

Comparison of self-rated and objective successful ageing in an international cohort

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ABSTRACT

Understanding predictors of successful ageing is essential to policy development promoting quality-of-life of an ageing population. Initial models precluded successful ageing in the presence of chronic disease/functional disability; however, this is discrepant with self-reported successful ageing. Indicators of social, psychological and physical health in 1,735 people aged 65–74, living in Canada, Columbia, Brazil or Albania, were analysed in the International Mobility in Ageing Study. Multiple logistic regression analysis was performed to estimate the change in self-rated successful ageing in relation to physical health, depression, social connectedness, resilience and site, while controlling for age, gender and income sufficiency. Sixty-five per cent of participants self-rated as ageing successfully; however, this was significantly different across sites ($p < 0.0005$, range 17–85%) and gender ($p = 0.019$). Using objective measures, 6 per cent were classified as ‘successful’, with significant variability amongst sites ($p < 0.0005$, range 0–12%). Subjective successful ageing was associated with fewer (not absence of) chronic diseases, absence of depression and less dysfunction in activities of daily living, but not with objective measures of physical dysfunction. Social connectedness and resilience also aligned with self-rated successful ageing. Traditional definitions of objective successful ageing are likely too restrictive, and thus, do not approximate self-rated successful ageing. International differences suggest that site could be a surrogate for variables other than physical/mental health and social engagement.

KEY WORDS—successful ageing, international, chronic disease, depression, resilience.

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Introduction

With global increases in life expectancy and an associated expansion of populations over age 65, interest in, and the importance of ageing research is growing (Li *et al.* 2014). In the late 1980s, Rowe and Khan (1987) proposed a model in which usual ageing, characterised by the presence of disease or functional disability, was contrasted with successful ageing. In their study, successful ageing was specifically defined by three factors: (a) a low probability of disease or disease-related disability; (b) high cognitive and physical functional capacity; and (c) active engagement in life. Although this influential paper propelled a significant amount of research, Rowe and Khan's definition of successful ageing has been criticised for suggesting that one cannot age successfully in the presence of chronic disease (Cosco *et al.* 2014; Strawbridge, Wallhagen and Cohen 2002).

Identification of modifiable predictors of successful ageing is of particular importance to public health policy makers and health-care providers interested in developing programmes that augment quality of life among an ageing population (Hsu and Jones 2012). Estimates of successful ageing have been highly variable across different studies, ranging from 0.4 to 91.7 per cent (mean 23.1%; Cosco *et al.* 2014). This variability may be attributable to differences in study populations across investigations and, perhaps more importantly, the absence of consensus about the definition of successful ageing. In their systematic review of 84 studies, Cosco *et al.* (2014) found that many constructs have been used to define successful ageing and that lower rates were reported in studies with more complex concepts (*e.g.* those that included metrics of physiologic/mental health, social engagement and subjective wellbeing).

A number of studies have examined predictors of the various constructs of successful ageing. One demonstrated that older age, resilience, the absence of depression and functional ability had independent additive effects on self-rated successful ageing (Jeste *et al.* 2013). Some studies of successful ageing have shown variability associated with gender as well as age (Hsu 2005; Jeste *et al.* 2013; Meng and D'Arcy 2014; Park, Jang and Kim 2010). Although these studies defined successful ageing according to variations on the Rowe and Khan definition, they did not examine the specific relationship between independent predictors, such as physical health or social circumstances, and subjective indicators of successful ageing.

The Rowe and Khan definition does not account for subjective perceptions of successful ageing. Perhaps as a result, few have considered this measure (Cernin, Lysack and Lichtenberg 2011; Cohen *et al.* 2009; Ibrahim, Cohen and Ramirez 2010; Jeste *et al.* 2013; Montross *et al.* 2006; Moore *et al.* 2015; Pruchno, Wilson-Genderson and Cartwright 2010; Vahia *et al.* 2012). Those reports that did, demonstrate a higher rate of

successful ageing when measured subjectively (average 71%) *versus* objectively (Cosco *et al.* 2014). Comparisons of subjective and objective measures within the same study population show large discrepancies in the two indicators ranging from 11 to 77 per cent (Cernin, Lysack and Lichtenberg 2011; Cohen *et al.* 2009; Montross *et al.* 2006; Pruchno, Wilson-Genderson and Cartwright 2010). As described by Jeste *et al.* (2013), individual perceptions of successful ageing may provide the better estimate given that self-rating contextualises one's physical and mental health/well-being, and social circumstances. Furthermore, in qualitative studies of self-defined successful ageing, physical health parameters were generally ranked as less important than were social circumstances (Tate, Swift and Bayomi 2013; Tate *et al.* 2009).

