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Successful Aging
Among The Oldest Old

ACADEMIC DISSERTATION
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For centuries, individuals and societies have shared the common goal of living longer with less morbidity and a high quality of life. In the 21st century, we are now witnessing a rapid decline in old age mortality and an unprecedented growth of very old populations. The increase in length of life does not necessarily imply improving health and quality of life, however. It is therefore important to consider the conditions for successful aging; how can people age in the best and most satisfactory ways. However, there is as yet no generally accepted definition of successful aging, nor any standard tool for its measurement. In this study, successful aging was approached from the point of view of the oldest old population.

This study set out to estimate the prevalence of successful aging; to identify factors associated with successful aging; and to examine successful aging as a predictor of entry into long-term care (LTC) and mortality among the oldest old. Successful aging was measured by different models that included physical, psychological and social components, but that had different criteria for success. The lay understanding of successful aging and its dimensions were studied by interviewing individuals who had already been successful in surviving.

The core data source for this research was the Vitality 90+ Study, which comprised community dwellers and institutionalized people living in Tampere, Finland. Data were collected by mailed questionnaires from individuals aged 90 and older in 2001, 2003, 2005, 2007 and 2010. The number of participants in each cross-sectional study ranged from 892 to 1,283, and in each wave, the response rate was ca 80%. In addition, life story interviews were conducted in 2012 with 45 individuals aged 90-91 years in order to gain a deeper understanding of successful aging from nonagenarians’ point of view. Data from two national registers were linked to the Vitality 90+ data. Finnish Population Register data on dates of death were obtained from Statistics Finland. The national registers – the Care Register for Health Care (Terveys-HILMO) and the Care Register for Social Welfare (Sosiaali-HILMO) – were also linked to the Vitality 90+ data to obtain information on entry into LTC.

The prevalence of successful aging ranged from 1.6% to 18%, depending on the model used. Successful aging was associated with male gender and living in the community. In some models successful aging was associated with younger age, being
married and a higher level of education. The models of successful aging that placed less emphasis on the absence of diseases and demanding physical activities were better predictors of the length of future life and entry into LTC than the most demanding models.

The life story interviews underscored the importance of physical, psychological and social functioning. The interviewees said it was more important for them to be pain-free rather than disease-free. Most interviewees described themselves as successful agers. Independence and a balanced and harmonious life were considered the main conditions for successful aging. The nonagenarian interviewees defined successful aging as a process. For them, success was a process from past to present, and they hoped their present good aging would continue in the future. Having a good death was considered part of successful and good aging.

The main components in the life story interviews were basically the same as those that appear in the biomedical model of successful ageing. Both the older interviewees and the researchers emphasized the importance of physical, psychological and social functioning in successful aging. However, the measurement of these components presents a major challenge for gerontologists. This study suggests that for the oldest old, successful aging should be possible even in the presence of some degree of disease and disability. It is impossible to present a single universal model of successful aging that applies to all old individuals and all age groups. Instead, it is necessary to take into account the changes that happen in the aging process and on this basis to work toward a better, more valid and useful model of successful aging that also applies to the oldest old.
TIIVISTELMÄ


Tutkimustehtävänä oli selvittää onnistuneen vanhenemisen yleisyyttä, tunnistaa siihen yhteydessä olevia tekijöitä, sekä tutkia, missä määrin se ennustaa pitkäaikaishoitoon siirtymistä ja kuolleisuutta. Onnistunutta vanhenemista mitattiin käyttäen erilaisia malleja jotka kaikki sisälsivät fyysisen, psykologisen ja sosiaalisen komponentin, mutta määrittelivät "onnistumisen" eri tavoin. Ihmisten omia tapoja ymmärtää onnistunut vanheneminen ja sen ulottuvuudet tutkittiin haastattelemalla henkilöitä, jotka olivat jo "onnistuneet" siinä mielessä, että olivat eläneet pitkään.

Onnistuneen vanhenemisen yleisyys vaihteli 1.6%-stä 18%-iin riippuen käytetystä mallista. Onnistunut vanheneminen oli yhteydessä sukupuolen ja asuinpaikan ja vanhukouluksen kohtuukseen. Sellaiset onnistuneen vanhenemisen mallit, joissa sairauksien poissaolo ja kyky vaativiin toimintoihin painottuvat vähemmän, ennustivat jäljellä olevaa eläinikää ja pitkääikaishoitoon siirtymistä paremmin kuin vaativimmat mallit.


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<td>ADL</td>
<td>Activities of daily living</td>
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<tr>
<td>CI</td>
<td>Confidence interval</td>
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<td>HR</td>
<td>Hazard ratio</td>
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<tr>
<td>IADL</td>
<td>Instrumental activities of daily living</td>
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<tr>
<td>IRR</td>
<td>Incidence rate ratio</td>
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<td>LTC</td>
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<td>OR</td>
<td>Odds ratio</td>
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<td>PhC</td>
<td>Physical component</td>
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<td>PIC</td>
<td>Personal identity code</td>
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<td>Psychological component</td>
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<td>SA</td>
<td>Successful aging</td>
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<td>SOC</td>
<td>Selective optimization with compensation</td>
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<td>Sosiaali-HILMO</td>
<td>The care register for social welfare</td>
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<td>Terveys-HILMO</td>
<td>The care register for health care</td>
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<tr>
<td>THL</td>
<td>National institute for health and welfare</td>
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Population aging and increasing longevity have raised concern about the quality of ever longer lives, prompting discussion and debate about concepts such as successful aging or healthy and good aging. As Tesch-Römer and Wahl (2016) point out, higher standards of living and other advances in society will not do away with disability or the need for care, but simply postpone them to a higher age and the last years of life. The concept of successful aging was introduced to help identify factors that can contribute to a good old age and to developing effective interventions that can improve the quality of life in old age.

In the field of gerontology, the concept of successful aging was first introduced by Robert J. Havighurst, who defined it as an individual's satisfaction and happiness in the social context (Havighurst, 1961). Ever since, gerontologists have worked to develop a framework for describing the ideal outcome of the aging process called successful aging. However, there is still no consensus on how to define or measure this concept.

Gerontologists have historically defined successful aging from two perspectives, either as a state of being or as a process. Rowe and Kahn (1997) support the idea of a state of being, while the model developed by Baltes and Baltes (1990) conceptualizes aging as a process of adaptation to change (Sadler & Biggs, 2006).

Successful aging can be measured, among others, from a biomedical, psychosocial or lay perspective (Bowling & Dieppe, 2005). From a biomedical perspective, successful aging is defined in terms of increased life expectancy: the focus is on the individual's physical and cognitive functioning and on the absence of disease and disability. Rowe and Kahn's (1997) model takes such a biomedical perspective and defines successful aging as a low probability of disease and disability, high cognitive and physical functioning, and active engagement with life. The psychological perspective on successful aging, then, emphasizes life satisfaction, social participation and psychological resources. The selection, optimization and compensation (SOC) model developed by Baltes and Baltes (1990) is based on this psychological perspective. There are also models that combine both the biomedical and psychological perspective. Young, Frick and Phelan's model (2009), for example, defines successful aging by using three components from Rowe and Kahn's model,
but adds that it is not necessary for an individual to succeed in all three components; instead, they can make use of compensation mechanisms. Bowling (2007a) maintains that the lay perspective provides a better understanding of successful aging based on individuals’ values. It remains unclear, however, exactly how successful and good aging should be defined and measured. Results on the prevalence of successful aging depend on the definition applied, the design of the study and the specific age group studied.

The oldest old are one group who by definition meet one of the major criteria of successful aging, namely longevity. Long lives are usually valued, but the health and quality of life of those who live long vary, and for some they may be poor. The oldest old are currently the fastest growing segment of the population, and for this reason alone questions around successful aging have gained wide currency in aging research. For both aging individuals and societies, the main issue of interest is how and to what extent it is possible to maintain health, independence, social engagement and other components of a quality and successful life in very old age. Are these same factors most highly valued among those people who have already reached very old age, or does the understanding of what constitutes good old age change with advancing age? Most earlier studies on successful aging have emphasized the aspects of health and functioning and largely neglected the social and psychological dimensions. There are only very few studies that have focused on successful aging among the oldest old, and very little is known about how very old people themselves understand good old age and successful aging.

This study investigates successful aging in nonagenarians (90+ years) from two perspectives: first, in the context of an epidemiological population study and second, by exploring the views and opinions of nonagenarians themselves. The purpose is to assess the prevalence of successful aging among nonagenarians and to identify which demographic factors are associated with successful aging. This is one of the first studies to examine the association of successful aging with mortality and entry into long-term care (LTC). It also sheds light on how the oldest old themselves perceive good and successful aging.

There is no standard model for defining or measuring successful aging. This study develops models for the quantitative measurement of successful aging based on the thoughts of Rowe and Kahn (1997) and Young et al. (2009). Rather than directly applying their indicators, the route chosen was to develop different models with different thresholds and on this basis to explore the feasibility of different ways of describing successful aging in research with the oldest old.
A long life has always been considered a desirable objective. Throughout history, people have searched for the elixir of life or the elixir of immortality. This dream of a longer life has gradually been coming true. According to a report the US National Research Council (2001), better living standards, advances in primary prevention and improved treatments have brought an increased life expectancy at birth and at older ages. Initially this was mainly through reduced infant and childhood mortality, but more recently changes have also been seen in the length of adult lives (Cheung & Robine, 2007).

Prolonged life expectancy towards the end of the human lifecycle has increased the size of the oldest population segments. Coupled with the decreased birth rate, this has profoundly changed population demographics (Satariano, 2006). The proportion of older people is increasing in all countries across the world (Hayward & Zhang, 2001). This is one of the most significant social transformations of the 21st century: as the baby boomer generation (for example, in the US people born between 1946 and 1964 and in Finland between 1944 and 1954) approaches 65, older people will soon account for over 20% of the total population in many countries (Satariano, 2006). This historic transformation has had and will continue to have major social, political and economic consequences.

With the prolongation of old age and the increasing heterogeneity of the elderly population it has become commonplace to make a distinction between three groups of older people, i.e. the young old (65-75), the middle old (75-85) and the oldest old (85+) (Zizza, Ellison, & Wernette, 2009). The oldest old, people aged 85 and over, are the fastest growing age group in the world (US National Research Council, 2001).

Mosby's Medical dictionary defines longevity as "the duration of an individual life beyond the norm for the species" (Longevity, n.d.). Martin, Hagberg and Poon (2012) describe the first and second-generation models of longevity research on extreme old age. First-generation models include information on genetics, intelligence, health information, social and environmental factors, personality, mood, adjustment and sexual relations. Second-generation models have worked with
broader categories and focused on negative and positive events, coping, emotion, functional capacity and lifestyles.

The oldest old individuals are in a stage of life where the aging process may be accelerated by higher risks of disease, frailty and dependence (Sole-Auro and Crimmins, 2013). At the population level, old age is a risk factor for disease, meaning that the oldest old are at a higher risk of comorbidity and frailty. Larsson and Thorslund (2006) and Meinow, Kåreholt, Thorslund and Parker (2015) found a strong association between health problems and age. In this stage of life, they will have more conditions, which may lead to frailty and dependence. However, in recent decades there has been increasing controversy over whether increased life expectancy at old age is associated with good health or with increased health problems as a result of accumulating degenerative disease and disability.

Engelaer, Van Bodegom and Westendorp (2013) argue that as more years are added to life, the period of frailty is postponed but fixed at the end of life. Samuelsson et al. (1997) studied five consecutive cohorts at the age of 100 in Sweden. They found that these centenarians were genetically a special group and that the incidence of severe disease was relatively low after age 80. On the other hand, Andersen-Ranberg, Scroll and Jeune (2001) found in their population study that all but one of the participants had chronic conditions, most of them several, and only a minor proportion were cognitively intact and functioning well. Yet many studies have shown that despite higher morbidity and impaired activities of daily living (ADL) in advanced age, the oldest old may perceive their health quite positively (Jopp & Rott, 2006). They can feel happy even in the presence of disease and limitations in functioning, and be satisfied with life in the same way as younger old individuals (Jopp & Rott, 2006).

Although the prevalence of morbidity is high among the oldest old, other factors also come into play in the quality of life of this age group. Indeed, the situation of the oldest old cannot be properly understood by studying morbidity or disability alone (Robine, Crimmins, Horiuchi, & Zeng, 2007). A serious study of longevity and the ability of individuals to resist stressors must consider a combination of factors including biology, the environment, disease and disability along with the health status of individuals (Robine et al., 2007). Clearly, health and longevity are very complex phenomena.

Longevity can be influenced by such factors as living arrangements, health behaviors and level of education. The likelihood of reaching very old age is higher in some countries than others, which may have to do with historical events. Sole-Auro and Crimmins (2013), for instance, suggest that the likelihood of reaching very old
age in the recent cohort of the oldest old may be related to the country's involvement in World War II. The likelihood of reaching age 80 is higher in non-combatant countries such as Sweden and Switzerland than in Italy, Belgium and Spain. Furthermore, the variation in life expectancy among the oldest old is not clearly linked to health differentials between countries (Sole-Auro & Crimmins, 2013).

The oldest old are the fastest growing group of the population in all countries due to a substantial decline in mortality in old age (Andersen-Ranberg, Petersen, Robine and Christensen, 2005). This age group is excluded from most studies because of their higher prevalence of physical and mental disabilities, or because they have a lower education and are more vulnerable and more often housebound and institutionalized than other age groups. Despite the challenges involved in studying the oldest old, it is paramount that the age group is included in research because the knowledge gained is crucial for purposes of policy development and care provision.
3 SUCCESSFUL AGING

3.1 The concept of successful aging

Success is a vague word that is understood and interpreted differently in different societies, cultures and historical eras and even by different individuals (Iwamasa & Iwasaki, 2011). In 1806, Webster’s dictionary defined success as being "fortunate, happy, kind and prosperous" (Ancestry, 2017); and in 2017, as "the attainment of wealth, fame and respect". The definition and measurement of success for aging has a long history. In an essay on old age in 44 BC, Cicero made a distinction between happy and unhappy old age, and said that if we take a positive view, old age does not seem at all bad because it is made inevitable by nature (Jarcho, 1971). Cicero associated old age with positive changes and wisdom, but also made the point that wealth made a difference. He continued that adjusting to old age is easier in a moral society. Finally, he stressed that it is essential to maintain physical and mental activities in old age (Jarcho, 1971).

Peterson and Martin (2015) say that the first author to use the term of success in the context of old age was Montaigne in 16th century France, where attitudes to old age were very negative. Later, the concept of successful aging was introduced in the field of gerontology by Havighurst (1961), who drew attention to the need for research in this area. He described successful aging as a major aim for gerontology, which provides instruction for societies and individuals on issues such as retirement policy, social security, housing, living arrangements, and how old individuals relate themselves to their family, or what to do in their free time. Gerontology must therefore develop a theory for successful aging so that it can provide sound advice (Havighurst, 1961). For Havighurst, successful aging was in essence about life satisfaction and happiness at the individual level, about subjective well-being (Havighurst, 1961). He defined it as adding life to years and getting satisfaction from life. Williams and Wirths (1965), then, defined success as life satisfaction, social engagement, feeling good about oneself and behaving according to one’s values and beliefs. Neugarten (1972) and Williams and Wirths (1965) said the main predictor of successful aging was personality. Palmore (1979) defined successful aging as surviving and longevity (to 75 years), health and happiness.
Ever since Havighurst's early calls for research into successful aging, scholars in several fields have been working to develop a definition of as well as tools for measuring successful aging. In 1987, Row and Kahn proposed a distinction between usual and successful aging, and ten years later in 1997 defined successful aging based on three components: a lower probability of disease and disease-related disabilities, high physical and cognitive functional capacity, and active engagement with life. Baltes and Baltes (1990) defined successful aging as adaptation to changes that may happen during the aging process and called it "selective optimization with compensation". Baltes and Carstensen (1996) defined successful aging as a process in which individuals master their goals.

There is some agreement that successful aging should be defined in broader terms than just health and longevity (Martin et al., 2014). Depp, Glatt and Jeste (2007) see longevity as the classical indicator of successful aging, which is impacted by heredity, environment, diseases and lifestyle. Schulz and Heckhausen (1996), among others, point out that if old people are categorized into diseased and normal populations, there will still be considerable heterogeneity within the normal category. Therefore, researchers have made a further distinction in the category of "normal" between usual and successful. Successful aging could be seen as a development and maintenance process throughout the life course that optimizes selection and failure compensation (Schulz & Heckhausen, 1996). In addition, successful aging could be considered in terms of what old people value in their own life and death. This is an area on which there is only very limited research.

Von Faber et al. (2001) suggest that successful aging can be defined from two different vantage-points: either as a state of being or as a process of continued adaptation. Objective measurements of successful aging at a certain time take the former view and define it as a state of being. One example is Rowe and Kahn's model of successful aging. Baltes and Baltes (1990) are among those who approach successful aging as a process associated with coping and adaptation.

Definitions of successful aging can be grounded in biomedical or psychological approaches, or a combination of both (Bowling & Dieppe, 2005). Some studies have set about defining successful aging on the basis of the lay perspective. Successful aging is a multidimensional concept and it seems that each definition is based on a different approach (see sections 3.3, 3.4 and 3.5).

The literature on successful aging has been extensively reviewed. Depp and Jeste (2006) identified 28 quantitative studies that had offered a definition for successful aging. Bowling (2007a) reviewed 170 qualitative and quantitative studies that used subjective or objective criteria for successful aging. Martinson and Berridge reviewed
67 articles with critiques and concerns about the concept of successful aging (Martinson & Berridge, 2014).

Despite all the research efforts so far, there is still no standard definition of successful aging. Indeed, defining successful aging remains a huge challenge which is compounded by the ambiguity of the term itself, the complications involved in the process of aging, the heterogeneity of older populations, and the dynamic nature of societies. The literature has dealt with successful aging either as an independent (predictor) or a dependent variable (outcome). It seems that in each discipline, say biomedical research or psychology, the aim has been to define the concept in the context of its own interests. For this reason, these studies have also produced different results on the prevalence of successful aging. Some researchers have attempted to find synonyms for successful aging that are easier to define or to apply empirically, such as productive aging, positive aging, active aging, vital aging, optimal aging, effective aging, healthy aging, independent aging, harmonized aging or simply aging well and good life (Bowling, 2007a; Depp & Jeste, 2006; Fernandez-Ballesteros, Molina, Schettini, & Santacreu, 2013). According to Fernandez-Ballesteros et al. (2013), these kin terms refer to the semantic network of aging well, which is the most common term from the lay perspective and which also enjoys international favor (Fernandez-Ballesteros et al., 2013).

However, each of these terms has its own description in the scientific literature. For example, healthy aging is typically defined as referring to functional independence and the absence of disease. It represents the biomedical perspective and is used more often in the biomedical field (Depp & Jeste, 2006). Healthy aging focuses on outcomes such as disability and diseases, both of which are key criteria for healthy aging. Successful aging, on the other hand, combines biomedical (physical and cognitive functions), social and psychological aspects, and has a broader meaning than healthy aging. According to Fernandez-Ballesteros et al. (2013), the inclusion of personality and environmental factors in the definition of healthy aging effectively brings it in line with the concept of aging well. In most studies, they say, successful aging can be taken to refer to aging well. Active aging, a concept introduced by the WHO in 2002, integrates health, participation and security, and is most commonly used in the socio-political arena (Fernandez-Ballesteros et al., 2013). Healthy and successful aging are the most frequently used terms in social, psychological and biomedical sciences (Fernandez-Ballesteros et al., 2013).
3.2 Successful aging in the grand theories of social gerontology

The three grand theories of social gerontology – disengagement theory, activity theory and continuation theory – each have their own understanding of success in the process of aging, with their own respective strengths and weaknesses. Disengagement theory was formulated by Cumming and Henry in 1961. According to Victor (2005), disengagement theory posits that aging itself causes inevitable withdrawal from interaction between an older individual and the social context to which they belong. The theory goes that older adults withdraw from society, work and family because of the rapid pace of change in technology, their lack of new knowledge, poor physical and mental performance, changes happening in society, and life events such as retirement. Disengagement would seem to be functional and beneficial in the sense that it transfers power from older to younger generations (Victor, 2005). Disengagement from activities, Victor continues, helps to prepare older people for death and the end of life. With less activity, older people also have less responsibility and therefore less pressure. At the same time, this will allow society to minimize the disruption caused by the death of an individual. Disengagement gradually facilitates the transfer of power from older to younger generations by reducing the roles of older individuals in society, restricting their social contacts and lessening their commitment to society’s norms. Both individuals and society gain benefits in the process of disengagement (Victor, 2005).

According to disengagement theory, successful aging is about seeking to disengage from active life and the individual’s acceptance of such disengagement. Its view of successful aging is based on the observation that as they grow older, people begin to withdraw from their younger age activities. However, disengagement does not mean that the individual is completely passive and dependent; it only weakens the bond to the social environment. It may be defined as "rocking chair inaction" or a carefree attitude toward responsibilities (Havighurst, 1963). Blau (1973) says that this theory leads to stereotyping the elderly in society. Nonetheless it has inspired the development of social gerontology and two other theories concerning the aging of individuals (Victor, 2005). Both activity theory and continuity theory are based on the idea of older people’s adaptation and integration into society, which is considered an integral part of successful aging.

Havighurst (1963) maintained that for practical and clinical gerontologists, the most favored social gerontological theory was activity theory. Activity theory also serves as the starting point for the theorizing of aging well by Fernandez-Ballesteros et al. (2013). Activity theory advocates active engagement with life and defines
successful aging as persistence with middle-age activities and attitudes, or substituting those activities if changes are necessary (Havighurst, 1963). New models of retirement living and the introduction of early retirement policy in the USA turned older individuals into valued leisure market customers (Havighurst, 1963). Activity theory prescribes that after retirement from a paid job, older people should look for other paid or voluntary roles in order to compensate for this loss. This, according to Victor (2005), is how activity theory sees the path to successful aging: people should be active and be engaged in middle life activities. Indeed, activity theory takes a more positive perspective than disengagement theory and maintains that older people can be integrated in society as full members. Activity theory was developed in response to and as an alternative to disengagement; yet it is also judgmental in that it understands interaction and activity as necessary prerequisites for good old age.

Havighurst (1963; 1961) took an individualized, subjective view of successful aging and defined it on the basis of the individual's behavior and lifestyle. This view on the consistency of adult behaviors and lifestyles throughout the lifespan led to the development of the continuity theory of aging by Atchley (1989). According to Atchley, adaptation to change provides the foundation for the theory of continued adult development. He considered it as continuing habits, performance, lifestyle and relations from midlife into later life. He identified two types of continuity in adult behavior, viz. external and internal continuity. The consistency of social characteristics refers to external continuity, while psychological characteristics refer to internal continuity. Most successful agers have enjoyed success in their midlife, and late life does not mark a radical break from the past.

While disengagement and activity theory both view successful aging in terms of a movement in a single direction, continuity theory works from the assumption that individuals will try out many directions in order to find a favorable lifestyle (Victor, 2005, p. 24). It does not prescribe that the individual should either become active or disengage in order to be successful (Victor, 2005, p. 25). Rather than expecting aging individuals to cope and adapt with changes in order to find a stable lifestyle, continuity theory supports the maintenance of ideas, personality traits, beliefs and a stable self-concept and lifestyle by individuals throughout their lifetime.

Addae-Dapaah and Ying (2013) say there is no single theory about successful aging that is applicable to each and every individual. Some may age successfully as they disengage from society, while others may age successfully as they remain active and engaged with society. The grand theories offer different perspectives on successful aging and provide a framework for understanding and organizing
empirical findings about aging. However, no theory alone can explain all aspects of successful aging.
3.3 Biomedical approaches

Biomedical models usually define successful aging in terms of longevity coupled with a minimum of disease and disability (Bowling & Dieppe, 2005). The main requirements are the maintenance of cognitive and physical health. Depp and Jeste (2006) found in their review that successful aging is often measured by objective criteria such as activities of daily living (ADL) and the ability to walk, or on the basis of cognitive functioning by assessing self-reported memory function or by taking cognitive screening tests. The most cited biomedical model is that developed by John W. Rowe and Robert L. Kahn (Bowling & Dieppe, 2005), who in 1987 distinguished between usual and successful aging and subsequently in 1997 introduced their prominent model. Rowe and Kahn's model has been operationalized, for instance, in the MacArthur Foundation studies on successful aging and associated factors (Jeste, Depp, & Vahia, 2010).

Rowe and Kahn (1998) define successful aging through three components: the low probability of disease and disability, high cognitive and physical functioning, and active engagement with life (Figure 1). They argue that successful aging is not only the absence of disease, but also comprises aspects beyond maintaining functional capacities.

Bowing and Iliffe (2011) describe this as a "broader biomedical approach" in that it adds the component of social engagement to the biomedical or health approach.

![Figure 1. Rowe and Kahn's (1997) model of successful aging.](image)

These three components in Rowe and Kahn's model each break down into constituent parts. The absence of disease and disability also implies the absence of risk factors for disease, such as hypertension or obesity. High physical and psychological capacities, then, refer to the individual's functional ability. Rowe and Kahn particularly highlight the importance of lifestyle to avoiding the risk factors for
disease and disability, pointing out that physical and cognitive capacities are essential for active engagement with life. Furthermore, they add that interindividual variability in physical and psychological functioning is an important element in increasing or decreasing the risk for disease and disability (Rowe & Kahn, 1997).

Rowe and Kahn (1998, p. 40) say that "successful aging goes beyond the potentials of individuals, it involves the activity which we have labelled engagement with life". They consider two forms of active engagement, i.e. interpersonal relations and productive activities. Interpersonal relations can be considered to involve contacts and transactions with others, information exchange and emotional support. Productive activity, then, refers to activities that create value in society, such as voluntary unpaid work. They identify three predictors of productive activity: functional capacity, education and self-efficacy (Rowe & Kahn, 1997).

Rowe and Kahn (1997) argue that individuals handle stressful situations by means of resilience. They use this notion to describe individuals who are successful now, but who did not necessarily meet the criteria of success in their past. Individuals move in and out of success during their life process, and successful agers manage to deal with stressful episodes, such as acute illness or loss of a partner, to overcome the situation and to meet the criteria of success again. However, Rowe and Kahn do not explain exactly how this happens.

In a critical assessment of Rowe and Kahn’s model from the point of view of the oldest old, it seems that they do not give serious enough attention to the heterogeneity of old adult populations and to the increased risk of disease and disability with advancing age. Their model divides older people into two groups, successful and unsuccessful. It is very rare for older people to be completely disease free, and therefore only the most robust elite of old individuals would qualify as successful agers.

In a recent overview of their previous model, Rowe and Kahn (2015) emphasize that their multidisciplinary definition of successful aging is a life course oriented model which is focused on "what successful aging is". However, they admit that they did not consider the importance of social factors such as race, gender, sexual orientation and socioeconomic status to the individual's capacity for successful aging. Likewise, their MacArthur Foundation studies ignored the effect of the interpersonal environment (e.g. family structure and friendship), microsocial influences (e.g. financial situation), access to high quality affordable health care, public transportation and urban design (Rowe & Kahn, 2015). Finally, Rowe and Kahn highlight the effects of success at the societal level (e.g. productivity and engagement) on successful aging at the individual level.
3.4 Psychological approaches

Psychological approaches to defining successful aging take a more subjective view and focus on the individual's experiences of life satisfaction, for example. Baltes and Baltes (1990) suggest that some models of successful aging place too much weight on subjective indicators: although essential, they are not alone sufficient for a meaningful assessment of successful aging. Bowling and Dieppe (2005), for their part, conclude that definitions of successful aging should consider not only the individual's psychological resources, but also social participation and functioning. The psychological approach, they maintain, should be expanded and developed into a psychosocial approach.

Havighurst (1963) defined successful agers as people who were satisfied with their past and present life. Later, Fisher (1992; 1995) considered life satisfaction as an antecedent of successful aging. Ryff (1989) mentioned not only life satisfaction, but also emphasized the importance of growth and progress in later life. She considered six positive functions for successful aging, namely self-acceptance, positive relations with others, autonomy, environmental mastery, having purpose in life, and personal growth. Aging, according to Ryff, is a developmental process which is always accompanied by growth. The review by Bowling (2007a) showed that the varied definitions of successful aging under the psychological approach have focused on such factors as personal growth, creativity, self-efficacy, autonomy, independence, effective coping strategies, sense of purpose, self-acceptance, self-worth and personality.

Bowling (2007a) observes that psychological approaches have faced criticism for their focus on the individual's autonomy as a cornerstone of successful aging. Nolan (2001) likewise argues that the emphasis on autonomy tends to marginalize frail individuals based on their dependence. Indeed, this view does not consider the importance of interdependence, reciprocity and need for recognition (Nolan, 2001).

Selective optimization with compensation (SOC) is a life span model developed by Baltes and Baltes (1990). One of the leading psychological models of successful aging, SOC focuses on successful adaptation and on this basis explains the nature of development and aging. The model views aging as a heterogeneous process that includes different pathways and outcomes. Rather than being concerned with "what successful aging is", its main focus is on "how people age successfully". It is interested in the processes that people apply as coping mechanisms in their life. The model does not consider success as an endpoint, but describes success as a process. This process has been defined as acceptance of the fact that individuals have
different goals and norms, as well as the identification of the ideal process through which individuals master and reach their goals in old age.

In the SOC model, the process of success is considered to involve three components: selection, optimization and compensation. Selection is a consequence of the changes that happen with aging in individuals and environmental resources, which increase the restrictions present in various life domains. In old age, changes are mostly seen as losses: they may involve restrictions in task performance or an avoidance of particular domains. This will cause the individual to try and readjust his or her goals. To make this adjustment, the individual may decide to change his or her environment or behavior in an active process of selection. The conscious avoidance of certain hard-to-accomplish activities is called passive selection. Sudden changes may cause the individual to react by means of selection (Baltes & Carstensen, 1996).

Optimization is the enrichment and growth of reserves or resources, the enrichment of new domains and goals or existing domains. Baltes and Wahl (1991) observe that most older individuals have the potential for optimization, but in the face of restrictive or overprotective environments choose not to make use of this potential. Compensation means that the individual resorts to alternative ways of reaching his or her goals. It follows selection behavior, but differs from selection in that while the goal remains the same, different strategies are applied to maintain these prior purposes (Baltes & Carstensen, 1996).

