Family Practice, 2014, Vol. 31, No. 5, 557–563
doi:10.1093/fampra/cmu035
Advance Access publication 1 July 2014

The burden of common chronic disease on health-related quality of life in an elderly community-dwelling population in the UK

Laura Parker[a], Grace M Moran[b], Lesley M Roberts[b], Melanie Calvert[b] and Deborah McCahon[b,*]

[a]University Hospitals Coventry and Warwickshire, Clifford Bridge Road, Walsgrave, Coventry CV2 2DX and [b]Primary Care Clinical Sciences, School of Health and Population Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK.

*Correspondence to Deborah McCahon, Primary Care Clinical Sciences, School of Health and Population Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK; E-mail: d.mccahon@bham.ac.uk

Received February 7 2014; revised May 20 2014; Accepted May 21 2014.

Abstract

Background. Given the high prevalence of chronic conditions and multimorbidity in the elderly, there is a need to determine which chronic conditions have the greatest impact on health-related quality of life (HRQL) and identify where additional intervention may be required.

Objective. To explore the impact of a range of common chronic conditions on HRQL in a community-based population aged 65 years or more in the UK.

Methods. Secondary analysis of data derived from a large ($n = 5849$) cross-sectional study. HRQL was assessed using the EuroQoL EQ-5D. Multivariable models were used to estimate the relative effect of 15 individual common chronic conditions and combinations of these conditions on HRQL.

Results. Mean age of participants was 74.6 years, 49.2% were male. The mean EQ-5D index score was 0.78 (standard deviation 0.2), range –0.43 to 1.00. Overall, 53% ($n = 3078$) of the cohort reported problems with pain, 39% ($n = 2273$) with mobility and 9% ($n = 529$) with self-care. Multivariate modelling demonstrated that impaired HRQL was significantly associated with 13 of the 15 common chronic conditions studied. Clinically meaningful reductions in EQ-5D index scores were observed for osteoarthritis (–0.081, $P = 0.0006$), neurological disease (–0.172, $P < 0.0001$) and depression (–0.269, $P < 0.001$).

Conclusions. This study quantifies the relative impact of 13 common chronic conditions on HRQL in a UK-based community-dwelling ageing population. Findings indicate that osteoarthritis, depression and neurological disease have a strong clinically important negative effect on HRQL. These findings may help clinical decision making and priority setting for management of individuals with multimorbidity.

Key words: Ageing, health-related quality of life, multimorbidity, primary care.

Introduction

By 2034, it is estimated that 23% of the UK population will be aged 65 and over (1). Currently, over 50% of individuals aged 65 and older have one or more chronic conditions and as such, are at increased risk of developing additional chronic disease (2,3). Furthermore, individuals with co-morbidity (the occurrence of more than one unrelated chronic condition) or multimorbidity (the coexistence or two or more chronic conditions) have more complex health care needs than those with a single

chronic disease and are more likely to have poorer quality of life and greater disability and mortality (4,5). The prevention and management of chronic disease and reduction of health inequalities in this increasing population pose a continuing challenge to policymakers particularly given the structure of the UK health system and guidelines, which have a single disease focus (6). In recent years, UK public health service delivery for older people has been reformed to promote active ageing (7), to sustain well-being and independence and improve health-related quality of life (HRQL) in this patient group (8).

Although there is much research evaluating HRQL of patients with a single, chronic condition, either from cohort studies or clinical trials, evidence of the impact of chronic conditions and specific multimorbidity in an ageing community-dwelling population is limited. A 1993 survey by Kind *et al.* (9) collected normative EQ-5D data from the UK general population aged 18 years and over and demonstrated significant differences in HRQL between subgroups of the population with respect to age, gender, social class, marital and housing status. This study, however, did not explore the impact of morbidity on HRQL in this population. Furthermore, the management of chronic disease in the UK has improved since these data were collected (10,11). More recently, two studies have demonstrated the impact of multimorbidity on HRQL (12,13). Heyworth *et al.* (10) demonstrated a significant and consistent decline in health status with increasing number of chronic conditions. Similarly, an evaluation of HRQL in a large (n = 5000) community-based South Asian and African-Caribbean population in the UK demonstrated a significant reduction in HRQL in the presence of a range of medical conditions and as number of co-morbidities increased (12). Although patient HRQL has been shown to deteriorate with increased number of morbidities, research that assesses the impact of multiple chronic diseases on health status in an older sample of the UK general population is limited (3,9,13). Given the high prevalence of chronic conditions and multimorbidity in the elderly population (14), there is a need to determine which chronic conditions have the greatest impact on HRQL and identify where additional intervention may be required. The aim of this study, therefore, was to further explore the impact of individual common chronic conditions on HRQL in a contemporary cohort of elderly community-dwelling individuals in the West Midlands region.

