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Health assets in older age: a systematic review

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ABSTRACT

Background

Finding ways to optimise health in older age is key to reducing the impact of population ageing on health care systems. A salutogenic approach takes into account an individual's health assets - internal or external strengths or accessible resources which improve and preserve physical, social and mental wellness, independence, and quality of life.

Methods

A systematic review of literature published between January 2000 and October 2015 was conducted to identify health assets in personal, social, economic and environmental domains which positively influence, or are protective of, health in community dwelling populations aged 65 and over.

Results

Twenty-seven publications, including 84,612 participants, were identified. Evidence supported strong positive relationships between higher scores of self-rated health, psychological wellbeing, and life satisfaction, and health in older age. Social network and contact, including engagement in leisure and social activities, were important support mechanisms. Education and financial resources consistently proved to be key economic health assets for older adults.

Conclusions

Health interventions focusing on the strongest evidence from this review can be implemented across the life course as a means of optimising health later in life. Factors are often interdependent and cumulative, but the evidence for multi-domain composite factors is limited. This suggests potential for an instrument to measure the cumulative effect of multi-domain health assets on health status of community dwelling individuals in older age.

Strengths and limitations of this study

- This review has evaluated an extensive range of health assets, highlighting the strongest evidence for factors that positively influence health in older age.

- Of the studies identified for inclusion in this review, methodological differences in study design, follow-up periods, population samples, and the way health assets and outcomes were measured precluded the pooling of results for meta-analysis.

- The cross-sectional designs of the majority of studies did not allow a cause-effect relationship to be examined between health asset indicators and subsequent health in older age.

What is already known on this subject?

- Determinants that influence health in older age are complex and wide-ranging
- Approaches to the promotion of health have been based on an 'illness' model focussing mainly on risk factors for disease, rather than those factors associated with a wellness model.
- Health is a dynamic balance between 'assets' which help a person maintain their independence in the community, and 'deficits', which threaten independence
- The concept of 'health assets' has not been widely explored in health care

What this study adds

- This systematic review summarises the evidence for 'heath assets' that positively influence, or are protective of, health in older age
- Identifying 'health assets' will support the design of effective policies and programmes for the promotion of health in older age
- Including 'health assets' in the model of health, empowers individuals to utilise their own resources and understanding to become agents of their own wellbeing
- This study highlights potential for a combined measure of health assets to evaluate cumulative factors known to positively influence health and well-being

INTRODUCTION

On a global level, people aged 65 or older are the fastest growing segment of the population.[1] Whilst global ageing is perceived as a success, the continued growth of this population will add increasing economic and social demands on all countries.[2] Enhancing 'health' in older age is key to reducing the impact of global ageing, and is therefore a fundamental issue for policy makers.[1]

Based on the World Health Organisation (WHO) definition, health in older age is described as a life course process of optimising opportunities for improving and preserving physical, social and mental wellness, independence, quality of life and enhancing successful transitions.[2,3] This holistic definition recognises that health is a continuum across multi-domains of well-being. Hence the determinants that influence health in older age are complex and wide-ranging.

Historically, approaches to the promotion of health have been based on an 'illness' model. The focus is mainly on risk factors for disease, 'health deficits', rather than those associated with improved outcomes. Although this approach is essential for understanding specific needs and priorities, it tends to define individuals in negative terms and may overlook important positive factors which improve public health.[4] In contrast, a 'wellness' model accentuates a salutogenic approach, concerned with identifying protective factors, 'health assets', to support health and wellbeing, rather than those that cause disease.[5] 'Health assets' are defined as an individual's internal or external strengths or accessible resources which enhance ability to optimise health.[4, 6, 7] Identifying 'health assets' that positively influence, or are protective of, health in older age will support the design of effective policies and programmes for the promotion of health in older age.

The WHO set out a framework categorising key determinants of healthy ageing in personal, environmental, behavioural, economic, and social domains, as well as health and social services resources.[2] Using this framework, a review of the literature was conducted to summarise 'heath assets' that positively influence, or are protective of, health in older age.

METHODS

Search Criteria

To address the study question "What health assets positively influence health in older age?", a systematic search of databases (PubMed, Medline, Embase, CINAHL, and PsycNet) was undertaken, using the search strategy presented in Table 1.

Table 1: Search Criteria	
Outcome terms[a]	health status OR successful ag*ing OR healthy ag*ing OR positive ag*ing OR ag*ing well OR frailty OR longevity
	AND
Factor terms	factor* OR predict* OR indicator* OR determinant
Filters	• published between January 2000 and October 2015 • human subjects • English language • population aged 65 or older
Notes	* is used to indicate the term is truncated or has spelling variation. [a] these terms were adopted in search criteria since this nomenclature dominates the literature describing a multidimensional composite measure of health status in older age[8]

Titles were screened (YHT) for appropriateness. Two authors (YHT, NMP) independently reviewed abstracts to further eliminate studies not meeting the selection criteria presented in Table 2. The full text of all remaining articles was retrieved and the decision to include in the review was made by two authors (YHT, NMP) in consultation with third author (REH) where doubt existed. In addition, reference lists of included articles were searched to identify other studies meeting the inclusion criteria.

Table 2: Selection Criteria

Criteria	Included	Excluded
Publication type	• published in peer reviewed scientific journals • reporting original research results • written in English	• reviews, book chapters, editorials, dissertations, theses and conference abstracts • "grey" literature
Study design	• observational studies with a primary aim to measure associations between key determinants and health in older age • quantitative studies	• qualitative studies
Population	• mean age at baseline ≥65 • non-institutionalised	• mean age at baseline <65 • hospitalised or in long term care
Study factor domains	• personal • social • economic • environmental	• behavioural or lifestyle factors[a] • factors which were part of multi-domain outcome measure
Outcome measure	• health status to include a composite measure across multi-domains of physical, mental and social well-being	• health measured as a single item question e.g. self-reported health or life satisfaction

Notes

[a] not included in this review as these factors have been a focus of a previous review[8]

Data Extraction

Two authors (YHT and NMP) independently extracted the data using a standardised instrument. Data were compared and agreement on study variables reached by consensus. Study characteristics recorded are listed in Table 3 (supplementary material). Measurement of the outcome, health status, as well as prevalence in the study population was documented. Factors which positively influenced (or were protective of) health status were classified under personal, social, economic and environmental domains.

Data Synthesis and Analysis

Data was synthesised and reported according to the PRISMA statement.[9] Due to the heterogeneity of study populations, outcome and predictor measures, a meta-analysis was not possible.

Study Quality

Studies were evaluated using a modified version of an epidemiological appraisal instrument,[10] comprising 20 questions; scores for each question ranged from 2 to 0, depending on whether the question was fully, partially, or not addressed. Study quality was independently assessed by two authors (YHT, NMP).

RESULTS

The search of online databases identified 2819 publications. Following the exclusion of duplicates (from two or more databases) and the screening of titles, 457 articles proceeded to abstract and full text screening. Of these, 435 failed to meet the specified selection criteria (Table 2), resulting in 22 eligible articles. Five articles were added following screening of references cited in eligible articles, taking the total number included in the review to 27. Figure 1 displays the flow diagram for selection of eligible articles for inclusion in the analysis.

< Figure 1: Flow diagram of article selection>

Study Characteristics

Study characteristics are shown in Table 3 (supplementary material). Publication dates of the 27 selected articles ranged from 2001 to 2014, analysing data from populations in the USA,[11-15] Canada,[16-18] Asia,[19-26] Europe,[27-30] the UK,[31, 32] Australia,[33-35] South America,[36] and Africa.[37] Studies included 24 separate population cohorts, with sample sizes ranging from 67 to 29,905 participants and mean age between 65 to 87 years. The majority of studies included both males and females, in which the proportion of females varied from 38% to 82%. Two studies[11, 15] included males only. Cross-sectional analysis was used in 22 studies, with the remaining five studies[11, 15, 27, 34, 37] using baseline data to predict subsequent health status outcome.

Health Status Outcome Measures

Twenty articles[11-15, 18-24, 26-28, 33-37] investigated factors in relation to successful or healthy ageing. Studies used different definitions, with the majority basing outcome measures on the model of Rowe and Kahn,[38] who defined successful ageing as the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities. Six studies,[16, 17, 25, 30-32] investigated factors in relation to frailty, a summary measure of health status conceptualised on a continuum from fitness to frailty.[39] The Frailty Index (FI) is a continuous score from 0 to 1, and is calculated as the proportion of deficits across multiple domains.[40, 41] One article[29] measured frailty as a scale (Tilburg Frailty Indicator) across physical, psychological, and social domains, with scores ranging from 0 to 15. Higher scores on both measures indicate a greater level of frailty. The FI was reported as a mean with standard deviation (SD).

Determinants of Health Status

Personal

A total of 17 articles investigated personal factors as determinants of health status.[11-13, 15, 16, 18-20, 23, 24, 27-29, 31, 33, 35, 37] Personal factors incorporate a wide range of attitudes, perceptions and internal resources that relate to health and well-being.

Self-rated health, measured on a scale from poor to excellent, was reported in five studies.[11, 18, 20, 33, 37] All but one[37] found a significant relationship between self-reported health and successful ageing, indicating those with better perceived health were more likely to age successfully than those with poorer self-reported health.

Well-being was investigated in 13 studies.[13, 15, 16, 18-20, 23, 24, 27-29, 31, 33] Worse scores on a composite measure of psychological well-being,[16, 31] as well as single measures of environmental mastery, self-acceptance, interpersonal relations, and personal growth[16] were associated with increased frailty. Higher levels of self-esteem, self-achievement, self-efficacy, interpersonal relationships,[19] having purpose in life[13] and religious beliefs[24] were found to be associated with successful ageing, while low morale was associated with lower functioning.[33] Successful agers expressed greater life satisfaction[13, 18, 20, 23] and a higher quality of life[24, 28] in cross-sectional analysis. However, quality of life was no longer a predictor of continued successful ageing in longitudinal follow-up.[27] Having fewer traumatic life events was found to be significant for those in the highest decile compared to lowest decile of successful ageing.[35]

Social

A total of 19 articles investigated social factors as determinants of health status.[11, 12, 15, 17, 18, 20-25, 27-29, 33-37] Composite measures of social risk and vulnerability were investigated in three studies.[17, 27, 28] Items used to provide an overall score of social risk included family and economic situation, housing, relationships and social support. Low social risk score was associated with successful ageing in cross-sectional analysis;[28] however, this association was no longer significant in longitudinal follow-up.[27] Social vulnerability included measures of communication, living situation, social support, social activities and life control. There was a weak to moderate correlation between the social vulnerability and frailty index scores.[17]

Marital status and living arrangements were investigated in 13 studies.[11, 18, 20-24, 27- 29, 34-36] Being married[18, 23] or not living alone[35] were found to be associated with successful ageing. In contrast, one study[28] found being widowed was associated with successful ageing at baseline, but not at follow-up.[27] Quality of marriage was examined in longitudinal analysis, where it was found having a stable marriage predicted successful ageing in a sample of core-city men, but not college men.[15]

Social network, commonly measured by the number of, and frequency of contact with, family, friends, and neighbours was investigated in seven studies.[20, 24, 25, 34-37] Individuals with a larger social network were found to age more successfully[20] or had lower levels of frailty.[25] Successful agers also reported frequent contact with friends,[20, 35, 37] while infrequent contact with relatives was associated with higher frailty in women, but not men.[25]

Social support, measured in terms of emotional and instrumental support was examined in six cohorts.[12, 20, 23, 24, 35, 36] Having more confidants, and support from family and friends were positively associated with successful ageing.[35, 36] Engagement in social activities was investigated in seven studies.[23- 25, 33, 34, 36, 37] Participation in domestic and household activities was a protective factor in successful ageing,[33] and infrequent participation in service to others was a risk factor for lower functioning[33] and higher levels of frailty.[25] A higher level of participation in community or leisure activities was found to be associated with successful ageing[23, 37] and with lower levels of frailty in females, but not males.[25]

Economic

Twenty-one studies investigated economic factors as determinants of health status,[11, 12, 14, 15, 18, 20-30, 32, 34-37] with the majority including education as an economic indicator.[11, 12, 15, 18, 20 - 30, 34-37] Level of attainment and years of education were the most common measures, with one study[12] also looking at quality of education measured as a reading score. Ten articles found successful agers had more years, or a higher level, of education either in cross-sectional[20-22, 24, 26, 28, 35] or longitudinal[11, 15, 27] analysis and one article found fewer years of education was associated with higher frailty.[30] Quality of education was found to mediate the relationship between both education and cognition with successful ageing.[12]

Income was investigated in seven studies.[18, 21, 22, 25, 26, 29, 36] Of these, three found having a higher personal[22] or household[21, 36] income was associated with successful ageing. Frailty was lowest for respondents with the highest monthly income,[29] though this relationship was generally non-linear. Adequacy of, or satisfaction with, financial resources was investigated in five articles.[20, 23-25, 30] Financial strain was negatively associated with successful ageing,[20] while being satisfied with one's economic situation contributed to successful ageing[23] and having inadequate finances was associated with higher frailty.[25, 30]

Occupation class or employment status was investigated in four articles,[21, 23, 25, 26] while a further study[14] examined the continuity and meaning of occupational engagement. Not being employed or being unemployed was found to be associated with poor health status.[26] Higher levels of frailty were reported for men who engaged in non-white collar jobs; however, this association did not prove significant for women.[25] In one study,[14] the meaning of longstanding productive occupation was significantly correlated with successful ageing.

Other single item economic indicators of successful ageing included housing (size, type)[24, 26] or possessions (property, household goods).[22, 37] One study[24] found that successful agers were significantly more likely to live in better housing.

Composite measures of economic status included Socio-Economic Indices for Area (SEIFA),[34] neighbourhood deprivation, and wealth[32]. Based on census data, the SEIFA is an index of relative socio-economic disadvantage, measuring, at an area level, factors such as income, education and occupational status. Being in the top SEIFA quintile was found to predict successful ageing.[34] Neighbourhood deprivation, based on the Index of Multiple Deprivation can similarly be measured at the area level and includes such dimensions as income, employment, education and living environment. Wealth was assessed by a range of questions relating to financial, housing and other assets. Lower levels of wealth and living in a more deprived neighbourhood were independently associated with higher levels of frailty.[32]

Environmental

Environmental factors were the least investigated domain, with three articles examining whether place of residence influenced successful ageing.[18, 21, 37] Each investigated the effect of urban versus rural locality using multivariate analysis. No significant findings were reported.

Study Quality

Using the modified Epidemiological Appraisal Instrument, scores for assessment of methodological quality ranged from 14 to 36, out of a possible 40 points, with an average score of 27.8 points.

Studies were classified into low (0 - 13), medium (14 – 27) or high quality (28 – 40) categories, determined by their final score. Study quality results are included in Table 3 (supplementary material).

DISCUSSION

This systematic review summarises the evidence for factors within personal, social, economic and environmental domains that can be termed as "health assets" of older adults. Of these, there was strong evidence from multiple high quality studies to suggest self-rated health, life satisfaction, psychological well-being, social network and contact, engagement in leisure and social activities, education, and financial resources are associated with health status in older populations. Such assets may prevent or delay adverse health outcomes in older adults and can explain why people at a similar level of health may have different outcomes when exposed to stressors. Health is thus a dynamic balance between assets which help a person maintain their independence in the community, and deficits, which threaten independence.[42]

The majority of studies measured factors individually, even though their effects are often interdependent and additive.[43] A small number of studies, however, used composite measures including a multi-domain measure of social vulnerability [17] or social risk [27, 28], and single domain composite measures of well-being[16, 31] or socioeconomic status.[32, 34] A multi-domain summative measure of protective factors was investigated in older adults in Beijing.[43] This study reported that for each accrued protective factor, the risk of health decline and death was reduced by 13% to 25%. These studies support the validity of an 'accumulated assets' approach, similar to the deficit accumulation model to assist in defining health status.[40] The theoretical framework underpinning 'health assets' is similar to that of 'heath deficits'; both measure an accumulation of factors across multiple domains that predict health outcomes. While an accumulation of health deficits predicts adverse outcomes, an accumulation of health assets may mitigate the effects of ill health. This highlights potential for a 'health assets' tool to evaluate cumulative factors known to positively influence health and well-being. Such a tool could be useful in epidemiological studies to examine why individuals with similar health status have different health outcomes depending on their level of health assets.

