PROLOGUE

- LONDON (Reuters) - Showing that a little flutter can do you good, a British woman stands to collect a cheque for 12,650 pounds on Friday after betting she would live to 100.
- Rosalind Strover from Sudbury in Suffolk plans to celebrate her centenary with her family at a nearby golf club.
- As well as the traditional congratulatory telegram from the queen, she will also receive a cheque for her winnings from bookmaker William Hill.
- Ten years ago, her daughter-in-law Jennifer wagered 100 pounds at 100-1 that she would reach her century, topping up the bet with a 50 pound stake a year later at 50-1.
MORTALITY DRIVERS

Smoking

- Smoking contributes to around one third of cancers\(^1\)
- Smoking also plays a major role in coronary heart disease
- Around 90% of lung cancer cases are directly linked with smoking\(^2\)
- Lung cancer is the second-biggest killer of UK males (after heart disease)\(^3\)

1 Doll and Peto (1981)
2 Cancer Research UK and ONS
3 ONS statistics

Diet

- Poor diet contributes to around one third of cancers\(^1\)
- Deficiencies of vitamins, minerals or trace elements lead to cancer\(^2\)
- Deficiency of micro-nutrients very common in developed world, despite easy availability of low-cost food
- UK Department of Health estimated in 2002 that average adult only consumed 3.4 portions of fruit and vegetables\(^3\)

2 Armit (1998)
3 Health Survey for England
MORTALITY DRIVERS
Other risk factors for cancer

- Alcohol
- Sexual activity
- Infection
- Genetic pre-disposition
- Occupation
- Environment

POPULATION MORTALITY:
SOCIO-ECONOMIC GROUP

Source: ONS Longitudinal Study
There are pronounced socio-economic differences in smoking incidence:

- Managerial/professional: 16%
- Routine and manual: 34%

Source: ONS "Smoking-related behaviour and attitudes, 2003". Figures are for males and females combined.

There are class differences even amongst smokers

- Proportion of smokers lighting up within five minutes of waking:
  - Managerial/professional: 9%
  - Routine and manual: 18%

Source: ONS "Living in Britain"

Households in highest income quintile have highest home consumption of fruit, vegetables and fish

- ...and the lowest consumption of milk, cream, sugar and confectionery
- Highest intake of many vitamins and minerals mainly found in households led by a "higher professional"
- Households with highest education levels have 50% higher consumption of fruit and vegetables
- Lower-income groups have highest consumption of fats

## Population Mortality: Regional Variation

### England
- SMR: 98

### Wales
- SMR: 102

### Northern Ireland
- SMR: 104

### Scotland
- SMR: 114

**Source:** Own calculations for ages 60-95 using GAD interim life tables 2000-2003. 100 = UK

<table>
<thead>
<tr>
<th>Region</th>
<th>SMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-East</td>
<td>93</td>
</tr>
<tr>
<td>South-West</td>
<td>93</td>
</tr>
<tr>
<td>East</td>
<td>95</td>
</tr>
<tr>
<td>London</td>
<td>97</td>
</tr>
<tr>
<td>Yorkshire and Humber</td>
<td>102</td>
</tr>
<tr>
<td>East Midlands</td>
<td>102</td>
</tr>
<tr>
<td>West Midlands</td>
<td>103</td>
</tr>
<tr>
<td>Wales</td>
<td>104</td>
</tr>
<tr>
<td>North-West</td>
<td>109</td>
</tr>
<tr>
<td>North-East</td>
<td>112</td>
</tr>
</tbody>
</table>

**Source:** ONS death registrations for 2003. England and Wales = 100
POPULATION MORTALITY DRIVERS
Regional variation in diet

- Scots have the highest per-household expenditure in the UK for soft drinks, desserts & ice creams, and cakes & confectionery
- Scots also have the lowest household consumption of vegetables
- The North-East has the lowest consumption in England for fruit and vegetables combined, with Northern Ireland even lower still.
- The Welsh have the highest household consumption of alcohol, fats & oils, and sugar & preserves.


ANNUITANT MORTALITY

Mortality differentials

- Mortality rates critical assumption for annuity business
- Strong differentials by age and gender
- Further differentials by geography and socio-economic group (occupation)
- With low interest rates, mortality assumptions become more important
POPULATION MORTALITY
Regional variation confounded with socio-economic group

<table>
<thead>
<tr>
<th>Region</th>
<th>SMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>South-East England</td>
<td>93</td>
</tr>
<tr>
<td>- Wokingham</td>
<td>85</td>
</tr>
<tr>
<td>- Milton Keynes</td>
<td>111</td>
</tr>
<tr>
<td>London</td>
<td>97</td>
</tr>
<tr>
<td>- Kensington and Chelsea</td>
<td>87</td>
</tr>
<tr>
<td>- Barking and Dagenham</td>
<td>113</td>
</tr>
<tr>
<td>Wales</td>
<td>104</td>
</tr>
<tr>
<td>- Ceredigion</td>
<td>88</td>
</tr>
<tr>
<td>- Blaenau Gwent</td>
<td>125</td>
</tr>
</tbody>
</table>

Source: ONS death registrations for 2003. England and Wales = 100

POPULATION v. ANNUITANT MORTALITY
Questions

- Are population differentials also found amongst annuitants?
- How to disentangle regional and lifestyle differentials?
- What financial impact does this all have?

