SIRKKA GOEBELER

Health and Illness at the Age of 90

■

ACADEMIC DISSERTATION
To be presented, with the permission of
the Faculty of Medicine of the University of Tampere,
for public discussion in the Small Auditorium of Building B,
Medical School of the University of Tampere,
Medisiinarinkatu 3, Tampere, on November 27th, 2009, at 12 o'clock.

UNIVERSITY OF TAMPERE

ACADEMIC DISSERTATION
University of Tampere, School of Public Health
Doctoral Programs in Public Health (DPPH)
Finland

Supervised by
Professor Antti Hervonen
University of Tampere
Finland
Professor Marja Jylhä
University of Tampere
Finland

Reviewed by
Professor Sirpa Hartikainen
University of Kuopio
Finland
Professor Kaisu Pitkälä
University of Helsinki
Finland

Distribution
Bookshop TAJU
P.O. Box 617
33014 University of Tampere
Finland

Tel. +358 3 3551 6055
Fax +358 3 3551 7685
taju@uta.fi
www.uta.fi/taju
http://granum.uta.fi

Cover design by
Juha Siro

Acta Universitatis Tamperensis 1484
ISBN 978-951-44-7930-4 (print)
ISSN-L 1455-1616
ISSN 1455-1616

Acta Electronica Universitatis Tamperensis 919
ISBN 978-951-44-7931-1 (pdf)
ISSN 1456-954X
http://acta.uta.fi

Tampereen Yliopistopaino Oy – Juvenes Print
Tampere 2009

Health and Illness at the Age of 90

Contents

My very aged grandmother taught me that one never changes in the inside. That under the wrinkled, ugly, and stiff armor was still the twelve-year-old girl who wanted to run with laughter. Who was now restricted within four walls to move around carefully avoiding the carpet edges, and who was not able to remember, if she had eaten today or not.

Iäkäs isoäitini opetti, että ihminen ei koskaan muutu sisältä. Että ryppyisen, ruman ja kankean kuoren alla oli yhä se kaksitoistavuotias tyttö, joka halusi juosta nauraen. Joka nyt oli rajoitettu neljän seinän sisälle liikkumaan maton reunoja varoen ja joka ei kyennyt muistamaan, oliko tänään syönyt vai ei.

List of Original Communications

I Goebeler S, Jylhä M and Hervonen A (2003): Medical history, cognitive status and mobility at the age of 90: A population-based study in Tampere, Finland. Aging Clin Exp Res 15:154-161.

II Goebeler S, Jylhä M and Hervonen A (2007): Self-reported medical history and self-rated health at age 90. Agreement with medical records. Aging Clin Exp Res 19:213-219.

III Goebeler S, Jylhä M and Hervonen A (2004): Use of hospitals at age 90. A population-based study. Arch Gerontol Geriatr 39:93-102.

IV Goebeler S, Jylhä M and Hervonen A: Survival of nonagenarians can be prospected using earlier medical history. Manuscript for Aging Clin Exp Res.

Abbreviations

CI	Confidence interval
ICD-10	International Classification of Disease, 10th revision
IQR	Inter-quartile range
MMSE	Mini-Mental State Examination
UN	United Nations
WHO	World Health Organization

Abstract

The oldest-old population is expanding rapidly. Currently in 2009, 0.6% of the population in Finland is 90 years old or older. There is a need for clinical information about this group that actively uses the social and health care but – as a marginal population – has not been systematically studied.

This thesis work studied the health and illnesses of the 90-year-olds with an aim to obtain population level information from several perspectives. The target population was all people born in 1907-1910 and living in the city of Tampere at the age 90. Sources of information used were medical records, city hospitals patient register and discharge database, a mailed questionnaire, testing for mobility and cognition, and finally population register data for mortality.

Four of five 90-year-olds were women (79%). More than two-thirds of the 90-year-olds lived in the community (72%). One-year mortality was nearly 20%. Morbidity was higher than in younger populations. Though women were more numerous, the few surviving 90-year-olds men appeared healthier.

The most common diagnosis groups in the patient history were cardiovascular diseases (78%), gastrointestinal diseases (59%), infections (54%), and injuries (50%). An average of eight chronic or severe diseases were mentioned in the patient history indicating multiple co-morbidities. The diagnosis of dementia was mentioned in every fourth case (27%); most of the demented 90-year-olds were living in institutions. Of all 90-year-olds, one third (38%) were able to move using no or a light support, 8% were bedridden.

Of the community-living 90-year-olds, 78% reported their current health as good or average, which result is similar to reports from younger generations. Poor self-rated health was associated with heart disease, stroke, rheumatoid arthritis, Parkinson's disease, or depression. The agreement of self-reported and medical records data was relatively good. As expected, many of the diagnosed diseases were underreported in the mailed

questionnaire. However, dementia, depression, and arthritis were reported more often than doctors had recorded them.

During one year, 43% of 90-year-olds men and 50% of 90-year-olds women were admitted to hospital. The mean length of stay for men was 19 days, for women 46 days. Of the 90-year-olds, 7% were permanently staying in hospitals. The most common diagnoses at discharge were cardiovascular diseases, infections, psychiatric diseases including dementia, and trauma. Of those who had been admitted to hospital once or more within the year, 32% died during the year, while the percentage for those not admitted was only 6%.

Altogether, one third (36%) of the original population lived to age 94. Factors associated with survival were living in the community, no earlier history of certain diseases (heart diseases, cancer, diabetes, dementia, and infections), only a few co-morbidities, fewer than four medicines in daily use, good cognitive state, and good mobility. There were only a few men alive at age 90, and their mortality stayed high. The strongest negative influences on survival were detected with living in an institution and with dementia, which often co-existed.

The 90-year-olds suffered from numerous chronic diseases influencing mobility and cognition, and they were still actively treated in hospitals. In connection to poor self-rated health, living in institutions, need for hospital care, and mortality, dementia seemed to be the greatest risk for health at age 90.

This study supports the hypothesis that nonagenarians – while still considered oldest-old – are at the older end of usual aging processes with numerous diseases and high mortality due to the diseases. There is no obvious indication that the nonagenarians would be healthier in the near future. Our society will have to be prepared to provide adequate care for the needs of the growing population of the oldest-old.

Lyhennelmä

Terveys ja sairaus 90 vuoden iässä

Vanhoista vanhimpien osuus väestössä kasvaa nopeasti. Tällä hetkellä 0,6% Suomen väestöstä on 90 vuotta täyttäneitä. Tarvitsemme kliinistä tietoa tästä aktiivisesti sosiaali- ja terveyspalveluja käyttävästä ryhmästä, jota ei ole marginaalisena väestönosana systemaattisesti tutkittu. Tämä väitöskirjatyö tutki 90-vuotiaiden terveyttä ja sairauksia tarkoituksena kerätä väestötason tietoa monesta näkökulmasta. Kohdeväestönä olivat kaikki 1907-1910-syntyneet 90-vuotiaat tamperelaiset. Tietolähteinä käytettiin sairauskertomuksia, sairaaloiden potilastietokantaa ja poistoilmoitusrekisteriä, kirjeitse tehtyä kyselytutkimusta, liikuntakyvyn ja muistin tutkimusta ja lopuksi väestörekisterin kuolintietoja.

Neljä viidestä 90-vuotiaasta oli naisia (79%). Yli kaksi kolmasosaa 90-vuotiaista asui kotonaan (72%). Sairastavuus oli suurempaa kuin nuoremmissa ikäryhmissä, ja yhden vuoden kuolleisuus oli lähes 20%. Vaikkakin naisia oli enemmän, vielä elossa olevat 90-vuotiaat miehet vaikuttivat terveemmiltä.

Yleisimmät diagnoosiryhmät sairaushistoriassa olivat sydän- ja verisuonisairaudet (78%), ruoansulatusjärjestelmän sairaudet (59%), infektiot (54%) ja vammat (50%). Sairauskertomuksissa mainittiin keskimäärin kahdeksan pitkäaikaista tai vakavaa sairautta, mikä kuvasi monien sairauksien esiintymistä yhdessä. Dementiadiagnoosi mainittiin joka neljännessä tapauksessa (27%); suurin osa dementoituneista 90-vuotiasita asui laitoksissa. Kaikista 90-vuotiaista kolmasosa (38%) kykeni liikkumaan ilman tukea tai keppiä käyttäen, 8% oli vuodepotilaita.

Kotona asuvista 90-vuotiasta 78% ilmoitti terveytensä hyväksi tai keskinkertaiseksi, mikä tulos on samanlainen kuin nuoremmilla väestöillä kuvattu. Heikko terveydentila oman arvion mukaan liittyi ilmoitettuun sydänsairauteen, aivohalvaukseen, nivelreumaan,

Parkinsonin tautiin ja masennukseen. Itse ilmoitettujen ja sairauskertomuksista todettujen sairaustilojen yhtäpitävyys oli melko hyvä. Odotetusti moni sairauskertomuksessa mainittu sairaus jäi kuitenkin ilmoittamatta kirjekyselyssä. Dementiaa, masennusta ja nivelsairauksia ilmoitettiin enemmän kuin sairauskertomuksiin oli kirjattu.

Yhden vuoden aikana 43% 90-vuotiaista miehistä ja 50% 90-vuotiaista naisista oli sairaalahoidossa. Keskimääräinen hoitoaika oli 19 päivää miehillä ja 46 päivää naisilla. 7% 90-vuotiaista oli pysyvästi sairaalahoidossa. Yleisimmät poistodiagnoosit olivat sydän- ja verisuonisairaudet, infektiot, psykiatriset sairaudet dementia mukaan lukien ja vammat. 32% sairaalahoidossa olleista kuoli vuoden seuranta-aikana, kun luku oli vain 6% niillä, jotka eivät olleet sairaalahoidossa.

Kaikkiaan yksi kolmasosa (36%) lähtöväestöstä eli 94-vuotiaaksi. Eloon jäämiseen liittyviä tekijöitä olivat asuminen omassa kodissa, ei tiettyjä sairauksia, kuten sydänsairauksia, syöpää, diabetesta, dementiaa tai infektioita, ei monta sairautta yhtä aikaa, alle neljä lääkettä päivittäisessä käytössä, hyvä muisti ja hyvä liikuntakyky. Vain muutama mies oli elänyt 90-vuotiaaksi, ja miesten kuolleisuus säilyi korkeana. Voimakkaimmin kuolleisuutta lisäsivät laitoshoito ja dementia, jotka usein esiintyivät yhdessä.

90-vuotiaat kärsivät useista sairauksista, jotka vaikuttivat liikuntakykyyn ja muistiin. Heitä hoidettiin vielä aktiivisesti sairaalahoidossa. Suurin terveysriski 90 vuoden iässä vaikutti olevan dementia, jolla oli yhteys terveydentilan huonoksi kokemiseen, laitoshoitoon, sairaalahoidon tarpeeseen ja kuolleisuuteen.

Tämä tutkimus tukee olettamusta, että 90 vuotta täyttäneet – vanhoista vanhimmat – sijoittuvat tavanomaisen vanhenemisen vanhempaan päähän lukuisine sairauksineen eivätkä ole poikkeuksellisen terveitä. Ei ole ilmeistä viitettä siitä, että 90 vuotta täyttäneet olisivat lähitulevaisuudessa terveempiä. Yhteiskuntamme tulee varautua tarjoamaan tarpeita vastaavaa asianmukaista hoitoa ja palveluja kasvavalle vanhoista vanhimpien väestölle.

1. Introduction

To live to the age of ninety is becoming common. While the population is rapidly aging and the proportion of the oldest-old is increasing, the question arises: how are the old? The oldest-old have outlived most of their contemporaries and showed thus exceptional health and successful aging. Idealistically, one could conclude they are very healthy. This is also the message from many earlier gerontological studies (Rowe and Kahn 1987, Roos and Havens 1991, Gonos 2000). Yet, in clinical practice one meets nonagenarians that are not healthy at all. This paradigm needs further exploring. Perhaps at the phase of rapidly aging population, the people may change, too. Or perhaps there is only lack of information on the health of the very old.

Life ends to death that is usually preceded by a period of illness. In addition to life experience and wisdom, old age is characterized by physical limitations and illnesses. Extension of human life span may lead to different balance states of aging and illness. One prospect is extension of life span with compression of morbidity. The theory of compression of morbidity suggests originally that, if the onset of chronic illness can be postponed to very old age and if this postponement is greater than the extension of the life span, the period of illness before death will be shorter (Fries 1980). If this is the ruling phenomenon, the oldest-old should be relatively healthy until a short time before death. Other prospects are that the time of illness at the end of life gets longer or that there is a dynamic equilibrium of illness preceding death with the extension of the life span (Cai and Lubitz 2007, Parker and Thorslund 2007). Knowing the health status of the oldest-old does not only serve the academic interest, but gives an idea how to develop the health and social care system facing the needs of this rapidly growing group of people.

2. Review of the Literature

2.1 Demographics of Aging

People are living longer than ever before. According the World Health Organization published facts about ageing, in 2000, there were 600 million people aged 60 and over, and the number will double by 2025 and triple by 2050. The fastest-growing population group in the developed world are those aged 80 and older, and in very old age there are twice as many women as men in all societies. (WHO 2009)

Human life-expectancy has increased dramatically during the last century (Figure 1) (for a review, see Wilmoth 2000 and Harman 2001). This is mainly due to the sharp decrease in childhood mortality (Christensen and Vaupel 1996), and Finland has been one of the most successful countries in reducing the child mortality. In the beginning of the twentieth century, the first year mortality in Finland was slightly over ten per cent of alive born children, when the number in 2007 was less than four per a thousand newborn (Statistics Finland 2008).

In 2008 in Finland, life-expectancy at birth was 75.9 years for men and 82.9 for women. The annual increase in the life-expectancy of a newborn is about two months. In 2007, the proportion of people aged 90 or older in Finland was 0.6%, when it was 0.4% in 1997 and 0.2% in 1987. (Statistics Finland 2008) A similar development is seen in most other developed countries (WHO 2009). Figure 2 shows how the life-expectancy increases also in later years. This is commonly believed to be partly due to the better health at adulthood because of improved social conditions, nourishment and health care, and partly due to the effective treatment of many severe diseases such as cancer and cardiovascular diseases (Christensen and Vaupel 1996, WHO 2009). Recently however, Robine and Paccaud (2005) published population statistics data from Switzerland showing that more than half of the increase in the number of the centenarians can be explained with the decline in Swiss mortality after 80. At all ages, life-expectancy for

men is lower than for women. In the Finnish population in 2007, the life-expectancy for the 90 years old was 3.65 years for men and 4.20 years for women (Statistics Finland 2008).

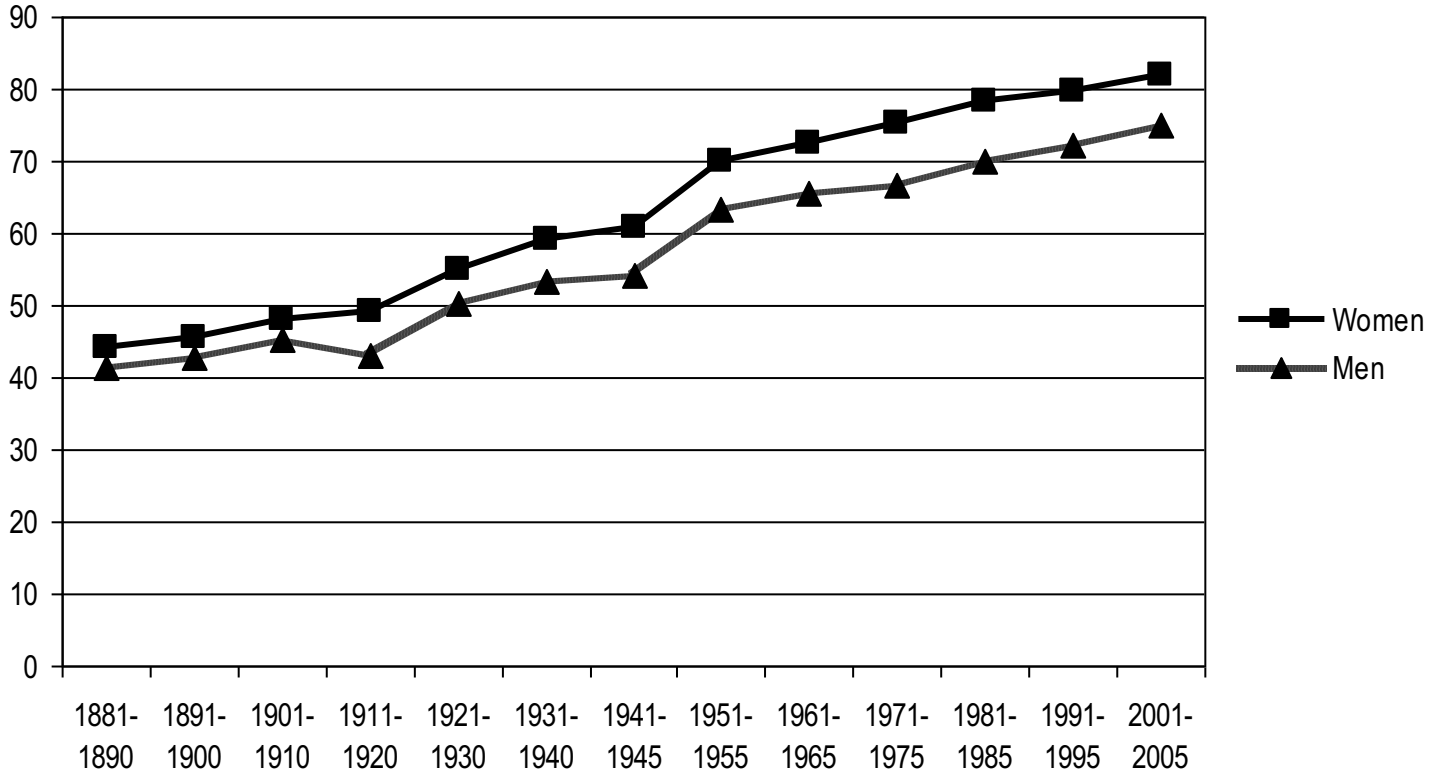

Figure 1. Life-expectancy at birth in Finland from 1880's to the 21st century. Source for data Statistics Finland, original publications 1881/90-1971/75: Väinö Kannisto - Mauri Nieminen: Revised Life Tables for Finland 1881-1990 and Statistics Finland Life Tables and Vital Statistics.