A person's health and wellbeing has many facets, resulting from a complex interplay between factors within multiple domains.[2] Such factors are highly influenced by cultural norms, gender specific roles,[3] resources and policies of the wider society.[44] The modifiability of these factors is therefore highly dependent on the individual and the context in which they live. While some factors are seemingly immutable at the individual level, population health policies to reduce poverty, provide social support, connection to culture, and equitable access to health care can protect against the effects of living in disadvantaged circumstances. Factors under personal control, for instance social participation, are more amenable to interventional programs and policies.[44] Providing support to persons to maintain or improve their engagement in leisure and social activities is likely to impact a wide range of other health related factors including social network and contact, independence, life satisfaction and wellbeing, and physical and mental health.

The mechanism through which health assets can influence health may be direct or indirect. For example, those on very low incomes may lack resources and access to nutritious food, adequate

housing, safe environments and health care, which can impact negatively on health. Financial and life stressors, as well as lack of resources, social support and connectedness can contribute directly to poorer health (for example, increased risk of high blood pressure, immune and circulatory complications) or indirectly, through less healthy coping skills and behaviours (for example, excessive alcohol consumption or substance abuse). Although self-rated health is a consistent indicator of objective health and a robust predictor of health outcomes, little is known about the mechanism by which it influences health status.[45] The degree of control that people believe they possess over their personal health may increase an individual's self-rated health and lower disease burden.[45]

Implications of Findings

Health interventions addressing personal, social, economic and environmental determinants may reduce health-related inequalities and the risk of disease late in life.[46, 47] This review provides evidence that can be applied across the life course to promote better health and well-being into old age.

Strengths and limitations of this study

This review has evaluated an extensive range of health assets, highlighting the strongest evidence for factors that positively influence health in older age.

Of the studies identified for inclusion in this review, methodological differences in study design, follow-up periods, population samples, and the way health assets and outcomes were measured precluded the pooling of results for meta-analysis. The cross-sectional designs of the majority of studies did not allow a cause-effect relationship to be examined between health asset indicators and subsequent health in older age.

Conclusions

Epidemiological evidence for health assets is essential in the preparation of effective measures aimed at enhancing health in older age. Including 'salutogenesis' in the model of health, empowers individuals to utilise their own resources and understanding to become agents of their own wellbeing.

Finding ways to implement the knowledge from this review in the form of effective interventions could be challenging when trying to modify more complex factors, and incorporate a whole of family or community approach. Focusing on single or small clusters of highly modifiable factors may provide a simple and sustainable starting point.

Finally, factors are often interdependent and cumulative, but the evidence for multi-domain composite factors is limited. This suggests potential for an instrument to measure the cumulative effect of multi-domain health assets on health status of community dwelling individuals in older age.

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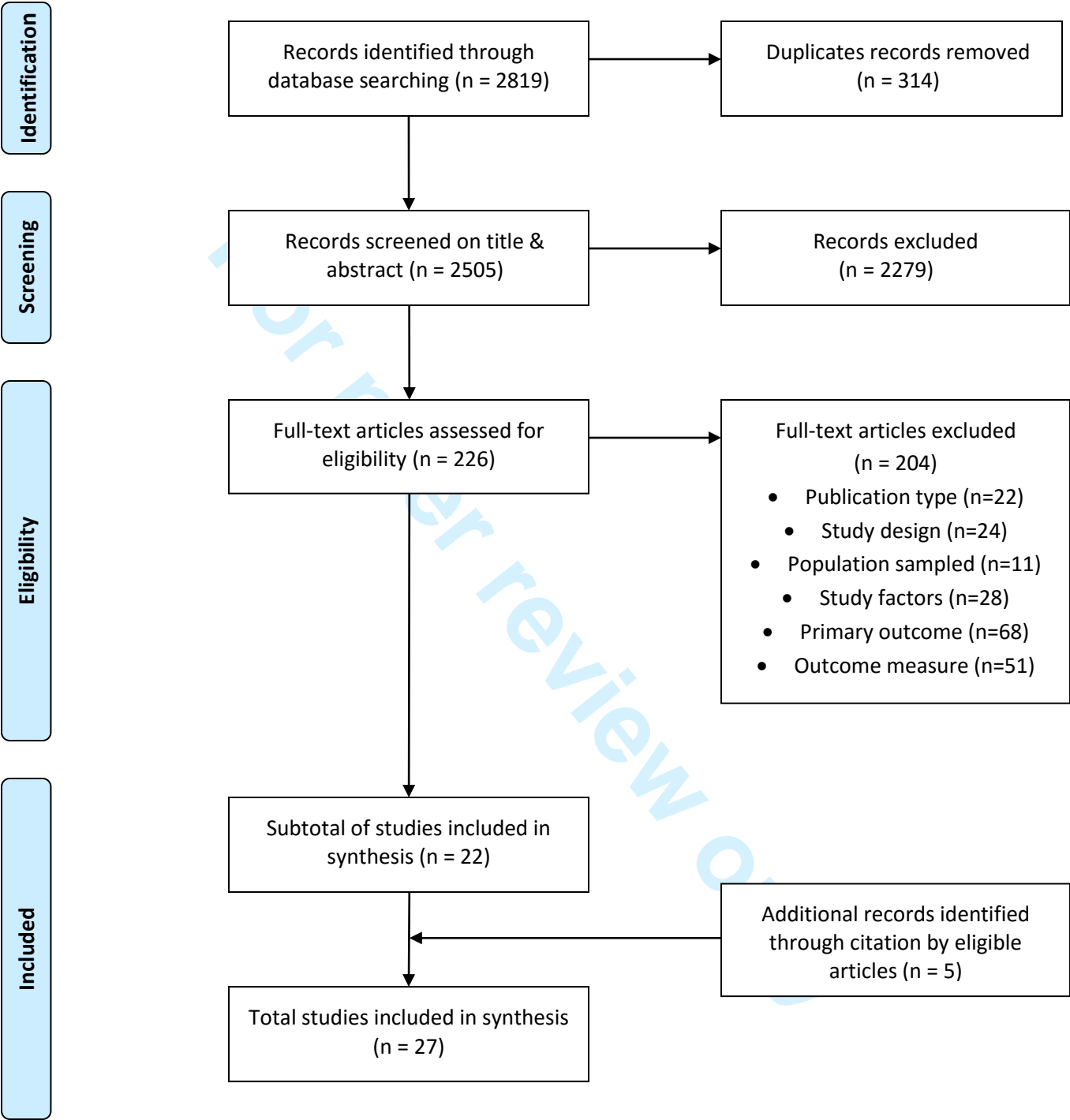
Figure 1: Flow diagram of article selection

Identification

Records identified through database searching (n = 2819)

Duplicates records removed (n = 314)

Screening

Records screened on title & abstract (n = 2505)

Records excluded (n = 2279)

Eligibility

Full-text articles assessed for eligibility (n = 226)

Full-text articles excluded (n = 204)
- Publication type (n=22)
- Study design (n=24)
- Population sampled (n=11)
- Study factors (n=28)
- Primary outcome (n=68)
- Outcome measure (n=51)

Included

Subtotal of studies included in synthesis (n = 22)

Additional records identified through citation by eligible articles (n = 5)

Total studies included in synthesis (n = 27)

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Author /Year /Country	Study name /Design /Data collection wave & year	Population / Characteristics	Main outcome /How measured /Prevalence	Predictors (Health Assets)	Findings
Andrew et al 2012 Canada[16]	**Canadian Study of Health and Ageing (CSHA)** Cross-sectional analysis of a population-based sample aged 65+ at baseline CHSA baseline 1991 CHSA-2 follow-up 5 years later	CHSA-2 N=5703 Mean age (SD) =79 (6) Females=61%	**Frailty** Measured by Frailty Index (FI) 33 health deficits −FI mean (SD)=0.17 (0.10)	**Personal** *Psychological well-being (PWB)* (based on the following six domains): - Autonomy - Personal growth - Environmental mastery - Positive relations - Purpose in life - Self-acceptance	Factors associated with increasing frailty in linear regression models: - *Worse PWB total score* - *Worse scores on* - *Personal growth* - *Environmental mastery* - *Positive relations* - *Self-acceptance* Study Quality – High
Andrew et al 2008 Canada[17]	**Canadian Study of Health and Ageing (CSHA)** Cross-sectional and longitudinal analysis (for mortality) of a population based sample aged 65+ at baseline CHSA Baseline 1991 FU every 5 years to 2001 **National Population Health Survey (NPHS)** Cross-sectional and longitudinal analysis (for mortality) of a panel survey of persons of all ages Baseline 1994 FU every 2 years to 2002	CHSA-2 N=3707 Mean age=78 Female=60% NPHS N=2648 Mean age=73 Females=58%	**Frailty** Measured by Frailty Index 40 items CHSA 23 items NPHS	**Social** *Social vulnerability* Includes: - Communication - Living situation - Social support - Social/leisure activities - Life control - Socio-economic status	Frailty had weak to moderate positive correlations with - *social vulnerability* Study Quality - Medium

1

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Andrews et al 2002 Australia[33]	**Australian Longitudinal Study of Ageing (ALSA)** Cross-sectional analysis of a population-based sample aged 70+ Baseline 1992	N=1403 Age range 70-85+ yrs. Female = 40%	**Successful ageing** Met criteria for tests on cognitive and physical functioning and physical performance. −High functioning =36% −Intermediate functioning=27% −Low functioning=37%	**Personal** - *Self-rated health* - *Importance of religion* - *Self esteem* - *Morale* - *Perceived control* **Social** - *Social participation* (household, service to others) - *Social activity*	Factors associated with low vs high functioning in logistic regression: - *Fair/poor self-rated health* - *Low morale* - *Low levels of activity* (domestic, household, service to others) Study Quality - High
Bell et al 2014 USA[11]	**Hawaii Lifespan Study** Longitudinal analysis of survivors from population-based 1965 Honolulu Heart Program Baseline 1991 FU 21 years to 2012	N=1292 Mean age (SD)= 76 (3) All male	**Healthy ageing** Met criteria for physical and cognitive function and absence of clinical disease. −Healthy survivors= 34% −Unhealthy survivors=43% −Non survivors=23%	**Personal** - *Self-rated health* **Social** - *Marital status* **Economic** - *Education*	Predictors of unhealthy vs. healthy survival in logistic regression: - *Fair or poor self-rated health* - *<12 years of education* Study Quality - High
Cernin et al 2011 USA[12]	**Stress and Success in Ageing through Good Health and Executive Functioning (SAGE)** Cross-sectional analysis of a convenience sample of older persons aged 59+ 2004	N=67 Mean age=73 Females=82%	**Successful ageing** Met objective criteria for tests on physical performance, physical and cognitive function. −Successful ageing=29.9%	**Social** - *Social support* **Economic** - *Education*	Factors associated with successful ageing in logistic regression: - *Higher quality of education* (reading score) Study Quality - Medium

2

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Cha et al 2012 Korea[19]	Cross-sectional analysis of a convenience sample of persons aged 60+ 2009	N=305 Mean age=71 Females=73%	**Successful ageing** Measured by physical, psychological and social functioning (range 19-95) −Successful ageing mean (SD)=64.3 (11.3)	**Personal** - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement*	Factors associated with successful ageing in multiple regression: Higher levels of - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement* Study Quality – High
Chaves et al 2009 Brazil[36]	Cross-sectional analysis of a random sample of households with at least one person aged 60+ 1996	N=345 Mean age (SD) =70 (7) Females=70%	**Successful ageing** Met criteria for health, physical, psychological and cognitive functioning. −Successful ageing= 62% −Normal ageing=38%	**Social** - *Marital status* - *Social network* - *Social support* - *Social activities* **Economic** - *Education* - *Income*	Factors associated with successful ageing in logistic regression: - *Having fewer living children* - *Having more confidants* - *Higher family income* Study Quality - High

3

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Chou & Chi 2002 Hong Kong[20]	Cross-sectional analysis of a representative sample aged 60+ 1995	N=1106 Age range 60-69=37% 70-79=45% 80+=18% Females =56%	**Successful ageing** Measured by physical, affective and cognitive functioning and productive involvement. Successful ageing (0-4) met criteria for high function on −4 criteria=0.7% −3 criteria=8.0% −2 criteria=24.7% −1 criterion=33.1% −0 criteria=33.5%	**Personal** - *Self-rated health* - *Life satisfaction* - *Stressful life events* **Social** - *Marital status* - *Social network* - *Social support* **Economic** - *Education* - *Income*	Factors associated with successful ageing in multiple regression analysis: - *Better self-rated health* - *Greater life satisfaction* - *More close relatives* - *Higher frequency of contact with friends* - *More years of education* - *Less financial strain* Study Quality - High
Formiga et al 2011 Spain[28]	**Octabaix study** Cross-sectional analysis of a longitudinal population-based of persons born in 1924 year olds Baseline 2009	N=328 Age =85 Females =62%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful aging=49.4% -Non successful aging =50.6%	**Personal** - Quality of Life **Social** - Marital status - Living arrangements - Social risk **Economic** - Education	Factors associated with successful ageing in bivariate analysis: - *Higher Quality of Life* - *Being widowed* - *Lower social risk* - *Higher level of education* Study Quality - High

4

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Formiga et al 2012 Spain[27]	**Octabaix study** Longitudinal population-based sample of persons born in 1924 Baseline 2009 FU 2 years	N=146 Age=87 Females=56%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful ageing at 2 year FU=61.6% -Non successful ageing=38.4%	**Personal** - *Quality of Life* **Social** - *Marital status* - *Living arrangements* - *Social risk* **Economic** - *Education*	Predictors of (continued) successful ageing in multiple regression: - *Higher level of education* Study Quality - High
Gobbens et al 2010 Netherlands[29]	Cross-sectional analysis of a representative sample of community dwellers aged 75+ 2008	N=484 Mean age (SD) =80 (4) Females=57%	**Frailty** Measured by Tilburg Frailty Indicator across physical, psychological and social domains (scale range 0-15). -Mean FI men=3.99 -Mean FI women=4.92	**Personal** - *Life events* **Social** - *Marital status* **Economic** - *Education* - *Income*	Factors associated with frailty in multiple regression: - *Medium level of income* Study Quality - High
Gureje et al 2014 Nigeria[37]	**Ibadan Study of Ageing (ISA)** Longitudinal study of representative sample aged 65+ Baseline 2003 FU yearly 2007-2009	N=930 Mean age=79 Females=39%	**Successful ageing** Met criteria on physical and functional health and life satisfaction. -Successful ageing=7.5%	**Personal** - *Self-rated health* **Social** - *Social network* - *Social participation* **Economic** - *Education* - *Material possessions* **Environment** - *Place of residence*	Predictors of successful ageing in multivariate analysis: - *Having contact with friends* - *Participation in community activities* Study Quality - High

5

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Hamid et al 2012 Malaysia[21]	**Mental Health and Quality of Life of Older Malaysians** Cross-sectional analysis of a national representative sample aged 60+ 2004	N =2749 Age groups: 60-69 =1408 70-79 =1005 80+ =329 Females =50%	**Successful ageing** Met criteria for physical and psycho-cognitive functioning and absence of major disease. -Successful ageing= 13.8%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Employment* **Environment** - *Place of residence*	Factors associated with successful ageing in logistic regression: - *Higher educational attainment* - *Higher household income* Study Quality – Medium
Hodge et al 2013 Australia[34]	**Melbourne Collaborative Study** Longitudinal population-based study Baseline 1990 - 1994 Follow-up 2003 – 2007	N=5512 Age=70+ Females =63%	**Successful ageing** Met criteria for physical and psychological functioning and survived to age 70, with absence of chronic disease. -Successful ageing= 21.5% -Usual ageing=78.5%	**Social** - *Marital status,* - *Living arrangements* - *Social network* - *Social activity* **Economic** - *Socio Economic Indexes For Areas (SEIFA)* - *Education*	Predictors of successful ageing in multivariate logistic regression: - *Being in the top SEIFA quintile* Study Quality – High
Hubbard et al 2014 UK[31]	**English Longitudinal Study of Ageing (ELSA)** Cross-sectional study of nationally representative population-based study of persons aged 50+ 2002	N=3225 Mean age=71 Females =52%	**Frailty Index** Measured by the Frailty Index 50 health deficits Mean FI for -Males= 0.110 -Females=0.138	**Personal** - *Well-being*	In multiple regression, higher frailty associated with: - *Poorer well-being* (with and without adjustment for levels of wealth and income) Study Quality - High