Baltes and Lang (1997) say that in the SOC model, successful aging is seen as a process of striking a positive balance between losses and gains. In order to achieve this positive balance, individuals will select those life domains that are important for them. Then they compensate for the losses of these important domains and adapt to the changes happening through the aging process and create an environment for lifelong successful development (Baltes & Lang, 1997). Losses and changes in physical, psychological or socioeconomic status are inevitable throughout life. Successful individuals, however, will consciously or unconsciously and actively or passively use selective optimization with compensation (Wiese, Freund, & Baltes, 2000). Freund and Baltes (1998) found an age-related decline in optimization and compensation at advanced ages. They (2002) report that the more frequent use of this strategy was related to higher intelligence and a higher level of cognitive functioning. Pruchno and Carr (2017) argue that resilience has a prominent role in successful aging, but Pruchno, Heid and Genderson (2015) suggest that successful aging and resilience are not equivalent constructs. Successful aging is currently defined first and foremost as an end state (Pruchno et al., 2015). Resilience becomes
a personality trait in adverse situations and is based on behavioral, functional, cultural and social resources. Resilience reflects the individual's coping responses and positive adaptation to any stressful changes, and therefore appears as a process. The achievement of successful aging as a state is only possible for select individuals, while resilience is an achievable goal for all (Pruchno & Carr, 2017).
3.5 Young, Frick and Phelan's model

Recently new definitions have emerged of successful aging that combine biomedical and psychological approaches. The model by Young, Frick and Phelan (2009) is a good example of this multidisciplinary approach. They highlight the heterogeneity of older individuals and describe aging as an individualized process. Young et al. (2009, p. 88-89) define successful aging as:

"a state wherein an individual is able to invoke adaptive psychological and social mechanisms to compensate for physiological limitations to achieve a sense of well-being, high self-assessed quality of life, and a sense of personal fulfilment even in the context of illness and disability".

Starting from the criticisms of biomedical approaches and the multiple pathways that can lead to successful aging, Young et al. (2009) introduce the idea of a compensation mechanism to offset developing physical limitations. Based on coping, adaptation, resilience and spirituality, the idea is that certain psychological and social mechanisms may compensate for physiological decline to allow the person to age successfully. These mechanisms may help the individual to sustain a state of well-being and high self-assessed quality of life.

The multidimensional model developed by Young et al. (2009) integrates three domains of successful aging, i.e. the physiological, psychological and social (see Figure 2). It is based on three principles, namely the heterogeneity of aging, multiple pathways to successful aging, and individual compensation mechanisms to adjust for the changes happening in the aging process. According to this model, individuals may have some limitations in any one of the three dimensions, but psychological mechanisms such as coping or resilience will nonetheless allow them to be successful. The model takes into account the inevitable rise in the prevalence of disease and disability in old age. In the other models, individuals with such disadvantages would not be considered successful agers.

This model by Young et al. (2009) has been used and validated in another study by Young, Fan, Parrish and Frick (2009). The model's discriminant and predictive validities were investigated by using three databases in the USA. The operationalized model integrated physiological, psychological and social components, and it was constructed based on scales corresponding to these three components. A summary score is compiled for each component. To measure successful aging, Young et al. dichotomized the scores (0/1) for each factor included in each component. The factors considered were comorbidity, impairment, cognitive function, emotional
vitality and engagement with life. The scores thus ranged from 0 to 5. To qualify as successful agers, individuals do not necessarily have to record a perfect score.

Young et al.’s (2009) basic idea was that psychological and social mechanisms could compensate for physical decline. Yet in the operationalization of their model, where all the dimensions produce 0 or 1 points, and three out of the five components (comorbidity, impairment and cognitive function) reflect physical functioning, there is in fact no possibility for such compensation. Another problem for studies applying the Young et al. model is that, in a paper measuring the predictive validity of successful aging (Young, Fan, Parrish and Frick, 2009), indicators of physical functioning were used as components of the predictor (successful ageing) but also as a component of the outcome.

Figure 2. Young et al.’s (2009) multi-dimensional model of successful aging. The central area (A) describes individuals who are successful in all three components. The other three areas (B, C, and D) represent individuals who are successful in two components of successful aging, but can still be qualified as successful agers.

Figure 2. Young et al.’s (2009) multi-dimensional model of successful aging. The central area (A) describes individuals who are successful in all three components. The other three areas (B, C, and D) represent individuals who are successful in two components of successful aging, but can still be qualified as successful agers.
3.6 Lay views

Lay views on successful aging are not driven by any pre-existing theories, but they can nonetheless provide important clues for the development a new theory-based definition of successful aging. Lay views represent ordinary people's own beliefs and values about aging (Torres, 2003) and can offer significant social input to theoretical models of successful aging (Bowling, 2007a; 2007b). This approach provides a platform for the voice of older individuals. From the lay perspective, successful aging is a combination of beliefs, basic resources (health, financial and social resources) and psychological elements, including cognitive and behavioral strategies (Jopp et al., 2015).

One of the first studies using the lay perspective to define the concept of successful aging was a qualitative data analysis by Day (1991), who was interested in how women understood the meaning of successful aging and how the social system affects their life. Later, Fisher (1995) canvassed the opinions of 40 participants about the essentials of successful aging. His findings were closely in line with those based on psychological models (see chapter 3.4). Von Faber et al. (2001) showed that the oldest old viewed successful aging as a process of adaptation rather than a state of being. They also value the domains of social functioning and well-being over physical and cognitive health.

In a systematic review of 26 studies, Cosco, Prina, Perales, Stephan and Brayne (2013) summarized lay perceptions of successful aging and identified a psychosocial component in all these studies. Biomedical components were identified in 76% and external components in 58% of the studies. Psychosocial components consisted of internal or social factors such as resilience, acceptance, adjustment, social roles and self-awareness, while biomedical components included cognitive and mental health, physiological health and function, health maintenance behaviors and longevity. However, longevity was only mentioned in two studies. External components were factors that are external to the individuals and were classified in two groups: environmental factors such as housing, and financial factors such as the capacity for financial self-support.

An earlier review of 15 studies by Bowling (2007a) also found that from the lay perspective, the concept of successful aging is multi-dimensional and contains similar elements as those identified in biomedical and psychological models. Physical and cognitive health and functioning also came up in many studies. Furthermore, the factors of psychological well-being and life satisfaction were highlighted. Psychological resources including personality, sense of purpose, self-acceptance,
spirituality, coping, positive outlook and sense of humor were identified, too. Social elements such as relationships, support, activities, life style, neighborhood, independence, financial circumstances and security were also present in the studies reviewed by Bowling (2007a).

There is no universal agreement on the impact of culture on lay perceptions of successful aging (Jopp et al., 2015). Keith, Fry and Ikels (1990) argue that the definition of successful aging may vary according to each individual's culture. The lay perspective provides the opportunity to define successful aging in the context of each individual's own culture rather than in the context of society's culture. Communities' cultural expectations and norms regarding the behavior of older adults may differ from older individuals' own expectations, culture and values (Lewis, 2011). Indeed, Iwamasa and Iwasaki (2011) reported cultural differences in this respect between Eastern/Asian and Western countries. Other studies have found less or no cultural differences (Fernandez-Ballesteros & Mendoza-Ruvalcaba, 2010; Jopp et al., 2015). Phelan, Anderson, Lacroix and Larson (2004) found no difference between Japanese Americans and white Americans in terms of how they rated the importance of successful aging characteristics. In their study in seven Latin American and three European countries, Fernandez-Ballesteros Garcia et al. (2011) found that lay definitions of successful aging are multidimensional and include physical, functional, psychological and social components. A study by Torres (2006) on Iranians who had migrated to Sweden found that definitions of successful aging can vary not only between, but also within cultures. Bowling (2007a) suggests that societies' cultural norms and expectations most probably are reflected in the way that professionals view and define successful aging, but not so much in lay definitions of successful aging.

Bowling (2007a) points out that even though it is important to consider the role of culture in notions of successful aging, this does not mean to say there are no common values that cut across cultures. Jopp et al. (2015) concluded that lay definitions of successful aging are less influenced by age and gender than those based on research and theory. The meaning of successful aging, they maintain, is mainly determined by shared ideas rather than by differences stemming from life stage, gender or culture.
3.7 Criticisms of the concept of successful aging

Although the concept of successful aging was originally developed with a view to highlighting the positive side of aging, its antithesis implies that some old adults are unsuccessful. In other words, the successful aging paradigm implies that older adults are either winners or losers. Liang and Luo (2012) present a number of criticisms against the concept of successful aging. First, they describe it as fundamentally ageist by nature, since it ignores the inevitable changes that happen with the aging process and so advocates the idea of agelessness. Second, the use of success to measure aging can conceal existing differences in society based on age, gender, race and class and create a hierarchical and unequal structure between successful and non-successful agers.

Another criticism by Liang and Luo (2012) is that measurements of successful aging based on Rowe and Kahn's model only consider quantifiable activities and ignore the fact that older people can select or adapt any activities in which they choose to engage. They also argue that the concept ignores the spiritual dimension of life, which gains increasing importance with advancing age. Its sole concern is with being active in society.

The third line of criticism concerns the very origins of successful aging. Successful aging advocates the idea of individual responsibility and judges individuals based on their productivity. In this sense it is closely parallel with the notion of capitalistic growth and consumerism in American society (Rubinstein & de Medeiros, 2014). Many gerontologists have criticized the paradigm of successful aging for its neoliberalist undertones (Liang and Luo, 2012; Rubinstein and de Medeiros, 2014). The ideology and policy of neoliberalism considers citizens as consumers whose democratic choices are best exercised by buying and selling. Neoliberalism supports deregulation, free trade, privatization and greatly reduced government spending (WHO: Neo-Liberal Ideas, 2018). Rubinstein and de Medeiros (2014) say that both these paradigms, successful aging and neoliberalism, consider individuals and their actions as key factors for their future success. Models of neoliberal governance and successful aging are aimed at reducing dependence on the state and promoting the individuals' responsibility. Therefore, most models of successful aging tend to ignore both social factors and biology.

Another goal for neoliberal governance has been to try and postpone retirement. The ideal old individual is someone who remains productive and who has an obligation to age well. Thereby, the risk of aging in a neoliberal society is reduced by continued employment, which is considered a risk management practice. In this
context, elderly women with care responsibilities and aging individuals with disabilities are stereotyped as unsuccessful agers, who are treated in society as individuals who have failed the duty of aging well (Rubinstein & de Medeiros, 2014). Based on a study of Canadian media, Rozanova (2010) also identified three neoliberal themes for successful aging: "individual choice, individual responsibility for non-successful aging, and how to age successfully by staying engaged". This view emphasizes the importance of individual effort and the responsibility of individuals in reducing the risk of disease and disability.

Rubinstein and de Medeiros (2014) maintain that neoliberalism has also influenced Row and Kahn's model, which encourages older adults to assume personal responsibility for being healthy. This model ignores the impact of genetic factors, the environment, social policy and society on people's life and success. It has encouraged people to stay healthy, even to change in order to become healthy, but it does not offer any guidelines for staying healthy (Rubinstein & de Medeiros, 2014). Dillaway and Byrnes (2009) call this idea a person-based explanation of successful aging, meaning that society seems to have no obligation to provide support for unsuccessful agers.

The fourth critique towards the idea of successful aging concerns its cultural blindness. Liang and Luo (2012) point out that most definitions of successful aging are based on mainstream American culture, which sees success in productivity, being ageless and independent. The individualist and activity-oriented approach to defining successful aging may be described as uncritical cultural blindness. Torres (2003) maintains that the emphasis on activity, independence, health and wealth highlights values that are typical of Western culture.
3.8 Empirical studies on successful aging

3.8.1 Who ages successfully?

The proportion of the oldest old who are aging successfully and who can be considered successful agers depends on the definition and methods applied. According to the review by Fernandez-Ballesteros and Mendoza-Ruvalcaba (2010), the prevalence of successful aging ranges from 6% to 59%. In a systematic review of 28 studies by Depp and Jeste (2006), the prevalence of successful aging ranged from 0.4% to 95%. Similarly, Cosco, Prina, Perales, Stephan and Brayne (2014) reported that the prevalence of successful aging ranged from 0.4% to 91.7% in the 69 studies that they reviewed. One of the main reasons for this wide variation obviously lies in the models used in the original studies (single or multi-criteria).

The definition of who qualifies as a successful ager must start from a clear differentiation between the predictors and indicators of successful aging. Phelan and Larson (2002) point out that in most studies, this distinction is not clear. For example, Strawbridge, Cohen, Shema and Kaplan (1996) used social functioning as a predictor of successful aging, while in many other studies it is used as an indicator.

Many studies have found that successful agers are more likely to be male, white, relatively wealthy, educated and healthier than others (Dillaway & Byrnes, 2009). Sociodemographic characteristics such as age, gender, education, income and marital status have also been found to be predictors of successful aging among young and the oldest old.

Age was reported to be a powerful negative predictor of successful aging in two studies, i.e. the ELEA study and the Mujeres Grandes study by Fernandez-Ballesteros and Mendoza-Ruvalcaba (Fernandez-Ballesteros Garcia et al., 2011).

Gender emerged as a predictor of successful aging in the study of Araujo, Ribeiro, Teixeira and Paul (2016) and in the ELEA study (Fernandez-Ballesteros Garcia et al., 2011) among centenarians: men had a higher probability of being successful agers. However, there is also a gender difference in health, which is also reflected in the aging process (Oksuzyan, Juel, Vaupel, & Christensen, 2008). Women have a longer life expectancy and a higher probability of diseases than men. But researchers are divided over gender differences in successful aging, especially in different categories of old age. Depp and Jeste (2006) found no association between gender and successful aging in the studies they reviewed, but in half of the longitudinal studies being female was described as a predictor of successful aging.
In a few studies, higher income has emerged as the best predictor of successful aging among centenarians (Araujo et al., 2016; Fernandez-Ballesteros Garcia et al., 2011).

Higher education is mentioned as a predictor of successful aging among young old (McLaughlin, Connell, Heeringa, Li, & Roberts, 2010) and also among the oldest old (Chou & Chi, 2002). In the ELEA study and the Mujeres Grandes data (Fernandez-Ballesteros Garcia et al., 2011; Fernandez-Ballesteros & Mendoza-Ruvalcaba, 2010), higher education was one of the most powerful predictors of successful aging, although it was not a predictor among centenarians in a recent study by Araujo et al. (2016).

Marital status has been associated with successful aging in younger old age in a number of studies (Bowling & Iliffe, 2006; Depp & Jeste, 2006), but it was not a predictor in the study by Araujo et al. (2016) among centenarians. Pruchno, Wilson-Genderson and Cartwright (2010) also found no significant difference between married and unmarried individuals in old age.

Fernandez-Ballesteros and Mendoza-Ruvalcaba (2010) showed that health and functioning domains as well as lifestyle, such as physical activities and drinking habits, were powerful predictors of successful aging. In their study, the psychological characteristic of intelligence emerged as a predictor of successful aging. Personality and certain psychosocial variables, such as family network and helping, were also mentioned.
3.8.2 Successful aging and mortality among the oldest old

The probability of living longer has continued to rise in recent decades, and even the very old now have an increasing number of years ahead of them. It is therefore important to identify and investigate the predictors of the length of further life. There is hardly any research on the associations between multidimensional successful aging and further survival. Only a few studies exploring successful aging and predictors of mortality have defined successful aging in terms of cognitive functioning alone (Negash et al., 2011; Paulson, Bowen, & Lichtenberg, 2011). There is, however, a large body of evidence on indicators that are usually understood as components of successful aging and mortality. Many predictors of survival have been described among younger adults, but it is not clear whether those predictors are the same in very old age. Based on longitudinal studies, some researchers have explained the selective mortality idea and how the risk factors of survival change with advancing age (Hagberg & Samuelsson, 2008; Louhija, 1994). It has been suggested that psychological indicators may be important predictors of survival in younger old age, while biomedical indicators gain increasing importance among the oldest old (Hagberg, 2007; Havens, 1996).

A study by Allard, Robine and Henon (2000) on centenarians underscores the importance of biomedical and health indicators in predicting mortality. Lower ADL performance (Poon, Johnson, Davey, & Martin, 2000; Tiainen, Luukkaala, Hervonen, & Jylhä, 2013), poor mobility (Tiainen et al., 2013), disability and a lower level of physical functioning (Allard et al, 2000; Nybo et al., 2003) have emerged as predictors of mortality among extreme survivors. Hagberg and Samuelsson (2008) reported that the number of medications, reduced hearing and vision, and lean weight predicted mortality among centenarians. Self-rated health has been found to be a predictor of mortality among people aged over 90 (Tiainen et al., 2013; Vuorisalmi, Luukkaala, Hervonen, & Jylhä, 2011).

Nybo et al. (2003) reported that risk factors for ill health such as smoking, obesity and alcohol consumption are no longer a risk factor for mortality among nonagenarians. This is in line with the results of Allard et al., (2000), who found that overweight and high cholesterol are predictors of survival among centenarians.

Hagberg and Samuelsson (2008) found that dementia increases the risk of mortality, while psychological variables such as verbal understanding, short-term memory and learning capacity are predictors of delayed mortality among centenarians. Lower cognitive functioning is a predictor of mortality among the oldest old (Allard et al., 2000; Nybo et al., 2003). Paulson et al. (2011) reported that
depression was a predictor of mortality in two-year and eight-year follow-up periods among the older old.

Yasuda et al. (1997) and Sun and Liu (2006) reported a positive association between a lower level of mortality and solitary and social activities, especially among the oldest old women in China. Similar results have been reported in studies among the young old (Welin, Larsson, Svärdssudd, Tibblin, & Tibblin, 1992). Active engagement with life decreases the risk of mortality in young old age (Welin et al., 1992). Glass, de Leon, Marottol, Berkman (1999) reported that social activities and productive activities in old adults may decrease the risk of mortality.

However, Lennartsson and Silverstein (2001) reported that family contacts in late old age do not prevent mortality, but solitary activities are more protective against mortality for men than for women after controlling for health and education.

In addition, Hagberg and Samuelsson (2008) reported that marital status, household finances, education and social network were not predictors of mortality among centenarians. Nybo et al. (2003) mentioned that a number of social factors, marital status and educational level lose their predictive power for survival in very old age. However, Enroth, Raitanen, Hervonen, Nosraty, & Jylhä (2015) found that total mortality and mortality caused by dementia among nonagenarians were higher in lower than in higher occupational classes. This difference was largely explained by differences in functional status. Living in an institution has been found to be a predictor of mortality (Allard et al., 2000; Tiainen et al., 2013) among the oldest old.

Gender is a well-known predictor of mortality, which is higher among men than women even in the oldest old (Tiainen et al., 2013; Poon et al., 2000).
Successful aging and long-term care

The continued increase in life expectancy raises the question as to whether longer lives will be accompanied by good health or poor health, including functional impairments and care needs (Parker & Thorslund, 2007). Salomon et al. (2013) found that with each one-year increase in life expectancy at birth, healthy life expectancy increases by no more than 0.8 years. As a result of the rapid growth of the elderly population, they said, health care needs are bound to increase. Aaltonen et al. (2017) reported that in 2013, 42.5% of the old individuals who spend the last two years of life in LTC were over 90 years old. According to Forma, Rissanen, Noro, Raitanen and Jylhä (2007), the need for services differs by age group because the oldest old are the most likely to experience a decline in functioning. Furthermore, the oldest old are more likely to experience a longer period of disability before death (Lunney, Lynn, Foley, Lipson, & Guralnik, 2003), and their functional decline before death occurs more rapidly (Guralnik, LaCroix, Branch, Kasl, & Wallace, 1991).

The future demand and need for care will depend on the health status of the growing older population. Even under the most optimistic expectations regarding the development of medical treatments, the need for care resources is bound to increase. Torres, Kabir and Winblad (1995) and Larsson and Thorslund (2006) showed that as the oldest old population continues to grow, the demand for care is bound to increase with the growing likelihood of disease and disability. The specific needs and scope of care differ between the younger old and the oldest old and, as Larsson and Thorslund (2006) reported, the highest costs of care in this age group result from home help and sheltered housing rather than medical care. They showed that the volume of medical care tends to increase slightly with age until early old age, but then begins to drop with advancing age. Forma et al. (2007) reported similar changes in the scope of care by age. The number of days that the oldest old spent in hospital decreased in the last two years of life, at the same time as the overall use of LTC increased between from 1998 to 2001.

LTC is defined and organized differently in different countries. LTC can refer to a range of services from medical to social services designed to support individuals

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1 The Finnish care system operates a distinction between health and social services. Primary medical care is provided via a network of health centres, while specialized (secondary and tertiary) care is provided through hospitals. Formal long-term care is provided in four different settings (Teperi, Porter, Vuorenkoski, & Baron, 2009): home care, sheltered housing, residential homes and health centres. Even though Finland has a relatively strong formal care system, long-term care still relies in large part on informal care provided by spouses, children, friends and relatives. Since 2006 municipalities have provided financial support for informal care.
who because of disability are unable to cope independently with activities of everyday living (McCall, 2001).

No earlier research has investigated the association of successful aging with LTC. However, many studies have examined the role of individual elements of successful aging as predictors of LTC. Problems with physical functioning (Luppa et al., 2010; Black, Rabin, and German, 1999) and poorer instrumental activities of daily living (IADL) performance (Cai, Salmon, & Rodgers, 2009; Bharucha, Pandav, Shen, Dodge, & Ganguli, 2004; Castora-Binkley, Meng, & Hyer, 2014) have a significant association with admission to nursing homes. There is some controversy over the association of activities of daily living (ADL) with LTC admission. Cai et al. (2009) found no association between limited ADL and admission to nursing homes, while Castora-Binkley et al. (2014), Gaugler, Duval, Anderson, and Kane (2007) and Luppa et al. (2010) did report an association with admission. There is some evidence that the existence of diseases and chronic conditions increases the risk of entering LTC (Banaszak-Holl et al., 2004; Kauppi, Raitanen, Stenholm, Aaltonen, Enroth, & Jylhä, 2017). However, the systematic review by Luppa et al. (2010) found that the number of prescriptions appears to be a stronger predictor of entering LTC than the existence of diseases. A similar result was reported in the longitudinal study by Bharucha et al. (2004).

Many longitudinal studies have found that psychological components of successful aging play a part in LTC admission. Cognitive impairment has been shown to be a predictor of LTC (Aguero-Torres, von Strauss, Viitanen, Winblad, & Fratiglioni, 2001; Finlayson, 2002; Shapiro & Tate, 1985; von Bonsdorff, Rantanen, Laukkanen, Suutama, & Heikkinen, 2006). The meta-analysis and systematic review by Gaugler et al. (2007) and Luppa et al. (2010) also produced strong evidence that dementia is a major predictor of entering LTC. It has also been shown that self-reported health and social factors are associated with an increased risk of entering LTC (Cai et al., 2009; Finlayson, 2002; Kauppi et al., 2017; Luppa et al., 2010; Shapiro & Tate, 1985). It seems then that a decline in each element of successful aging can result in increased dependence, which may also increase needs for LTC.

Based on these findings the question that needs to be asked then is this: Do all these factors that taken together constitute successful aging, predict entry into LTC?
AIMS OF THE STUDY

The trend to increasing longevity has turned the research spotlight to successful aging. However, despite the extensive theoretical and empirical literature, there is still no consensus on how successful aging should be defined and measured. Furthermore, there is a scarcity of research concerning the oldest old. Little is known about how very old people themselves understand good old age and successful aging: do they value the same factors that are generally understood as the key components of successful aging? Promoting successful aging is a major goal for aging societies, but it remains unclear whether it delays entry into LTC and mortality in the oldest old.

The main aim of this study was to measure the prevalence of successful aging and associated factors, and to examine successful aging as a predictor of both entry into LTC and mortality among the oldest old. A further aim was to uncover the meaning and the elements of successful aging among the oldest old by exploring the views of people who have already succeeded in surviving. These main aims were broken down into the following goals for four sub-studies:

To estimate the prevalence of successful aging by using six different models including physical, psychological and social dimensions, and to investigate whether successful aging is associated with sociodemographic factors among nonagenarians.

To investigate the meaning and dimensions of successful aging as they appear in interviews with people aged 90-91.

To investigate the association of successful aging and its three dimensions (physical, psychological and social) with survival in four-year and seven-year follow-ups among nonagenarians.

To explore the association between successful aging and entry into LTC among nonagenarians in two-year and five-year follow-ups.

Both quantitative and qualitative approaches were applied. The prevalence of successful aging, defined as high levels of health and social and psychological function, and its associations with future survival and entry into LTC were examined by using data from a population-based survey of people aged 90+. Life story interviews were used to analyze conceptions of good old age among men and women at the age of 90-91. These analyses also made it possible to contrast the conventional,
health-focused understanding of good and successful aging with the views of very old people themselves. Based on its findings, the study discusses the feasibility of different models of successful aging among the oldest old.
5 DATA AND METHODS

5.1 Data sources

5.1.1 Mailed surveys in the Vitality 90+ Study

The main data sources for this study consisted of the Vitality 90+ surveys in 2001, 2003, 2007 and 2010. Vitality 90+ is a population-based prospective multidisciplinary research programmed on nonagenarians in Tampere, Finland. Mailed questionnaires were sent out to community-dwelling people aged 90 and over in 1995, 1996 and 1998. Since 2001, Vitality 90+ has also involved institutionalized people. Surveys have been carried out in 2001, 2003, 2007, 2010 and 2014. Reminders were sent to those who did not respond within a month. The number of participants varied in different surveys, and the response rates ranged between 79% and 86% (Table 1). Proxy responses were obtained if the subjects were not able to answer the questionnaire. Subjects who were able to answer the questions but who had difficulties reading or writing were allowed to have help from family or staff members to complete the questionnaire. In addition to the questionnaire data, face-to-face interviews, physical examinations, performance tests and blood draws were obtained for subsamples.

<table>
<thead>
<tr>
<th>Participants in Vitality 90+</th>
<th>Survey year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
</tr>
<tr>
<td>Total participants (N)</td>
<td>892</td>
</tr>
<tr>
<td>Men (N)</td>
<td>171</td>
</tr>
<tr>
<td>Women (N)</td>
<td>721</td>
</tr>
<tr>
<td>Response rate (%)</td>
<td>79</td>
</tr>
<tr>
<td>Proxy response (%)</td>
<td>23</td>
</tr>
<tr>
<td>Living in the community (%)</td>
<td>61</td>
</tr>
</tbody>
</table>

For earlier stages of the research and data collection in the Vitality 90+ Study, ethical approval was obtained from the Ethics Committee of the City of Tampere. Later stages came under the purview of the Ethics Committee of the Pirkanmaa
Hospital District. Informed consent was obtained from the participants or their legally authorized representatives.

The questionnaire included 27 itemized questions (see Appendix) about place of living, marital status, length of education, main occupation, mobility and ADL functioning, diseases diagnosed by a doctor, self-rated health, depression or depressive feelings, vision and hearing (only in 2010 questionnaire), receiving help, contacts with others, opinions about living to 100, and opinions on the status of elderly citizens in present-day society compared to the participants' childhood. Identical questions were used in all surveys, although in 2010 a number of new items were added.
5.1.2 Life story interviews in the Vitality 90+ Study

Life story interviews were carried out with 45 individuals born in 1921-1922. Invitations with a short questionnaire were sent out to every fifth woman and man in the age group 90–91 living in Tampere. Almost half or 46% of the women and 63% of the men responded to the questionnaire; 25% of the women and 48% of the men indicated that they were willing to participate in the interview; and 25 women and 20 men were interviewed. Information about the research project was provided to the participants, and the interviewees or their legal representative were asked to sign a written informed consent form. The interviews were conducted in the participants' homes by native Finnish-speaking researchers, three gerontologists and two medical students. The students had received training to conduct interviews with old individuals. All interviews were tape-recorded and subsequently transcribed. Most of the interviews took 90-120 minutes, but the shortest interview lasted 34 minutes and the longest three hours and 20 minutes. The interviewees were first asked to tell their life story from childhood to the present day in their own words. They were then asked questions about their health, retirement, leisure activities and housing. The interview protocol also included items to canvas opinions regarding old age, longevity and older people's status in society. For the purpose of our analysis, the respondents were asked to define how they understood "a good old age" (hyvä vanhuus) and what was needed to achieve that.

The corpus of interviews ran to a total of 1,200 pages. However, the sections concerning successful and good aging only amounted to 33 pages, which were used for the purposes of sub-study II.
5.1.3 Register data

Register data collected for administrative purposes on the population and care services use are also available for research purposes. All individuals who reside in Finland permanently have a unique personal identity code (PIC), which remains unchanged during the person’s lifetime. Based on this personal identity code it is possible to link data from health and welfare registers for research purposes (Gissler & Haukka, 2004).

This study made use of two national registers. First, dates of death were obtained from Statistics Finland, which receives this information from the Finnish Population Register. This information was linked to the Vitality 90+ data using personal identity codes.

Information about entry into LTC was drawn from the Care Register for Health Care (Terveys-HILMO) and the Care Register for Social Welfare (Sosiaali-HILMO).

The Care Register for Health Care contains individualized data from providers of hospital services and health centers, admission and discharge data, diagnoses and treatments provided. Basic data include information about the service provider, data on the patient, data on the start date of care and date of discharge, and data on the treatment received by the patient. It also provides information on the annual number of patients in health centers and hospitals, day surgeries and special outpatient care (Care Register for Health Care - THL, 2018).

The Care Register for Social Welfare (Sosiaali-HILMO) contains data on care episodes for residents in residential homes and sheltered housing units with 24-hour assistance, as well as in home care. It registers data on service providers, clients, admissions, discharge to care, as well as on services and care received (Forma, 2011).

The Vitality 90+ data and these two register databases were linked by the National Institute for Health and Welfare (THL).

Approval for this data linkage was obtained from the Ethics Committee of the Pirkanmaa Hospital District. Permission to use the register data was granted by the National Institute for Health and Welfare. The linked data were made available to the research group without personal identity codes.
5.2 Measures

5.2.1 Successful aging

Several different indicators were constructed in this study for the measurement of successful aging. This decision was based on the evidence from earlier research and existing models of successful aging, the specific study population, and the data available in the Vitality 90+ Study. Successful aging was understood as a multidimensional phenomenon. The models were developed following the thinking of Rowe and Kahn (1997) for the dimensions included and Young et al. (2009) in that successful aging was considered possible even in the presence of disease and disability, the assumption being that social and psychological compensation mechanisms are at work. It is well known from earlier research that a great majority of people aged 90+, the group in focus in this study, have chronic diseases and some level of disability. Therefore, models that consider freedom from disease and disability as necessary requirements for successful aging would by definition exclude the oldest old from success. As there is only little earlier research on successful aging and feasible models of successful aging among the oldest old, the decision was made to construct several different models for this research and to explore their associations with different outcomes. The models included physical, psychological and social dimensions, but their specific combinations and the criteria for success varied from one model to another. The choice of variables included in the different dimensions of successful aging was influenced by the fact that the Vitality 90+ Study was not originally planned as an investigation into successful aging, and therefore some compromises had to be made regarding individual variables.

No gold standard exists for measuring successful aging, but the indicators used vary in different studies, which emphasize either physical, psychological or social components, or a combination of these components.

Physical component (PhC)

In all three quantitative sub-studies, the physical component of successful aging included two elements: diseases and functioning.

The participants were asked whether they had the following conditions diagnosed by a physician: 1) heart problems, 2) stroke, 3) circulatory problems in the
brain, 4) diabetes, 5) arthritis, 6) Parkinson's disease, 7) hip fracture and 8) dementia or memory problems.

Functioning was measured as self-reported ability to perform three mobility functions (walking 400 meters, using stairs and moving about indoors) and two ADL activities (getting in and out of bed, and dressing/undressing). The response options were dichotomized as independent (1=yes, without difficulty & 2=yes, with difficulty) and dependent (3=only with help & 4=not at all).

