Associations with successful ageing in the "Healthy Old People in Edinburgh" cohort: Being well, fit and healthy

John M. Starr[1], Ian J. Deary[2], and Sally Macintyre[3]

[1]Geriatric Medicine Unit, and [2]Department of Psychology, University of Edinburgh, Edinburgh, [3]MRC Social and Public Health Sciences Unit, Glasgow, Scotland, UK

ABSTRACT. ***Background and aims:*** *Six hundred and three community-resident, healthy, unmedicated people aged 70 years and over had psychometric testing and blood pressure measured in 1990-1. Participants were followed up in 1994-5, 1997-8 and in this fourth wave of the project, 1999-2000, to determine key predictors of, and associations with successful ageing.* ***Methods:*** *Current status of all cohort participants was determined. Those traced and alive were invited for re-assessment. Those who agreed underwent psychometric testing, including memory and fluid intelligence tests, a number of physiological measurements, including blood pressure, grip strength and respiratory function, and questionnaires were administered enquiring about disability, self-esteem, and a range of socioeconomic and socioenvironmental items.* ***Results:*** *At Wave 4, 201 participants were visited and re-tested adequately. During follow-up, mortality (N=210) was predicted by gender, occupation, premorbid intelligence and blood pressure. Disability related to age, weight, respiratory function, grip strength and current mental ability. A model of health was developed that comprised dimensions of medical well-being (absence of disease), physiological fitness and self-perceived health. The latter related strongly to disability and pre-morbid intelligence. Except for memory score at Wave 3, medical well-being related poorly to any predictor variable from Waves 1-3. Physiological fitness related to age, gender and current mental ability.* ***Conclusions:*** *The concept of successful ageing is complex, but this cohort of older people related their perceived health closely to lack of disability. In this cohort, current socioeconomic and socioenvironmental factors were not strongly linked with health at this age. (Aging Clin Exp Res 2003; 15: 336-342)*

INTRODUCTION

During the last decade, much research has focussed on 'successful ageing' (1). There has been a shift from equating health in old age as the absence of disease, as we did at the outset of the "Healthy Old People in Edinburgh" (HOPE) study (2), to an emphasis on absence of dependency with maintained physical fitness (3). More recently, health outcomes, including mortality, have been linked with psychosocial pathways (4). Unlike the older health measures of mortality and morbidity, many newer measures, such as disability, are a matter of degree (5). A corollary of this is that disability and dependency relate more strongly to other continuous measures, particularly of physical and mental abilities (5), than individual diagnoses. In a Scottish cohort born in 1921, we found that predictors of successful ageing were different for diagnosed morbidity, physiological fitness and disability (6). Furthermore, childhood IQ predicted both disability in old age (6) and mortality across the life span (7). We argued that health in old age needs to be understood both in context of the life course and in the contemporary socioenvironmental milieu. In particular, childhood IQ may determine both access to material resources in adulthood and personal choice of health-related behaviours like smoking. A life course approach also helps focus attention upstream on the causes of poor health and inequalities in health, paralleling the shift from a purely medical model of successful ageing (8). Early life data, such as those for the 1921 birth cohort, are only rarely available, although some, such as occupation and education, can be reliably collected retrospectively. However, traces of early life physical data may remain manifest in old age. For example, demi-span is an index of original height prior to any effects of age-associated bone disease (9). Similarly, there are 'archaeological' psychometric measures. We found the National Adult Reading Test (NART) (10),

Key words: Disability, functional independence, older people, predictors of mortality, pre-morbid intelligence, self-perceived health, successful ageing.

Correspondence: J.M. Starr, FRCPEd, Royal Victoria Hospital, Craigleith Road, Edinburgh EH4 2DN, UK.
E-mail: John.Starr@ed.ac.uk

Received October 2, 2002; accepted in revised form May 5, 2003.

commonly used to estimate pre-morbid IQ (2), correlates strongly with childhood IQ (11). We therefore sought to investigate successful ageing in our ongoing study incorporating a pseudo-lifecourse design.