The centrality of social circumstances to subjective successful ageing suggests that cultural norms and values, which are so much a part of an individual's social milieu, may also be of importance. There is some relevant research comparing Latino and Caucasian Americans (Angel 2009; Herrera *et al.* 2011; Hilton *et al.* 2012). One study suggested a stronger association between successful ageing and self-esteem in Latino Americans, while among Caucasian Americans, good health and independence were central (Hilton *et al.* 2012). However, primary studies across countries and cultures have not been reported. Such cross-cultural comparisons could increase understanding of how contextual circumstances shape success in ageing (Rowe and Kahn 2015).

The objective of this study was to compare the prevalence of self-rated (subjective) and objective successful ageing in an international cohort study. We also examined the contribution of social characteristics, psychological factors (depression/resilience) and physical health parameters to subjective successful ageing. We used data from the International Mobility in Ageing Study (IMIAS), a prospective longitudinal study of physical health, depression and function that includes social and psychological variables. We hypothesised that successful ageing would vary with cultural context (*i.e.* by site), gender and social circumstances among participants from North America, Latin America and Europe. Based on existing evidence, we also expected that there would be limited concordance between objective and subjective measures of successful ageing.

Methods

Data collection

The IMIAS collected prospective longitudinal data on physical health, depression and function, socio-economic status and lifecourse events by

directly interviewing participants. Approximately 400 community-dwelling adults (200 men and 200 women) age 65–74 were enrolled at each site, including Natal (Brazil), Manizales (Columbia), Tirana (Albania), Saint-Hyacinthe (Quebec, Canada) and Kingston (Ontario, Canada). Participants (N = 1,995) were recruited in 2012, with ethics approval in all of the five investigation sites. In accordance with ethics requirements, recruitment at Canadian sites was conducted by sending potential participants an invitation letter from their primary care physicians. At the other three sites, participants were recruited directly by randomly inviting those registered at neighbourhood health centres (Sousa *et al.* 2014). A screening assessment tool for dementia in populations with little education, the Leganes Cognitive Test, was used to exclude those making four or more errors and therefore deemed unable to answer questions accurately. Data collection was conducted in interview format and interviewer training was standardised across sites. All scales used in this study had been previously validated among older, international populations. To date, data were collected in 2012, 2014 and 2016. For the 2014 data collection relevant to this study there was a retention rate of 85 per cent (N = 1,694). With the exception of the chronic diseases and social engagement variables (which were obtained from the 2012 data-set), all of the data used in the present study were from 2014, as discussed below.

Outcome variable: self-rated successful ageing

In order to assess participants' perceptions about their own ageing, they were asked to locate themselves on a visual analogue scale ranging from 'unsuccessful ageing' (minimum score: 1) to 'successful ageing' (maximum score: 10) in response to the question: 'In general, if you consider all aspects of your life, to what extent do you think you have aged successfully?' As these data were right skewed, they were categorised for logistic regression analysis. Categorisation for the self-rated successful ageing variable duplicated that used in others' studies (Cernin, Lysack and Lichtenberg 2011; Cohen *et al.* 2009; Montross *et al.* 2006; Pruchno, Wilson-Genderson and Cartwright 2010) and was based on the observed distribution of the data. There appeared to be a demarcation in the data between 7 and 8, so this was chosen as the cut-off for 'successful' (8–10) *versus* 'usual' ageing (1–7).

Explanatory variables

Site. We hypothesised that location would have an impact on both subjective and objective successful ageing. This was included in the regression analysis as a categorical variable.

Number of chronic diseases. Participants were asked about previous diagnoses of diabetes, hypertension, cancer, chronic lung disease, coronary heart disease, cerebral aneurysm/stroke and osteoarthritis. The 2012 data were collected by asking ‘Has a doctor or nurse ever told you that you have [condition x]’, whereas in 2014 participants were asked ‘Since 2012, has a doctor told you that you have [condition x]’. As a result, in order to assess whether a given participant had ever been diagnosed with any of the chronic conditions listed above, the answers from both years were combined, and the total number of chronic disease diagnoses was summed across the 2012 and 2014 data-sets, accounting for and removing duplications in responses. The total number of chronic diseases was used as a continuous variable in the analysis and ranged from 0 to 7.