6

Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Jang et al 2009 Korea[22]	Cross-sectional analysis of a representative sample of residents aged 65 + 2003	N=1825 Mean age (SD) =73 (6) Females = 65%	**Successful ageing** Met criteria for physical, psychological and social functioning and subjective well-being and low level of chronic disease -Successful ageing= 23.7%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Material possessions*	Factors associated with successful ageing in logistic regression: - *Higher years of education* - *Higher personal income* Study Quality - Medium
Kozar-Westman et al 2013 USA[13]	Cross-sectional analysis of persons living in assisted living facilities	N =200 Mean age (SD) =80 (10)	**Successful ageing** Measured by successful ageing inventory (SAI) - 20 item Range 0-80 higher scores denote greater successful ageing. -Successful ageing mean (SD) = 64.1 (10.8)	**Personal** - *Life satisfaction* - *Purpose in Life*	Successful ageing positively correlated with: -*Life satisfaction* -*Purpose in Life* Study Quality - Medium
Lang et al 2009 UK[32]	**English Longitudinal Study of Ageing (ELSA)** Cross-sectional, nationally representative population-based study of persons aged 50+ 2002	N =4818 Mean age =74 Females =55%	**Frailty** Measured by the Frailty Index 58 health deficits Mean FI for -Males= 0.13 -Females=0.16	**Economic** - *Assets* - *Neighbourhood deprivation*	Associations with higher frailty in multi linear regression: - *Lower levels of wealth* - *Greater neighbourhood deprivation* Study Quality – High

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Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Li et al 2006 China[23]	**Shanghai Dementia Survey** Cross-sectional survey of random sample of community-dwellers aged 65+ 2000 - 2001	N=1516 Mean age (SD) =73 (6) Females =53%	**Successful ageing** Met criteria on psychological and physical functioning, with no disabilities. -Successful ageing=46.2% -Usual ageing=40.1% -Remainder excluded because of cognitive impairment	**Personal** - *Life satisfaction* - *Life Events* **Social** - *Marital status* - *Social support* - *Leisure activities* **Economic** - *Education* - *Economic status* - *Employment*	Successful ageing in logistic regression is associated with: - *Greater life satisfaction* - *Being currently married* - *More leisure activities* - *Being satisfied with economic situation* Study Quality - High
Meng & D'Arcy 2013 Canada[18]	**Canadian Community Health Survey: Healthy Ageing** Cross-sectional survey of a national sample of persons aged 45+ 2008 - 2009	N=8154 Aged 65+	**Successful ageing** Measured by the absence of major disease and met criteria for cognitive and physical functioning and life engagement. -Successful ageing=37.2%	**Personal** - *Self-rated health* - *Life satisfaction* **Social** - *Marital status* **Economic** - *Education* - *Income* **Environment** - *Place of residence*	Factors associated with successful ageing in logistic regression: - *Better self-rated health* - *Greater life satisfaction* - *Being married* Study Quality - High
Ng. C et al 2014 Singapore[26]	**Marine Parade Elderly Needs Survey** Cross-sectional survey of a stratified random sample of community dwelling adults aged 60+ from a national database of dwellings 2011	N=2444 60-64 = 807 65-74 =1183 75-84 =341 85+ =113 Females=57.2%	**Healthy ageing** Met criteria on physical, mental and social health. -Health at risk=19% -Relatively healthy=81%	**Economic** - *Education* - *Income* - *Employment* - *Housing type*	Factors associated with Health at Risk in logistic regression: - *Primary or lower education* - *Not employed or unemployed* Study Quality – Medium

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Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Ng et al 2009 Singapore[24]	**Singapore Longitudinal Ageing Study (SLAS)** Cross-sectional population based study of persons aged 55+ 2003 – 2004	N=1281 Mean (SD)=72 (6) Females =60%	**Successful ageing** Met criteria for physical health and functioning, cognitive, emotional and social functioning and life satisfaction -Successful ageing=28.6% -Non successful ageing=71.4%	**Personal** - *Religious beliefs* - *Quality of life (QoL)* **Social** - *Marital status* - *Living arrangements* - *Social network* - *Social support* - *Social activity* **Economic** - *Education* - *Financial resources* - *Housing type*	Factors associated with successful ageing in multivariate analysis: - *Better scores on physical and mental well-being (QoL)* - *Having religious beliefs* - *More years of education* - *Better housing* Study Quality - High
Parslow et al 2011 Australia[35]	**Survey of Mental Health and Well-being** Cross-sectional population-based sample aged 60+ 2007	N=2,286 Mean age (SD) =71(7) Females = 51%	**Successful ageing** Met criteria for physical and mental health, life satisfaction, cognitive functioning (weighted scores ranged from 4.6-16.26) Successful ageing Mean (SD) weighted score = 12.9 (1.6) -Highest decile=8.4% -Lowest decile=10.3%	**Personal** - *Traumatic life events* **Social** - *Living arrangements* - *Social network* - *Social support* **Economic** - *Education*	Factors associated with being highest decile compared with lowest decile of successful ageing - *Fewer traumatic life events* - *More contact with friends* - *Being able to rely on, confide in family, friends* - *Less likely to live alone* - *Higher level of education* Study Quality – High

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Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Romero-Ortuno 2014 Europe[30]	**Survey of Health, Ageing and Retirement in Europe (SHARE)** Cross-sectional analysis of a representative sample of community dwellers from 12 European countries aged 50+ Baseline 2004-05	N=29,905 Mean age (SD) Females=65(10) Males=64(10) Females = 54%	**Frailty** Measured by the Frailty index 40 health deficits FI in quartiles by gender and age group	**Economic** - *Education* - *Income*	Predictors of higher frailty in multivariate ordinal regression - *Fewer years of education* - *Difficulties making ends meet* Study Quality - High
Stevens-Ratchford 2011 USA[14]	Cross-sectional study of convenience sample of community dwellers aged 55+	N= 292 Mean age=72 Females = 67%	**Successful ageing** Measured by the absence of disease and met criteria for cognitive and physical functioning and engagement with life. Measured by Successful Ageing Profile (SAP) -Successful ageing mean (SD)=34 (6) (Range 14-68)	**Economic** - *Productive engagement*	Successful ageing had weak to moderate positive correlations with: - *Continuity of long standing occupation* - *Meaning of long standing occupation* - *Continuity of productive occupation* - *Meaning of productive occupation* Study Quality – Medium

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Table 1: Studies measuring the relationship between personal, social, economic, and environmental health assets and health status in older age

Vaillant & Mukamal 2001 USA[15]	**Harvard Study of Adult Development** Longitudinal study of male adolescents (college students and core city youths) Baseline at age 50 FU 15 to 25 years	College men N=237 Aged 75-80 Core-city men N=332 Aged 65-70	**Successful ageing** Met criteria for objective and subjective physical and mental health, years of active life, life satisfaction and social support. SA (happy-well) College men (75-80) = 26% Core-city men (65-70) = 29%	**Personal** - *Coping mechanisms* **Social** - *Marital stability* **Economic** - *Education*	Predictors of successful ageing most vs least successful ageing groups in multivariate models: -*Having mature coping defences* -*Stable marriage* (core-city men) - *More years of education* (core-city men) Study Quality - Medium
Woo et al 2005 Hong-Kong[25]	Cross-sectional analysis of a stratified random sample aged 70+ 1990-1991	N=2,032 Age=70+ Females =51%	**Frailty** Measured by the Frailty Index 62 health deficits Mean (SD) FI for - Females=0.156 (0.08) - Males=0.128 (0.08)	**Social** - *Social network* - *Social participation* **Economic** - *Education* - *Income* - *Occupation*	Factors associated with higher frailty in multiple regression: For males - *Occupation* (non-white collar job) - *Inadequate finances* - *Few relatives and neighbours* - *Infrequent participation in helping others* For females -*Inadequate finances* -*Infrequent contact with relatives* -*Infrequent participation in helping others* - *Infrequent participation in community/ religious activities* Study Quality - Medium

11

PRISMA 2009 Checklist

/Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Yes
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Yes
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	1-3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	This review is registered with PROSPERO: CRD42016035286
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	2-3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	1-2
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	2-3
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	4
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A

PRISMA 2009 Checklist

Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	3-4

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	3
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	3
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1 pg. 4
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	4 Table 1, pg. 4
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 1, pg. 4
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 1, pg. 4
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Table 1, pg. 4 Pg. 7
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	7-9
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	8-9
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	7-9
FUNDING			

PRISMA 2009 Checklist

Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	N/A

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BMJ Open

Health assets in older age: a systematic review

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Title

Health assets in older age: a systematic review

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1. Health assets
2. Health status
3. Aged
4. Psychosocial factors
5. Environmental factors
6. Economic factors

Word count, excluding title page, abstract, tables, and references: 3739

ABSTRACT

Background

Finding ways to optimise health in older age is key to reducing the impact of population ageing on health and social care systems. A salutogenic approach takes into account an individual's health assets - internal or external strengths or accessible resources which improve and preserve physical, social and mental wellness, independence, and quality of life. The aim of this narrative systematic review was to provide a summary and appraisal of the evidence for factors that act as health assets within personal, social, economic and environmental domains.

Methods

Systematic searches of databases were conducted for literature published in peer reviewed journals between January 2000 and November 2016. Selection criteria included community dwelling populations aged 65 and over and publications written in English. Data on study population, design, measures of health status, factors within the four previously stated domains, and results were extracted. Study quality was independently assessed using an appraisal instrument.

Results

Twenty-three publications, including 78,422 participants, from more than 13 different countries were identified for inclusion in this review. There was strong evidence that higher scores of self-rated health, psychological wellbeing, and life satisfaction were associated with better health in older age. Social network and contact with family and friends, engagement in leisure and social activities, were important support mechanisms. Education and financial resources consistently proved to be key economic health assets for older adults.

Conclusions

Implementing an asset based approach to health promotion uncovers the skills, knowledge, connections and the potential of the individual and the community. This approach is an ideal opportunity for government health bodies and their partners to respond to the challenges faced by global ageing.

Factors are often interdependent and cumulative, suggesting the potential for an instrument to measure the accumulated effect of health assets on health status on older adults.

Strengths and limitations of this study

- This review has evaluated an extensive range of health assets, highlighting the evidence for factors that positively influence health in older age.

- Of the studies identified for inclusion in this review, methodological differences in study design, follow-up periods, population samples, and the way health assets and health status were measured precluded the pooling of results for meta-analysis.

- The cross-sectional designs of the majority of studies did not allow a cause-effect relationship to be examined between health asset indicators and subsequent health in older age.

What is already known on this subject?

- Determinants that influence health in older age are complex and wide-ranging
- Approaches to the promotion of health have been based on an 'illness' model focussing mainly on risk factors for disease, rather than those factors associated with a wellness model.
- Health is a dynamic balance between 'assets' which help a person maintain their independence in the community, and 'deficits', which threaten independence
- The concept of 'health assets' has not been widely explored in health care

What this study adds

- This systematic review summarises the evidence for 'health assets' that positively influence, or are protective of, health in older age
- Identifying 'health assets' will support the design of effective policies and programmes for the promotion of health in older age
- Including 'health assets' in the health model, empowers individuals to utilise their own resources and understanding to become agents of their own wellbeing
- This study highlights potential for a composite measure of health assets to evaluate cumulative factors known to positively influence health and well-being

INTRODUCTION

On a global level, people aged 65 or older are the fastest growing segment of the population.[1] Whilst global ageing is perceived as a success, the continued growth of this population will add increasing economic and social demands on all countries.[2] This demographic shift in global ageing also entails fundamental social, economic and development challenges and opportunities, not the least of which is the increasing priority to meet the needs of older persons while enabling them to have longer, healthier and more productive lives.[3] Identifying ways to enhance health and well-being in older age is key to reducing the impact of global ageing, and is therefore a fundamental issue for policy makers.[1]

Based on the World Health Organisation (WHO) definition, health in older age is described as a life course process of optimising opportunities for improving and preserving physical, social and mental wellness, independence, quality of life and enhancing successful transitions.[2, 4] This holistic definition recognises that health is multifactorial, spanning across the various domains of well-being. Hence factors that influence health are complex and wide-ranging.

In 2002, the World Health Organization (WHO) published the Active ageing: a policy framework.[2] This framework identifies six key domains of active ageing: economic, behavioural, personal, social, health and social services, and the physical environment.[2] This framework highlights the need for quality evidence to support appropriate policies and programs across all domains to promote health in older age.

Historically, approaches to the promotion of health have been based on an 'illness' model. The focus is mainly on risk factors for disease, 'health deficits', rather than those associated with improving health status. While the presence of risk factors increases the likelihood of poor health, their absence does not necessarily increase the likelihood of good health. This approach of identifying risk factors for disease is essential for understanding specific needs and priorities; however, it tends to define individuals in negative terms and may overlook important positive factors which improve public health.[5]

In contrast, a 'wellness' model accentuates a salutogenic approach, concerned with identifying protective factors, 'health assets', to support health and wellbeing, rather than those that cause disease.[6] 'Health assets' are defined as an individual's internal or external strengths or accessible resources which enhance ability to optimise health.[5, 7, 8] Identifying 'health assets' that positively influence or are protective of health in older age will support the design of effective policies and programs for the promotion of health in older age.

Previous reviews in this research area have examined the concept of health assets in a health care context.[7, 9] Other similar systematic reviews include Peel et al.,[10] who identified a broad range of behavioural predictors, and Depp and Jeste,[11] who examined demographic, psychosocial, and biomedical correlates of successful aging. To our knowledge, however, no other review has provided an overview of 'health assets' or positive health determinants, with a focus on personal, social, economic and environmental predictors of positive health in older age in community-dwelling adults.

The aim of this review was to conduct a narrative summary and appraisal of evidence, published from the year 2000 onwards, for factors that have potential to act as health assets and promote health in older age. Based on the WHO active ageing policy framework, factors within the personal,

environmental, economic, and social domains were selected with a focus only on those that are protective of health in older age and are amenable to change through policy or intervention.

METHODS

Literature search

In October 2014, a systematic search of databases (PubMed, Medline, Embase, CINAHL, and PsycNet) for literature was undertaken to address the study question "What health assets positively influence health in older age?" Further, additional articles were identified by manually reviewing the references lists of included papers. An updated literature search using the same methodology was conducted in November 2016. The search strategy for this literature search is presented in Table 1.

Table 1: Search Criteria	
Outcome terms[a]	health status OR successful ag*ing OR healthy ag*ing OR positive ag*ing OR ag*ing well OR longevity
	AND
Factor terms	factor* OR predict* OR indicator* OR determinant
Filters	- published between January 2000 and November 2016 - human subjects - English language - population aged 65 or older
Notes	* is used to indicate the term is truncated or has spelling variation. [a] these terms were adopted in search criteria since this nomenclature dominates the literature describing a multidimensional composite measure of health status in older age[10]

Titles were screened (YHT) for appropriateness. Two authors (YHT, NMP) independently reviewed abstracts to further eliminate studies not meeting the selection criteria presented in Table 2. The full text of all remaining articles was retrieved and the decision to include in the review was made by two authors (YHT, NMP) in consultation with third author (REH) where doubt existed. In addition, reference lists of included articles were searched to identify other studies meeting the inclusion criteria.

