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Coming of age : treatment and outcomes in older patients with breast cancer

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Citation

Derks, M. G. M. (2018, June 20). *Coming of age : treatment and outcomes in older patients with breast cancer*. Retrieved from <https://hdl.handle.net/1887/62859>

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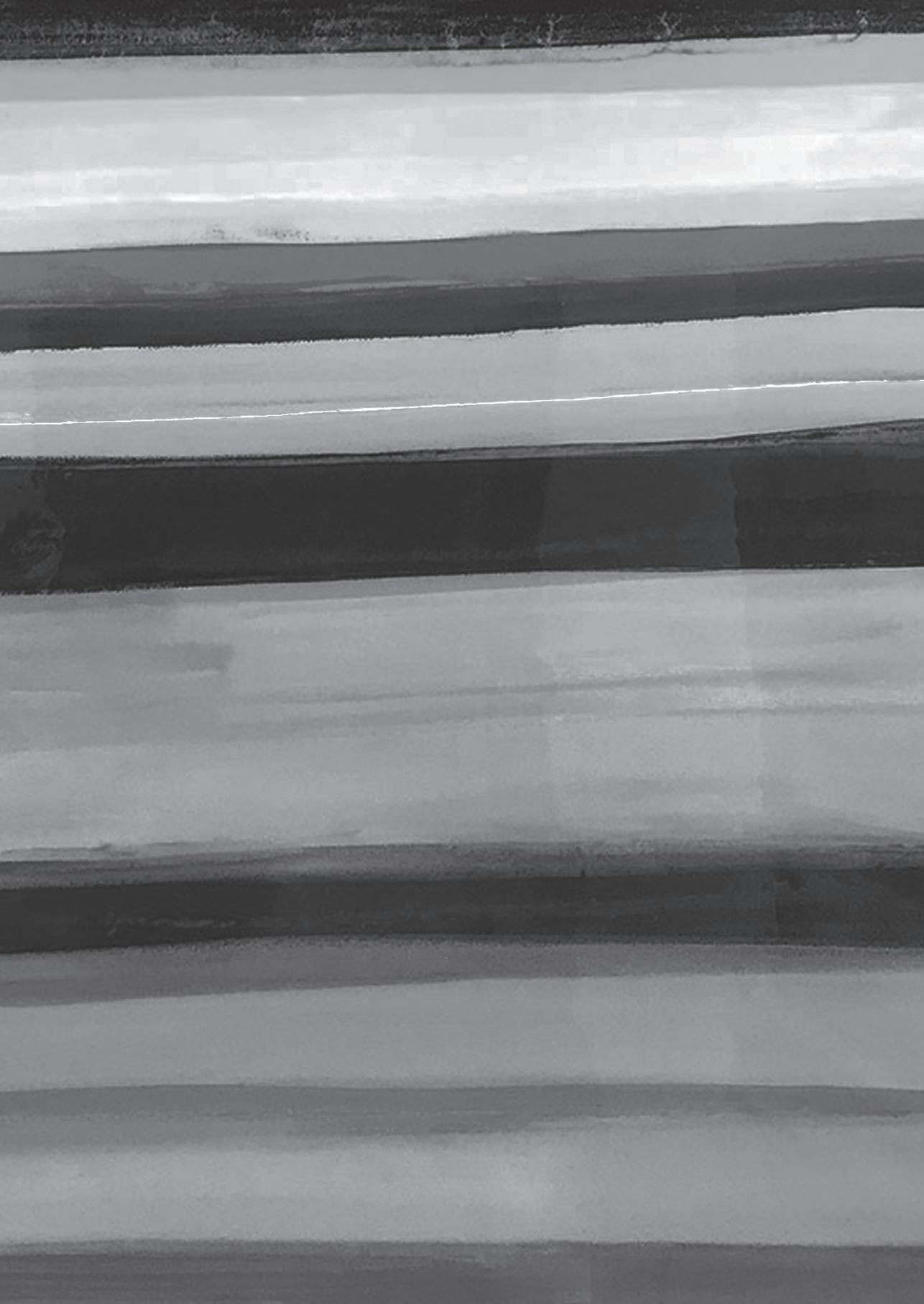
Issue Date: 2018-06-20





PART III

From research setting to
clinical practice:
improving methodology
in studies in older patients





CHAPTER 7

Successful ageing: a study
of the literature using a
citation network analysis

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Maturitas. 2016 Nov;93:4-12.

ABSTRACT

Background: Growing old goes with an increased risk of disease and a loss of functioning on several bodily and mental domains and some argue that maintaining health and functioning is essential for a successful old age. Paradoxically, studies have shown that overall wellbeing follows a curvilinear pattern with the lowest point at middle age but increases thereafter up to very old age.

Objective: To shed further light on this paradox, we reviewed the existing literature on how scholars define successful ageing and how they weigh the contribution of health and functioning to define success.