Activities of daily living (ADLs). Participants were asked ‘do you have any difficulty with ADLs’, such as walking across a room, dressing, bathing/showering, eating, getting in and out of bed or chairs, and using the toilet. Responses were ranked as ‘none at all’, ‘a little’, ‘some’, ‘a lot’ or ‘unable to do’. Existing research has suggested that any difficulty in ADLs should be recorded as limitation (Cosco *et al.* 2014). These measures were then used to approximate categories of ‘no ADL dysfunction’, ‘minimal ADL dysfunction’ representing difficulty in one or two ADLs and ‘significant ADL dysfunction’ representing difficulty in three or more ADLs. This was used as a categorical variable.

Depression. Participants were screened using the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff 1977), a 20-item inventory. Response options for each question were coded as ‘rarely/none of the time’, ‘some or little of the time’, ‘occasionally or a moderate amount of time’ or ‘most of the time’. The total depression score was calculated as the sum of all answers for a total of 0–60 points. Those who did not answer more than four questions were excluded. A binary variable for depressed (16 points or greater) *versus* not depressed (0–15 points) was calculated from individual summed scores.

Nagi questionnaire – functional limitations. The Nagi scale (Nagi 1976) was used to assess subjective difficulties with climbing a flight of stairs or walking 400 metres (quarter of a mile). Answers were summed and participants were grouped into two categories ‘no difficulties’ or ‘any difficulty’.

Short physical performance battery (SPPB). The SPPB assessed objective lower extremity function, including static balance, gait speed, and getting in and out of a chair, with scoring as previously described (Puthoff 2008).

The SPPB score was used as a categorical variable separated by scores of greater than or equal to 8 and less than 8.

Social engagement. As previously reported (Phillips *et al.* 2016), social engagement was measured as a continuous variable with answers scored as 0 for responses of ‘no engagement or at least once per year or at least once per month’ and 1 for responses of ‘at least once per week or almost everyday’. Participants were asked about involvement in three domains including: (a) attending a community/recreation centre, senior/golden age or professional association; (b) strolling about stores, boutiques or malls; or (c) participation in religious activities (committees, services or choirs). The overall social engagement score was the sum of scores across these activities ranging from 0 to 3 and was used as a continuous variable.

Objective successful ageing. Objective successful ageing was approximated using a modification of the Rowe and Kahn definition including: the absence of ADL dysfunction, no Nagi limitations, SPPB score ≥ 8 , no depression (CES-D ≤ 15), no chronic disease and some form of social engagement ≥ 1 . Although cognitive function was used in the original Rowe and Kahn definition, it was not relevant in this population as part of the exclusion criteria included a cut-off for cognitive function. Depression was not used in early studies examining Rowe and Khan’s ‘successful ageing’; however, it has become a common feature in modern constructs of this concept (Cosco *et al.* 2014).

Resilience. Wagnild’s Resilience Scale (Wagnild and Young 1993) assesses an individual’s resilience with questions about equanimity, perseverance, self-reliance, meaningfulness and existential aloneness. Each of 14 statements is evaluated on a seven-point scale ranging from strongly disagree to strongly agree. The data were categorised into two groups based on high (>82 points) and average/low resilience (<81), based on previous reports (Phillips *et al.* 2016). This scale demonstrated high internal reliability amongst women and men and across multiple cultural settings and in previous IMIAS studies (Cronbach’s $\alpha = 0.90$) (Phillips *et al.* 2016).

Confounding variables

Given large differences in the range of income among international sites, it was not appropriate to use income as a surrogate for socio-economic status. Therefore, income sufficiency was estimated by asking study participants ‘To what extent does your income allow you to meet your needs?’ Possible answers included ‘very well’, ‘suitably’, ‘not very well’ and ‘not at all’, the latter two were collapsed into the ‘not suitably’ category and used

as a categorical variable. Age and gender were also accounted for as confounding variables in the regression models.

Statistical analyses

All analyses were conducted using SPSS Statistics Version 24. Comparisons of patient characteristics across sites and/or genders were performed using one-way analysis of variance and Pearson's chi-squared analysis for continuous and categorical variables, respectively. Multiple logistic regression models were performed to estimate the effect of chronic disease, ADL limitation, depression, functional ability, resilience and site on the probability of subjective successful ageing, while controlling for age, gender and income sufficiency. Multiple logistic regression models were performed to estimate the probability of the outcome variable (self-reported successful ageing) in relation to the change in explanatory variables. Multicollinearity between variables was shown to be negligible. In order to examine the independent contribution of objective health measures and social variables to self-rated successful ageing, they were tested in separate models. All models accounted for age, sex, study site and income sufficiency. Furthermore, a measure of fit (Cox and Snell R -squared) was calculated for each model under study. The models examined were as follows:

- Model type 1: health measures (*i.e.* comorbidities, SPPB and Nagi).
- Model type 2: social engagement.
- Model type 3: all the health and social variables tested in the previous two models together.
- Model type 4: all variables in Model 3 in addition to resilience.