Table 2: Selection Criteria

Criteria	Included	Excluded
Publication type	• published in peer reviewed scientific journals • reporting original research results • written in English	• reviews, book chapters, editorials, dissertations, theses and conference abstracts • "grey" literature
Study design	• observational studies with a primary aim to measure associations between key determinants and health in older age • quantitative studies	• qualitative studies • studies evaluating models for healthy ageing
Population	• mean age at baseline ≥65 • community dwelling	• mean age at baseline <65 • hospitalised, residing in long term care or assisted living communities
Study factor domains	• personal • social • economic • environmental	• behavioural or lifestyle factors [a] • factors which were part of multi-domain outcome measure
Outcome measure	• health status to include a composite measure across multi-domains of physical, mental and social well-being	• health measured as a single item question e.g. self-reported health or life satisfaction

Notes

[a] not included in this review as these factors have been a focus of a previous review[10]

Data Extraction

Two authors (YHT and NMP) independently extracted the data on study population, study design, measures of health status, all modifiable social, personal, economic and environmental factors, analyses, and results using a standardised spreadsheet. Data were compared and agreement on study variables reached by consensus. Study characteristics recorded are listed in Table 3 (supplementary material). Measurement of the outcome, health status, as well as prevalence in the study population was documented. Factors which positively influenced (or were protective of) health status were classified under personal, social, economic and environmental domains.

Data Synthesis and Analysis

Data was synthesised and reported according to the PRISMA statement.[12] Due to the heterogeneity of study populations, outcome and predictor measures, a meta-analysis was not possible.

Study Quality

Studies were evaluated using a modified version of an epidemiological appraisal instrument,[13] comprising 20 questions; scores for each question ranged from 2 to 0, depending on whether the question was fully, partially, or not addressed. An average score was calculated for each study, which could then be classified into low, medium or high quality categories. The criteria for quality assessment and the number of studies scoring a minimum of 1 point for each item is included in Table 4 supplementary material. Study quality was independently assessed by two authors (YHT, NMP) based on the instrument guidelines.[13]

Review Quality

A PRISMA 2009 checklist for this review is included in Table 5 supplementary material. This review is registered with PROSPERO study ID: CRD42016035286.

RESULTS

The search of online databases in October 2014 identified 2819 publications. Following the exclusion of duplicates (from two or more databases) and the screening of titles and abstracts, 226 articles proceeded to full text screening. Of these, 204 failed to meet the specified selection criteria (Table 2), resulting in 22 eligible articles. Five articles were added following screening of references cited in eligible articles, taking the total number to 27. An updated literature search identified an additional three articles, as well as one article from searching the reference lists of these articles. Seven articles were excluded following the decision to remove papers reporting on factors associated with a negative health outcome (such as frailty). The final number of articles included in this review is 23. Figure 1 displays the flow diagram for selection of eligible articles for inclusion in the analysis.

< Figure 1: Flow diagram of article selection>

Study Characteristics

Study characteristics are shown in Table 3 (supplementary material). Publication dates of the 23 selected articles ranged from 2001 to 2016, analysing data from populations in the USA,[14-17] Canada,[18, 19] Asia,[20-27] Europe,[28-30] Australia,[31-33], Mexico,[34] South America,[35] and Africa.[36] Studies included 22 different population cohorts, with sample sizes ranging from 67 to 10,048 participants and mean age between 70 to 87 years. Most studies included both males and females, in which the proportion of females varied from 39% to 82%. Two were male only.[14, 17] Cross-sectional analysis was used in 16 studies, with the remaining seven studies[14, 17, 19, 25, 29, 32, 36] using baseline data to predict subsequent health status.

Health Status Measures

All but one article investigated factors in relation to successful or healthy ageing. Studies used different definitions, with the majority basing health measures on the model of Rowe and Kahn,[37] who defined successful ageing as the avoidance of disease and disability, the maintenance of high

physical and cognitive function, and sustained engagement in social and productive activities. One article[25] measured health status using a health index, which, similar to the healthy ageing model, assessed physical and cognitive function, psychological well-being and subjective health to provide a composite measure. The prevalence of successful/healthy ageing ranged from 1% in the Hong-Kong sample, meeting criteria for high functioning in all four domains (physical, affective and cognitive functioning and productive involvement),[21] to 81% in a community sample from Singapore,[26] who met criteria on physical mental and social health.

Determinants of Health Status

Personal

A total of twelve articles investigated personal factors as determinants of health status.[14, 17, 18, 20, 21, 24, 27, 29-31, 33, 36] Personal factors incorporate a wide range of attitudes, perceptions and internal resources that relate to health and well-being.

Self-rated health, measured on a scale from poor to excellent, was investigated in five studies.[14, 18, 21, 31, 36] A significant relationship between self-reported health and successful ageing was reported in all but one study,[36] suggesting those who perceived their health as good to excellent were more likely to age successfully than those who perceived their health as fair to poor.

Well-being was investigated in nine studies.[17, 18, 20, 21, 24, 27, 29-31] Higher levels of self-esteem, self-achievement, self-efficacy, interpersonal relationships,[20] and religious beliefs[27] were found to be associated with successful ageing, while a higher morale was associated with higher functioning.[31] Successful agers expressed greater life satisfaction[18, 21, 24] and a higher quality of life[27, 30] in cross-sectional analysis. However, quality of life was no longer a predictor of continued successful ageing in the Octabaix study in longitudinal follow-up.[29] Having mature coping mechanisms[17] and fewer traumatic life events[33] were also found to be associated with successful ageing.

Social

A total of 19 articles investigated social factors as determinants of health status.[14, 15, 17, 18, 21-25, 27-36] Two studies screened multiple factors to create a composite measure of social risk. Formiga et al.[29, 30] used the Gijon scale to assessing family and economic situation, housing, relationships and social support as a composite measure of social risk. Data were collected from this Spanish sample at both baseline and two-year follow-up. A lower score on the social risk scale was associated with successful ageing in cross-sectional analysis;[30] however, this association was no longer significant in longitudinal follow-up.[29] Sowa et al.[28] used a psychosocial index based on a combination of social and personal factors, including employment, social participation, leisure activities and satisfaction with social network, in a subsample of the European SHARE data. A higher score on the psychological index was associated with better health in cross-sectional analysis in both the male and female samples.

Marital status and living arrangements were investigated in 13 articles.[14, 18, 21-24, 27, 29, 30, 32-35] Being married, or not living alone, were positively associated with successful ageing.[18, 24, 33, 34] In contrast, the Octabaix study found being widowed was associated with successful ageing at baseline, 85 years of age, but not at follow-up two years later.[29, 30] A longitudinal study, of two cohorts of adolescent boys (college students and city youth) in the USA, investigated marriage stability and its ability to predict health status in later life. [17] For the city cohort, having a stable

marriage in mid-life was a predictor for successful ageing in later life. This factor did not influence health status in the college cohort.

Social network, commonly measured by the number and frequency of contact with family, friends, and neighbours was investigated in seven studies.[21, 25, 27, 32, 33, 35, 36] Having a wide social network[21] and close contact with friends[21, 33, 36] was found to support successful ageing in all but one[35] of these studies. Li and Zhang[25] investigated a range of social support network types and their effect on health status in a chinese population, aged 80 and over. Those who had a diverse network, including contact with family and friends, as well as participation in social activities, had better health than those with either a restricted, friend, or family only focused network type. However, a South American study,[35] using cross-sectional analysis, found having fewer living children was associated with successful ageing in their largely female (70%) sample.

Social support, measured in terms of emotional or instrumental support was investigated in five study cohorts; three of which found having confidants and support from family and friends were positively associated with successful ageing.[21, 33, 35] In an Australian sample of persons aged 70 and over,[31] providing support to others in cross-sectional analysis was significantly associated with higher level functioning.

Engagement in social activities was investigated in six studies.[24, 27, 31, 32, 35, 36] Participation in community-leisure activities was found to be associated with successful ageing in two study cohorts. [24, 36] Finally, participation in domestic and household activities was found to be a protective factor in successful ageing in a sample of older Australians.[31].

Economic

A total of 20 studies investigated economic factors as determinants of health status.[14-19, 21-24, 26-30, 32-36] All studies included education as an economic indicator in their investigations, with level of attainment and years of study the most common measures of education. Thirteen of these studies found, more years, or a higher level, of education was associated with, or predictive of, successful ageing in cross-sectional,[21-23, 26-28, 30, 33, 34] as well as longitudinal[14, 17, 19, 29] data analysis. One study focused on the quality of education derived from a reading score, [15] showing that a higher quality of education was associated with successful ageing.

Income was investigated in eight studies.[18, 19, 21-23, 26, 34, 35] In cross-sectional analyses, having higher personal,[23] or household[22, 35] income was associated with successful ageing. Financial strain was investigated in three studies, cross-sectional[21, 24] and longitudinal analysis[19] of this data found those reporting that their financial resources were adequate for their needs were more likely to age successfully than those experiencing financial strain.

Occupation class or employment status was investigated in four articles.[16, 19, 22, 24] Of these, one study[26] found being employed was associated with better health, and a second[16] found a weak to moderate correlation between continuity and meaning of occupation and successful ageing.

The influence of housing type[26, 27] and material possessions[23, 36] on successful ageing was investigated in four studies. One study[27] found better housing was associated with successful ageing in cross-sectional analysis.

A composite measure of socioeconomic status was investigated in data from the Melbourne collaborative study[32]. Based on census data, the Socio Economic Index for Areas (SEIFA) is an index

of relative socio-economic disadvantage, measuring, at an area level, factors such as income, education and occupational status. Longitudinal analysis found, being in the top SEIFA quintile was a predictor of successful ageing.

Environmental

Environmental factors, including geographical location[28] and place of residence,[18, 22, 36] were investigated in relation to successful ageing in four studies. The latter three studies examined the effect of urban versus rural locality on successful ageing and found no significant relationship. However, those residing in Western or Southern Europe were more likely to be in the healthy ageing group, compared with those in Central Europe.

Study Quality

Using the modified Epidemiological Appraisal Instrument, scores for assessment of methodological quality ranged from 14 to 36, out of a possible 40 points, with an average score of 27.8 points. Studies were classified into low (0 - 13), medium (14 – 27) or high quality (28 – 40) categories, determined by their final score. Study quality results are included in Table 3 (supplementary material). The assessment criteria that were most poorly reported by the studies included in this review were the participation rates, and the reliability and validity of the exposure variables (Table 4 supplementary material).

DISCUSSION

This narrative systematic review summarises the evidence for factors within personal, social, economic and environmental domains that can be termed "health assets" of older adults. Of these, there was strong evidence from multiple high quality studies to suggest self-rated health, life satisfaction, psychological well-being, social networks, engagement in leisure and social activities, education, and financial resources are associated with health status in community dwelling older populations.

Although the review included studies from a diverse range of countries in the developed and developing world, cross national comparisons of factors influencing ageing well were not possible because of differences in population sample characteristics, health status and study factor measures. The prevalence of successful ageing covered a wide range from 1% to 81%. The one study incorporating cross-country comparisons found the differences in healthy ageing could be attributed to the prevalence of chronic conditions in Central–Eastern Europe as opposed to Western or Southern Europe. Education was the most commonly studied factor in this review with strong evidence cross-nationally that a higher level of education is widely associated with positive health in older age.

The majority of studies included in this review measured factors individually, even though their effects are often interdependent and additive.[38] A small number of studies, however, used composite measures including a multi-domain measure of social risk,[29, 30] and single domain multi-factor measure of socioeconomic status.[32] A multi-domain summative measure of protective factors was investigated in older adults in Beijing.[38] This study reported that for each accrued protective factor, the risk of health decline and death was reduced by 13% to 25%. This data suggests that the more protective factors the individual possesses, the more the risk of poor health is reduced and the greater the opportunity for recovery. The rationale underpinning the study of

'health assets' is similar to that of 'health deficits'; both measure an accumulation of factors across multiple domains that predict health status. While an accumulation of deficits predicts ill health, an accumulation of health assets may mitigate risk and promote good health. This highlights potential for a 'health assets' tool to evaluate cumulative factors known to positively influence health and well-being. Such a tool could be useful in epidemiological studies to examine why individuals have different health outcomes depending on their level of health assets.

A person's health and wellbeing has many facets, resulting from a complex interplay between factors within multiple domains.[2] Such factors are highly influenced by cultural norms, gender specific roles,[3] and the resources and policies of the wider society.[39] The modifiability of these factors therefore can be highly dependent on the individual and the context in which they live. While some factors are seemingly immutable at the individual level, population health policies to reduce poverty, provide social support, connection to culture, and equitable access to health care can protect against the effects of living in disadvantaged circumstances. Other factors under personal control, for example engagement in leisure and social activities, are more amenable to interventional programs and policies.[39] Furthermore, enabling people to develop and maintain varied social networks and participation in social and recreational activities, may not only help them on a social level, but can also have a positive impact in other domains including maintaining independence, life satisfaction, wellbeing, and physical and mental health.

The mechanism through which health assets can influence health may be direct or indirect. For example, those on very low incomes may lack resources and access to adequate housing, safe environments and health care, which can impact negatively on health. Financial and life stressors, as well as lack of resources, social support and connectedness can contribute directly to poorer physiological health (for example, increased risk of high blood pressure, immune and circulatory complications) or indirectly, through less healthy coping skills and behaviours (for example, excessive alcohol consumption or substance abuse). Although self-rated health is a consistent indicator of objective health and a robust predictor of health outcomes, little is known about the mechanism by which it influences health status.[40] The degree of control that people believe they possess over their personal health may increase an individual's self-rated health and lower disease burden.[40]

Implications of Findings

Health interventions addressing personal, social, economic and environmental determinants may reduce health-related inequalities and the risk of disease late in life.[41, 42] This review provides evidence of health assets that can be applied across the life course to promote better health and well-being into old age.

Although many health assets are already present in our lives, the individual and others around them may not necessarily be mindful or make purposeful use of them. Empowering people to recognise and build on their potential health assets may help protect and promote health status. An asset based approach to health promotion exposes and values the skills, knowledge, connections and the potential of the individual and those around them.[43] The aim of this approach is to strike a balance between meeting the needs and nurturing the strengths and resources of the individual and community. Demographic changes in global ageing means that more people will require help and support. This assets based approach is an ideal opportunity for government health bodies and their partners to respond to these challenges.

Strengths and limitations of this study

This review has evaluated an extensive range of health assets, highlighting the strongest evidence for factors that positively influence health in older age.

Methodological differences in study design, follow-up periods, population samples, and the way health assets and outcomes were measured by the studies included in this review precluded the pooling of results for meta-analysis. Including only papers published in English is acknowledged as a limitation, affecting cross-cultural comparisons and ability to generalise results to non-English speaking countries.

Cross-sectional analysis in the majority of studies did not allow for investigation of causality, while longitudinal analysis was largely unidirectional, with study factors such as better self-rated health, social network support, and higher educational attainment predicting subsequent successful ageing. Only one study[25] examined bidirectional relationships, showing that social network types were predictive of subsequent health status, but also that a decline in health affects social network type.

Conclusions

This systematic review summarises the evidence for health assets, thus adding to the currently limited body of literature within this field. This evidence is essential for the preparation of appropriate policies and effective health interventions.

Health assets are the individual's accessible internal or external strengths and resources; empowering people to recognise and build on their health assets may help protect and promote health status in older age. Implementing an asset based approach to health promotion uncovers the skills, knowledge, connections and the potential of the individual and the community. This approach is an ideal opportunity for government health bodies and their partners to respond to the challenges faced by global ageing.

Factors known to influence health are often interdependent and cumulative, but the effect on health of a multi-domain, composite measure of positive factors is largely unknown. This suggests potential for an instrument to measure the cumulative effect of multi-domain health assets on health status in older adults.