The HOPE cohort comprises 603 community-resident people aged 70 years and over, who submitted to some basic psychometric testing, including the NART, and had blood pressure measured in 1990-1 (2). At baseline, none of the participants was on regular medication or had ongoing medical illness. Participants were followed up in 1994-5 (N=429) and 1997-8 (N=301), with repeat measures of blood pressure and more extensive psychometric testing (12, 13). The fourth wave of the project, 1999-2000, repeated the previous assessments, but in addition more extensive socioenvironmental, physiological and disability data were collected. Our two principal aims were to provide a more informative model of successful ageing and identify key variables that predict health, disability and death in advanced old age.

METHODS

Participants

The fourth wave of follow-up contacted study participants through General Practitioners by letter of invitation with approval from the Local Ethics Committee, as in previous waves. We invited only those participants seen on three previous occasions, and expected to visit 220, of whom 50 would remain disease-free and untreated. We estimated we needed to see 107 subjects at Wave 4 to achieve 80% power for hypothesis testing. For those not visited, we determined current status, including death, from searching General Practice, Primary Care Division and General Register Office data. Death was determined up until December 31, 2000.

Measures

For those subjects revisited, health, cognitive and blood pressure data were collected as previously established (2, 12, 13). We also measured grip strength, Peak Expiratory Flow Rate (PEFR), Forced Expiratory Volume in one second (FEV1) and Forced Vital Capacity (FVC). Cognitive measures included:

1) A broad screening test of current ability (the Mini-Mental State Examination, MMSE) (14);
2) An estimate of 'prior' or 'pre-morbid' IQ (National Adult Reading Test, NART) (10);
3) A non-verbal test of fluid intelligence (Raven's Progressive Matrices) (15); and
4) A verbal memory test (Immediate and delayed recall Logical Memory sub-scales from the Wechsler Memory Scale, summed to provide Memory) (16).

We also collected data on aspects of health likely to reflect early life socioeconomic conditions, current psychosocial and material resources, and local socioenvironmental conditions. These were based on measures used in the MRC's 'West of Scotland twenty-07 study, Health in the Community' (17).

1. Measures that reflect earlier social influences:
   a) Demi-span;
   b) Shoe size;
   c) Dentition (number of teeth or year of loss).
2. Current health related behaviour and psychosocial resources:
   a) Nutritional - Weight and dietary assessment from the Mini Nutritional Assessment (18);
   b) Rosenberg Self-esteem scale (19);
   c) Fear of crime (mugging, burglary, vandalism, etc.);
   d) Social support and social networks (number of personal contacts and telephone contacts per week from relatives and friends);
   e) Household composition and family circumstances (number of people per generation in household, together with their employment and health status).
3. Material and socioenvironmental resources:
   a) Housing type (detached, semi-detached, terraced, low-rise or high-rise apartment, etc.), tenure (owned, privately rented, or rented from Local Authority or Housing Association) and number of rooms;
   b) Housing insulation (double glazing, roof insulation, etc.) and heating system (central heating, individual gas or electric heaters, coal fire);
   c) Access to private transport (personal or family ownership of a car or van);
   d) Access to healthcare – number of patients on GP list;
   e) Local amenities (proximity of post [*mail]* boxes, green space, grocery store, dentist, launderette, leisure centre, health centre, public telephone, etc.), objectively measured on local area map and by participant report;
   f) Full unit post [*zip]* code (to allow Carstairs' deprivation scores comprising small area summary weighted statistics for employment, car ownership, proportion of ethnic minorities, etc. [20] to be applied).

In addition we also administered a brief, validated functional scale (Townsend ADL scale, 21).

RESULTS

Two hundred and eighty-seven participants had valid data for Waves 1-3 of the study. Status at Wave 4 is shown in Table 1. There was a significant difference in baseline age between groups ($F=2.42$, $p=0.027$), but in no other baseline variable (gender, occupation, education, deprivation score, blood pressure, MMSE, NART).