Methods: We performed a novel, hypothesis-free and quantitative analysis of citation networks exploring the literature on successful ageing that exists in the Web of Science Core Collection Database using the CitNetExplorer software. Outcomes were visualized using timeline based citation patterns. The clusters and sub-clusters of citation networks identified were starting points for in depth qualitative analysis.

Results: Within the literature from 1902 through 2015, two distinct citation networks were identified. The first cluster had 1,146 publications and 3,946 citation links. It focused on successful ageing from the perspective of older persons themselves. Analysis of the various sub-clusters emphasized the importance of coping strategies, psycho-social engagement, and cultural differences. The second cluster had 609 publications and 1,682 citation links and viewed successful ageing based on the objective measurements as determined by researchers. Subsequent sub-clustering analysis pointed to different domains of functioning and various ways of assessment.

Conclusion: In the current literature two mutual exclusive concepts of successful ageing are circulating that depend on whether the individual himself or an outsider judges the situation. These different points of view help to explain the disability paradox as successful ageing lies in the eyes of the beholder.

INTRODUCTION

How can people age successfully? Worldwide, many people prioritize good health as an important goal in their lives¹ and some consider health and functioning in old age as a prerequisite when striving for successful ageing.² Growing old, however, presents us with a plethora of debilitating consequences, among which there are disabilities, cognitive decline, and loss of social relationships.³ When we assume health to be the driving force for successful ageing while at the same time ageing is associated with an increased risk for diseases and loss of functioning, we would expect that ageing is associated with a gradual decline in wellbeing. In contrast to this expectation, previous research has shown that in many countries around the world, overall wellbeing follows a curvilinear pattern that reaches its nadir at middle age but increases thereafter up to very old age.^{4,5}

Why then are there so many people experiencing high levels of wellbeing despite the fact that their bodies fail? This remarkable observation has been previously described in the setting of rehabilitation. The 'disability paradox' indicates that people with severe physical disabilities rate their own wellbeing rather positively. This experience of wellbeing is unexpected for outsiders, but becomes understandable as people are able to adapt to their disabilities.⁶ When extrapolating the disability paradox to people growing older, maintaining good physical health might not be the only necessary prerequisite when striving to be successful in old age.

To shed further light on this paradox we delved into the literature on the scholarly definition of successful ageing and the contribution of health to success in old age. To this end we conducted an innovative and combined quantitative and qualitative assessment of the literature on successful ageing.

METHODS

Considering the extensive literature on successful ageing, and to get a better understanding of how the concept has evolved, we decided to analyse citation networks using CitNet-Explorer software. This software programme enables us to perform a hypothesis-free and exploratory quantitative analysis, and a visualization of the citation links of the relevant scientific literature.⁷

A search on Web of Science Core Collection Database was performed on all literature with "Successful Aging" or "Successful Ageing" in the title only, at the 28th July 2015. Both terms were used because they are spelled differently in the Unites States and the United Kingdom. The search resulted in 1,233 articles. The full record contents of these primary articles, as

well as the secondary articles that have been cited were used as input for the CitNetExplorer tool.

Clustering analysis in the citation network was performed to identify clusters of publications that are strongly connected to each other in terms of citation publications,⁸ forming an intellectual network. A cluster can be interpreted to represent a confined intellectual topic in the scientific literature. For all clustering analyses, the default resolution parameter (1.00) from the CitNetExplorer programme was used. The resolution parameter determines the level of detail at which clusters are identified. The higher the value of the parameter, the larger the number of clusters that will be obtained.⁷ The minimum cluster size set to 10 publications and small clusters with number of publications below the minimum cluster size to be merged as much as possible with other clusters. Clusters were visually identified in the citation network by using colours.

The biggest clusters were then further explored for more detailed citation networks using the 'drill down' feature of the CitNexExplorer software programme. The various sub-clusters were characterized with identifying the pioneering publication, the publication with highest citation score, and the most recent publication. Relevant clusters and sub-clusters were then scrutinized for in depth qualitative review of the literature and reported in a tabular format.

RESULTS

Quantitative Analysis

After downloading full record contents of the 1,233 publications that were identified by our primary search on 'successful aging' or 'successful ageing' from the Web of Science Core Collection database, the CitNetExplorer program identified 2,638 secondary, citation linked publications. We thus obtained and analysed a citation network consisting of 3,871 publications with 10,804 citation links, within the time window 1902 through 2015.

Clustering analysis resulted into ten main clusters of publications and due to the minimum size requirement, 603 publications do not belong to a cluster. Table 1 provides citation network information for all 10 main clusters, with the clusters ordered according to cluster size, descending from the largest to the smallest cluster. As seen in Table 1, the first three clusters contain the majority of publications and citation links. The first cluster is the biggest in size with 1,146 publications, 3,946 citation links and 77 publications with a citation score of ≥ 10 . The second and the third cluster consist of 609 publications and 1,682 citation links, respectively 541 publications and 1,234 citation links. The other remaining seven clusters were smaller, representing less than 10% of all publications and less than 6% of the total number of citations links per cluster. It appears that the number of the 100 most

frequently cited publications are within the first and the second cluster with substantially higher numbers (57 and 33 respectively) than in the third cluster (6). The seven clusters only contributed with four out of the 100 most cited papers.