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Figure 1: Flow diagram of article selection

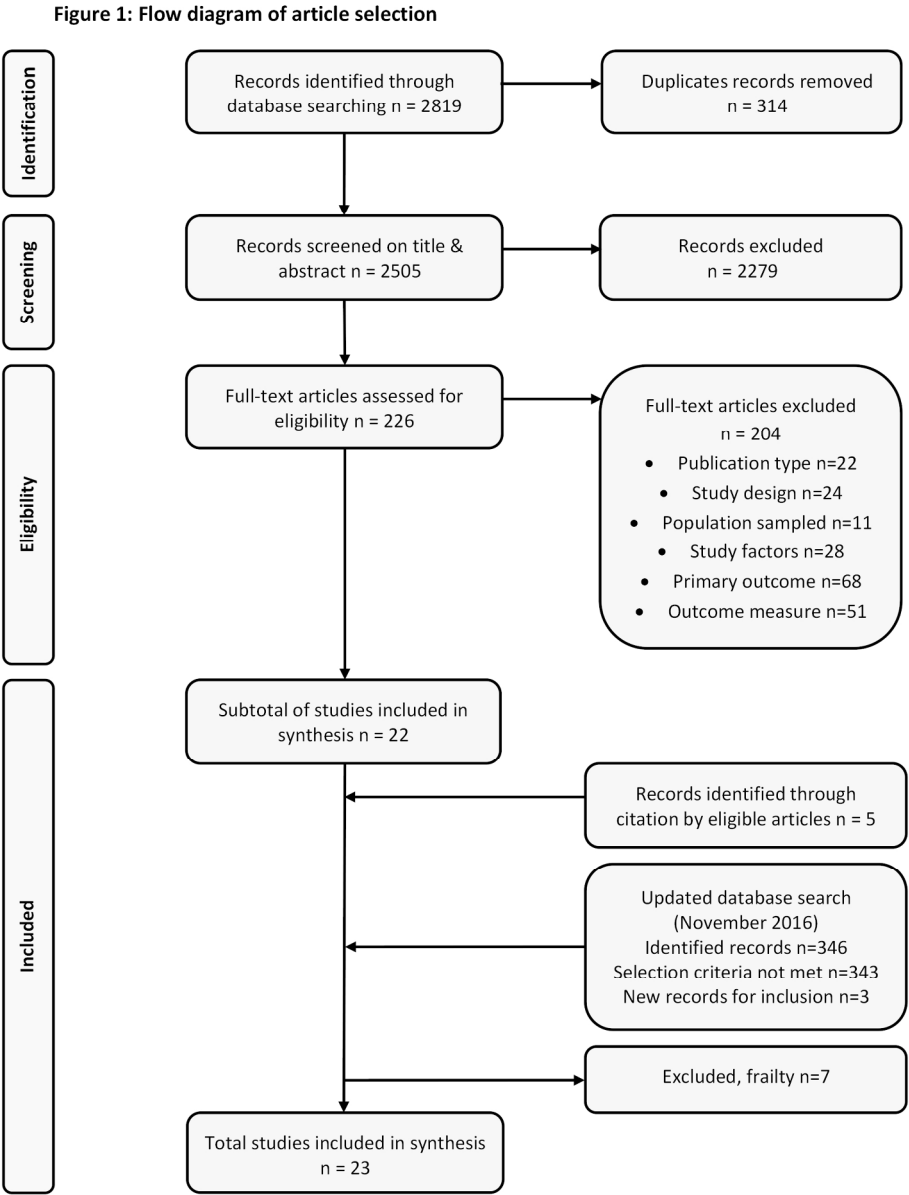|	
Identification	Records identified through database searching n = 2819 → Duplicates records removed n = 314
Screening	Records screened on title & abstract n = 2505 → Records excluded n = 2279
Eligibility	Full-text articles assessed for eligibility n = 226 → Full-text articles excluded n = 204: Publication type n=22; Study design n=24; Population sampled n=11; Study factors n=28; Primary outcome n=68; Outcome measure n=51
Included	Subtotal of studies included in synthesis n = 22 ← Records identified through citation by eligible articles n = 5; ← Updated database search (November 2016) Identified records n=346, Selection criteria not met n=343, New records for inclusion n=3; → Excluded, frailty n=7; Total studies included in synthesis n = 23

Figure 1: flow diagram of article selection

173x229mm (300 x 300 DPI)

Table 3: Characteristics of included studies

Author /Year /Country	Study name /Design /Data collection wave & year	Population / Characteristics	Main outcome /How measured /Prevalence	Predictors (Health Assets)	Findings
Andrews et al 2002 Australia[31]	**Australian Longitudinal Study of Ageing (ALSA)** Cross-sectional analysis of a population-based sample aged 70+ Baseline 1992	N=1403 Age range 70-85+ years Female =40%	**Successful ageing** Met criteria for tests on cognitive and physical functioning and physical performance. −High functioning =36% −Intermediate functioning =27% −Low functioning =37%	**Personal** - *Self-rated health* - *Importance of religion* - *Self esteem* - *Morale* - *Perceived control* **Social** - *Social participation* (household, service to others) - *Social activity*	Factors associated with higher vs lower functioning in logistic regression: - *Excellent/good self-rated health* - *Higher morale* - *Higher levels of activity* (domestic, household, service to others) Study Quality - High
Arias-Merino 2012 Mexico[34]	**Health, Wellbeing, and Aging Study (SABE)** Cross-sectional analysis of a multistage, proportional, randomised sample of persons aged 60+	N=3116 Mean age(SD) 72(9) Female =63%	**Successful ageing** Met criteria for chronic disease, disability, physical & cognitive functioning, and being active -Successful ageing =13%	**Social** - *Marital status* **Economic** - *Education* - *Income*	Predictors of successful ageing in logistic regression: - *Being married* - *Higher education* Study Quality - High
Bell et al 2014 USA[14]	**Hawaii Lifespan Study** Longitudinal study of survivors from population-based 1965 Honolulu Heart Program Baseline 1991 FU 21 years to 2012	N=1292 Mean age(SD) = 76(3) All male	**Healthy ageing** Met criteria for physical and cognitive function and absence of clinical disease. −Healthy survivors =34% −Unhealthy survivors =43% Non survivors =23%	**Personal** - *Self-rated health* **Social** - *Marital status* **Economic** - *Education*	Predictors of unhealthy vs. healthy survival in logistic regression: - *Fair or poor self-rated health* - *<12 years of education* Study Quality - High

Cernin et al 2011 USA[15]	**Stress and Success in Ageing through Good Health and Executive Functioning (SAGE)** Cross-sectional analysis of a convenience sample of older persons aged 59+ 2004	N=67 Mean age =73 Females =82%	**Successful ageing** Met objective criteria for tests on physical performance, physical and cognitive function. −Successful ageing =30%	**Social** - *Social support* **Economic** - *Education*	Factors associated with successful ageing in logistic regression: - *Higher quality of education* (reading score) Study Quality - Medium
Cha et al 2012 Korea[20]	Cross-sectional analysis of a convenience sample of persons aged 60+ 2009	N=305 Mean age =71 Females =73%	**Successful ageing** Measured by physical, psychological and social functioning (range 19-95) −Successful ageing mean(SD) =64(11)	**Personal** - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement*	Factors associated with successful ageing in multiple regression: Higher levels of - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement* Study Quality – High
Chaves et al 2009 Brazil[35]	Cross-sectional analysis of a random sample of households with at least one person aged 60+ 1996	N=345 Mean age(SD) =70(7) Females =70%	**Successful ageing** Met criteria for health, physical, psychological and cognitive functioning. −Successful ageing =62% −Normal ageing =38%	**Social** - *Marital status* - *Social network* - *Social support* - *Social activities* **Economic** - *Education* - *Income*	Factors associated with successful ageing in logistic regression: - *Having fewer living children* - *Having more confidants* - *Higher family income* Study Quality - High
Chou & Chi 2002 Hong Kong[21]	Cross-sectional analysis of a representative sample aged 60+ 1995	N=1106 Age range 60-69 =37% 70-79 =45% 80+ =18% Females =56%	**Successful ageing** Measured by physical, affective and cognitive functioning and productive involvement. Successful ageing (0-4) met criteria for high function on	**Personal** - *Self-rated health* - *Life satisfaction* - *Stressful life events* **Social** - *Marital status* - *Social network* - *Social support*	Factors associated with successful ageing in multiple regression analysis: - *Better self-rated health* - *Greater life satisfaction* - *More close relatives* - *Higher frequency of contact with friends*

			−4 criteria =1% −3 criteria =8% −2 criteria =25% −1 criterion =33% −0 criteria =34%	**Economic** - *Education* - *Income*	- *More years of education* - *Less financial strain* Study Quality - High
Formiga et al 2011 Spain[30]	**Octabaix study** Cross-sectional analysis of a longitudinal population-based sample of persons born in 1924 Baseline 2009	N=328 Age =85 Females =62%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful aging =49% -Non successful aging =51%	**Personal** - Quality of Life **Social** - Marital status - Living arrangements - Social risk **Economic** - Education	Factors associated with successful ageing in bivariate analysis: - *Higher Quality of Life* - *Being widowed* - *Lower social risk* - *Higher level of education* Study Quality - High
Formiga et al 2012 Spain[29]	**Octabaix study** Longitudinal population-based sample of persons born in 1924 Baseline 2009 FU 2 years	N=146 Age =87 Females =56%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful ageing at 2 year FU =62% -Non successful ageing =38%	**Personal** - *Quality of Life* **Social** - *Marital status* - *Living arrangements* - *Social risk* **Economic** - *Education*	Predictors of (continued) successful ageing in multiple regression: - *Higher level of education* Study Quality - High
Gureje et al 2014 Nigeria[36]	**Ibadan Study of Ageing (ISA)** Longitudinal study of representative sample aged 65+ Baseline 2003 FU yearly 2007-2009	N=930 Mean age =79 Females =39%	**Successful ageing** Met criteria on physical and functional health and life satisfaction. -Successful ageing =8%	**Personal** - *Self-rated health* **Social** - *Social network* - *Social participation* **Economic** - *Education* - *Material possessions* **Environment** - *Place of residence*	Predictors of successful ageing in multivariate analysis: - *Having contact with friends* - *Participation in community activities* Study Quality - High

Hamid et al 2012 Malaysia[22]	**Mental Health and Quality of Life of Older Malaysians** Cross-sectional analysis of a national representative sample aged 60+ 2004	N =2749 Age groups: 60-69 =1408 70-79 =1005 80+ =329 Females =50%	**Successful ageing** Met criteria for physical and psycho-cognitive functioning and absence of major disease. -Successful ageing =14%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Employment* **Environment** - *Place of residence*	Factors associated with successful ageing in logistic regression: - *Higher educational attainment* - *Higher household income* Study Quality – Medium
Hodge et al 2013 Australia[32]	**Melbourne Collaborative Study** Longitudinal population-based study Baseline 1990 - 1994 Follow-up 2003 – 2007	N=5512 Age =70+ Females =63%	**Successful ageing** Met criteria for physical and psychological functioning and survived to age 70, with absence of chronic disease. -Successful ageing =22% -Usual ageing =79%	**Social** - *Marital status* - *Living arrangement* - *Social network* - *Social activity* **Economic** - *Socio Economic Indexes For Areas (SEIFA)* - *Education*	Predictors of successful ageing in multivariate logistic regression: - *Being in the top SEIFA quintile* Study Quality – High
Jang et al 2009 Korea[23]	Cross-sectional analysis of a representative sample of residents aged 65 + 2003	N=1825 Mean age(SD) =73(6) Females =65%	**Successful ageing** Met criteria for physical, psychological and social functioning and subjective well-being and low level of chronic disease -Successful ageing =24%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Material possessions*	Factors associated with successful ageing in logistic regression: - *Higher years of education* - *Higher personal income* Study Quality - Medium
Li et al 2006 China[24]	**Shanghai Dementia Survey** Cross-sectional analysis of a random sample of community-dwellers aged 65+ 2000 - 2001	N=1516 Mean age(SD) =73(6) Females =53%	**Successful ageing** Met criteria on psychological and physical functioning, with no disabilities. -Successful ageing =46% -Usual ageing =40%	**Personal** - *Life satisfaction* - *Life Events* **Social** - *Marital status* - *Social support* - *Leisure activities* **Economic**	Factors associated with successful ageing using logistic regression: - *Greater life satisfaction* - *Being currently married* - *More leisure activities* - *Being satisfied with economic situation*

				- *Education* - *Economic status* - *Employment*	Study Quality - High
Li & Zhang 2015 China[25]	**Chinese Longitudinal Healthy Longevity Survey (CLHLS)** Longitudinal Health Survey of persons aged 80+ Data analysis of three waves 2005, 2008 and 2012	N=4190 Age range (64 – 114) Mean age(SD) baseline: 78(9) Females =54%	**Health Index** Met criteria on physical & cognitive function, psychological well-being and subjective health Health Index range -9.69-2.86 Mean(SD) =0.58(1.34)	**Social** *Social support networks* - *Diverse* - *Friend-focussed* - *Family-focussed* - *Restricted*	Factors associated with better (higher) Health Index in linear regression: - *Diverse network type* Study Quality - High
Meng & D'Arcy 2013 Canada[18]	**Canadian Community Health Survey: Healthy Ageing** Cross-sectional analysis of a national sample of persons aged 45+ 2008 - 2009	N=8154 Aged 65+	**Successful ageing** Measured by the absence of major disease and met criteria for cognitive and physical functioning and life engagement. -Successful ageing=37%	**Personal** - *Self-rated health* - *Life satisfaction* **Social** - *Marital status* **Economic** - *Education* - *Income* **Environment** - *Place of residence*	Factors associated with successful ageing using logistic regression: - *Better self-rated health* - *Greater life satisfaction* - *Being married* Study Quality - High
Ng. C et al 2014 Singapore[26]	**Marine Parade Elderly Needs Survey** Cross-sectional analysis of a stratified random sample of community dwelling adults aged 60+ from a national database of dwellings 2011	N=2444 60-64 =807 65-74 =1183 75-84 =341 85+ =113 Females =57%	**Healthy ageing** Met criteria on physical, mental and social health. -Health at risk=19% -Relatively healthy=81%	**Economic** - *Education* - *Income* - *Employment* - *Housing type*	Factors associated with Health at Risk using logistic regression: - *Higher level education* - *Employed* Study Quality – Medium
Ng et al 2009 Singapore[27]	**Singapore Longitudinal Ageing Study (SLAS)**	N=1281 Mean(SD) =72(6)	**Successful ageing** Met criteria for physical health and functioning,	**Personal** - *Religious beliefs* - *Quality of life (QoL)*	Factors associated with successful ageing in multivariate analysis:

	Cross-sectional analysis of a population based study of persons aged 55+ 2003 – 2004	Females =60%	cognitive, emotional and social functioning and life satisfaction -Successful ageing=29% -Non successful ageing=71%	**Social** - *Marital status* - *Living arrangements* - *Social network* - *Social support* - *Social activity* **Economic** - *Education* - *Financial resources* - *Housing type*	- *Better scores on physical and mental well-being (QoL)* - *Having religious beliefs* - *More years of education* - *Better housing* Study Quality - High
Parslow et al 2011 Australia[33]	**Survey of Mental Health and Well-being** Cross-sectional analysis of a population-based sample aged 60+ 2007	N=2,286 Mean age(SD) =71(7) Females =51%	**Successful ageing** Met criteria for physical and mental health, life satisfaction, cognitive functioning (weighted scores ranged from 4.6-16.26) Successful ageing Mean(SD) weighted score =13(2) -Highest decile =8% -Lowest decile =10%	**Personal** - *Traumatic life events* **Social** - *Living arrangements* - *Social network* - *Social support* **Economic** - *Education*	Factors associated with being highest decile compared with lowest decile of successful ageing - *Fewer traumatic life events* - *More contact with friends* - *Being able to rely on, confide in family, friends* - *Less likely to live alone* - *Higher level of education* Study Quality – High
Sowa et al. 2016 Europe[28]	**Survey of Health Ageing and Retirement in Europe (SHARE)** Longitudinal survey from 20 European countries of persons aged 50+. Cross-sectional analysis of a subsample of data from 6 European countries in wave 4 (2010-2011)	Males N=5139 Females N=5909 Age groups Males 60-67 =39% 68-79 =47% 80+ =15% Females 60-67 =39% 68-79 =43% 80+ =18%	**Healthy ageing** Met criteria for self-assessed health, functional capabilities and meaning of life Healthy ageing - Males =47% - Females =41%	**Social** *Psychosocial index incorporating:* - *Employment* - *Social participation* - *Leisure activities* - *Social network satisfaction* - *Life satisfaction* **Economic** - *Socioeconomic status*	Factors associated with better health using logistic regression: Males & females - *Being in Western or Southern Europe vs Central Europe* - *Higher level of education* - *Higher psychosocial index score* Study Quality - High