Methods

Study population

We used individual patient data collected in the Birmingham Elderly Thyroid Study (BETS) (15). The design and principal results of the BETS have been previously published (15). Ethical approval was granted for the BETS by the Scottish Multi-Centre Research Ethic Committee and as appropriate by local research ethic committees (reference WH/MREC/01/0/24). Ethical approval for secondary analyses of these data was granted by the University of Birmingham Bachelor of Medical Science Population Sciences and Humanities and internal ethics review committee on 08 February 2011. In brief, the primary aim of BETS was to estimate the prevalence of subclinical thyroid dysfunction in the population aged 65 years or more. Twenty primary care practices in the West Midlands, UK, were recruited during 2002. From these, all patients aged 65 and over were invited to participate by letter, unless their general practitioner (GP) deemed it inappropriate to approach them for reasons such as recent bereavement, reduced capacity due to dementia or if they had previously received anti-thyroid therapy. Overall, 85% of eligible patients responded and 46% of respondents were willing to attend a screening appointment at which they were given questionnaires for self-completion. The level of co-morbidity among the screened population was comparable with the general population, e.g. diabetes 11.5% and 7.3% in males and females aged 64–75 years in the screened population, compared with 8.5% and 6.4% in males and female in the general population; coronary heart disease: 17.2% and 5.6% in males and females in the screened population aged 65–74 years, compared with 18.4% and 11.2% in males and females, respectively, in the general population.

HRQL assessment using the EQ-5D

All BETS participants were asked to rate the severity of problems they experienced in 5 areas: mobility, self-care, usual activities, pain, and anxiety or depression using the EQ-5D questionnaire. The participant provided a score (1: no problems; 2: moderate problems; 3: severe problems) for each parameter, which was then translated to an index score. The index score was calculated based on the regression model developed by Dolan *et al.* (16). The EQ-5D index scores reflect 243 possible health states plus two additional states (unconscious and dead). An index score of 1 reflects best possible HRQL (i.e. a score of 1 in each of the five parameters) and an index score of <1 is indicative of impaired HRQL.

At the initial BETS screening appointment participants also completed the Hospital Anxiety and Depression Scale (HADS) and self-reported smoking status and presence of all major current medical diagnoses. Routine general practice records were reviewed to verify current diagnoses. Data were stored on the BETS database.

For the purposes of this study, the following data were extracted from the BETS database: EQ-5D descriptive profile scores and index score; age at the start of BETS; gender; smoking status and socio-economic status based upon the Index of Multiple Deprivation (IMD) 2004. Presence of a medical history of each of the following conditions was also extracted: cardiac

arrhythmia, including atrial fibrillation; cancer; cerebrovascular disease, including stroke and transient ischaemic attack (TIA); dementia; diabetes; heart failure and valvular disease; hypertension; ischaemic coronary heart disease, including ischaemic heart disease, coronary heart disease and angina; peripheral vascular disease, including peripheral venous and arterial disease; pulmonary disease, including chronic obstructive pulmonary disease and asthma; renal disease (grade 3 or grade 4 chronic kidney failure); rheumatoid arthritis; osteoarthritis and neurological disease, e.g. Parkinson's.

Presence of depression was based on a HADS score of >7, determined at screening upon entry to BETS. The HADS has been frequently used in both the clinical and research setting, and both the questionnaire itself, and the use of 7 as a cut-off for depression, has been validated (17). Those with missing HADS scores were assumed negative for the condition (n = 15).

The IMD 2004 was used as a proxy measure of socio-economic deprivation for this population. IMD 2004 is a measure of deprivation at a small area level comprised of seven domains (barriers to housing and services, crime, education skills and training, employment, health deprivation, income and living environment) (18).

Ethnicity data were not collected during BETS. Geocoding, an indirect method for estimation of ethnicity of the study participants, was therefore used. Geocoding has been shown to produce reasonable estimates for ethnicity when direct data on major ethnic group are not available (19). This technique involved using the participant's postcode to identify the area where they lived and linking this information to UK census data relating to that geographical area. Ethnicity was then inferred based upon the predominant ethnicity of persons living within that area.