Of the original 603 participants, 201 were retested adequately; 55 seen for Waves 1-3 were alive, but not retested adequately (Table 1); a further 31 participants had died between Waves 3 and 4; 179 participants had died prior to Wave 3 (total of 210 deaths, 34.8%), and 89 participants (not adequately tested for all Waves 1-3) were confirmed as still alive, leaving 48 participants (8.0%) un-

Table 1 - *Outcome at Wave 4 of those participants adequately tested in Waves 1-3.*

Status of participants	Number of participants (%)	Mean age at baseline (years)
Visited and tested adequately	201 (70.0%)	74.2
Dead	31 (10.8%)	75.3
Refused to participate	33 (11.5%)	75.6
Failed to reply	4 (1.4%)	75.5
Moved out of area	2 (0.7%)	71.5
Untraceable	0	
Re-tested inadequately	9 (3.1%)	77.8
Too unwell	7 (2.4%)	75.0

traced. Status by Wave 4 was associated with only one baseline characteristic, MMSE (F=4.08, $p<0.001$); *post hoc* testing identified only one significant difference between groups, that between those retested adequately (mean MMSE 28.5) and the 89 subjects not tested adequately, but still alive (mean MMSE 27.5). Neither baseline age ($p=0.33$) nor gender ($p=0.40$) predicted overall status at Wave 4.

Predictors of death

Death was predicted by gender (OR 1.93, 95% CI 1.47-2.53, male compared with female) and occupation (managerial OR 3.06, 95% CI 1.06-8.81, skilled manual OR 3.21, 95% CI 1.13-9.09, and unskilled manual OR 4.30, 95% CI 1.47-12.6 at significant higher risk than the non-classified group, comprised mostly of women who had never worked). The only other significant predictors in addition to these were baseline NART-predicted IQ (OR 0.98, 95% CI 0.95-0.996 per IQ point), systolic BP (OR 1.01, 95% CI 1.003-1.015 per mmHg) and diastolic BP (OR 1.02, 95% CI 1.004-1.03 per mmHg). NART remained significant with diastolic BP in the model and retained a statistical trend ($p=0.079$) with systolic BP. Baseline age, MMSE, education, deprivation and living alone were not significantly associated with survival.

Predictors of disability

The mean Townsend disability score of those visited at Wave 4 was 2.75 (median 1, range 0-18), indicating that those seen generally remained independent. There was no significant difference ($p=0.29$) between men (N=72, mean 2.40) and women (N=129, mean 2.95). Variables identified as significant covariates of the Townsend score were age ($p=0.002$, partial $eta^2=0.050$), weight ($p=0.029$, partial $eta^2=0.025$), PEFR ($p=0.007$, partial $eta^2=0.037$), grip strength ($p=0.031$, partial $eta^2=0.024$) and current MMSE ($p<0.001$, partial $eta^2=0.140$), the model explaining 31.9% of variance. Presence or absence of disease significantly improved the model to explain 37.1% of variance – as, independently, did medication use to 35.5%. No other variables (physical, psychological, self-esteem, diet, socioenvironmental or self-perceived health status) improved the model further. On excluding presence or absence of disease from the model, only condensation in the home (mean for those with no condensation 2.2, with condensation 4.2, $p=0.01$, partial $eta^2=0.049$) significantly increased the variance explained. Adjusting for significant covariates, presence of disease increased the Townsend disability score by 1.8 points (95% CI 0.91-2.61 points).

Predictors of well-being, fitness and health

Well-being had previously been defined in terms of recognised disease or medication use in the HOPE study. Of the 201 subjects re-tested adequately at Wave 4, 73 (36.3%) remained on no regular medication. The frequency of different disease categories is shown in Table 2. Apart from hypertension, individual disease categories accounted for only small numbers, thus precluding detection of any between-disease heterogeneity, so, as previously, the presence or absence of disease was considered. Of the variables observed during the first three waves, only lower memory score at Wave 3 predicted disease at Wave 4 (OR 0.97, 95% CI 0.95-1.00) in a forward conditional logistic regression model, and this with only marginal significance ($p=0.046$). Adding pseudo-life course variables did not improve the model, neither did including any of the socioenvironmental variables collected at Wave 4.