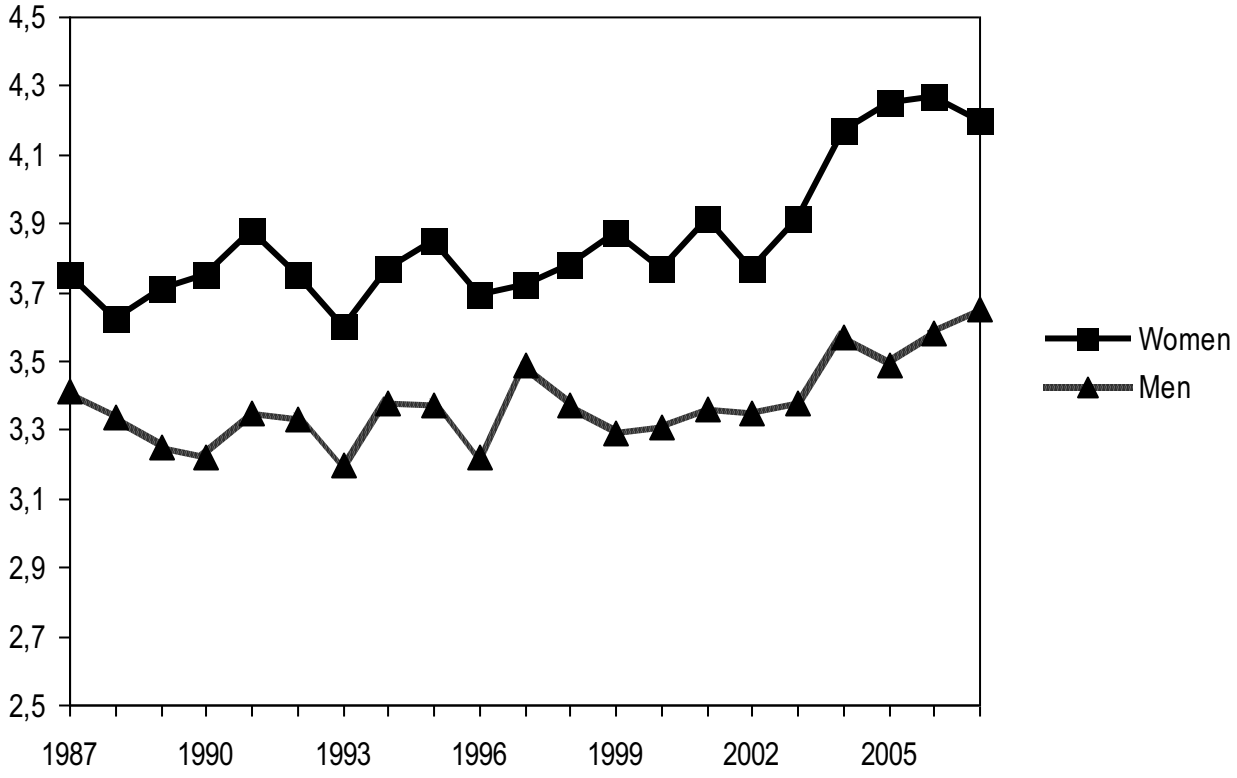

Figure 2. Life-expectancy at age 90 in Finland from 1987-2007. Source for data Statistics Finland.

In 2008, the life-expectancy at the age of 65 was around 84 years, but mortality increased rapidly after this age (Statistics Finland 2008). The maximum of the average life-span has not been determined, yet. When in 1920's the ultimate forecast was 65 years – which was already at that time true for Australian non-maori women, more recently, 85-90 years has been suggested based on mortality on known age-associated illnesses (Fries 1988, Olshansky et al. 1990, Harman 2001, Harman 2006). According to Olshansky et al. (1990), increasing the life-expectation with five years from the current 80 years would need cutting death rates by 65% at every age. This calculation suggested that even if all deaths due to heart disease and cancer were eliminated, the life-expectation of 85 years would not be reached. Opposingly, the mathematical evidence presented by the

demographists Oeppen and Vaupel (2002) suggests, that there is no ultimate limit, and that the average life-span of 100 years can be reached already in 60 years.

Will the average life-span continue to increase? All future forecasts of population aging are not as optimistic as the ones by Oeppen and Vaupel (2002). Mostly due life-style factors, there are new prospects of cutting down the current development. Tobacco smoking, alcohol use, and especially overweight are associated with metabolic syndrome and earlier onset of diabetes, cardiovascular diseases and cancer and may lead to decline in the increase or even shorter life-expectation (Struijs et al. 2005, Lipscombe and Hux 2007, Parker and Thorslund 2007).

2.2 Who Is Old – How Old?

Medical research has for long classified subjects as children, adults and older people or elderly. The name elderly is often used for everyone above the age 65 or in some sources above age 60. The classification of elderly can be culture-dependent and can be associated with the age of retiring from active work life. In many areas, official retirement occurs around age 65, and retirement from work life can be seen as a natural division into producing people and dependants. (WHO 2008) This classification was somewhat acceptable before, when the average life-span was shorter. In 2008, the group of people above 65 corresponds to 16.5 per cent of population in Finland (Statistics Finland 2008). This group includes the vast population of 65-years old recently retired relatively healthy people who have life-expectation of 20 years as well as the few nonagenarians and centenarians with life-expectation of a couple of years.

Since the 1980's, gerontological research has divided the older people commonly into the young-old, the old-old, and the oldest-old (Suzman and Riley 1985). These groups are not defined exactly; a rough synthesis of age ranges is introduced in Table 1. The chronological age is more specifically defined using the groups septuagenarian, octogenarian, nonagenarian, centenarian and super-centenarian referring to people who

have reached the named decade in their life with the super-centenarians being 110 years old and older (Robine and Vaupel 2001). A problem with any division of ageing people into subgroups is that people age differently. There is no certain physical age when the aging changes can be first detected. Genders age differently, and people with early illnesses may have a disadvantage for aging (for a review, see Rowe and Kahn 1987).

Table 1. Classifications of the old.

Age group	Common range of age
Elderly	60-65 and older (1)
Young-old	65-74 (2)
Old / Middle-Old	75-84 (2)
Septuagenarians	70 and older (2)
Old-old	70-89 (3, 4)
Octogenarians	80 and older (2)
Oldest-old	85 and older (2)
Nonagenarians	90 and older (2)
Centenarians	100 and older (2)
Supercentenarians	110 and older (2, 5)

1 WHO 2008, 2 Wikipedia 2009,3 Forman et al. 1992, 4 Cherry et al. 2008, 5 Robine and Vaupel 2001.

2.3 Compression of Morbidity, Compression of Disability

Increasing the average life span without significantly changing the maximum life span results in compression of mortality at the end of life (for a review, see Riggs 1992 and Olshansky and Carnes 1997). This is also called Gompertzian aging. While compression

of mortality with increasing longevity is a well known trend, it is currently discussed, whether the time of morbidity in aging populations is equally compressed, whether it is expanded or whether there is equilibrium of morbidity with the population aging (Fries 1998, Cai and Lubitz 2007, Parker and Thorslund 2007). It is possible that the time of being ill gets longer, if the age at onset of diseases stays the same and the interventions causing the extension of the life span occur after the onset of the illnesses (extension of morbidity). If the period of illness is postponed but not changed, the time of morbidity stays the same (equilibrium of morbidity). There are indications, however, that the age at onset of diseases is delayed to a greater extent than mortality resulting in compression of morbidity with the compression of mortality (Fries 1998 and 2003). These results have been criticized by stating that in many studies it is indeed onset of disability that is measured rather than morbidity of chronic diseases (Parker and Thorslund 2007). If the prevalences of chronic diseases are measured, the morbidity may be extended as it was shown by Parker et al. in Sweden (2005).

Some twenty years ago, it seemed that compression of morbidity was not happening. Instead of an increase of active years, the years of morbidity increased, and there was no evidence of postponing the onset of illnesses with the population aging (Brody and Miles 1990). It was argued that, while the time of onset illnesses might not change and the morbidity with chronic conditions might even increase, with early, active, and proper care of the illnesses the disability and death could be postponed (Schroll 1992). The hypothesis could be tested later by studying cohorts born 10 and 20 years apart (Cai and Lubitz 2007, Manton et al. 2008, Freedman et al. 2002, Crimmins et al. 2009). Strong evidence for compression of disability was found in a study, in which two elderly cohorts born 20 years apart were followed for 24 years, and it appeared that the younger cohorts were not only living longer but they were longer healthy (Manton et al. 2008). Even though the life-expectancy has continuously increased, the new epidemic of obesity and diabetes may in the future lower the life-expectancy (Catenacci et al. 2009, Walter et al. 2009).

With postponing disability, the active life expectancy has increased (Manton and Stallard 1991, Freedman et al. 2002, Crimmins et al. 2009). Active life expectancy refers to the years lived in good health without functional limitations (Katz et al. 1983). Here,

however, the gender-specific and age-specific differences grow even bigger. While a higher proportion of men's life-expectancy at age 65 was active, women at age 65 had larger amounts of active life expectancy. At age 85, the men had a higher absolute amount of active life expectancy than women (Manton and Stallard 1991).

2.4 Successful Aging and Longevity

There have always been those who have lived to a very old age. While life-expectancy has increased significantly (Wilmoth 2000 and Harman 2001, Robine and Paccaud 2005), the ultimatum of human life span changes very slowly, being now around 120 years of age (Wilmoth et al. 2000). Some old sources refer to people having lived significantly older, but there is no reliable documentation on that. Mortality increases rapidly after the 90^{th} birthday, and those who reach their 100^{th} year can be considered survivors (Evert et al. 2003). In the Finnish cohorts born in the first decade of the twentieth century, one in 5 lived to 90-years age, but only one in 100 lived to the age of 100 (Statistics Finland 2008). Thus, only every twentieth 90-year-olds lived to age 100 and nineteen of twenty died, most likely due to an illness.

The aging processes by definition are irreversible deteriorating events that occur with advancing age and meet everyone (for a review, see Hayflick 2007). The speed of these processes can, however, vary. Reaching extreme old age does not seem to follow the common laws of aging, and the known age-related diseases may be present or may not (Barrett 1985, Hagberg and Samuelsson 2008). It is customary to talk about successful aging meaning aging free of diseases and disabilities (Vaillant and Mukamal 2001), or, from the biological point of view, aging so that the extrinsic factors influencing the aging process are neutral or positive (Rowe and Kahn 1987). Despite the centenarians can be held as examples of successful aging for their old age alone, they are not free from illnesses and disabilities (Louhija 1994, Samuelsson et al. 1997, Andersen-Ranberg et al. 2001, Motta et al. 2005, Terry et al. 2008). According to Terry et al. (2008), nearly one-third of centenarians have age-related morbidities for 15 or more years, but compression of disability rather than morbidity is a key feature for survival to old age.

2.5 The Health and Functioning of the Nonagenarians

2.5.1 The Oldest-Old

The natural history of gerontology has evolved from studying older people or the elderly separately from younger adult people to studying ever older and older people (Boscoe 2008). It is recognized that disability and illnesses are more common rather towards the end of life at very old age than among the recently retired population (Williams et al. 1972, Murray and Lopez 1997, Marengoni et al. 2009), and this has created the practical need to further divide the old population (Boscoe 2008).

With the rapid increase of the population aged 85 or more, the term oldest-old was first introduced in a special journal issue dedicated for them in 1985 (Cornoni-Huntley et al. 1985, Suzman and Riley 1985). While the extreme-old centenarians and supercentenarians can be studied as a model of human aging in biological sense (Perls and Terry 2003, Willcox et al. 2008), practical information of the larger and thus population-wise meaningful group of the oldest-old is needed (Suzman and Riley 1985, Jylhä and Hervonen 1999, Boscoe 2008). The oldest-old have many characteristics special to very old age, but, in addition, as a larger group they are also an essential part of the society (Boscoe 2008, Vaupel 1997). Thus, how the oldest-old are and what happens to them makes a difference.

2.5.2 Health, Disease, and Functioning

In several studies, it has been noted that most of the oldest old live in the community, and more of the nonagenarian men than women live in the community (von Heideken Wågert et al. 2006, Xie et al. 2008). Earlier attitudes towards the oldest-old expressed the respect on reaching very old age and assumed that the oldest-old were healthy or at least healthier than the younger old (Jensen and Bellecci 1987, Hitt et al. 1999). In 1987, Jensen and Bellecci compared nonagenarian men to men twenty years younger, and stated that the nonagenarians were more physically active, consumed less alcohol, smoked less, used fewer medications but had more heart disease, visual and hearing problems, and lower

scores of cognitive function (1987). However, in most studies in the past decade that have looked into different aspects of health, the oldest-old appear to be more ill than the younger (von Strauss et al. 2000, Hall et al. 2005, von Heideken Wågert et al. 2006, Corrada et al. 2008, Xie et al 2008). A New Zealand study shows that the known exponential relationship of age with morbidity and mortality for people aged sixty-five to eighty-four years did not continue for people aged ninety years and older. At ages 90 and older, the mortality rates and indicators of morbidity were considerably lower than expected. (Wilkinson and Sainsbury 1998)

Studying an unselected normal population of the oldest-old other than the centenarians is rare. Some studies with a large and representative sample of the oldest-old have been published, such as the Italian Longitudinal Study on Aging (ILSA) (Maggi et al. 1994), the Kungsholmen project (Fratiglioni et al. 1992), Leiden 85+ Study (von Faber et al. 2001), and the Danish study on 1905-born (Nybo et al. 2001b). Functional status and self-rated health are reported more often than health and medical history. Table 2. shows a collection of studies on the oldest-old. In many of them, the start point of the study was at age below 90, but the age was reached with follow-up.

Table 2. Studies on nonagenarians

Study	Focus	Age	N (n of oldest)	Publications
Berlin Aging Study	Psycho-social, internal medicine	70-105	516 (90+: 52)	1-2
Danish 1905 Cohort	Health, life style, functional, cognitive	90	2262	3-6
Helsinki Vantaa 75-85,	Health	75-85	hundreds (85: 255)	7-8
ILSA*	Diabetes, cardiovascular, neurological disorders	65-85	5632 (80-85: 1408)	9-14
Kungsholmen Project	Dementia, health	75 and older	2368 (85+: 518)	15-17
Leiden 85+ Study	Functional status, morbidity, mortality	85	599 (90 at follow-up: 275)	18-20
Umeå 85+	Morbidity, health, age, gender	85 and older	253	21-22
Vantaa 85+	Cognition, genetics	85 and older	533	23
Vitality 90+	Health, life style, functional, cognition, genetics	90 and older	thousands	24-25

*Italian Longitudinal Study on Aging

1 Wernicke and Reischies 1994, 2 Smith et al. 2002, 3 Nybo et al. 2001a, 4 Nybo et al. 2001b, 5 Andersen et al. 2002, ,6 Nybo et al. 2003, 7 Tilvis et al. 1995, 8 Tilvis et al. 2004, 9 Maggi et al. 1994, 10 The Italian Longitudinal Study on Aging Working Group 1997, 11 Di Carlo et al 2002, 12 Noale et al. 2003, 13 Farchi et al. 2004, 14 Maggi et al. 2006, 15 von Strauss et al. 2003, 16 Marengoni et al. 2009, 17 Fratiglioni et al. 1992, 18 den Elzen et al. 2009, 19 von Faber et al. 2001, 20 Bootsma-van der Wiel et al. 2005, 21 von Heideken Wågert et al. 2006, 22 Bergdahl et al. 2005, 23 Myllykangas et al. 2000, 24 Jylhä and Hervonen 1999, 25 Niemi et al. 2003.

2.5.2.1 Self-Rated Health

A Swedish study on very old subjects indicated, that while morbidity was best viewed from medical records, self-reports gave additional information especially for less objective health problems (Nilsson et al. 2002). The reported medical history can be complemented using self-rated health, which is known to be a good indicator of morbidity and mortality (van Doorn and Kasl 1998, Bosworth et al. 1999, Helmer et al. 1999, Hoeymans et al. 1999, Jylhä et al. 2006). However, among the very old, self-rated health and physician-rated health do not necessarily agree (Kivinen et al. 1998). Centenarian studies have shown that the oldest-old often estimate their health good or satisfactory when interviewed, even though they suffer from several chronic conditions (Louhija 1994, Andersen-Ranberg et al. 1999). Most nonagenarians report their health very good or good in spite of physical limitations (Nybo et al. 2001b, Xie et al. 2008). At the presence of chronic diseases, relatively good self-rated health may reflect the low expectations for health at very old age (Jylhä 2001). Self-rated health can rise from different viewpoints depending on the reference group – global, age-comparative, and self-comparative self-rated health, and when these were studied separately, the perceptions were more positive for the age-comparative self-rated-health, compared to the pessimistic ratings of the self-comparative measure, particularly for the oldest-old (Sargent-Cox et al. 2008).

2.5.2.2 Cognition

Where medical research has succeeded in finding relief to many age-related physical diseases, dementia stays as a key problem of the aging population (Baldereschi et al. 1999) with incidence up to 10% per year after age 85 (Aevarsson and Skoog 1996). Among the oldest-old, the prevalence of dementia is high and may continue to increase with advancing age (Hall et al. 2005, Berlau et al. 2007) unless there are significant changes in the preventiong and postponing of the disease (Ferri et al. 2005). Study results on the prevalence of dementia among the oldest-old vary greatly depending on the

diagnostic criteria (Heeren et al. 1991, Skoog et al. 1993, Ebly et al. 1994, Olafsdottir et al. 2000, Berlau et al. 2007). In a wide population study, the prevalence of dementia after age 90 was even 45% in women and 28% in men. In women, the prevalence doubled every five years of age. (Corrada et al. 2008) Neurophysiological dementia tests may show cognitive deterioration that does not cause functional disabilities (Corey-Bloom et al. 1996, Graham et al. 1997), raising the question, whether dementia screening tests can be reliably used at very old ages. Poor physical health (Frisoni et al. 2000) and depression (Geerlings et al. 2000) are examples of conditions that may lead to decreased test results without clinical dementia. There are earlier indications that test results may be partially age-dependent. Reischies and Geiselman showed that at age 85 and older the sensitivity of Mini-Mental State Examination (MMSE) is very good, but specificity for dementia is lower than in a younger age group (1997).

2.5.2.3 Mobility and Disability

In the Danish 1905-born cohort, the self-reported disability and functional limitations in nonagenarians were high. Of the men, 19% and 22% of the women severely disabled, and 50% of the men and 41% of the women not disabled. Men performed better in the physical performance tests than women, even though the men's mortality was higher. (Nybo et al. 2001b) The Swedish Kungsholmen project reported similar results in disability with 73% of the nonagenarians being functionally independent. In the nonagenarian women the prevalence and also incidence of long-term disability were higher than in men, but significant gender differences in mortality were not detected (von Strauss et al. 2003, Marengoni et al. 2009). In the Leiden 85-plus study, disability in activities of daily living was present in 17% of the oldest-old. Of the chronic diseases studied, stroke, Parkinson's disease and dementia were associated with disability. (Bootsma-van der Wiel et al. 2005)

In the very old, accumulation of limitations in mobility and cognitive deficits predict institutionalization (von Bonsdorff et al. 2006). Functional disablities may be associated with chronic illnessess (Marengoni et al. 2009) or be part of geriatric syndromes, especially sarcopenia (Baumgartner et al 1998,). Sarcopenia refers to the age-related

decline in lean body mass that affects the functional capacity of older adults (Rosenberg 1997), and its prevalence may be more than 50% in people older than 80 years (Baumgartner et al 1998). In a Spanish population aged 65 and older, only 62.3% of respondents reported having no disabilities, even though the prevalence of chronic conditions was high with 95.5% reporting at least one chronic condition (Valderrama-Gama et al. 2002).