Table 1. Citation Network Information for All Main Clusters

Main Cluster	Number of Publications	Number of Citation Links	Number of Citations* Median (Range)	Number of Publications with ≥ 10 Citations*	Number of Publications in 100 Most Cited Publication
1 Blue	1,146	3,946	2 (0-106)	77	57
2 Green	609	1,682	2 (0-181)	35	33
3 Purple	541	1,234	2 (0-42)	10	6
4 Orange	359	702	2 (0-11)	2	0
5 Yellow	257	452	2 (0-11)	3	0
6 Brown	193	371	2 (0-20)	4	2
7 Pink	60	73	2 (0-7)	0	0
8 Light Blue	47	63	2 (0-13)	1	1
9 Lime	46	71	2 (1-33)	2	1
10 Red	10	16	2 (0-2)	0	0

*Citation scores obtained from CitNetExplorer results

Figure 1 shows a timeline-based network visualization of citation links including the 100 most cited publications. In this visualization, each circle represents a publication that is labelled by the last name of the first author, while curved lines represent citation links. The vertical axis represents a timeline and describes the year in which the article was published, with more recent publications being located below older publications. If two linked publications appeared in the same year, then the citing publication is always located somewhere below the corresponding cited publication. The location of publications on the horizontal axis is determined by the closeness of publications in the citation networks. In other words, the closer the circles are positioned to each other, the closer the publications are related to each other.

As is seen in Figure 1, the blue (first) and the green (second) network represent the majority of publications in a network with many citation links that are closely related to each other. The purple (third) network is positioned at a far distance from the two main networks without any citation links to the main network. Based on these findings and the low number of publications represented in the 100 most cited publications, the third and other smaller clusters were not analysed further. The first two clusters, which will be analysed further, are rooted in two classical publications, from here on referred to as the Havighurst-cluster and the Katz-cluster.

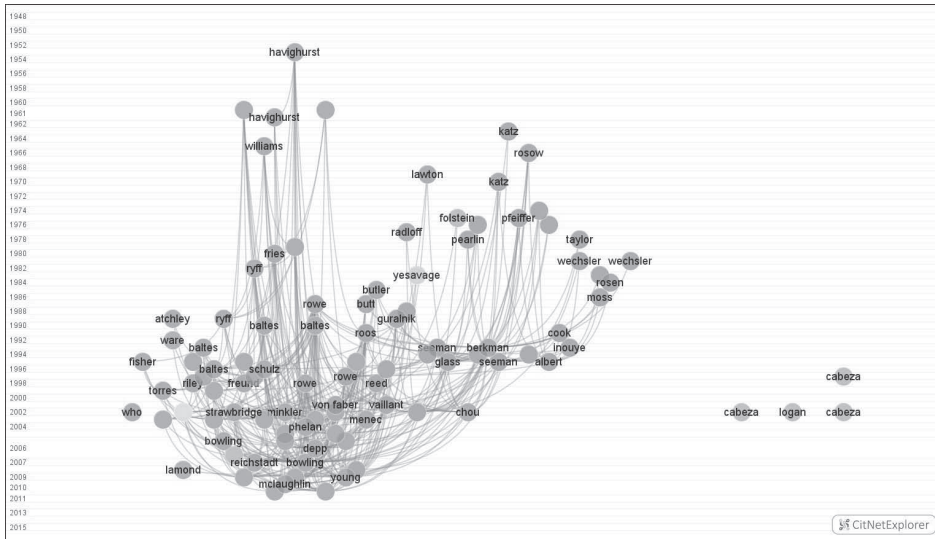


Figure 1. Bibliometric Networks Visualizing the 100 Most Cited Publications on “Successful Ageing”

Qualitative Analysis

A more detailed description of the Havighurst-cluster and the Katz-cluster is presented in Table 2. The Havighurst-cluster consists of publications discussing the topic of successful ageing from the older person’s point of view. These publications advocate the urgency of taking into account older people’s perspectives as they indicate which aspects of life are important and to what extent these aspects determine older people’s experience of success. In contrast, publications included in the Katz-cluster tend to discuss the topic of successful ageing purely from the perspective of researchers or clinicians. In general, this cluster examines quantitatively physical functioning assessments and predictors, using such analyses as a categorization of successful ageing. Timewise, the two main groups have started publishing articles on this topic in the same period. However, in the first 30 years these two clusters do not interact with each other and only started to cite each other from 1987 onwards. Over time, the two clusters seemed to be moving closer to each other on the horizontal axis, suggesting that they started to acknowledge the importance of each other perspectives. From Figure 1 it seems as if there were no new publications after 2011, but this visualised network reflects only the 100 most frequently cited publications out of the extensive literature. Consequently, papers that have been published more recently but not yet have been extensively cited are not included.