				Environmental - *Geographical location in Europe*	
Stevens-Ratchford 2011 USA[16]	Cross-sectional analysis of convenience sample of community dwellers aged 55+	N= 292 Mean age =72 Females =67%	**Successful ageing** Measured by the absence of disease and met criteria for cognitive and physical functioning and engagement with life. Measured by Successful Ageing Profile (SAP) -Successful ageing mean(SD) =34(6) (Range 14-68)	**Economic** - *Productive engagement*	Successful ageing had weak to moderate positive correlations with: - *Continuity of long standing occupation* - *Meaning of long standing occupation* - *Continuity of productive occupation* - *Meaning of productive occupation* Study Quality – Medium
Vaillant & Mukamal 2001 USA[17]	**Harvard Study of Adult Development** Longitudinal study of male adolescents (college students and core city youths) Baseline at age 50 FU 15 to 25 years	College men N=237 Aged 75-80 Core-city men N=332 Aged 65-70	**Successful ageing** Met criteria for objective and subjective physical and mental health, years of active life, life satisfaction and social support. Successful Ageing (happy-well) -College men (75-80) =26% -Core-city men (65-70) =29%	**Personal** - *Coping mechanisms* **Social** - *Marital stability* **Economic** - *Education*	Predictors of successful ageing (most vs. least) using multivariate analysis: - *Having mature coping defences* - *Stable marriage* (core-city men) - *More years of education* (core-city men) Study Quality - Medium
White et al 2015 Canada[19]	**Manitoba Study of Health and Aging (MSHA)** Longitudinal study of community based adults aged 65+ Baseline 1991 – 1992 Follow-up 1996 – 1997	N=946 Mean age(SD) 77(6) years Female =61%	**Health ageing** Met criteria for physical, cognitive, social and psychological health -Healthy ageing =38%	**Economic** - *Education* - *Income* - *Occupation*	Factors associated with healthy ageing using logistic regression: - *Higher level of education* - *High level satisfaction with finances* Study Quality - High

Appendix 1: The criteria for quality assessment and the number of studies scoring a minimum of 1 point for each item

Criterion	Assessment item description	Studies scoring 1 or 2 on this assessment item N
METHODS	1. Is the hypothesis/aim/objective of study clearly defined?	23
	2. Are all the exposure variables clearly described?	22
	3. Are the main outcomes clearly described?	23
	4. Is the study design clearly described?	22
	5. Is the source of the subject population (including sampling frame) clearly described?	20
	6. Are the eligibility criteria for subject selection clearly described?	21
POPULATION BACKGROUND	7. Are the participation rates reported? Are ascertainment of record availability described?	9
	8. Are the characteristics of study participants described?	23
	9. Have characteristics of subjects lost after entry or not participating from eligible population been described?	13
ANALYSIS	10. Is there adequate adjustment for covariates and confounders in analysis?	18
	11. Are important covariates and confounders described?	19
	12. Are statistical methods clearly described?	23
RELIABILITY & VALIDITY	13. Are the exposure variables reliable?	9
	14. Are the exposure variables valid?	8
	15. Are outcome measures reliable?	19
	16. Are outcome measures valid?	19
RESULTS	17. Are main findings clearly described?	23
	18. Does the study provide estimates of random variability for outcomes or exposures (CI, SD)?	19
	19. Does the study provide estimates of statistical parameters (regression coefficients, odds ratios)?	20
	20. Can study results be applied to the eligible population?	18

TABLE 5: PRISMA CHECKLIST

SECTION/TOPIC	#	CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Yes
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Yes
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Introduction, pages 1 & 2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Introduction, pages 1 & 2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	This review is registered with PROSPERO: CRD42016035286
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Methods, pages 2 & 3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Methods, pages 2 & 3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Methods, page 2 & 3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, table 1 & 2
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, page 3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, page 3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Methods, pages 2 & 3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A

	Section/topic	#	Checklist item	Reported on page #
	Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Methods, page 3
	Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Methods, page 3 & 4
	Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Methods, page 4
RESULTS				
	Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1, page 4
	Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary material table 3: Characteristics of selected studies
	Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see Item 12).	Supplementary material table 3: Characteristics of selected studies
	Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Supplementary material table 3: Characteristics of selected studies
	Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
	Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Supplementary material table 4: Criteria for quality assessment
	Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION				
	Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Discussion, pages 7-9
	Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Discussion, page 9
	Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion, pages 7-9
FUNDING				
	Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	N/A

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Health assets in older age: a systematic review

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Title

Health assets in older age: a systematic review

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Key words

1. Health assets
2. Health status
3. Healthy ageing
4. Psychosocial factors
5. Environmental factors
6. Economic factors

Word count, excluding title page, abstract, tables, and references: 3812

ABSTRACT

Background

Finding ways to optimise health in older age is key to reducing the impact of population ageing on health and social care systems. A salutogenic approach takes into account an individual's health assets - internal or external strengths or accessible resources which improve and preserve physical, social and mental wellness, independence, and quality of life. The aim of this narrative systematic review was to provide a summary and appraisal of the evidence for factors that act as health assets within personal, social, economic and environmental domains.

Methods

Systematic searches of databases were conducted for literature published in peer reviewed journals between January 2000 and November 2016. Selection criteria included community dwelling populations aged 65 and over and publications written in English. Data on study population, design, measures of health status, factors within the four previously stated domains, and results were extracted. Study quality was independently assessed using an appraisal instrument.

Results

Twenty-three publications, including 78,422 participants, from more than 13 different countries were identified for inclusion in this review. There was strong evidence that higher scores of self-rated health, psychological wellbeing, and life satisfaction were associated with better health in older age. Social network and contact with family and friends, engagement in leisure and social activities, were important support mechanisms. Education and financial resources consistently proved to be key economic health assets for older adults.

Conclusions

Implementing an asset based approach to health promotion uncovers the skills, knowledge, connections and the potential of the individual and the community. This approach is an ideal opportunity for government health bodies and their partners to respond to the challenges faced by global ageing.

Factors are often interdependent and cumulative, suggesting the potential for an instrument to measure the accumulated effect of health assets on health status on older adults.

Strengths and limitations of this study

- This review has evaluated an extensive range of health assets, highlighting the evidence for factors that positively influence health in older age.

- Of the studies identified for inclusion in this review, methodological differences in study design, follow-up periods, population samples, and the way health assets and health status were measured precluded the pooling of results for meta-analysis.

- The cross-sectional designs of the majority of studies did not allow a cause-effect relationship to be examined between health asset indicators and subsequent health in older age.

INTRODUCTION

On a global level, people aged 65 or older are the fastest growing segment of the population.[1] Whilst global ageing is perceived as a success, the continued growth of this population will add increasing economic and social demands on all countries.[2] This demographic shift in global ageing also entails fundamental social, economic and development challenges and opportunities, not the least of which is the increasing priority to meet the needs of older persons while enabling them to have longer, healthier and more productive lives.[3] Identifying ways to enhance health and well-being in older age is key to reducing the impact of global ageing, and is therefore a fundamental issue for policy makers.[1]

Based on the World Health Organisation (WHO) definition, health in older age is described as a life course process of optimising opportunities for improving and preserving physical, social and mental wellness, independence, quality of life and enhancing successful transitions.[2, 4] This holistic definition recognises that health is multifactorial, spanning across the various domains of well-being. Hence factors that influence health are complex and wide-ranging.

In 2002, the World Health Organization (WHO) published the Active ageing: a policy framework.[2] This framework identifies six key domains of active ageing: economic, behavioural, personal, social, health and social services, and the physical environment.[2] This framework highlights the need for quality evidence to support appropriate policies and programs across all domains to promote health in older age.

Historically, approaches to the promotion of health have been based on an 'illness' model. The focus is mainly on risk factors for disease, 'health deficits', rather than those associated with improving health status. While the presence of risk factors increases the likelihood of poor health, their absence does not necessarily increase the likelihood of good health. This approach of identifying risk factors for disease is essential for understanding specific needs and priorities; however, it tends to define individuals in negative terms and may overlook important positive factors which improve public health.[5]

In contrast, a 'wellness' model accentuates a salutogenic approach, concerned with identifying protective factors, 'health assets', to support health and wellbeing, rather than those that cause disease.[6] 'Health assets' are defined as an individual's internal or external strengths or accessible resources which enhance ability to optimise health.[5, 7, 8] Identifying 'health assets' that positively influence or are protective of health in older age will support the design of effective policies and programs for the promotion of health in older age.

Previous reviews in this research area have examined the concept of health assets in a health care context.[7, 9] Other similar systematic reviews include Peel et al.,[10] who identified a broad range of behavioural predictors, and Depp and Jeste,[11] who examined demographic, psychosocial, and biomedical correlates of successful aging. To our knowledge, however, no other review has provided an overview of 'health assets' or positive health determinants, with a focus on personal, social, economic and environmental predictors of positive health in older age in community-dwelling adults.

The aim of this review was to conduct a narrative summary and appraisal of evidence, published from the year 2000 onwards, for factors that have potential to act as health assets and promote health in older age. Based on the WHO active ageing policy framework, factors within the personal,

environmental, economic, and social domains were selected with a focus on only those that are protective of health in older age and potentially amenable to change through policy or intervention. Behavioural and lifestyle factors were excluded from this review as they have been the subject of a previous systematic review.[10]

METHODS

Literature search

In October 2014, a systematic search of databases (PubMed, Medline, Embase, CINAHL, and PsycNet) for literature was undertaken to address the study question "What health assets positively influence health in older age?" Further, additional articles were identified by manually reviewing the references lists of included papers. An updated literature search using the same methodology was conducted in November 2016. The search strategy for this literature search is presented in Table 1.

Table 1: Search criteria

Outcome terms[a]	health status OR successful ag*ing OR healthy ag*ing OR positive ag*ing OR ag*ing well OR longevity
	AND
Factor terms	factor* OR predict* OR indicator* OR determinant
Filters	• published between January 2000 and November 2016 • human subjects • English language • population aged 65 or older
Notes	* is used to indicate the term is truncated or has spelling variation. [a] these terms were adopted in search criteria since this nomenclature dominates the literature describing a multidimensional composite measure of health status in older age[10]

Titles were screened (YHT) for appropriateness. Two authors (YHT, NMP) independently reviewed abstracts to further eliminate studies not meeting the selection criteria presented in Table 2. The full text of all remaining articles was retrieved and the decision to include in the review was made by two authors (YHT, NMP) in consultation with third author (REH) where doubt existed. In addition, reference lists of included articles were searched to identify other studies meeting the inclusion criteria.

Table 2: Selection criteria

Criteria	Included	Excluded
Publication type	• published in peer reviewed scientific journals • reporting original research results • written in English	• reviews, book chapters, editorials, dissertations, theses and conference abstracts • "grey" literature
Study design	• observational studies with a primary aim to measure associations between key determinants and health in older age • quantitative studies	• qualitative studies • studies evaluating models for healthy ageing
Population	• mean age at baseline ≥65 • community dwelling	• mean age at baseline <65 • hospitalised, residing in long term care or assisted living communities
Study factor domains	• personal • social • economic • environmental	• behavioural or lifestyle factors [a] • factors which were part of multi-domain outcome measure
Outcome measure	• health status to include a composite measure across multi-domains of physical, mental and social well-being	• health measured as a single item question e.g. self-reported health or life satisfaction
Notes		
[a] not included in this review as these factors have been a focus of a previous review[10]		

Data Extraction

Two authors (YHT and NMP) independently extracted the data on study population, study design, measures of health status, all modifiable social, personal, economic and environmental factors, analyses, and results using a standardised spreadsheet. Data were compared and agreement on study variables reached by consensus. Study characteristics are reported in Table 3. Measurement of the outcome, health status, as well as prevalence in the study population was documented. Factors which positively influenced (or were protective of) health status were classified under personal, social, economic and environmental domains.

Data Synthesis and Analysis

Data was synthesised and reported according to the PRISMA statement.[12] Due to the heterogeneity of study populations, outcome and predictor measures, a meta-analysis was not possible.

Study Quality

Studies were evaluated for methodological quality using an appraisal instrument, previously proven to be a valid and reliable tool for use in epidemiological studies.[13] Twenty questions relevant to comparative and observational studies were used from this instrument; scores for each question ranged from 2 to 0, depending on whether the question was fully, partially, or not addressed. An average score was calculated for each study, which could then be classified into low, medium or high quality categories. The criteria for quality assessment and the number of studies scoring a minimum of 1 point for each assessment item is included in supplementary material (S1). Study quality was independently assessed by two authors (YHT, NMP) based on the instrument guidelines.[13]

Review Quality

A PRISMA 2009 checklist for this review is included in supplementary material (S2). This review is registered with PROSPERO study ID: CRD42016035286.

RESULTS

The search of online databases in October 2014 identified 2819 publications. Following the exclusion of duplicates (from two or more databases) and the screening of titles and abstracts, 226 articles proceeded to full text screening. Of these, 204 failed to meet the specified selection criteria (Table 2), resulting in 22 eligible articles. Five articles were added following screening of references cited in eligible articles, taking the total number to 27. An updated literature search identified an additional three articles, as well as one article from searching the reference lists of these articles. Seven articles were excluded following the decision to remove papers reporting on factors associated with a negative health outcome (such as frailty). The final number of articles included in this review is 23. Figure 1 displays the flow diagram for selection of eligible articles for inclusion in the analysis.

<Figure 1: flow diagram of article selection>

Study Characteristics

Study characteristics are reported in Table 3. Publication dates of the 23 selected articles ranged from 2001 to 2016, analysing data from populations in the USA,[14-17] Canada,[18, 19] Asia,[20-27] Europe,[28-30] Australia,[31-33], Mexico,[34] South America,[35] and Africa.[36] Studies included 22 different population cohorts, with sample sizes ranging from 67 to 10,048 participants and mean age between 70 to 87 years. Most studies included both males and females, in which the proportion of females varied from 39% to 82%. Two were male only.[14, 17] Cross-sectional analysis was used in 16 studies, with the remaining seven studies[14, 17, 19, 25, 29, 32, 36] using baseline data to predict subsequent health status.