When in younger populations, chronic conditions forecast mortality better than disabilities, in the nonagenarian population, the disability showed to be a better indicator for mortality (Lee et al. 2008, Marengoni et al. 2009). Naeim et al. (2007) suggested that self-estimate of one's functional limitation may have value as a marker of severity of disease and predicts serve as a good predictive measure for mortality, especially in specific illnesses such as cancer.

2.5.2.4 Morbidity

There are few studies providing population-level information on morbidity of the oldest-old. Scattered data on certain diseases is available through multiple studies, but the study groups are often very selected and small. In the Umeå 85+ Study, a majority of a small local age cohort, 253 people older than 85 years were studied using multiple sources for information (von Heideken Wågert et al. 2006). Prevalences of chronic diseases were high compared to those of the Leiden 85-plus study (Bootsma-van der Wiel et al. 2005) for 85-years old and older or those reported from the Kungsholmen project, a community-based survey in Stockholm for 75 years old and older (Marengoni et al. 2009). Table 3. introduces some of the published morbidity data from these three studies.

Prevalence of many diseases increase with advancing age, cancer being perhaps the best-known example with increase in incidence until very old age post 90 years (Miyaishi et al. 2000, Stanta et al. 1997). In addition to increase of prevalence of many diseases, multimorbidity is known to increase with age up to 78% in patients 80 years old and older (van den Akker M et al. 1998). In the Kungsholmen project, about 80% of nonagenarians had at least one chronic disease, but three quarters were functionally independent (von Strauss et al. 2000).

Table 3. Prevalences of chronic or severe medical conditions among the 90-year-olds according to literature.

	Study		
	Umeå 85+ N=86 (90)	Leiden 85+ N=586 (85)	Kungsholmen N=1,099 (77+)
Disease	(1)	(2)	(3)
Anemia			13%
Cancer	12% (past 5 years)		5%
Diabetes	12%	14%	5%
Cerebro-vascular disease	29%	10% (stroke)	7%
Heart failure	29%		18%
Atrial fibrillation	21%		10%
Myocardial infarction		10%	
Coronary heart disease			15%
Hypertension	50%		38%
Dementia	27%	10%	21%
Depression	34%		8%
Parkinson's disease		3%	
Eye disease (cataract)	37%		15% (any)
Eye disease (glaukoma)	19%		
Lung disease		12%	5%
Arthritis		33%	
Urinary tract infection	29%		
Hip fracture	23%	6%	4%

1 von Heideken Wågert et al. 2006, 2 Bootsma-van der Wiel et al. 2005, 3 Marengoni et al. 2009

2.5.3 Need for Health Care

Does the increase in number of the oldest old mean that we have a rapidly growing population that suffers from numerous diseases and increasingly uses health care services? In the USA from 1986 to 1993, the use of hospitals and nursing homes during the last year of life declined for people aged 85 and older (Liao et al. 2000). In the same study, it was reported that restrictions in activities of daily living decreased and quality of life improved. However, it is obvious that not only health status of older people but also the changing practices of health care influence the use of services. Vallgarda (1999) states that the hospitalisation rates have been increasing remarkably in the older age groups for both sexes since the 1970's. This increase seems to be greater than what could be estimated based on the proportion of the older people in the population. The number of admissions and readmissions of the older people to hospital has increased significantly (Säynäjäkangas et al. 1997, Vallgarda 1999). This development is more evident with certain individual diagnoses. For example, the rate of hospital admissions for pneumonia among aged 65 and older increased significantly from 1972 to 1993 in Finland, and the increase was particularly high among men aged 85 years or older (Säynäjäkangas et al. 1997).

A small proportion of the Danish 1905 cohort was studied on the use of hospitals at age 92-93 years. About 30% of the local population studied were hospitalized at least once during the year of study. However, in the past 25 years, the average number of hospitalizations was only 4 and the mean number of days in hospital 38. (Nybo et al. 2001a)

While very old age increases the mortality in severe conditions such as hip fracture or acute myocardial infarction, many of the oldest-old also survive these conditions. The outcome of intensive care for the oldest-old was poor with about 40% in-hospital mortality (Chelluri et al. 1992, Rellos et al. 2006). However, as the one-year-mortality in this age group is 20%, the increase of risk of death due to intensive care is relatively lower than it appears. Similarly, in acute myocardial infarction, one-year-mortality in nonagenarians was 47%, causing therefore about 30 per cent unit increase to the average

(Hovanesyan and Rich 2008). Knowing the risks of large surgical operations in very old people, a cautious evaluation of the need to operate was suggested earlier (Michel et al. 1984). With more experience and a growing oldest-old population with conditions requiring surgery, it has been shown that, for example in hip fracture operations, the outcomes are generally good in nonagenarians, and the risk is not associated with age (Jennings and Boer 1999, Formiga et al. 2003). Nowadays, even heart operations are recommended based on the patient's clinical condition, and not based on the patient's age (Bacchetta et al. 2003).

2.5.4 Medication

The use of medication in the aged has increased in the past decades (Jylhä, 1994). The use of medication increases with age, and Linjakumpu et al. (2002) reported as high as 97% use of prescription drugs by 84-years-old and older. The trend of increase in medication has continued in recent years and among the oldest-old as well (Linjakumpu et al. 2002, Jyrkkä et al. 2006).

The older people form a special group in respect of drug therapy due to changed pharmacodynamics and pharmacokinetics, many individual differences, and many illnesses (Zhan et al. 2001, Fick et al. 2003). Multiple chronic conditions may require medication, increasing the risk of polypharmacy (Fick et al. 2003). Treating drug-induced symptoms with additional medication increases polypharmacy (Rochon et al. 1999).

2.5.5 Causes and Predictors of Mortality

According to Statistics Finland, the most common underlying causes of death of the elderly men in 2007 were coronary heart disease, cerebro-vascular diseases, dementia, lung cancer, and prostate cancer. The most common causes of death for elderly women were coronary heart disease, dementia, cerebro-vascular diseases, other cardiac diseases, and injuries (Statistics Finland 2008). Autopsies are not frequently performed on the very old, and the written cause of death is often based on a clinician's best estimate (Berzlanovich et al. 2005).

Multiple co-morbidities and long-term disabilities give the clinician an impression of continuum to death. Sometimes, the cause of death in very old age is described being due to frailty, which is often described as status of global impairment of physiological reserves involving multiple organ systems (for a review, see Topinková 2008). With a different view in an autopsy study, the most deaths in nonagenarians and centenarians were caused by ischemic heart disease, bronchopneumonia, fractures, acute myocardial infarction, cerebro-vascular accident, and ruptured aneurysm, and only about 20% of the deaths were multifactorial (John and Koelmeyer 2001, Berzlanovich et al. 2005)

In the oldest-old, the association of chronic conditions with mortality is not as clear as in the younger populations (Jylhä et al. 2006). In a vast study on Danish nonagenarians, self-reported chronic conditions did not predict mortality (Nybo et al. 2003). However, disability and cognitive impairment were significant risk factors in men and women, and a significant association with mortality was detected with poor self-rated health in women (Nybo et al. 2003). Small sample size in the studies of the oldest-old often limits the significance of results. In the NonaSantfeliu study on nonagerian mortality, the only significant indicators on mortality seemed to be age, heart failure and nutritional status (Formiga et al. 2007).

3. Aims of the Study

Hypothesis

The 90-year-olds are at the oldest end of usual aging. Surviving to very old age does not equal to good health, when the age group mortality is high and mortality is associated with morbidity.

To test the hypothesis, the following aspects were studied:

1. Based on the information received through medical records and self-reports, how are morbidity, mobility, and cognition of the 90-year-olds? (I, III)

2. How good is the data agreement of health information from different sources for chronic illnesses, for cognition, and for functional capacity? (II, IV)

3. How does the self-rated health relate to information obtained from medical records and from self-reports of the 90-year-olds? (II, IV)

4. To which extent and due to which illnesses do the 90-year-olds use hospitals? (III)

5. To which extent do the medical record data, MMSE, functional capacity, self-rated health and medication predict mortality in a four-year follow-up? (IV)

4. Subjects and Methods

4.1 Cohorts

The study was focused on the health of 90-year-olds people living in Tampere. For most parts of the study, the target population consisted of all people born in 1907-1908 and living in Tampere in January 1999, and of all people born in 1909-1910 and living in Tampere in January 2000. These cohorts together form the core study population of 914 subjects, 189 men (20.7%) and 725 women (79.3%) (Figure 3.).

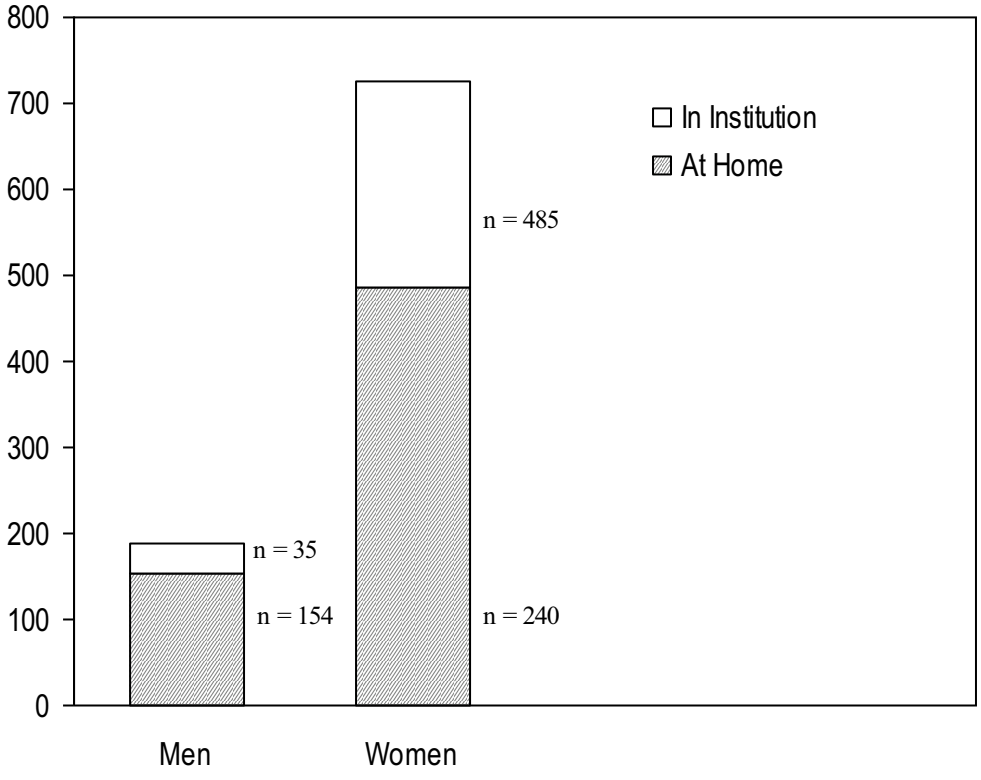

Figure 3. 1907-1908 and 1909-1910-born at age 90. Men, women, home, institutions.

The population register gave information on gender and living arrangement. The main approach was to study the health of these people using medical records for physician-recorded data on illnesses, memory and mobility. This data was supplemented by a mailed interview for experienced health and illnesses, and by testing the cognition and activities of daily living. Hospital patient database and patient discharge database were studied for essentially the same population. However, hospital patient database and patient discharge database were available only for a limited range of time because of the database reorganizations. For this reason, a year older population data of the 1907-1910-born in Tampere was used for hospital use, and the total number of subjects was 1077, 222 men (20.6%) and 855 women (79.4%).

Mortality of the study population was followed for four years using population register data. Among the 90-year-olds, annual mortality exceeds 20% of the population, which is visualized in Figure 4.

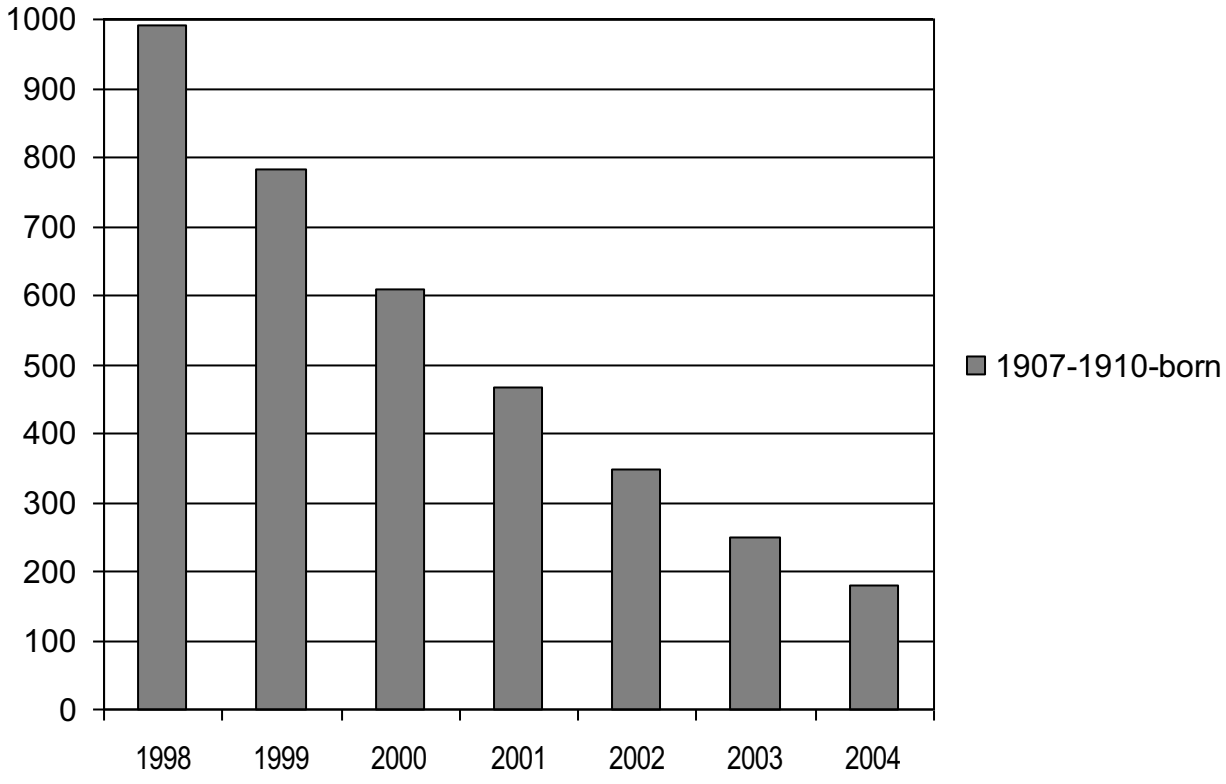

Figure 4. Tampere 1907-1910-born population in years 1998-2004 (Statistics Finland 2008).

As mentioned above, several sources were used to obtain a more comprehensive picture about the nonagenarian health. Figure 5. presents a flow-chart showing the relationships among the data sources and the parts of the population they covered.

4.2 Health Care System and Medical Records in the Region

Tampere is a growing technology and industrial city of ca 200,000 inhabitants located in Southern Finland. Of its current population, 1.5% are 85 years old or older. The public health benefits cover everyone. The public health care system in Finland is organized into hierarchic levels that are closely integrated with one another. Tampere hosts one of the five university hospitals in Finland. In addition, there are a general hospital and four geriatric hospitals in the city. The four geriatric hospitals have somewhat different profiles: 1) geriatric for mainly short-term treatment, 2) geriatric for short-term and long-term care of the city's nursing home residents, 3) long-term treatment of mostly bedridden patients and 4) psycho-geriatrics. The university hospital only provides highly specialized acute care; rehabilitation after treatment in the university hospital is continued in city hospitals. The city health centers with outpatient clinics are connected with the general hospital; two of the geriatric hospitals also provide outpatient services. At the time of the study, there were no private in-patient hospitals in the region. However, there were several private outpatient clinics in Tampere. The city hospitals' and health centers' combined systematic medical records reach back to 1972. Since 1972, physicians have been required to keep records of each patient visit by law, and all records since then are archived. Records have to report reason for each visit, patient's medical history, symptoms, diagnosis, and treatment. The clinic secretary ascertains that the physician has properly completed the records, and these records then follow the patient in the city health care system. As there are no private hospitals, any disease leading to hospitalization in Tampere after the year 1972 therefore shows usually in the public

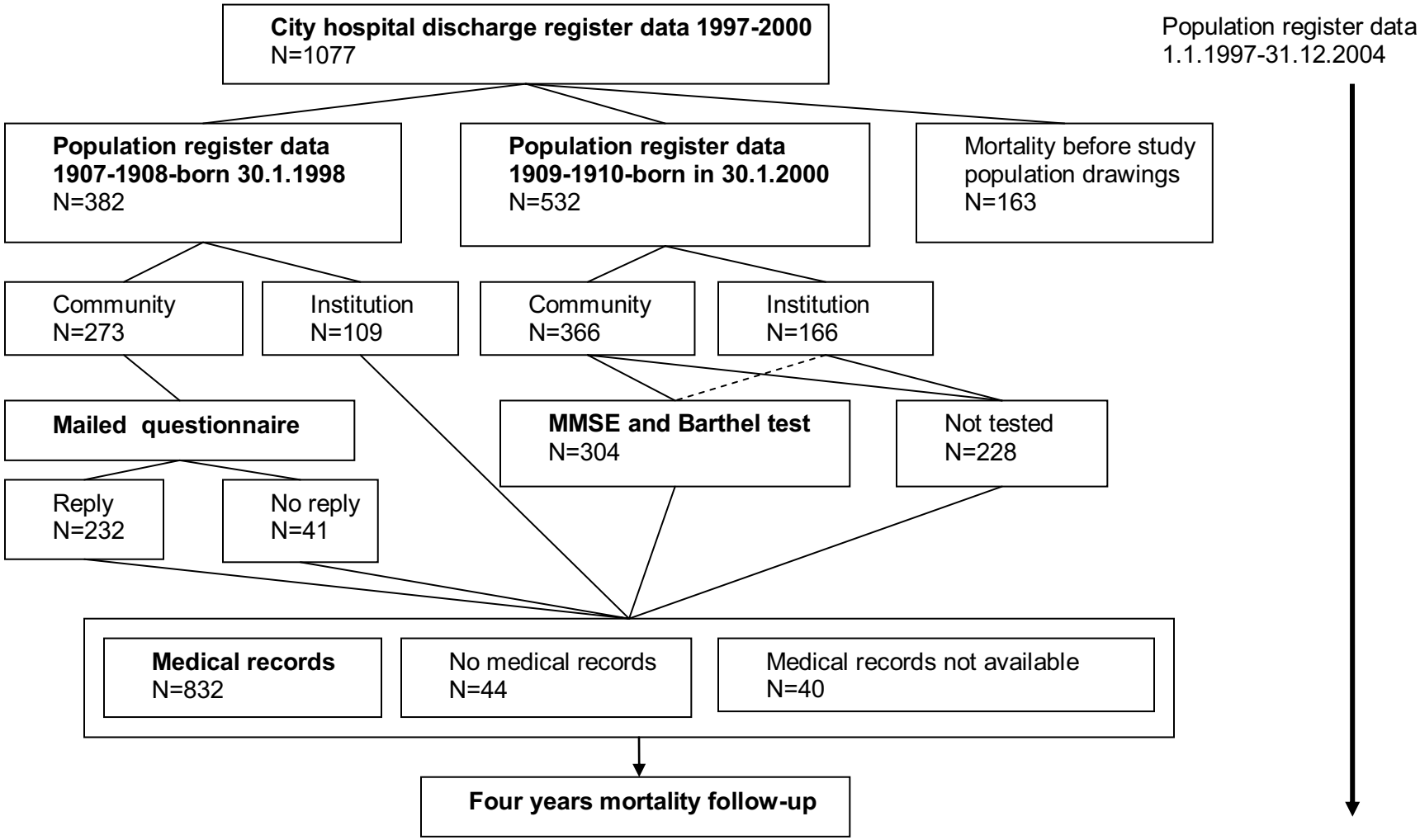

Figure 5. The 90-year-olds in Tampere. Data sources.

health records. A common practice is that earlier illnesses such as severe infections or operations are recorded as well. However, if a person chooses to use only the private health care physicians, information about chronic diseases and earlier hospitalizations is not available from the city records.

