Models for forecasting the health of the population
(illustrated for local areas in Northern England)

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Aim and outline

- Aim
  - To discuss how best to construct a model for forecasting the health of populations
- Ingredients
  - Who needs health projections?
  - Why are they needed?
  - For what populations?
  - Which dependent variables to use?
  - Which determinants to build in?
  - What kinds of projections?
- Methods and Examples
  - Northern England (Rees et al 2011)
  - Ten Advanced Countries (Sanderson & Scherbov 2010)
  - WHO member states (Mathers & Loncar 2006)
- Discussion
  - The way forward

How do health/illness forecasts connect with health expectancies?

- Health expectancies are forecasts but they assume constant period prevalence rates for health/illness and a stationary population
- The period expectancies need to developed into cohort expectancies
- To do this we need to model both mortality rates and the health illness prevalence rates over time (past and future)
- Such projected rates are one of the inputs to cohort-component projection models to which we add fertility rates, international migration for national populations and add internal migration for sub-national populations

UK trends in life expectancy, past and future

Type	Life Expectancies				Annual change		
Sex, age	1982	2012	2042	2062	1982-2012	2012-2042	2042-2062
Period							
Men, age 0	71.1	79.0	84.7	87.3	0.26	0.19	0.13
Men, age 65	13.0	18.3	22.8	24.9	0.18	0.15	0.11
Women, age 0	77.0	82.7	87.9	90.3	0.19	0.17	0.12
Women, age 65	17.0	20.7	25.2	27.2	0.12	0.15	0.10
Cohort							
Men, age 0	85.1	90.6	95.1	98.0	0.18	0.15	0.15
Men, age 65	14.2	21.2	24.7	27.0	0.23	0.12	0.12
Women, age 0	89.2	93.9	98.0	100.7	0.16	0.14	0.14
Women, age 65	18.0	23.9	27.2	29.5	0.20	0.11	0.12

Source: ONS (2013) National Population Projections, 2012 Based, Principal Projection, Mortality Assumptions

UK trends in health expectancies and years not in good health

Measure	1981	1991	2001	2000-02	2000-02	2008-10
	GH3	GH3	GH3	GH3	GH5	GH5
Men, age 0						
HE	**64.4**	**66.1**	**67.0**	**66.8**	**60.4**	**63.9**
YNGH	**6.3**	**7.1**	**8.7**	**8.9**	**15.3**	**14.2**
Women, age 0						
HE	**66.7**	**68.6**	**68.8**	**69.9**	**62.4**	**66.1**
YNGH	**10.1**	**10.1**	**11.6**	**10.5**	**18.0**	**16.0**
Men, age 65						
HE	**9.9**	**10.8**	**11.6**	**11.9**	**9.4**	**10.2**
YNGH	**3.1**	**3.4**	**4.3**	**4.1**	**6.6**	**7.7**
Women, age 65						
HE	**11.9**	**13.0**	**13.2**	**14.0**	**10.8**	**11.7**
YNGH	**5.0**	**4.9**	**5.8**	**5.0**	**8.2**	**8.8**

GH3 = General Health Question, 3 response categories
GH5 = General Health Question, 5 response categories
Source: Office for National Statistics, Health Expectancy statistics

Who needs health/illness projections?

- **Governments/agencies**: international, national and sub-national
- **Private companies:** health, holidays, consultancy
- **NGOs:** with an interest in health or disease
- **Researchers:** on health issues from a very wide range of disciplines

Health Care Spending

- Central assumption is for per capita health spending to rise with GDP, adjusted for population changes
- But output of health care will only rise in line with the output of the rest of the economy if productivity growth is the same (we assume 2.2% a year)
- But productivity growth in health care c.0.8% a year since 1979. If it stays that way, health spending would need to rise 3.6% a year in real terms for health care output growth to match rest of economy

Source:
Slide 28, Presentation of the Fiscal Responsibility Report 2012, by Robert Chote, Chairman, Office for Budget Responsibility, 12 July 2012. Chart B.6 from OBR (2012), Annex B.