In sub-study I, the physical component included vision and hearing. Information on vision and hearing was collected in the 2010 survey. This was measured by asking the respondents whether they could read the newspaper and hear what another person was saying when alone with this person. The answers were coded as "yes" even if the respondent used vision or hearing aids.

**Psychological component (PsC)**

The psychological component included three elements, namely 1) having depression or depressive feelings, 2) self-rated health, and 3) opinion about whether it is good to live to 100 years. Self-rated health was dichotomized as good (very good, fairly good and average) or poor (fairly poor and poor).

Proxy responses were allowed in the Vitality 90+ Study if the participant was unable independently to give the answers. Because of the high number of proxy responses to the items concerning self-rated health and opinions about living to 100 years, there was a high frequency of missing values for PsC. Proxy responses were given for participants who were in poor health and more frail than others. If data for these individuals had been missing, the prevalence of successful aging would likely have been overestimated. Therefore, imputation was done and the missing data for these two questions were replaced by the most negative response options to these questions. In any case, these individuals would not have shown success in the physical component.

**Social component (SC)**

The social component was composed of two elements: the frequency of meetings with children and the frequency of phone contacts with family members or friends. If the interviewee's most recent contact was less than two weeks ago, the answer was coded as having had contact. About one-fifth of the participants did not have children, but in order to prevent them from being excluded from the analysis they
were categorized as having contacts with children if they had any phone contacts during the past two weeks.

Table 2. Components of successful aging used in different models in the three sub-studies. Dots indicate the elements included in different components of the models, M1- M6 refer to the number of the model in each sub-study.

<table>
<thead>
<tr>
<th>Components</th>
<th>Elements for each components of successful aging</th>
<th>Sub-study I - Models</th>
<th>Sub-study III - Models</th>
<th>Sub-study IV - Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M1  M2  M3  M4  M5  M6</td>
<td>M1  M2  M3  M4  M6</td>
<td>M1  M2  M3  M4  M6</td>
</tr>
<tr>
<td>Disease¹</td>
<td>Dementia</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Absence of diseases'</td>
<td>·</td>
<td>·</td>
<td>·</td>
</tr>
<tr>
<td></td>
<td>Less than three diseases</td>
<td>·</td>
<td>·</td>
<td>·</td>
</tr>
<tr>
<td>Physical Functioning</td>
<td>Moving about indoors</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Walking 400 meters</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Using stairs</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Getting in and out of bed</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Dressing and undressing</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td>Senses</td>
<td>Ability to read newspaper</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Ability to hear another person when alone with her/him.</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td>Psychological</td>
<td>Depression/Depressive feelings</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Self-rated health</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Opinion on living to 100 years</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td>Social</td>
<td>Frequency of meetings with children</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
<tr>
<td></td>
<td>Frequency of talking on phone with family members or friends</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
<td>· · · · · · · · · · ·</td>
</tr>
</tbody>
</table>

¹ Diseases: heart problem, stroke, circulatory problems in the brain, diabetes, arthritis, Parkinson's disease, hip fracture
5.2.2 Long-term care

Long-term care (LTC), which was used as an outcome variable in sub-study IV, was defined as uninterrupted care of 90 days or more for an individual who was unable to self-care (Finlayson, 2002; Martikainen et al., 2009) in a residential home, in sheltered housing with round-the-clock assistance, or on a health center inpatient ward (Martikainen et al., 2009). This period of 90 days could be spent at the same place or several locations without returning to the community for more than one night.
5.2.3 Mortality

Mortality was used as an outcome variable in sub-study III. In sub-study IV, mortality was used as a competing outcome variable that could prevent LTC entry.
5.2.4 Covariates

Age, gender, marital status, level of education, place of living (community or institution), living alone, receiving help, and year of participation in the study were considered as covariates in the quantitative sub-studies. Year of participation in the study was included because during the study years the Finnish care system was being overhauled.

In sub-study I, age, gender, marital status, level of education and place of living were considered as sociodemographic factors that may be associated with successful aging. Age was grouped into three categories, viz. 90-91, 92-93 and 94-107 years. Marital status was dichotomized as married or not married. Place of residence was dichotomized as in the community or in an institution. Living in service housing without round-the-clock assistance and living in a private home were categorized as living in the community. Living in residential care, service housing with round-the-clock assistance and hospital were categorized as living in an institution. Level of education was classified into four categories: low (elementary school), middle (lower secondary school), high (vocational and folk high school) and highest (college and academic education).

In sub-studies III and VI, age and gender were considered as covariates in the analysis. In addition, living alone, receiving help and year of participation in the survey were considered as covariates in sub-study IV. The question concerning receipt of help with dressing, washing or cooking presented four response options: (1) yes, approximately every day, (2) yes, sometimes, (3) I do not receive help even though I would need it, and (4) I do not need help, I do the housework myself. The response was categorized as a dichotomous variable: yes (1+2) and no (3+4).
5.3 Analyses

5.3.1 Design

Each sub-study had a different design depending on its aims. Table 3 describes the aims of each sub-study and the methods used to address their research questions. It also shows the outcomes and independent variables used in each sub-study. The basic characteristics of the participants in each study are presented in Table 4.

Briefly:

1) Sub-study I had a cross-sectional design and used the Vitality 90+ survey data from the mailed questionnaires in 2010. Of all the community dwellers and institutionalized individuals who resided in Tampere (N=1,630), 79% responded (N=1,283). Proxy responses accounted for 22% of all responses.

2) In sub-study II, life story interviews with people aged 90-91 were used to define successful aging through the eyes of the oldest old group. The analysis focused on those data segments where the participants discussed their views of good and successful aging. The interviews were conducted in Finnish and the transcribed data was translated into English.

3) In sub-study III, mortality was followed up among successful and non-successful agers. The Vitality 90+ survey data from 2001 and 2003 were combined to form a larger sample size for use in this sub-study. The response rates were 79% in 2001 (N=892) and 86% in 2003 (N=963). These two surveys provided 1,370 participants, 485 of whom answered questionnaires in both years. For each participant, only the baseline response for the year when (s)he entered the study was included in the analysis. This combined baseline data of 1,379 participants was linked to Finnish Population Register data, which provides the date of death for the participants. Subjects were followed up for four and seven years.

4) Sub-study IV used a follow-up design. The Vitality 90+ surveys from 2001, 2003, 2007 and 2010 were combined, and the combined data was linked with data from the Care Register for Health Care (Terveys-HILMO) and the Care Register for Social Welfare (Sosiaali-HILMO). The survey data was also linked with the Population Register data to obtain information on date of death. The participants who lived in the community at baseline were followed for two years, and subjects from three earlier surveys in 2001, 2003 and 2007 were followed for five years.
Table 3. Designs, aims, methods, independent variables and outcomes in sub-studies I–IV.

<table>
<thead>
<tr>
<th>Sub-study number and design</th>
<th>Aims</th>
<th>Methods</th>
<th>Independent variables</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Cross-sectional</td>
<td>To estimate the prevalence of successful aging and to investigate whether successful aging is associated with sociodemographic factors among the oldest old</td>
<td>Prevalence rate, Chi square test, logistic regression</td>
<td>Age, gender, marital status, level of education and place of residence</td>
</tr>
<tr>
<td>II</td>
<td>Qualitative</td>
<td>To understand the meaning and dimensions of successful aging as they appear in the speech of persons aged 90–91</td>
<td>Thematic analysis with an inductive approach to some segments of life story interviews</td>
<td>-</td>
</tr>
<tr>
<td>III</td>
<td>4-year and 7-year follow-up</td>
<td>To investigate whether successful aging predicts mortality among the oldest old</td>
<td>Chi square test, Cox proportional hazard for survival</td>
<td>Age, gender</td>
</tr>
<tr>
<td>IV</td>
<td>2-year and 5-year follow-up</td>
<td>To investigate whether successful aging predicts entering LTC among the oldest old</td>
<td>Incidence rate and incidence ratio, competing risk analysis</td>
<td>Gender, living circumstances (living alone), receiving help and first year of participation in the study</td>
</tr>
</tbody>
</table>

Table 4. Designs, data sources and participants’ characteristics in three quantitative sub-studies.

<table>
<thead>
<tr>
<th>Sub-study number and design</th>
<th>Year of surveys</th>
<th>Participants (N)</th>
<th>Men (%)</th>
<th>Proxy respondents (%)</th>
<th>Living in the community (%)</th>
<th>Link to registers data</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2010</td>
<td>1,283</td>
<td>18.8</td>
<td>22</td>
<td>59</td>
<td>-</td>
</tr>
<tr>
<td>III</td>
<td>2001 and 2003</td>
<td>1,370</td>
<td>20.1</td>
<td>21.3</td>
<td>56.1</td>
<td>Population register</td>
</tr>
</tbody>
</table>
5.3.2 Statistical analysis

Descriptive statistics

The frequencies and percentages of successful aging as well as its components and elements were summarized in sub-studies I, III and IV. The associations of successful aging (measured by six different models) with age, gender, marital status, place of living and educational level were examined using Chi-square test in sub-study I. In sub-study III, Chi-square test was used to compare survival among successful and non-successful agers with four models of successful aging for four-year and seven-year follow-up periods. In sub-studies I and III, Chi-square tests were performed separately for women and men.

The incidence rate or incidence density of entry into LTC for both successful and non-successful agers and the incidence rate ratio between these two groups were calculated for each model of successful aging in sub-study IV.

The incidence rate is the number of cases per person-year of observation. In the calculation of the incidence rate of LTC entry among successful agers, the nominator was the annual number of individuals entering LTC during the follow-up periods (two and five years). The denominator was the community-living successfully aging population at risk of entering LTC expressed as person-time. The use of person-time made it possible to handle situations where there were dropouts in the study or cases lost to follow-up. This means that the follow-up period is not the same for all individuals. The denominator was the sum of the follow-periods up within two and five years for each participant in the group of successful and non-successful agers (separately).

The incidence rate ratio (IRR) is the ratio of two incidence rates (for successful agers and non-successful agers). To calculate IRR, the incidence rate for successful agers who entered LTC was divided by the incidence rate for non-successful agers who entered LTC. IRR thus gives a relative measure for the effect of entering LTC.
Explanatory analyses

Independent associations of the six different models of successful aging with sociodemographic factors were examined by using multivariate logistic regression analysis. These sociodemographic characteristics were age, gender, marital status, education and place of living. All predictors were included in the model simultaneously. The result was reported as odd ratios (OR) with 95% confidence intervals (CI). This analysis was used in sub-study I.

To determine the association of successful aging and its components with mortality, Cox proportional hazard regression was used. Adjustment for age and gender was performed. Hazard ratios (HRs) with 95% CI were reported. This method was applied in sub-study III.

To investigate whether successful aging can predict entry into LTC in sub-study IV, mortality before entering LTC was considered a competing risk, and competing risk regression analysis was used instead of standard survival analysis. This analysis estimates the cumulative incidence of entering LTC in the presence of mortality. In these analyses, only those who lived at home at baseline were included.

As the result could also be affected by living arrangements, receiving help, and year of baseline survey, the competing risk analysis models were adjusted for these factors. In our analysis, age did not change the sub-hazard ratios (SHRs). According to Wong, Elderkamp-de Groot, Polder and van Excel (2010), the relationship between age and LTC use can be nonlinear, and therefore the second order polynomial and square root of age could also be applied in the competing risk models. As no significant result was found, age was excluded from the competing risk analysis and gender, living arrangement, need for help, and year of baseline survey were included in the analysis instead. Due to changes in LTC admission policy in Finland between 2001 and 2010, the year of baseline survey was considered an important factor.

In all sub-studies the most demanding model of successful aging was Model 1, which yielded a very low prevalence of successful aging. Therefore, rather than testing the null hypothesis (e.g. Model 1 of successful aging does not predict mortality) and using p<0.05 as a rigid criterion for statistical significance, we calculated p-values for a range of other hypotheses by using the p-value function (a graphical approach). This method is known as quantitative data measurement, used graphically for testing significance (Rothman, Johnson, & Sugano, 1999).
Sensitivity analysis

Two elements of the psychological component of successful aging, i.e. opinions on living to 100 and self rated health, had high proportions of missing data because of proxy responses. The missing data were treated by imputation. Sensitivity analysis was used to evaluate the influence of imputation of proxy responses in the psychological component. The Cox proportional hazard analyses for the different models were compared with and without proxy respondents. Sensitivity analysis confirmed that the imputation did not change the association of successful aging and PsC with mortality in sub-study III.
5.3.3  Thematic analysis of life story interviews

Sub-study II was a thematic analysis using an inductive approach. The analysis was carried out by three independent researchers, two gerontologists and one health scientist. Coding was done in two language datasets independently by the three researchers. The inductive approach involves reading and re-reading the data for any themes related to good old age and coding them separately, without paying attention to the themes that previous researchers may have identified. The thematic analysis was conducted at a semantic level, identifying the explicit and surface meanings of the data.
6 FINDINGS

6.1 Prevalence of successful aging and associated factors

One of the main aims of sub-study I was to establish the prevalence of successful aging among nonagenarians. In the absence of a gold standard for the measurement of successful aging, six models of successful aging were constructed\(^2\) by using different thresholds for success in physical, psychological and social components (see also Table 2). Four of these models consisted of different elements of the physical component. In addition to the physical component, Model 5 included the psychological component and Model 6 the social component. The prevalence of successful aging for Model 1 to Model 6 was 1.6%, 6.3%, 5.7%, 6.8%, 6.3% and 18.3%, respectively. Figure 3 shows the prevalence of successful aging in the six models by age, gender, place of living and level of education. The prevalence of successful aging decreased with increasing age in all six models.

Gender differences were significant in all models except Model 6. In all models the prevalence of successful aging was significantly higher among people living in the community than those who lived in an institution. The prevalence of successful aging was higher among individuals with higher educational levels in all models of successful aging, and in Model 2 and Model 6 the differences between the educational groups were significant (Figure 3).

\(^2\) Models of successful aging in sub-study I:
Model 1. No disease, able to hear and read, independent in all five activities + psychological component + social component
Model 2. Less than three diseases, no dementia, able to hear and read, independent in three easier activities + psychological component + social component
Model 3. No dementia, able to hear and read, independent in all five activities + psychological component + social component
Model 4. Able to hear and read, independent in all five activities + psychological component + social component
Model 5. No dementia, able to hear and read, independent in all five activities + psychological component
Model 6. No dementia, able to hear and read, independent in all five activities + social component
Figure 3. Prevalence of successful aging in six models (M1-M6) of successful aging according to (A) age, (B) gender, (C) place of living and (D) level of education.
Figure 4. Association of successful aging with age, gender, marital status, education and place of living. Multivariate logistic regression (Odd ratios (♦) and 95% confidence intervals (─)) in six models (M1-M6) of successful aging. Reference categories for sociodemographics were 94+, men, unmarried, low education and institution. All predictors were entered in the model simultaneously.
The results of logistic regression analysis (Figure 4) showed that gender was associated with successful aging in all models except Model 6; being a woman reduced the chance of aging successfully. Model 6 was the only model in which all sociodemographic variables except for gender had a significant association with successful aging. Being younger than 94 increased the likelihood of successful aging in Model 6. Living in the community increased the likelihood of successful aging in all Models except Model 1. Marital status was not associated with successful aging in any model. The highest educational level was associated with successful aging in Model 6 and Model 2.
6.2 The oldest olds' perception of successful aging

The results of the qualitative sub-study II illustrate the views of the oldest old themselves on good and successful aging. Conducted at the semantic level, the analysis involved identifying sub-themes and combining them into broader thematic categories. Each theme was considered a component of successful aging.

With just one exception, all the participants regarded themselves as successful agers and referred to themselves when describing successful aging. Physical, social, and cognitive and psychological themes were mentioned in most interviews (Figure 5).

Two themes, namely independence and continuity, were mostly discussed in connection with other themes. This means that when the interviewees were talking about other components, they linked them with one of these themes as well.

**Continuity** was mentioned when the participants were talking about the elements of good old age in the process of life. It was discussed from two vantage-points, i.e. a) from one's earlier life to the current situation and b) from one's current situation to the future. The participants were happy with whatever they already had, even when they mentioned losses (such as hearing). They say they would be happy if the current situation continued, as they would be able to do what they wanted. With regard to their age and not knowing the future, they still wanted to continue their life in the same way as before. If their condition deteriorated, they wanted death to come soon. Continuity was also described in terms of a continuum from past to present, with the elements of good life from previous stages carried over into old age. Being the same person and doing what they wanted could also be interpreted as maintaining the same identity throughout the life process. The interviewees did not see old age as a separate or static stage of life. Good old age, for them, was about living in harmony, a continuation of their former life from a younger age through to the present. A harmonized and balanced life was expressed by terms such as a rich life, a balanced life, a happy life, or living in peace.

The interviewees often mentioned the importance of independence, which was interwoven with physical activities, financial freedom, autonomy, decision-making and self-mastery. They were aware of the prospect of gradually losing their independence during the coming years. Self-mastery and the exercise of autonomy in daily living were regarded as the most important elements of good aging. Having control over one's own life and the ability to make decisions on health issues such as whether or not to go and see the doctor, were acknowledged as the essentials of
good aging. The interviewees also mentioned having the financial resources to purchase medicines and other essentials.

**Living circumstances.** The interviewees appreciated the importance of having a nice home and being able to live on one's own. Good aging meant living in one's own home and not being institutionalized. They did not want to live in an institution or care facilities, which they described as unpleasant. Being surrounded by other people and not being alone were also mentioned as components of good aging, although this did not mean sharing one's home with others.

**Physical functioning.** Good health, functional ability, being active, and being pain free were all mentioned in the interviews, but the absence of diseases other than dementia and depression was never mentioned directly or indirectly as elements of good aging. Some interviewees also made reference to enjoying continued physical and mental ability. Being healthy was considered important not only to good aging as such, but it was also recognized as an enabling factor for other elements of good aging, such as autonomy or living in one's own home.

**Cognitive functioning and psychological components** were mentioned in many interviews as an important part of the good aging process. The interviewees were afraid of developing dementia or other cognitive problems, since they saw this as one of the reasons for being institutionalized. Memory problems were regarded as an obstacle to keeping up with the times and to learning new things. Self-acceptance, self-satisfaction, coping and adaptation were also expressed, all factors that may be categorized among the psychological components of successful aging.

**Social functioning** was mentioned in most interviews. It was expressed in different ways, for instance by reference to social networks, social roles, recreation and entertainment. Having people around oneself – family, friends and good neighbors – was considered an important element of good aging. Social roles such as taking care of grandchildren, helping others and being a member of an organization as well as social activities such as going out with others and engaging in leisure activities were also mentioned as part of good aging.

Interestingly, the oldest old defined successful aging not only in terms of the quality of life, but also the quality of death. Death was explicitly mentioned as an element of good aging. It was mostly mentioned in connection with the possibility of losing any elements of good life in the future. Loss of identity, independence (physical or financial), autonomy and dignity was a major concern: the interviewees wished rather to reach the end of their life. They also said they would want a painless, quick and easy death.
**Social:**

**social network:** having family, friends, children, grandchildren, good neighbours, being surrounded by people and having company, having a partner and a good marriage, not being alone

**social roles:** doing things for the family (taking care of grandchildren or partner, helping others, being a member of organizations, and having social interaction and relations with others

**recreation and entertainment:** going out in company, having hobbies, keeping going, listening to music and visiting the family

---

**Physical:**

**Mobility:** ability to walk, good mobility, good function

**Activities:** doing exercises and being physically active

**Health:** good physical condition, not smoking, having no pain

---

**Life circumstances:**

Environment (nice home and not being institutionalized)

Sense of security

Free from responsibilities

No care transition

Not being alone

---

**Cognitive and psychological:**

Mental health, No dementia, Feeling mentally good, No depression or cognitive problems, No painful memories, Happiness and joy, Keeping one's personality, Accepting reality, Self-acceptance, Self-contentment & focusing on the present, Accepting others, Positive outlook, Positive attitude, Tolerance, Coping - adaptation & adjustment, Maintaining an interest, Humility, Self-esteem, Self-respect, Satisfaction (with life), Calm personality, No arguments & conflict, Being open & honest, Peace of mind, Not feeling lonely, Keeping up to date - learning new things & having good memories

---

**Independent:**

Physical independence

Financial independence

Authorities

Decision-making

Self-mastery

---

**Successful aging**

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**Balanced and harmonized life:**

Living in harmony

Rich life

Balanced life

Normal life

Happy life

Living in peace

---

**Death:**

Not being afraid of death

Easy death

Nice death

Painless death

---

**Figure 5.** Components of good aging as defined by the oldest old (themes and subthemes). Continuity was interwoven with the highlighted themes.
6.3 Successful aging as a predictor of survival

Sub-study III introduced four models\(^3\) of successful aging: Model 1 was the most demanding, Model 4 the least demanding model. The proportion of survivors at the end of the four-year and seven-year follow-up among successful and non-successful agers in each of the four models are presented in Figure 6.

![Figure 6. Proportion of survivors after four-year and seven-year follow-up in four models of successful aging.](image)

In the total population, the frequency of survival was higher among successful agers in the four-year follow-up, and differences were significant in Models 2, 3 and

\(^3\) Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks

Model 2: Fewer than three diseases, no dementia, independent in three less demanding functional activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks

Model 3: No dementia, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks

Model 4: Fewer than three diseases, no dementia, independent in three less demanding functional activities + no depressiveness, self-rated health average or better, + phone contacts, met children during past two weeks
4. Survival was higher among successful agers in the seven-year follow-up in all models, but the difference was only significant in Model 4 (p < 0.05).

In women, survival was higher among successful agers in both follow-ups in Model 1 (37.4% and 17%, respectively). The differences between successful and non-successful agers were significant in Models 2, 3 and 4 in the four-year follow-up and only in Model 4 in the seven-year follow-up. In men, the survival rates for successful and non-successful men differed significantly only in Model 4 in the four-year follow-up.

Cox regression analysis showed that all models of successful aging except Model 1 predicted survival in the total population and among women (Table 5) in both follow-ups. Among men only Model 4 in both follow-ups predicted further survival.

**Table 5.** Successful aging models (M1-M4) as predictors of survival among the oldest old in four-year and seven-year follow-up by gender and in total population. Cox regression analysis adjusted for age in men and women, and for age and gender in total population, Hazard ratio with 95% confidence interval.

<table>
<thead>
<tr>
<th></th>
<th>Total population</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4-year</td>
<td>7-year</td>
<td>4-year</td>
</tr>
<tr>
<td>M1</td>
<td>0.71 (0.43-1.16)</td>
<td>0.81 (0.53-1.21)</td>
<td>0.72 (0.40-1.31)</td>
</tr>
<tr>
<td>M2</td>
<td>0.59 (0.41-0.83)</td>
<td>0.74 (0.56-0.97)</td>
<td>0.51 (0.33-0.79)</td>
</tr>
<tr>
<td>M3</td>
<td>0.60 (0.44-0.62)</td>
<td>0.72 (0.57-0.92)</td>
<td>0.56 (0.38-0.82)</td>
</tr>
<tr>
<td>M4</td>
<td>0.53 (0.45-0.62)</td>
<td>0.63 (0.55-0.72)</td>
<td>0.54 (0.45-0.65)</td>
</tr>
</tbody>
</table>

Model 1 was the only model that did not predict survival in the total population. Therefore, p-value function graphs were used to assess whether a non-significant result for the prediction of survival by Model 1 implies no relationship between survival and successful aging defined by this model in both follow-ups, or whether the finding is due to a small sample size. P-value function graphs were used to calculate p-values for a range of hypotheses other than the null hypothesis. The p-value measures the compatibility between the data and the null hypothesis, but this function calculates compatibility between the data and every possible value for the prediction of survival. P-value graphs for Model 1, the most demanding model in the four-year and seven-year follow-ups, shows that with a larger sample size and with better precision, successful aging could have been a predictor of survival in four years (Figure 7).
Figure 7. P-value functions for Model 1, in four-year and seven-year follow-ups.

In Model 3, predictions for mortality differed between the genders. Model 3 allowed the presence of diseases, but required independence in all five activities. Successful aging, as defined by this model, did not predict survival among men. Figure 8 shows the p-value function graph for Model 3 among men and women. The comparison between men and women indicates that successful aging is a better predictor among women. However, if we had a larger sample size for men, which would give greater precision, Model 3 could also be a predictor of survival among men.

Figure 8. P-value functions for Model 3 in men and women.
6.4 Successful aging as a predictor of entering long-term care

After two years 22% and after five years 40% of the study population who lived at home at baseline ended up in LTC (Table 6). In the total study group and among women, the number of people who entered LTC was greater than the number who died during the two-year and five-year follow-ups, while the opposite was true for men. Women had a higher probability of entering LTC than men. The results showed that the frequency of death was higher than the frequency of entering LTC among men, in both follow-up periods.

Table 6. Frequency (%) of death and entering LTC in two-year and five-year follow-ups.

<table>
<thead>
<tr>
<th>Follow-up</th>
<th>Total study group</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-year</td>
<td>Entered LTC</td>
<td>22.2</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Died</td>
<td>18.3</td>
<td>17.1</td>
</tr>
<tr>
<td>5-year</td>
<td>Entered LTC</td>
<td>40.6</td>
<td>43.4</td>
</tr>
<tr>
<td></td>
<td>Died</td>
<td>36.1</td>
<td>32.7</td>
</tr>
</tbody>
</table>

Successful and non-successful agers’ entry into LTC was compared by first calculating the incidence rate (cases per 100 per year) for both genders and the two-year and five-year follow-up periods and for four successful aging models\(^4\) (Table 7). The results showed that in the total study group, the incidence rate for entering LTC was lower among successful agers than non-successful agers in both follow-up periods. The analysis was conducted separately for each gender, and the incidence rate for women had the same pattern as for the total study group. However, if men were followed for a longer period (5-year) the incidence rate was no longer lower among successful than among non-successful agers.

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\(^4\) Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks

Model 2: No disease, independent in five functional activities + no depressiveness, self-rated health average or better + phone contacts, met children during past two weeks

Model 3: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better + phone contacts, met children during past two weeks

Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks
Table 7. Incidence rate of entering LTC (cases per 100 per year if followed for 2 or 5 years) for successful and non-successful agers according to four models of successful aging.

<table>
<thead>
<tr>
<th>Model</th>
<th>Group</th>
<th>Total study group</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2-year 5-year</td>
<td>2-year 5-year</td>
<td>2-year 5-year</td>
</tr>
<tr>
<td>M1</td>
<td>Successful</td>
<td>9 14</td>
<td>13 14</td>
<td>5 13</td>
</tr>
<tr>
<td></td>
<td>Non-successful</td>
<td>14 16</td>
<td>16 17</td>
<td>10 12</td>
</tr>
<tr>
<td>M2</td>
<td>Successful</td>
<td>8 11</td>
<td>8 11</td>
<td>8 11</td>
</tr>
<tr>
<td></td>
<td>Non-successful</td>
<td>14 16</td>
<td>16 17</td>
<td>9 11</td>
</tr>
<tr>
<td>M3</td>
<td>Successful</td>
<td>10 11</td>
<td>10 11</td>
<td>8 12</td>
</tr>
<tr>
<td></td>
<td>Non-successful</td>
<td>17 19</td>
<td>19 22</td>
<td>10 11</td>
</tr>
<tr>
<td>M4</td>
<td>Successful</td>
<td>10 12</td>
<td>11 12</td>
<td>7 13</td>
</tr>
<tr>
<td></td>
<td>Non-successful</td>
<td>15 16</td>
<td>16 18</td>
<td>10 11</td>
</tr>
</tbody>
</table>

Mortality was high among the nonagenarians (see Table 5) and a competing outcome for entry into LTC. Therefore, competing risk analysis was used instead of Cox regression analysis. Table 8 shows the results for predicting entry into LTC in the presence of mortality in two-year and five-year follow-ups.

When mortality was taken into account in the competing risk analysis, the result was still in line with that for the incidence rate. Model 1 of successful aging, the most demanding model, did not predict entry into LTC. Of the four models, Model 3 was clearly the most significant predictor of entry into LTC.

Among women and the total study group, entry into LTC was significantly less likely for successful agers than non-successful agers in Model 3; this was true in both the two-year and the five-year follow-up. Model 2 was a significant predictor for women and the total study group in the two-year follow-up, and for women in the five-year follow-up. Model 4 was a significant predictor for women in the five-year follow-up and for the total study group in both the two-year and the five-year follow-up.

When competing risk analysis was adjusted for living arrangement, need for help, study year, and in the total study group also for gender, the only predictor of entry

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3 Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks

Model 2: No disease, independent in five functional activities + no depressiveness, self-rated health average or better + phone contacts, met children during past two weeks

Model 3: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better + phone contacts, met children during past two weeks

Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live to 100 years + phone contacts, met children during past two weeks
into LTC was Model 3 in the whole group and in women, but not in men. This was true for both the two-year and the five-year follow-up. For men, none of the models predicted long-term care. In the five-year follow-up, sub-hazards for men were above 1, except for unadjusted Model 4, indicating that being successful did not protect men from entry into LTC.

Apparently, adjustment for living arrangement, need for help and year of baseline survey shifted the sub-hazard ratios to the left (closer to 1) and attenuated the association of successful aging with LTC. For example, the sub-hazard ratio for the total study group in unadjusted analysis for Model 3 of successful aging was 0.60 in the two-year follow-up. This means that the sub-hazard for entry into LTC among successful agers is 60% of the sub-hazard for non-successful agers. In other words, being successful reduces the incidence of entering LTC by 40%. Adjustment increased the sub-hazard to 70%. This means that the sub-hazard for entry into LTC among successful agers is 70% of the sub-hazard for non-successful agers, and being successful reduces the incidence of LTC entry by 30%.

Table 8. Association of successful aging models with LTC for total study group, men and women, in two-year and five-year follow-ups, competing risk analysis (sub-hazard ratios with 95% confidence intervals).