Results

Self-rated and objective successful ageing

Patient characteristics are described in [Table 1](#). Overall self-rated successful ageing across all sites demonstrated a positively skewed, non-normal distribution (Kolmogorov–Smirnov, $p < 0.01$) ([Figure 1A](#)), with a median response of 8 (interquartile range = 3). The proportion of participants who considered themselves to be ageing successfully was 65 per cent. However, comparison of the proportion of self-rated successful agers across sites varied significantly (Pearson's χ^2 , $p < 0.0005$) ([Figure 1B](#)) and ranged from 17 per cent (Tirana) to 86 per cent (Kingston). Also significant was the difference between men and women with fewer women (63%) than men (68%) viewing their ageing as successful (Pearson's χ^2 , $p = 0.019$) ([Figure 1C](#)).

TABLE 1. *Patient characteristics*

	Kingston, Ontario	Saint-Hyacinthe, Quebec	Tirana, Albania	Manizales, Columbia	Natal, Brazil	Total	<i>p</i>	
N	316	341	356	368	313	1,694		
Mean age	71.26	70.58	71.31	71.44	71.56	71.23		
			<i>Frequencies (%)</i>					
Sex:								
Male	140 (44)	159 (47)	166 (47)	182 (49)	148 (47)	795 (47)		
Female	176 (56)	182 (53)	190 (53)	186 (51)	165 (53)	899 (53)		
Income sufficiency:							<0.0005	
Very sufficient	217 (69)	180 (53)	9 (3)	9 (3)	16 (5)	431 (25)		
Suitable	85 (27)	144 (42)	112 (31)	108 (29)	98 (31)	547 (32)		
Not suitable	14 (4)	17 (5)	235 (66)	251 (68)	199 (64)	716 (42)		
Self-reported successful ageing:							<0.0005	
Usual ageing (0–7)	45 (14)	58 (17)	297 (83)	116 (32)	63 (20)	579 (34)		
Successful ageing (8–10)	271 (86)	283 (83)	59 (17)	252 (68)	250 (80)	1,115 (66)		
Number of diseases:							<0.0005	
0	45 (14)	51 (15)	24 (7)	79 (21)	29 (9)	228 (13)		
1	88 (28)	100 (29)	81 (23)	119 (32)	82 (26)	470 (28)		
2	99 (31)	104 (30)	123 (35)	98 (27)	103 (33)	527 (31)		
3	51 (16)	53 (16)	83 (23)	46 (13)	73 (23)	306 (18)		
4	30 (9)	21 (6)	37 (10)	18 (5)	21 (7)	127 (7)		
5	3 (1)	11 (3)	7 (2)	8 (2)	4 (1)	33 (2)		
6	0 (0)	1 (0)	1 (0)	0 (0)	1 (0)	3 (0)		
ADL – number with dysfunction:							<0.0005	
0	252 (80)	295 (87)	190 (53)	270 (73)	223 (71)	1,230 (73)		
1	26 (8)	31 (9)	38 (11)	51 (14)	46 (15)	192 (11)		
2	15 (5)	12 (4)	34 (10)	20 (5)	23 (7)	104 (6)		
3	9 (3)	3 (1)	18 (5)	10 (3)	9 (3)	49 (3)		
4	8 (3)	0 (0)	24 (7)	9 (2)	4 (1)	45 (3)		
5	4 (1)	0 (0)	36 (10)	7 (2)	6 (2)	53 (3)		
6	2 (1)	0 (0)	16 (4)	1 (0)	2 (1)	21 (1)		

CES-D:							<0.0005
Not depressed	290 (92)	309 (91)	244 (69)	303 (82)	265 (85)	1,411 (83)	
Depressed	26 (8)	32 (9)	112 (31)	65 (18)	48 (15)	283 (17)	
Nagi scale:							<0.0005
No difficulty	257 (81)	257 (75)	86 (24)	223 (61)	183 (58)	1,006 (59)	
Any difficulty	59 (19)	84 (25)	270 (76)	145 (39)	130 (42)	688 (41)	
SPPB:							<0.0005
≥8	289 (91)	321 (94)	285 (80)	275 (75)	257 (82)	1,427 (84)	
<8	27 (9)	20 (6)	71 (20)	93 (25)	56 (18)	267 (16)	
Social engagement – number of activities:							<0.0005
0	70 (22)	124 (36)	325 (91)	105 (29)	133 (42)	757 (44)	
1	144 (46)	140 (41)	27 (8)	24 (7)	126 (40)	461 (27)	
2	86 (27)	62 (18)	4 (1)	169 (46)	46 (15)	367 (22)	
3	15 (5)	15 (4)	0 (0)	70 (19)	8 (3)	109 (6)	
Resilience:							<0.0005
High resilience	132 (42)	133 (39)	253 (71)	108 (29)	173 (55)	799 (47)	
Low resilience	184 (58)	208 (61)	103 (29)	260 (71)	140 (45)	895 (53)	

Notes: ADL: activities of daily living. CES-D: Center for Epidemiologic Studies Depression Scale. SPPB: short physical performance battery.