Table 3: Characteristics of included studies

Author /Year /Country	Study name /Design /Data collection wave & year	Population / Characteristics	Main outcome /How measured /Prevalence	Predictors (Health Assets)	Findings
Andrews et al 2002 Australia[31]	**Australian Longitudinal Study of Ageing (ALSA)** Cross-sectional analysis of a population-based sample aged 70+ Baseline 1992	N=1403 Age range 70-85+ years Female =40%	**Successful ageing** Met criteria for tests on cognitive and physical functioning and physical performance. −High functioning =36% −Intermediate functioning =27% −Low functioning =37%	**Personal** - *Self-rated health* - *Importance of religion* - *Self esteem* - *Morale* - *Perceived control* **Social** - *Social participation* (household, service to others) - *Social activity*	Factors associated with higher vs lower functioning in logistic regression: - *Excellent/good self-rated health* - *Higher morale* - *Higher levels of activity* (domestic, household, service to others) Study Quality - High
Arias-Merino 2012 Mexico[34]	**Health, Wellbeing, and Aging Study (SABE)** Cross-sectional analysis of a multistage, proportional, randomised sample of persons aged 60+	N=3116 Mean age(SD) 72(9) Female =63%	**Successful ageing** Met criteria for chronic disease, disability, physical & cognitive functioning, and being active -Successful ageing =13%	**Social** - *Marital status* **Economic** - *Education* - *Income*	Predictors of successful ageing in logistic regression: - *Being married* - *Higher education* Study Quality - High
Bell et al 2014 USA[14]	**Hawaii Lifespan Study** Longitudinal study of survivors from population-based 1965 Honolulu Heart Program Baseline 1991 FU 21 years to 2012	N=1292 Mean age(SD) = 76(3) All male	**Healthy ageing** Met criteria for physical and cognitive function and absence of clinical disease. −Healthy survivors =34% −Unhealthy survivors =43% Non survivors =23%	**Personal** - *Self-rated health* **Social** - *Marital status* **Economic** - *Education*	Predictors of unhealthy vs. healthy survival in logistic regression: - *Fair or poor self-rated health* - *<12 years of education* Study Quality - High

Cernin et al 2011 USA[15]	**Stress and Success in Ageing through Good Health and Executive Functioning (SAGE)** Cross-sectional analysis of a convenience sample of older persons aged 59+ 2004	N=67 Mean age =73 Females =82%	**Successful ageing** Met objective criteria for tests on physical performance, physical and cognitive function. −Successful ageing =30%	**Social** - *Social support* **Economic** - *Education*	Factors associated with successful ageing in logistic regression: - *Higher quality of education (reading score)* Study Quality - Medium
Cha et al 2012 Korea[20]	Cross-sectional analysis of a convenience sample of persons aged 60+ 2009	N=305 Mean age =71 Females =73%	**Successful ageing** Measured by physical, psychological and social functioning (range 19-95) −Successful ageing mean(SD) =64(11)	**Personal** - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement*	Factors associated with successful ageing in multiple regression: Higher levels of - *Self-esteem* - *Self-efficacy* - *Interpersonal relationships* - *Self-achievement* Study Quality – High
Chaves et al 2009 Brazil[35]	Cross-sectional analysis of a random sample of households with at least one person aged 60+ 1996	N=345 Mean age(SD) =70(7) Females =70%	**Successful ageing** Met criteria for health, physical, psychological and cognitive functioning. −Successful ageing =62% −Normal ageing =38%	**Social** - *Marital status* - *Social network* - *Social support* - *Social activities* **Economic** - *Education* - *Income*	Factors associated with successful ageing in logistic regression: - *Having fewer living children* - *Having more confidants* - *Higher family income* Study Quality - High

Chou & Chi 2002 Hong Kong[21]	Cross-sectional analysis of a representative sample aged 60+ 1995	N=1106 Age range 60-69 =37% 70-79 =45% 80+ =18% Females =56%	**Successful ageing** Measured by physical, affective and cognitive functioning and productive involvement. Successful ageing (0-4) met criteria for high function on −4 criteria =1% −3 criteria =8% −2 criteria =25% −1 criterion =33% −0 criteria =34%	**Personal** - *Self-rated health* - *Life satisfaction* - *Stressful life events* **Social** - *Marital status* - *Social network* - *Social support* **Economic** - *Education* - *Income*	Factors associated with successful ageing in multiple regression analysis: - *Better self-rated health* - *Greater life satisfaction* - *More close relatives* - *Higher frequency of contact with friends* - *More years of education* - *Less financial strain* Study Quality - High
Formiga et al 2011 Spain[30]	**Octabaix study** Cross-sectional analysis of a longitudinal population-based sample of persons born in 1924 Baseline 2009	N=328 Age =85 Females =62%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful aging =49% -Non successful aging =51%	**Personal** - Quality of Life **Social** - Marital status - Living arrangements - Social risk **Economic** - Education	Factors associated with successful ageing in bivariate analysis: - *Higher Quality of Life* - *Being widowed* - *Lower social risk* - *Higher level of education* Study Quality - High
Formiga et al 2012 Spain[29]	**Octabaix study** Longitudinal population-based sample of persons born in 1924 Baseline 2009 FU 2 years	N=146 Age =87 Females =56%	**Successful ageing** Non-institutionalised who met criteria for physical and cognitive functioning. -Successful ageing at 2 year FU =62% -Non successful ageing =38%	**Personal** - *Quality of Life* **Social** - *Marital status* - *Living arrangements* - *Social risk* **Economic** - *Education*	Predictors of (continued) successful ageing in multiple regression: - *Higher level of education* Study Quality - High

Gureje et al 2014 Nigeria[36]	**Ibadan Study of Ageing (ISA)** Longitudinal study of representative sample aged 65+ Baseline 2003 FU yearly 2007-2009	N=930 Mean age =79 Females =39%	**Successful ageing** Met criteria on physical and functional health and life satisfaction. -Successful ageing =8%	**Personal** - *Self-rated health* **Social** - *Social network* - *Social participation* **Economic** - *Education* - *Material possessions* **Environment** - *Place of residence*	Predictors of successful ageing in multivariate analysis: - *Having contact with friends* - *Participation in community activities* Study Quality - High
Hamid et al 2012 Malaysia[22]	**Mental Health and Quality of Life of Older Malaysians** Cross-sectional analysis of a national representative sample aged 60+ 2004	N =2749 Age groups: 60-69 =1408 70-79 =1005 80+ =329 Females =50%	**Successful ageing** Met criteria for physical and psycho-cognitive functioning and absence of major disease. -Successful ageing =14%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Employment* **Environment** - *Place of residence*	Factors associated with successful ageing in logistic regression: - *Higher educational attainment* - *Higher household income* Study Quality – Medium
Hodge et al 2013 Australia[32]	**Melbourne Collaborative Study** Longitudinal population-based study Baseline 1990 - 1994 Follow-up 2003 – 2007	N=5512 Age =70+ Females =63%	**Successful ageing** Met criteria for physical and psychological functioning and survived to age 70, with absence of chronic disease. -Successful ageing =22% -Usual ageing =79%	**Social** - *Marital status,* - *Living arrangements* - *Social network* - *Social activity* **Economic** - *Socio Economic Indexes For Areas (SEIFA)* - *Education*	Predictors of successful ageing in multivariate logistic regression: - *Being in the top SEIFA quintile* Study Quality – High

Jang et al 2009 Korea[23]	Cross-sectional analysis of a representative sample of residents aged 65 + 2003	N=1825 Mean age(SD) =73(6) Females =65%	**Successful ageing** Met criteria for physical, psychological and social functioning and subjective well-being and low level of chronic disease -Successful ageing =24%	**Social** - *Marital status* **Economic** - *Education* - *Income* - *Material possessions*	Factors associated with successful ageing in logistic regression: - *Higher years of education* - *Higher personal income* Study Quality - Medium
Li et al 2006 China[24]	**Shanghai Dementia Survey** Cross-sectional analysis of a random sample of community-dwellers aged 65+ 2000 - 2001	N=1516 Mean age(SD) =73(6) Females =53%	**Successful ageing** Met criteria on psychological and physical functioning, with no disabilities. -Successful ageing =46% -Usual ageing =40% -Remainder excluded because of cognitive impairment	**Personal** - *Life satisfaction* - *Life Events* **Social** - *Marital status* - *Social support* - *Leisure activities* **Economic** - *Education* - *Economic status* - *Employment*	Factors associated with successful ageing using logistic regression: - *Greater life satisfaction* - *Being currently married* - *More leisure activities* - *Being satisfied with economic situation* Study Quality - High
Li & Zhang 2015 China[25]	**Chinese Longitudinal Healthy Longevity Survey (CLHLS)** Longitudinal Health Survey of persons aged 80+ Data analysis of three waves 2005, 2008 and 2012	N=4190 Age range (64 – 114) Mean age(SD) baseline: 78(9) Females =54%	**Health Index** Met criteria on physical & cognitive function, psychological well-being and subjective health Health Index range -9.69-2.86 Mean(SD) =0.58(1.34)	**Social** *Social support networks* - *Diverse* - *Friend-focussed* - *Family-focussed* - *Restricted*	Factors associated with better (higher) Health Index in linear regression: - *Diverse network type* Study Quality - High

Meng & D'Arcy 2013 Canada[18]	**Canadian Community Health Survey: Healthy Ageing** Cross-sectional analysis of a national sample of persons aged 45+ 2008 - 2009	N=8154 Aged 65+	**Successful ageing** Measured by the absence of major disease and met criteria for cognitive and physical functioning and life engagement. -Successful ageing=37%	**Personal** - *Self-rated health* - *Life satisfaction* **Social** - *Marital status* **Economic** - *Education* - *Income* **Environment** - *Place of residence*	Factors associated with successful ageing using logistic regression: - *Better self-rated health* - *Greater life satisfaction* - *Being married* Study Quality - High
Ng. C et al 2014 Singapore[26]	**Marine Parade Elderly Needs Survey** Cross-sectional analysis of a stratified random sample of community dwelling adults aged 60+ from a national database of dwellings 2011	N=2444 60-64 =807 65-74 =1183 75-84 =341 85+ =113 Females =57%	**Healthy ageing** Met criteria on physical, mental and social health. -Health at risk=19% -Relatively healthy=81%	**Economic** - *Education* - *Income* - *Employment* - *Housing type*	Factors associated with Health at Risk using logistic regression: - *Higher level education* - *Employed* Study Quality – Medium
Ng et al 2009 Singapore[27]	**Singapore Longitudinal Ageing Study (SLAS)** Cross-sectional analysis of a population based study of persons aged 55+ 2003 – 2004	N=1281 Mean(SD) =72(6) Females =60%	**Successful ageing** Met criteria for physical health and functioning, cognitive, emotional and social functioning and life satisfaction -Successful ageing=29% -Non successful ageing=71%	**Personal** - *Religious beliefs* - *Quality of life (QoL)* **Social** - *Marital status* - *Living arrangements* - *Social network* - *Social support* - *Social activity* **Economic** - *Education* - *Financial resources* - *Housing type*	Factors associated with successful ageing in multivariate analysis: - *Better scores on physical and mental well-being (QoL)* - *Having religious beliefs* - *More years of education* - *Better housing* Study Quality - High

Parslow et al 2011 Australia[33]	**Survey of Mental Health and Well-being** Cross-sectional analysis of a population-based sample aged 60+ 2007	N=2,286 Mean age(SD) =71(7) Females =51%	**Successful ageing** Met criteria for physical and mental health, life satisfaction, cognitive functioning (weighted scores ranged from 4.6-16.26) Successful ageing Mean(SD) weighted score =13(2) -Highest decile =8% -Lowest decile =10%	**Personal** - *Traumatic life events* **Social** - *Living arrangements* - *Social network* - *Social support* **Economic** - *Education*	Factors associated with being highest decile compared with lowest decile of successful ageing - *Fewer traumatic life events* - *More contact with friends* - *Being able to rely on, confide in family, friends* - *Less likely to live alone* - *Higher level of education* Study Quality – High
Sowa et al. 2016 Europe[28]	**Survey of Health Ageing and Retirement in Europe (SHARE)** Longitudinal survey from 20 European countries of persons aged 50+. Cross-sectional analysis of a subsample of data from 6 European countries in wave 4 (2010-2011)	Males N=5139 Females N=5909 Age groups Males 60-67 =39% 68-79 =47% 80+ =15% Females 60-67 =39% 68-79 =43% 80+ =18%	**Healthy ageing** Met criteria for self-assessed health, functional capabilities and meaning of life Healthy ageing - Males =47% - Females =41%	**Social** *Psychosocial index incorporating:* - *Employment* - *Social participation* - *Leisure activities* - *Social network satisfaction* - *Life satisfaction* **Economic** - *Socioeconomic status* **Environmental** - *Geographical location in Europe*	Factors associated with better health using logistic regression: Males & females - *Being in Western or Southern Europe vs Central Europe* - *Higher level of education* - *Higher psychosocial index score* Study Quality - High

Stevens-Ratchford 2011 USA[16]	Cross-sectional analysis of convenience sample of community dwellers aged 55+	N= 292 Mean age =72 Females =67%	**Successful ageing** Measured by the absence of disease and met criteria for cognitive and physical functioning and engagement with life. Measured by Successful Ageing Profile (SAP) -Successful ageing mean(SD) =34(6) (Range 14-68)	**Economic** - *Productive engagement*	Successful ageing had weak to moderate positive correlations with: - *Continuity of long standing occupation* - *Meaning of long standing occupation* - *Continuity of productive occupation* - *Meaning of productive occupation* Study Quality – Medium
Vaillant & Mukamal 2001 USA[17]	**Harvard Study of Adult Development** Longitudinal study of male adolescents (college students and core city youths) Baseline at age 50 FU 15 to 25 years	College men N=237 Aged 75-80 Core-city men N=332 Aged 65-70	**Successful ageing** Met criteria for objective and subjective physical and mental health, years of active life, life satisfaction and social support. Successful Ageing (happy-well) -College men (75-80) =26% -Core-city men (65-70) =29%	**Personal** - *Coping mechanisms* **Social** - *Marital stability* **Economic** - *Education*	Predictors of successful ageing (most vs. least) using multivariate analysis: - *Having mature coping defences* - *Stable marriage* (core-city men) - *More years of education* (core-city men) Study Quality - Medium
White et al 2015 Canada[19]	**Manitoba Study of Health and Aging (MSHA)** Longitudinal study of community based adults aged 65+ Baseline 1991 – 1992 Follow-up 1996 – 1997	N=946 Mean age(SD) 77(6) years Female =61%	**Health ageing** Met criteria for physical, cognitive, social and psychological health -Healthy ageing =38%	**Economic** - *Education* - *Income* - *Occupation*	Factors associated with healthy ageing using logistic regression: - *Higher level of education* - *High level satisfaction with finances* Study Quality - High

Health Status Measures

All but one article investigated factors in relation to successful or healthy ageing. Studies used different definitions, with the majority basing health measures on the model of Rowe and Kahn,[37] who defined successful ageing as the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities. One article[25] measured health status using a health index, which, similar to the healthy ageing model, assessed physical and cognitive function, psychological well-being and subjective health to provide a composite measure. The prevalence of successful/healthy ageing ranged from 1% in the Hong-Kong sample, meeting criteria for high functioning in all four domains (physical, affective and cognitive functioning and productive involvement),[21] to 81% in a community sample from Singapore,[26] who met criteria on physical mental and social health.

Determinants of Health Status

Personal

A total of twelve articles investigated personal factors as determinants of health status.[14, 17, 18, 20, 21, 24, 27, 29-31, 33, 36] Personal factors incorporate a wide range of attitudes, perceptions and internal resources that relate to health and well-being.

Self-rated health, measured on a scale from poor to excellent, was investigated in five studies.[14, 18, 21, 31, 36] A significant relationship between self-reported health and successful ageing was reported in all but one study,[36] suggesting those who perceived their health as good to excellent were more likely to age successfully than those who perceived their health as fair to poor.

Well-being was investigated in nine studies.[17, 18, 20, 21, 24, 27, 29-31] Higher levels of self-esteem, self-achievement, self-efficacy, interpersonal relationships,[20] and religious beliefs[27] were found to be associated with successful ageing, while a higher morale was associated with higher functioning.[31] Successful agers expressed greater life satisfaction[18, 21, 24] and a higher quality of life[27, 30] in cross-sectional analysis. However, quality of life was no longer a predictor of continued successful ageing in the Octabaix study in longitudinal follow-up.[29] Having mature coping mechanisms[17] and fewer traumatic life events[33] were also found to be associated with successful ageing.

Social

A total of 19 articles investigated social factors as determinants of health status.[14, 15, 17, 18, 21-25, 27-36] Two studies screened multiple factors to create a composite measure of social risk. Formiga et al.[29, 30] used the Gijon scale to assessing family and economic situation, housing, relationships and social support as a composite measure of social risk. Data were collected from this Spanish sample at both baseline and two-year follow-up. A lower score on the social risk scale was associated with successful ageing in cross-sectional analysis;[30] however, this association was no longer significant in longitudinal follow-up.[29] Sowa et al.[28] used a psychosocial index based on a combination of social and personal factors, including employment, social participation, leisure activities and satisfaction with social network, in a subsample of the European SHARE data. A higher score on the psychological index was associated with better health in cross-sectional analysis in both the male and female samples.

Marital status and living arrangements were investigated in 13 articles.[14, 18, 21-24, 27, 29, 30, 32-35] Being married, or not living alone, were positively associated with successful ageing.[18, 24, 33, 34] In contrast, the Octabaix study found being widowed was associated with successful ageing at baseline, 85 years of age, but not at follow-up two years later.[29, 30] A longitudinal study, of two cohorts of adolescent boys (college students and city youth) in the USA, investigated marriage stability and its ability to predict health status in later life. [17] For the city cohort, having a stable marriage in mid-life was a predictor for successful ageing in later life. This factor did not influence health status in the college cohort.