Statistical analyses

Analyses were performed using SAS V9.2 (SAS Institute, Cary, NC). Descriptive data were expressed as proportions of the cohort, medians with interquartile ranges (IQRs) or means with standard deviations. Prior to any multivariable analysis, non-linear functional forms were considered for all continuous variables, including log transformation and restricted cubic splines. More complex forms were only included in the final backwards selection if they improved model fit as judged by Akaike's Information Criterion (20). The relationship between EQ-5D score and the candidate explanatory variables was assessed using backwards stepwise selection with a 0.05 level of significance for inclusion. The final model included general practice as a random effect to account for clustering at the practice level (21). Model estimates were used to predict EQ-5D scores for patients with differing demographics and morbidity.

Results

Analysis was performed on data from 5849 subjects, having excluded 32 participants (0.5%) with missing EQ-5D data prior to analysis. The characteristics of participants are shown in Table 1. The mean age of participants was 73.6 years (standard deviation [SD] 5.6) and 2879 (49.2%) were male. A total of 2081 (35.7%) participants had one morbidity and 1519 (25.9%)

Table 1. Characteristics of the study cohort

Characteristic	n = 5849 (%)
Gender	
Male	2879 (49.2)
Female	2970 (50.8)
Age	
60–69	1719 (29.4)
70–79	3125 (53.4)
≥80	1005 (17.2)
Ethnicity (inferred by geocoding)	
White	5727 (97.9)
Asian	110 (1.9)
Black	12 (0.2)
Deprivation quintile[a]	
Class I (34.23–86.36)	1010 (17.3)
Class II (21.17–34.22)	1225 (20.9)
Class III (13.73–21.16)	1414 (24.2)
Class IV (8.36–13.72)	942 (16.1)
Class V (0.59–8.35)	1258 (21.5)
Smoker	
Yes	582 (10.0)
No	5267 (90.0)
Morbidities	
Cancer (any)	310 (5.3)
Cardiovascular	
Arrhythmia (including atrial fibrillation)	344 (5.9)
Stroke or TIA	86 (1.5)
Heart failure	184 (3.2)
Hypertension	2308 (39.5)
Ischaemic coronary heart disease	457 (7.8)
Perivascular disease	53 (0.9)
Neurological	
Dementia	18 (0.3)
Neurological disease	83 (1.4)
Musculoskeletal	
Osteoarthritis	84 (1.4)
Rheumatoid arthritis	138 (2.4)
Endocrine	
Diabetes	526 (9.0)
Other	
Depression	527 (9.0)
Renal disease	49 (0.8)
Pulmonary disease	615 (10.5)
Median number of morbidities	1 (IQR 2: range 0–3)

[a]West Midland reference values for IMD 2004.

had two or more morbidities. The median number of morbidities was 1 (IQR 2). Each socio-economic group was represented within the study cohort. Geocoding was used to infer ethnic group and resulted in 97.9% of the study population being categorized as White, 1.9% Asian and 0.2% Black. The proportion of the study population categorized to each of the major ethnic groups was compared with ethnicity data for England derived from the 2011 census. Results show that a smaller proportion of the population of England are White (92.2%) compared with the study population and a larger proportion of the population of England are Asian (3.9%) or Black (2%) compared with the study population (22).

The proportions of individuals reporting problems in each EQ-5D dimensions are shown in Table 2. This demonstrates that the most commonly reported problem is pain, with over half of the sample population complaining of 'any' problems within this parameter. Over a third of participants reported problems with mobility, whereas just 9% reported any problems with self-care. The mean EQ-5D index score for the study population was 0.78 (SD 0.2), range −0.43 to 1.0. Problems with pain were reported by 56.2% of females aged 65–69, 60% of females aged 70–79 and 65.6% of females aged 80 years or more (Table 3).

Patient characteristics associated with quality of life

Multivariable regression demonstrated that higher EQ-5D index scores are significantly associated with male gender and the absence of a medical history of morbidities. Lower EQ-5D index scores were significantly associated with smoking, increased age and increased deprivation (Table 4). Increased deprivation was associated with reduced HRQL with an estimated reduction of 0.002 per unit increase in deprivation score ($P < 0.001$).

The presence of 13 of the 15 common chronic conditions studied was also significantly associated with reduced HRQL. Compared with individuals not having osteoarthritis, having osteoarthritis was associated with a statistically significant reduction in EQ-5D index score (−0.08; $P = 0.006$).