A total of 832 cases were studied using public health care physicians' records from the city health centers and hospitals. This corresponds to 90.7% of the basic population. The missing 9.3%, 84 people altogether, fell into two categories: 44 people did not have health records in the city hospitals or health centers and 40 people had records, which were not available at the time of the study. There was no significant difference between community-dwelling and institutionalized groups (10.8% and 8.9%, respectively) or between men and women (7.9% and 9.5%, respectively) in the proportion of drop-outs. Of the 44 subjects with no health records in the city hospitals, 10 replied to our mailed questionnaire of health (II) and 20 gave information on medication to a related study in the Vitality 90+ framework (Jylhä and Hervonen 1999). The questions of these two studies were not identical, but, combining above mentioned data, at least 23 subjects with no medical records reported one or more chronic diseases, most often a heart disease, dementia or rheumatoid arthritis (9 of 10 cases), or daily use of 3 or more prescription medicines (14 of 20 cases). This suggests that subjects with no medical records may have had health problems comparable to subjects with available records.

The city hospitals and health centers medical records were used for collecting diagnoses of chronic diseases or diseases that required hospitalization at any time of the subjects' life as well as physicians' remarks on their memory and mobility. All physician-recorded remarks were included if the disease was identified. The diagnostic background was not further confirmed. When the diagnosis was made in the health center, the diagnostic criteria were normally available. However, if the diagnosis was made in the university hospital or by a specialist from the private sector, no diagnostic criteria were presented in the records. Thus, for example the diagnosis of dementia or depression was accepted without any further statements of neuropsychological testing. A plain description of symptoms of common geriatric diseases was not recorded as a diagnosis. A remark of forgetfulness was not recorded as "dementia" without an explicit diagnosis of dementia. The medical history was listed as follows: diagnosis, year when diagnosed and

year when mentioned if the year of diagnosis was not mentioned. The data was coded according to the International Classification of Diseases, 10th Revision (ICD-10) (International Statistical Classification of Diseases and Related Health Problems 2009.). Some conditions could be classified in more than one way, and of those dementia was placed under psychiatric disorders, transient ischemic attack under neurological disorders, and respiratory and uninary infections under the corresponding organ group rather than under infections, following the most common choices used in the medical records. Hereby, I use the term 'life-time prevalence' for the current and past medical conditions that appeared in the public health records since 1972. Most records mentioned some major illnesses prior to 1972, such as appendicitis, gall stones, or scarlet fever. Manual registering by a physician was chosen, as coding for diagnoses was varying and overlapping.

Medical records remarks about memory and mobility were recorded from the time of ± 2 years from the 90th birthday, preferably at the age of 90. Data was available for 578 subjects (70.1% of those with medical records available). Mini-Mental State Examination scores were rarely available, and physicians' remarks of memory were used for cognition. Memory was coded as follows: good, forgetful, poor memory, demented. This classification was chosen according to the common remarks in the doctors' status descriptions. I accepted a clear statement about the memory or a remark referring to cognitive skills, but statements such as "active and cheerful patient" or "in good health for his/her age" were coded 'missing' as they did not directly indicate good cognitive state.

Mobility was coded as follows: good (moves with no support or uses light support as a walking stick), moderate support (uses rollator), heavy support (uses wheel chair or needs supporting persons to move) and bedridden. This coding is based on the most common doctors' remarks. Mobility testing scales were rarely available.

4.3 Hospital Patient Database and Hospital Discharge Register

One-year retrospective data on each cohort was collected from hospital registers and the population register (III).

Data was collected from the population register, the city hospital discharge register, the university hospital discharge register, and the city hospital patient database, which covers the general and geriatric hospitals in the region. I recorded the number of admissions, length of stay per admission, number of hospital days in calendar year, main diagnosis, and hospital. A narrow minority of the 90-year-olds had used the university hospital services during the follow-up period. For these admissions, I was able to obtain other data but not the main diagnosis.

In the hierarchic health care system, patients typically first enter a general hospital for acute care; any prolonged treatment would then be continued in a geriatric hospital. For the purposes of this study, a continuous chain of treatment from one hospital to another was regarded as one period and classified according to the last hospital. Only admissions to the university hospital were always recorded separately, even though the rehabilitation afterwards was often carried out in the city hospitals. If the subject was already in hospital in the beginning of the follow-up, an initial value of 1 admission was given. All days in hospitals were included independent on whether the reason for admission was medical or rather social. In some cases, an old person was admitted to hospital for the caretaker's vacation, and there was no obvious medical reason for the need of care.

4.4 Mailed Questionnaire

A mailed-questionnaire was sent to the home-dwelling 1907-1908-born population (II). Altogether, 232 people responded to our questionnaire (87.0% of men and 84.3% of women). In 31.7% of the cases, some other person had assisted the 90-year-olds in filing the questionnaire. Full medical records were available for 90.1% of the respondents with their informed consent. With a participation rate of 85.0%, the final data of this study cover 76.6% of the population of the home-dwelling 90-year-olds (N = 209).

The questionnaire consisted of 32 questions. For 31 of them, respondents were asked to select from 2-5 given options, and one question, asking for occupation, was open-ended. The questionnaire was designed with attention to clarity and readability. Most questions were about managing daily life. Respondents were asked to evaluate their current health on the scale 'very good', 'fairly good', 'average', 'fairly poor', and 'very poor'. Subsequently, eleven common geriatric conditions were asked, as follows: "Has a doctor detected any of the following diseases in you?" The selected diseases were hypertension, heart disease, stroke, diabetes, cancer, dementia, depression, Parkinson's disease, hip fracture, osteoarthritis, and rheumatoid arthritis.

For analysis, self-rated health was re-classified for analysis into three groups instead of the original five, combining 'fairly good' with 'good' and 'fairly poor' with 'poor'. For this study, physicians' remarks on memory were re-classified into two groups, 'good' or 'impaired'.

4.5 Physical Tests

Clinical testing covered 57% of the 1909-1910-born. For testing, a major limiting factor was mortality before testing and during the test period. The testing was carried out during the year 2000, and of the 383 people still alive in the beginning of 2001, 73.1% were tested (n=280). All city residents born in 1909-1910 (n = 534, 106 men and 428 women) were contacted by letter and by phone for recruiting participants. Additionally, a trained nurse or a medical student visited the city nursing homes looking for subjects in good enough condition to participate. There were 305 participants (57.0% of the 1909-1910-born population, 68.9% of men and 54.2% of women, 65.0% of the home-dwelling population and 39.8% of those living in institutions). A trained nurse or a medical student visited the subjects, and did a short interview followed by the Mini-Mental State Examination (MMSE) (Folstein et al. 1975) and the Barthel test for activities of daily living (Mahoney and Barthel 1965). The Mini-Mental State Examination is a brief test mapping different aspects of cognition, and has been considered a valid screening test for dementia (Kahle-Wrobleski et al. 2007). The test gives maximally 30 points, if all tasks

are correctly performed. The Barthel test for activities of daily living is examining the ability to independently manage daily activities such as feeding or grooming as well as physical condition with measures of ability to get up, to walk on a flat surface, and to walk stairs with a maximum score of 100 points (Folstein et al. 1975). The final number of tested subjects was 300 (74 men and 226 women), as one subject refused to do the MMSE and in four cases, the interviewer judged their dementia so severe that administrating the Mini-Mental test would have been a major stress to the subjects.

4.6 Survival

Accurate data on dates of death for all subjects was obtained from Statistics Finland. The follow-up period for this paper was set to about four years using the 94th birthday as the end point, until which age 63.6% of the original cohorts died. This allowed using survival statistics and presenting the individual associations of the studied variables for future use as a reference.

4.7 Ethical Concerns

The study protocol was reviewed and accepted by the Tampere City Ethical Committee (permission number 1592/403/96).

4.8 Statistical Methods

The medical history was presented in frequency tables showing prevalences of chronic illnesses and earlier severe conditions. Comparisons between the groups were performed using the Pearson corrected t-test for normally distributed continuous variables, Mann-Whitney U-test for continuous variables with skewed distribution, and χ^2-test for distributions of categorical variables. For analyzing agreement of data from two sources, Cohen's κ-test was used. In κ-test coefficient values below 0.40 were considered poor to

fair accuracy, 0.40-0.60 moderate accuracy, 0.60-0.80 substantial accuracy, and 0.80-1.00 almost perfect accuracy, as earlier suggested by Landis and Koch (1977). In addition to comparison of frequencies with χ^2-test, Kaplan-Meier analysis with Mantel-Cox method for evaluation of significance was used for survival analysis. SPSS was used for statistical analysis (SPSS Inc., Chicago, USA).

5. Summary of the Results

Four out of five 1907-1910-born 90-year-olds in Tampere were women and one out of five men (79.3% and 20.7%). Most were living in their homes in the community (66.9% of women and 81.5% of men). (Figure 3.)

5.1 Morbidity

5.1.1 Past and Current Medical Conditions

The medical records revealed about a hundred different medical conditions in the medical history of the 90-year-olds that were classified according to ICD-10. The rarest conditions were not separately analyzed but were included in the main diagnosis groups. Table 4. is briefly presenting the most common medical conditions, whereas more detailed lists can be found in Appendix I and Appendix II.

Table 4. The lifetime prevalence of medical conditions according to medical records. The conditions are ordered according to ICD-10, and the diagnoses whose frequency was 10% or more are presented.

Class	Disease	Frequency (%)
A Bacterial infections		
B Viral infections		
C Malignant tumors		
	Cancer other than basalioma	13.8
D0-48 Benign tumors		
D50-99 Hematological diseases		
	Anemia	16.8

E Endocrinological diseases		
	Thyroid disease	15.2
	Diabetes	12.9
F Psychiatric diseases		
	Dementia	24.6
	Depression	10.7
G Neurological diseases		
	Transient ischemic attack	10.1
H0-59 Eye diseases		
	Cataract	13.7
	Glaucoma	10.2
H60-99 Ear diseases		
I Cardiovascular diseases		
	Coronary heart disease	44.8
	Chronic heart failure	36.7
	Hypertension	36.1
	Atrial fibrillation	22.6
	Stroke	16.9
	Myocardiac infarct	15.0
	Varicose veins	10.0
J Respiratory diseases		
	Respiratory infections	27.7
K Gastrointestinal diseases		
	Gall stones	27.1
	Functional bowel disease	18.1
	Hernia	15.3
	Appendicitis	14.1
	Diverticulosis	13.4
L Skin diseases		
M Musculoskeletal diseases		
	Osteoarthritis	22.7
	Diseases of back	10.6

N Urinary tract diseases		
	Urinary tract infections	26.0
	Prostate hyperplasia (men)	42.9
O-Q Diseases during pregnancy, perinatal diseases and malformations		
R Symptoms		
	Vertigo	10.6
S-Y Trauma		
	All fractures	40.4
	Hip fracture	17.2
	Wrist facture	14.6
W Other reasons for using health care		

Including operations and severe infections at younger age, the average number of diagnoses of severe or chronic diseases in the medical records was 8 (IQR 2-14) (median (IQR), range 0-20). The average number was 7 (IQR 1-13) for men (range 0-18) and 8 (IQR 2-14) for women (range 0-20). This difference was not significant in the Mann-Whitney U test. In the institution-living 90-year-olds, the median was 9 (IQR 2-15), whereas the values for the community-living were 7 (IQR 1-13, $p = 0.000$). Of the 90-year-olds, 14.8% had up to three recorded diagnosis of chronic diseases and other severe illnesses or traumas, most commonly a cardiovascular disease. Of the 90-year-olds,, 36.4% had 10 or more recorded illnesses that were either chronic or had required hospital care.

Specific diagnoses that were mainly seen among the institution-living nonagenarians were dementia, depression, diabetes, urinary tract infections, and hip fracture. In addition, other conditions commonly impairing a person's ability to live independently were more common in institutions. These include severe heart diseases, brain circulatory diseases, diseases impairing mobility, and eye diseases. The prevalences of individual conditions are shown in Table 5. There was no significant difference in the life-time prevalence of cancer, hematological diseases, or gastrointestinal diseases between the types of

dwelling.The nonagenarians in institutions had commonly a history of dementia with more than half (64.9%, n=131) of the subjects suffering from it, while one out of six subjects living in community had dementia. When all cases with dementia were removed from the analysis to reveal other conditions, the illnesses more common in the institution-living stayed otherwise the same, but additionally osteoporosis (7.6%, 16.0%, p = 0.006), diverticulosis (12.6%, 19.3%, p = 0.042), constipation (17.0%, 25.2%, p = 0.028), and coronary heart disease (42.1%, 52.1%, p = 0.031) showed association with living in institution.

Table 5. The lifetime prevalence of diseases that were more frequent in the institution-dwelling population.

	Frequency (%)		
Disease	Home	Institution	Significance
Infections	47.7	67.2	<0.001
Dementia	14.5	54.2	<0.001
Depression	5.8	20.3	<0.001
Psychosis	1.7	7.2	<0.001
Chronic heart failure	32.4	43.5	0.013
Stroke	15.2	21.2	0.038
Transient ischemic attack	8.6	16.3	0.012
Diabetes	10.6	18.6	0.002
Disease of the back	41.8	50.0	0.018
Osteoarthritis	20.5	28.0	0.012
Hip fracture	14.7	23.3	0.003
Eye diseases	19.9	29.9	0.002

5.1.2 Self-Reported Morbidity and Inter-Source Agreement

Of the community-living 90-year-olds, 76.6% replied to the mailed questionnaire. There were no significant gender differences in responses to the questionnaire or availability of medical records of the respondents ($p = 0.376$ and $p = 0.239$, respectively). The presence of 11 common diseases was asked. Of the selected diseases (see Table 6.), men reported 1.6 ± 1.1 diseases (mean ± SD), whereas women reported 2.3 ± 1.4 diseases (mean ± SD). The gender difference was significant ($p = 0.002$).

Table 6. shows the prevalences of the selected diseases based on medical records (columns D+) and self-reports (columns P+), source-dependent prevalences of the diseases, concordance and discordance of the data, and κ-statistics for agreement of the data. Inter-source agreement showed substantial accuracy in the clearly defined conditions diabetes, hip fracture, and Parkinson's disease. In these diseases 19.0%, 29.6%, and 40.0%, of the diagnosed patients reported negative ([D+P-] / [D+P+ + D+P-]), but only 4.0% of all subjects reported diabetes and 6.5% a hip fracture that was not recorded in the medical records (D-P+). Many diseases were reported less often than the medical records indicated, for example only half of the patients with diagnosed cardiovascular diseases or cancer reported them. Agreement was independent of physician-recorded impaired memory ($0.157 \leq p \geq 0.709$), indicating that the mismatching answers were not mainly a result of poor cognition. Neither was underreporting diagnosed diseases associated with good self-rated health ($0.274 \leq p \geq 0{,}864$).

The common joint diseases osteoarthritis and rheumatoid arthritis were often reported by subjects who did not have these diseases mentioned in their medical records and *vice versa*. To check, whether confusion in identifying the conditions was causing this, the groups were combined. However, this did not remove the disagreement of the data ($\kappa = 0.20$).

The subjects reported more often dementia (28.0%) and depression (19.0%) than the medical records (12.0% and 6.5%, respectively), suggesting that physicians had either failed to recognize these conditions in the 90-year-olds, did not consider recording them

essential, or that the mild problems in memory or depression were not sufficient to make a diagnosis.

Table 6. Comparison between medical records and reports by the 90-year-olds: prevalences of diseases and agreement ot the sources. D+ recorded by the doctor, D- not recorded, P+ reported by the 90-year-olds, P- not reported. PreM prevalence using medical records PreP prevalence using subjects reports, C concordance, Disc discordance.

	Data groups (%)				Prevalence and data concordance				
	D+P+	D+P-	D-P+	D-P-	PreM	PreP	C	Disc	K
Disease	1	2	3	4	1+2	1+3	1+4	2+3	
Heart disease	44.1	31.7	4.5	19.8	75.8	48.6	63.9	36.1	0.288
Hypertension	21.4	20.5	5.9	52.2	41.9	27.3	73.6	26.4	0.432
Stroke	5.5	8.3	0.5	85.7	13.7	5.9	91.1	8.9	0.509
Cancer	8.4	7.9	3.4	80.2	16.3	12.8	88.6	11.4	0.532
Diabetes	6.4	1.5	4.0	88.1	7.9	10.4	94.5	5.5	0.673
Dementia	9.5	2.5	18.5	69.5	12.0	28.0	79.0	21.0	0.369
Depression	2.5	4.0	16.5	77.0	6.5	19.0	79.5	20.5	0.110
Parkinson's disease	3.0	2.0	0.0	95.0	5.0	3.0	98.0	2.0	0.740
Rheumatoid arthritis	1.5	0.5	10.4	87.6	2.0	11.9	89.1	10.9	0.187
Osteoarthritis	12.0	10.5	21.0	56.5	22.5	33.0	68.5	31.5	0.225
Arthritis, combined	14.1	11.2	23.9	50.7	25.3	40.0	64.8	35.2	0.204
Hip fracture	11.9	5.0	6.5	76.6	16.9	18.4	88.5	11.5	0.607

5.2 Mobility and Activities of Daily Living

Mobility was evaluated based on physician's remarks in the medical records (available for 67.4% of all subjects) and using Barthel test (32.8% of all subjects).