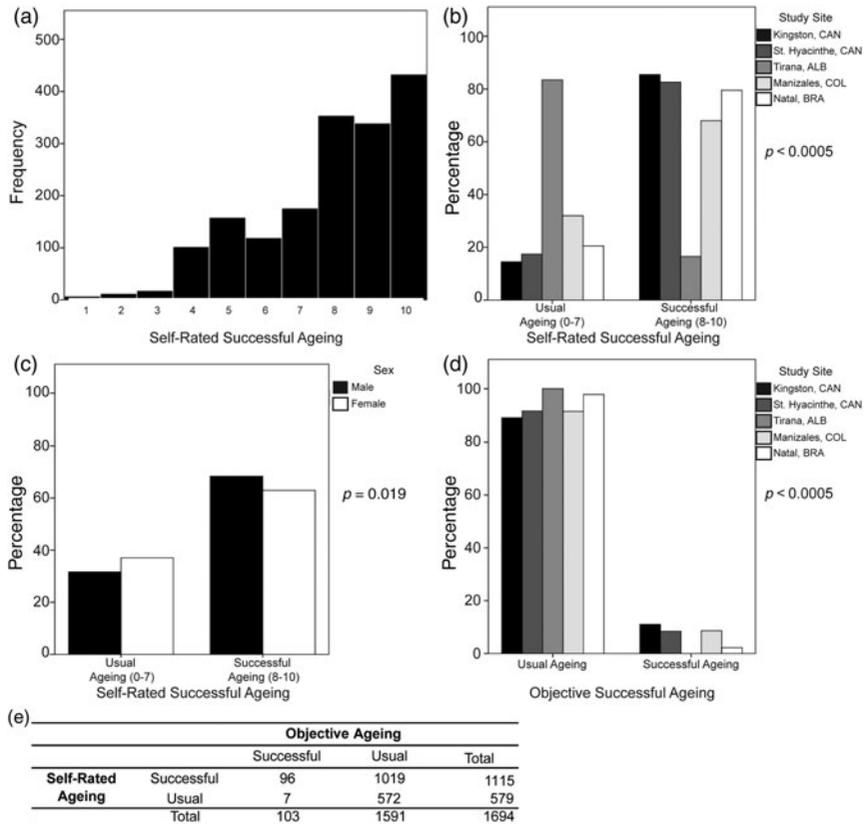


Figure 1. Self-rated and objective successful ageing.

Notes: (A) Overall distribution of self-rated successful ageing shows a right-skewed, non-normal distribution (Kolmogorov–Smirnov, $p < 0.01$). (B) The self-rated successful ageing variable was categorised into usual and successful ageing. A statistically significant difference was observed in the distribution of successful ageing across international sites (Pearson's χ^2 , $p < 0.0005$). (C) The proportion of successful agers between male and female participants was also statistically significant (Pearson's χ^2 , $p = 0.019$). (D) The proportion of objectively measured successful ageing individuals is different across international sites (Pearson's χ^2 , $p < 0.0005$). (E) Comparison of self-rated and objective successful ageing shows an average of 10 per cent overlap ($\kappa = 0.0528$). Objective successful was defined as the absence of activities of daily living dysfunction, no Nagi limitations, short physical performance battery within normal limits, no depression and no chronic disease. CAN: Canada. ALB: Albania. COL: Columbia. BRA: Brazil.

There was a marked divergence between self-rated and objective successful ageing. Using the approximated Rowe and Khan model that equates objective successful ageing with the absence of chronic disease and/or functional limitation (Figure 1D), only 6 per cent of participants met these criteria (Figure 1E). Again there was significant variability across sites ($p < 0.0005$, range 0–12%).

Objective physical health, depression and successful ageing (Model 1)

To explore the discrepancy between objective and subjective estimates of successful ageing, we performed a multiple logistic regression of objective physical health parameters and depression with the outcome variable of self-rated successful ageing (Table 2, Model 1). Age and sex were controlled for in the analysis; however, they did not prove to be significant. Because location was a strong correlate of self-rated successful ageing we controlled for it as well. Furthermore, income sufficiency was positively associated with self-rated successful ageing in all analyses. Those with greater income sufficiency were more likely to self-identify as ageing successfully.