Physiological measures comprised systolic and diastolic BP, demi-span, weight, grip strength, FEV1, FVC and PEFR. Apart from a moderate correlation between systolic BP and demi-span ($r= -0.16$, $p=0.021$), blood pressure did not correlate with any other physiological measure, whilst there were strong inter-correlations between the other measures. In view of this, principal components extraction was performed for these other measures (excluding PEFR, since both FEV1 and FVC

Table 2 - *Numbers and percentages of HOPE subjects with different categories of disease at Wave 4.*

Disease category	Number of participants	Percentage of participants
None	47	23.4
Cardiovascular	16	8.0
Cerebrovascular	5	2.5
Neoplasia	4	2.0
Hypertension	25	12.4
Diabetes	2	1.0
Thyroid disorder	2	1.0
Dementia	2	1.0
Other vascular diseases	1	0.5
Other single disease	38	18.9
Multiple disease	59	29.4

Table 3 - *Mean scores by self-perceived health status at Wave 4 of the HOPE study. Means for two subjects reporting poor health are not shown, due to small group size.*

Variable	Fair health	Good health	Excellent health
Current Raven	22.0	28.8	29.1
Current Memory	28.5	35.9	37.8
Current MMSE	26.1	27.9	28.1
FEV1 (L/s)	1.55	1.67	1.79
Diet (MNA score)	7.9	8.2	8.4
Disability	5.7	2.5	1.4
Self-esteem	4.1	7.3	9.6

were available as better measures of respiratory function) that provided a single factor accounting for 65.7% of the variance. This factor may be considered to represent a 'frailty' scale, from small, weak, poor respiratory function to big, strong, good respiratory function. Physiological health correlated strongly and negatively with disability (Spearman rho= -0.33, $p<0.001$), negatively with age (r= -0.17, $p=0.019$), positively with Raven's matrices (r=0.39, $p<0.001$) and memory (r=0.24, $p=0.001$), but not significantly with Wave 4 MMSE. As expected, the factor was significantly greater for men, who tend to be bigger and stronger than women ($p<0.001$).

Participants rated their health as excellent (N=46, 22.9%), good (N=119, 59.2%), fair (N=33, 16.4%) or poor (N=2, 1.0%); one subject failed to rate health status. Table 3 shows mean scores for variables with significant univariate associations according to self-perceived health. The optimal model comprised the Townsend disability score ($p<0.001$), FEV1 ($p=0.027$) and gender ($p=0.001$), men reporting worse health than women. Self-esteem ($p=0.003$) improved the model, but causal direction is unclear. Excluding disability, the optimal model comprised FEV1, self-esteem, gender and property ownership ($p=0.002$), although the latter may reflect the health status of some participants in residential homes and other supported facilities. Considering participants in 'excellent' self-perceived health as an index of successful ageing, only two variables were associated with health: the Townsend disability score (OR 0.84, 95% CI 0.71-0.997 per point) and baseline NART-predicted IQ (OR 1.07, 95% CI 1.01-1.14 per IQ point). Mean NART-IQ for participants in excellent health was 119.0, compared with 116.3 for those not in excellent health. Disease, medication use and physiological fitness were not significantly associated with self-perceived health.

Apart from the association between condensation in the home and disability, none of the household, social network or socioenvironmental variables were significantly associated with well-being, fitness or self-perceived health.