Physicians' recent remark on mobility was available for 616/832 subjects with medical records. Half of them (49.6%) needed no or only light support such as a walking stick to

move. Using a rollator was common (28.7%). Every tenth (11.2%) was bedridden. It is not surprising that the proportion of bed-patients was higher in the institutions (19.9%) than in the community (3.8%, $p < 0.001$). Mobility at home and in institutions is visualized in Figure 6. More men needed no or light support than women (men 69.6%, women 45.8%, $p = 0.000$). The gender difference was visible in both community-living (men 77.6%, women 59.6%, $p = 0.004$) and in institution-living (men 40.7%, women 22.8%) 90-year-olds. However, the group of institution-living men was very small (n=35), and the gender difference of mobility in the institution-living was not statistically significant.

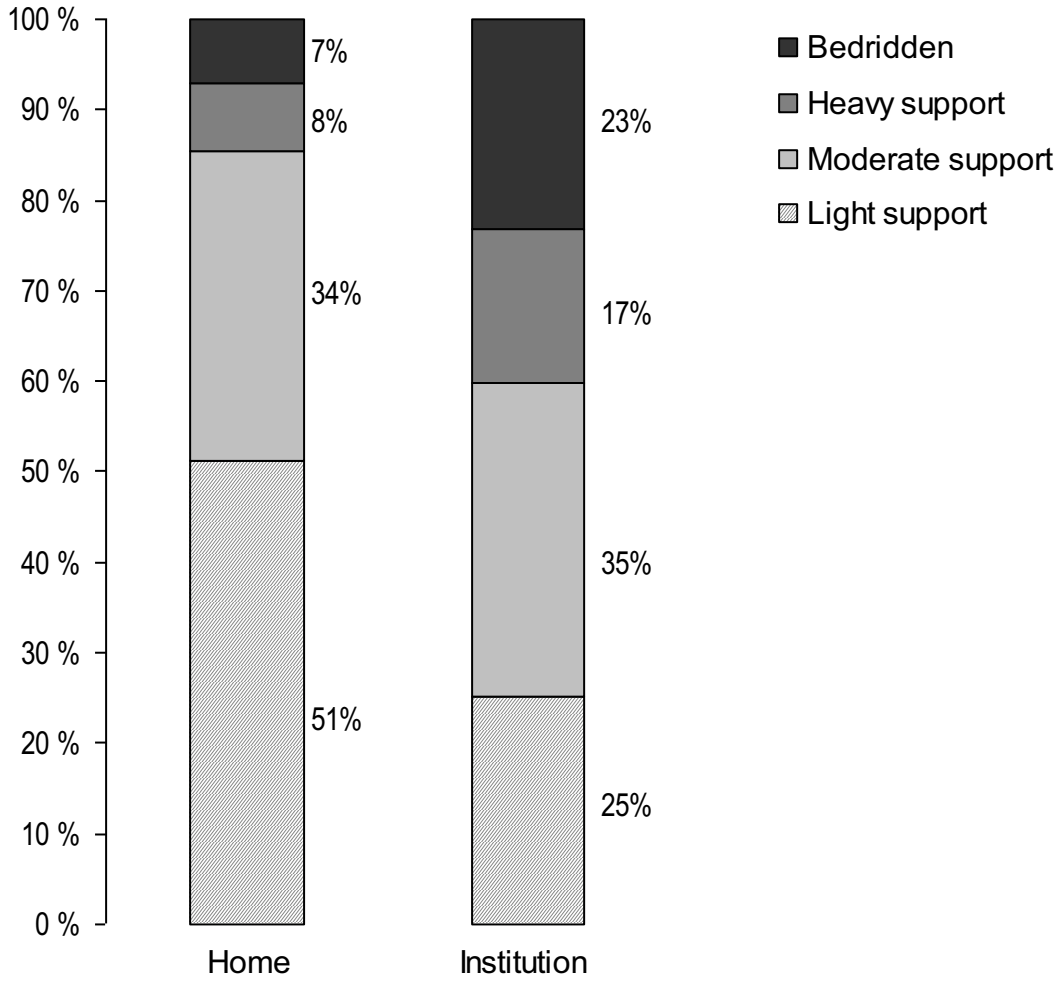

Figure 6. Mobility in 90-year-olds living at home (69.9%, n=639) or in institutions (30.1%, n=275) based on physician's remarks in the medical records.

The Barthel test for activities of daily living was performed on 300 subjects. Tested cases were those in relatively good health, which resulted in a significant selection bias. Among the tested subjects, the median test result in Barthel test was 95 (IQR 70-100). There was no gender difference (men 95 (IQR 75-100), women 95 (IQR 70-100) p = 0.758), but the results were better in community-living (home 100 (IQR 90-100), institution 52 (IQR 10-92) p = 0.000). Of the tested, 40.7% received the maximum test result 100.

5.3 Cognition

The cognitive state was evaluated based on physician's remarks in the medical records (available for 63.2% of all 1909-1910-born subjects) and using MMSE test (32.8% of all 1909-1910-born subjects).

Physicians' recent remarks on memory were available for 578 subjects. About half of the subjects were evaluated to have good memory (48.3%) while one third (33.7%) were given the statement "demented". Including the expressions 'forgetful' and 'poor memory', the data indicated memory problems in at least 35.9% of the study population. As expected, there were clearly more demented people in the institutions (53.0% demented) than in the community (11.9% demented, p < 0.001) (Figure 7.). Of all cases with the memory remark, more men than women had the rating 'good' (men 61.7%, women 44.3%, p = 0.004). The gender difference was visible in both community-living (men 70.5%, women 59.2%) and in institution-living 90-year-olds (men 33.3%, women 20.5%), but there was no evident statistical significance.

Memory testing using the Mini-Mental State Examination was performed on 300 subjects. The tested subjects were relatively healthy, and the selection bias was obvious. The median MMSE result for all cases was 25 (IQR 18-30). There was no gender difference (men 26 (IQR 19-30), women 25 (IQR 18-30) p = 0.755), but the results were better in community-living (home 26 (IQR 20-30), institution 21 (IQR 11.5-30) p = 0.000). Of the tested, 37.3% received a test result of 26 or higher. Based on the testing, at least 21.0% of the 90-year-olds can be estimated to have relatively good cognitive skills with the test result 26 or higher (112/534).

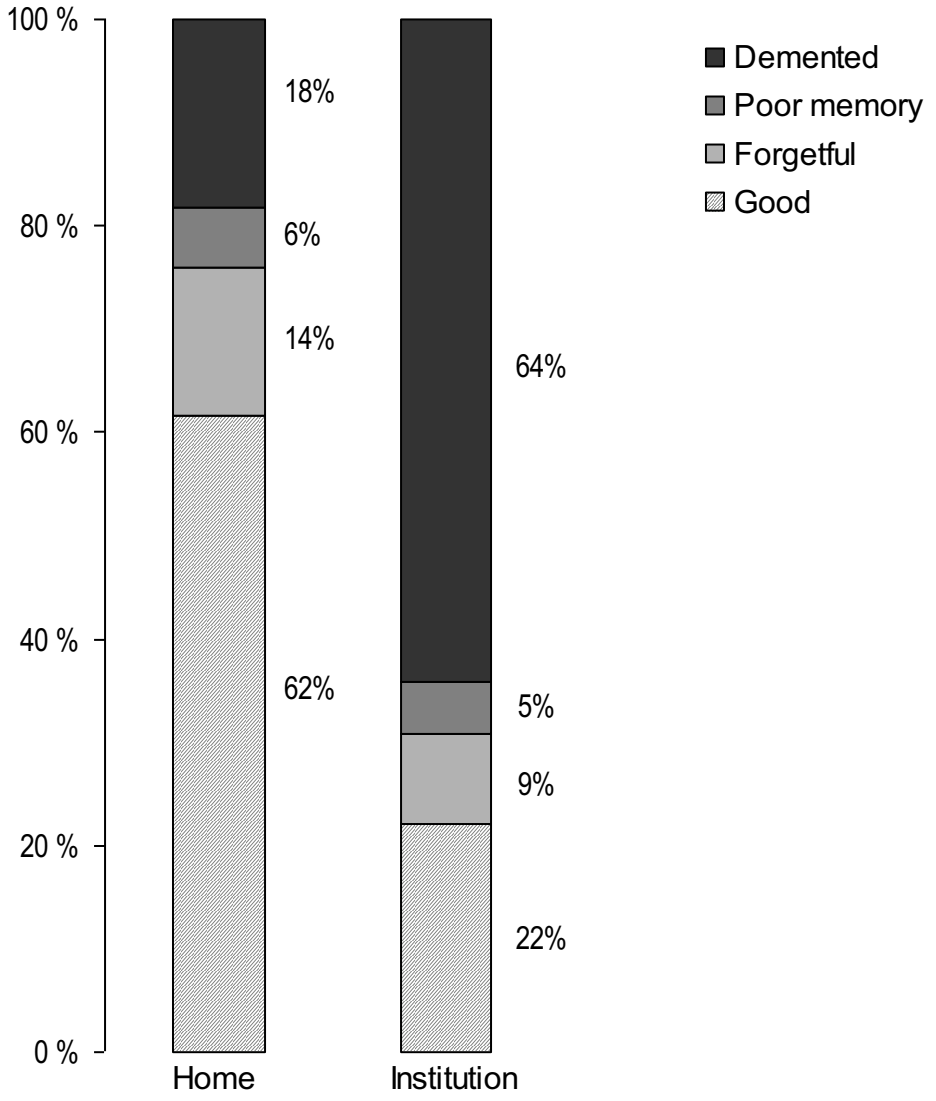

Figure 7. Cognitive state in 90-year-olds living at home (69.9%, n=639) or in institutions (30.1%, n=275) based on physician's remarks in the medical records

There was a strong association between the MMSE score and the physician's remark on memory in the medical records (Table 7.). However, in groups of "impaired memory" and "demented", there were numerous cases with MMSE test result of higher than 25 ("impaired memory" 8 of 30 cases and "demented" 4 of 36 cases). In cases with no remark on memory, the tested memory appeared to be rather good (mean 24.1, SD 4.6, range 9-30).

Table 7. Association of MMSE test result to physician recorded remark on cognitive state.

	MMSE			
Physician's remarks	N	median	IQR	range
Not recorded	114	25	20-30	9-30
"Good"	95	27	23-30	13-30
"Impaired"	30	22	14-30	10-30
"Demented"	36	14	2-26	0-28

5.4 Association of Mobility to Cognition

The problems with memory and mobility were concentrated in the institution-living 90-year-olds (see above). Additionally, poor mobility was associated with physician-recorded dementia. Of those with dementia diagnosis, 39.2% were bedridden or needed heavy support for moving, whereas of those with no recorded diagnosis of dementia, only 7.8% needed heavy support for moving ($p < 0.0001$). This may partly be due to the facts that end-state dementia leads to physical inability, and that the majority of the bedridden people may have been evaluated to be demented.

5.5 Self-Rated Health

Of the home-living 1907-1908-born 90-year-olds, 232 subjects replied to our mailed questionnaire (76.6% of the community-living). Of them, 77.5% evaluated their current health good or average. The gender difference was significant: 91.6% of men reported their health good or average, whereas only 72.5% of women did ($p = 0.028$). Poor self-rated health was associated with certain conditions recorded in the medical records or in the questionnaire and also with multiple co-morbidities ($p<0.001$).

Table 8. Self-rated health in 90-year-olds. Association with diagnosed and self-reported diseases. Rheumatoid arthritis and osteoarthritis were combined before analysis. D+ diagnosed by physician. P+ self-reported.

Disease	Self-rated health				
	Very good n (%)	Good n (%)	Average n (%)	Poor n (%)	Very poor n (%)
Heart disease D+ (n=156)	3 (2)	54 (35)	58 (37)	31 (20)	10 (6)
Heart disease P+ (n=109)	1 (1)	37 (34)	39 (36)	22 (20)	10 (9)
Hypertension D+ (n=87)	1 (1)	29 (33)	35 (40)	18 (21)	4 (5)
Hypertension P+ (n=63)	0 (0)	22 (35)	26 (41)	11 (18)	4 (6)
Stroke D+ (n=29)	0 (0)	8 (28)	9 (31)	11 (38)	1 (3)
Stroke P+ (n=12)	0 (0)	0 (0)	4 (33)	7 (59)	1 (8)
Cancer D+ (n=33)	1 (3)	10 (30)	17 (52)	5 (15)	0 (0)
Cancer P+ (n=24)	1 (4)	7 (29)	11 (46)	5 (21)	0 (0)
Diabetes D+ (n=17)	0 (0)	7 (42)	5 (29)	5 (29)	0 (0)
Diabetes P+ (n=23)	1 (4)	9 (39)	6 (26)	5 (22)	2 (9)
Dementia D+ (n=23)	0 (0)	4 (17)	6 (29)	9 (37)	4 (17)
Dementia P+ (n=61)	1 (2)	20 (33)	22 (36)	12 (20)	6 (10)
Depression D+ (n=14)	0 (0)	3 (21)	6 (43)	4 (29)	1 (7)
Depression P+ (n=41)	0 (0)	8 (19)	14 (34)	15 (37)	4 (10)
Parkinson's disease D+ (n=10)	0 (0)	0 (0)	4 (40)	4 (40)	2 (20)
Parkinson's disease P+ (n=6)	0 (0)	0 (0)	0 (0)	4 (67)	2 (33)
Arthritis, combined D+ (n=52)	1 (2)	19 (37)	22 (42)	7 (13)	3 (6)
Arthritis, combined P+ (n=85)	1 (1)	23 (27)	36 (42)	20 (24)	5 (6)
Hip fracture D+ (n=34)	1 (3)	7 (21)	18 (52)	7 (21)	1 (3)
Hip fracture P+ (n=38)	0 (0)	8 (21)	20 (54)	9 (24)	1 (3)

The subjects reporting the following diseases rated their health fairly poor or poor significantly more often than those without the diseases: Parkinson's disease (100.0% fairly poor or poor, $p = 0.0001$), stroke (66.6% fairly poor or poor, $p = 0.0002$), depression (46.3% fairly poor or poor, $p = 0.0006$), rheumatoid arthritis (38.7% fairly poor or poor, $p = 0.0384$), and heart disease (29.4% fairly poor or poor, $p = 0.0370$).

Parkinson's disease, stroke, and depression were associated with poor self-rated health also when mentioned in the medical records. Additionally, physician-recorded dementia diagnosis was strongly related to poor self-rated health (52.5% fairly poor or poor, p = 0.0004). Table 8. shows the distribution of self-rated health with respect to selected illnesses. Interestingly, self-rated health was not better, if a physician-recorded disease was not reported in the questionnaire ($0.274 \leq p \geq 0{,}864$).

5.6 Use of Medication

A recent list of medication was given in 78.2% of the medical records (639 cases, 69.9% of all subjects). "No medication" was registered for only 6.1% of cases. At the other end, there were up to 17 different medicines listed for one person's daily use. Polypharmacy may reflect multiple co-morbidities, therapy-resistant conditions, and also unnecessary medication.

More medication was recorded in the medical records of insitution-living 90-year-olds than for the community living, and the number of prescribed medicines was higher for women than men (Table 9.). Gender difference and difference in the type of living for all cases and within genders were statistically significant (P = 0.000).

Table 9. Use of medication. Median number of medicines prescribed, inter-quartile range and range are shown.

	Women		Men		All	
	Median	IQR(range)	Median	IQR(range)	Median	IQR(range)
Community	5	1-9(0-15)	4	0-9(0-11)	4	1-7(0-15)
Institution	7	3-11(0-17)	6	2-10(1-11)	7	3-11(0-17)
All	5	0-10(0-17)	4	0-8(0.11)	5	1-9(0-17)

5.7 Use of Hospitals

During a one-year follow-up at age 90, the cohorts of 1907-1910 born, altogether 1,077 people, had a total of 1,108 admissions and 44,215 hospital days (1,042 admissions, 43,551 hospital days in the city hospitals and 76 admissions, 664 hospital days in the university hospital). This is 41 hospital days per each 90 years old person per year. During one year, 48.8% of the study group, 43.2% of men and 50.3% of women, had been in hospital at least once. Men spent significantly fewer days in hospital than women. The average number of days in hospital per year was 19 ± 55 days (mean ± S.D.) for 90-year-olds men and 46 ± 94 days (mean ± S.D.) for 90-year-olds women ($p < 0.001$). If only those who were admitted to hospital at least once are included ($n = 560$), the average number of days in hospital per year was 45 ± 78 days (mean ± S.D.) or 19 (median) for men and 91 ± 115 days (mean ± S.D.) or 34 (median) for women. The gender differences were significant ($p < 0.001$). In the population, 6.7% ($n = 72$) were staying in hospitals permanently, and, in these cases, the length of stay ranged from 1 to 44 years. Only 5 (6.9%) of the permanently hospitalized were men, which is significantly smaller than the proportion of men in the population. About 31% of the population lived in other institutions such as nursing homes at the time of the study.

The number of admissions to hospital during one calendar year ranged from 0 to 13, although more than one period was rare. For eight or more admissions, the reason was always social, which in most cases meant arranging respite care and relief for the primary caregiver.

The main diagnosis at discharge was most typically in the category of cardiovascular diseases (28.8%), followed by injuries (16.3%), infections (12.4%), and psychiatric diseases including dementia (11.6%) (Table 10.). Psychiatric diseases including dementia and cardiovascular diseases needed the most days in hospital, accounting for 36.3% and 25.5% of all days in hospital. Table 11. lists the diagnoses resulting in the most hospital days and admissions. The most common individual diagnoses at discharge were hip fracture (10.8%), dementia (9.3%), coronary heart disease (8.6%), respiratory infections (6.9%) and chronic heart failure (6.8%). Dementia, coronary heart disease and stroke resulted in the most days in hospital (34.1%, 7.9% and 6.9% of all days in hospital,

respectively). Interestingly, several common diseases at very old age such as cancer (1.1% of all days in hospital), functional bowel diseases (0.7% of all days in hospital) and diabetes (0.5% of all days in hospital) were rarely the cause of a hospital period in the population aged 90.

Table 10. Days in hospital in one calendar year per 1,000 90-year-olds persons classified according to main diagnosis at discharge.

ICD-Class		Hospital days
F	Psychiatric diseases including dementia	14,662
I	Cardiovascular diseases	10,326
S-Y	Injuries	3, 063
J	Respiratory diseases including infections	1,382
M	Connective tissue diseases	1,266
N	Urinary tract diseases including infections	1,022
G	Neurological diseases other than dementia	809
K	Gastrointestinal diseases	804
W	Other reasons for using health care services	558
R	Symptoms (urinary symptoms, collapse and vertigo)	487
C	Malignant tumors	426
D50-99	Hematological diseases	273
A-B	Bacterial and viral infections	241
E	Endocrinological diseases	186
L	Skin diseases	132
D0-48	Benign tumors	79
H	Eye and ear diseases	72

The mean length of stay closely correlated with type of hospital, ranging from 9 days in the university hospital and 16 days in the general hospital to 231 days in the geriatric hospital with mostly bedridden patients. The hospitals also differed in regard to the typical diseases treated, mortality, and the proportion of men (see Appendix III for details). The number of days in hospital for the 90-year-olds population was the highest

for geriatric hospitals specializing in long-term care, but the largest number of admissions was recorded for the general hospital.