The reduction in EQ-5D index score in patients with a history of depression was estimated at a decrease of 0.27 units ($P < 0.001$) on a scale where a minimally clinically important

Table 2. Percentage of respondents reporting problems in each EQ-5D dimension

EQ-5D dimension	No problem, *n* (%)	Moderate problems, *n* (%)	Severe problems, *n* (%)
Mobility	3576 (60.98)	2258 (38.60)	15 (0.35)
Self-care	5319 (90.93)	503 (8.60)	27 (0.46)
Usual activities	4320 (78.85)	1368 (23.40)	161 (2.75)
Pain	2771 (47.38)	2761 (47.20)	317 (5.42)
Anxiety	4548 (77.75)	1243 (21.25)	58 (0.99)

Table 3. Proportions of respondents reporting any problems in each EQ-5D dimension by age and gender

Age group (years)	65–69	70–79	>80
	n (%)	*n* (%)	*n* (%)
EQ-5D dimension			
Mobility			
All	520 (30.3)	1194 (38.2)	559 (55.6)
Male	238 (28.3)	548 (34.3)	217 (49.2)
Female	282 (32.8)	646 (42.3)	342 (60.6)
Self-care			
All	123 (7.2)	263 (8.4)	144 (14.3)
Male	52 (6.28)	116 (7.3)	57 (12.9)
Female	71 (8.1)	147 (9.6)	87 (15.4)
Usual activities			
All	367 (21.4)	773 (24.7)	389 (38.7)
Male	147 (17.5)	307 (19.2)	139 (31.5)
Female	220 (25.0)	466 (30.5)	250 (44.3)
Pain			
All	847 (49.3)	1637 (52.4)	594 (59.1)
Male	353 (42.2)	720 (45.01)	224 (50.8)
Female	494 (56.2)	917 (60.1)	370 (65.6)
Anxiety			
All	369 (21.57)	683 (21.8)	249 (24.8)
Male	135 (16.1)	250 (15.7)	78 (17.7)
Female	234 (26.6)	433 (28.4)	171 (30.3)

Table 4. Results of regression analysis examining the association between candidate variables and EQ-5D index score

	Estimate[a]	Lower CI[b]	Upper CI[b]	*P* value
Intercept	2.399	2.082	2.718	<0.0001
Male	0.063	0.052	0.074	<0.0001
Log age	−0.358	−0.432	−0.284	<0.0001
Smoker	−0.021	−0.040	−0.003	0.0247
IMD score 2004[c]	−0.002	−0.002	−0.002	<0.0001
Medical history of				
Hypertension	−0.020	−0.031	−0.008	0.008
Heart failure	−0.035	−0.067	−0.004	0.029
Cancer	−0.037	−0.0062	−0.012	0.0032
Stroke or TIA	−0.046	−0.092	−0.001	0.0458
Pulmonary disease	−0.054	−0.072	−0.036	<0.0001
Rheumatoid arthritis	−0.059	−0.095	−0.023	0.0015
Diabetes	−0.061	−0.080	−0.041	<0.0001
Ischaemic coronary heart disease	−0.061	−0.081	−0.040	<0.0001
Renal disease	−0.064	−0.124	−0.00	0.038
Perivascular disease	−0.075	−0.133	−0.017	0.0115
Osteoarthritis	−0.081	−0.128	−0.035	0.0006
Neurological disease	−0.172	−0.218	−0.125	<0.0001
Depression	−0.269	−0.289	−0.250	<0.0001

[a]Estimate of absolute risk.
[b]95% confidence intervals.
[c]Untransformed variable.

difference has been estimated at 0.07 (23). Compared with individuals not having neurological disease, having neurological disease was associated with lower EQ-5D index scores, with an average reduction of 0.17 ($P < 0.0001$).

Candidate variables that were eliminated during backwards stepwise selection (i.e. were not statistically significant) were as follows: ethnicity, total number of morbidities and a medical history of arrhythmia or dementia. The level of variance in EQ-5D index score explained by this model was 22%.

Estimated health utility

The model estimates reported in Table 4 were used to predict EQ-5D scores for patients with differing demographics and morbidity. For example, the EQ-5D index score for a 78-year-old, female, smoker, resident in a deprived area with depression, osteoarthritis and pulmonary disease was estimated as 0.35. Predicted EQ-5D index scores the most prevalent conditions in the study population and for conditions that were found to be associated with clinically meaningful reductions in HRQL are presented (Table 5).