<table>
<thead>
<tr>
<th>Category</th>
<th>Follow-up</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total study group</td>
<td>2-year</td>
<td>0.70 (0.38 - 1.32)</td>
<td>0.62 (0.41 - 0.94)</td>
<td>0.60 (0.48 - 0.73)</td>
<td>0.66 (0.48 - 0.92)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.69 (0.43 - 1.11)</td>
<td>0.79 (0.62 - 1.02)</td>
<td>0.69 (0.60 - 0.80)</td>
<td>0.76 (0.61 - 0.94)</td>
</tr>
<tr>
<td>Women</td>
<td>2-year</td>
<td>0.84 (0.42 - 1.70)</td>
<td>0.56 (0.35 - 0.91)</td>
<td>0.54 (0.43 - 0.68)</td>
<td>0.69 (0.48 - 1.01)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.60 (0.31 - 1.16)</td>
<td>0.71 (0.53 - 0.96)</td>
<td>0.60 (0.51 - 0.71)</td>
<td>0.75 (0.58 - 0.97)</td>
</tr>
<tr>
<td>Men</td>
<td>2-year</td>
<td>0.58 (0.15 - 2.30)</td>
<td>1.01 (0.46 - 2.20)</td>
<td>0.89 (0.53 - 1.49)</td>
<td>0.73 (0.37 - 1.43)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>1.10 (0.55 - 2.22)</td>
<td>1.24 (0.75 - 2.03)</td>
<td>1.27 (0.85 - 1.72)</td>
<td>0.94 (0.60 - 1.46)</td>
</tr>
<tr>
<td><strong>Adjusted¹</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total study group</td>
<td>2-year</td>
<td>0.87 (0.46 - 1.64)</td>
<td>0.79 (0.52 - 1.19)</td>
<td>0.70 (0.56 - 0.87)</td>
<td>0.77 (0.55 - 1.07)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>1.07 (0.63 - 1.84)</td>
<td>0.98 (0.71 - 1.35)</td>
<td>0.71 (0.59 - 0.86)</td>
<td>0.89 (0.66 - 1.17)</td>
</tr>
<tr>
<td>Women</td>
<td>2-year</td>
<td>0.99 (0.49 - 2.02)</td>
<td>0.72 (0.44 - 1.17)</td>
<td>0.66 (0.52 - 0.84)</td>
<td>0.77 (0.52 - 1.12)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.95 (0.46 - 1.98)</td>
<td>0.89 (0.60 - 1.30)</td>
<td>0.62 (0.50 - 0.77)</td>
<td>0.81 (0.59 - 1.11)</td>
</tr>
<tr>
<td>Man</td>
<td>2-year</td>
<td>1.53 (0.76 - 3.09)</td>
<td>1.38 (0.77 - 2.47)</td>
<td>1.37 (0.90 - 2.09)</td>
<td>1.22 (0.75 - 1.99)</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.66 (0.17 - 2.61)</td>
<td>1.09 (0.48 - 2.48)</td>
<td>0.96 (0.57 - 1.60)</td>
<td>0.78 (0.40 - 1.52)</td>
</tr>
</tbody>
</table>

¹Adjusted for living arrangement, need for help, study year, and in total study group also for gender.
7 DISCUSSION

7.1 Main findings

7.1.1 Prevalence of successful aging and associated factors

To the best of our knowledge, this is the first study that compares different models of successful aging and their predictors and outcomes in the oldest old population. The prevalence of successful aging was found to range from 1.6% to 18.3% depending on the model applied and the threshold for measuring success. There are only few earlier reports on the prevalence of successful aging among the oldest old. Von Faber et al. (2001) found a low prevalence of successful aging in this age group. Formiga et al. (2011) focused on measuring the health, physical functioning and quality of life of nonagenarian community dwellers, and reported a 12% prevalence of successful aging.

As there exists no gold standard for the measurement of successful ageing, and as only few earlier studies have made such measurements among very old people, this study set out to construct and explore six different models for successful ageing. The prevalence of successful aging was lowest in the most demanding of these models. If absence of disease or a demanding physical component, for instance, was included in the model, it was much harder to meet the criteria for success at very old age. If absence of disease and demanding physical activities were omitted from the model, then the prevalence of successful aging increased. This finding suggests that successful aging, as defined in most earlier studies, is rare among the oldest old because of their increased physical impairments. Among the oldest old, therefore, the most demanding criteria for successful aging should be used with caution, and less demanding criteria should be considered.

Sociodemographic factors are known to affect the individual's health and life. It is widely reported that age has a strong association with successful aging (Depp & Jeste, 2006). This study showed that even at an advanced age, successful aging decreases with higher age. In the models that had less demanding criteria for success, age group differences were significant.
Gender emerged as an important predictor of successful aging in this study. The prevalence of successful aging was higher among men. This finding is in line with the results of Araújo et al. (2016), who reported that among centenarians male sex was a predictor of successful aging. However, the systematic review by Depp and Jeste (2006) did not show a consistent pattern for gender. They observed that although gender did not associate with successful aging, it was a known factor associated with longevity. The reason why some studies indicated no association with a number of sociodemographic factors, they suggested, lay in the exclusion of institutionalized individuals or the inclusion of proxy respondents.

In this study the prevalence of successful aging was higher in the highest education category, but a significant association was only found in Model 6. Pruchno et al. (2010) reported that higher education was associated with successful aging among old individuals. The systematic review by Depp and Jeste (2006) produced limited evidence (4 out of 9 studies) for an association between successful aging and higher education.

This study showed that place of living was significantly associated with successful aging, except for Model 1. Von Faber et al. (2001) similarly reported a lower prevalence of successful aging among the oldest old who lived in an institution as compared to community dwellers. Marital status did not predict successful aging in this study. The same result was reported in the systematic review by Depp and Jeste (2006) and later in a study by Chaves, Camozzato, Eizirik and Kay (2009).

In contrast to many earlier studies, this study also included institutionalized people and proxy respondents. This may in part explain the differences observed in the prevalence of successful aging between men and women, which was not seen in Depp and Jeste's systematic review (2006). Recently, Kelfve, Thorslund and Lennartsson (2013) have investigated the impact of excluding institutionalized people or those unable to answer themselves, a group with more physical and psychological problems than those who live at home and who are able to respond themselves. They concluded that this exclusion is conducive to considerable positive bias in findings for the oldest old. In our study, the inclusion of institutionalized and proxy individuals meant that we were able to avoid the trap of overestimating the prevalence of successful aging and that the findings can be generalized to the population of this age group.
7.1.2 Successful aging from the long survivors' point of view

Interviews with 45 individuals aged 90-91 provided an excellent opportunity to see how the oldest old themselves understand good old age. The interviewees mentioned the same physical, social and psychological elements that are included in most quantitative studies on successful ageing. This is an important finding in view of the observation made by Martin et al. (2012) that the oldest old are a heterogeneous group and that their life is different before and after 80 years of living. Therefore, successful aging may differ between the young old and the oldest old. The results of our qualitative interviews, however, were in line with the findings of previous studies on older individuals (Bowling, 2007 a; Bowling b; Depp & Jeste, 2006). One interesting finding was that the interviewees never mentioned absence of disease in general as an element of good aging. All that mattered for them was not having dementia or cognitive diseases. While physical abilities were only mentioned in passing, the importance of the psychological component to good aging was given greater weight. The prominence of psychological and cognitive themes supports the SOC model developed by Baltes (1997). This model emphasizes how inner resources such as coping and adaptation are applied and can help individuals improve any specific situation. In our study, the interviewees mentioned a positive outlook and attitude, coping and adaptation, self-acceptance and self-satisfaction as important factors to successful aging.

Continuity was mentioned in connection with other elements of successful aging such as independence. In particular, reference was made to continuity from what the interviewees had had in the past and to continuity from what they have now to be carried on in the future. In their view, the good life they had achieved in their past life could continue through the process of ageing.

Living circumstances, death and independence were also mentioned as important elements of good aging. The interviewees considered themselves good agers and hoped that their current situation would continue in the future. In case this was not possible or if they had to give up their independence, death was also identified as part of good aging. The quality of death was equally important as the quality of life. The interviewees wished for a painless and easy death at the end of a satisfying life.

Most interviewees in this study described themselves as good agers. Indeed, they represented the healthiest part of the oldest old population.
Successful agers were found to have higher survival rates in both shorter and longer follow-up periods. Cox regression analysis showed that with the exception of the most demanding model (Model 1), all models of successful aging predicted survival in both follow-up periods in the total population.

In women, successful aging was a predictor of survival in all models except for the most demanding one. On the other hand, the least demanding model (Model 4) of successful aging was the only model which predicted survival among men.

This study suggested that successful aging could predict further survival even among long survivors. The application of the most rigorous criteria for successful aging could result in a very small and select group of successful agers among the oldest old population. This small sample size may be one reason why no association was found between the most demanding model of successful aging and survival. The p-value function graph showed that if we had had a larger sample size, the most demanding model would also have predicted survival.
7.1.4 Successful aging as a predictor of long-term care (LTC)

Most of the reported components of successful aging reduce the risk of LTC (Luppa et al., 2010). However, to the best of the author's knowledge, there is no earlier research that explores the association of successful aging with LTC.

This study showed that successful agers are less likely to enter LTC after two and five years. However, the analysis did not produce conclusive results for men. Adjustment for living arrangements, needing help and year of participation in the survey weakened the association of successful aging and entry into LTC. The model with less demanding criteria for physical components provided the strongest prediction for entry into LTC for the total study population and for women.

In the five-year follow-up, successful aging seemed to be less protective against entry into LTC. This result could be due to the rapid changes in the health status of the oldest old.
7.1.5 Gender differences

This study was not explicitly concerned with gender differences, but it is important to note that the population predominantly consisted of women and that earlier research has found notable health and life situation differences between the oldest old men and women (Von Heideken Wagert et al., 2006). Therefore, the decision was made in the quantitative sub-studies to stratify the analyses by gender. These analyses found that the prevalence of successful aging was higher for men and that the gender difference was statistically significant. This could be due in part to the higher prevalence of diseases and disabilities among women. A number of studies have found that women live longer with more disability (Tiainen, et al., 2013). These findings may be a reflection of lifelong differences in biology, but also of the social context. Depp and Jeste (2006) reported that there is no consistency in the literature about gender differences in successful aging.

In this study, successful aging was examined as a predictor of survival and entry into LTC, and gender differences were observed in all models of successful aging. The mortality rate was higher among men than women in both successful and non-successful agers, but in most models successful aging did not predict survival among men. One possible explanation is the small size of the male population plus the small number of successful elites (because of the demanding criteria applied). Successful aging was a better predictor for women, but it may also have emerged as a predictor for men had the sample size been larger. In other words, successful aging can be a predictor of survival for both women and men. In this study men had a higher mortality and a lower rate of entering LTC than women, and during the follow-up periods they were more likely to die than to enter LTC. Earlier analyses in the Vitality 90+ Study have shown that at the same level of functional disability, women live longer than men (Tiainen et al., 2013). The same gender difference is seen in the findings of this study. Part of the explanation may lie in women’s higher likelihood of being widowed, which is known to increase the risk of LTC entry (Luppa et al., 2010; Martikainen et al., 2009).

Successful aging is a multidimensional paradigm in which gender (as a demographic factor) represents a combination of differences in physical, psychological and social components. This study provided evidence of gender differences in survival and entry into LTC among successful and non-successful agers, but it is not clear to what extent the differences reflect true differences in successful aging between men and women, and to what extent they reflect the social definition of gender roles.
7.2 Methodological considerations

7.2.1 The Vitality 90+ surveys

One of the major strengths of this study was that it used the Vitality 90+ dataset, which covers the whole population aged over 90 in Tampere, regardless of where they lived (institution or community). The response rate was very high, providing a non-biased picture of the very old population. The data also covers frail individuals, as proxy responses were accepted. The inclusion of proxy responses is widely recognized as important in studying the oldest old population (Kelfve et al., 2013). In this study, about 20% of the responses were by proxy. On the other hand, the high proxy response rate did cause difficulty in categorizing some components of successful aging, such as self-rated health and opinions about living to 100 years.

However, the Vitality 90+ Study was not originally planned for the purpose of studying successful aging, and therefore not all components of successful aging could be measured in the most optimal way. Compromises had to be made in measuring the psychological and social components of successful aging. For example, information about meeting relatives or friends was not available in the questionnaires. The respondents were only asked about meetings with their children, but more than one-fifth of the respondents had no children. The missing data was replaced by "yes" if the respondents had phone contact with other people during the past two weeks before filling the questionnaire. However, sensitivity analyses implied that the imputations did not bias the findings.

Another limitation of this study was the use of self-reported diseases and the absence of information on disease severity. However, the validity of self-reported dementia was reported in the study of Goebeler, Jylhä and Hervonen (2007), and it is discussed in more detail in sub-study III.
7.2.2 Register data

The survey data was linked with comprehensive national register data. Two registers were used in this study, i.e. the Finnish Population Register to obtain dates of death and the Care Registers for Health Care and for Social Welfare. Sund (2003) reports that Finnish register data are highly accurate. This linkage made it possible to follow up the participants in the Vitality 90+ Study. Indeed, it was an important advantage for this study to have access to information on care use for long follow-up periods.
7.2.3 Statistical analysis

The use of competing risk analysis represents another strength of this study since mortality appeared as a competing outcome to entry into LTC.

The very old population is female dominant. The differing results found for men and women may be explained by the nature of the data. Most of our analyses of men produced no significant results. P-value function analysis provided the opportunity to check the results for the male population and to see whether the non-existing association between the models of successful aging and mortality in men was caused by a small sample size or whether it really is the case that these associations differ between the genders.
7.2.4 Analysis of the qualitative life story interviews

An important strength of this study was that it consulted the views of the oldest old to see how they themselves defined successful aging. The individual respondents' cultural and social values were also considered in order to be able to properly interpret the meanings they assigned to successful aging. In the Finnish language, the concept of success is mostly understood as referring to success in a business or career context. Therefore, the participants in this study were asked what in their view constituted good ageing and good old age. Some other studies in non-English speaking countries have also used an indirect translation of successful aging (Nygren, 2006; Romo et al., 2013).

Thematic data analysis was also conducted at the semantic level. Therefore, no latent analysis was conducted of the interviewees' interpretations of successful aging (Braun & Clarke, 2006).

Another consideration is the generalizability of the study. The interviews for this study were carried out with the youngest age group of nonagenarians (90-91 years). Only three interviewees regarded their own health as poor, suggesting that the healthiest part of the population took part in the study. Furthermore, 44 of 45 participants lived in the community. All except one interviewee described their own life as an example of good aging. In short, the situation and opinions of the interviewees were probably more optimistic than they would have been in the total group of people aged 90 and older.
7.2.5 Ethical considerations

Key ethical considerations in research with older people have to do with data collection, data use and reporting the results. The data sources for this research were the Vitality 90+ surveys and interviews; Statistics Finland register data on deaths, obtained from the Finnish Population Register; and the Care Register for Health Care (Terveys-HILMO) and the Care Register for Social Welfare (Sosiaali-HILMO).

The research protocols for the Vitality 90+ surveys were approved by the ethic committees of the City of Tampere and the Pirkanmaa Hospital District. Informed consent was obtained from all respondents or their legal representatives.

For the qualitative part of the study, invitations to life story interviews and a short questionnaire were sent to every fifth woman and man living in the city of Tampere and born in 1921–22. Before the interviews they were given information about the study and told that participation was voluntarily; they were free to decide not to answer the questions and to discontinue the interview at any time. The principles of anonymity were also explained to the interviewees. Informed consent was obtained from all respondents.

Permission to use the register data was obtained from the National Institute for Health and Welfare. For the third and fourth sub-studies, register data and Vitality 90+ data were used. Data linkage was performed by the National Institute for Health and Welfare (THL) using unique personal identity codes. In order to ensure data confidentiality all personal identity codes were removed from the data before they were returned to the researchers.
7.3 Suggestions for models of successful aging for the oldest old

There is no gold standard model for defining or measuring successful aging. Most models of successful aging claim to be multidimensional, but in fact they predominantly focus on biological or psychological factors. Furthermore, most existing models are unsuitable for use with the oldest old because they would yield zero rates for successful aging (Andersen-Ranberg et al., 2001). In the quantitative part of our study, we applied the thinking of Rowe and Kahn (1997) and Young et al. (2009) to develop our successful aging models. Rowe and Kahn's model has faced many criticisms over the years, but as Dillaway and Byrnes (2009) point out, it still is the best known and a widely used model in the field of gerontology as it combines all components of successful aging, i.e. the physiological, psychological and social. This model eclipsed disengagement theory and the thinking that changes in old age are unavoidable (Johnson & Mutchler, 2014). However, Stowe and Cooney (2015) encourage caution in the use of this model in its current form. The model developed by Young et al. also considers the three components of successful aging and is probably better applicable to the oldest old population in that it considers compensation mechanisms for physical limitations. These compensation mechanisms include psychological and social domains. According to this model, successful aging is achievable even in the presence of disease and disability. Indeed, Young et al. (2009) refer to a coping mechanism as a sense of personal fulfillment even if old individuals experience difficulties with physical decline and diseases.

The Young et al. (2009) model, which maintains that there are multiple pathways to successful aging, is not a physically oriented definition. Their model has moved beyond the more frequently used model of Rowe and Kahn, which emphasizes disease and disability. It highlights psychological and social mechanisms such as coping, adaptation, resilience and spirituality, as well as valuing social ties (Young et al., 2009). These mechanisms allow the individual to age successfully, and whoever has the ability to use these mechanisms will be regarded as a successful ager. Therefore, successful aging is not restricted to people who experience no disease or disability.

Although the models proposed by Rowe and Kahn (1997) and Young et al. (2009) served as the foundation for the successful aging models developed in this study, they were not applied as such. Instead, different models were constructed with different thresholds to explore their applicability and feasibility among the oldest old. In addition, these models were slightly modified in each sub-study.
Data collection for the Vitality 90+ Study was not originally designed and intended for the purpose of measuring successful aging. Therefore, data limitations restricted the options open to developing the models for measurement of successful aging among the oldest old, and meant it was not possible to introduce an ideal model for this purpose. On the other hand, the interviews with the oldest old showed that with just one exception, all participants regarded themselves as successful agers. Furthermore, they were not concerned about any other disease than dementia. Coupled with the quantitative results, these findings suggested that the model of successful aging should not be restricted to the absence of disease alone – providing important direction for future research aimed at developing more accurate ways of measuring successful aging among the oldest old.

The models of successful aging that involved less demanding physical criteria were better predictors of future survival and entry into LTC. The ability of a successful aging model to predict future events is regarded as the "predictive validity" of the model to measure successful aging (Young, Fan, Parrish, & Frick, 2009). This predictive validity indicated that less demanding models provide for more accurate measurements of successful aging. Additionally, the ability to predict future events in the fastest growing segments of the population could contribute to better planning regarding future health needs within those segments.

The different models yielded different prevalences for successful aging. The findings of the first sub-study indicated a very low prevalence when the most demanding physical criteria were applied. The use of less demanding criteria increased the prevalence of successful aging. This provides a plausible explanation for why the prevalence of successful aging has varied in previous studies. This study suggested that the prevalence of successful aging decreases with advancing age. On the other hand, the lay models suggested that many of the oldest old regard themselves as successful agers.

Physical functioning was an important criterion of good aging for the oldest old themselves. Psychological and social functioning was also recognized as an element of good aging. Furthermore, living circumstances, independence, and having a good death appeared in their descriptions of successful aging. In the interviews, continuity from the past to the present and future emerged as an important element of successful aging. The absence of disease, by contrast, was not mentioned as an important element of successful aging, with the notable exception of the absence of dementia and depression. The absence of dementia was included in all the models developed and tested in this study, since this condition is known to seriously affect the quality of life of demented people and to undermine their coping mechanisms.
The lay perspective – the interviews with the oldest old – also lends support to those models in our study where "success" was considered possible even in the presence of some disease and functional disabilities. These models, rather than the model that assumed the total absence of disease and disability, were also the best predictors of survival and avoiding long-term care. Those criteria should be taken into consideration when developing a model for measuring successful aging in the oldest old.

Models of successful aging that had less demanding physical criteria proved to be better predictors of future survival and entry into LTC. Indeed, it is important to recognize that for purposes of assessing successful aging for the oldest old, the model applied should understand and measure successful aging differently than in the case of younger adults. A suitable model for the oldest old needs to place less emphasis on diseases and disabilities and more emphasis on psychological and social functioning.
8 CONCLUSIONS

1) The prevalence of successful aging varies depending on the model used.

2) The oldest old people who had been successful in survival, defined successful and good aging in terms of independence and a balanced and harmonious life. Their understanding also stressed the importance of physical, psychological and social functioning. These factors were accompanied by continuity. Good health was also important, but more in the sense of being pain-free rather than disease-free. From this the inference can be drawn that the participants saw aging as a process and hope to have success in each stage of this process. The last stage in this process is death, which marks the end of the life course. Good death was considered an integral part of good aging.

3) Less demanding models of successful aging, which allow for the existence of some diseases and functional problems, could provide more accurate predictions of future life and entry into LTC.

Successful aging is a long-standing positive paradigm in the field of gerontology, yet there is still no universally accepted definition or a gold standard for its measurement. It has been suggested that the definition of successful aging should be culturally relevant, age-specific, and consider the complexity of the aging process and changes in the human lifespan. Also and importantly, it is vital to consider lay people's views and values: after all, it is from these lay views and values that the notion of successful aging has originally evolved.

Finally, no single model of successful aging can be universally applicable to old individuals. Therefore, to properly measure successful aging among the oldest old, it is necessary to use a model that is specifically designed for use with this age group and that takes into account their age-related physical changes.
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Tampere, April 2018

Lily
THE VITALITY 90+ QUESTIONNAIRE, 2010

Please answer the following questions by circling the most appropriate alternative. For question 24, you can answer by circling the appropriate alternative and in writing. For question 25, you can answer by writing.

1. Where do you live?
   • Private apartment
   • Service housing; staff available during daytime only
   • Service housing; staff available 24 hours
   • Old people’s home
   • Nursing home or dementia home

2. With whom do you live (you can choose more than one alternative)?
   • Alone
   • With a spouse
   • With children
   • With grandchildren
   • With someone else

3. Is someone helping you at home e.g. with dressing, washing, or cooking?
   • Yes, approximately every day
   • Yes, sometimes
   • I do not receive help even though I would need it
   • I do not need help, I do my own housework

4. Who helps you most often in everyday life, e.g. in cooking, cleaning, or shopping?
   • Children and their family
   • Spouse, other relative, or a friend
   • Home helper
   • Someone else

5. Do you receive visits from a home helper at least once a week?
   • Yes
   • No
6. What was the last time you went outside (your apartment)?
   • Today or yesterday
   • Less than a week ago
   • During the past week or two
   • Several weeks ago
   • Several months ago
   • Years ago

7. When you go out, do you at least sometimes use a walking aid or receive help from another person?
   • Never
   • I use a walking stick
   • I use a walker
   • I use a cradle
   • Someone supports me
   • I use a wheelchair
   • I do not go outside

8. How would you describe your functional ability? Is it (This question only in 2010)
   • Very good
   • Fairly good
   • Average
   • Fairly poor
   • Poor

9. Are you able to move about indoors?
   • Yes, without difficulty
   • Yes, with difficulty
   • Only if someone is helping me
   • No

10. Are you able to walk 400 meters?
    • Yes, without difficulty
    • Yes, with difficulty
    • Only if someone is helping me
    • No

11. Are you able to use stairs?
    • Yes, without difficulty
    • Yes, with difficulty
    • Only if someone is helping me
    • No

12. Are you able to dress and undress?
    • Yes, without difficulty
    • Yes, with difficulty
    • Only if someone is helping me
    • No
13. Are you able to get in and out of bed?
• Yes, without difficulty
• Yes, with difficulty
• Only if someone is helping me
• No

14. Are you able to cut your toenails? (This question only in 2010)
• Yes, without difficulty
• Yes, with difficulty
• Only if someone is helping me
• No

15. How is your health? Is it
• Very good
• Fairly good
• Average
• Fairly poor
• Poor

16. Is it good for a human being to live to 100 years?
• Yes
• No

17. Have you been diagnosed with any of the following diseases?
   Yes No
   • Blood pressure, high blood pressure
   • Heart problems (coronary heart disease, infarction, arrhythmia)
   • Calcification of vessels
   • Dementia, Alzheimer's disease, weakening memory
   • Stroke
   • Circulatory problems in brain
   • Diabetes
   • Rheumatic disorder
   • Arthrosis
   • Parkinson's disease
   • Hip fracture
   • Depression

18. Are you able to read newspapers (with eyeglasses if you have them)? (This question only in 2010)
• Yes
• Partly (e.g. the biggest headlines)
• No
19. Are you able to hear a person talking when he/she is in the same room with you (with a hearing device, if you use it)? (This question only in 2010)
   • Yes
   • Partly (e.g. if he/she raises his/her voice)
   • No

20. When was the last time you met your children?
   • I have no children
   • Today or yesterday
   • Less than a week ago
   • In the past week or two
   • Several weeks ago
   • Several months ago
   • Years ago

21. When was the last time you were on the phone with a family member, relative or friend?
   • Today or yesterday
   • Less than a week ago
   • In the past week or two
   • Several weeks ago
   • Several months ago
   • Years ago

22. Please indicate your gender (This question only in 2010)
   • Male
   • Female

23. What is your marital status? (This question only in 2010)
   • Unmarried
   • Married
   • Divorced
   • Widowed

24. What education have you received? (This question only in 2010)
   • Elementary school
   • Lower secondary school
   • Vocational school
   • Folk high school
   • Upper secondary school
   • College education
   • Academic education
   Length of education (in years)?

25. In what occupation have you spent most of your working life?
26. How would you describe the status of elderly citizens in society today when compared to your childhood?
   • Better
   • About the same
   • Worse

27. Where are you staying at the moment (when answering these questions)?
   • Private apartment
   • Service housing; staff available during daytime only
   • Service housing; staff available 24 hours
   • Old people's home
   • Nursing home or dementia home
   • Health center or hospital

28. Finally, we would like to know who answered these questions:
   • Respondent him- or herself (possibly with help from another person to write the answers)
   • Family member, relative or friend helped answering
   • Family member, relative or friend answered on the respondent's behalf
   • Home helper helped in answering
   • Home helper answered on the respondent's behalf
Research Article

Is There Successful Aging for Nonagenarians? The Vitality 90+ Study

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Abstract

Objectives. This study was designed (1) to estimate the prevalence of successful aging among nonagenarians based on six different models and (2) to investigate whether successful aging is associated with socio-demographic factors.

Methods. A mailed survey was conducted with people aged 90+ in Tampere in 2010. Responses were received from 1283 people. The prevalence of successful aging was measured by six multidimensional models including physical, social, and psychological components. Age, sex, marital status, level of education, and place of living were studied as factors associated with successful aging.

Results. The prevalence of successful aging varied from 1.6% to 18.3% depending on the model applied. Successful aging was more prevalent in men, and also more prevalent among community-living people. In most models, successful aging was also associated with younger age, being married, and a higher level of education.

Discussion. Models which emphasize the absence of disease and activity as criteria for successful aging may not be the most relevant and applicable in oldest old. Instead, preference should be given to models that focus more on autonomy, adaptation and sense of purpose. Age-sensitive approaches would help us better understand the potential of successful aging among individuals who already have success in longevity.

1. Introduction

Increasing longevity is one of the great achievements of our civilization, but it has also given rise to discussion about good and successful aging. The concept of successful aging has attracted much debate, but there is still no universally accepted definition or standard measurement tool for it. The Encyclopedia of Aging defines successful aging as survival (longevity), health (lack of disabilities), and life satisfaction (happiness) [1]. It appears that the main sources of difficulty lay in the ambiguity of the meaning of “success,” in the complexity of the aging process, the rapid changes taking place in society, and the changing characteristics of the older population.

Discussions on successful aging have taken two main perspectives: one defines successful aging as a state of being, while the other understands it as a process of adaptation, described as doing the best with what one has [2]. Studies taking the adaptation approach have often found that older people themselves feel they are aging successfully, even though traditional quantitative models say otherwise [3, 4]. Successful aging as a state of being, then, is an objective measurable condition at a certain point in time, demonstrating the positive extreme of normal aging. The most influential model of successful aging as a state of being was introduced by Rowe and Kahn [5–8], who characterize “success” as absence of disease and disability, maintained physical and mental functioning, and active engagement with life. Many studies and definitions take the view that successful aging is possible only among individuals without disease and impairment. Obviously such categorizations are likely to exclude most older people, typically the oldest-old, from the possibility of successful aging [9].

Successful aging is of course impossible in the absence of aging. Still, according to Bowling [3], longevity is only rarely mentioned in lay or biomedical definitions. In studies using quantitative measures, younger age is one of the most regular predictors of successful aging [10, 11], and the rate of “success” drops dramatically in very old age. This may largely be due to the usual focus on physical deficits.
Indeed, several researchers have emphasized the need to use multidimensional models and to adopt different conceptual approaches to studying different age groups [3, 12]. Recently, Young et al. [13] suggested that successful aging may coexist with diseases and functional limitations if compensatory psychological and social mechanisms are used. Their model considers three important principles: the heterogeneity of aging, multiple pathways to successful aging, and individual compensation mechanisms to adjust for age-related changes.

The oldest-old group of nonagenarians meets the key biomedical criterion of successful aging that is longevity. They are also a rapidly growing age group that is heterogeneous in terms of health and functioning: a large majority have some health problems but are independent in basic everyday activities [14].

In this study, we investigate successful aging in an unselected population of nonagenarians, applying several different models that include physical, social, and psychological dimensions. The models differ with respect to the threshold for “success” on the physical, social, and psychological dimensions. Our aim is not to introduce an ideal universal model, but rather to demonstrate the variation in the prevalence of successful aging by applying different criteria. The first objective of this study was to construct six different models of successful aging and to use these models to estimate the prevalence of successful aging among nonagenarians. The second objective was to investigate whether successful aging in nonagenarians, defined in several different ways, is associated with sociodemographic factors.

2. Methods

2.1. Data. The Vitality 90+ study is a population-based multidisciplinary research program on nonagenarians in the city of Tampere, Finland. In the context of this program, mailed surveys were conducted with all community-dwelling people in 1996 and 1998, and with both community-dwelling and institutionalized people four times since 2001. This study used the data from the mailed survey in 2010. A questionnaire was sent to all individuals aged 90 or over in Tampere (N = 1630). Responses were received from 1283 people, giving a response rate of 79%. Proxy responses were obtained from 222 of the subjects who were themselves unable to answer the questions. For additional 20%, the respondent chose the answers but someone else helped in reading the questions or writing down the answers.

The research protocol was approved by the City of Tampere Ethics Committee. Informed consent was obtained from all respondents or their legal representatives.

2.2. Independent Variables. We explored the associations of five sociodemographic factors with successful aging: age, sex, marital status, level of education, and place of living. Age was categorized into three groups: 90-91, 92-93, and 94–107. Marital status was classified as currently married and currently unmarried, including never married, divorced, and widowed. Education was categorized into four groups as low (no more than elementary schooling), middle (lower secondary school), high (vocational school, folk high school, or upper secondary school), and highest (college and academic education). Place of living was dichotomized as community (private and service housing) and institution (residential care, service housing with 24-hour assistance, and hospitals).

2.3. Components of Successful Aging. Our dependent variable was successful aging. It was described by six different models that were constructed using psychical, social, and psychological indicators.

The physical component included three elements: diseases, functioning, and senses. The participants were asked whether they had been told by a doctor that they had (1) a heart problem, (2) stroke, (3) circulatory problems in the brain, (4) diabetes, (5) arthritis, (6) Parkinson’s diseases, (7) hip fracture, or (8) dementia or memory problems. For the measurement of functional ability, the participants were asked whether they were able to perform independently (a) three mobility activities: moving about indoors, walking 400 meters, using stairs and (b) two ADL activities: getting in and out of bed and dressing and undressing. The response options, (1) yes, without difficulty; (2) yes, with difficulty; (3) only with help; (4) not at all, were categorized as independent (1 + 2) and dependent (3 + 4). The participants were also asked whether they were able to read the newspaper, with glasses if they used glasses (vision), and to hear what another person was saying when they were alone with them, with hearing aid if they used a hearing aid (hearing).