For every one-point increase in the number of chronic diseases, the odds of successful ageing decreased by 14 per cent ($p=0.013$). In addition, having no perceived functional limitations (measured with the Nagi) increased the odds of self-rated successful ageing by 116 per cent ($p<0.0005$). Similarly, not being depressed increased the odds of self-rated successful ageing by 78 per cent ($p<0.0005$). People with no ADL dysfunction were 79 per cent more likely to rate themselves as successfully ageing ($p=0.027$). However, SPPB scores did not align with perceptions of successful ageing ($p=0.173$).

Social engagement and successful ageing (Model 2)

Rowe and Khan (1987) posited that participation in life would align with objectively measured successful ageing. To assess this parameter we examined the impact of social engagement on self-rated successful ageing (Table 2, Model 2). As above, location remained a strong predictor of the outcome in this model. For each one-point increase in social engagement there was a 36 per cent increase in the chances of self-rated successful ageing. Sex/gender was also statistically significant in this model, with the odds of self-identifying as ageing successfully 50 per cent higher in male participants.

Social engagement and objective health (Model 3)

We then combined these explanatory variables, that is, social and health parameters, social engagement and objective health measures together to look at their overall and independent impacts on successful ageing (Table 2, Model 3). Combinations of these explanatory parameters increased the Cox and Snell R^2 to 0.342. As in the models assessing social and objective health independently, location and income sufficiency remained strong predictors of self-rated successful ageing. Social

TABLE 2. Odds ratio from logistic regression analyses of self-rated successful ageing

Variable	Model 1 (objective health)		Model 2 (social)		Model 3 (social and health)		Model 4 (social, health, resilience)	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Constant	0.562	0.723	5.622	0.256	0.569	0.730	0.683	0.819
Age	1.006 (0.963, 1.051)	0.776	0.986 (0.946, 1.028)	0.512	1.004 (0.960, 1.049)	0.876	1.015 (0.971, 1.062)	0.509
Sex (Ref. Female):								
Male	1.006 (0.770, 1.312)	0.968	1.457 (1.136, 1.869)	0.003	1.080 (0.824, 1.415)	0.577	1.146 (0.870, 1.509)	0.332
Study site (Ref. Natal, Brazil):								
Kingston, Ontario	0.603 (0.357, 1.019)	0.059	0.614 (0.374, 1.009)	0.054	0.569 (0.335, 0.967)	0.037	0.562 (0.327, 0.967)	0.037
Saint-Hyacinthe, Quebec	0.521 (0.321, 0.845)	0.008	0.575 (0.364, 0.909)	0.018	0.518 (0.318, 0.843)	0.008	0.493 (0.299, 0.812)	0.005
Tirana, Albania	0.060 (0.039, 0.092)	<0.0005	0.057 (0.038, 0.086)	<0.0005	0.071 (0.046, 0.110)	<0.0005	0.066 (0.042, 0.103)	<0.0005
Manizales, Columbia	0.495 (0.337, 0.727)	<0.0005	0.447 (0.307, 0.651)	<0.0005	0.386 (0.257, 0.581)	<0.0005	0.269 (0.174, 0.416)	<0.0005
Income sufficiency (Ref. Not suitable):								
Very suitable	2.827 (1.756, 4.552)	<0.0005	4.026 (2.548, 6.360)	<0.0005	2.656 (1.644, 4.292)	<0.0005	2.256 (1.379, 3.691)	0.001
Suitable	1.568 (1.135, 2.166)	0.006	1.908 (1.407, 2.587)	<0.0005	1.535 (1.109, 2.123)	0.010	1.346 (0.964, 1.880)	0.081
Number of diseases	0.862 (0.772, 0.962)	0.008	–	–	0.866 (0.775, 0.967)	0.010	0.865 (0.774, 0.967)	0.011
SPPB (Ref. <8):								
≥8	1.303 (0.890, 1.906)	0.173	–	–	1.229 (0.837, 1.805)	0.292	1.230 (0.829, 1.825)	0.304
Nagi scale (Ref. Difficulty):								
No difficulty	2.621 (1.937, 3.548)	<0.0005	–	–	2.653 (1.958, 3.594)	<0.0005	2.491 (1.829, 3.391)	<0.0005
CES-D (Ref. Depressed):								
Not depressed	1.793 (1.271, 2.529)	0.001	–	–	1.811 (1.281, 2.559)	0.001	1.389 (0.970, 1.990)	0.073
ADL dysfunction (Ref. Significant ADL dysfunction):								
No ADL dysfunction	1.792 (1.070, 3.002)	0.027	–	–	1.776 (1.058, 2.982)	0.030	1.617 (0.950, 2.753)	0.077
Mild ADL dysfunction	1.546 (0.917, 2.605)	0.102	–	–	1.489 (0.882, 2.514)	0.137	1.383 (0.807, 2.372)	0.238
Social engagement	–	–	1.361 (1.175, 1.576)	<0.0005	1.345 (1.150, 1.574)	<0.0005	1.372 (1.168, 1.612)	<0.0005
Resilience (Ref. High resilience):								
Low resilience	–	–	–	–	–	–	0.356 (0.268, 0.473)	<0.0005
Cox and Snell <i>R</i> ²	0.337		0.289		0.342		0.362	