In the Havighurst-cluster, the pioneering publication was published in 1953, a book by Havighurst et al titled ‘Older People.’⁹ This book describes the lives of older people in a small town in the United States and the challenges they faced when growing older. At that time, descriptions

Table 2. Highlights of Literature Visualized in the 100 Most Cited Publications on “Successful Ageing”

	Havighurst-cluster				Katz-cluster			
	Year Published	Number of Citations*	First Author	Title	Year Published	Number of Citations*	First Author	Title
Pioneers	1953	15	Havighurst ⁹	<i>Older People</i>	1963	31	Katz ¹²	<i>Studies of Illness in the Aged</i> <i>The Index of ADL: A Standardized Measure of Biological and Subjective Function</i>
Highest Citation Score	2006	106	Depp ¹⁰	<i>Definitions and predictors of Successful Aging: A Comprehensive Review of Larger Quantitative Studies</i>	1987	181	Rowe ¹³	<i>Human Aging: Usual and Successful</i>
Most Recent	2010	21	Pruchno ¹¹	<i>Successful Aging: Early Influences and Contemporary Characteristics</i>	2008	14	Britton ¹⁴	<i>Successful Aging: The Contribution of Early-Life and Midlife Risk Factors</i>
Topic of Discussion	A definition of successful ageing needs to include the subjective perception of older people.				Successful ageing as an objective quantified measurement of declining physical performance.			
Overall Conclusion	This cluster is still developing and there is no consensus yet.				Within this cluster, there is a consensus that you can objectify successful ageing using physical measurements.			

*Citation scores obtained from CitNetExplorer results

of old age problems were based on younger people's perception of older people. The authors then decided to see the problems through the eyes of older people themselves, making this book the first highly cited publication looking at successful ageing outside the medical domain. The most frequently cited article in this cluster, Depp et al, was published in 2006.¹⁰ This is a review of studies focusing on older individuals who met the criteria of successful ageing. The authors acknowledged that successful ageing has been defined, operationalized, measured, and predicted in several ways. They pointed out that there is a separation between these operationalized definitions, developmental processes throughout the life span, and definitions of successful ageing according to older adults themselves. They highlighted the need to expand the primarily physical definitions to a wider definition that encompasses bio-psycho-social factors. They proposed that the ideal definition should be acceptable to everyone involved including researchers, clinicians, and older people themselves. The most recent article that was highly cited came from Pruchno et al in 2010,¹¹ which noted that although objective criteria are important components of successful ageing, they do not tell the whole story. They argued that success is a function of value judgments as well as objective criteria, thus highlighting the importance of adaptive processes that adults undergo when they grow older.

The pioneering publication of the Katz-cluster was published in 1963 and written by Katz et al.¹² In this paper, they introduced the Index of Activities of Daily Living (Instrumental ADL), a systematic approach to measure physical performance in a population of older or chronically ill persons. It was introduced to be used as an objective guide to study the ageing process and the course of disease. In the original article it was not proposed as an instrument to distinguish between 'usual' and 'successful' aging within an older population, but in later studies on successful ageing it was very frequently used to make this distinction. The most frequently cited publication in this cluster is the paper written by Rowe and Kahn in 1987¹³, introducing the concept of successful ageing for biomedical research purposes. In their paper, they argued that there is substantial heterogeneity among older persons and added an additional category to the traditionally used 'normal aged' and 'diseased aged' categories. They argued that within the category of normal ageing, a distinction can be made between 'usual' ageing and 'successful' ageing and that successful ageing can be differentiated from usual ageing by the impact of extrinsic factors. Rowe and Kahn made the assumption that there was a causal relationship between extrinsic factors and the process of ageing. While in the normal ageing group extrinsic factors may contribute or accelerate the ageing process, in the successful ageing group, extrinsic factors have a neutral or even protective role in this process. Within this cluster the most recent highly cited article was by Britton et al¹⁴ and it was based on the model of Rowe and Kahn. It tried to identify early life and midlife risk factors influencing successful ageing. They classified successful ageing as the absence of significant disease and the ability to maintain good physical and mental functioning as validated by objective measurements.

The Havighurst-subclusters

There were 1,146 publications and 3,946 citation links in the Havighurst-cluster and further analysis resulted into 11 sub-clusters (see Supplementary Table 1). The five biggest sub-clusters are summarized in Table 3 and visualized in Supplementary Figure 1. All other six sub-clusters were substantially smaller, each representing less than 70 publications and less than 100 of the citation links studied and were therefore not analysed further.