Table 11. Top ten list of diagnoses resulting in most hospital days at age 90. Hospital days per 1,000 90-year-olds persons/year, hospital periods at age 90, and mean length of stay per period.

Disease	Hospital days	Periods	Length of stay (mean)
Dementia	13,773	97	552
Coronary heart disease	3,451	90	66
Stroke	3,014	41	174
Chronic heart failure	2,068	71	32
Hip fracture	1,998	113	26
Respiratory infections	1,251	72	22
Depression	1,006	15	104
Urinary tract infections	988	40	26
Psychosis	966	8	1290
Atherosclerosis	953	39	29

5.8 Gender

There were fewer men than women aged 90, but a smaller percentage of men were living in institutions (men: 18.5%, n=35, women: 33.1%, n=240). They had slightly fewer chronic illnesses based on medical records (men: median 6 (IQR 1-11), women: median 7 (IQR 2-12)), and more men than women had good memory function (men: 61.7%, n=71, women: 44.3%, n=203). More men needed no or light support than women (men 69.6%, women 45.8%, p = 0.000). The gender difference was visible in both community-living (men 77.6%, women 59.6%, p =0.004) and in institution-living 90-year-olds (men 40.7%, women 22.8%), but the latter comparison is lacking statistical significance with the small group of men in institutions (n=35). In the Barthel test for activities of daily living, however, no gender differences were detected (men 95 (IQR 75-100), women 95 (IQR 70-100) p = 0.758).

Table 12. Gender differences in form of living, health, and morbidity at the age of 90 years.

		Gender		
		Women N=725	Men N=189	Significance
Of the original birth class reached this age (Statistics Finland 2008)		10.8	2.9	
Living in the community		68.8	83.1	<0.001
Good cognition (medical records)		44.7	62.4	<0.001
Move independently		69.9	71.3	0.409
Co-morbidities* median (IQR)		8 (2-14)	7 (1-13)	0.204
History with	Infections	52.4	58.6	0.087
	Cancer	15.8	24.9	0.005
	Cardiovascular	79.9	72.2	0.021
	Lung	7.7	5.9	0.277
	Diabetes	13.5	10.7	0.200
	Dementia	26.2	18.3	0.020
	Depression	12.3	4.7	0.002
	Digestive system diseases	56.5	66.9	0.009
	Connective tissue diseases	46.6	35.5	0.006
	Urinary	3.8	3.0	0.395
	Injuries	49.5	33.1	<0.001

* Number or recorded chronic illnesses or medical conditions that required hospital care at any time of the subjects' life.

While most diseases were equally common in men and women, a few showed gender differences. Even though generally less ill, men had more often cancer (men: 24.9%, n=42, women:15.8%, n=103), hepatitis (men: 2,4%, n=4, women: n=0), lung infections (men 36.1%, n=61, women 25.6%, n=167), peptic ulcer (men: 14.2%, n=24, women: 8.7%, n=57), hernia (men: 35.5%, n=60, women: 10.1%, n=66), and uric arthritis (men:

7.7%, n=13, women: 4,1%, n=27). The male gender associated prostate hyperplasia (47.3%, n=80) and prostate cancer (8.7%, n=14) were common.

The number of prescribed medicines was higher for women (5 (IQR 0-10)) than for men (4 (IQR 0-8) $p<0.001$). During one year, 48.8% of the study group, 43.2% of men and 50.3% of women, had been in hospital at least once. Men spent significantly fewer days in hospital than women (19 ± 55 days (mean ± S.D.) and 46 ± 94 days (mean ± S.D.), respectively, ($p < 0.001$)). Table 12. summarises the medical records data for gender differences. A detailed list of medical conditions can be found in Appendix I.

Of the selected 11 medical conditions asked in the mailed questionnaire, men reported significantly fewer than women (men 1.6 ± 1.1 diseases (mean ± SD), women 2.3 ± 1.4 diseases (mean ± SD), $p = 0.002$). The community-living men evaluated their health better than women. Of men, 91.6% reported their health good or average, whereas only 72.5% of women did ($p = 0.028$).

5.9 Survival and Its Predictors

Mortality was studied in a one-year follow-up of all Tampere 1907-1910 born during the calendar year they turned 90, and with the population sample of 1907-1910-born follow-up until age 94, by which age two out of three in the original study groups had died.

The one-year follow-up at age 90 was using population register data and hospital discharge registers. During the year of study, 18.6% of the study population died (n = 200, 17.1% of men, n = 38, 18.9% of women, n = 162). Of them, 83.1% died either in hospital or shortly after discharge from hospital. Of the institution-living, 29.4% died, whereas only 10.7% of the community-living died. Among those 90-year-olds who had one or more hospital admissions, one-year mortality was 32.2% with no evident gender differences. One-year mortality for those who had no admissions to hospitals was only 6.2%. The most common diagnoses at the last discharge were dementia (17.0%) and coronary disease (15.5%).

Two thirds (63.6%) of the study cohorts born in 1907-1910 died before age 94. The gender differences in the whole cohort mortality in the study period were minor (men

67.7% and women 62.5%), but living in an institution was associated with an increase in mortality (institution 80.4% and community 56.3%). In institutions, the mortality was nearly equal for both genders, but women living in the community had an advantage over men. Figures 8. and 9. show the mortality curves of men and women, as well as mortality in institution-living and home-living populations. Life-expectancy calculations for the 90-year-olds men and women and those living in institutions and at home are shown in table 13.

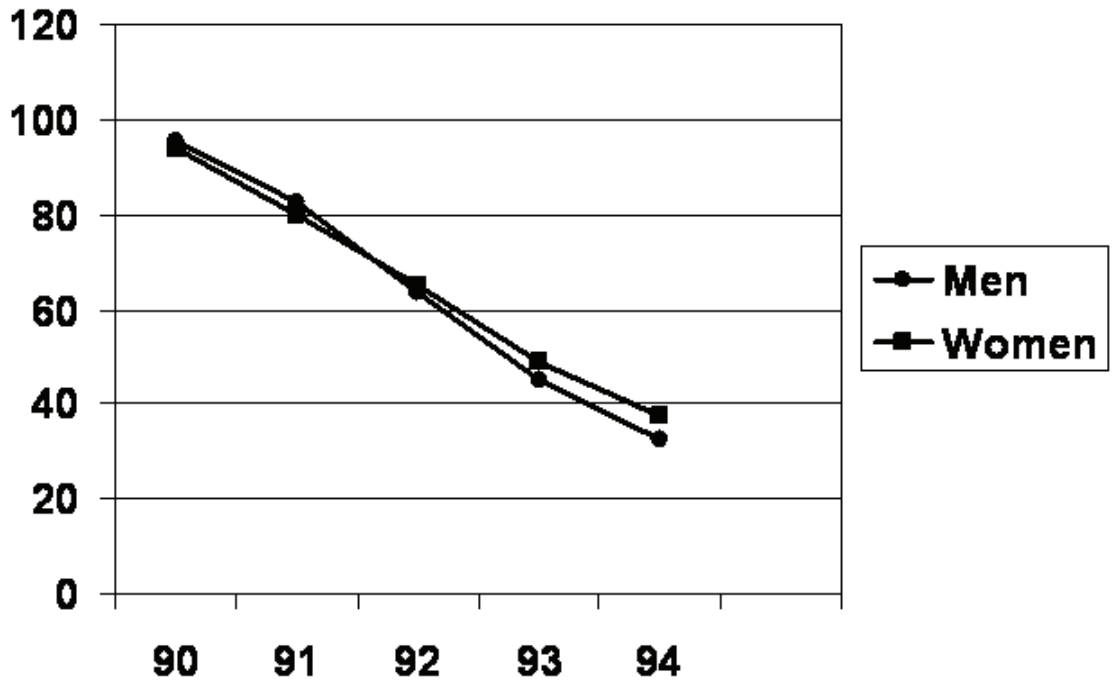

Figure 8. Nonagenarian mortality. Men and women. The diagram shows how many percent of the original cohorts born 1907-1910 reached each birthday.

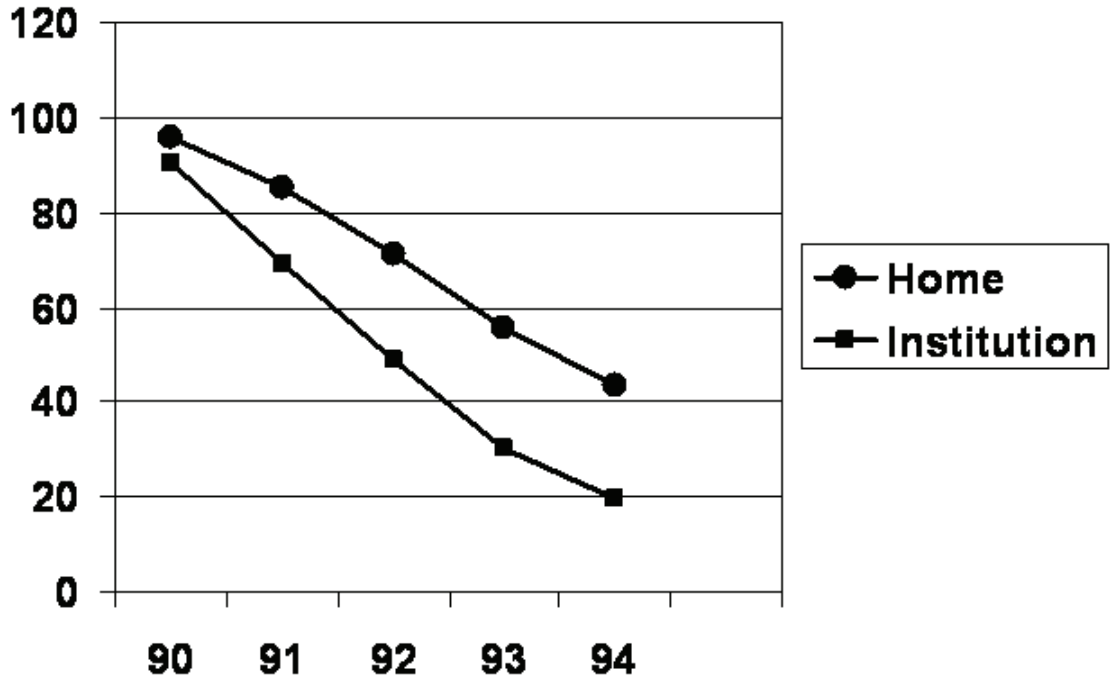

Figure 9. Nonagenarian mortality. Living in the community or in institutions. The diagram shows how many percent of the original cohorts born 1907-1910 reached each birthday.

Table 13. Expected survival of a 90-year-olds in the study groups. Follow-up time until the 94th birthday.

	Life-expectancy	
Grouping factor	Age (95% confidence interval)	Significance
All (n=914)	92.9 (92.8-93.0)	
Men (n=189)	92.8 (92.6-93.1)	
Women (n=725)	92.9 (92.7-93.0)	0.267
Home (n=639)	93.2 (93.0-93.3)	
Institution (n=275)	92.1 (91.9-92.4)	<0.001

When the medical records contained any physicians' remarks on the cognition, the mortality increased from 55.7% with "no remark on memory" to 65.9% with "remark on memory" (p=0.004). Mortality values in the classes "no remark on memory" (55.7%) and "memory good" (55.6%) were almost equal. This may indicate that memory was recorded mostly in cases of dementia or in cases of poor state of health. Even though fewer of the men were recorded to be demented according to the medical records (16.5% of men, 25.5% of women), all of the men classified "demented" (n = 28) died before age 94. Of the demented women, 72.0% died.

Similarly, all 13 men needing heavier support for moving than a walking aid (7.6%) died before age 94 (survival 0%), while of the 114 (17.5%) women needing heavy support for moving 14 survived (survival 12.3%).

Just as well as the medical records remarks on mobility and memory, good results from MMSE and Barthel testing were suggesting higher survival. The median of MMSE was 26 (IQR 21-30) for those who survived to 94 and 24 (IQR 15.5-30) for those who died (p = 0.003). The results were similar for both genders, though, with no statistical significance for men (men 26 (IQR 21.75-30) and 25 (IQR 17-30) p=0.428, women 26 (IQR 21-30) and 23 (IQR 14-30) p=0.003). The home-living subjects had better survival and higher MMSE scores than the institution-living subjects, and the independent association of MMSE result to survival was weaker (home MMSE of survivors 26 (IQR 21-30) and MMSE of the deceased 25 (IQR 18-30) p=0.057, institution survivors 23 (IQR 11.5-30) and 20 (IQR 9.5-30) p=0.618).

For all tested subjects, the median test result of the Barthel test was 100 (IQR 90-100) for those who survived to 94, and 90 for the deceased (IQR 50-100) (p = 0.000). Even though this result was statistically significant, a known selection bias in testing preferably subjects in good health influences on the statistical power of the results of subgroups. The results of the Barthel test were similar for both genders (men survivors 95 (IQR 82.5-100) and deceased 90 (IQR 65-100) p=0.104, women survivors 100 (IQR 90-100) and deceased 85 (IQR 43.75-100) p=0.000). While the test results were good for the home-living subjects (home survivors 100 (IQR 95-100) and deceased 95 (IQR 80-100) p=0.000), the results in institutions were generally poorer with a median of 60 (IQR 20-100) for the survivors and a median of 45 (IQR 2.5-87.5) for the deceased (p=0.260).

Life-expectancy at age 90 was significantly reduced with worsening cognitive state and poorer functional state, independent of whether physicians' remark in the medical records on memory or mobility or the MMSE test or the Barthel test for activities of daily living were used as the measure, as shown in Table 14.

Table 14. Expected survival of a 90-year-olds in the study groups. Follow-up time until the 94th birthday. Medical record remarks on memory, classified MMSE test results, mobility, and classified Barthel test results.

	Life-expectancy	
Grouping factor	Age (95% confidence interval)	Significance
Memory		
Good memory (n=274)	93.3 (93.0-93.5)	
Poor memory (n=104)	92.8 (92.4-93.2)	
Demented (n=195)	92.0 (91.8-92.3)	<0.001
MMSE test result		
26-30 (n=140)	93.3 (93.0-93.6)	
21-25 (n=83)	93.2 (92.9-93.5)	
≤ 20 (n=80)	92.6 (92.9-93.3)	0.001
Mobility		
Walks without support (n=182)	93.3 (93.0-93.6)	
Walking stick (n=130)	93.3 (92.9-93.6)	
Rollator (n=177)	92.5 (92.3-92.8)	
Wheelchair (n=27)	91.7 (91.1-92.2)	
Heavy support (n=31)	91.7 (91.1-92.2)	
Bed (n=69)	91.6 (91.3-92.0)	<0.001
Barthel test result		
100 (n=122)	93.4 (93.1-93.6)	
60-99 (n=134)	93.1 (92.8-93.4)	
≤ 60 (n=48)	92.3 (91.8-92.7)	<0.001

When the number of medicines for daily use shown in medical records was linked to survival, no medication and up to three drugs per day (27.8% of the cases with a remark on the use of medication) were associated with improved survival at age 94. Survival in the group for which medication was not registered (52.9%) matched with the survival rate for 0-3 prescribed drugs (54.8%). Already with four daily medicines the survival rate dropped from 53.7% to 46.3%. Survival profiles with respect to registered medication were similar for men and women. Life-expectancy with respect to medication is shown in Table 15.

Table 15. Expected survival of a 90-year-olds in the study groups. Follow-up time until the 94th birthday. Number of medicines for daily use in medical records.

Grouping factor	Life-expectancy	
	Age (95% confidence interval)	Significance
No medication (n=42)	93.7 (93.2-94.2)	
1-3 medicines (n=149)	93.6 (93.3-93.9)	
4-6 medicines (n=266)	92.7 (92.5-93.0)	
7-9 medicines (n=158)	92.4 (92.1-92.7)	
10-12 medicines (n=62)	91.7 (91.3-92.1)	
13 or more medicines (n=9)	91.0 (90.2-91.7)	<0.001

Many of the diseases mentioned in the medical history reduced the chance of survival. Of common conditions recorded, many cardiovascular diseases, cancer, dementia, diabetes, thyroid disease, gout, hip fracture, and respiratory and urinary tract infections increased the nonagenarian 4-year mortality from 63.6% to 70% or more, dementia being the disease with the strongest correlation to 4-year mortality. Statistical significance was reached in many cases for the 90-year old women, but the lower survival rate and small number of the 90-year old men resulted in fewer significant results. With most medical conditions, men had a lower prevalence, but the case mortality was approximately the same as in women. However, no men with certain diseases in the medical history survived to age 94. These were: venous thrombosis (n= 6), severe atherosclerosis (n=6), urinary tract infection (n=22), kidney disease other than kidney stones (n=5), and rib

fracture (n=6). In addition, almost all men with dementia diagnosis (29 out of 31), uric arthitis (12 out of 13), or hip fracture (13 out of 15) died. A detailed list of all recorded diseases in both genders with respect to four-year mortality at age 90 is given in Appendix IV. Medical condition-associated influence in life-expectation at age 90 is studied in Table 16., which shows conditions with prevalence of 10% or more in the medical records.

Co-morbidities have an influence on mortality. If there were at most two recorded chronic or severe medical conditions in the medical history, 62.9% of the subjects survived to age 94, while with any higher number of registered conditions, the survival dropped to 33.5% (p=0.000). This result was not gender-dependent (men with less than three conditions: survival 60.0%, women 63.8%). The average number of recorded severe or chronic illnesses was 5 (IQR 0-10) for those who survived to 94 and 8 (IQR 3-13) for those who died (p = 0.000). This result was similar in both genders (men 5 (IQR 0-10) and 7 (IQR 2-12), p=0.002, women 5 (IQR 0-10) and 8 (IQR 3-13) p=0.000) and types of living (home 5 (IQR 1-9) and 7 (IQR 2-12) p=0.000, institution 7 (IQR 1-13) and 8 (IQR 2-14), p=0.061).

Self-rated health was a strong indicator for mortality among the community-dwelling 90-year-olds. The life-expectancy of the participants in the questionnaire was almost a year higher (93.7 (CI 93.5-93.9)) than in the whole study population (92.9 (CI 92.8-93.0)). In this subgroup, those reporting their health as very good had significantly longer life-expectancy (95.0 (CI 93.5-96.5)) than those reporting their health as very poor 93.0 (CI 93.5-93.9)) (Table 17.).

Table 16. Expected survival of a 90-year-olds in the study groups. Follow-up time until the 94th birthday. Common geriatric illnesses with prevalence of 10% or more in the study cohorts based on medical records.