DISCUSSION

The number of subjects participating successfully in Wave 4 was much as predicted at Wave 3 – perhaps a little better than expected, given that follow-up actually occurred six months later than planned. Similarly, the number of subjects who remained disease-free and untreated was as predicted. These observations were therefore reassuring for previous health outcome modelling, and supported the use of similar analyses for this Wave. In short, we collected adequate data to test the original hypotheses with far greater power than originally allowed for by our worst-case estimates of survivors. Nevertheless, for some variables (e.g., proximity to amenities, use of phone, etc.), there were only small numbers of subjects in some sub-groups, limiting the power to test the effects of these on some outcomes. This was because the sample mostly resided in an urban environment, and we were thus unable to examine the effects of rural socioeconomic deprivation.

Two important indices of successful ageing are longevity and maintaining functional independence. In the HOPE cohort gender, occupation and elevated blood pressure were all predictors of death as expected, although age itself was not significant. This may reflect baseline selection for good health, attenuating the effects of age-associated disease. In addition, higher pre-morbid IQ protected participants from death, as it did in the 1921 birth cohort (7). This association was independent of occupation, education or deprivation index of area of residence. Unlike the 1921 cohort, however, pre-morbid IQ was not directly associated with functional independence at follow-up. Nevertheless, the current MMSE score was significantly associated, and itself was strongly dependent on pre-morbid IQ. Avoiding disability, unlike mortality, was related to age and also a number of measures of physiological fitness. Once these were adjusted, the presence of a medical condition had a moderate influence, accounting for around 5% of variance in scores. This finding is consistent with other studies of physical fitness and functional independence (22, 23).

The validity of functional independence as a measure of successful ageing was confirmed by its significant association with self-perceived health in this cohort. FEV1, an important component of physiological fitness, was also associated with self-perceived health, but presence of disease or medication use was not. Hence, although morbidity may be thought to be an index of successful ageing from a medical perspective, it was unimportant for this sample of people in their eighth, ninth and tenth decades of life. Interestingly, women considered themselves in better health than men, as did those participants with higher pre-morbid IQ. In the 1921 cohort, three components of health status in old age were identified: medical well-being, physiological fitness, and disability (6). This study allowed us to develop this model and infer a

spectrum of measures of successful ageing from medical well-being, incorporating mortality and morbidity, through physiological fitness, in which cognitive and physical measures are closely correlated, to self-perceived health, that correlates strongly with maintained functional independence but in the context of personal attributes such as gender and pre-morbid IQ. Table 4 summarises factors relating to these dimensions of being well, fit and healthy. These are similar to those found in the 1921 birth cohort (6): notably, the absence of any associations with medical well-being in old age except for the marginally significant one with better memory at Wave 3. This lack of associations is probably due to the high prevalence of morbidity in the old, even in an initially well cohort, and the fact that any diagnosis (e.g., ischaemic heart disease, chronic obstructive pulmonary disease, etc.) covers a very wide range of severity. In addition to heterogeneity in severity within specific diagnoses, the sample size precludes examination of differences between diagnostic categories except for the most common. Lumping all the different disease categories together to represent the unsuccessful outcome of being medically 'sick' necessarily reduces variance and thus power to detect significant associations.

The concept of successful ageing extends beyond predominantly health measures to encompass other aspects of so-called 'quality of life'. In the Berlin Aging Study, successful ageing included measures of morale, mood and lack of loneliness (24); psychometric intelligence, personality traits and subjective health reports were all significant correlates of these 'quality of life' measures. Moreover, such cognitive, health and psychosocial measures also predict longevity (25). The findings from the HOPE cohort support this shift towards greater emphasis on the importance of self-perceived health in older people. Thus, we observed a significant association between self-esteem and self-perceived health but not diagnosed disease. This contrasts with a 'functional' ageing construct, which emphasises the accumulation of specific age-related deficits that may be related to chronological age as a measure of success (26). The Berlin group found that an individual's response to such deficits was critical in determining successful ageing (24). Indeed, beyond the individual, the social networks supporting her/him are also important in this regard, although not necessarily in a simplistic way (27, 28). Hence, the lack of many significant associations between socioenvironmental variables and health status in this cohort does not imply that these are unimportant for broader constructs of successful ageing. Nevertheless, our observations suggest that interventions to modify such socioenvironmental factors such as housing, social networks and access to amenities will have little impact on health status in older people living in a fairly well-provided city. Again, although lack of resources has been shown to affect successful ageing (29), the response of the individual can have a paradoxical effect (30). Our study suggests that strategies targeting the prevention of disability and maintaining physical fitness are likely to be of greater benefit. Within this strategy, prevention of specific diseases, with the exception of those impacting on cognition, are of limited value.