Why are health/illness forecasts needed?

- **Short-term:** monitoring, providing an estimate for the current year because of publication lags (a now-cast)
  - e.g. Malvezzi et al 2014, European cancer mortality predictions for the year 2014, *Annals of Oncology*
- **Medium-term:** funding allocation in the next 3 year budget period
  - e.g. NHS England, based on advice from the *Advisory Committee on Resource Allocation* (ACRA)
- **Longer-term:** fiscal planning–health and social care spend are growing parts of the national budgets
  - e.g. Office of Budget Responsibility, *Fiscal Responsibility Report 2012*, Annex B, Long-term pressures on health spending
  - e.g. Office of Budget Responsibility, *Fiscal Responsibility Report 2013*, Annex B, Long-term care projections

Results: non-interest spending

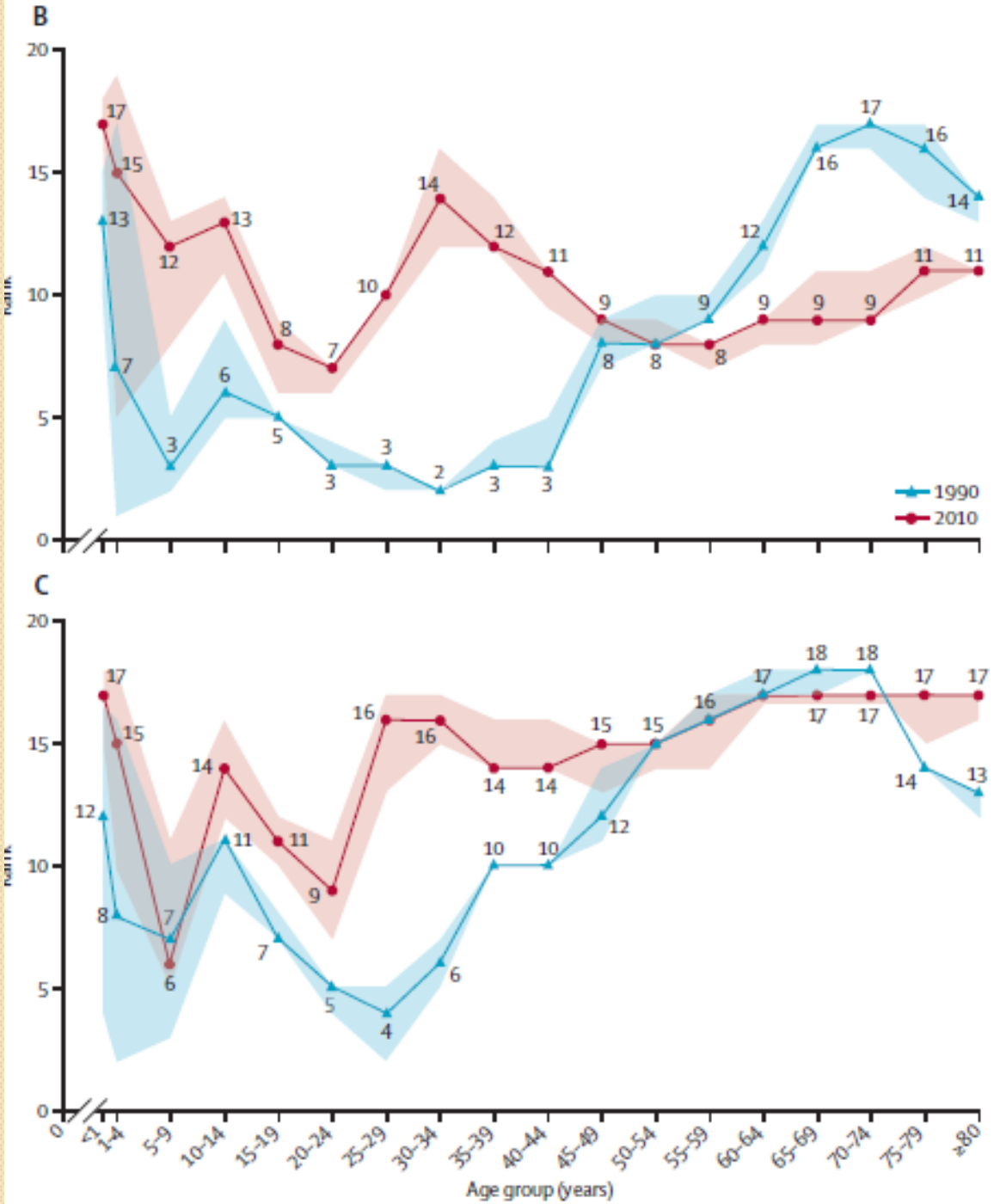
	Per cent of GDP							
	Estimate		FSR Projection					
	2011-12	2016-17	2021-22	2031-32	2041-42	2051-52	2060-61	2061-62
Health	8.1	6.8	7.1	7.7	8.3	8.7	9.0	9.1
Long-term care	1.3	1.1	1.2	1.5	1.7	1.9	2.0	2.0
Education	5.7	4.5	4.6	4.6	4.4	4.4	4.5	4.5
State pensions	5.7	5.6	5.3	6.1	7.0	7.3	8.2	8.3
Pensioner benefits	1.2	1.1	1.1	1.2	1.3	1.2	1.2	1.2
Public service pensions	2.1	2.2	2.0	1.7	1.5	1.3	1.3	1.3
Total age-related spending	**24.1**	**21.3**	**21.3**	**22.8**	**24.2**	**24.9**	**26.2**	**26.3**
Other social benefits	6.3	5.1	5.3	5.2	5.1	5.2	5.2	5.2
Other spending	12.2	9.2	9.2	9.2	9.2	9.3	9.3	9.3
Primary spending	**42.6**	**35.6**	**35.8**	**37.2**	**38.5**	**39.4**	**40.7**	**40.8**