Discussion

Summary of main findings

This study demonstrates the burden of common chronic conditions on HRQL in an ageing UK-based community-dwelling population. Overall, 13 of the 15 individual common chronic conditions studied were strongly associated with reduced HRQL in this patient population after adjustment for age, gender, ethnicity, socio-economic status and presence of the other chronic conditions. Furthermore, results suggest that in this patient group, osteoarthritis, neurological disease and depression have a clinically significant negative impact on HRQL (as defined by a reduction in EQ-5D index score of 0.07 or more units, compared with respondents without each of these conditions).

This study identified common chronic conditions that have a strong statistically significant and clinically meaningful impact on HRQL in a UK-based elderly community-dwelling individuals. Furthermore, the multivariate model enabled estimation of the likely impact of different combinations of common chronic conditions on HRQL in this population. Given that older people have frequent contact with primary-care-based services, these findings are particularly relevant to GPs. A better understanding of the relative burden of these common conditions can help GPs focus on those conditions that have the greatest impact on HRQL and inform priority setting when managing individuals with multimorbidity. The quantification of the relative impact of these common conditions is also of significant value in informing policy and guideline development. Study findings highlight areas where intervention may have the greatest opportunity to demonstrate cost-effectiveness through increased HRQL. Impaired HRQL in patients with osteoarthritis has been shown to be predictive of increased health care resource use (24). At this time, the management of osteoarthritis does not generate additional reward for general practices under the UK Quality

Table 5. Estimated utility scores for patients of different age and gender accounting for deprivation and co-morbidity

Multimorbidities	Gender	Age (years)	Deprivation index (IMD 2004[a])	Smoker	EQ-5D score[b]
0	M	69	11.0	N	0.93
	F	69	11.0	N	0.86
	M	78	31.1	Y	0.82
	F	78	31.1	Y	0.76
Hypertension, ischaemic coronary heart disease, diabetes	M	69	11.0	N	0.79
	F	69	11.0	N	0.72
	M	78	31.1	Y	0.68
	F	78	31.1	Y	0.62
Neurological disease	M	69	11.0	N	0.75
	F	69	11.0	N	0.69
	M	78	31.1	Y	0.65
	F	78	31.1	Y	0.58
Depression, osteoarthritis, pulmonary disease	M	69	11.0	N	0.52
	F	69	11.0	N	0.46
	M	78	31.1	Y	0.42
	F	78	31.1	Y	0.35

[a]The IMD 2004 is a measure of deprivation at a small area level comprised of seven domains (barriers to housing and services, crime, education skills and training, employment, health deprivation, income and living environment). Higher scores reflect higher levels of deprivation.

[b]EQ-5D scores provide a value for HRQL, with a score of 1.00 indicative of full health and scores <1 reflecting impaired HRQL. EQ-5D scores were estimated based on the regression coefficients provided in Table 4 using IQR estimates for IMD and age.

Outcomes Framework, a reward and incentive programme with performance indicators against which general practice levels of achievement are assessed (25,26). Considering the prevalence of osteoarthritis in the UK and the detrimental impact of osteoarthritis on HRQL demonstrated in this study (reduction of −0.081, $P = 0.0006$), it may be appropriate to consider the inclusion of a specific management plan for osteoarthritis in the Quality of Outcome Framework.

In this study, depression and neurological disease were associated with statistically significant reductions in EQ-5D index score of a magnitude, which is considered to be clinically important. Similarly, depression and Parkinson's disease were shown to have a strong negative impact on HRQL in multimorbid elderly patients in Germany (27).

In the presence of co-existing conditions, depression is often considered as co-morbidity to an index disease and as such may be treated with secondary importance. It may be more appropriate to consider depression using the concept of multimorbidity where two or more conditions coexist but one is not considered more central. The current UK health system is based around single conditions. However, it is increasingly being acknowledged that there is a need for a health system and guidelines, which take into consideration multimorbidity (4). Findings from a systematic review of interventions for multimorbidity suggested that interventions were more effective if they were aimed at specific combinations of common conditions (5).