The limitations of the urban setting of our sample, its size, and the use of a classification system to define medical well-being that was intended to differentiate between pathologies rather than quantify illness, have already been mentioned. It would have been of great benefit to have collected physical and socioenvironmental data during earlier waves. The extension in methodology reflected our evolving understanding of health status, especially the complex relationship between physiological variables like blood pressure and disease (13). Nevertheless, we did not collect data on other aspects found relevant to successful ageing such as mood (31), sexuality (32), spirituality (33), resilience and wisdom (34).

One key finding that emerged at Wave 4 was the importance of pre-morbid IQ in old age. The influence of education, a strong correlate of pre-morbid IQ, is well recognised (31, 35, 36). Given that women from this epoch had limited occupational and educational opportunities, NART-estimated IQ expresses greater variance than either of these and is probably a better variable to use when adjusting for earlier socioeconomic inequalities. Whether there is also a direct causal link between pre-morbid intelligence and physical disease remains uncertain, although one could argue that this might be mediated through life-style choices. Indeed, the importance of including pre-morbid intelligence in any model of health may lie in its generalisability. Life-style choices and socioeconomic conditions may vary greatly between populations,

Table 4 - *Principal associations of different dimensions of health in the HOPE cohort. Gender and FEV1 only relate to being healthy once disability is excluded.*

Well	Fit	Healthy
Memory at Wave 3 – positive	Age – negative	Disability – negative
	Gender- men > women	Pre-morbid mental ability – positive
	Current mental ability – positive	(Gender – women > men)
		(FEV1 – positive)

but higher pre-morbid intelligence may confer a similar advantage, whatever the specific context. With the relatively extensive socioenvironmental and life-style data collected in this study, only a proportion of these may have been relevant to health for sub-groups within the cohort (e.g., typically, car driving for men, grocery store access for women, etc.). Hence, we may fail to detect important determinants of health if there are no general factors. Perhaps in old age there is a greater diversity as to the particular socioenvironmental factors which individual people value as important for health. A corollary of this is that studies from various settings may identify different 'key' psychosocial factors. Perhaps, if our participants had been recruited from a traditional mining area just a few miles south of the city, we might have found a greater role played by social networks.

CONCLUSIONS

When we planned this fourth wave of the study, we sought to shift our paradigm of 'successful ageing' from a purely medical one to include broader measures. Life expectancy and dependency were considered *a priori* useful for public health planning. We identified premorbid intelligence as an important direct or indirect influence on both longevity and disability, similar to our findings in the 1921 Aberdeen birth cohort. Moreover, disability and pre-morbid intelligence were the key determinants of self-perceived health. Since this wave (Wave 4) was planned, several papers on successful ageing have pointed to a wide variety of associations with this putative construct. These, together with our own findings, bring into question the concept of 'successful ageing' as a monolithic entity. Havighurst's original concept of 'successful aging' was 'adding life to years' (37) and has generated a number of paradigms focussing on specific aspects of ageing (social engagement [38]; social activity [39]; and avoiding significant disease or disability [40]). Our model comprises a spectrum of medical well-being (as opposed to morbidity), physiological fitness (as opposed to frailty) and self-perceived health. Apart from functional independence, the participants' own ideas of health, considered as a homogeneous cohort, failed to relate to any socioenvironmental variable. With premorbid intelligence, the other important determinant of self-perceived health, our model relates closely to Atchley's 'continuity theory' of successful ageing (41). Thus, instead of some over-arching mythic idea, what is considered pertinent to 'successful ageing' appears to be defined at an individual, or at least small group, level in urban communities, where a vast range of different life course experiences are represented, built on previous life experiences. In particular, although there is a clear discrepancy between medically-defined well-being and self-perceived health, as in the Berlin Aging study (42), premorbid intelligence may facilitate more 'successful' responses to loss of functional independence (24). Alternatively, higher premorbid intelligence may just reflect some common cause, so that those who are 'successful' in their youth continue to be 'successful' as they age. The challenge we face in planning the next wave is measuring 'successful ageing' in terms of the community rather than the individual. Meanwhile, we will continue to focus on determinants of a long and disability-free life.