ANNUITANT MORTALITY
Mortality differentials

- Important differentials by socio-economic group and region...
- ...but two critical barriers to applying population data to annuities:
  - (i) annuitants are a small and select subset of the population
  - (ii) how to disentangle regional effects (and others) from socio-economic mix?
ANNUITANT MORTALITY
Prudential's background

- Major writer of individual and bulk annuities in UK
- Large data set: 750,000 annuities (30% of CMIB data)
- All annuity types, sizes and sources (depth of data)

ANNUITANT MORTALITY
Modeling differentials

- Fit Generalised Linear Model (GLM) to experience data
- Establish expected age and gender effects…
- …but also regional and lifestyle differentials…
- …and differentials by duration (initial selection) and amount (pension size).

ANNUITANT MORTALITY
Strength of differentials relative to gender

<table>
<thead>
<tr>
<th>Rating factor</th>
<th>Explanatory power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>2095</td>
</tr>
<tr>
<td>Gender</td>
<td>100</td>
</tr>
<tr>
<td>Lifestyle</td>
<td>51</td>
</tr>
<tr>
<td>Duration</td>
<td>25</td>
</tr>
<tr>
<td>Amount</td>
<td>8</td>
</tr>
<tr>
<td>Region</td>
<td>8</td>
</tr>
</tbody>
</table>

Source: Richards & Jones (2004). Explanatory power is the drop in scaled deviance for the main effect plus one half of drop for related two-way interactions, expressed relative to gender (=100).
### FINANCIAL IMPACT

#### Mortality differentials

<table>
<thead>
<tr>
<th>Differential</th>
<th>Annuity</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>13.39</td>
<td>n/a</td>
</tr>
<tr>
<td>Female→Male</td>
<td>12.14</td>
<td>-9.3%</td>
</tr>
<tr>
<td>High→Low status</td>
<td>10.94</td>
<td>-9.9%</td>
</tr>
<tr>
<td>Short→Long duration</td>
<td>9.88</td>
<td>-9.7%</td>
</tr>
<tr>
<td>High→Low income</td>
<td>9.36</td>
<td>-5.2%</td>
</tr>
<tr>
<td>South→North</td>
<td>8.90</td>
<td>-4.9%</td>
</tr>
<tr>
<td>Overall</td>
<td>n/a</td>
<td>-33.6%</td>
</tr>
</tbody>
</table>


### FINANCIAL IMPACT

#### Actual ratings for two bulk schemes in 2004 Q1

- Manufacturer of hydraulic assemblies in NW England
  - heavy mortality
  - rated 145% PMA92c2003
- Finance company with members in affluent suburbs
  - light mortality
  - rated 90% PMA92c2003
- Price difference of 11% in annuity factor

### COHORT EFFECTS
COHORT EFFECTS

Background

- Analysis of relative improvement:

Males and females

Source: Richards and Jones (2004). Own calculations using GAD data.

COHORT EFFECTS

Cause-of-death classification

- International Classification of Death (ICD)
- ICD1 has 192 codes (including one for “Plague”)
- ICD9 has 5,292 codes (including eight for “Plague”)
- Tracking trends in exact cause of death is difficult!
- Easier to track a few broad classifications
**COHORT EFFECTS**
Projected mortality improvements

<table>
<thead>
<tr>
<th>Year</th>
<th>Mortality Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1944</td>
<td>-5.0%</td>
</tr>
<tr>
<td>1950</td>
<td>-3.0%</td>
</tr>
<tr>
<td>1956</td>
<td>-1.0%</td>
</tr>
<tr>
<td>1962</td>
<td>1.0%</td>
</tr>
<tr>
<td>1968</td>
<td>3.0%</td>
</tr>
<tr>
<td>1974</td>
<td>5.0%</td>
</tr>
<tr>
<td>1980</td>
<td>7.0%</td>
</tr>
<tr>
<td>1986</td>
<td>9.0%</td>
</tr>
</tbody>
</table>

Source: Own calculations using linear extrapolation of ONS data.

**SUMMARY**

- Population mortality differentials are echoed in annuitant differentials
- These differentials make big differences in prices and reserves
- Cohort effects apply to women almost as much as men
- Mortality improvements may accelerate over next decade

**Q&A**

More material on annuitant mortality available at:
- www.prudential.co.uk/prudentialplc/investor_home/presentations/investors_30apr04/mortality.pdf
- www.sias.org.uk/papers/longevity.pdf