Prevalence of multimorbidity increases with age, with the majority of people over 65 years having chronic multimorbidites (14). Notably in this study, total number of chronic conditions was not associated with reduced HRQL. This is in contrast to the findings of other studies, which have demonstrated an association between increasing number of chronic conditions and EQ-5D index scores (10,12,28). The prediction model did, however, enable exploration of different combinations of common chronic conditions to identify which have the greatest impact on HRQL in community-based individuals with multimorbidity while controlling for age, gender, socioeconomic status and ethnicity. In addition to enabling clinicians to set priorities for management of patient's with multimorbidity, this prediction model could also be used to inform research concerning prognosis prediction based upon HRQL. This in turn could aid clinical decision making as well as allocation of resources for research (29).

Strengths and limitations

The sample size ($n = 5849$) used was large when compared with other similar studies and has thus provided more accurate results, reflected in the small confidence intervals for regression model estimates. Furthermore, data reported are consistent with utility scores reported by Kind *et al.* (9).

This study was a secondary analysis of pre-collected data and has thus been limited by the aims and methods of the previous researchers. The variables used were selected and measured by the original BETS research team. The final model explains only 22% of the residual variance suggesting that there are other factors which influence HRQL that have not been captured in this study. Furthermore, data were collected from just one point in time, and thus only association, not causality, can be inferred from the results. Therefore, it is unclear whether significantly associated variables are causing a poorer HRQL, or whether a poor HRQL leads the individual to partake in certain behaviours.

Although the EQ-5D has been widely used in health surveys as a tool for measurement of HRQL, the EQ-5D index score can be criticized for not evaluating an individual's overall perceived HRQL. The EQ-5D is multidimensional and allows measurement of an individual's emotional, social and physical well-being and as such fulfils the accepted definition of HRQL provided by Revicki *et al.* (30). As a generic measure of HRQL, the EQ-5D allows comparison of HRQL across different conditions, an essential requirement for this study. Another advantage of the EQ-5D index is that it can be used to calculate quality-adjusted life years for use within cost utility analysis and as such is frequently used by the Institute for Health and Clinical Excellence for development of health care guidelines (31). Lastly, although the findings suggest that ethnicity is not associated with HRQL, geocoding may have impacted on the model findings. Findings related to ethnicity, therefore, should be interpreted with caution.

Conclusions

This study quantifies the relative impact of individual common chronic conditions on HRQL in a community-dwelling, ageing population. Findings suggest that in this patient group, osteoarthritis, neurological disease and depression are strongly associated with clinically important reductions in HRQL. Focus of health care and services on conditions that have the greatest impact on HRQL may improve outcomes in patients with multimorbidity.

Acknowledgements

The authors would like to thank the patients and GPs who participated in BETS and also the general practice staff who facilitated collection of data. The authors would also like to acknowledge the following co-investigators for BETS: Prof. James Parle, Prof. Jayne Franklyn, Prof. Michael Gammage, Dr Sayeed Haque, Mr Roger Holder, Dr Helen Pattison, Mrs Andrea Roalfe and Prof. Sue Wilson.

Declaration

Funding: The original Birmingham Elderly Thyroid study (BETs) was funded by the Health Care Foundation. (http://www.health.org.uk/).

Ethical approval: Scottish Multi-Centre Research Ethic Committee, local research ethic committees (reference WH/MREC/01/0/24), University of Birmingham Bachelor of Medical Science Population Sciences and Humanities and internal ethics review committee.
Conflict of interest: none. All authors, with the exception of LP, are employed by the University of Birmingham.