The psychological component was described by three variables. The participants were asked whether they suffered from depression or had depressive feelings (yes, no). Present self-rated health was categorized as average or good (very good, fairly good, and average) and poor (fairly poor and poor). Self-rated health was included in the psychological components because it is a subjective measure with no predetermined criteria: it reflects not only the more objective components of health, but also and importantly the age-related way in which the individual adjusts and adapts to different health problems [15]. The participants were also asked whether they thought it was good for people to live to be 100 years (yes, no).

The social component was measured by two questions: the frequency of meetings with children (six categories from today or yesterday to several years ago) and the frequency of talking on the phone with family members or friends (six categories from today or yesterday to several years ago). One-fifth (20.1%) of the respondents had no children. If these participants had had telephone contacts during the past two weeks, they were categorized as having had contact with children.

The percentage of missing data varied between the different variables. The highest figures were recorded for two psychological variables. Part of the reason for this was that these questions were not asked of proxy respondents. Most of these participants lived in institutions and had multiple health problems. To avoid reducing the number of participants in the analyses, we categorized both proxy responses and other missing values in these two variables at the negative extreme (poor self-rated health and thinking
that it is not good to live to be 100). This imputation was done to avoid overestimation of the prevalence of successful aging, which would happen if the frailest participants were lost from the analyses.

2.4. Constructing Six Models of Successful Aging. Following Rowe and Kahn [6] and Young et al. [13], we defined successful aging as consisting of three components as shown in Figure 1. Six different models were constructed with different thresholds. The main differences between the models are in the physical component, where we defined four alternative criteria for “success,” ranging from most to least demanding as follows:

- Criterion 1: absence of disease + good vision and hearing + independence in all five activities.
- Criterion 2: less than three diseases, no dementia, good vision and hearing, and independence in ADL and moving about indoors (independent in 3 easier activities).
- Criterion 3: no dementia, good vision and hearing, and independence in all five activities.
- Criterion 4: good vision and hearing, and independence in all five activities.

In the psychological component, “success” was defined as absence of depressiveness, average or good self-rated health, and agreement with the view that it is good to live to be 100.

In the social component, “success” was defined as having met one’s children and having talked on the phone with family members or friends during the past two weeks.

The six models of successful aging were constructed as follows:

- Model 1: Physical component criterion 1 and psychological component & social component.
- Model 2: Physical component criterion 2 and psychological component & social component.
- Model 3: Physical component criterion 3 and psychological component & social component.
- Model 4: Physical component criterion 4 and psychological component & social component.
- Model 5: Physical component criterion 3 and psychological component.
- Model 6: Physical component criterion 3 and social component.

2.5. Analysis. The prevalence of successful aging in different sociodemographic categories was compared by cross tabulation using the Chi-square test. Logistic regression models were used to assess the independent associations of different models of successful aging with sociodemographic factors. Odds ratios (ORs) and 95% confidence intervals (95% CI) were calculated. These analyses were performed using the SPSS Package 16.

3. Results

Most of the participants (85.9%) were under 95 years of age, and more than 80% were women. These figures well reflect the distributions in the general population. Only 12.1% were still married and 37.5% lived in an institution. The majority had no more than elementary schooling (Table 1). Heart problems, arthritis, and dementia were the most frequent diseases, and only 14.7% of men and 10.2% of women did not have any of the eight conditions listed in the questionnaire. Four in ten respondents were independent in all five activities, and seven in ten were independent in ADL and moving about indoors. According to different criteria, 5.3 to 25.2% were aging successfully if only the physical
component was considered. In the psychological component, the prevalence of successful aging was 20%, in the social component the figure was markedly higher at 75%. Men had better scores than women in both the physical component (most criteria) and the psychological component (Table 2).

The prevalence of successful aging varied between the six models (Table 3). It was lowest (1.6%) for Model 1, which required absence of all diseases, independence in all five activities, and good vision and hearing, in addition to the psychological and social components, and highest (18.3%) for Model 6, which required the absence of dementia, independence in functioning, the ability to hear and read, as well as meeting the psychological and social criteria, and at 18.3% for Model 6, which required the absence of dementia, independence in functioning, the ability to hear and read, and meeting the social criteria. However, the main socioeconomic predictors remained largely the same across the models.

It is obvious that the absence of disease is the most demanding criterion for measuring successful aging. Disease and at least some functional deterioration are almost inevitable in very old age. Only 11% of the nonagenarians in our study had no major disease, and only 5.3% were both free of disease, able to hear and see, and independent in five daily activities (physical dimension criterion 1). Very few earlier studies have attempted to estimate the prevalence of successful aging in nonagenarians or in very old age in general. von Faber et al. [2] classified only 10% of community-dwelling and 1.9% of institutionalized participants aged 85 or over as successful agers. In the NonaSantfeliu study by Formiga et al. [17], the figure was 12% with community-dwelling nonagenarians. These studies emphasized the role of health and physical functioning, but also included some social or quality-of-life measures. It is clear that especially when the focus is on the physical dimension, successful aging will be very rare among people experiencing longevity.

Rowe and Kahn [6] included productive activities in their model of successful aging but these can hardly be expected from nonagenarians. Horgas et al. [18] showed that the daily activities of individuals aged 90 or over differed from other age groups, and in all categories this age group was engaged in significantly less activity than others. This implies that the social dimension of successful aging among the oldest old should be measured using different criteria and against different activities than in the case of the younger old and should be seen in relation to the situation of the best performers in the same age group.

In cross-sectional analysis, we limited our examination to socioeconomic predictors that at least potentially have played a role in the lives of the individuals for a longer time, and, with the exception of place of living, are not supposed to be influenced by factors that were thought to be components of successful aging. In most studies age has emerged as one of the strongest predictors of successful aging [18]. In our study, persons aged 94 or over were less likely to meet the successful aging criteria than the younger age groups. The difference

### Table 1: Population characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>90–91</td>
<td>44.5</td>
</tr>
<tr>
<td>92–93</td>
<td>25.5</td>
</tr>
<tr>
<td>94+</td>
<td>30.0</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>81.2</td>
</tr>
<tr>
<td>Men</td>
<td>18.8</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
</tr>
<tr>
<td>Unmarried</td>
<td>87.9</td>
</tr>
<tr>
<td>Married</td>
<td>12.1</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>56.4</td>
</tr>
<tr>
<td>Middle</td>
<td>9.9</td>
</tr>
<tr>
<td>High</td>
<td>22.7</td>
</tr>
<tr>
<td>Higher</td>
<td>11.0</td>
</tr>
<tr>
<td>Place of living</td>
<td></td>
</tr>
<tr>
<td>Community</td>
<td>62.5</td>
</tr>
<tr>
<td>Institution</td>
<td>37.5</td>
</tr>
</tbody>
</table>

4. Discussion

This paper examined one of the most prominent concepts in aging research, successful aging, by constructing six different models to measure it among nonagenarians. The models were based on work by Rowe and Kahn, Rowe, and Young et al. [6–8, 13, 16], although not the exact same indicators were used. According to Young et al. [13] and Rowe and Khan [6], successful aging is typically understood as comprising three main domains: physical (in Young et al.: physiological), psychological, and social (in Young et al.: sociological). The results showed that the prevalence of successful aging varies markedly from one model to another, standing at 1.6% for Model 1 that required the absence of any disease, independence in functioning, and the ability to hear and read, as well as meeting the psychological and social criteria, and at 18.3% for Model 6, which required the absence of dementia, independence in functioning, the ability to hear and read, and meeting the social criteria. However, the main socioeconomic predictors remained largely the same across the models.

Finally, logistic regression models were calculated to examine the independent association of different sociodemographic indicators with the six models of successful aging (Table 4).

In four models, higher age was independently associated with less successful aging. Gender was another predictive variable, and in all models except model 6, men were significantly more successful in aging than women. Higher education was a significant predictor in two models, and in Model 6 both those with a high and the highest educational level differed significantly from those with the lowest level of education. Marital status did not play an independent role, but place of living was a significant determinant of successful aging in all but Model 1.
Table 2: Frequency (%) of the variables composing three components of successful aging in men and women.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men (N = 226–238) %</th>
<th>Women (N = 1006–1038) %</th>
<th>P value</th>
<th>All (N = 1227–1283) %</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical component</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No heart problem</td>
<td>42.4</td>
<td>47.1</td>
<td>0.192</td>
<td>46.2</td>
</tr>
<tr>
<td>No stroke</td>
<td>96.2</td>
<td>94.4</td>
<td>0.250</td>
<td>94.7</td>
</tr>
<tr>
<td>No circulatory problems in brain</td>
<td>78.6</td>
<td>79.3</td>
<td>0.798</td>
<td>79.2</td>
</tr>
<tr>
<td>No diabetes</td>
<td>85.7</td>
<td>88.8</td>
<td>0.178</td>
<td>88.2</td>
</tr>
<tr>
<td>No arthritis</td>
<td>69.7</td>
<td>54.3</td>
<td>&lt;0.001</td>
<td>57.2</td>
</tr>
<tr>
<td>No Parkinson's disease</td>
<td>99.6</td>
<td>98.3</td>
<td>0.148</td>
<td>98.6</td>
</tr>
<tr>
<td>No hip fracture</td>
<td>89.2</td>
<td>81.3</td>
<td>0.003</td>
<td>82.8</td>
</tr>
<tr>
<td>No dementia</td>
<td>66.4</td>
<td>59.2</td>
<td>0.033</td>
<td>60.6</td>
</tr>
<tr>
<td>No disease</td>
<td>14.7</td>
<td>10.2</td>
<td>0.045</td>
<td>11.0</td>
</tr>
<tr>
<td>2 or less diseases with no dementia</td>
<td>39.5</td>
<td>29.8</td>
<td>0.004</td>
<td>31.6</td>
</tr>
<tr>
<td>Able to see</td>
<td>72.8</td>
<td>59.9</td>
<td>&lt;0.001</td>
<td>62.3</td>
</tr>
<tr>
<td>Able to hear</td>
<td>68.1</td>
<td>71.5</td>
<td>0.299</td>
<td>70.9</td>
</tr>
<tr>
<td>Able to see and hear</td>
<td>53.2</td>
<td>48.2</td>
<td>0.170</td>
<td>49.2</td>
</tr>
<tr>
<td>Independent in five activities</td>
<td>58.3</td>
<td>34.9</td>
<td>&lt;0.001</td>
<td>39.2</td>
</tr>
<tr>
<td>Independent in 3 easier activities</td>
<td>83.0</td>
<td>72.5</td>
<td>&lt;0.001</td>
<td>74.5</td>
</tr>
<tr>
<td>Criterion 1*</td>
<td>7.7</td>
<td>4.8</td>
<td>&lt;0.001</td>
<td>5.3</td>
</tr>
<tr>
<td>Criterion 2*</td>
<td>28.3</td>
<td>26.1</td>
<td>0.500</td>
<td>26.5</td>
</tr>
<tr>
<td>Criterion 3*</td>
<td>24.8</td>
<td>19.1</td>
<td>0.050</td>
<td>20.2</td>
</tr>
<tr>
<td>Criterion 4*</td>
<td>33.9</td>
<td>23.2</td>
<td>&lt;0.001</td>
<td>25.2</td>
</tr>
<tr>
<td><strong>Psychological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No depressiveness</td>
<td>87.8</td>
<td>79.6</td>
<td>0.004</td>
<td>81.2</td>
</tr>
<tr>
<td>Self-rated health average or good</td>
<td>72.3</td>
<td>61.4</td>
<td>0.002</td>
<td>63.4</td>
</tr>
<tr>
<td>Willing to live up to 100 years</td>
<td>42.4</td>
<td>24.8</td>
<td>&lt;0.001</td>
<td>28.1</td>
</tr>
<tr>
<td>Psychological component</td>
<td>34.0</td>
<td>16.7</td>
<td>&lt;0.001</td>
<td>20.0</td>
</tr>
<tr>
<td><strong>Social engagement</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Met children during past 2 weeks</td>
<td>92.7</td>
<td>93.5</td>
<td>0.644</td>
<td>93.4</td>
</tr>
<tr>
<td>Phone contacts</td>
<td>84.6</td>
<td>79.4</td>
<td>0.070</td>
<td>80.4</td>
</tr>
<tr>
<td>Social component</td>
<td>78.8</td>
<td>74.4</td>
<td>0.166</td>
<td>75.2</td>
</tr>
</tbody>
</table>

* Criterions. Criterion 1: No disease, and able to hear and read, and independent in all five activities. Criterion 2: Less than 3 diseases, no dementia, able to hear and read, and independent in three easier activities. Criterion 3: No dementia, able to hear and read, and independent in 5 activities. Criterion 4: Able to hear and read, independent in 5 activities.
between the age groups was significant for all except Model 1, and it was greatest in Model 6 where the overall prevalence of successful aging was highest. After adjusting for other sociodemographic variables, a significant age difference still persisted in four models.

In our study, the prevalence of successful aging was consistently higher for men, and in all except the last model the differences were also significant after the adjustments. Earlier studies [10] show no consistent patterns of gender differences, but the results seem to be dependent on the model used. McLaughlin et al. [11] found no gender difference in prevalence, but higher odds of successful aging in women after controlling for sociodemographic variables. Our findings among nonagenarians are only partly explained by the high prevalence of disabilities and disease in women, as men had clearly better scores in the psychological component as well. These disparities are likely to reflect differential survival, lifelong differences in biological, health, and social conditions.

Marital status was associated with successful aging in unadjusted analysis but not in the adjusted models, where the uneven age and gender distribution of the variable was controlled for.

Education is known to have an impact on health and lifestyle, and it reflects socioeconomic status; therefore, it can also be considered a potential predictor of successful aging. Most of the studies reviewed by Depp and Jeste [10] found no differences according to educational level, but the analysis by McLaughlin et al. [11] in the Health and Retirement Study showed that the prevalence of successful aging was higher in groups with a higher education and household income. The study of Pruchno et al. [19] revealed that a higher level of formal education is associated with successful aging. Our findings with an older group than in these studies showed a graded increase in the prevalence of successful aging with higher education, although the difference was not significant for all models. The discrepancy between the findings may at least partly be due to sampling bias. In several studies institutionalized people and those of lower social position were less likely to participate [10], while our study represents the whole age group in the region.

Place of living is not usually considered a predictor of successful aging and in many (but not all, see e.g., von Faber et al. [2]) studies samples only include community-dwelling individuals. In our study, we wanted to take account of the possibility of successful aging even in an institution.

---

Table 3: Prevalence of successful aging (%) according to the six models in different socioeconomic categories.

<table>
<thead>
<tr>
<th>Models of successful aging*</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total prevalence</td>
<td>1.6</td>
<td>6.3</td>
<td>5.7</td>
<td>6.8</td>
<td>6.3</td>
<td>18.3</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90–91</td>
<td>1.9</td>
<td>7.9</td>
<td>6.5</td>
<td>7.5</td>
<td>7.5</td>
<td>23.8</td>
</tr>
<tr>
<td>92–93</td>
<td>2.5</td>
<td>6.8</td>
<td>7.1</td>
<td>8.6</td>
<td>7.7</td>
<td>21.2</td>
</tr>
<tr>
<td>94+</td>
<td>0.5</td>
<td>3.4</td>
<td>3.2</td>
<td>4.2</td>
<td>3.4</td>
<td>7.8</td>
</tr>
<tr>
<td>( P ) value</td>
<td>0.104</td>
<td>0.021</td>
<td>0.042</td>
<td>0.048</td>
<td>0.022</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>4.7</td>
<td>12.4</td>
<td>11.1</td>
<td>13.2</td>
<td>12.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Women</td>
<td>1</td>
<td>5</td>
<td>4.5</td>
<td>5.5</td>
<td>5.1</td>
<td>17.5</td>
</tr>
<tr>
<td>( P ) value</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>0.095</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>3.3</td>
<td>11.8</td>
<td>11.8</td>
<td>14.5</td>
<td>12.5</td>
<td>24.2</td>
</tr>
<tr>
<td>Not married</td>
<td>1.4</td>
<td>5.6</td>
<td>4.9</td>
<td>5.9</td>
<td>5.6</td>
<td>17.6</td>
</tr>
<tr>
<td>( P ) value</td>
<td>0.095</td>
<td>0.003</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>0.001</td>
<td>0.03</td>
</tr>
<tr>
<td>Place of living</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community</td>
<td>2.3</td>
<td>8.4</td>
<td>7.6</td>
<td>9.1</td>
<td>8.2</td>
<td>25.9</td>
</tr>
<tr>
<td>Institution</td>
<td>0.6</td>
<td>2.9</td>
<td>2.5</td>
<td>3.1</td>
<td>2.5</td>
<td>6.1</td>
</tr>
<tr>
<td>( P ) value</td>
<td>0.026</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.3</td>
<td>4.7</td>
<td>4.6</td>
<td>6</td>
<td>5.8</td>
<td>14.4</td>
</tr>
<tr>
<td>Middle</td>
<td>1.6</td>
<td>7.4</td>
<td>4.9</td>
<td>4.9</td>
<td>5.7</td>
<td>20.5</td>
</tr>
<tr>
<td>High</td>
<td>2.1</td>
<td>7.5</td>
<td>7.1</td>
<td>8.2</td>
<td>7.2</td>
<td>22.6</td>
</tr>
<tr>
<td>Higher</td>
<td>3</td>
<td>12.5</td>
<td>9.6</td>
<td>11.9</td>
<td>9.6</td>
<td>29.1</td>
</tr>
<tr>
<td>( P ) value</td>
<td>0.51</td>
<td>0.005</td>
<td>0.093</td>
<td>0.058</td>
<td>0.377</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 4: Associations of successful aging, according to the six models, with socioeconomic characteristics. A multivariate logistic regression model, all the predictors included in the model simultaneously. Odds ratios (OR) and 95% confidence intervals (CI).

<table>
<thead>
<tr>
<th>Models of successful aging</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
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<tr>
<td>90–91</td>
<td>2.74  (0.59–12.76)</td>
<td>1.93  (0.99–3.78)</td>
<td>1.68  (0.83–3.4)</td>
<td>1.43  (0.76–2.66)</td>
<td>1.82  (0.93–3.57)</td>
<td>2.85  (1.81–4.49)</td>
</tr>
<tr>
<td>92–93</td>
<td>3.93  (0.82–18.89)</td>
<td>2.15  (1.02–4.53)</td>
<td>1.76  (0.91–3.42)</td>
<td>1.93  (1.0–3.73)</td>
<td>2.14  (1.05–4.40)</td>
<td>2.90  (1.79–4.73)</td>
</tr>
<tr>
<td>94+</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Women</td>
<td>0.20  (0.07–0.54)</td>
<td>0.46  (0.26–0.82)</td>
<td>0.53  (0.29–0.96)</td>
<td>0.54  (0.31–0.94)</td>
<td>0.47  (0.27–0.83)</td>
<td>0.98  (0.06–1.50)</td>
</tr>
<tr>
<td>Marital status</td>
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</tr>
<tr>
<td>Unmarried</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Married</td>
<td>0.85  (0.26–2.73)</td>
<td>1.17  (0.61–2.26)</td>
<td>1.60  (0.82–3.12)</td>
<td>1.71  (0.92–3.16)</td>
<td>1.42  (0.74–2.7)</td>
<td>1.11  (0.69–1.81)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Middle</td>
<td>1.64  (0.34–7.88)</td>
<td>1.77  (0.81–3.85)</td>
<td>1.16  (0.47–2.87)</td>
<td>0.89  (0.37–2.18)</td>
<td>1.10  (0.47–2.54)</td>
<td>1.57  (0.94–2.63)</td>
</tr>
<tr>
<td>High</td>
<td>1.14  (0.39–3.33)</td>
<td>1.28  (0.72–2.3)</td>
<td>1.23  (0.68–2.22)</td>
<td>1.10  (0.64–1.91)</td>
<td>0.95  (0.54–1.69)</td>
<td>1.45  (1.00–2.11)</td>
</tr>
<tr>
<td>Higher</td>
<td>1.35  (0.38–4.6)</td>
<td>2.03  (1.06–3.89)</td>
<td>1.48  (0.73–2.99)</td>
<td>1.45  (0.76–2.76)</td>
<td>1.14  (0.57–2.28)</td>
<td>2.00  (1.26–3.17)</td>
</tr>
<tr>
<td>Place of living</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community</td>
<td>3.11  (0.89–10.8)</td>
<td>2.48  (1.36–4.53)</td>
<td>2.66  (1.39–5.05)</td>
<td>2.64  (1.48–4.72)</td>
<td>3.18  (1.68–6.0)</td>
<td>4.30  (2.83–6.53)</td>
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<tr>
<td>Institution</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
However, the results showed that the prevalence of successful aging was clearly lower for those living in institutions, and this was also true for the adjusted models. Our earlier analyses (not shown here) indicated that disease, disability, and problems with hearing and seeing are more prevalent in institutions, as is self-rated health, which partly explains this finding.

4.1. Strengths and Limitations. The major strength of this study is that it covers the whole population aged 90 or over in the area concerned, including institutionalized people as well as proxy responses. The response rate was high. Our earlier and ongoing analyses suggest that the information on health and functioning collected by mailed questionnaires among nonagenarians is sufficiently valid and reliable [20, 21]; particularly as for a majority for those suffering from dementia, the answers were given by a proxy respondent.

In order to gain a broad and thorough understanding of successful aging, we included both physical, psychological, and social components in our analyses. Unlike most other studies, we also included the ability to see and hear as an important contributing factor to independence and quality of life. The main limitations of our study have to do with the measures used to assess the social and psychological components. Our only information about meeting with other people concerned meetings with children; no data were available about other family members or friends. One-fifth of the respondents had no children, and we decided to give them a positive score for social contacts if they had made or received any telephone calls during the past two weeks. One-fifth of our responses were from proxies, who were not asked about self-rated health or living to be 100. Therefore, we had a high percentage of missing or proxy answers to two questions regarding the psychological dimension of successful aging. In order not to overestimate the prevalence of successful aging, we scored this missing data and proxy answers as negative. These kinds of problems are unavoidable in unselected samples of very old people, but they nonetheless add some uncertainty to our findings. Another obvious limitation of our study is that we had no direct questions designed to capture our respondents’ self-evaluations of their life.

4.2. Implications. Our study in a nonselected population of persons aged 90 or over supports earlier findings that the prevalence of successful aging is highly dependent on the model applied, but in every case successful aging is associated with age, gender, and socioeconomic status. However, it is apparent that with any model that defines successful aging as a state of being and that uses criteria commonly used for younger age groups, successful aging remains a rare situation among the oldest old. An increased likelihood of health and functional problems, often followed by reduced opportunities for active social engagement, is normative consequences of biological aging and typical of extreme longevity. Therefore, in very old age, rather than models emphasizing the absence of disease and activity, emphasis should be given to approaches focusing on autonomy, adaptation, and sense of purpose [3, 22, 23]. These age-sensitive approaches would help us better understand the potential of successful aging among those individuals who have already had success in longevity.

Acknowledgments

Gerontology Research Center is a joint effort between the Universities of Jyväskylä and Tampere. This study was supported by Grants from the CIMO Fund to L. Nosraty and from the Competitive Research Funding of Tampere University Hospital (9M025) to M. Jylhä. The authors wish to thank Anna-Maija Koivisto, M.S. agree, for her statistical help and advice.

References


Perceptions by the oldest old of successful aging, Vitality 90+ Study
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Purpose: To discover how 90–91-year-olds see a good old age and identify the dimensions of good and successful aging that appear in their talk.
Design and methods: Life-story interviews with 45 community-dwelling nonagenarians (25 women and 20 men), conducted in the context of the Vitality 90 + Study. In the interviews the respondents were asked to give their opinions about a good old age and its constituents. The answers were subjected to thematic analysis with an inductive approach.

Results: The dimensions identified in most popular theories of successful aging, such as the physical, the cognitive, the psychological and social functioning, were also found in our study. But we were also able to identify new themes that have rarely been mentioned in previous studies of successful aging. These themes were “living circumstances”, emphasizing the importance of having one’s own home and living there as long as possible, “independence” in relation to various aspects of life and a “good death”. The respondents saw themselves as having a good old age.

Implications: Definitions of a good old age provided by the oldest old themselves give new insights into the concept of successful aging. Good health is important, but more in the sense of being pain-free than of being disease-free. Social and cognitive aspects seem to be more important than physical health. The important things for our nonagenarian respondents were to continue living independently, preferably in their own homes, and to have a quick and easy death rather than being institutionalized.

Keywords: Good aging
Healthy aging
Lay model
Nonagenarians
Qualitative method

Increasing life expectancy and attempts to add quality to those extra years of life have heightened interest in understanding successful aging and developed a higher expectation for a good life in old age. In societies where longevity is common, quality of life and a good old age are challenges and achieving a good old age enhances continued quality of life during aging. The complexity of the aging process and ongoing social changes in the context of varied cultures and norms, in addition to the ambiguous meaning of success, make it problematic to find a universal definition for successful aging (Iwamasa & Iwasaki, 2011). Indeed, success in aging still remains a challenging topic in the field of gerontology. Different interpretations have led to a shift in the discourse, from successful aging to terms such as “healthy aging”, “aging well”, “harmonious aging”, “robust aging”, “optimal aging”, “positive aging”, “productive aging” and “active aging” (Depp & Jeste, 2006).

According to Von Faber et al. (2001), successful aging can be approached from two main perspectives. One perspective examined the concept of successful aging as a state of being at a certain moment. An example of that is Rowe and Kahn (1997) which adopts a biomedical approach and objective measures, referring to successful aging as a “positive extreme of normal aging”. The other perspective regards successful aging as a process, and one’s adaptation to that aging process, such as that shown in Baltes and Baltes (1990) which defines

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successful aging as a process involving three components: selection, optimization, and compensation. Bowling (2007a) mentioned that most researchers have chosen their own outcome indicators and created their own definitions of successful aging. Those definitions and models of successful aging attempt to prescribe how people should age rather than understanding how elderly people as a heterogenic group define the process themselves as they age (Chapman, 2005).

The perspectives of older adults are needed due to the disagreements which can occur regarding any single definition. Lay models of successful aging give elderly lay people the possibility to voice their understanding and express their opinions on the topic of successful aging. These lay views can be varied or overlap with professional opinions (Cosco, Prina, Perales, Stephan, & Brayne, 2013). Those personal views are essential to a better understanding of the reality of successful aging. They could also help in developing a realistic definition of successful aging and in contributing to providing better patient-centered care (Phelan, Anderson, Lacroix, & Larson, 2004). It is thus important to investigate lay views in order to ensure that theoretical models have social significance and are representative of people’s values (Bowling & Dieppe, 2005).

Perceptions of what constitutes successful aging are not only individual but also cultural. Prevailing cultural concepts of what is required for successful aging have an impact on old people’s experiences. If perfect health is valued as an ultimate goal, old age, with its increasing health problems, may be experienced as a form of failure. On the other hand, if social dimensions and adaptation are emphasized as important elements of successful aging, it could well be easier to feel satisfied with life.

In earlier studies of lay views, definitions have included such parameters as physical, mental and cognitive health, psychological well-being and life satisfaction, happiness, social relationships, support, activity and productivity, personal growth, a sense of purpose, self-acceptance, coping, spirituality, one’s neighborhood, and financial circumstances and security (Bowling, 2007a, 2007b; Bowling & Iliffe, 2006; Glass, 2003). Bowling and Dieppe (2005) compared various models and definitions of successful aging, finding that lay views seem to overlap with biomedical and psychosocial models, but were more multidimensional and contextual.

Many studies suggest that in the context of successful aging we cannot use a universal model for all age groups, different backgrounds and cultures. However, most studies have focused on people younger than 85 years of age, and the situations of the very old—who face the greatest challenges concerning quality of life—is largely unknown. An investigation of the views of the oldest old themselves, without using predetermined operational definitions, is therefore needed.

The main aim of this study was to investigate the meaning and content of good and successful aging by the oldest old people, aged 90+ in Tampere, Finland. The topic of good and successful aging among those people was approached by using qualitative data from life-story interviews with the oldest old.

Methodological approaches of the study

Participants

The data set used in this study comes from the larger life-story interview study, Vitality 90+ in 2012. The whole data corpus consists of some 1200 pages. For this study we analyzed only one question posed during the interviews. The total transcribed data set analyzed here is 33 pages. An invitation to the life-story interview and a short questionnaire were sent to every fifth woman and man born in 1921–22, living in the city of Tampere, Southern Finland. The response rate to the questionnaire was 46% among women and 63% among men. Only 25% of the female respondents were willing to grant an interview, compared with 48% of the male respondents. The interview participants included 25 women and 20 men aged 90–91. Informed consent was obtained from all respondents or from their legal representatives.

Demographic characteristics of the participants are presented in Table 1. According to the questionnaires, 24 of the interviewees did not need any outside help with light housework, 14 sometimes needed help and 7 needed help daily. The most frequent response regarding self-rated health was “average” (28 persons); 14 said their health was good or fairly good and three said it was poor. One interview, which was carried out with a woman suffering from severe dementia, was excluded from the study.

The life-story interview technique was applied, thus putting emphasis on eliciting individual narratives (Atkinson, 1998). Participants were interviewed in their own homes. The interviews were conducted by three researchers who were experts in the field of aging studies and by two medical students who had received training in conducting interviews. All interviewers were native Finnish speakers. All interviews were tape-recorded and transcribed. The shortest interview lasted 34 min, and the longest 3 h and 20 min. Most of the interviews took between 90 min and 120 min.

During individual interviews, the participants were first asked to tell their life story from childhood to the present day in their own words. After the life story had been related, additional questions were posed concerning health, retirement, hobbies and housing, as well as the person’s opinions regarding old age, longevity and older people’s status in society. The respondents were also asked to define what they considered to be a good old age (in Finnish “hyvä vanhuus”) and what they felt was needed to achieve it.

Table 1
Demographic characteristics of participants (numbers) in the life-story interviews.

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants in interviews</td>
<td>20</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Married</td>
<td>9</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Widowed</td>
<td>11</td>
<td>17</td>
<td>28</td>
</tr>
<tr>
<td>Former occupation</td>
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<tr>
<td>Blue collar</td>
<td>10</td>
<td>17</td>
<td>27</td>
</tr>
<tr>
<td>White collar</td>
<td>10</td>
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<td>28</td>
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<tr>
<td>Place of living</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Alone</td>
<td>11</td>
<td>23</td>
<td>34</td>
</tr>
<tr>
<td>With a spouse</td>
<td>9</td>
<td>2</td>
<td>11</td>
</tr>
</tbody>
</table>
One's understanding of successful aging depend on one's culture (Keith, Fry, & Ikels, 1990; Torres, 2001). The way in which questions are asked makes a difference, and the interpretation of findings is also culture-dependent. As Torres (2001) suggests, in order to make sense of research results that draw on individuals' understanding of successful aging, we need for that term to recognize the cultural and social values that shape meaning and understanding for the individuals concerned. In this regard, asking this oldest old age group in Finland about successful aging was not possible. The concept of “success” within the context of aging is not familiar to older Finnish people. The word tends to refer to business or career success, rather than to one's private or personal life. Therefore, the question was posed in a manner which would be more comprehensible to them. We used the term “hyvä vanhuaus” which translates as “good old age”. Actually in much other research into successful aging involving languages other than English, an indirect translation has also been used (Nygren, 2006, Romo et al., 2013). We asked: “What do you think constitutes a good old age? What do you need in order to experience a good old age? What things are associated with it? And what do you think a good old age is?” Thus, when referring to our own study in this paper, we prefer to use the concept “good old age” rather than “successful aging”.