The first sub-cluster mainly revolves around successful ageing as viewed by the older people themselves. Studies by Strawbridge et al,¹⁵ Montross et al,¹⁶ and Phelan et al¹⁷ found the discrepancy between the successful ageing definition as operationalized by researchers and successful aging according to perception of older people. They noted that many older people with chronic diseases and functional limitations rated themselves as highly successful although they may not meet the operationalized definition of successful aging. Phelan et al¹⁷ argued that the model of successful aging needs to be multidimensional; taking into account all aspects of health including physical, functional, psychological, and social domains. Bowling et al¹⁸ proposed to place successful ageing on a continuum of achievement rather than strict dichotomous cut-offs for categorization of success and failure because the current definition is unrealistic for most people. In another paper, Bowling et al also highlighted the urgency of including elements that matter to older people¹⁹, although Knight et al noted that not all aspects are seen as equally important by all participants²⁰. The most recent publication in this sub-cluster, Cosco et al²¹ emphasized on the lack of consistency in the definition of successful ageing as the underlying weakness for research focusing on this domain.

The second sub-cluster focused on the nature of development and maintenance in ageing with the focus on successful adaptation throughout the life course, as described by Schulz et al²². Studies²³ viewed successful ageing as achieving life goals in spite of losses as a result of the dynamic between three processes: selection, optimisation, and compensation as developed by Baltes and Baltes.²⁴ Ryff et al²⁵ criticized studies which emphasized on the negative side of ageing, neglecting the possibility of continued growth and development as people grow older. Further, Lupien et al²⁶ showed that well-being and positive views of ageing are protective against the damaging effects of age.

The third sub-cluster focused more on the application of psychosocial models as strategies for life management. The most popular model is the selection-optimisation-compensation model as applied by Abraham et al²⁷ and Freund et al,²⁸ while other additional models are also acknowledged,²⁹ for example proactive coping,³⁰ socio-emotional selectivity,³¹ assimilative and accommodative coping,³² and primary and secondary control model.³³ Although varied, in general these models have something in common; they emphasize the adaptation of goals and standards in the face of age-related changes of resources.

Table 3. Highlights of Literature Visualized in the Sub-clustering Results of the Havighurst-cluster

Sub-cluster	1	2	3	4	5
Number of Publications	310	191	155	152	97
Number of Citation Links	1,062	404	319	300	152
Pioneers	Havighurst et al (1953) ⁹ <i>Older People</i>	Lawton et al (1969) ⁴⁷ <i>Assessment of Older People: Self-maintaining and Instrumental Activities of Daily Living.</i>	Williams et al (1965) ⁴⁸ <i>Lives Through the Years: Styles of Life and Successful Aging</i>	Baltes et al (1993) ⁴⁹ <i>The Aging Mind: Potential and Limits.</i>	Reed et al (1998) ⁵⁰ <i>Predictors of Healthy Aging in Men with High Life Expectancies</i>
Highest Citation Score	Depp et al (2006) ¹⁰ <i>Definitions and Predictors of Successful Aging: A Comprehensive Review of Larger Quantitative Studies</i>	Schulz et al (1996) ²² <i>A Life Span Model of Successful Aging</i>	Williams et al (1965) ⁴⁸ <i>Lives Through the Years: Styles of Life and Successful Aging</i>	Holstein et al (2003) ³⁴ <i>Self, Society, and the "New Gerontology"</i>	Pruchno et al (2010) ¹¹ <i>Successful aging: Early Influences and Contemporary Characteristics</i>
Most Recent	Cosco et al (2014) ²¹ <i>Operational Definitions of Successful Aging: A Systematic Review</i>	Lupien et al (2004) ²⁶ <i>Successful Aging: From Cell to Self</i>	Ouwehand et al (2007) ⁵¹ <i>A Review of Successful Aging Models: Proposing Proactive Coping as An Important Additional Strategy</i>	Liang et al (2012) ⁵² <i>Toward A Discourse Shift in Social Gerontology: From Successful Aging to Harmonious Aging</i>	Hank et al (2011) ³⁸ <i>How "Successful" Do Older Europeans Age? Findings from SHARE</i>

The fourth sub-cluster criticized the primarily physical-oriented term of successful ageing. Holstein et al³⁴ and Minkler et al³⁵ warned that this may encourage ageism and discrimination, further stigmatizing and marginalizing older people who may not meet the narrowly defined term of successful ageing. Therefore, Dillaway et al³⁶ noted that researchers and clinicians should be more careful when adopting successful ageing terminology without understanding the potential socio-political consequences. They called for a new, expanded conceptualization of successful ageing which is more multidimensional and incorporate lay people's perspectives which has been shown to predict quality of life more powerfully compared to the more simpler models.³⁷

The fifth sub-cluster focused on the cross-national perspective of successful ageing. In this sub-cluster, the subjective perspective is not apparent as it revolves around healthy ageing based on objective measurements, taking into account the different cultural backgrounds in different countries. For example Hank et al³⁸ observed the cross-national variation in successful ageing among European countries using objective measurements. However, the highest cited publication in this sub-cluster, Pruchno et al,¹¹ analysed people who aged successfully according to both subjective and objective criteria, none, and one or the other criteria by applying mathematical model from directly measured variables. They argued for a multidimensional model of successful ageing comprising both objective and subjective indicators.