	Life-expectancy	
Grouping factor	Age (95% confidence interval)	Significance
All (n=832)	92.9 (92.8-93.0)	
Heart failure (n=169)	92.0 (91.8-92.3)	<0.001
Dementia (n=202)	92.1 (91.8-92.3)	<0.001
Stroke(n=139)	92.1 (91.8-92.4)	<0.001
Diabetes(n=106)	92.2 (92.0-92.5)	<0.001
Urinary tract infection (n=214)	92.2 (92.0-92.5)	<0.001
Respiratory infection (n=228)	92.3 (92.1-92.6)	<0.001
Cardiac infarction (n=123)	92.5 (92.2-92.9)	0.022
Hip fracture (n=141)	92.5 (92.2-92.8)	0,006
Any infectious disease (n=441)	92.5 (92.3-92.7)	0.000
Cancer (n=145)	92.5 (92.2-92.8)	0.007
Functional bowel disease (n=149)	92.5 (92.2-92.9)	0.016
Atrial fibrillation (n=186)	92.6 (92.3-928)	0.002
Coronary disease (n=368)	92.6 (92.4-92.8)	<0.001
Thyroid disease (n=125)	92.6 (92.2-92.9)	0.063
Diverticulosis (n=110)	92.6 (92.2-93.0)	0.213
Anaemia (n=138)	92.7 (92.3-93.0)	0.077
Hypertension (n=297)	92.8 (92.6-93.0)	0.144
Any injury (incl. hip fr.) (n=408)	92.8 (92.6-93.0)	0.066
Gall bladder disease (n=223)	92.8 (92.6-93.1)	0.477
Hernia (n=126)	92.9 (92.6-93.3)	0.625
Eye disease (n=188)	92.9 (92.6-93.2)	0.643
Arthrosis (n=187)	92.9 (92.6-93.2)	0.866

Table 17. Expected survival of a 90-year-olds in the study groups. Follow-up time until the 94th birthday. Self-rated health of the community-living nonagenarians that replied to the mailed questionnaire.

	Life-expectancy	
Self-rated health	Age (95% confidence interval)	Significance
All (n=230)	93.7 (93.5-93.9)	
Very good health (n=5)	95.0 (93.5-96.5)	
Good health (n=85)	94.1 (93.8-94.4)	
Average health (n=88)	93.7 (93.3-94.0)	
Poor health (n=37)	93.2 (92.5-93.9)	
Very poor health (n=15)	93.0 (93.5-93.9)	<0.001

6. Discussion

6.1 Evaluation of Methods

6.1.1 Data Coverage

6.1.1.1 Study Cohorts

To obtain a comprehensive picture of the health of the 90 years old population, a relatively small local cohort was studied. The study settings were favorable in Tampere, where the Vitality 90+ project had started a few years earlier (Jylhä and Hervonen 1999), and there were an existing network and experience reaching the old. At the end of the 1990's and the beginning of the third millennium, about 150-250 people reached the age of 90 in Tampere annually. Combining four annual cohorts gave a reasonable size study group still allowing recovering the medical records data. As most of the 90-year-olds were women, the number of men in the studies was less than 200, and the results for this group were more sensitive to individual influence. This was the case especially when rare conditions were studied or when the group was further divided into subgroups.

The study cohorts were drawn from the population register, which data gave information on gender and address, which could be used for tracking whether a person lived in the community or in an institution. The population register data is updated biweekly, and the data covers everyone. The population data for the 1907-1908-born was obtained in the beginning of 1998 and the data for the 1909-1910-born in the beginning of 1999. In the Vitality 90+ framework, multiple studies were done using the same cohorts. Therefore, the study groups were accepted as given. As the annual mortality in nonagenarians is about 20%, a shift in the mean age of the study group caused that the

younger cohort was larger. This shift did not, however, significantly change the results of the analyses, and, eventually, the data could be pooled for the studies.

6.1.1.2 Hospital Discharge Register Data

Due to software changes, the city hospital discharge register data was available only for the years 1998-2000, which lead to the choice of studying one calendar year for each cohort. The population register data for the study cohorts was not drawn in the beginning of January, and updates take a few weeks to appear in the population register. With this time gap before defining our study groups in 1998 and 1999, new cases with no other information than the status 'deceased' appeared in the city statistics and hospital discharge register. Within these limitations, the hospital discharge register gave good population-level data on the admissions, hospital days, hospital types, and mortality. However, the accuracy of the diagnosis at discharge could not be verified. For instance, pneumonia as the discharge diagnosis and the immediate cause of death after five years in hospital did not reveal the original reasons for the need of hospital care. Diagnoses were also received as ICD-10 codes only, with some obvious typing errors – more errors may have remained undetected. Hospital discharge registers may record some conditions more accurately than others. The Finnish hospital discharge register has been shown to be valid for reporting stroke (Leppälä et al. 1999), but, for example, myocardial infarction can be more reliably found in hospital registers than hypertension (Elo and Karlberg 2008).

6.1.1.3 Medical Records

Since 1972, every doctor has been obliged to enter data on each visit of a patient to the patient records that are then available at the successive call for the next physician even if the reason for the call is not the same. City hospitals and health centers use the same patient records that are following the patient. When combining this with the high degree of use of public health services by the nonagenarians, a long-term and often complete patient history was available for research. This type of setting usually favors the people living in institutions, where health inspections are frequently carried out (Nilsson et al.

2002). Even though the community-living 90-year-olds were well reached for this study, it is possible that, for the institution-living patients, there was more detailed information available, especially about their cognition and physical condition. For many institutions, a doctor's referral is needed for admission, which would mean a thorough health inspection.

At the time of the study, the city hospitals' and health centers' medical records were printed on paper – or the oldest records were micro-chipped. Thus, the records had to be studied manually. Each record had a summary page for diagnoses and hospital periods. This was not considered sufficient as a source, because information on earlier diagnoses, treatments elsewhere, and some chronic conditions were often mentioned only in the physician's notes. While reading through the complete paperwork was time-consuming, it was at the same time very educative. It appeared that most records covered the earlier medical history well, described the onset of chronic illnesses, and estimated the current condition to varying extent. As there were general rules what needed to be mentioned in the records but no rules for choice of words, the research task could not be given to a nurse or a student. Doctors used their right to describe the situation in their own words, too. An example for this was: "The patient is in good health for her age (90 years). She got slight dizziness when fixing the house gutters on a ladder." This type of sentence emphasizes the good health aside mentioning a symptom of an illness.

Medical records were available for 90.7% of the population through the public health care system, which is more than sufficient coverage. In Finland, the public health care benefits cover everyone, and the public health care system is commonly used, especially among the old population. Choosing the medical records as the source of data assumes that the study subjects have had a reason to visit a doctor at some point in their later life. The 44 drop-outs with no records were all living in the community. They may have used private doctors, but any severe recent illness is not likely, because the private sector offered only outpatient services at the time of the study. The fact that they had no hospital stays within the past 28 years suggests that these people may have been among the healthiest in their cohort. Nevertheless, the data received through the mailed questionnaire showed that the majority of them reported at least one chronic condition such as dementia or heart disease. The 40 drop-outs who had records that were not

accessible at the time of the study had recently seen a doctor or were on a physician's waiting list, and the records were at the physician's office. Most of them came from the community-living population as well, but the visit to a doctor or stay at a hospital indicated a possible health problem.

6.1.1.4 Questionnaire

While population-level data on the 90-year-olds could be obtained through data archives, replying the questionnaire and participating in testing required the subjects' own input. This lead to an obvious selection bias, which has also been described for other studies on the very elderly (Freedman et al. 1996, Jylhä and Hervonen 1999). Reaching the study groups in person took time, during which a small proportion of the cohort died. Additionally, poor physical condition, and, for example, admission to a hospital, would prevent replying or testing. The target group for the questionnaire was the 1907-1908-born community-living people. Three quarters of them replied to the questionnaire, which is a relatively good coverage and was reached by promoting the study in the media and by contacting the subjects by phone before sending the questionnaire.

6.1.1.5 Mini-Mental State Examination and Barthel Test for Activities of Daily Living

The target group for the testing was the 1909-1910-born, primarily community-living. MMSE-testing and Barthel testing were done on about half of the 1909-1910-born, and the results can be best used as information supporting other data.

Mini-Mental State Examination is a relatively robust test best used to screen dementia, and does not necessarily detect mild cognitive deterioration (de Jager et al. 2009). Most of the tasks are verbal questions, and poor hearing may interfere remarkably on the test result. Only the few last points are given according to drawing and writing skills, and, therefore, the test is less dependent on vision or motoric coordination. As the test can be easily conducted by a trained nurse and doesn't require extensive time or any special equipment, MMSE is one of the most commonly used cognitive tests world-wide (Folstein et al. 1975, Tombaugh and McIntyre 1992). Despite critisism to the sensitivity

and specificity of the test, the use of MMSE has been validated also for the oldest-old (Kahle-Wrobleski et al. 2007). In the present study, the strong data agreement between MMSE and physician-recorded memory suggests that these both are essentially measuring the same variable.

Barthel test for activities of daily living is a ten-point questionnaire covering e.g. ability to eat independently, ability walk, and ability to walk up stairs (Mahoney and Barthel 1965). As a very crude measure, it indicates different states of poor physical condition, but cannot differentiate between usual and good physical condition. The test is easy to apply, but, even among the oldest-old, the scale was limiting the information obtained, as more than half of the tested 90-year-olds achieved the highest score.

6.1.2 Statistical Methods

An important value of this study lies in providing reference data for future studies and health and social care planning. The simple analytical methods allow re-calculating and re-analyzing, and selecting details from the studies. Some of the data was pooled, because of relatively small study groups for this kind of study. With such a narrow population, I was careful in applying advanced statistical methods in predicting mortality, but used the Kaplan-Meier statistics, which still allows inspecting individual variables. Even though the long data tables are not elegant, they show the extent and detail of the collected information.

6.2 Morbidity and Predictors of Mortality

The medical records of the 90-year-olds revealed multiple chronic illnesses and medical conditions that led to hospital care in the past. For this study, the onset times of the illnesses were not brought to the database. Many of the subjects had survived life-threatening illnesses such as acute myocardial infarction or stroke. None of the illnesses mentioned in the medical records at or before age 90 resulted in 100% mortality before age 94, and the highest mortality rate was for dementia patients with 80% mortality.

There were some rare severe conditions missing from the diagnosis list of the 90-year-olds. At least bleeding in the brain, aortic aneurysm, and liver cirrhosis were not mentioned in their records, and this might be due to the deadly nature of these illnesses.

Cardiovascular diseases were the most common group of diagnoses with the prevalence of 78.3%. This group had a wide range of illnesses such as coronary disease, stroke, or deep vein thrombosis. While early operations for varicose veins did not lower the chances to survive another few years, most chronic conditions were associated with mortality, especially in women. Most of the cases with cardiovascular diseases had cardiac diseases (prevalence 72.5%) including hypertension, coronary heart disease, myocardial infarction, atrial fibrillation, chronic heart failure, and some less common diseases of the heart such as valve diseases. With such a high prevalence, it would be tempting to say that cardiac diseases belong to usual aging. Isolated hypertension was rare, with the prevalence less than 5%. In the Umeå85+ study the prevalence of hypertension alone was reported to be more than 50% (von Heideken Wågert et al. 2006), whereas von Strauss et al. reported overall cardiovascular morbidity to be lower than 50% in nonagenarians (von Strauss et al. 2000). The study populations may be different, but a significant influence may come from the method of collecting data.

The prevalence of dementia among the community-living was 12.4% and 52.4% in the institutions. This strong association to the target group may explain the earlier published prevalence of dementia in the oldest-old ranging from 10% in the Leiden 90-plus study (Bootsma-van der Wiel et al. 2005) to 27% in the Umeå85+ study (von Heideken Wågert et al. 2006). The data does not tell whether the diagnostic criteria were different according to the place of living, if the doctors evaluated mild cognitive impairment as dementia, or whether a significant number of dementia-patients were not diagnosed. It has been reported earlier that the stages of dementia in the community-living and in institutions are different: most of the demented patients in institutions suffer from severe dementia, whereas those living at home are at a relatively mild stage of the disease (Fratiglioni et al 1994). Interestingly, the survival of dementia-patients until age 94 was equal in the community and in the institutions (18.3% and 17.6%), supporting the hypothesis that the same condition was measured.

Dementia appears to be the heaviest burden for health even in the nonagenarians with 26% prevalence based on medical records and over 80% mortality in 4 years. Dementia is known to lead to multiple disabilities and also increases the risks, for example, for infectious diseases and accidental falling (Eberle et al. 1993, Aevarsson et al. 1998, Frisoni et al. 2000, Börjesson-Hanson et al. 2007, Formiga et al. 2008).. Medical record-registered dementia correlated well with MMSE test results and was a clear prognostic factor for mortality. Low MMSE test result alone has proven to be a good indicator of mortality for the old-old population (Strandberg et al. 2009). In this study, with respect to medical records, it appeared that "no news is good news", as no physician's remark on memory was associated with a high MMSE score and with improved survival. It is possible, that the physicians were more likely to record the cognitive state if the overall condition of the patient was poor.

Other psychiatric disorders like depression were significantly more common in the institutionalized population, as well. The actual prevalence of depression may be higher than this data shows. While the prevalence of depression according to this study was similar to the Leiden 85-plus study (11% and 8% (Marengoni et al. 2009), respectively), the prevalence in Umeå85+ study was as high as 34% (Heideken Wågert et al. 2006). Unlike with dementia, it was not a common practice to record a statement on life satisfaction or depression. Depression has been reported to be related to early dementia (Geerlings et al. 2000a, Geerlings et al. 2000b). In this study, depression was seen in mostly non-demented subjects with good memory or mildly impaired memory. It is possible that depression of severely demented patients has not been recorded.

Infections were very common in the institutionalized population. This was probably rather the result of poor mobility and poor resistance to diseases in an environment where the pathogens were easily available, than the symptom leading to institutionalization. A published comparison was found in the Umeå study (Heideken Wågert et al. 2006), in which the prevalence of urinary tract infections was almost equal to this study (29% and 26%, respectively). The high prevalence of infections may be related to the weakened immune system of the old (Plewa 1990, Smith et al. 1992).

Hip fracture is associated with falls and result in an increased risk of death (Kannus et al. 1996). The incidence of hip fractures has significantly increased (Lönnroos et al.

2006) The prevalence of hip fracture varied in the three above mentioned reference studies from 4% (Marengoni et al. 2009) and 6% (Bootsma-van der Wiel et al. 2005) to 23% (Heideken Wågert et al. 2006), whereas in this study it was 17%.

Some fairly common illnesses of the old such as atherosclerosis or functional bowel diseases had very low prevalence according to the records. This could partially be due to high mortality earlier with such illnesses, but another possible explanation is the lack of use of these diagnoses. For example, the diagnosis atherosclerosis includes several organ systems, and the diagnoses associated with it may be hypertension, coronary heart disease and diabetes. Thus, the diagnosis would be used isolated from the others only if severe atherosclerosis leads to a chronic ulcer and a limb amputation. Or functional bowel disease might be mentioned only when it requires hospital care.

This study did not classify the severity of the diseases. There might be a significant difference in the cardiovascular status and symptoms between the community-living and institution-living. Similarly, it is likely that the functional bowel diseases such as diverticulosis and constipation would be causing more symptoms in the bedridden subjects in institutions.

Increase of prevalence of many chronic conditions with aging has been recognized earlier (Bild et al. 1993, Kawas et al. 2000, DeRijke et al. 2000). As this is in contradiction to the generally accepted good health of the 90-year-olds, the question arises, whether the 90-year-olds appear healthy, whether the illnesses of this age group are not as disabling as earlier, or whether the health expectations are so much lower, that minor disabilities are ignored. Earlier studies indicated that in the oldest-old disability rather than morbidity may influence the self-experienced health (Lee et al. 2008).

In this study, self-rated health, good memory, good mobility, use of less than four prescription medicines, and living in the community were associated with longer life-expectancy. Accordint to Ben-Ezra and Schmotkin (2006), age, sex, disability, and self-rated health are the best predictors of mortality in the oldest-old, but the predictive value of any variable decreases over time. All cause mortality decreases over time. Both chronic medical conditions and functional disabilities predict mortality among the oldest-old, but, with advancing age, the importance of the functional state increases rapidly (Lee et al. 2008).

6.3 Inter-Source Data Agreement

6.3.1 Morbidity

Information on health was received through several channels, of which the medical records, hospital discharge database, and the questionnaire gave direct information on morbidity. Most of the data was taken from medical records.

Using medical records as a data source has been criticized earlier mostly for the lack of coverage and for the lack of detail (Zhu et al. 1999, Nilsson et al. 2002). For this study, there was plenty of data available, probably due to the high usage of the public health care, the double-checked completion of the medical records by the physician, and due to the manual approach.

Self-reported data on diseases was received through a questionnaire. The questionnaire was asking widely about the health and social situation of the subjects, and open-ended questions were avoided. This limited the received information to eleven common geriatric diseases. When the data agreement with medical records was studied, the inter-source agreement showed a similar pattern to earlier studies in younger populations, but the data agreement was generally poorer (Kehoe et al. 1994, Kriegsman et al. 1996, Haapanen et al. 1997). The method of studying data agreement using κ-statistics is sensitive to the prevalence of an illness, and with a higher prevalence the agreement appears lower. This may explain the lower data agreement in the 90-year-olds compared to younger populations. One could argue that poor cognition may affect the results, but the data agreement was not significantly influenced by the presence of dementia or if a caregiver assisted in filling the form. Also, when the data was studied keeping the medical records data as a gold standard, the reported data sensitivity in the 90-year-olds was lower than in earlier studies on younger populations, but the data was as specific as for the younger populations (Kehoe et al. 1994, Kriegsman et al. 1996, Haapanen et al. 1997). Clearly defined conditions such as diabetes or cancer were reported more accurately than diseases easily mixed with similar conditions.

Among the reasons for the common underreporting of diagnosed diseases may be impaired cognition, not being informed about the diseases, or simply poor attention when

filing the questionnaire. The patient's self-awareness of certain medical conditions may be influenced by the physician. Especially, if there are no disturbing symptoms, people do not necessarily find out about some conditions such as hypertension unless their doctor informs them properly. Identifying medical conditions may also be unclear, for example, in the case of rheumatoid arthritis, which can be mixed with osteoarthritis or other joint diseases.

Interesting information received through the questionnaire was reporting dementia and depression as well as arthritis more than the public health care records indicated. This may be related to non-treated conditions or also reflect the opposing expectations of the aged persons and their doctors. A mild change in cognition may be experienced as dementia by the subject, while the physician may judge that as normal to the age or not detect it during a short patient visit. Also depression may be experienced this way.

6.3.2 Cognition and Mobility

Information on cognition was received from two sources: medical records and MMSE-testing. The MMSE test is considered a crude method for dementia testing and susceptible for errors caused by deficits other than impaired memory (Reischies and Geiselmann 1997). However, as a relatively short test it is used in screening and has been shown to reliably identify dementia even in the oldest-old (Kahle-Wrobleski et al. 2007). In medical records, memory test results were rarely available, but physicians had commonly written a remark describing the cognition of very old patients. The MMSE could be applied only to a relatively small proportion of the 90-year-olds. However, high agreement between the physicians' remarks on cognition and MMSE test result suggests that they appear to measure the same variable, and can be used as an estimate of the cognitive state.

