
<tr>
<td>Income</td>
<td>Overall health/function</td>
<td>HbA1c</td>
</tr>
<tr>
<td>Health behavior</td>
<td>SAH</td>
<td>BMI</td>
</tr>
<tr>
<td>Smoking</td>
<td>ADL limitations</td>
<td>Waist circumference</td>
</tr>
<tr>
<td>Physical activity</td>
<td>IADL limitations</td>
<td>CRP</td>
</tr>
<tr>
<td></td>
<td>Mobility limitations</td>
<td>WBC count</td>
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<tr>
<td></td>
<td></td>
<td>Serum creatinine (SCr)</td>
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<tr>
<td></td>
<td></td>
<td>Homocysteine (Hcy)</td>
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<td></td>
<td></td>
<td>Serum albumin</td>
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</tbody>
</table>

- SAH: Systolic Arterial Hypertension
- ADL: Activities of Daily Living
- IADL: Instrumental Activities of Daily Living
- CRP: C-Reactive Protein
Area Under the Receiver Operating Characteristic Curve (AUC)

- Objective: assess predictive ability rather than magnitude of the associations
- AUC summarizes ability to discriminate between decedents and survivors.
- Range:
  - $0.5 = \text{no better than chance and}$
  - $1.0 = \text{perfect accuracy}$
- $\Delta \text{AUC}>0.01 \text{ considered meaningful}$
Evaluating discrimination with the area under the ROC curve (AUC)

**Sensitivity:** predict death if R died

**Specificity:** predict survival if R survived

___A   Strong model
___B   Weak model
_ _ _   Random coin toss
Top 10 Predictors by Age Group

Ages 20-64
- Income
- Educ
- Smoking
- 5+ Meds
- Hosp Stays
- SAH
- IADL
- ADL
- Albumin
- Mobility

Ages 65-79
- SAH
- IADL
- Mobility
- ADL
- Exercise
- Smoking
- 5+ Meds
- Hosp Stays
- IADL
- ADL
- Albumin
- Mobility

Ages 80+
- IADL
- ADL
- Mobility
- SAH
- Albumin
- 5+ Meds
- Hosp Stays
- Heart dis.
- Hcy
- Exercise

Social/demographic factors
Health behaviors
Illness-related
Overall health/physical function
Biomarkers
Differences by Age Group

- SAH and physical function among strongest predictors in all age groups
- Importance declines with age:
  - Social factors (education, income, marital status)
  - Smoking (selective survival?)
- Biomarkers:
  - Albumin is a top predictor in all age groups
  - Homocysteine emerges among the top 10 only for the oldest age group
Top 10 Predictors by Sex, Ages 80+

Men

Women

Gain in AUC

IADL
Mobility
ADL
SAH
5+ Meds
Heart dis.
Stroke
Heart Rate

Social/demographic factors
Health behaviors
Illness-related
Overall health/physical function
Biomarkers
Differences by Race/Ethnicity

- Disability measures are weaker predictors for younger blacks
- Disease diagnosis: at ages 65-79, heart disease is strongest for whites, cancer for blacks, and stroke for Latinos
- Number of hospitalizations ranks particularly high among blacks younger than 80.
How Do Biomarkers Fare?

• Serum albumin top predictor in most subgroups
  – More likely to be a marker of morbidity and survival risk than a causal, modifiable factor

• Standard clinical markers (hypertension, cholesterol, and obesity) are generally weak discriminators

• More important: Serum creatinine, homocysteine, & CRP (but again, not necessarily causal)
Conclusions

• Self-reported health & physical function among the best predictors in all subgroups
  – More proximate than social/behavioral factors
  – Integrates an accumulation of biological processes over a lifetime not easily captured in one-time measurement of a biomarker

• Although most of the strongest predictors perform well across subgroups, prognostic indexes may need to be optimized for specific demographic groups
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