The Katz-subclusters

There were 609 publications and 1682 citation links in the Katz-cluster and sub-clustering analysis resulted into 10 sub-clusters (see Supplementary Table 2). Highlights of literature in the three biggest sub-clusters are summarized in Table 4 and visualized in Supplementary Figure 2. All other seven sub-clusters were substantially smaller, each representing less than 60 publications and less than 100 citation links studied and were therefore not analysed further.

In contrast to findings from sub-clustering of the Havighurst-cluster, there is no obvious pattern recognizable in the qualitative analysis across the sub-clusters of the Katz-cluster. This could best be explained by the fact that the overwhelming majority of the cited papers apply a similar framework for their studies, which was mainly based on the MacArthur study. The MacArthur studies aimed to identify risk factors that were associated with successful ageing and could offer potential for effective intervention to promote successful ageing on both the individual and the population level. In order to identify these predictors, Berkman et al³⁹ first developed a model to identify older persons which could be considered to have aged successfully. Predetermined objective criteria of physical and cognitive functioning were used to define high, medium, and low functioning subgroups within a cohort popula-

Table 4. Highlights of Literature Visualized in the Sub-clustering Results of the Katz-cluster

Sub-cluster	1	2	3
Number of Publications	162	72	63
Number of Citation Links	493	115	120
Pioneers	Katz et al (1963) ¹² <i>Studies of Illness in the Aged</i> <i>The Index of ADL: A</i> <i>Standardized Measure of</i> <i>Biological and Subjective</i> <i>Function</i>	Wechsler et al (1981) ⁴⁰ <i>Wechsler Adult Intelligence</i> <i>Scale - Revised</i>	Holmes et al (1967) ⁵³ <i>The Social Readjustment</i> <i>Rating Scale</i>
Highest Citation Score	Berkman et al (1993) ³⁹ <i>High, Usual, and Impaired</i> <i>Functioning in Community-</i> <i>Dwelling Older Men and</i> <i>Women – Findings from</i> <i>the Macarthur Foundation</i> <i>Research Network on Successful</i> <i>Aging</i>	Wechsler et al (1981) ⁴⁰ <i>Wechsler Adult Intelligence</i> <i>Scale - Revised</i>	Rowe et al (1987) ¹³ <i>Human Aging – Usual and</i> <i>Successful</i>
Most Recent	Andrews et al (2002) ⁴² <i>Successful Aging in the</i> <i>Australian Longitudinal</i> <i>Study of Aging: Applying the</i> <i>Macarthur Model Cross-</i> <i>Nationally</i>	Wong et al (1989) ⁴³ <i>Personal Meaning and</i> <i>Successful Aging</i>	Rowe et al (1997) ⁵⁴ <i>Successful Aging</i>

tion of community dwelling older persons aged 70-79. They hypothesized that high levels of cognitive and physical functioning were necessary for independence and quality of life, and a high level of functioning was therefore used as a proxy for successful ageing. For follow up studies, successful ageing was described as maintenance of high level of functioning over time according to objective measurements. To measure the level of cognitive and physical functioning, validated instruments were used. The sub-clusters reflect the different approaches to operationalize this objective definition of successful ageing, reflected in highly cited papers describing different instruments such as the Wechsler Intelligence Scale⁴⁰ and the Boston Naming test⁴¹ for cognitive functioning and the original paper by Katz et al,¹² introducing the IADL for physical functioning.

Using the definition of successful ageing as established by the MacArthur study, several other studies replicated this objective approach in observational cohort studies.⁴²⁻⁴⁵ Most studies in the Katz-cluster focused on finding demographic, behavioural, psycho-social, and biological predictors which were associated with better performance or maintenance of high level functioning. Each study has their own set of risk factors covering one or more

predictors, with some overlapping others. Although in this cluster, successful ageing is defined as combination of physical and cognitive functioning, most studies chose to focus on either one or the other. The authors of these studies either categorized people as successfully aged based on physical or cognitive cut-offs, or used changes in physical or cognitive performance as a proxy for successful ageing.

DISCUSSION

Exploratory analysis of citation patterns in the scientific literature on successful ageing resulted into a dichotomy between the two main networks of publications; the Havighurst-cluster and the Katz-cluster. Starting from two seminal contributions, the two main groups started to publish highly cited manuscripts but it took 30 years before the two clusters started to acknowledge each other. In addition, the citation analysis showed the two clusters moving closer to each other, interrelating each other's publications. In the later years, citation patterns showed that the majority of frequently cited publications come from the Havighurst-cluster.