ACKNOWLEDGEMENTS

The study was supported by a grant from the Chief Scientist's Office, Scotland. We wish to thank all the participants and their family doctors who have cooperated in the study over the last ten years. Ian Deary is the recipient of a Royal Society-Wolfson Research Merit Award.

REFERENCES

1. Rowe JW, Kahn RL. Successful aging. New York: Dell, 1999.
2. Starr JM, Whalley LJ, Inch S, Shering PA. The quantification of the relative effects of age and NART-predicted IQ on cognitive function in healthy old people. Int J Geriatr Psychiatry 1992; 7: 153-7.
3. Metz D. Innovation to prevent dependency in old age. BMJ 2000; 320: 460-1.
4. Glass TA, Mendes de Leon C, Marottoli RA, Berkman RF. Population based study of social and productive activities as predictors of survival among elderly Americans. BMJ 1999; 319: 478-83.
5. Medical Research Council Cognitive Function and Ageing Study (MRC CFAS) and Resource Implications Study (RIS MRC CFAS). Profile of disability in elderly people: estimates from a longitudinal population study. BMJ 1999; 318: 1108-11.
6. Starr JM, Deary IJ, Lemmon H, Whalley LJ. Mental ability age 11 years and health status age 77 years. Age Ageing 2000; 29: 253-8.
7. Whalley LJ, Deary IJ. Longitudinal cohort study of childhood IQ and survival up to age 76. BMJ 2001; 322: 1-5.
8. Macintyre S. Prevention and the reduction of health inequalities. BMJ 2000; 320: 1399-400.
9. Bassey EJ. Longitudinal changes in selected physical capabilities: muscle strength, flexibility and body size. Age Ageing 1998; 27(Suppl 3): 12-6.
10. Nelson HE. National Adult Reading Test (NART). Test Manual 1982 (Part I). Nelson HE, Willison JR. NART Test Manual 1991 (Part II). NFER-NELSON Publishing Company Ltd, England.
11. Deary IJ, Whalley LJ, Lemmon H, Crawford JR, Starr JM. The stability of individual differences in mental ability from childhood to old age: follow-up of the 1932 Scottish Mental Survey. Intelligence 2000; 28: 49-55.
12. Starr JM, Deary IJ, Inch S, Cross S, MacLennan WJ. Age-associated cognitive decline in healthy old people. Age Ageing 1997; 26: 295-300.
13. Starr JM, Inch S, Cross S, Deary IJ. Seven year follow-up of blood pressure in the Healthy Old People in Edinburgh (HOPE) cohort. J Hum Hypertens 2000; 14: 773-8.
14. Folstein MF, Folstein SE, McHugh PR. 'Mini-Mental State': A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975; 12: 189-98.
15. Raven JC, Court JH, Raven J. Manual for Raven's progressive matrices and vocabulary scales. London: HK Lewis and Co., 1977.