Data analysis

The analysis in this study was based on the interview segments that concerned opinions about a good old age and what is needed to achieve it. At first participants’ opinions regarding a good old age were separated from the data corpus. Two of the authors also read through the entire data corpus of all the life-story interviews in order to check that no comments relevant to the research questions of this study had been left out. Those separate segments were translated from Finnish into English. The first author manually coded the English transcript and the third author coded the Finnish transcript.

We used thematic analysis with an inductive approach (Braun & Clarke, 2006), and we analyzed the dataset in order to understand the interviewees’ interpretations of good aging at the semantic level (Braun & Clarke, 2006).

Three of the researchers were gerontologists, therefore being unfamiliar with successful aging was unavoidable. However, we were open to people's own understanding of a good old age and analyses were data driven. The third researcher, who did the coding in the Finnish language, was a health scientist and was not engaged with the successful aging literature beforehand (Braun & Clarke, 2006; Tuckett, 2005). The first round of coding was done independently by the first and third authors.

Disagreements over the description of codes were resolved through discussion among the researchers, and codes were then refined as appropriate. The list of codes was finalized by group consensus, and resulted in a list of themes (see Appendix 1). For consistency, each of the individual themes in relation to the original data (Finnish language data) set was checked by the fourth author, who was one of the interviewers. By means of this process, a set of themes was derived which could characterize an oldest old’s perception of a good old age.

Results

The result of our study as themes and subthemes is presented in Table 2. Some of the themes were in line with earlier studies on successful aging (Bowling & Dieppe, 2005; Cosco et al., 2013). Physical, social, cognitive and psychological themes were also specifically mentioned by our respondents, but discussion was mostly interwoven with two other themes: life circumstances and independence. The comments concerning independence covered financial aspects, as well as independence in physical functioning and the hope of keeping that independence until the end of life. In addition, we recognized such themes as dying and a harmonious and balanced life, which have rarely been treated in other qualitative and quantitative studies. To start with, we will present the themes which are rarely mentioned in other studies and, subsequently, we will refer to the more familiar themes connected with successful aging.

<table>
<thead>
<tr>
<th>Component</th>
<th>Subcategories and examples in the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death</td>
<td>Not being afraid of death, an easy death, a nice death, a painless death</td>
</tr>
<tr>
<td></td>
<td>Living in harmony, a rich life, a balanced life, a normal life, a happy life, living in peace</td>
</tr>
<tr>
<td>A balanced and harmonious life</td>
<td>Physical independence, financial independence, autonomy and decision-making and self-mastery</td>
</tr>
<tr>
<td>Independence</td>
<td>Environment (a nice home and not being institutionalized), a sense of security, freedom from responsibilities, no transitions of care, not being alone</td>
</tr>
<tr>
<td>Life circumstances</td>
<td>Mobility: Ability to walk, good mobility, good function</td>
</tr>
<tr>
<td>Physical</td>
<td>Activities: Doing exercise and being physically active</td>
</tr>
<tr>
<td>Cognitive and psychological</td>
<td>Health: Good physical condition, not smoking, not having pain</td>
</tr>
<tr>
<td></td>
<td>Mental health, absence of dementia, feeling good (mentally), absence of depression or cognitive problems, no painful memories, happiness and joy, preserving one's own personality, accepting reality, self-acceptance and self-contentment and focusing on the present, accepting others, a positive outlook and a positive attitude, tolerance, coping and adaptation and adjustment, maintaining an interest, humility, self-esteem, self-respect, satisfaction (with life), a calm personality, no arguments and conflict, being open and honest, peace of mind, not feeling loneliness, keeping up to date, learning new things and having a good memory</td>
</tr>
<tr>
<td>Social</td>
<td>Social network: family, friends, children, grandchildren, good neighbors, being surrounded by people and having company, having a partner and a good marriage, not being alone</td>
</tr>
<tr>
<td></td>
<td>Social roles: doing things for the family (taking care of grandchildren or a partner), helping others, being a member of an organization, having social interactions and relationships with others</td>
</tr>
<tr>
<td></td>
<td>Recreation and entertainment: going out with others, having hobbies, keeping going, listening to music, visiting family</td>
</tr>
</tbody>
</table>

Table 2

Components of successful aging and its subcategories and examples, as defined by the oldest old.
Continuity in the process of aging

Many studies on aging mention that continuity in the process of aging could lead to well-being (Atchley, 1989; Baltes & Baltes, 1990; Baltes & Carstensen, 1996; Nimrod & Kleiber, 2007). Continuity theory is used in relation to adaptation in old age to changes which occur in the process of aging.

In our study, interviewees wished to retain the essential elements of a good old age until the end of life. They saw aging as a process of life and considered the continuation of what they had had in this process of life to be good and successful aging. It appeared in their interviews in two ways:

A) They were aware that the present state might not continue, but at the same time they were looking toward the future, even at the age of 90. For instance, one of the participants, in the context of existing impairments, mentioned keeping things as they were now in the following manner:

What is it like? It's just like this, like my own I can do what I like. If this continues, I will be quite content. And if only I could get my hearing back, I would be happy. A good old age is like this, that one gets to be on their own I don't know about what will happen when I'm in bad condition. I would hope that I'd pass away soon.

((7, female, alone, no home help))

Another female participant who receives daily home help, still feels her life is good and wants to keep it that way:

I like what I have. Especially if I can continue like this, living here and having them take care of me.

((12, female, alone, receiving daily home help))

B) Respondents referred to their past and saw the continuation of their past into the present as an important element of a good and successful old age. A male participant talked about 'being the same person' and 'having the same elements' as highlighting the continuation of what he had had before.

First and foremost, health and then being able to function. And an environment that allows you to be the same person, to have the same elements that you've always had.

((44, male, alone no home help))

Continuity was interwoven with other themes so it was not possible to ignore it when selecting the other initial themes for the process of analysis.

Death

Death and dying are an inevitable consequence of aging. It is somewhat of a paradox that the more successful you are at healthy aging and longevity, the more death will be a part of your life. Nonetheless, death is rarely mentioned in studies of successful aging. The phenomenon of death appeared in our interviews, in particular during the course of discussion concerning good aging. It was directly mentioned as a component of good aging, often expressed with the words “an easy death”.

All I need is for our heavenly Father to take me to him. My most sincere wish is that I won't have to lie in a bed anywhere. Goodness me, that would be horrible.

((19, female, living alone, no home help))

In this case the interviewee has also referred to the possibility of being institutionalized. Mention of death occurred either in the context of fear about being institutionalized or hospitalized (quite often because of dementia), or in a psychological context, as with the interviewee who said: “What can I say about it, not much... I'm in balance mentally, not afraid of death” (37, male, living with a spouse, no home help). Retaining one's dignity and independence is thus part of both quality of life and quality of death.

A harmonious and balanced life

Some researchers have suggested that the phrase “harmonious aging” should be used as an alternative to “successful aging” (Liang & Luo, 2012). They defined harmonious aging in terms of personal relationships and inter-dependency. Having a relationship was important to our respondents (as discussed in the section on social relationships) but not exactly in line with the findings of Liang and Luo (2012). Nevertheless, the importance of relationships was often mentioned but not in the form of interdependence as seen in Eastern Asian counties. For example this extract ends with “you look after yourself” emphasizing one's own responsibility.

Well, at least keeping up relationships. And trying to live so that there are no—how should I put it? That you keep on good terms with everyone, and that you look after yourself.

((4, female, living with spouse, no home help))

Some of our participants also emphasized in their responses living in harmony, speaking in terms such as “a rich life”, “a balanced life”, “a normal life”, “a happy life” or “living in peace”. Aging and old age are not static stages. Aging can even be understood as something that begins at birth. For our interviewees it was difficult to distinguish between good adulthood and good aging. Since an individual’s old age is affected by previous life events, decisions and circumstances, late life does not necessarily represent a radical break with the past. Our respondents felt that their own old age was good. However, there was one participant who had negative views regarding old age and her own aging. She elaborated on the impact of previous life events, and of memories that could be painful. This shows that events and choices which occur at a younger age can influence feelings in old age.

Is it a punishment for us to have to live so long? And these memories, they never go away. No matter what pills you take, it doesn’t take away the burden that I’ve been carrying right up till today. When I began to understand this life, what it is, I can’t say it’s thanks to my mother.

((42, female, living in an assisted living center, receiving daily home help))

Studies on successful aging have frequently discussed the role of spirituality in the process of life and old age, but findings vary (McCann Mortimer, Ward, & Winefield, 2008; Parker et al., 2002). Spirituality has been referred to in many studies as a
“forgetting factor” (Crowther, Parker, Achenbaum, Larimore, & Koenig, 2002). In some studies, it is mentioned as an important factor in the lives of older people; however, there is very little empirical evidence about the association between successful aging, spirituality and faith (Maki, 2005). In our study only two interviewees talked directly about spirituality and faith. One of them put it this way:

“The most important thing for me is my relationship with God”. (20, male, living alone, receiving occasional home help)

One male respondent gave a long answer to the question about a good old age. He started by talking about accepting others, and linked that especially to old age. To him good aging meant a certain kind of spiritual growth, becoming a better person.

A good old age means a lot of things. One is that you learn to accept other people. And I say other people on purpose, regardless of whether they’re men or women, old or young, what language they speak, etc. Regardless of whether they still have both arms or legs or whatever. What’s important is that you learn to accept other people no matter what they are like. That’s a part of aging well. That you’ve learnt to accept other people’s flats or furniture or dress or any everyday thing, regardless of whether you like it or not… That shouldn’t bother older people—that’s what young people are for. This is my answer: old age is permissive; it accepts other people as they are. It is a time when religions don’t matter… But part of a successful old age is that you can accept another person’s religious, spiritual and political ideologies—in short, you can truly listen to that person. (14, male, living alone, no home help)

Independence

Independence emerged as a theme in half of the interviews. It was considered with respect to physical independence, financial independence, autonomy, decision-making and self-mastery.

More than a quarter of the participants emphasized financial independence and having enough money to buy essentials and medications. Having a sufficient pension was the most important aspect of financial freedom: “Well, health of course and then sufficient income. I mean that your pension is enough to cover all medical costs and the like” (16, female, living in sheltered accommodation, receiving occasional home help). One female participant emphasized the varied perceptions of good aging. For her, having self-mastery was the most important thing, but she also acknowledged that this might not apply to all older people. This extract also highlights some of the typical features of the individualistic Finnish culture. ‘Not being patronized’ and ‘letting people live as they want’ are important for Finnish people of any age (Kälviäinen, 2012).

Let’s see, old age and good. I think it depends on what people think constitutes good. Some people need a lot of security, but I wouldn’t like to be patronized or taken care of yet… But that’s a tricky question. It’s so individual—I like what I have. And I’ve said that when I start to lose it, it’s time for them to step in. I would say at least staying pretty healthy. I’ve been able to take care of things and my work and everything, so in that sense nothing has been that important. And being myself. Living how I want to live and not caring too much about other people’s lives. I mean, let them live as they want to live. (23, female, living alone, no home help)

According to de Moraes and de Azevedo e Souza (2005) the maintenance of independence for daily life activities and autonomy could predict successful aging. The ability to make one’s decisions and having the freedom to act according to one’s own best interest are also identified by many researchers (Ford et al., 2000). A sense of autonomy can usually result in well-being and a positive attitude for older people. Autonomy in decision-making is an important element of successful aging. However, this decision-making could be affected by one’s living circumstances and social relationships. One male respondent explained at length and emphatically the importance of having freedom and control over his life and his decisions. At the end of his answer, he laughed and revealed the limits of his freedom by acknowledging that only his wife has the power over his decisions.

Well, old age is being able to do what you want. I don’t know how good it should be. When nobody bosses you around and you can do what feels good. At least in that sense we’ve been… if someone comes and I have one of my bad days, I sometimes do, although very rarely, if I’ve fallen on my head for example. And then someone comes and says that you must see a doctor. I’ve had the right to decide if I get to die here or go to the doctor. I don’t have to go, and I won’t go. I can decide for myself what I like and what I do. Nobody can tell me what to do. Except my wife. (28, male, living with spouse, receiving occasional home help)

Living circumstances

Living circumstances turned out to be an important element of a good old age. Having a nice home of one’s own was something to be proud of. “I think my old age is good, I’m happy. I have a good home here” (35, female, living alone, no home help). Living in one’s own home was also a part of independence and self-mastery. The meaning of having one’s own home and living independently is culture-dependent. In Finland very few older people live with their children, and independence at all ages is highly valued. Finnish older people wish to live in their own homes and want to manage on their own as long as possible (Jolanki, 2009). Independent living of older people is also a guiding principle of Finnish social policy.

The discussions about living in one’s own home often drew contrasts with institutional facilities for older people, as in this excerpt:

Well, the first condition is to stay fit enough to be able to live on your own. And to live at home; I’d much rather live here at home than in some institution. (5, male, living alone, receiving daily home help)

This kind of comment can be linked to a decade-long ongoing Finnish discussion regarding the poor quality of institutional care in Finland. There is frequently news coverage
regarding the poor quality of care provided for older people in municipal nursing homes. In this context, being able to live in one’s own home is in itself enough to constitute successful aging.

A good old age is this, like mine, this is good. It makes me sick when I watch the telly, showing old people in those institutions. And they always say they’re not doing well. And it just makes me ill to see that, but my situation is good.

[(29, female, living alone, no home help)]

Not being alone and being surrounded by people was mentioned in many cases. But when the respondents said that it was important not to be alone, this did not necessarily mean that they shared their home with someone. Most of our respondents were living alone, but it was important to have people around: “Good old age means you have people you know, that you do not have to be alone” (11, male, living alone, no home help).

New angles on physical, cognitive, psychological and social functioning

We also considered themes which have previously been treated in many qualitative and quantitative studies about successful aging (Bowling & Dieppe, 2005; Cosco et al., 2013, Rowe & Kahn, 1997) but our interviewees talked about those themes for the most part from novel angles and within new contexts.

Physical functioning

Physical functioning is one of the most dominant themes in studies of successful aging (Bowling & Dieppe, 2005), and proved to be so in our study as well. It was articulated in interviews in terms of having good health and functional ability, being active and being pain-free. Good health is an essential part of a successful old age and our interviewees also focused on health in general as a highly important issue. In addition, being healthy also enables one to be autonomous, which is another important component of successful and good aging. These two were often linked in statements such as the following: “There is one major thing: health and not being hospitalized” (25, male, living with spouse, no home help), or in talking about the wish “to be healthy and to have all-round exercise” (18, female, living alone, receiving daily home help).

When asked about good and successful aging, interviewees did not address the absence of disease; they were, however, asked directly about their illnesses in another part of the interview.

Some interviewees, after presenting health in general as the most important issue, went on to talk about physical and mental health in more detail. An important matter raised by interviewees was continuation of sufficient health (as in the extract mentioned in the continuity theme by participant 44). At the age of 90, being healthy might most often mean feeling healthy—not being in pain—and considering one’s functional ability to be good enough. Health was seen as a means, not as a goal.

Cognitive functioning and psychological components

Cognitive functioning was as important to our interviewees as physical functioning. They regarded mental health and cognitive functioning as one of the basic elements of good aging. Absence of dementia and other cognitive problems was emphasized in many interviews. The interviewees often made comparisons with other very old people who have memory problems. The importance of keeping up to date, learning new things and having a good memory was also emphasized in interviews.

In this extract, the participant highlights the importance of cognitive over physical health.

What mostly controls it is your personal health. That determines what you can do. Or what you can receive, like information. And what you can do yourself—older people can be active as well. To wake yourself up, that's what I'd call it. But then we have these people with memory disorders; they're a sad lot. Often they’re in good physical condition, but when a family member comes to visit, they don't recognize them.

[(24, male, living in sheltered accommodation, no home help)]

Participants' responses that could be categorized as psychological components included mention of good mental health, self-acceptance and self-satisfaction, a focus on the present, a positive outlook and attitude, coping and adaptation, as well as the absence of depression. Here is a typical example.

I would say I am living a good old age. How should I put it? First of all, it’s wonderful when people can be the same as they were before; it is the basis of everything. And to have a good memory and maintain an interest in and curiosity about things.

[(8, female, living alone, no home help)]

The psychological component plays a large role in some of the models of successful aging (Bowling, 2007a, 2007b), and many studies have found evidence of its importance, even in the context of the disabilities and illnesses that are inevitable in the process of aging (Poon, Gueldner, & Sprouse, 2003; Young, Frick, & Phelan, 2009). By using psychological strategies, it is possible to experience good and successful aging, as was the case with the participants in our study.

One participant gave an example of a 100-year-old person whom he thinks is living a good old age.

I've known these people; one of them was 100 years old. He lived at the disabled veterans’ home and had such a positive outlook on life. You just have to accept things for what they are. And you live in the way you think best. It has to come from within. It might help if you don’t take it too seriously if something happens.

[(9, male, living with spouse, no home help)]

Social functioning

Most of the responses were related to some area of social functioning, which was categorized under three themes: 1) social networks, 2) social roles, and 3) recreation and entertainment.
Social networks consist of family, friends and good neighbors. In many interviews it was emphasized that being surrounded by people and having company, having a partner and a good marriage, and not being lonely are important aspects of a successful old age.

Although very few of our respondents were still married (most of them were widowed), a good marriage was often mentioned in their responses. It seems that the fact of having had a good marriage was still a source of life satisfaction. For example, here is one widow’s response to the question about good old age:

*I can say I have had such a rich life, our marriage had such a solid base... and then, of course, the best of all was when I found myself such a wonderful man.*

[(29, female, living alone, no home help)]

Neighbors were also important to social functioning, as well as representing a vital source of everyday help:

*I have such good neighbors, they are my best friends... and I could not wish for a better next-door neighbor. He clears the snow in the winter, and if I need help with anything, I can rely on him.*

[(5, male, living alone, receiving daily home help)]

When one is 90 years old, most of one’s friends have passed away. That might be one reason why respondents often emphasize the importance of having friends of all ages:

*All you can do is try to be positive and to be social, talk to people. It is terribly important to everyone and I have good friends, young ones as well.*

[(9, male, living with spouse, no home help)]

Meaningful social roles are an important aspect of a good life at any age. In the interviews, things such as taking care of one’s grandchildren or partner, helping others, being a member of an organization, and having social interactions and relationships with other people were mentioned. The ability to maintain a meaningful social life in old age and to continue previous social activities was also important:

*And to adjust to everything, and helping. I even used to be active in the trade union movement because I want to help those who are worse off. I have always been like that; I want to help the underdog.*

[(29, female, living alone, no home help)]

Grandchildren give meaning to life in old age, and even at the age of 90 some interviewees were still able to contribute by taking care of them:

*Our grandchildren—we have 11—have definitely enriched our lives in retirement. At first we had our hands full because our daughters [laughs] were quick to leave the grandkids with us, but even so, it was a blessing. And they were just the right age then. And it’s just like one grandchild said. He’s from Helsinki and was probably about five at the time. He’d spent at least a week with us again, and we had gone to Orivesi to pick mushrooms. When we were driving home, he said: “Grandpa, when I go home to Helsinki tomorrow, you will be so bored and have nothing to do.” [Laughs.] And I thought yes, that was well said.*

[(3, male, living with spouse, receiving occasional home help)]

Recreation and entertainment consisted of activities such as going out with others, having hobbies, listening to music and visiting family members.

One male participant responded to the question “What do you think constitutes a good old age?” as follows:

*The old age I’m having. Enough financial independence, average health at worst. And then good relations with my ex-family and others, to have lived in harmony. And you have some kinds of hobbies, you need to cherish them.*

[(43, male, living alone, no home help)]

Discussion

This study is based on life-story interviews with nonagenarians. The aim was to discover how the oldest old themselves see a good old age. The participants in this study were mostly living independently, had no memory disorders, and made independent decisions concerning their lives. The sample was highly selective, but we see this as a strength of the study. The respondents can be regarded as experts on successful aging. When they were asked what a good old age is, they referred to their own current lives and gave examples from them.

In our interviews we used the notion of “good” rather than “successful” aging, because “successful aging” would not have made much sense to our Finnish nonagenarian interviewees. This also seems to be a problem in many other studies on successful aging, even when the language used is English (Romo et al., 2013). Depp and Jeste (2006) state that there is no agreement about the terms in use, such as “healthy aging”, “successful aging”, “productive aging”, “active aging”, “aging well”, and so on. Another study conducted in the Nordic countries by Nygren (2006) also used the term “good aging”.

Our results partly confirm the findings of previous studies (Wiest, Schüz, & Wurm, 2013) but they also show that oldest old’s views are far more diverse and complex than any single theory or model of successful aging. Our results were in line with many earlier studies, in the sense that physical, social and psychological components were frequently mentioned by our respondents. However, some elements of these components were less emphasized in our study than in earlier studies. For example, the interviewees did not talk about the absence of disease in the context of good aging, although it is an important element in biomedical models in the field (Rowe & Kahn, 1987). Indeed, the inclusion of illness and disability in models of successful aging has been criticized, and Young et al.’s (2009) study also excluded the absence of disease. Only the absence of dementia could be seen as an important component of a successful old age (Nosraty, Sarkeala, Hervonen, & Jylha, 2012). The respondents were more focused on overall health and functional and cognitive ability as important elements. Being pain-free and able to carry out daily tasks was far more important to our respondents than not having certain diagnosed diseases.
In addition to the components already dealt with in previous studies, we also found three overarching themes, namely living circumstances, independence and death, which have rarely been included as components of successful aging. Living circumstances have been presented in many studies as a predictor, but in lay models it is a component in its own right. Living circumstances might be seen as an external factor that helps individuals compensate for losses they have experienced. Living circumstances and independence were intertwined in our respondents’ discussions. It seems that even when they were discussing living circumstances, such as having a nice home or not being institutionalized, they were referring to retaining their independence for as long as possible. Living independently and especially not in an institution was an important aspect of a sense of autonomy and self-mastery. Although the word itself was not used by our respondents, they probably felt quite “successful” to be able to live independently at the age of 90.

Death is an issue which is rarely mentioned in the context of successful aging. In our case it turned out that our respondents talked about death in the interviews primarily when asked what a good old age is. Because of their advanced age and familiarity with death, they indicated that if their current quality of life became threatened, they would wish to have a good death, preferably suddenly and without pain, in their own home. They talked of their wishes for this kind of death in combination with other issues such as retaining their autonomy (choice and control) and preserving their personality.

Independence and autonomy are important elements of quality of life in the aging process. Successful and good aging is a part of that process. If any dimension of functioning (physical, cognitive or social) worsens, interviewees would like to apply psychological mechanisms or to change their living circumstances in order to cope with that loss. If they cannot maintain their quality of life in relation to autonomy and independence in this process, then they wish for quality of death as a successful ending to their life (McCann Mortimer et al., 2008).

In line with Cosco et al.’s systematic review of lay perspectives on successful aging, the psychological component was identified in our study (Cosco et al., 2013). Our findings also included some evidence to support the model of selective optimization with compensation (Baltes, 1997). Psychosocial components emerged from our data more often than did physical components, and it seems that this is not unique to our study. The studies of the lay models that were included in Cosco et al.’s systematic review also reached the same result (Cosco et al., 2013). As Baltes & Carstensen (1996) state, a process-oriented approach considers the interplay of the gains and losses inherent in old age. Successful aging does not mean that older people are ageless; rather, it means achieving a balance between what they lose and what they gain. When interviewees spoke about the roots of their experiences of a good old age, previous life events such as marriage and employment also played a role. A successful old age is a state of being that is the result of the aging process across one’s lifespan. It should be studied simultaneously as both a state of being and a continuity in the process of aging. Continuity was brought up in many interviews directly or indirectly. Continuity was mentioned when the interviewees talked about the elements of good aging which they had had before and still have. Nevertheless, continuity was also referred to in the form of wishing to preserve positive elements of their present life in their future years of life. If good and successful aging were to be in some way threatened, the interviewees wished for a pain-free or sudden death, preferably in their own home, and without losing what is important to them until the last stage of life.

Our findings send a clear message that successful aging can be seen as a positive continuation of the aging process, and that this success can be achieved throughout one’s life course. People expect to meet the requirements of success throughout their life course, as well as experiencing it at each moment of their aging process. The final stage of the life course is death. A painless, peaceful and sudden death at home was desired by our interviewees as a successful ending to the life process.

**Conclusion**

This study captured the perceptions of a number of oldest old people who were not only successful with regard to longevity but who also felt they were living a good old age. The result of this study did not support only one theory and model of successful aging; it reflected a combination of the known models and added new meaning through presenting the last and final stage of life as a good death. According to our study, being independent and autonomous in old age is also important. Future studies should recognize age and culture differences when considering the prerequisites for good and successful aging, and more studies are needed to explore the comparison of lay perceptions of different age groups.

**Appendix I The coding process**

Transcripts (in Finnish and in English) were coded independently by two researchers. Thematic analysis with an inductive approach was used. In this appendix we provide an example of how the coding was made. The validity of the coding was checked by the fourth author, who was one of the interviewers.

**Interview No. 13**

Q: How do you see a good old age?

A: Naturally, it involves being sane and fairly pain-free. And then I hope that when the time comes, I can go easily, just fall asleep in my bed never to wake up. Very often I hope I won’t have to suffer. I have one of those papers saying that I can’t be kept alive against my will if I’m dying. Summers are pretty nice, but winter is another thing. In the summer, I can spend time outside, chatting with my neighbors, so I have company. But winter is difficult, when you can’t do that. Last winter was especially hard because I couldn’t go out for weeks, what with the weather. But I’ve been… I have a pretty good hip and at least I can go outside. And I use a walker outside, and I always keep my walker next to my bed at night so I won’t fall.

… (in the context of talking about how the world has changed)

A: It is horrible when you turn 90. Why do people have to live so long? But there are some 114-year-olds, it is impossible. I don’t understand. I just hope for a clean end. The worst would be to wither away, with other people turning you over in your bed.
References


ABSTRACT

Objective: To discover whether successful aging, understood as a multidimensional concept, predicts further survival in very old people. Method: The population sample consisted of 1,370 persons aged 90 or over in the Vitality 90+ study. Four alternative models of successful aging were constructed, each of them consisting of physical, psychological, and social dimensions. Mortality was followed up after 4 and 7 years. Results: Three out of four models significantly predicted survival at both follow-ups for the whole group. Separately, “success” in the physical, psychological, and social components was also associated with higher survival. The associations were stronger in women than in men. Discussion: Successful aging, measured using physical, psychological, and social dimensions, predicts the length of future life in nonagenarians.

KEYWORDS

survival, nonagenarians, longevity, health, well-being
INTRODUCTION

With increasing longevity, societies face a new challenge in terms of the quality of old age. One of the major topics in discussions and empiric research on this theme is “successful aging,” a concept used as early as the beginning of the 1960s. Havighurst (1961) and Neugarten (1972) emphasized the role of social and psychological dimensions such as maintenance of activity, life satisfaction, positive self-concept, and ability to adapt as major elements of successful aging, while Rowe and Kahn (1997) defined it as absence of disease and disability, maintained physical and mental functioning, and active engagement with life. Since then, researchers have discussed whether “success” in aging should be understood in absolute measures or as a relative advantage within one’s own age group and whether it should best be measured by external criteria set by researchers or mainly defined and evaluated by old people themselves. Most often, successful aging has been operationalized in terms of physical, cognitive, or functional status (Depp & Jeste, 2006; Phelan & Larson, 2002; Strawbridge, Cohen, Shema, & Kaplan, 1996), and in many papers on successful aging, only one dimension or one single indicator has been used. Recent discussions, again, have emphasized multidimensional approaches and the role of social engagement and adaptation, creating the potential to age “successfully” even with chronic disease and other health problems (Pruchno & Wilson-Genderson, 2012; Young, Frick, & Phelan, 2009).

Very old people—nonagenarians and centenarians—constitute a special group in research on successful aging. They obviously meet one important criterion of success, longevity; but studies with representative population samples show that in medical terms, they can hardly be regarded as healthy (Andersen-Ranberg, Schroll, & Jeune, 2001; Tiainen, Luukkaala, Hervonen, & Jylhä, 2013). In the Georgian Centenarian Study (Cho, Martin, & Poon, 2012), 15% of octogenarians but none of the centenarians were considered “successful” according to the Rowe and Kahn (1997) criteria, but when subjective health, perceived economic status, and happiness were considered as an alternative model, 62% of octogenarians and 48% of centenarians were successful.

In our earlier work, we have examined the prevalence of and factors associated with successful aging in a representative population sample of nonagenarians (Nosraty, Sarkeala, Hervonen, & Jylhä, 2012). Following Rowe and Kahn (1997) and Young et al. (2009), we defined successful aging as consisting of physical, psychological, and
social components. We constructed six different models as different combinations of variables describing these components. The prevalence varied from 1.6% in the most demanding model (which required, for example, the absence of all diseases and full independence in functioning) to 18.3% (in the model that allowed diseases other than dementia and did not include the psychological component [PsC]; Nosraty et al., 2012). The aim of this study was to investigate whether successful aging, a descriptor of a good quality of life, also predicts the length of future life in very old people. Over the past two or three decades, the probability of surviving until the age of 90 and life expectancy at the age of 90 have both increased rapidly. It is fair to say that today’s nonagenarians not only have a past but also a future. Survivors aged 90 or older are not a homogeneous group even in respect to mortality, and it is not clear whether their mortality and survival are predicted by the same indicators as younger age groups. It has been suggested that mortality in this age group is a stochastic process rather than being predicted by specific risk factors (Poon et al., 2000). Other studies, however, have revealed that mortality at the age of 90 or above is predicted by health and physical functioning (Allard, Robine, & Henon, 2000; Martelin, Koskinen, & Valkonen, 1998; Nybo et al., 2003; Tiainen et al., 2013), self-rated health (Vuorisalmi, Luukkaala, Hervonen, & Jylhä, 2011), comorbidity (Formiga et al., 2011), and cognitive functioning (Negash et al., 2011), which are known to be associated with mortality in younger old age and are usually understood as components of successful aging.

Less is known about the role of social and psychological factors. Yasuda et al. (1997) and Sun and Liu (2006) found that, among people aged 80 and above in China, both solitary and social activities were associated with lower mortality, and the effect of customary solitary activities such as doing house-work and gardening, or reading newspapers and watching TV, remained significant even when physical and cognitive status and physical exercise were controlled for. The role of social contacts is more controversial. Yasuda et al. (1997) found that contacts with children, friends, and group organizations were associated with lower mortality among women aged 75 years or above.

In a Swedish study with people aged 77 or older, both contacts with friends and solitary activities predicted lower mortality, but after controlling for health and education, only solitary activities remained significant (Lennartsson & Silverstein, 2001). For social contacts or social activity, we found no studies focusing especially on nonagenarians or centenarians.
There are also hardly any studies that investigate the role of multidimensional successful aging in connection with mortality in very old people. If we take the importance of the multidimensional character of “success” seriously, assuming that different dimensions together produce something greater than their parts, and that different dimensions can compensate for each other in producing a good old age, better understanding is needed about the role of multidimensional successful aging in the survival of long-lived persons. In this study, we investigated the association of successful aging (represented by four different models) and its physical, social, and psychological components with mortality at 4 years (1,461 days) and 7 years (2,525 days) among nonagenarians.