Office for **Budget Responsibility**

Source: Slide 28, Presentation of the Fiscal Responsibility Report 2012, by Robert Chote, Chairman, Office for Budget Responsibility, 12 July 2012

For what populations are health/illness projections needed?

- **World countries** to plan international projects to reduce illness rates
  - e.g. Polio, HIV, Malaria, Traffic Accidents
- **National populations** to assess performance against comparators
  - e.g. Murray et al 2013, UK health performance: findings of the Global Burden of Disease study 2010
- **Sub-national areas** to allocate funding for health care from a national budget
  - e.g. NHS England allocates funding to Clinical Commissioning Groups (CCGs), Primary Care Area Teams (PCATs) and Local Authority Districts (LADs)



Example:
How does the UK compare?

Figure 1: Age-specific mortality in the UK Ranks among 15 EU members + 4 Others (AU,CA,US,NO)
B: Men, C: Women

Source:
Murray et al. (2013) UK health performance: findings of the Global Burden of Disease Study 2010, Lancet, http://dx.doi.org/10.1016/S0140-6736(13)60355-4

The UK ranks worsen up to ages 50-54. UK ranks poorly in the older ages but ranks for men have improved for ages 65-69 and 70-74

Which health/illness variables should we use?

- General health measures
  - Sourced from surveys to give as up to date a picture as possible
  - Sourced from censuses to give as spatially detailed a picture as possible
  - Should not be afraid to model a combination
  - Feeds into assessment of fitness to work longer, labour force and productivity projections
- Illness measures
  - Cause of death measures (vital statistics from ONS)
  - Reported incidence measures (GP diagnosis statistics – Care data from NHS??)
  - Treatment measures (Hospital Episode Statistics)
  - Feeds into interventions, actions to deal with short-term (flu) or long-term (tobacco-related) epidemics

What determinants should we use?