Qualitative assessment of the citation networks further confirmed the distinct characteristics of the two clusters. The Havighurst-cluster focused on successful ageing from the perspective of older persons themselves, while the Katz-cluster stayed within the objective measurements determined by researchers. Intention-wise, the Havighurst-cluster advocated the view of older persons, warning the harm of medical categorization of success and failure in stigmatizing and marginalizing older persons and encouraging ageism. On the other hand, the Katz-cluster focused on identifying risk factors for prevention. Across the lifespan, the Havighurst-cluster highlighted the importance of process of adaptation of goals in the face of losses while in the Katz-cluster, to be successful older persons have to maintain their functioning within the cut-offs that were predetermined by researchers. Overall, the principle difference is the discrepancy between the thoughts of older people about successful ageing themselves and the successful ageing concepts as applied by researchers from an outsider perspective.

Why is there such a discrepancy between the two clusters representing perspectives of older people and researchers respectively? As an explanation, we introduce a conceptual framework to explain successful ageing by adopting the anthropologists' approach. In 1954, the American linguist Pike introduced the concepts of 'etic' and 'emic' to describe the meaning of words the interpretation of an event from a different point of view.⁴⁶ Briefly, the 'etic' perspective is used to describe a phenomenon as viewed and interpreted by someone outside the experience and emphasizes what the observer considers to be important. In contrast, the 'emic' perspective describes a phenomenon from an internal point of view based on the

individual's observation, explanatory framework, norms, values and interpretations. These perspectives originated from the linguistic discipline and are now extensively used within anthropology, but one can imagine that these could also be applied within the two main clusters identified in the citation networks. In the Katz-cluster, studies apply their definition of successful ageing as an external perspective on the older population; therefore this can be viewed as an 'etic' classification. On the other hand, the studies in the Havighurst-cluster try to define successful ageing from an older people's perspective. These studies represent the 'emic' approach, emphasizing the need of accounting how older persons themselves view and experience health when aiming for a successful old age. However, in some studies, the Havighurst-cluster operationalized emic perspectives using an etic approach by applying mathematical models or scoring systems. On the whole, these different perspectives enable us to explain the disability paradox as a result of two opposing views on observed and experienced success in old age.

The purpose of this manuscript is to reflect on the definition of 'successful ageing' as used by a great variety of scholars, including those who come from the humanities. As the definition of successful ageing is not a numerical endpoint, such as an absolute or a relative risk, our investigation does not lend itself for a traditional precision-weighted analysis. Instead of a classic meta-analysis, we used automated bibliographic networks of papers, and the number of citations to determine the relevance of the scientific contribution. Effectively, this method provides us with a quality-weighted analysis of the narrative data on successful ageing. It allows to summarize the abundant literature on the topic using a hypothesis free approach. With this method we overcome a subjective interpretation of the material, as the importance of the contribution is determined by the number of citations and thus by the field itself.

The strength of this study lies in the novel methodological approach to guide us on reviewing the extensive literature on successful ageing. We delved into this literature using the CitNetExplorer tool to analyse citation patterns, allowing us to perform hypothesis-free, exploratory analysis thus minimizing bias. Further, we did not have any inclusion or exclusion criteria and included all studies from the search term 'successful ageing' in all years documented in the Web of Science Database. Using CitNetExplorer we were able to obtain timeline based visualization of citation networks to guide our qualitative assessment. The tool also allowed us to assess an extensive literature over a very long time window. The novel method is also accompanied with some limitations. It prevented us from analyzing the citation patterns of the most recent publications because papers need to be published long enough to be frequently cited and included in the network. In addition, CitNetExplorer can only import articles and its references from the Web of Science Database. For this reason, we were not able to perform a search in a different database. Therefore, we could have missed relevant publications that were not included in the Web of Science Database. Furthermore,

the software programme does not provide the opportunity to include or exclude a reference manually. Therefore, some articles identified by the CitNetExplorer tool did not have successful ageing as their main topic. Mostly, these were papers that were frequently used as a reference to describe a measurement instrument (such as the Wechsler Intelligence Scale or the Katz Activities of Daily Living). Although these references seem not directly related to the topic, they are helpful in defining the concept of successful ageing over time.

In conclusion, the novel methodological approach that we used to explore the extensive literature led to a clear divide in the field of successful ageing. Two distinct concepts emerged, describing successful ageing from opposing perspectives which could be described according to other academic disciplines as 'etic' and 'emic'. The etic approach focused on objective measures defined by researchers to describe success. The emic approach focused on successful ageing from the perspective of older persons themselves. This explains the paradox between observed and experienced success in old age as successful ageing as wellbeing is determined by people themselves.

Acknowledgements

Our special thanks go out to Bernard Jeune for critically reading and commenting on this paper.