Data and Method

Data Sources

The Vitality 90+ study is a population-based multidisciplinary research program on nonagenarians in the city of Tampere, Finland (Jylhä, Enroth, & Luukkaala, 2013; Jylhä & Hervonen, 1999). In this program, mailed surveys were carried out with all community-dwelling people aged 90+ in 1996 and 1998 and with all people aged 90+, irrespective of where they lived, on four occasions since 2001. The present study used the data from the mailed surveys in 2001 and 2003. Names, addresses, and places of residence of the target population were drawn from the Tampere City Population Register.

Dates of death were received from the Finnish Population Register on the basis of unique personal identity code of each inhabitant in Finland. Informed consent was obtained from all respondents or their legal representatives. The research protocol was approved by the City of Tampere Ethics Committee.

Participants

For this study, data from two Vitality 90+ cross-sectional mailed surveys (2001 and 2003) were combined to increase the number of participants. In the original surveys, the number of participants was 892 in 2001 and 963 in 2003; the response rates were
79% and 86%, respectively. The questionnaires were identical in both years. As all
the inhabitants of Tampere aged 90 or over were included in each study year, there
were 485 participants who answered the questionnaire both in 2001 and 2003. To
avoid duplication, the participants were included in the present analysis only in the
year when they entered the study. This resulted in 1,370 participants, and this is the
sample analyzed in this study.

Due to the high rate of physical and mental health problems in the oldest group, not
all participants were able to answer the questions themselves, and proxy respondents
were needed. Altogether 21.3% of the questionnaires were answered by the proxies:
6.7% were answered by family members or other relatives, 14.1% by staff at nursing
homes or hospitals, and 0.5% by home care staff. An additional 6% received help
with reading the questions or recording the answers, but the participants chose the
answers themselves; they were therefore included in the self-response group.

Measures of Successful Aging

Our indicator of successful aging included three components: physical,
psychological, and social. The components were the same as in our earlier study
(Nosraty et al., 2012), but as not all the variables used were available in the 2001 and
2003 data, the physical dimension and the psychological dimension are not exactly
identical with the earlier cross-sectional study.

Physical component. Two elements, diseases and functioning, were considered for
measuring the physical component (PhC). The participants were asked whether they
had been told by the doctor that they had a heart problem, stroke, circulatory
problems in the brain, diabetes, arthritis, Parkinson’s disease, hip fracture, or
dementia or memory problems. For functional ability, the participants were asked
whether they were able to move about indoors, walk 400 m, use stairs, get into and
out of bed, and dress and undress. The response options were (1) yes, without
difficulty; (2) yes, with difficulty; (3) only with help; and (4) not at all; and those
measures were categorized as independent (1+2) and dependent (3+4). Moving
about indoors, getting in and out of bed, and dressing and undressing were
considered less demanding activities than walking 400 m and using stairs.
We constructed four different alternatives for the PhC as follows:

**PhC 1:** Absence of disease, independent in all five functional activities

**PhC 2:** Fewer than three diseases, absence of dementia, independent in three less demanding activities (getting in and out of bed, dressing and undressing, and moving about indoors)

**PhC 3:** Absence of dementia, independent in five functional activities

**PhC 4:** Absence of dementia, independent in three less demanding activities

**Psychological component.** The PsC was measured by three variables. Participants were asked whether the doctor had told them that they had depression or depressive feelings (yes/no). Self-rated health was the second variable included in the PsC. Self-rated health represents an individual’s subjective perception of his or her overall health. The cognitive process of selection of information and interpretation of meanings has a strong psychological dimension, reflecting the psychological characteristics and disposition of the individual (Huisman & Deeg, 2010; Jylhä, 2009). Several studies imply that with higher age, the association of self-rated health with disease and functioning weakens and the importance of the psychological factors increase (Galen-kamp et al., 2013). Therefore, it is justified to include self-rated health in the PsC of successful aging. For the analyses, self-rated health was categorized as good (very good or fairly good or average) or poor (fairly poor or poor).

The participants were also asked whether they thought it is good for people to live to be 100 years old (yes/no). This was used as an indirect measure of their satisfaction and zest for life, as a direct question was considered potentially sensitive.

As self-rated health and the opinion about living up to 100 invited genuinely subjective evaluations without a defined standard, we did not accept proxy answers for these questions. In cases of proxy respondents (21.3%), the answers for these two questions were coded as missing.

However, we did not want to exclude these cases from the mortality analysis, as this would mean losing the most frail participants and result in misleading findings. We therefore coded the missing values (proxy respondents) for these two questions as
“not successful” if these participants did not meet the criteria of “success” in either the social component (SC) or the PhC, because they would in any case be categorized as “non-successful” agers. We constructed two versions of the PsC, one including the variable on the willingness to live up to 100 and another without it. Thus, in the two different versions of the PsCs, “success” was defined as follows:

PsC 1: Absence of depressiveness, self-rated health average or better, willing to live up to 100 years

PsC 2: Absence of depressiveness, self-rated health average or better

Social component. For the SC, two questions were considered: the frequency of meetings with children (six categories from today or yesterday to several years ago) and the frequency of talking on the phone with family members or friends (six categories from today or yesterday to several years ago). More than one quarter (26.2%) of the respondents had no children. If these participants had had telephone contacts during the past week, we included them in the same category as people who had had contacts with children. In the SC, “success” was defined as having met one’s children and having talked on the phone with family members or friends during the past 2 weeks.

Models of Successful Aging

For our analyses, we constructed four models of successful aging combining the three dimensions, following the criteria used in Rowe and Kahn (1997) and Young et al. (2009). As there is no ideal model for measuring successful aging, we defined four alternative criteria for “success.” All of the models included PhC, PsC, and SC, but they varied in detail.

Model 1: Absence of diseases including dementia and independence in all five activities (PhC 1) plus absence of depressiveness, average or better self-rated health, and agreement that it is good to live to be 100 (PsC 1), plus met children during past 2 weeks and phone contact during the past week (SC).

Model 2: Fewer than three diseases, absence of dementia, independence in three less demanding activities (PhC 2) plus absence of depressiveness, self-rated health
average or better, agreement that it is good to live to be 100 (PsC 1), plus met children during past 2 weeks and phone contacts during past week (SC).

**Model 3:** Absence of dementia and independence in five activities (PhC 3) plus absence of depressiveness, self-rated health average or better, agreement that it is good to live to be 100 (PsC 1), plus met children during past 2 weeks and phone contacts during past week (SC).

**Model 4:** Fewer than three diseases, no dementia, independence in three less demanding activities (PhC 4) plus absence of depressiveness, self-rated health average or better (PsC 2) plus phone contacts and met children during past 2 weeks (SC).

All these models followed same lines of theoretical thinking, including the same three components, but the variables describing these three components differed to some extent, reflecting the different levels of criteria for successful aging. The main difference between the first three models was in the PhC, which was the most demanding in Model 1 and the least demanding in Model 3. In Model 4, the PsC differed from the others in that it did not include agreement with the statement that it is good to live to be 100. Among the 1,370 participants, the number of “successful agers” varied, with 30 in Model 1, 70 in Model 2, 90 in Model 3, and 385 in Model 4. The frequency was lower for models that included more demanding criteria for success and higher for those where the demands were lower.

**Analysis**

Frequencies and percentage of variables in each model of successful aging at baseline are reported for men and women and for the whole sample. Survival among successful and non-successful agers in the 4- and 7-year follow-up periods was compared using the chi-square test. Cox proportional hazard models adjusted for age and gender were applied to explore the association of successful aging and its components with mortality. Hazard ratios (HR) with 95% confidence intervals (CI) were calculated. The confidence interval or P (CI/P) value function was used to evaluate the quantitative measurement of data graphically for significance testing (Rothman, Johnson, & Sugano, 1999) in Model 1.
Sensitivity analysis was used to assess whether the inclusion of proxy respondents with the PsC coded as missing influenced the result of the Cox proportional hazard analysis compared with models where proxy respondents were excluded. We found that the replacement did not essentially change the association of the successful aging models or PsC with mortality. All analyses were performed using SPSS 19 statistical software.

Results

Most of the participants (91.6%) were 90 to 94 years old. While the age range of the participants was 90 to 106, median age was 91. One fifth of participants were men. Proxy responses were obtained from 21.3% of the participants. More than half of the participants lived in a private home, men more often than women. Mortality was high (Table 1): Survival after 4 years was 36.4% (32.6% of men and 37.4% of women) and after 7 years, it was 16.1% (12.7% of men and 17% of women).

The percentage and frequency of successful aging according to four models and components of successful aging in men and women are shown in Table 1. The prevalence of successful aging varied according to model. Of the 1,370 participants, 2.2% (n = 30) were successful agers according to Model 1 (the most demanding model) and 28.2% (n = 385) according to Model 4. Successful aging was more common in men than women in all models, and differences were significant for Models 2 and 3. The success rate according to PhC varied from 9.9% to 49.7%. The success rate was higher for social than for the two versions of PsCs (78.1% compared with 25.4% and 51.4%). Both PhC and PsC showed higher success for men than women.

Table 2 presents the percentage of survivors in the successful and non-successful groups after 4 years and 7 years. At the 4-year follow-up, the percentage of survivors was higher for successful than for non-successful agers of both genders according to all models; the difference was significant in the total group and for women in Models 2 to 4, and for men in Model 4. At the 7-year follow-up, the same pattern was seen—higher survival for successful agers than non-successful agers—but the difference was significant only for the total group and for the women in Model 4. Regarding the components of successful aging, in the total group and in women, all the components were predictive of mortality in both follow-ups. In men, PhCs 2
and 3 and PsC 2 predicted mortality in both follow-ups, but PsC 1 was not significant in either follow-ups. The other components showed at least a borderline association in the shorter follow-up but not in the longer follow-up.

Table 1. Frequency (%) of Three Components of Successful Aging and Four Different Models of Successful Aging in Men and Women.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men n=219-274</th>
<th>Women n=922-1084</th>
<th>All n=1177-1370</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years, mean)</td>
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<td>91.8</td>
<td>91.8</td>
<td>.01</td>
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<td>Proxy answers</td>
<td>15.3</td>
<td>22.8</td>
<td>21.3</td>
<td>.01</td>
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<td>Living at private home</td>
<td>67.6</td>
<td>53.2</td>
<td>56.1</td>
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<td>Alive 1461 days (4-year follow-up)</td>
<td>32.6</td>
<td>37.4</td>
<td>36.4</td>
<td>.14</td>
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<tr>
<td>Alive 2525 days (7-year follow-up)</td>
<td>12.7</td>
<td>17.0</td>
<td>16.1</td>
<td>.08</td>
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<tr>
<td>Successful aging according to different models</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Successful</td>
<td>3.3</td>
<td>1.9</td>
<td>2.2</td>
<td>.17</td>
</tr>
<tr>
<td>Not successful</td>
<td>96.7</td>
<td>98.1</td>
<td>97.8</td>
<td></td>
</tr>
<tr>
<td>Model 2</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>Successful</td>
<td>7.7</td>
<td>4.5</td>
<td>5.1</td>
<td>.03</td>
</tr>
<tr>
<td>Not successful</td>
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<td>95.5</td>
<td>94.1</td>
<td></td>
</tr>
<tr>
<td>Model 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Successful</td>
<td>9.5</td>
<td>5.9</td>
<td>6.6</td>
<td>.03</td>
</tr>
<tr>
<td>Not successful</td>
<td>91.5</td>
<td>94.1</td>
<td>93.4</td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td></td>
<td></td>
<td></td>
<td>.01</td>
</tr>
<tr>
<td>Successful</td>
<td>30.9</td>
<td>27.5</td>
<td>28.2</td>
<td>.26</td>
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<tr>
<td>Not successful</td>
<td>69.1</td>
<td>72.5</td>
<td>71.8</td>
<td></td>
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<tr>
<td>PhC Independent in five activitiesa</td>
<td>61.3</td>
<td>39.7</td>
<td>44.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Independent in three less demanding activitiesa</td>
<td>81.3</td>
<td>71.1</td>
<td>73.1</td>
<td>.01</td>
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<tr>
<td>No dementia</td>
<td>60.9</td>
<td>57.4</td>
<td>58.1</td>
<td>.29</td>
</tr>
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<td>No disease</td>
<td>16.7</td>
<td>10.3</td>
<td>11.6</td>
<td>.01</td>
</tr>
<tr>
<td>Less than three diseases</td>
<td>61.7</td>
<td>48.8</td>
<td>51.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PhC 1: No disease, independent in five functional activities</td>
<td>15.0</td>
<td>8.6</td>
<td>9.9</td>
<td>.01</td>
</tr>
<tr>
<td>PhC 2: Less than three diseases, no dementia, independent in three less demanding activities</td>
<td>52.5</td>
<td>41.3</td>
<td>43.6</td>
<td>.01</td>
</tr>
<tr>
<td>PhC 3: No dementia, independent in five functional activities</td>
<td>43.4</td>
<td>28.0</td>
<td>31.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PhC 4: No dementia, independent in three less demanding activities</td>
<td>55.9</td>
<td>48.1</td>
<td>49.7</td>
<td>.02</td>
</tr>
<tr>
<td>PsC No depressiveness</td>
<td>78.1</td>
<td>75.8</td>
<td>76.2</td>
<td>.42</td>
</tr>
<tr>
<td>Self-rated health average or betterb</td>
<td>82.8</td>
<td>79.0</td>
<td>79.8</td>
<td>.21</td>
</tr>
<tr>
<td>Willing to live to 100 years</td>
<td>42.7</td>
<td>30.5</td>
<td>33.4</td>
<td>.01</td>
</tr>
<tr>
<td>PsC 1: No depressiveness, self-rated health average or better, willing to live to 100 years</td>
<td>12.1</td>
<td>6.8</td>
<td>7.9</td>
<td>.01</td>
</tr>
<tr>
<td>PsC 2: No depressiveness, self-rated health average or better</td>
<td>57.3</td>
<td>50.0</td>
<td>51.4</td>
<td>.03</td>
</tr>
<tr>
<td>SC Meet children during last 2 weeks</td>
<td>87.9</td>
<td>87.5</td>
<td>87.6</td>
<td>.88</td>
</tr>
<tr>
<td>Phone contacts</td>
<td>82.6</td>
<td>81.1</td>
<td>81.4</td>
<td>.56</td>
</tr>
<tr>
<td>SC Phone contacts, met children during past 2 weeks</td>
<td>77.2</td>
<td>78.3</td>
<td>78.1</td>
<td>.70</td>
</tr>
</tbody>
</table>

* Men vs. women for the p values

Note. PhC = physical component; PsC = psychological component; SC = social component.
Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 2: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 3: No dementia, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, + phone contacts, met children during past 2 weeks.

Due to the high percentage of proxy responses and high percentage of missing values, the number of respondents is low (self-rated health, n = 1,052; willing to live up to 100 years, n = 844).

Cox proportional hazard models were applied to examine the association between successful aging and mortality separately for men and women, adjusted for age, and for the total sample, adjusted for age and gender (Table 3). All models of successful aging apart from Model 1 significantly predicted higher survival at both follow-ups for the total group and for women. Model 4 was the strongest predictor of survival in all groups. With Models 2 and 3, significant associations were found for women but not for men.

Success in each of the three components of successful aging—the psychological, the social, and the physical—was associated with lower mortality at the 4-year and the 7-year follow-up in the total study group and in women. In men, PsC 1, which included willingness to live up to 100, and PhC 1, which emphasized the absence of disease, were not significant predictors of mortality. The SC did not predict survival for men at either follow-up (Table 3).
Table 2. Percentage of Survivors at 4- and 7-Years Follow-Up According to Each Model of Successful Aging and Their Components in Both Genders Separately and for All Participants Together.

<table>
<thead>
<tr>
<th>Model 1*</th>
<th>Successful agers</th>
<th>Non-successful agers</th>
<th>P value</th>
<th>Alive at 4-year follow-up (%)</th>
<th>Alive at 7-year follow-up (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>All</td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Model 1a</td>
<td>44.4</td>
<td>47.6</td>
<td>46.7</td>
<td>22.2</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>32.1</td>
<td>37.2</td>
<td>36.2</td>
<td>12.1</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>.44</td>
<td>.33</td>
<td>.24</td>
<td>.36</td>
<td>.81</td>
</tr>
<tr>
<td>Model 2a</td>
<td>38.1</td>
<td>59.2</td>
<td>52.9</td>
<td>14.3</td>
<td>24.5</td>
</tr>
<tr>
<td></td>
<td>34.0</td>
<td>39.0</td>
<td>38.0</td>
<td>12.3</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>.70</td>
<td>.01</td>
<td>.02</td>
<td>.79</td>
<td>.16</td>
</tr>
<tr>
<td>Model 3a</td>
<td>38.5</td>
<td>66.3</td>
<td>51.1</td>
<td>15.4</td>
<td>25.0</td>
</tr>
<tr>
<td></td>
<td>33.5</td>
<td>39.3</td>
<td>38.1</td>
<td>12.1</td>
<td>16.6</td>
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<td>.61</td>
<td>.01</td>
<td>.02</td>
<td>.63</td>
<td>.08</td>
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<td>Model 4a</td>
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<td>53.0</td>
<td>48.5</td>
<td>14.1</td>
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<td>&lt;.001</td>
<td>.64</td>
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<tr>
<td>PhC 1a</td>
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<td>12.5</td>
<td>30.0</td>
</tr>
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<td></td>
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<td>27.0</td>
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<td>&lt;.001</td>
<td>&lt;.01</td>
<td>.01</td>
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<tr>
<td>PhC 3a</td>
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<td>48.9</td>
<td>47.7</td>
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<td>&lt;.001</td>
<td>&lt;.01</td>
<td>.03</td>
<td>&lt;.001</td>
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<tr>
<td>PhC 4a</td>
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<td>48.5</td>
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<td>26.8</td>
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<td>11.4</td>
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<td>&lt;.001</td>
<td>.12</td>
<td>&lt;.001</td>
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<tr>
<td>PsC 1a</td>
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<td>27.5</td>
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<td></td>
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<td>.01</td>
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<td>.01</td>
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<tr>
<td>PsC 2a</td>
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<td>0.51</td>
<td>0.01</td>
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</table>

*Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 2: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 3: No dementia, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better + phone contacts, met children during past 2 weeks. PhC 1: No disease, independent in five functional activities. PhC 2: Fewer than three diseases, no dementia, independent in three less demanding activities. PsC 1: No depressiveness, self-rated health average or better, willing to live up to 100 years. PsC 2: No depressiveness, self-rated health average or better. SC: Phone contacts, met children during past 2 weeks.

PhC = physical component; PsC = psychological component; SC = social component.

Table 3. Adjusted Cox Proportional Hazard Analysis of Four Different Models of Successful Aging and Their Components for Both Genders and All Participants Together.

<table>
<thead>
<tr>
<th>Model</th>
<th>4 years follow-up HR (95%CI)</th>
<th>7 years follow-up HR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td>Model 1</td>
<td>0.66 (0.27-1.60)</td>
<td>0.72 (0.40-1.31)</td>
</tr>
<tr>
<td>Model 2</td>
<td>0.76 (0.43-1.33)</td>
<td>0.51 (0.33-0.79)</td>
</tr>
<tr>
<td>Model 3</td>
<td>0.68 (0.41-1.14)</td>
<td>0.56 (0.38-0.82)</td>
</tr>
<tr>
<td>Model 4</td>
<td>0.49 (0.35-0.68)</td>
<td>0.54 (0.45-0.65)</td>
</tr>
<tr>
<td>PhC 1</td>
<td>0.58 (0.37-0.91)</td>
<td>0.53 (0.38-0.73)</td>
</tr>
<tr>
<td>PhC 2</td>
<td>0.39 (0.29-0.54)</td>
<td>0.52 (0.43-0.63)</td>
</tr>
<tr>
<td>PhC 3</td>
<td>0.47 (0.35-0.63)</td>
<td>0.52 (0.44-0.61)</td>
</tr>
<tr>
<td>PhC 4</td>
<td>0.48 (0.36-0.65)</td>
<td>0.53 (0.45-0.62)</td>
</tr>
<tr>
<td>PsC 1</td>
<td>0.57 (0.35-0.94)</td>
<td>0.54 (0.38-0.78)</td>
</tr>
<tr>
<td>PsC 2</td>
<td>0.75 (0.42-0.76)</td>
<td>0.52 (0.45-0.61)</td>
</tr>
<tr>
<td>SC</td>
<td>0.73 (0.51-1.05)</td>
<td>0.58 (0.48-0.69)</td>
</tr>
</tbody>
</table>

Note. All models are adjusted for age, and the models for both genders together are adjusted also for gender. Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks. Model 2: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks. Model 3: No dementia, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks. Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better + phone contacts, met children during past 2 weeks. PhC 1: No disease, independent in five functional activities. PhC 2: Fewer than three diseases, no dementia, independent in three less demanding activities. PhC 3: No dementia, independent in five functional activities. PsC 1: No depressiveness, self-rated health average or better, willing to live up to 100 years. PsC 2: No depressiveness, self-rated health average or better. SC: Phone contacts, met children during past 2 weeks. HR = hazard ratios; CI = confidence intervals; PhC = physical component; PsC = psychological component; SC = social component.
Discussion

This article studies the role of successful aging in predicting mortality and survival in a representative population sample of 1,370 nonagenarians during follow-up periods of 4 and 7 years. In literature, the models of successful aging vary, but most of them include a physical or health component, a cognitive or psychological component, and a SC. In our data, we generated four models that all included the three dimensions but used different criteria for “success” in the PhC and PsC. We found that three out of the four models of successful aging were able to predict survival at both follow-ups. Only Model 1, the most demanding model where the PhC required absence of disease and independence in functioning, was not a significant predictor.

Why, then, did the people with very good health not show better survival than others? The result could be interpreted in two different ways. First, as Model 1 picks up only a very elite group for the category of “success,” a significant number of reasonably healthy and highly functioning people are relegated to the “non-successful” group. For example, according to Model 1, those who had arthritis as their only diagnosis, or those who only needed help in using stairs, belonged to the group of non-successful agers. These conditions are not likely to be fatal or to be strong predictors of mortality. Thus, the demanding criteria for “success” probably dilute the differences in mortality between the successful and non-successful group. However, the demanding Model 1 distinguished a very small group (prevalence 2.2%) which may lead to incorrect interpretation of the association between successful aging and mortality. The CI/P value function graph used by Rothman (Rothman, 2012; Rothman et al., 1999) suggests that if we had a larger sample, leading to a better precision, Model 1 would also have been a significant predictor.

The gender differences also deserve a closer look. In each model, successful aging was more common among men than among women, but for both the successful and the non-successful, survival rates were somewhat higher in women than in men. In the Cox proportional hazard models, the HR for both genders implied lower mortality for those with successful aging, but the CI indicated statistical significance for men only in Model 4. The group of men, however, was rather small, as only one fifth of participants were male, which reflects the proportion of men in the basic population.
Our research also provides evidence that each component of successful aging predicted mortality in the total population at both follow-up points. In both genders and at both follow-up times, mortality was lower for those who met the criteria of the PhC and PsC of successful aging. The association of the SC, however, was significant only for women, although it also showed borderline significance for men at the 4-year follow-up. The stronger role of social relations for women is in line with Rasulo, Christensen, and Tomassini (2005), who in a Danish study demonstrated a significant association between social relations and survival only for women. As regard the psychology component, it is worth noting that the variable showing the lowest rate of success—only 33%—was the opinion that is good to live to be 100.

A major strength of our study is that it includes all individuals aged 90 and above in Tampere, irrespective of health or type of residence, and the response rate was high. In many studies of the oldest old, the most frail and institutionalized people are excluded, which necessarily leads to over-positive findings on health and functioning. To reach a high response rate in a non-selected group of very old people, it was necessary to accept proxy responses if the participants themselves were unable to answer the questions; this was the case for 21.3% of the participants. Due to high rate of physical and cognitive problems, inclusion of proxy answers is the only way to avoid serious bias in the favor of healthier part of the population (Gu, 2008; Kelfve, Thorslund, & Lennartsson, 2013; National Research Council, 2009; Rodgers & Herzog, 1992) and, in our case, to reach a realistic picture of “successful aging” in the oldest old. For proxy responses, answers were coded as missing to the questions on self-rated health and living up to 100 that invited individual subjective evaluation. These missing cases were coded as “non-successful” if they belonged to the “non-successful” group in the PhC and SC, and they were thus included in the mortality analysis. Our sample, as it was a combination of two consecutive surveys, includes slightly more people aged 90 to 91 and slightly fewer people aged 92 and older than in the 90+ population in Tampere at the time of these surveys, but the proportion of people aged 92 and above is very low in the population, too, and this is not likely to hamper the generalizability of our findings to the total population. A further advantage in the study is the long follow-up time.

People suffering from cognitive problems such as dementia were included in this study. For advanced dementia, the answers were received through a proxy. However, there were cases where the respondent herself or himself reported having a diagnosis
of dementia or having memory problems recognized by a doctor. Potentially, on this point, the good coverage of the basic population might also constitute a weakness because of potential problems in the reliability of the data. In earlier rounds of the Vitality 90+ study, Goebeler, Jylhä, and Hervonen (2007) compared dementia reported in the questionnaire (by the person himself/herself or by a proxy) with hospital records and with death certificates. They found that if proxy respondents are used for more severe cases, self-reports are reasonably reliable for those answering for themselves. Although self-reporting is not a perfect measure of memory disorders, over-reporting seemed more frequent than under-reporting. Another question is the reliability of other information given by a person with memory problems. Earlier, Walker, Maxwell, Hogan, and Ebly (2004) showed that self-reported health (SRH) was predictive of mortality in a group with mild-to-moderate cognitive decline. In the Vitality 90+ study, the analysis did not reveal specific reliability problems in answers given personally by people with reported memory problems (Jylhä et al., 2013). Today, conditions causing memory problems are often diagnosed at an early stage, allowing the patients many more years of reasonably high functioning.

Our measures of successful aging were all based on self-reports received through mailed questionnaires. Therefore, the severity of diseases in not known, and it was not possible to use measures of cognitive status, such as Mini-Mental State Examination (MMSE). This represents a clear weakness in our study. The questionnaires include both objective indicators such as disease, and subjective indicators such as opinions about living to the age of 100. The measures available for use, however, were not perfect. Given the age of the target population, the mailed questionnaire could only include a very limited number of questions, and the data collection was not planned exclusively for the objectives of this study. The variables in the PhC ere well-validated and widely used standard measures, but measures of other components were more ad hoc. For the psychology component, in addition to depression or depressiveness, self-rated health and illingness to live up to 100 were used. Self-rated health is a predictor of mortality in nonagenarians (Vuorisalmi et al., 2011) and it is considered a reliable summary measure of health status. Yet, it is known that the link between diagnosed conditions and functional status on one hand and SRH on the other hand weakens with age (Cheng, Fung, & Chan, 2007; Pinquart, 2001; Schinitiker, 2005), and toward higher age, it increasingly reflects psychological adaptation and adjustment to the present situation. For the two variables in the psychology component, missing values due to proxy respondents were replaced, but
the sensitivity analyses suggested that this did not essentially influence the results. For the SC, only two variables were available, which is a clear weakness.

Measuring successful aging can provide valuable information about the present situation and well-being of the oldest old. Our study showed that successful aging, measured as a combination of three dimensions, is also a strong predictor of the length of future life even in a population that already has lived exceptionally long. The findings also imply that not only the PhC—absence of disease and high functioning—but also the PsC and SC are associated with survival. In nonagenarians and centenarians, absence of disease is rare and may not be a very useful criterion of successful aging; a more relaxed PhC criterion also proved to be a stronger predictor of survival.

In all, our study indicates that even at the age of 90 or above, successful agers also live longer. Yet it is not clear, as our findings imply, whether long survival is what very old people themselves prefer. So the association of successful aging with survival can improve our understanding of successful aging and different ways to measure it, but it should not prevent us from seeing that the focus of successful aging in very old age should be on the quality, not the quantity, of life.

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Declaration of Conflicting Interests

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References


Successful Aging as a Predictor of Long-Term Care Among Oldest Old: The Vitality 90+ Study

Lily Nosraty¹, Jutta Pulkki¹, Jani Raitanen¹,², Linda Enroth¹, and Marja Jylhä¹

Abstract

Aim: The aim of the study was to investigate whether successful aging (SA) predicts entering long-term care (LTC) among nonagenarians. Methods: Data originated from the linkage of the Vitality 90+ Study surveys with register data from Finnish Population Register and Care Registers. Altogether 1,966 community-dwelling individuals were followed for 2 years and 1,354 individuals for 5 years. Four models of SA were constructed by varying combinations of physical, psychological, and social components. Competing risk regression analysis was used. Findings: The incidence rate for entering LTC was lower for successful agers. Three models of SA presented a significantly decreased risk for entering LTC in the whole group and in women. The impact of SA was attenuated when living alone, needing help, and the year of participation were adjusted for, but was still significant for Model 3. Conclusion: Nonagenarians who meet the multidimensional criteria of SA are less likely to enter LTC than those aging less successfully.

Keywords

cumulative incidence, institutionalization, mortality, good aging

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Long life is universally desired, and in many countries, it is achieved. The increased number of the extremely old individuals today is a result of numerous developments in the human history. Along with long life, also disadvantages appear: only few people at the age of 90 or older are entirely free of health problems and many are in need of help and care. The oldest old have more functional limitations than the young-old and old-old (Cubanski, Voris, Kitchman, Neuman, & Potetz, 2005), and are more likely to suffer from dementia and other major cognitive impairments (Jorm, Korten, & Henderson, 1987; Poon et al., 2012; Yang, Slavin, & Sachdev, 2013). Due to these problems, individuals at very old age are also the largest user group of long-term care (LTC) (Havens, 1996). The increased proportion and number of very old individuals in need for LTC, together with diminishing public resources in many countries, including Finland, have led to the introduction of new policies for the future of LTC (Pulkki et al., 2015) and a strong preference for living in the community with or without home care. To implement this policy, it is important to have a better understanding of the factors leading to LTC in the rapidly expanding group of the oldest old.

In the past two decades, numerous studies have examined the predictors for entering LTC. Many studies have recognized that physical and psychological functioning, the number of health conditions, and self-rated health and social factors are associated with LTC (Finlayson, 2002; Luppa et al., 2010; Shapiro & Tate, 1985). Cai, Salmon, and Rodgers (2009) reported in a population aged 78 years an average increased risk of admission to a nursing home with older age, lower self-reported health, worse instrumental activities of daily living (IADL), psychiatric problems, and living alone, but not with ADL. In contrast, being female and having a better cognitive function reduced the risk of admission to a nursing home. Black, Rabins, and German (1999) reported functional status and mental morbidity as the predictors of admission to nursing home. Luppa et al. (2010), in their systematic review, categorized the evidence on the predictors of institutionalization as strong, moderate, and week. They found strong evidence for lower self-reported health, ADL, LADL, cognitive impairment and dementia, and the high number of prescriptions as predictors of institutionalization. Gender, living alone, income, diseases like stroke, hypertension, arthritis, respiratory diseases, incontinence, and depression were predictors with inclusive evidence. Activity Level and the social network were predictors with moderate evidence. However, Martikainen et al. (2009) have demonstrated the importance of gender differences and living arrangement in entering institutional LTC. Cohen and Bulanda (2016) demonstrated that social support facilitates admission to nursing homes.