- Demographic
  - Age✓ Sex ✓ Ethnicity?
- Economic
  - Income ✓ Occupation? Industry? Social class?
- Human Capital
  - Education-years? Education-levels✓ Qualifications?
- Health Care Technology/Productivity
  - Home tests✓ Immunization✓ Telecare✓
- Health Care Policy
  - Total spending on health and social care
  - Distribution of funding across health types and health care areas
  - Public/Private, Central/Local, Treatment/Prevention
  - NICE (National Institute for Health and Care Excellence)
  - Drugs, Equipment, Salaries/Wages

How should we deal with uncertainty?

- Projections are about the future, which is **uncertain**
- Demographers have traditionally handled this through judging what is high and low around a baseline for each driver and producing **variant projections**
- Another way is by constructing **scenarios** that work out the consequences of particular **events** or **policies**
- Statistical theory and simulation is being increasing applied to demographic projections but, to date, only fertility and mortality have been handled effectively. **Migration** has been neglected
- Rather than a discrete set of projected populations, researchers are developing **probability distributions** of future populations

Qualitative linkage of trends/policies in mortality to create policy scenarios for EU member states and NUTS2 regions

Trend or Policy	Growing Social Europe	Expanding Market Europe	Limited Social Europe	Challenged Market Europe
Lifestyle: Smoking	Prevalence falls	Trend continues	Prevalence falls	Trends continue
Lifestyle: Diet/Obesity	No epidemic	No epidemic	Epidemic	Epidemic
Lifestyle: Alcohol	Prevalence falls	Trend continues	Prevalence falls	Trends continue
Medical Advances	Continue	Continue	Slow	Slow
National Health Inequalities	Reduced	Persistent	Reduced	Persistent
Regional Health Inequalities	Reduced	Persistent	Reduced	Persistent

