An absolute risk prediction model for rehospitalisation in adults with chronic heart failure

Presented by
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- My PhD supervisors:
  - Professor Patricia Davidson
  - Dr Phillip Newton
  - Professor Gavin Leslie
Objectives

- Identify the burden of heart failure
- Identify current risk models and their limitations
- Describe the development of the absolute risk model
- Describe factors that predict the risk of rehospitalisation (CHF)
- Identify clinical relevance of the absolute risk model
What do we know

– Incidence & Prevalence of heart failure – Limited Australian Data

(Field B 2003)

– Self reported data has limitations
What do we know

Europe and USA data obtained from longitudinal studies

- Hillingdon heart failure study (UK)
- The Helsinki Ageing Study (Finland)
- Framingham study (USA)
What do we know

- Incidence: 5.1 million adults in the United States (Go and colleagues, 2013)
- 15 million in Europe (Dickstein and colleagues, 2008)
- CHF occurs in 1.5–2.0% of Australians
- Prevalence
  - 10% in people aged 65 years and older
  - over 50% in people aged 85 years

(National Heart Foundation of Australia and the Cardiac Society of Australia and New Zealand, 2011)
Burden of the disease

- **50%** of people who develop heart failure die within **5 years** \( (\text{Go and colleagues, 2013}) \)

- Cardiovascular disease
  - Primary cause of death in Males and Females \( (\text{ABS, 2012}) \)
  - More females than males have CHF, highest in Inner regional areas \( (\text{AIHW, 2011}) \)
Burden of the disease

- Heart failure amounted to $416 million in 1993–94 (AIHW 2001)

- Currently, estimated at over $1 billion per year (Krum and colleagues, 2009)

- Expenditure due to hospitalisation followed by pharmacotherapies
Burden of the disease

- This number is increasing 43,408 in 1993–94 to 49,307 in 2007–08
- Heart failure is the PRIMARY reason for hospitalisation
- >65 years of age

(National Heart Foundation, 2013)

- Hospitalisation increases the risk for rehospitalisation & mortality
Measuring risk

- **Relative risk**
  - comparing the risk in two different groups of people
  - individuals with heart failure and those without heart failure

- **Absolute risk**
  - Individual’s overall risk
  - Presented as a percentage

- A limitation of the *relative risk* is that it does not inform you of an *INDIVIDUAL’S ACTUAL RISK*
# Current risk models in heart failure and their limitations

<table>
<thead>
<tr>
<th>Source</th>
<th>Study type</th>
<th>Data source</th>
<th>Study location</th>
<th>No. of hospitals/no. of patients</th>
<th>Study outcome</th>
<th>Follow-up period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chin and Goldman (1997)</td>
<td>Prospective cohort</td>
<td>Medical record review</td>
<td>Boston, U.S.A.</td>
<td>1/257</td>
<td>All-cause readmission or death</td>
<td>60 days</td>
</tr>
<tr>
<td>Felker et al (2004)</td>
<td>RCT cohort</td>
<td>Collected during RCT</td>
<td>U.S.A.</td>
<td>78/949</td>
<td>All-cause readmission or death</td>
<td>60 days</td>
</tr>
<tr>
<td>Yamokoski et al (2007)</td>
<td>RCT cohort</td>
<td>Collected during RCT</td>
<td>U.S.A. and Canada</td>
<td>26/373</td>
<td>All-cause readmission</td>
<td>6 months</td>
</tr>
<tr>
<td>Amarasingham et al (2010)</td>
<td>Prospective cohort</td>
<td>Electronic medical record review</td>
<td>Texas, U.S.A.</td>
<td>1(136)/1372</td>
<td>All-cause readmission or death</td>
<td>18 months</td>
</tr>
</tbody>
</table>
What this model adds…

Development of the absolute risk model

- Identified factors for risk from previous models (Betihavas et al, 2012)

- Identified factors from Integrative review of the literature (Betihavas et al, 2013)

- Identified factors from heart failure experts (Betihavas et al, 2013)

- Tested within a cohort of an Australian RCT
  - W.H.I.C.H. study (Stewart et al, 2012)
Methods

Statistical methods

- A modified Cox’s proportional hazards model (Therneau, 2000)
- Bootstrap methods
- Variables selected using backward-deletion-method
  - with a generous $p$-value for retention (0.2).
- Procedure was repeated 200-times (Harrell et al, 1998)
- Verification of the proportional hazards: Schoenfeld residual plots (Grambsch, 1994)
Methods

Model validation

- C statistic 0.80
- Accuracy of prediction in similar populations
- Sub-sample of 50 patients
- To estimate biases between the rates of readmission (Harrell, 2001)
- Using the final model a nomogram for predicting the probability of rehospitalisation for a cardiovascular event within 28-days or 1-year, for an individual with CHF was developed
## Results for risk of readmission for a cardiovascular event

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Hazard Ratios (95% Confidence Interval)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
</tr>
<tr>
<td>Age (each 10-year increase)</td>
<td>1.18 (1.05, 1.33)</td>
</tr>
<tr>
<td>Women versus men</td>
<td>1.12 (0.79, 1.60)</td>
</tr>
<tr>
<td>Lives alone</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>Yes</td>
<td>1.07 (0.76, 1.51)</td>
</tr>
<tr>
<td>Sedentary</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>Yes</td>
<td>1.72 (1.12, 2.62)</td>
</tr>
<tr>
<td>No. of comorbid conditions</td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>2-4</td>
<td>1.32 (0.31, 5.62)</td>
</tr>
<tr>
<td>5+</td>
<td>2.31 (0.57, 9.34)</td>
</tr>
<tr>
<td>Number of years with CHF</td>
<td></td>
</tr>
<tr>
<td>&lt; 10</td>
<td>1.0 (ref)</td>
</tr>
<tr>
<td>10+</td>
<td>1.56 (0.93, 2.63)</td>
</tr>
</tbody>
</table>
Absolute risk model

Points

Age (yrs)

Woman

Lives Alone

Sedentary

Charlson Index

Years of Heart Failure

Total Points

28-day risk of readmission

1-year risk of readmission
Absolute risk model
Absolute risk model

Points

Age (yrs)

Woman

Lives Alone

Sendentary

Charlson Index

Years of Heart Failure

Total Points

28-day risk of readmission

1-year risk of readmission
Absolute risk model
Absolute risk model

Points

Age (yrs)

Woman

Lives Alone

Sendentary

Charlson Index

Years of Heart Failure

Total Points

28-day risk of readmission

1-year risk of readmission
Absolute risk model
Absolute risk model
Absolute risk model
Clinical significance of the model

- Clinically relevant to an Australian population
- Timely
- Clinically applicable
- Identify adults with CHF at risk of rehospitalisation
- Provides an absolute risk score for 28 days and 1 year
- Strategies implemented by healthcare providers to prevent rehospitalisation
References

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Thank you for your attention