References

1. ONS Aging. *Office for National Statistics, UK Statistics Authority*. http://www.statistics.gov.uk/hub/population/ageing/older-people (accessed June 2014).
2. Calvert MJ, Freemantle N, Cleland JG. The impact of chronic heart failure on health-related quality of life data acquired in the baseline phase of the CARE-HF study. *Eur J Heart Fail* 2005; **7**: 243–51.
3. Fortin M, Bravo G, Hudon C, Vanasse A, Lapointe L. Prevalence of multimorbidity among adults seen in family practice. *Ann Fam Med* 2005; **3**: 223–8.
4. Boyde CM, Fortin M. Future of multimorbidity research: how should understanding of multimorbidity inform health system design? *Public Health Rev* 2010; **32**: 451.
5. Smith SM, Soubhi H, Fortin M, Hudon C, O'Dowd T. Managing patients with multimorbidity: systematic review of interventions in primary care and community settings. *Br Med J* 2012; **345**: e5205.
6. Healthy Lives Healthy People. *Our Strategy for Public Health in England*. *GOV.UK* http://www.official-documents.gov.uk/document/cm79/7985/7985.pdf (accessed June 2014).
7. WHO. What is Active Ageing? http://www.who.int/ageing/active_ageing/en/index.html (accessed June 2014).
8. Department of Health. National Service Framework for Older People. GOV.UK http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4003066 (accessed June 2014).
9. Kind P, Dolan P, Gudex C, Williams A. Variations in population health status: results from a United Kingdom national questionnaire survey. *Br Med J* 1998; **316**: 736–41.
10. Heyworth IT, Hazell ML, Linehan MF, Frank TL. How do common chronic conditions affect health-related quality of life? *Br J Gen Pract* 2009; **59**: e353–8.
11. Murray J, Saxena S, Millett C *et al*. Reductions in risk factors for secondary prevention of coronary heart disease by ethnic group in south-west London: 10-year longitudinal study (1998-2007). *Fam Pract* 2010; **27**: 430–8.
12. Calvert M, Duffy H, Freemantle N *et al*. Population health status of South Asian and African-Caribbean communities in the United Kingdom. *BMC Health Serv Res* 2012; **12**: 101.
13. Calvert M, Shankar A, McManus RJ, Lester H, Freemantle N. Effect of the quality and outcomes framework on diabetes care in the United Kingdom: retrospective cohort study. *Br Med J* 2009; **338**: b1870.
14. Barnett K, Mercer SW, Norbury M *et al*. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012; **380**: 37–43.
15. Wilson S, Parle JV, Roberts LM *et al*. Prevalence of subclinical thyroid dysfunction and its relation to socioeconomic deprivation in the elderly: a community-based cross-sectional survey. *J Clin Endocrinol Metab* 2006; **91**: 4809–16.
16. Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; **35**: 1095–108.
17. Bjelland I, Dahl AA, Haug TT, Neckelmann D. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. *J Psychosom Res* 2002; **52**: 69–77.
18. Watson V, Sutton M, Dibben C, Ryan M. Deriving weights for the index of multiple deprivation based on societal preferences: the application of a discrete choice experiment. OPHI working paper. 2008.
19. Fiscella K, Fremont AM. Use of geocoding and surname analysis to estimate race and ethnicity. *Health Serv Res* 2006; **41**: 1482–500.
20. Bozdogan H. Model selection and Akaike's Information Criterion (AIC): the general theory and its analytical extensions. *Psychometrika* 1987; **52**: 345–70.
21. McCulloch CE, Searle SR. *Generalized, Linear, and Mixed Models*. New York, NY: John Wiley, 2001.
22. Census Data. *Office for National Statistics, UK statistics Authority*. http://www.ons.gov.uk/ons/guide-method/census/2011/census-data/index.html (accessed June 2014).
23. Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res* 2005; **14**: 1523–32.
24. Ethgen O, Kahler KH, Kong SX, Reginster JY, Wolfe F. The effect of health related quality of life on reported use of health care resources in patients with osteoarthritis and rheumatoid arthritis: a longitudinal analysis. *J Rheumatol* 2002; **29**: 1147–55.
25. Quality and Outcomes Framework Guidance for GMS Contract 2011/12. NHS employers.org. http://www.nhsemployers.org/Aboutus/Publications/Pages/QOF_guidance_GMS_contract_2011_12.aspx (accessed June 2014).
26. National Institute for Clinical Excellence. About the Quality and Outcomes Framework. http://www.nice.org.uk/aboutnice/qof/qof.jsp (accessed June 2014).
27. Brettschneider C, Leicht H, Bickel H *et al*. Relative impact of multimorbid chronic conditions on health-related quality of life–results from the MultiCare Cohort Study. *PLoS One* 2013; **8**: e66742.
28. Sullivan PW, Ghushchyan VH, Bayliss EA. The impact of co-morbidity burden on preference-based health-related quality of life in the United States. *Pharmacoeconomics* 2012; **30**: 431–42.
29. Persad G, Wertheimer A, Emanuel EJ. Principles for allocation of scarce medical interventions. *Lancet* 2009; **373**: 423–31.
30. Revicki DA. Health related quality of life in the evaluation of medical therapy for chronic illness. *J Fam Prac* 1989; **29**: 377–80.
31. Wailoo A, Davis S, Tosh J. The Incorporation of Health Benefits in Cost Utility Analysis Using the EQ-5D. http://www.nicedsu.org.uk/PDFs%20of%20reports/DSU%20EQ5D%20final%20report%20-%20submitted.pdf (last accessed June 2014).