Social network, commonly measured by the number and frequency of contact with family, friends, and neighbours was investigated in seven studies.[21, 25, 27, 32, 33, 35, 36] Having a wide social network[21] and close contact with friends[21, 33, 36] was found to support successful ageing in all but one[35] of these studies. Li and Zhang[25] investigated a range of social support network types and their effect on health status in a chinese population, aged 80 and over. Those who had a diverse network, including contact with family and friends, as well as participation in social activities, had better health than those with either a restricted, friend, or family only focused network type. However, a South American study,[35] using cross-sectional analysis, found having fewer living children was associated with successful ageing in their largely female (70%) sample.

Social support, measured in terms of emotional or instrumental support was investigated in five study cohorts; three of which found having confidants and support from family and friends were positively associated with successful ageing.[21, 33, 35] In an Australian sample of persons aged 70 and over,[31] providing support to others in cross-sectional analysis was significantly associated with higher level functioning.

Engagement in social activities was investigated in six studies.[24, 27, 31, 32, 35, 36] Participation in community-leisure activities was found to be associated with successful ageing in two study cohorts. [24, 36] Finally, participation in domestic and household activities was found to be a protective factor in successful ageing in a sample of older Australians.[31].

Economic

A total of 20 studies investigated economic factors as determinants of health status.[14-19, 21-24, 26-30, 32-36] All studies included education as an economic indicator in their investigations, with level of attainment and years of study the most common measures of education. Thirteen of these studies found, more years, or a higher level, of education was associated with, or predictive of, successful ageing in cross-sectional,[21-23, 26-28, 30, 33, 34] as well as longitudinal[14, 17, 19, 29] data analysis. One study focused on the quality of education derived from a reading score, [15] showing that a higher quality of education was associated with successful ageing.

Income was investigated in eight studies.[18, 19, 21-23, 26, 34, 35] In cross-sectional analyses, having higher personal,[23] or household[22, 35] income was associated with successful ageing. Financial strain was investigated in three studies, cross-sectional[21, 24] and longitudinal analysis[19] of this data found those reporting that their financial resources were adequate for their needs were more likely to age successfully than those experiencing financial strain.

Occupation class or employment status was investigated in four articles.[16, 19, 22, 24] Of these, one study[26] found being employed was associated with better health, and a second[16] found a weak to moderate correlation between continuity and meaning of occupation and successful ageing.

The influence of housing type[26, 27] and material possessions[23, 36] on successful ageing was investigated in four studies. One study[27] found better housing was associated with successful ageing in cross-sectional analysis.

A composite measure of socioeconomic status was investigated in data from the Melbourne collaborative study[32]. Based on census data, the Socio Economic Index for Areas (SEIFA) is an index of relative socio-economic disadvantage, measuring, at an area level, factors such as income, education and occupational status. Longitudinal analysis found, being in the top SEIFA quintile was a predictor of successful ageing.

Environmental

Environmental factors, including geographical location[28] and place of residence,[18, 22, 36] were investigated in relation to successful ageing in four studies. The latter three studies examined the effect of urban versus rural locality on successful ageing and found no significant relationship. However, those residing in Western or Southern Europe were more likely to be in the healthy ageing group, compared with those in Central Europe.

Study Quality

Using the modified Epidemiological Appraisal Instrument, scores for assessment of methodological quality ranged from 14 to 36, out of a possible 40 points, with an average score of 27.8 points. Studies were classified into low (0 - 13), medium (14 – 27) or high quality (28 – 40) categories, determined by their final score. Study quality results are reported in Table 3. The assessment criteria that were most poorly reported by the studies included in this review were the participation rates, and the reliability and validity of the exposure variables (Supplementary material S1).

DISCUSSION

This narrative systematic review summarises the evidence for factors within personal, social, economic and environmental domains that can be termed "health assets" of older adults. Of these, there was strong evidence from multiple high quality studies to suggest self-rated health, life satisfaction, psychological well-being, social networks, engagement in leisure and social activities, education, and financial resources are associated with health status in community dwelling older populations.

Although the review included studies from a diverse range of countries in the developed and developing world, cross national comparisons of factors influencing ageing well were not possible because of differences in population sample characteristics, health status and study factor measures. The prevalence of successful ageing covered a wide range from 1% to 81%. The one study incorporating cross-country comparisons found the differences in healthy ageing could be attributed to the prevalence of chronic conditions in Central–Eastern Europe as opposed to Western or Southern Europe. Education was the most commonly studied factor in this review with strong evidence cross-nationally that a higher level of education is widely associated with positive health in older age. This study was unable to identify any specific trends in health assets that were attributable to geographical diversity. However, we recognise that differences in access to resources and health care services can vary significantly by geographical location and consequently impact health.

The majority of studies included in this review measured factors individually, even though their effects are often interdependent and additive.[38] A small number of studies, however, used composite measures including a multi-domain measure of social risk,[29, 30] and single domain multi-factor measure of socioeconomic status.[32] A multi-domain summative measure of protective factors was investigated in older adults in Beijing.[38] This study reported that for each accrued protective factor, the risk of health decline and death was reduced by 13% to 25%. This data suggests that the more protective factors the individual possesses, the more the risk of poor health is reduced and the greater the opportunity for recovery. The rationale underpinning the study of 'health assets' is similar to that of 'health deficits'; both measure an accumulation of factors across multiple domains that predict health status. While an accumulation of deficits predicts ill health, an accumulation of health assets may mitigate risk and promote good health. This highlights potential for a 'health assets' tool to evaluate cumulative factors known to positively influence health and well-being. Such a tool could be useful in epidemiological studies to examine why individuals have different health outcomes depending on their level of health assets.

A person's health and wellbeing has many facets, resulting from a complex interplay between factors within multiple domains.[2] Such factors are highly influenced by cultural norms, gender specific roles,[3] and the resources and policies of the wider society.[39] The modifiability of these factors therefore can be highly dependent on the individual and the context in which they live. While some factors are seemingly immutable at the individual level, population health policies to reduce poverty, provide social support, connection to culture, and equitable access to health care can protect against the effects of living in disadvantaged circumstances. Other factors under personal control, for example engagement in leisure and social activities, are more amenable to interventional programs and policies.[39] Furthermore, enabling people to develop and maintain varied social networks and participation in social and recreational activities, may not only help them on a social level, but can also have a positive impact in other domains including maintaining independence, life satisfaction, wellbeing, and physical and mental health.

The mechanism through which health assets can influence health may be direct or indirect. For example, those on very low incomes may lack resources and access to adequate housing, safe environments and health care, which can impact negatively on health. Financial and life stressors, as well as lack of resources, social support and connectedness can contribute directly to poorer physiological health (for example, increased risk of high blood pressure, immune and circulatory complications) or indirectly, through less healthy coping skills and behaviours (for example, excessive alcohol consumption or substance abuse). Although self-rated health is a consistent indicator of objective health and a robust predictor of health outcomes, little is known about the mechanism by which it influences health status.[40] The degree of control that people believe they possess over their personal health may increase an individual's self-rated health and lower disease burden.[40]

Implications of Findings

Health interventions addressing personal, social, economic and environmental determinants may reduce health-related inequalities and the risk of disease late in life.[41, 42] This review provides evidence of health assets that can be applied across the life course to promote better health and well-being into old age.

Although many health assets are already present in our lives, the individual and others around them may not necessarily be mindful or make purposeful use of them. Empowering people to recognise

and build on their potential health assets may help protect and promote health status. An asset based approach to health promotion exposes and values the skills, knowledge, connections and the potential of the individual and those around them.[43] The aim of this approach is to strike a balance between meeting the needs and nurturing the strengths and resources of the individual and community. Demographic changes in global ageing means that more people will require help and support. This assets based approach is an ideal opportunity for government health bodies and their partners to respond to these challenges.

Strengths and limitations of this study

This review has evaluated an extensive range of health assets, highlighting the strongest evidence for factors that positively influence health in older age.

Methodological differences in study design, follow-up periods, population samples, and the way health assets and outcomes were measured by the studies included in this review precluded the pooling of results for meta-analysis. Including only papers published in English is acknowledged as a limitation, affecting cross-cultural comparisons and ability to generalise results to non-English speaking countries.

Cross-sectional analysis in the majority of studies did not allow for investigation of causality, while longitudinal analysis was largely unidirectional, with study factors such as better self-rated health, social network support, and higher educational attainment predicting subsequent successful ageing. Only one study[25] examined bidirectional relationships, showing that social network types were predictive of subsequent health status, but also that a decline in health affects social network type.

Conclusions

This systematic review summarises the evidence for health assets, thus adding to the currently limited body of literature within this field. This evidence is essential for the preparation of appropriate policies and effective health interventions.

Health assets are the individual's accessible internal or external strengths and resources; empowering people to recognise and build on their health assets may help protect and promote health status in older age. Implementing an asset based approach to health promotion uncovers the skills, knowledge, connections and the potential of the individual and the community. This approach is an ideal opportunity for government health bodies and their partners to respond to the challenges faced by global ageing.

Factors known to influence health are often interdependent and cumulative, but the effect on health of a multi-domain, composite measure of positive factors is largely unknown. This suggests potential for an instrument to measure the cumulative effect of multi-domain health assets on health status in older adults.

<Supplementary material S1: Criteria and scoring for quality assessment>

<Supplementary material S2: PRISMA research checklist>

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Figure 1: Flow diagram of article selection

Identification

Records identified through database searching n = 2819

Duplicates records removed n = 314

Screening

Records screened on title & abstract n = 2505

Records excluded n = 2279

Eligibility

Full-text articles assessed for eligibility n = 226

Full-text articles excluded n = 204
- Publication type n=22
- Study design n=24
- Population sampled n=11
- Study factors n=28
- Primary outcome n=68
- Outcome measure n=51

Included

Subtotal of studies included in synthesis n = 22

Records identified through citation by eligible articles n = 5

Updated database search (November 2016) Identified records n=346 Selection criteria not met n=343 New records for inclusion n=3

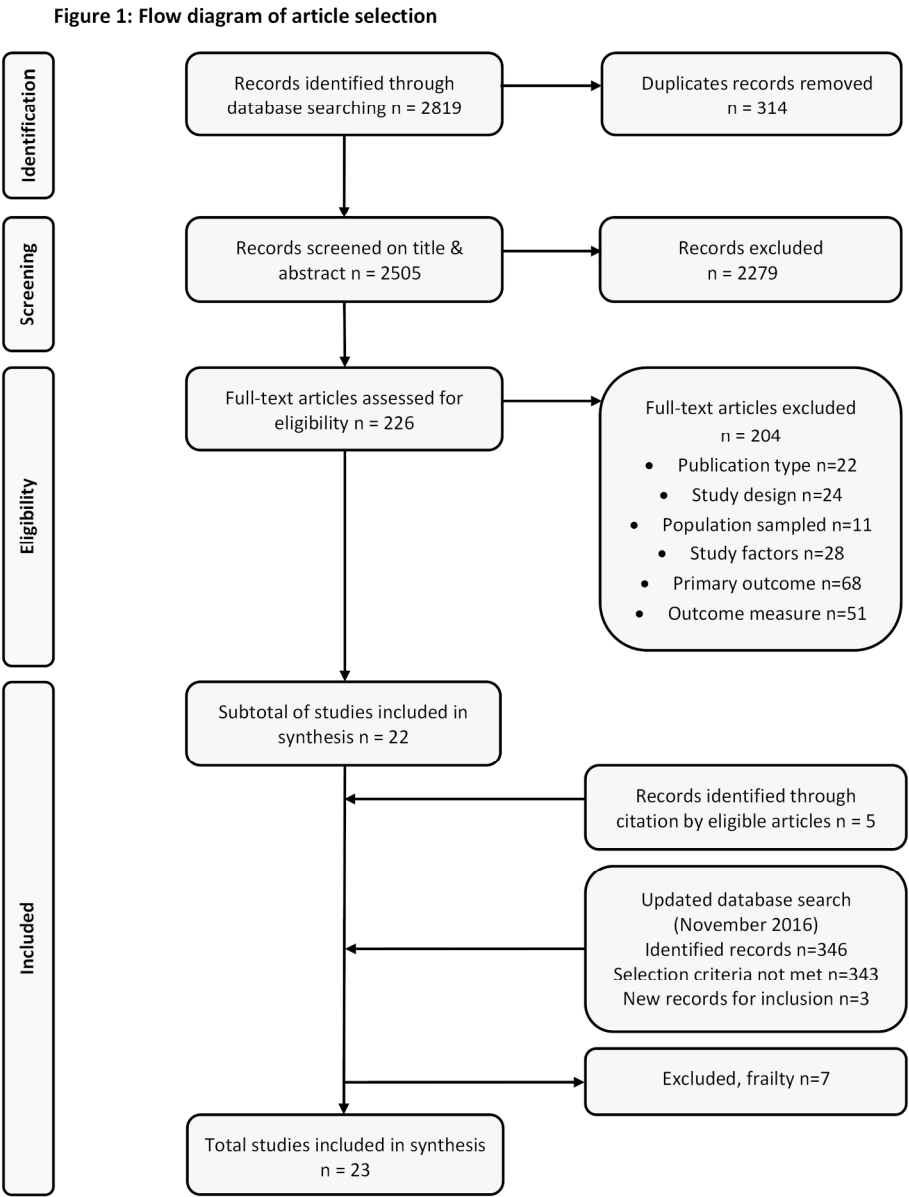Excluded, frailty n=7

Total studies included in synthesis n = 23

Figure 1: Flow diagram of article selection
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173x229mm (300 x 300 DPI)

S1: Criteria and scoring for quality assessment

Criterion	Assessment item description	Number of studies scoring minimum of 1 on assessment item
METHODS	1. Is the hypothesis/aim/objective of study clearly defined?	23
	2. Are all the exposure variables clearly described?	22
	3. Are the main outcomes clearly described?	23
	4. Is the study design clearly described?	22
	5. Is the source of the subject population (including sampling frame) clearly described?	20
	6. Are the eligibility criteria for subject selection clearly described?	21
POPULATION BACKGROUND	7. Are the participation rates reported? Are ascertainment of record availability described?	9
	8. Are the characteristics of study participants described?	23
	9. Have characteristics of subjects lost after entry or not participating from eligible population been described?	13
ANALYSIS	10. Is there adequate adjustment for covariates and confounders in analysis?	18
	11. Are important covariates and confounders described?	19
	12. Are statistical methods clearly described?	23
RELIABILITY & VALIDITY	13. Are the exposure variables reliable?	9
	14. Are the exposure variables valid?	8
	15. Are outcome measures reliable?	19
	16. Are outcome measures valid?	19
RESULTS	17. Are main findings clearly described?	23
	18. Does the study provide estimates of random variability for outcomes or exposures (CI, SD)?	19
	19. Does the study provide estimates of statistical parameters (regression coefficients, odds ratios)?	20
	20. Can study results be applied to the eligible population?	18

S2: PRISMA RESEARCH CHECKLIST

SECTION/TOPIC	#	CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Yes
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Yes
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Introduction, pages 1 & 2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Introduction, pages 1 & 2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	This review is registered with PROSPERO: CRD42016035286
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Methods, pages 2 & 3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Methods, pages 2 & 3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Methods, page 2 & 3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, table 1 & 2
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, page 3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, page 3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Methods, pages 2 & 3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A

	Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Methods, page 3
	Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Methods, page 3 & 4
	Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Methods, page 4
RESULTS				
	Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Figure 1, page 4
	Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary material table 3: Characteristics of selected studies
	Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see Item 12).	Supplementary material table 3: Characteristics of selected studies
	Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Supplementary material table 3: Characteristics of selected studies
	Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
	Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	Supplementary material table 4: Criteria for quality assessment
	Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION				
	Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Discussion, pages 7-9
	Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Discussion, page 9
	Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion, pages 7-9
FUNDING				
	Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	N/A