Source: ESPON Programme, DEMIFER Project, Annex 6

Scenarios used in GBD 2002 Projections

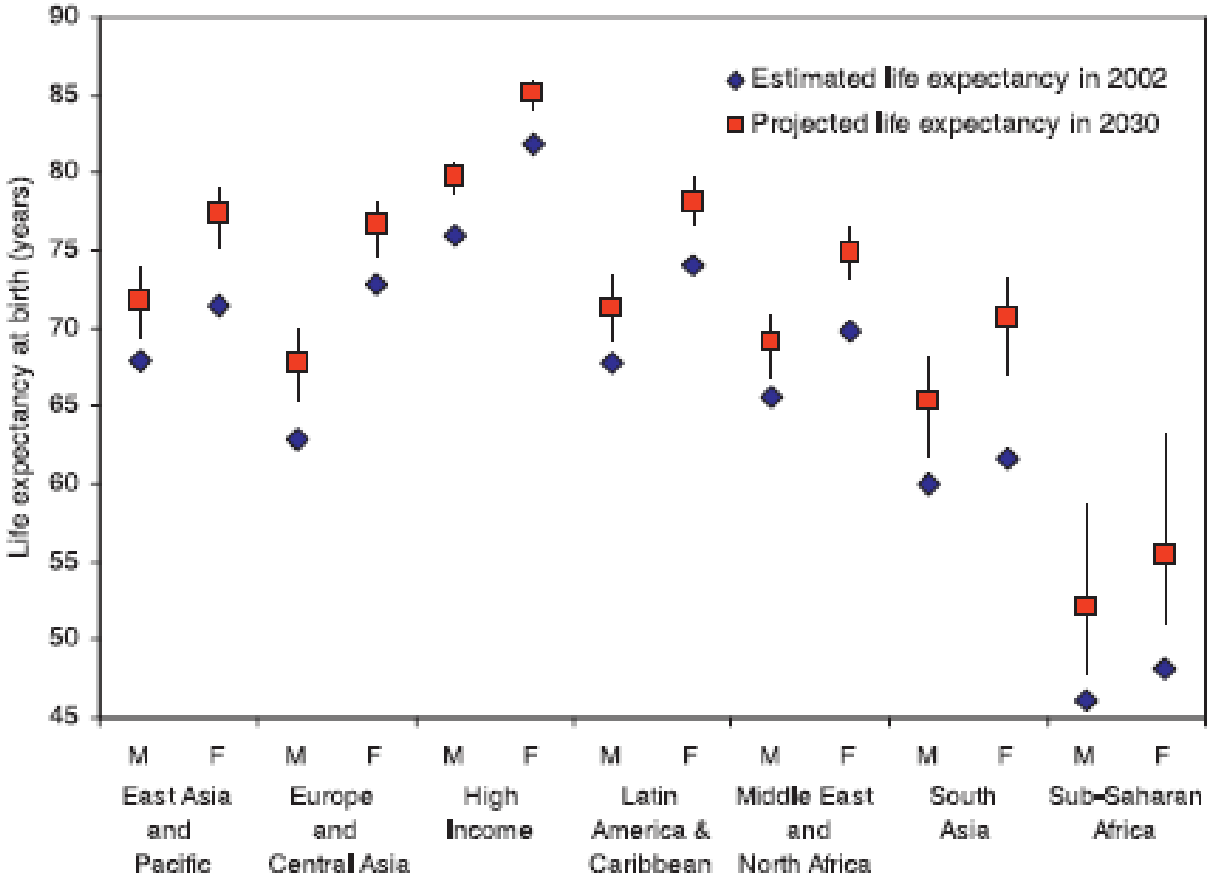


Figure 1. Projected Life Expectancy at Birth in 2030 by World Bank Region and Sex: Baseline, Optimistic, and Pessimistic Scenarios Compared with 2002 Estimates

doi: 10.1371/journal.pmed.0030442.g001

Source: Mathers & Loncar 2006

Methods: Northern England Example

- **Features**
  - Used existing projection methodology (ETHPOP) for LADs in England (Rees et al 2013): bi-regional model. Extracted 87 LADs from national 352 LADs and 3 Home Countries
  - Estimated LAD prevalence rates by age, sex and ethnicity for health and illness for 2001
  - Applied rates to projected populations from a Trend projection aligned to NPP2008 and a UPTAP-ER projection with same assumptions but different model for international migration
- **Issues**
  - Is ethnic disaggregation needed? (Referee's comment)
  - How can the health/illness prevalence rates be projected? (Harmonizing national surveys and local censuses)
  - How can more explicit connections to the drivers be introduced? (E.g. changing education levels – comment by Wolfgang Lutz)
  - How can we make outcomes a function of funding allocations? (Rees 2013b, Response to ONS Consultation on the Census)

Projected population with limiting long-term illness, Northern England, 2011-2036

Local Enterprise Partnership	TREND-EF Projection			UPTAP-ER Projection		
	LLTI Population (1000s)			LLTI Population (1000s)		
	2011	2036	% Change	2011	2036	% Change
Leeds City Region	624	839	+34%	622	808	+30%
Tees Valley	139	166	+20%	139	162	+17%
Northern England	3268	4163	+25%	3251	4007	+22%

These projections demonstrate the impacts of population ageing with constant limiting long-term illness prevalence from 2001 Census.

Source: Rees et al 2011

Projected changes in people with dementia, heart disease or stroke, 2011-2036, Northern England

Local Enterprise Partnership	Dementia			Heart Disease			Stroke		
	Population (1000s)			Population (1000s)			Population (1000s)		
	2011	2036	%△	2011	2036	%△	2011	2036	%△
Leeds City Region	38	73	+92%	37	53	44%	16.4	23.8	+45%
North Yorkshire	8	14	+76%	8	11	+34%	3.5	4.7	+36%
Northern England	212	387	+83%	201	273	+36%	92	126	+37%

These projections show the impact of population ageing on persons with dementia, heart disease and stroke between 2011 and 2036.
In Northern England the numbers with Dementia increase by 83%, with heart disease by 36% and with stroke by 37%, based on the lower population scenario (UPTAP-ER).
Source: Buckner et al 2011