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Supplementary Table 1. Citation Network Information for Havighurst-cluster

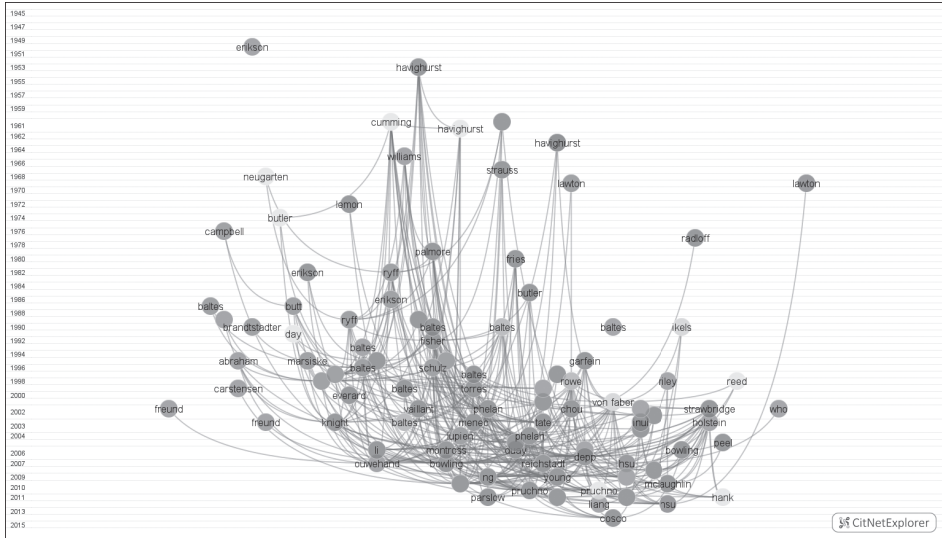
Sub-cluster	Number of Publications	Number of Citation Links	Number of Citations* Median (Range)	Number of Publications with ≥ 10 Citations*
All	1,146	3,946	2 (0-106)	77
1	310	1,062	4 (0-106)	40
2	191	404	3 (0-35)	12
3	155	319	2 (0-17)	4
4	152	300	2 (0-28)	9
5	97	152	2 (0-21)	3
6	61	93	2 (0-10)	1
7	46	54	2 (0-22)	1
8	37	56	2 (0-45)	1
9	36	48	2 (0-38)	3
10	35	57	2 (0-10)	1
11	26	28	0 (0-104)	2

*Citation scores obtained from CitNetExplorer results

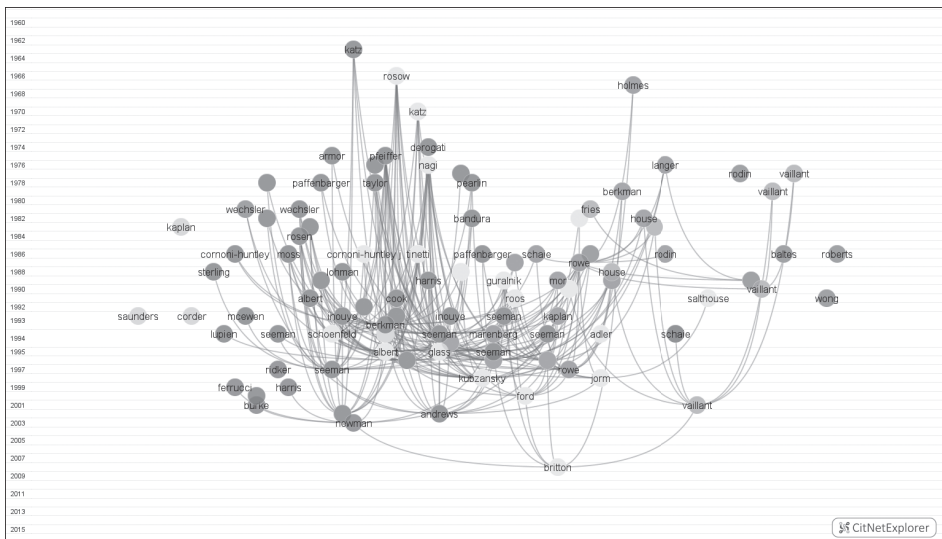
Supplementary Table 2. Citation Network Information for Katz-cluster

Sub-cluster	Number of Publications	Number of Citation Links	Number of Citations* Median (Range)	Number of Publications with ≥ 10 Citations*
All	609	1,682	2 (0-181)	35
1	162	493	3 (0-81)	19
2	72	115	2 (0-12)	1
3	63	120	2 (0-181)	2
4	60	80	2 (0-48)	1
5	58	99	2 (0-36)	5
6	56	79	2 (0-11)	1
7	41	71	2 (0-27)	2
8	41	80	2 (0-12)	1
9	40	55	3 (0-36)	3
10	16	15	2 (0-7)	0

*Citation scores obtained from CitNetExplorer results



Supplementary Figure 1. Bibliometric Networks Visualizing of 100 Most Cited Publications from Sub-clustering of the Havighurst-cluster



Supplementary Figure 2. Bibliometric Networks Visualizing of 100 Most Cited Publications from Sub-clustering of the Katz-cluster