Notes: N = 1,694 with complete data. OR: odds ratio. CI: confidence interval. Ref.: reference group. SPPB: short physical performance battery. CES-D: Center for Epidemiologic Studies Depression Scale. ADL: activities of daily living.

engagement and all objective health parameters except for SPPB score were also significant.

Resilience (Model 4)

Resilience was added to the combined social and objective health model to assess its contribution to self-rated successful ageing (Table 2, Model 4). This further increased the Cox and Snell R^2 to 0.362, suggesting that this model explained 36.2 per cent of the variance in self-rated successful ageing. Age and sex did not significantly contribute to the model, whereas location and income sufficiency were, once again, strongly associated with successful ageing. Number of chronic diseases was inversely related to successful ageing ($p = 0.011$). In addition, no ADL dysfunction ($p < 0.0005$), no difficulty with Nagi activities ($p < 0.0005$) and social engagement ($p < 0.0005$) were all positively associated with self-rated successful ageing. In this model, depression was no longer significant, however, high resilience was positively associated with self-rated successful ageing, compared to low resilience ($p < 0.0005$). Specifically, participants with low resilience were 64 per cent less likely to self-rate as ageing successfully. As above, high *versus* low SPPB scores were not significantly associated with self-rated successful ageing.

Discussion

The determinants of self-rated successful ageing among IMIAS participants aligned with, but were much broader and less medical than those defined by Rowe and Khan. In our study, self-rated successful ageing was shaped by the different cultural norms and values across diverse international sites. Objective successful ageing, more in keeping with the usual definition, was rare even though the majority described subjective success in ageing, again with site-to-site variability. Greater objective successful ageing, as indicated by better health (*i.e.* fewer chronic diseases, an absence of depression, fewer limitations in ADLs), did, nevertheless, align with more successful self-rated ageing. However, perceptions of success in ageing also aligned with non-biological and social circumstances. More extensive social engagement, resilience and, particularly, cultural milieu were strongly linked to self-reported successful ageing. Our finding that location was the strongest predictor of self-rated successful ageing suggests that there remain unexplored cross-cultural determinants of ageing successfully for which site is a proxy measure.

To the best of our knowledge, this research represents the first cross-cultural, international study of self-rated successful ageing compared with

more traditional and medical measures. Our methodology allowed for cross-sectional comparison of successful ageing across an age-matched cohort of participants from high- and middle-income countries with distinct cultural values and norms. High rates of self-reported successful ageing were observed in Canadian and Latin American cohorts; however, significantly lower rates were observed in Albania. Rates of objective successful ageing were much lower than subjective rates across all sites, and were lower in Albania and Brazil than in Columbia or Canada. While for Albanian participants both measures were low, among the Brazilian's studied, the gap between high subjective and low objective measures of ageing success was marked. Specifically, the Brazilian cohort's self-rating paralleled that of the North American and Columbian groups, highlighting that particularly in that setting, physical health parameters and depression are not necessarily the key measures of, and contributors to, self-rated successful ageing.

Multiple models were used to examine the contribution of physical/mental health parameters and socio-economic variables, which showed that Model 4 accounting for social, health and resilience variables best explained the subjective ageing variable with a Cox and Snell R^2 of 0.362. Overall, differences in the perception of successful ageing appear to be driven by variables not entirely captured by measuring physical health/disease, depression, social engagement and income sufficiency. Similar predictive values were observed for measures of objective health alone and in combination with social parameters and resilience (Models 1, 3 and 4); whereas, social parameters alone (Model 2) had lower predictability of subjective successful ageing. Across all analyses, location was a strong explanatory variable in this study and is likely a surrogate for national circumstances and norms such as cultural values, outlook on life or social capital. Other IMIAS analyses have described the variable life expectancy among the study sites, which could impart a survival bias with the 'healthiest' people in Brazil, Columbia and Albania participating in this study (Sousa *et al.* 2014). This might contribute to an optimism that inflates both perceptions of self-rated ageing success and proportions without chronic disease in these settings. However, despite having a significant burden of poor health and, therefore, limited objective success in ageing, the Brazilian cohort rated their ageing success as high. This reinforces the argument that cultural and site-specific social factors contribute to the differences observed. With a larger sample from each site, it might be possible to examine differences in the contribution of each explanatory variable across sites and deepen understanding of those cultural strengths.