Table 7 Trended LLSI prevalence rates (%), persons, UK

Ages	2010	2020	2035	2050
0–4	2.8	1.9	1.2	0.8
5–15	5.6	3.7	2.1	1.2
16–44	10.8	10.1	9.3	8.6
45–64	23.2	19.6	15.1	11.7
65–74	35.1	32.2	28.3	25.0
75+	47.1	47.4	48.0	48.7
All ages	17.8	16.6	14.9	13.4

Computed from GHS and GLS Surveys, ONS (2012b) using 2000–2010 Exponential Regression Intercept and Slope and 2005–2010 Intercept

Table 8 Persons with Limiting Long Standing Illness (LLSI) using constant and trended prevalence rates, UK

	Constant LLSI rates model				Trended LSSI rates model			Trended model as % of constant		
Ages	2010	2020	2035	2050	2020	2035	2050	2020	2035	2050
0–4	107	115	110	120	78	46	35	68	42	29
5–15	399	425	469	467	283	178	105	67	38	22
16–44	2761	2765	2899	3016	2593	2488	2393	94	86	79
45–64	3711	3954	3905	4145	3330	2542	2087	84	65	50
65–74	1892	2290	2738	2536	2101	2213	1807	92	81	71
75+	2284	2646	3880	5206	2662	3950	5382	101	102	103
All ages	11153	12195	14002	15491	11047	11417	11809	91	82	76

Persons in 1000s. Percentages are computed by dividing trended rate projections by constant rate projections

Figuring out trends

What if favourable trends for 2000-2010 continued?

Source:
Rees et al 2013

Methods: Sanderson and Scherbov model

- **Features**
  - Cohort-component models with disability prevalence rates from EU-SILC for 10 advanced countries
  - Focusses on Prospective Old Age Dependency Ratio, which defines old as ages at which there are 15 years to death
  - Finds Adult Disability Dependency Ratios under this definition do not change much to 2045-50
- **Issues**
  - Some countries now adjusting state pension systems to increasing longevity (e.g. Netherlands, Sweden, UK) but others are backsliding (e.g. Germany, France)
  - The private sector has largely abandoned defined benefit schemes pushing people to work longer
  - The method for projecting disability prevalence rates is to link the shifts to mortality decline. As mortality declines so does disability. This is not what HE researchers have found. HE can increase faster or slower than LE depending on country, period and policy (see Salomon et al 2012, GBD2010 study).

Methods: Mathers and Lancar 2006

- **Features**
  - Builds on GBD 1990 projection by Murray and Lopez 1996
  - Use cause of death information, taking a disease approach
  - Uses UN country projections for the fertility and migration assumptions but makes the mortality projections the sum of the cause-specific projections
  - Using an extensive time series (1950-2000) for WHO countries builds socio-economic models for projecting broad cause-broad age specific mortality rates
  - Regression equations of the form:
    - $\ln M_{a,k,i} = C_{a,k,i} + ß_1 \ln Y + ß_2 \ln HC + ß_3 (\ln Y)^2 + ß_4 T + ß_5 \ln SI$
      - where $M_{a,k,i}$ is the mortality rate for age group a, sex k and cause i
      - $C_{a,k,i}$ = constant, Y = GDP per capita, HC = human capital, T = time, SI = smoking impact
  - Adjustments for some specific diseases e.g. HIV/AIDS and groups of countries e.g. tobacco caused diseases
- **Issues**
  - Updating to GBD2010 study with trends to 2010 (I guess in progress)
  - Acknowledges uncertainties and deals with them via optimistic and pessimistic scenarios

Discussion

- This review should help in the design of a model for projecting health/illness for UK sub-national area populations
- The model should include detailed analysis of trends (as in Mathers and Loncar)
- The model should look carefully at the trends in mortality and in disease separately (as suggested by the critique of Sanderson and Scherbov)
- The model should include as one determinant NHS funding allocations and explicit tests of the hypotheses in Rees (2013b)
- These were some of the intentions of a Newcastle led Centre for Health Expectancies and Futures (CHEF) bid to ESRC which failed in February at the last hurdle
- One of the panel criticisms was a lack of sufficient theory: this review responds to that comment

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