In many studies, all these indicators are considered as components of successful aging (Cosco, Stephan, & Brayne, 2014; Depp & Jeste, 2006). Depp
and Jeste (2006) in their systematic review explored the predictors of successful aging such as physical functioning, cognitive functioning, life satisfaction, social engagement, presence of illness, longevity, and self-rated health in previous studies. Successful aging indicators in the domain of physical and cognitive functioning are more difficult to achieve with age (Pruchno, Wilson-Genderson, & Cartwright, 2010). On the contrary, social aspects of life and psychological well-being do not necessarily decline with age. The question is, if each of those indicators alone predicts entering LTC, what is the role of multidimensional successful aging which is the combination of these indicators, as a predictor of entering LTC. However, to the best of our knowledge, there is no study to investigate the association of the multidimensional model of successful aging and entering LTC. Also, even if the oldest old are the most frequent users of LTC, not much is known about predictors of LTC in nonagenarians and centenarians.

In the influential model of Rowe and Kahn (1997), successful aging is defined as an absence of disease and disability, maintenance of physical and cognitive functioning, and active engagement with life. Obviously, these components of successful aging are likely to reduce the risk of LTC. Yet as there are hardly any individuals beyond 90 years of age without chronic conditions or impairments, the Kahn and Row definition seems to exclude from successful aging the individuals who have managed to live a long life. This implies a need to reexamine and renegotiate the understanding and the definition of success and good old age as Wahl, Deeg, and Litwin (2016) have pointed out. Several researchers have suggested that the concept of successful aging should also be expanded to be applicable to people with some disabilities and even to those living in institutions (Ramage-Morin, 2006; Reker, 2002). Young, Frick, and Phelan (2009) suggested a multidisciplinary model with physical, sociological and psychological dimensions, arguing that each of them is important, but they can compensate each other, so that old age can be good and successful even when accompanied by disease and functional limitations. In our earlier studies, we have explored the usefulness of different models, all including physical, psychological, and social components but different criteria of “success,” as indicators of successful aging and as predictors of mortality in nonagenarians (Nosraty, Enroth, Raitanen, Hervonen & Jylhä, 2015).

The aim of this study is to investigate whether successful old age, defined as a combination of physical, psychological, and social dimensions, also means avoidance or delay of the need for LTC. More specifically, we will examine whether successful aging is associated with entering LTC in a short and long follow-up period among the oldest old. For measuring successful aging, we use an application of the model by Young et al. (2009). As the threshold of “success”
has not been defined by any study, we applied four models of successful aging, ranging from less demanding to more demanding, as predictors of entering LTC. Our goal is not to define an overall best model for measuring successful aging in nonagenarians. Rather, we aim to explore different models and their usefulness as predictors on LTC in a very old population.

Data and Method

Data

This study combined mailed surveys in the Vitality 90+ Study with register data from the Finnish Population Register and care registers; Care Register for Health Care, and Care Register for Social Welfare.

The Vitality 90+ Study is a population-based multidisciplinary research program on nonagenarians in the city of Tampere, Finland (Jylhä, Enroth, & Luukkaala, 2013). Since 2001, mailed surveys were carried out with all people aged 90+, irrespective of where they lived, on five occasions. Informed consent was obtained from participants or their proxies. The ethics committee of the city of Tampere or the ethics committee of the Pirkanmaa Hospital District, depending on the study year, approved the Vitality 90+ Study. The well-being and health-related information in this study comes from those surveys in 2001, 2003, 2007, and 2010.

Information about entering LTC was obtained from the above-mentioned care registers which are a unique, reliable, and accurate source of information with nationwide coverage. Dates of death were received from Statistics Finland which obtained that information from the Finnish Population Register. The linkage of these data was carried out by the National Institute for Health and Welfare. For this linkage, the unique personal identity code which is assigned to all national residents was used. Before the analysis, the personal identification codes were removed from the data, to maintain the confidentiality of the data. The permission for using the register data was granted by the National Institute for Health and Welfare.

Subjects

In the Vitality 90+ Study, surveys were mailed to all the inhabitants in Tampere aged 90 or over in each study year. The number of participants was 892 in 2001, 963 in 2003, 944 in 2007, and 1,277 in 2010, and the response rates were 79%, 86%, 82%, and 80%, respectively. For this study, data from these mailed surveys (2001, 2003, 2007, and 2010) were combined to increase the number of participants. The participants were included in the analysis in
the year when they entered the study, and this was the year when the successful aging was measured (baseline). The surviving participants in the Vitality 90+ Study responded in more than one study year, but only the baseline measure in the first year of their participation was included in our analyses. This resulted in 2,862 subjects. Only people who lived in the community at the baseline (1,966 subjects) were included in the follow-up analyses for entering LTC and mortality. The common closing date for the follow-up was the beginning of January 2013. The maximum follow-up time for the 2001 survey was 11.6 years, but for the 2010 survey less than 3 years. Therefore, we used all four surveys \( n = 1,966 \) to follow participants for 2 years and the first three surveys \( n = 1,354 \) for the 5-year follow-up. The proportion of proxy responses in the final community living study group was 4.1%.

**Dependent Variable**

The main outcome variable was entering LTC. LTC is defined as the care provided over a continued period of time for a person who is unable to self-care (Finlayson, 2002). We specified LTC similar to Martikainen et al. (2009) as care in a residential home, sheltered housing with 24-hr assistance, or health center inpatient ward residence for at least 90 days, either in the same care setting or different settings, but without interruptions such as stays at home. Hospitals other than health center inpatient wards were defined as LTC in cases where the subject moved from the hospital to a residential home, sheltered housing, or health center inpatient ward immediately without interruptions, and the period of care together lasted at least 90 days.

As mortality in this age group is high, ignoring it could result in misleading findings on predictors of LTC. Therefore, mortality was considered a competing independent outcome for LTC, and was taken into account in the analyses.

**Independent Variables**

Demographic characteristics and living conditions: gender, living circumstances (living alone), needing help, and the year of baseline survey were included in the analysis as independent variables.

The mailed surveys included a question concerning the respondent’s living condition as living alone or not. Also the participants were asked whether someone was helping them at home for dressing, washing, or cooking. The options were (a) yes approximately every day; (b) yes, sometimes; (c) I do not receive help even though I would need it; and (d) I do not need help, I am doing the housework by myself. This response was categorized as a dichotomous variable *yes* \( (1 + 2) \) and *no* \( (3 + 4) \).
Table 1. Four Models of Successful Aging and Their Components.

<table>
<thead>
<tr>
<th>Components of successful aging</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhC 1 (Physical Component 1)</td>
<td></td>
<td></td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Absence of diseases (including dementia) + independence in all five functional activities</td>
<td></td>
<td></td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>PhC 2 (Physical Component 2)</td>
<td></td>
<td></td>
<td></td>
<td>■</td>
</tr>
<tr>
<td>Less than three diseases + absence of dementia + independence in three less demanding activities</td>
<td></td>
<td></td>
<td></td>
<td>■</td>
</tr>
<tr>
<td>PsC 1 (Psychological Component 1)</td>
<td></td>
<td>■</td>
<td></td>
<td>■</td>
</tr>
<tr>
<td>Absence of depressiveness + self-rated health as good + agreement that it is good to live to be 100</td>
<td></td>
<td>■</td>
<td></td>
<td>■</td>
</tr>
<tr>
<td>PsC 2 (Psychological Component 2)</td>
<td></td>
<td></td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Absence of depressiveness + self-rated health as good</td>
<td></td>
<td></td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>SC (social component)</td>
<td></td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Phone contacts during the past week + met children during the past two weeks</td>
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</table>

Measures of Successful Aging

In research literature, there is no standard measure for successful aging, and little understanding of the applicability of the existing models to the very old populations. Our concept of successful aging is in line with Young et al. (2009), suggesting that successful aging is possible also in the presence of disease and disabilities, if social and psychological compensatory mechanisms are used. Similar to our previous studies (Nosraty et al., 2015), we explored four alternative models of successful aging, all consisting of three components—physical, psychological, and social—following the criteria used in Rowe and Kahn (1997), Young et al. (2009), and Nosraty, Sarkeala, Hervonen, and Jylha (2012). All the models were based on the same theoretical understanding, but they varied in detail, and particularly in the criteria of “success” (Table 1). The choice of the individual variables was influenced by the fact that the Vitality 90+ Study was not originally planned as a study on successful aging. Yet the variables cover the three dimensions and largely include measures previously used in indicators of successful aging.
Physical component (PhC). Diseases and functioning were considered when measuring the PhC. Self-reported diseases, heart disease, stroke, circulatory problems in the brain, diabetes, arthritis, Parkinson’s disease, hip fracture, and dementia or memory problems, were the first element of PhC. Functional ability measured the ability to move about indoors, walk 400 meters, use the stairs, get in and out of bed, and dress and undress. The responses were categorized as independent (Yes, without or with difficulties), and dependent (Only with help, and not at all). Among the five activities, walking 400 m and using the stairs were considered more demanding than the other three activities and, as such, they were used only in the most demanding PhC 1.

Two alternatives for PhCs were constructed, the first being more demanding than the second:

PhC 1: Absence of disease and independence in all five functional activities
PhC 2: Less than three diseases, absence of dementia, independent in three less demanding activities (getting in and out of the bed, dressing and undressing, and moving about indoors)

Psychological component (PsC). PsC included three elements: (a) self-reported physician-diagnosed depression or depressive feelings, (b) self-rated health, and (c) the respondent’s opinion regarding the desirability of living up to 100 years. Depression, in many studies, is one of the elements measuring successful aging (Depp & Jeste, 2006). Self-rated health measures an individual’s subjective perception of her or his health. It is considered a measure of health, but also one reflecting the psychological characteristics and disposition of the individual (Huisman & Deeg, 2010; Jylhä, 2009). With higher age, self-rated health is increasingly likely to reflect adaptation to declining health, rather than the level of health as such (Galenkamp, Braam, Huisman, & Deeg, 2013). We dichotomized self-rated health as good (very good, fairly good, and average) and poor (fairly poor and poor). We also asked the respondents, whether they thought it is good for people to live up to 100 years. Because of its potential sensitivity, the question referred to people in general rather than the willingness of the participant him- or herself to live up to 100 years. The dichotomous response (yes/no) was used as an indirect measure of zest for life and life satisfaction (Glasberg, Pellfolk, & Fagerström, 2014), one of the most frequently used components of successful aging (Depp & Jeste, 2006). Self-rated health and the opinion about living up to 100 years were asked only when the respondent him- or herself answered the questions. For proxy answers, we replaced missing data with “poor” for self-related health, and “no” for the opinion regarding living up to 100 years. By this imputation, we
avoided the missing cases in the analysis. Proxies represented participants with health and functional problems who were not able to answer to the questionnaire by themselves. Therefore, replacement did not change the number of successful agers in the data.

Two versions of the PsC were constructed, one including the opinion about living up to 100 and another without it:

**PsC 1:** Absence of depressiveness, self-rated health as good, positive opinion on living to 100 years

**PsC 2:** Absence of depressiveness, self-rated health as good

**Social component (SC).** SC was constructed from the frequency of meetings with children and the frequency of telephone contact with family members or friends (six categories from today or yesterday to several years ago). Individuals without children were common among our respondents (26.2%). If these participants had telephone contact during the past week, we included them in the same category as people who had contact with children.

Success for these categories was defined as meeting children during the past 2 weeks and having phone contact during the past week.

**Models of Successful Aging**

The four alternative models for successful aging and their components are described in Table 1. The models differ in whether total absence of diseases and functional independence is required or not, and whether they include a positive opinion of living up to 100 years. Model 1 requires absence of all eight chronic diseases included in the survey, full functional independence, absence of depressiveness, good self-rated health, and agreement that it is good to live up to 100 years; it also includes phone contacts during the past week and meeting with children during past 2 weeks. Model 2 differs from Model 1 in that positive opinion about living up to 100 is not included. In Model 3, PsCs and SCs are similar to Model 2, but it allows two chronic conditions but not dementia, and it also allows dependence in two more demanding activities. Finally, Model 4 differs from Model 3 in that, similar to Model 2, it assumes a positive opinion to living up to 100 years. Model 3 can be regarded as a less demanding model while Model 1 seems to be the most demanding model.

**Statistical Analysis**

Percentages of four different models of successful aging and their components at the baseline were calculated for all community-dwelling participants,
and separately for men and women. These 1,966 participants (from 2001, 2003, 2007, and 2010) were followed for 2 years, and out of them, 1,354 participants (excluding the participants from the 2010 survey) were followed for up to 5 years. The follow-up time started at the index date on which each subject participated in the baseline study. Participants were followed until entering LTC or death or the end of the follow-up, whichever came first.

The incidence rate for entering LTC for successful and nonsuccessful agers and the incidence rate ratio comparing these two groups were calculated for each model of successful aging.

As mortality is high among nonagenarians, we considered death before entering LTC a competing risk. According to Gutierrez (2010), competing risk analysis generalizes standard survival analysis to cases in which subjects are exposed to more than one cause of failure. Competing risk calculates the probability of the event of interest happening before a given time, this calculation is called cumulative incidence function. The probability of an interested event is a function of both the event of interest and the competing event. The analysis estimates subhazard ratios (SHRs) and measures the effects of covariates on the cumulative incidence of an interested event. Competing risk regression was used to estimate the association between the models of successful aging and entering LTC, treating death as an independent competing risk. All competing risk analyses were adjusted for gender, living alone, needing help, and the year of the baseline survey.

We further adjusted the analyses for age, but this changed the SHRs by less than 10%. Due to the possible nonlinear relationship between age and LTC utilization reported in other studies (Wong, Elderkamp-de Groot, Polder, & van Exel, 2010), we also used the second order polynomial and the square root of age in the competing risk models, but the results did not reach statistical significance. Therefore, age was excluded from the final models.

STATA/SE 13.1 statistical software for Windows was used for analysis. Level at significance was set to 5%.

**Results**

During the 2-year follow-up period, 22.2% of the participants entered LTC and 18.8% died. Among men, 15.5% entered LTC and 24% died, and among women, the figures were 24.3% and 17.1%. During the 5-year follow-up, 40.6% entered LTC and 36.1% died. Among men, 29.8% entered LTC and 46.8% died, and among women, the figures were 43.9% and 32.7%. In women, a higher proportion entered LTC than died without entering LTC, but the opposite was true for men.
Table 2. Percentage of Successful Aging According to the Four Models and Their Components at the Baseline Among Community-Dwelling Men, Women, and Both Genders Together (%).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Men</th>
<th>Women</th>
<th>All</th>
<th>Men vs. women</th>
<th>p value (χ² test)</th>
</tr>
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<td>Proxy answers</td>
<td>4.3</td>
<td>4.1</td>
<td>4.1</td>
<td>.83</td>
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<tr>
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<td>79.0</td>
<td>71.7</td>
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<td></td>
</tr>
<tr>
<td>Needing help</td>
<td>52.24</td>
<td>52.19</td>
<td>5.20</td>
<td>.93</td>
<td></td>
</tr>
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<td>Successful aging models</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1a</td>
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<td>3.2</td>
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</tr>
<tr>
<td>Model 2b</td>
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<td>9.2</td>
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<tr>
<td>Model 3c</td>
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</tr>
<tr>
<td>Model 4d</td>
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<td>13.0</td>
<td>15.1</td>
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</tr>
<tr>
<td>Physical component (PhC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent in five activities</td>
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<td>55.3</td>
<td>59.2</td>
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<td></td>
</tr>
<tr>
<td>Independent in three less demanding activities</td>
<td>93.0</td>
<td>94.0</td>
<td>93.8</td>
<td>.42</td>
<td></td>
</tr>
<tr>
<td>No dementia</td>
<td>67.8</td>
<td>73.2</td>
<td>71.9</td>
<td>.025</td>
<td></td>
</tr>
<tr>
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<td>13.6</td>
<td>15.0</td>
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<tr>
<td>Less than three diseases</td>
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<td>82.6</td>
<td>83.8</td>
<td>.008</td>
<td></td>
</tr>
<tr>
<td>PhC 1: No disease, independent in five functional activities</td>
<td>15.3</td>
<td>9.7</td>
<td>11.0</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>PhC 2: Less than three diseases, no dementia, independent in three less demanding activities</td>
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<td>58.5</td>
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<td></td>
<td></td>
<td></td>
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<tr>
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<td>83.2</td>
<td>83.5</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Self-rated health average or better</td>
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<td>79.6</td>
<td>80.3</td>
<td>.17</td>
<td></td>
</tr>
<tr>
<td>Willing to live to 100 years</td>
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<td>26.6</td>
<td>30.0</td>
<td>&lt;.001</td>
<td></td>
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<tr>
<td>PsC 1: No depressiveness, self-rated health average or better, willing to live to 100 years</td>
<td>34.0</td>
<td>21.5</td>
<td>24.5</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>PsC 2: No depressiveness, self-rated health average or better</td>
<td>72.0</td>
<td>69.7</td>
<td>70.3</td>
<td>.36</td>
<td></td>
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<tr>
<td>Social component (SC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Met children during past 2 weeks</td>
<td>90.1</td>
<td>94.1</td>
<td>93.1</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>Phone contacts</td>
<td>90.1</td>
<td>95.5</td>
<td>94.2</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>SC: Phone contacts, met children during past 2 weeks</td>
<td>83.8</td>
<td>92.0</td>
<td>90.1</td>
<td>&lt;.001</td>
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</table>

More than two thirds (71%) of the participants lived alone, women more often than men. Needing help did not differ between women (52.19%) and men (52.24%) (Table 2). The prevalence of successful aging varied according to the model, being 3.2% in Model 1, which was the most demanding model,
Successful aging was more common in men than women in all models, and differences were significant except in the Model 3. Table 2 shows the frequencies of successful aging and their components in the different models.

Table 3 presents the incidence rates and incidence rate ratios of entering LTC among the successful and nonsuccessful groups after 2- and 5-year follow-up periods. At both follow-up periods and among both genders, in all models, the incidence rate of entering LTC was lower among successful agers; the difference was significant in the total group and among women in

<table>
<thead>
<tr>
<th>Model 1 of successful aging&lt;sup&gt;a&lt;/sup&gt;</th>
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</thead>
<tbody>
<tr>
<td>Successful agers (incidence rate)</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Nonsuccessful agers (incidence rate)</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Incidence rate ratio</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>p value</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
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<table>
<thead>
<tr>
<th>Model 2 of successful aging&lt;sup&gt;b&lt;/sup&gt;</th>
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<tbody>
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<td>Successful agers</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Nonsuccessful agers</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Incidence rate ratio</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>p value</td>
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<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
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<td>All</td>
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<table>
<thead>
<tr>
<th>Model 3 of successful aging&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful agers</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Nonsuccessful agers</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
<tr>
<td>Incidence rate ratio</td>
</tr>
<tr>
<td>Men</td>
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<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
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<tr>
<td>p value</td>
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<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
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<table>
<thead>
<tr>
<th>Model 4 of successful aging&lt;sup&gt;d&lt;/sup&gt;</th>
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<tbody>
<tr>
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<tr>
<td>Women</td>
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<tr>
<td>All</td>
</tr>
<tr>
<td>Nonsuccessful agers</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
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<tr>
<td>All</td>
</tr>
<tr>
<td>Incidence rate ratio</td>
</tr>
<tr>
<td>Men</td>
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<tr>
<td>Women</td>
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<td>All</td>
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<tr>
<td>p value</td>
</tr>
<tr>
<td>Men</td>
</tr>
<tr>
<td>Women</td>
</tr>
<tr>
<td>All</td>
</tr>
</tbody>
</table>

Note. LTC = long-term care; SA = successful aging.

<sup>a</sup>Model 1: No disease, independent in five functional activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.

<sup>b</sup>Model 2: No disease, independent in five functional activities + no depressiveness, self-rated health average or better + phone contacts, met children during past 2 weeks.

<sup>c</sup>Model 3: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better + phone contacts, met children during past 2 weeks.

<sup>d</sup>Model 4: Fewer than three diseases, no dementia, independent in three less demanding activities + no depressiveness, self-rated health average or better, willing to live up to 100 years + phone contacts, met children during past 2 weeks.
all models, except for Model 1. If we follow them longer, the incidence rate increases. For example, according to Model 3, if we follow 100 nonsuccessful agers over a 2-year follow-up period, 17 of them will enter LTC per year, while only 10 of the successful agers will do so.

When mortality was taken into account as a competing risk, successful aging still reduced the risk of entering LTC (Table 4). Unadjusted results in Table 4 are largely similar to incidence ratios shown in Table 3. For example, in Model 3, in total population, the subhazard of entering LTC for the successful aging group is 60% of the subhazard for nonsuccessful agers. It means that being successful reduces the incidence of entering LTC by 40%. Adjustment for living arrangement, needing help, and the participation year changed the incidence risks. Still, successful agers according to Model 3 had a significantly (30%) lower risk of entering LTC than nonsuccessful agers. This was true for women and the whole study group. In men, successful aging did not protect from entering LTC: Rather, in the 5-year follow-up, even if the associations were nonsignificant, it seemed to increase the risk.

Discussion

This study examined four varied models of successful aging as predictors of entering LTC among the oldest old during 2 and 5 years, by linking Vitality 90+ data with data from national registers. As there is no gold standard definition of successful aging but the definitions vary from one study to another, we constructed four different models of successful aging with different combinations of three components. The PhCs and PsCs were generated as easy or demanding alternatives while the SC had only one option. For predicting entering LTC, we used competing risk regression to take into account the high mortality rate among the oldest old.

The results showed the higher incidence rate and risk of entering LTC for nonsuccessful agers in total population and in women. However, Model 1 was an exception. The likely explanation is that this model, with a low prevalence and very high demands for “success” distinguished a very small elite group as successful agers, leaving many participants with reasonably favorable characteristics in the “nonsuccessful” group. Therefore, the difference between these was not significant.

Comparing the results of Tables 3 and 4 revealed the agreement of two ways of measuring incidence. Table 3 presented the incidence rate and incidence rate ratio, and Table 4 used the competing risk regression to measure cumulative incidence (risk) during the total follow-up periods. The findings imply that whether mortality is taken into account or not, successful agers as
<table>
<thead>
<tr>
<th>Models of successful aging</th>
<th>2-year follow-up unadjusted SHR (95% CI)</th>
<th>5-year follow-up unadjusted SHR (95% CI)</th>
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<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1 of successful aging</td>
<td>0.58 [0.15, 2.30]</td>
<td>0.84 [0.42, 1.70]</td>
</tr>
<tr>
<td></td>
<td>1.10 [0.55, 2.22]</td>
<td>0.60 [0.31, 1.16]</td>
</tr>
<tr>
<td>Model 2 of successful aging</td>
<td>1.01 [0.46, 2.20]</td>
<td>0.56 [0.35, 0.91]</td>
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<tr>
<td></td>
<td>1.24 [0.75, 2.03]</td>
<td>0.71 [0.53, 0.96]</td>
</tr>
<tr>
<td>Model 3 of successful aging</td>
<td>0.89 [0.53, 1.49]</td>
<td>0.54 [0.43, 0.68]</td>
</tr>
<tr>
<td></td>
<td>1.10 [0.75, 1.72]</td>
<td>0.71 [0.51, 0.71]</td>
</tr>
<tr>
<td>Model 4 of successful aging</td>
<td>0.73 [0.37, 1.43]</td>
<td>0.69 [0.48, 1.01]</td>
</tr>
<tr>
<td></td>
<td>0.79 [0.60, 1.46]</td>
<td>0.75 [0.58, 0.97]</td>
</tr>
</tbody>
</table>

Note. Unadjusted and adjusted SHRs with 95% CIs from competing risk regression analysis. Men, women, and both genders together. Statistically significant (<.05) results are bolded. LTC = long-term care; SHR = subhazard ratios; CI = confidence interval.

The analyses were adjusted for living arrangements, need for help, and study year. The models for total are additionally adjusted for gender.

Components of each model are presented in the footnote of Table 3.
a total group, and successfully aging women, but not men, are less likely to enter LTC than those who do not meet the criteria of “success.” Adjustment for living arrangements, needing help, and the participation year attenuated the associations but being successful according to Model 3 still significantly decreased the risk of entering LTC. In Model 3, total absence or disease or disability was not required for “success,” but the criteria included absence of dementia and depressiveness, ability to do basic tasks such as getting in and out of bed, dressing and undressing, and the ability to move about indoors, and average or better self-rated health and social contacts. The combination of these factors was able to distinguish those who still manage, in spite of some difficulties, to practice their independency and stay at their own home.

Comparing the results for the long and short follow-up periods implies that success may become less protective over time. This may be explained by the fact that a person’s health situation changes rapidly at very old age, and during a long period of time, more changes are likely to have happened. As the number of participants differed between the two follow-up periods, we performed the competing risk regression analysis for the 2-year follow-up period with the 2010 survey participants excluded (similar participants in both follow-up periods, 1,354 participants). The results showed less precision (wider confidence interval [CI]) with small changes or no changes in SHR which were not substantial. Therefore, we reported the result with a higher number of participants for the 2-year follow-up to have better precision.

We found that the impact of successful aging on entering LTC was stronger among women than among men. During both follow-up times, entering LTC was higher than mortality for women but the opposite was true for men. Interestingly, in the longer follow-up, successful aging seemed to increase the likelihood of entering LTC among men, even if the findings were not statistically significant. In part, this could be explained by higher mortality among men. It is known that at the same level of disability, women survive longer (Tiainen, Luukkaala, Hervonen, & Jylhä, 2013). Therefore, the most likely scenario for “nonsuccessful” women is LTC, while for men, it is death, and only for men who are “successful” enough to live longer, LTC is the likely option. Furthermore, living arrangements differ between men and women. Although women, even at this high age, mostly live alone, men are more likely to live with their partner; therefore, they could stay at home and receive help until they are very frail (Oksuzyan, Juel, Vaupel, & Christensen, 2008).

This study had the unique strength of inviting all over 90-year-old people in the area to the Vitality 90+ Study and a high response rate. Comprehensive national register data, linked with the Vitality 90+ data, made it possible to investigate entering LTC in the exceptionally large number of subjects who were over 90 years old.
The methodological strength of this study is our method of analysis. Another possible method, survival analysis, treats the participants who die in the same way as the participants who lost to follow-up (censored). It means that those who die and censor remained at the same risk of entering LTC as the remaining participants. In contrast, in competing risk regression, mortality is considered informative by default. It calculates the cumulative incidence function, separating the hazard into subhazards.

A number of limitations also exist in our study. Our measures of successful aging were based on self-reports and the severity of diseases were not considered here. Yet our earlier comparisons of self-reports with hospital records in nonagenarian samples imply sufficiently high reliability of self-reported diagnoses (Goebeler, Jylhä, & Hervonen, 2007).

Because of the subjectivity in the definition of successful aging and the lack of a gold standard definition, the measures of successful aging vary between studies. The indicators that require absence of disease and disability are problematic when studying the oldest old, as very few in this group meet the criteria. These were the reasons why we introduced four different models of successful aging, all including PhCs, PsCs, and SCs, but with different criteria concerning “success.” We found that in the total group of nonagenarians and in women, three of our four models were able to predict the likelihood of entering LTC. The most robust predictor was the model which did not assume total freedom from disease or disability but did assume freedom of dementia and depression, ability to manage basic functional tasks, and relatively positive self-rated health and social contacts with other people. Our study implies that to predict entering LTC among the oldest old, models of successful aging that are able to distinguish the frail people from others, rather than “normal agers” from totally healthy and highly functional rare “elites,” are likely to prove most useful and feasible. Earlier, we found that a model with the same components is also a strong predictor of mortality (Nosraty et al., 2015).

Our findings have implications for understanding and promoting good aging. Salomon et al. (2013), in their study including 187 countries, found that with one additional year in life expectancy at birth, healthy life expectancy only increased 0.8 years. This means that both healthy and disabled life expectancies are getting longer, and that the rapidly growing older populations will be followed by growing needs for care. Therefore, it is important to identify targets for intervention in the attempts to promote independent living and delay care needs. Since its introduction in the field of gerontology, the idea of successful aging is to identify factors to prevent dependence and improve the quality of life in old age. With increasing longevity, it is obvious that, as suggested by Tesch-Römer and Wahl (2016), instead of a dichotomy
of successful aging without disease and disability versus nonsuccessful aging with disease and functional disability, there is a need to expand the concept of successful aging to reflect the quality of life and desirable living situations also for those with some health problems. In our understanding, this expansion could move the emphasis of success in aging from ideal states of being to autonomy, adaptation, and resilience—a feasible target for promotion of health, well-being, and developing round-the-clock care in long-living societies.

Declaration of Conflicting Interests
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Note
1. For introducing covariates in the context of competing risk, we used a model according to Fine and Gray that calculates cumulative incidence function and focuses on the probability of each event type.

Fine and Gray model for the subhazard associated with type $j$ is as follows:

$$\tilde{\lambda}(t, x) = \tilde{\lambda}_j(t) \exp \{x' \beta_j\},$$

where $\tilde{\lambda}_j(t)$ is the baseline subhazard for events of type $j$ and $\exp \{x' \beta\}$ is the relative risk associated with covariates $x$.

References


**Author Biographies**

**Lily Nosraty** earned a Master’s degree in health studies form The University of Paisley (currently known as the University of the West of Scotland), UK. She worked as a lecturer at the community medicine Department. She also has experience in evidence based medicine by collaborating with the Oxford Center for Evidence-based Medicine, UK. She enrolled in The Doctoral Programs in Ageing Studies (DOPAS) in 2010 at the University of Tampere (UTA). She is currently working on “The Vitality 90+” data. Her research Focus is on successful aging and the oldest old.

**Jutta Pulkki** is working currently as a postdoctoral researcher. She has studied welfare services and benefits as well welfare politics in Finland and holds a PhD degree in social and health policy. She has examined the use and distribution of rehabilitation services, long-term care, and purchases of medicines by using national register data. In addition, she has studied old age politics by analyzing the parliamentary debates in Finland.

**Jani Raitanen** has a master’s of science in statistics. He has been working as a research fellow at the UTA since 1999 and at the UKK Institute for Health Promotion in Finland since 2009. His main tasks include data management and analysis as well as consulting for students in statistical issues.

**Linda Enroth** received her master’s degree in health sciences from the UTA in Finland. She is currently enrolled in a doctoral program in Health Sciences at UTA and is part of the Nordic Research Project, Social Inequalities in Ageing (SIA). Her research focus is on health and functioning among the oldest old with special attention in health inequalities.

**Marja Jylhä** is the professor of gerontology at the School of Health Sciences, UTA, and the director of the Gerontology Research Center (GEREC). Currently she is the president of the Nordic Federation of Gerontology. Her research interests include longevity, self-rated health, and new challenges to the aging society.