16. Wechsler D. A standardized memory scale for clinical use. J Psychol 1945; 19: 87-95.
17. Sooman A, Macintyre S. Health perceptions of the local environment in socially contrasting neighbourhoods in Glasgow. Health & Place 1995; 1: 15-26.
18. Guigoz Y, Vellas B, Garry PJ. Mini Nutritional Assessment: a practical assessment tool for grading the nutritional state of elderly patients. Facts Res Gerontol 1994; 4: 113-43.
19. Rosenberg M. Society and the adolescent self image. Princeton, NJ: Princeton University Press, 1965.
20. Carstairs V, Morris R. Deprivation and Health in Scotland. Aberdeen, Aberdeen University Press, 1991.
21. Townsend P. Poverty in the United Kingdom. Harmondsworth: Penguin, 1979.
22. Morey MC, Pieper CF, Cornoni-Huntley J. Physical fitness and functional limitations in community-dwelling older adults. Med Sci Sports Exerc 1998; 30: 715-23.
23. Davis JW, Ross PD, Preston SD, Nevitt MC, Wasnich RD. Strength, physical activity, and body mass index: relationship to performance-based measures and activities of daily living among older Japanese women in Hawaii. J Am Geriatr Soc 1998; 46: 274-9.
24. Freund AM, Baltes PB. Selection, optimization, and compensation as strategies of life management: correlations with subjective indicators of successful aging. Psychol Aging 1998; 13: 531-43.
25. Korten AE, Jorm AF, Jiao Z, et al. Health, cognitive and psychosocial factors as predictors of mortality in an elderly community sample. J Epidemiol Community Health 1999; 53: 83-8.
26. Graham JE, Mitnitski AB, Mogilner AJ, Rockwood K. Dynamics of cognitive aging: distinguishing functional age and disease from chronologic age in a population. Am J Epidemiol 1999; 150: 1045-54.
27. Unger JB, McAvay G, Bruce ML, Berkman L, Seeman T. Variation in the impact of social network characteristics on physical functioning in elderly persons: MacArthur Studies of Successful Aging. J Gerontol 1999; 54: S245-51.
28. Seeman TE, Bruce ML, McAvay GJ. Social network characteristics and onset of ADL disability: MacArthur studies of successful aging. J Gerontol 1996; 51: S191-200.
29. Baltes MM, Lang FR. Everyday functioning and successful aging: the impact of resources. Psychol Aging 1997; 12: 433-43.
30. Barusch AS. Self-concepts of low-income older women: not old or poor, but fortunate and blessed. Int J Aging Hum Dev 1997; 44: 269-82.
31. Meeks S, Murrell SA. Contribution of education to health and life satisfaction in older adults mediated by negative affect. J Aging Health 2001; 13: 92-119.
32. Bortz WM, Wallace DH. Physical fitness, aging, and sexuality. West J Med 1999; 170: 167-9.
33. Parker MW, Fuller GF, Koenig HG, et al. Soldier and family wellness across the life course: a developmental model of successful aging, spirituality, and health. Military Medicine 201; 166: 561-70.
34. Rowe JW, Kahn RL. Successful aging and disease prevention. Adv Ren Replace Ther 2000; 7: 70-7.
35. Kubzansky LD, Berkman LF, Glass TA, Seeman TE. Is educational attainment associated with shared determinants of health in the elderly? Findings from the MacArthur Studies of Successful Aging. Psychosom Med 1998; 60: 578-85.
36. Strawbridge WJ, Cohen RD, Shema SJ, Kaplan GA. Successful aging: predictors and associated activities. Am J Epidemiol 1996; 144: 135-41.
37. Havighurst RJ. Successful aging. Gerontologist 1961; 1: 8-13.
38. Cumming E, Henry WE. Growing old: The process of disengagement. New York: Basic Books, Inc., 1961.
39. Lemon BW, Bengtson VL, Petersen JA. An exploration of the activity theory of aging: activity types and life expectation among in-movers to a retirement community. J Gerontol 1972; 27: 511-23.
40. Fries JF, Crapo LM. Vitality and aging. San Francisco: W.H. Freeman, 1981.
41. Atchley RC. The social forces in later life: an introduction to social gerontology. Belmont, CA: Wadsworth, 1972.
42. Borchelt M, Gilberg R, Horgas AL, Geiselmann B. On the significance of morbidity and disability in old age. In Baltes PB, Mayer KU, Eds. The Berlin Aging Study: aging from 70 to 100. New York: Cambridge University Press, 1999: 403-29.