Consistent with previous studies, gender differences in successful ageing were observed (Hsu 2005; Park, Jang and Kim 2010). One study examining objective successful ageing suggested that women's disadvantage arose from

socio-economic factors (Park, Jang and Kim 2010). The gender discrepancy we observed in self-rated successful ageing between men and women could arise from gender differences in social engagement, given sex was only significant in models that accounted for social parameters alone. As reported elsewhere, social support networks were varied for men and women, and functional decline in the elderly was associated with less social engagement; indeed, the effect was more significant in men than women (Unger *et al.* 1999), as was observed in the current study.

As others have reported (Cernin, Lysack and Lichtenberg 2011; Cohen *et al.* 2009; Montross *et al.* 2006; Pruchno, Wilson-Genderson and Cartwright 2010; Strawbridge, Wallhagen and Cohen 2002), self-rated successful ageing did not align closely with the commonly used objective construct of successful ageing, highlighting how discrepant findings may reflect divergence in the constructs used, as much as true differences in results (Cosco *et al.* 2014). As initially described by Rowe and Khan (1987) and subsequently modified by more modern constructs (Cosco *et al.* 2014), fewer chronic diseases and the absence of depression was associated with increased self-rated successful ageing. Interestingly, in our study, few participants had a complete absence of chronic disease, and yet most considered themselves to be ageing successfully. As others have suggested (Jeste, Depp and Vahia 2010; Parslow, Lewis and Nay 2011), our data demonstrate that although burden of disease might be an important predictor of successful ageing, it is not unusual for older adults to perceive that they are ageing successfully in the presence of chronic illness.

Greater subjective physical ability as measured by Nagi scores and absence of ADL dysfunction was associated with greater self-rated successful ageing. By contrast, SPPB score, an objective measure of physical function, was not significant in any of our models. These data, in the context of the limited overlap between self-rated and objective successful ageing, might also suggest that constructs used to evaluate objective successful ageing are often too restrictive, especially in terms of the health parameters that are most commonly employed (Cosco *et al.* 2014).

Whether being resilient augments perceptions of successful ageing, or conversely, whether the circumstances that foster successful ageing also build resilience, cannot be determined from our findings. In reality, both may be operating. Regardless, including an indicator of resilience added explanatory value. Others have demonstrated that resilience strengthens the relationship between self-rated successful ageing and mental health (namely depression), but not physical health parameters (Moore *et al.* 2015). In yet another study resilience appeared to have a positive impact on self-rated successful ageing comparable to that of physical health (Jeste *et al.* 2013). Together these data suggest that augmenting the

malleable attribute of resilience could also contribute to older adults' perception of their success in ageing.

While our study provides a unique resource for the evaluation of successful ageing in the context of physical, psychological and social variables, and across diverse cultures and indices of development (Sousa *et al.* 2014), there are some limitations to the research itself, and to generalising findings from it. Prior analyses have shown that the education level of the Kingston participants was higher than that of their age group within the same community, suggesting a possible selection bias (Sousa *et al.* 2014). The overall selection of community-dwelling individuals may bias towards higher rates of successful ageing. Similarly, recruiting persons 65–75 years old at the start of the study could impart a survival bias (especially in non-Canadian sites), and might limit applicability to other age groups. Finally, as described earlier, since participants have outlived their life expectancy at birth in all but the North American sites, the high level of self-rated successful ageing in the Latin American study samples may reflect a healthiness and optimism borne of this survival rather than of the indicators measured.

Few studies have comprehensively examined the association between depression and physical health parameters and self-rated successful ageing. Furthermore, no study has examined the predictors of successful ageing across geographically, economically and socially diverse populations. Our novel findings suggest that a focus on and increase in physical and mental health alone will be less effective in promoting successful ageing than would be interventions that encourage social engagement and improved resilience. In addition, these data show that there are important differences in the factors contributing to successful ageing in different countries/cultures. As the global population continues to age, a deeper understanding of the determinants of perceived successful ageing will be important to maintain or even improve the quality of life of older individuals and to develop cost-effective, person-centred policies that promote their wellbeing, recognising that this is a different construct than promoting health and preventing illness.

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