The Barthel test is a valid method used for measuring physical condition (Sulter et al. 1999). With this measure, the validity of the method was not a problem, but rather the data coverage as only a part of the cohorts were studied. Therefore, a wider coverage on the physical condition was received through the medical records remarks on mobility. Only ability to move independently, using aids for moving, and need for assistance was

evaluated. Other physical deficits were not studied. Mostly, this was due to the lack of consistent remarks on factors like vision and hearing in the medical records.

However, as the selection bias for MMSE and the Barthel test was evident so that mainly subjects in good health were tested and the testing alone predicted better survival, the results lack statistical significance in most of the study subgroups.

6.4 Characteristics in the Institunionalized Population

Of the 90-year-olds, 28.7% lived permanently in institutions. The individual reasons for institutional care were not studied, but the health of those living in institutions was generally worse than the health of the community-living. Medical records were mostly available (90.9%), and physicians had recorded the cognitive state (81.2%) or mobility (84.4%) frequently. Almost two thirds of the institution-living 90-year-olds were demented while less than every fourth were estimated having normal cognition. Nearly 20% of the 90-year-olds living in an institution were bedridden, an additional 20% needed assistance in moving, and only 25% were able to move without more than a light support. Nearly all of the bedridden patients had a remark on cognition, and 95.5% of those were diagnosed demented. Most of those with the memory remark better than demented needed moderate support for moving. This information alone describes the importance of dementia as the main reason for institutional care among the 90-year-olds. Dementia has been attributed to be the main reason for institutional care in old age (Hébert et al. 2001, Matthews and Dening 2002, Nihtilä et al. 2008).

There were several other diseases, which were more common in institutions than in the community also when demented patients were excluded from the analysis. Common to these illnesses was that they are causing physical inabilities as with stroke or hip fracture or require special care as with diabetes. Similar findings have been recently presented by Nihtilä et al. (2008). Infections appear to be a common problem in long-term care as it has been earlier indicated at younger ages (for a review, see Yoshikawa and Norman 1996). Infections in the medical history were common among the institution-living 90-year-olds, whether demented or not.

With all measures, the health of the institution-living 90-year-olds was worse than that of the community-living. This can easily be understood as the need for care is usually related to health problems. Also mortality in institutions was high with 80.4% mortality until the age of 94. Even if the demented subjects are removed from the analysis, the mortality in the institution-living was 74.8%. In the community-living, the dementia-related mortality was equally high as in the institutions, whereas mortality without dementia was slightly less than 50% until the age 94.

Did living in institutions diminish or remove the need for hospital care as suggested by Menec et al. (2007)? During one year, 65.3% of the institution-living were admitted to hospitals. If the permanently hospitalized patients are excluded, 43.9% were admitted, which percentage is almost equal to that of the community-living 90-year-olds (42.6%). Altogether, the institution-living 90-year-olds were admitted more often to hospitals than the community-living, and, as some of them lived in the hospitals, the number of hospital days was greater. In this study, care in the institutions did not remove or diminish the need for inpatient care.

6.5 Need for Hospital Care

About one half of the population aged 90 were in hospital for some period during one calendar year. In Denmark, 38% of community-living people at age 80 and over had been to hospital during a two-year period (Almind, 1985). There are several studies which indicate that the use of hospitals in the last year of life decreases with age (Henderson et al. 1990, Cartwright 1991, Brameld et al. 1998). However, the very old spent significantly longer times in hospital, if admitted (Henderson et al. 1990). The decreased use of hospitals before death may be related to the fact that significantly more of the oldest-old live in institutions with 24-hour care than of the younger groups. In Finland, 24.0% of the population of 85 and older lived in institutions, whereas only 6.5% of the 75-84-year-old lived in institutions (STAKES, 2001). Yet, in this study, the same proportion of institution-living 90-year-olds were admitted to a hospital as of community-living.

Most days spent in hospitals among the 90 years old population in Tampere were due to dementia. The increase in dementia with the aging of the population may lead to a growing demand for long-term hospital beds specializing in the care of demented patients. Some medical conditions that are common among the very old such as diabetes, functional bowel diseases, and cancer were rarely the main cause of hospitalization. Partially, this may be due to the less aggressive course of these diseases at very old age, but, especially with cancer, it has been shown that relative and absolute cancer mortality decreases at very high ages (deRijke et al. 2000). It is possible that stricter criteria for hospital admission are applied at age 90.

It seems that the outcome of treatment in the oldest-old is mainly dependent on their physical condition rather than their age (Mayer-Oakes et al. 1991, Chelluri et al. 1992, Alarcon et al. 1999), and even intensive care may lead to recovery (Mayer-Oakes et al. 1991). Hamel et al. have shown that the aggressiveness of care has less influence on the outcome of the treatment in the very old than the severity of the disease and the functional status of the patient (1999).

In this study, one-third of the 90-year-olds who were treated in hospital died within the one-year follow-up, while the mortality was about 6% in those not admitted. However, deaths were less common among long-term patients, and mortality was 40% among those hospitalized for less than a year. The result is similar to that reported by the HELP study, where 40% of people at age 80 and over and hospitalized due to an acute disease died within a two-year period (Teno et al. 2000). In this study, mortality was related to the selection of patients at different types of hospital. Mortality was very high in hospitals connected to a nursing home. These hospitals had mostly patients with severe acute diseases and permanently bedridden patients. Mortality in general hospitals was relatively low, even though they are responsible for most of the acute medicine and surgery. This is most probably due to the characteristics of the patients: most of the patients in general hospital are home-dwelling and functionally independent.

6.6 Gender

The first indication of gender differences at the age of 90 years is the proportion of each gender: only one of five 90-year-olds were men. According to Statistics Finland, life expectancy at birth was 48.18 years for women and 45.31 for men born in 1901-1910 (Stasitstics Finland 2008). During the last century, two major events caused increased mortality of men: the Civil War in 1918 and the Second World War in 1939-1945. At the time of the Civil war, the study cohorts were children whose mortality did not remarkably increase because of the war. During the Second World War in Finland, ca 103,000 more men than women died. However, the age group mostly affected was the 1911-1920-born, in which group also the life expectancy of men decreased because of the war. Our study cohorts were not influenced to that extent. Deaths due to violent causes are generally more common in men than in women, but the main causes of deaths are illnesses in all adult age groups (Statistics Finland 2008). Most of the 1907-1910-born men had died younger because of illnesses. Either they got ill earlier, had more severe illnesses, or were less resistant to illnesses than women.

Were the few surviving men alive at age 90 healthier than the women? They estimated their health better, they reported fewer illnesses, and fewer co-morbidities were recorded in the medical records for men. Fewer of the men were living in institutions. They spent fewer days in hospitals. They had less medication prescribed. The men needed or used less assistance in filling the mailed questionnaire. They were evaluated by their physician to need less support for moving and have better cognitive skills. Men had suffered less from cardiovascular diseases, dementia, and thyroid diseases, but more often from cancer, pulmonary diseases, and infections. Men had less often a history of bone fractures in the old age. All this suggests that the few surviving men were healthier than women at the age of 90 years. The findings are consistent with earlier studies on the health of old generations (Perls et al. 1993, Nybo et al. 2001b, von Strauss et al. 2003, Xie et al. 2008).

At the same time, those men with impaired memory or with deficits in physical abilities, those with history of fractures, and those that ended up in hospitals or institutional care died within a few years. Mortality in younger ages had been high for men, and only the healthiest had survived. And yet their mortality stayed higher even in

the short follow-up period. Possibly, the men's health was not as resistant to present illnesses as the women's. Studies on old age frailty indicate that women accumulate more deficits at younger age than men, but survive longer, suggesting that women may be less vulnerable to the deficits or that women adapt better during a longer time of accumulating deficits (Kulminski et al. 2007). About 10% of all women had stayed for years as bed-patients, whereas less than 2% of men were bed-ridden. Some indication on gender differences in immuno-genetic background associated with longevity has been suggested earlier (Lio et al. 2003, Caruso et al. 2004, Wikby et al. 2008).

6.7 How Healthy Are the Nonagenarians?

The history of numerous illnesses indicates that the 90-year-olds are not exceptionally healthy. As the disease-associated mortality was high, the illnesses the 90-year-olds carry are not less dangerous than the same illnesses in the younger populations. Even the oldest-old are affected by the common diseases of the population, and the prevalence may increase with age. With the majority of the 90-year-olds having multiple diagnoses, it can not be concluded that one needs to stay healthy to reach the age 90 years and older, even though the lack of certain conditions improves the chances.

Where medical history of the 90-year-olds showed that overall morbidity was high among the oldest-old, and co-morbidities were more common than in younger populations, the self-rated health stayed approximately as good as in younger populations (McFadden et al. 2008). Most 90-year-olds estimated their health good or average in spite of numerous diseases. Certain diseases such as stroke and depression were related to poor self-rated health, which is consistent with earlier studies with younger populations (Kivinen et al. 1998, Hoeymans et al. 1999). An interesting finding was the strong association of the poor self-rated health with the diagnosed dementia (54% poor) and only a moderate association to the reported dementia (30% poor), which may indicate false positive self-reports of dementia in cases with minor memory problems without clinical importance.

In the generally healthier community-living 90-year-olds, the self-rated health was a good indicator for mortality until 94 in both genders, with the difference that the men's mortality was higher. This gender difference and higher mortality vs. self-rated health may be related to the adjusted expectations of health in the nonagenarians (Jylhä et al. 2001).

7. Summary and Conclusions

The 90-year-olds are a heterogeneous group with good experienced health and a history of multiple chronic illnesses. Their use of hospitals is high, and medications numerous. Morbidity is greater than at younger ages, and mortality is high. Men are fewer than women, but healthier, still being at a greater risk to die. In spite of illnesses, the 90-year-olds estimate their health similarly to the younger populations. The expectations for health by the oldest-old and by the surrounding society may have been adjusted with the age and physical limitations. An average person would already be dead; therefore the health of a nonagenarian must be better than average.

Most of the nonagenarians are able to live at their home with the support of their families and the society. Many of them have good cognitive status and good mobility despite numerous diseases and are therefore able to live independently. Dementia is very common in institutions among the 90-year-olds, and this may indicate it being also the final reason for moving to an institution from home.

The nonagenarians are the source population for centenarians, but only about 5% of the 90-year-olds will reach the age of 100. A medical diagnosis alone does not predict survival, even though certain illnesses are clearly associated with increased mortality. Their survival is not arbitrary, but defined by multiple factors. According to this study, the survival of the 90-year-olds may be best estimated with self-rated health and measures of independence and mobility along with physician-estimated cognitive state.

Only a few men survive to the age of 90, and their mortality stays high. With all measures used, however, the men appeared healthier than women. Even though earlier morbidity of the 1907-1910-born men cannot be evaluated based on this study, the results support the hypothesis that men are less resistant to chronic illnesses.

To date's 90-year-olds are at the peak of morbidity, whereas mortality continues to increase. This study supports the hypothesis that nonagenarians – while still considered

oldest-old – are at the older end of usual aging processes with numerous diseases and high mortality due to the diseases, and not exceptionally healthy. Today's nonagenarians resemble in respect of morbidity much of the 80-years-old a few decades ago.

The population is aging, and the fastest-growing group are the oldest. Illnesses, their symptoms, or disabilities may appear later, and at the same time people may survive longer with their illnesses. The population shift to older is evident. Whether, one day, the centenarians are like today's nonagenarians remains to be seen. Longevity after age 90 does not seem arbitrary, and the advice for longer life at age 90 stays the same as before: live independent as long as you can, have a clear head, keep the ability to move, and avoid lethal illnesses if you can.

8. Acknowledgements

First of all, I wish to express my gratitude for all the 90-year-olds who participated to this study through the Vitality 90+ Project. This work would not exist without them, and it wouldn't be of much interest, if they hadn't been so many.

I thank the city of Tampere for providing me with an access to the health record database and for assistance in collecting hospital data. I hope this study will in return help understanding health problems and need for health care for the oldest-old in the region.

My supervisor Professor Antti Hervonen, MD, PhD, introduced the research world to me. He gave the ignition for this study by repeatedly stating how the nonagenarians are mainly healthy or at least tough survivors, which statement was contradicting my common knowledge. Despite my efforts in trying to prove him wrong, he was encouraging and supporting this study during all these years it took, and at the end helping with his excellent network of contacts in research. I am truly grateful.

My supervisor Professor Marja Jylhä, MD, PhD, ensured that the result of my excavations in the city hospitals archives ended up being research papers and a thesis. Her always relevant questions and comments shaped the publications, and her practical help and knowledge was invaluable. I am especially grateful for the positive attitude she kept when after a year or two I finally came up with a draft of a manuscript. She said "Great, wonderful!", and promptly gave her suggestions for improving the paper.

I thank Professor Pekka Karhunen, MD, PhD, for supporting this study during the years I was working in his department specializing in forensic medicine. With his enthusiasm he created a research-positive atmosphere.

I warmly thank Professors Kaisu Pitkälä, MD, PhD, and Sirpa Hartikainen, MD, PhD, who reviewed the thesis manuscript and gave valuable comments and suggestions to improve the text.

Ms. Nina Mäkinen was assisting in organizing the data, and her support in finding the right data files, contacts, and numerous other details I needed, cannot be thanked enough.

I warmly thank Ms. Anna-Maija Koivisto, BSci. and Ms. Heini Huhtala, BSci. for their help in statistics solutions and presentation.

Numerous co-workers in the School of Public Health, the Medical School, and the University Hospital have contributed in this work by practical help, discussions, and creating an inspiring environment. Thank you all!

I would like to thank my friends and family for encouraging me and for believing that this study would actually be finished one day. Time spent with friends and discussing about life, universe, and everything uncover what is of meaning and why to learn more by doing research and by living.

Finally, I would like to thank my husband Mr. Juergen Goebeler for proof-reading the thesis, and even more for the never-ending support for this work that took so much of my time and energy. The love and support of my family, Juergen and our daughter Jessica, has made my life worthwhile and given me the best reason to work on and finish this study.

9. References

Aevarsson O and Skoog IA (1996): A population-based study on the incidence of dementia disorders between 85 and 88 years of age. J Am Geriatr Soc 44:1455-1460.

Aevarsson O, Svanborg A and Skoog I (1998): Seven-year survival rate after age 85 years: relation to Alzheimer disease and vascular dementia. Arch Neurol 55:1226-1232.

Alarcon T, Barcena A, Gonzalez-Montalvo JI, Penalosa C and Salgado A (1999): Factors predictive of outcome on admission to an acute geriatric ward. Age Ageing 28:429-432.

Almind G (1985): Risk factors in eighty-plus year-olds living at home: an investigation of a Danish community. Int J Aging Hum Dev 21:227-234.

Andersen K, Nybo H, Gaist D, Petersen HC, McGue M, Jeune B, Vaupel JW and Christensen K (2002): Cognitive impairment and mortality among nonagenarians: the Danish 1905 cohort survey. Dement Geriatr Cogn Disord 13:156-163.

Andersen-Ranberg K, Christensen K, Jeune B, Skytthe A, Vasegaard L and Vaupel JW (1999): Declining physical abilities with age: a cross-sectional study of older twins and centenarians in Denmark. Age Ageing 28: 373-377.

Andersen-Ranberg K, Schroll M and Jeune B (2001): Healthy centenarians do not exist, but autonomous centenarians do: a population-based study of morbidity among Danish centenarians. J Am Geriatr Soc 49:900-908.

Bacchetta MD, Ko W, Girardi LN, Mack CA, Krieger KH, Isom OW and Lee LY (2003): Outcomes of cardiac surgery in nonagenarians: a 10-year experience. Ann Thorac Surg 75:1215-1220.

Baldereschi M, Di Carlo A, Maggi S, Grigoletto F, Scarlato G, Amaducci L and Inzitari D. (1999): Dementia is a major predictor of death among the Italian elderly. ILSA Working Group. Italian Longitudinal Study on Aging. Neurology 52:709-713.

Barrett JC (1985): The mortality of centenarians in England and Wales. Arch Gerontol Geriatr 4:211-218.

Baumgartner RN, Koehler KM, Gallagher D, Romero L, Heymsfield SB, Ross RR, Garry PJ and Lindeman RD (1998): Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 147:755-763.

Ben-Ezra M and Shmotkin D (2006): Predictors of mortality in the old-old in Israel: the cross-sectional and longitudinal aging study. J Am Geriatr Soc 54:906–911.

Bergdahl E, Gustavsson JM, Kallin K, von Heideken Wågert P, Lundman B, Bucht G and Gustafson Y (2005): Depression among the oldest old: the Umeå 85+ study. Int Psychogeriatr 17:557-575.

Berlau D, Corrada M, Paganini-Hill A, Brookmeyer R and Kawas C (2007): Incidence of dementia continues to increase after age 90: results from the 90+ Study, Neurology 68 (Suppl 1) S01.003.

Berzlanovich AM, Keil W, Waldhoer T, Sim E, Fasching P and Fazeny-Dörner B (2005): Do centenarians die healthy? An autopsy study. J Gerontol A Biol Sci Med Sci 60:862-865.

Bild DE, Fitzpatrick A, Fried LP, Wong ND, Haan MN, Lyles M, Bovill E, Polak JF and Schulz R (1993): Age-related trends in cardiovascular morbidity and physical functioning in the elderly: the Cardiovascular Health Study. J Am Geriatr Soc 41:1047-1056.

Bootsma-van der Wiel A, de Craen AJ, Van Exel E, Macfarlane PW, Gussekloo J and Westendorp RG (2005): Association between chronic diseases and disability in elderly subjects with low and high income: the Leiden 85-plus Study. Eur J Public Health 15:494-497.

Börjesson-Hanson A, Gustafson D and Skoog I (2007): Five-year mortality in relation to dementia and cognitive function in 95-year-olds. Neurology 69:2069-2075.

Boscoe FP (2008): Subdividing the age group of 85 years and older to improve US disease reporting. Am J Public Health 98:1167-1170.

Bosworth HB, Siegler IC, Brummett BH, Barefoot JC, Williams RB, Clapp-Channing NE and Mark DB (1999): The association between self-rated health and mortality in a well-characterized sample of coronary artery disease patients. Med Care 37:1226-1236.

Brameld KJ, Holman CD, Bass AJ, Codde JP and Rouse IL (1998): Hospitalisation of the elderly during the last year of life: an application of record linkage in Western Australia 1985-1994. J Epidemiol Community Health 52:740-744.

Bravell ME, Berg S and Malmberg B (2008): Health, functional capacity, formal care, and survival in the oldest old: a longitudinal study. Arch Gerontol Geriatr 46:1-14.

Brody JA and Miles TP (1990): Mortality postponed and the unmasking of age-dependent non-fatal conditions. Aging (Milano) 2:283-289.

Cai L and Lubitz J (2007): Was there compression of disability for older Americans from 1992 to 2003? Demography 44:479-495.

Cartwright A (1991): The role of hospitals in caring for people in the last year of their lives. Age Ageing 20:271-274.

Caruso C, Aquino A, Candore G, Scola L, Colonna-Romano G and Lio D (2004): Looking for immunological risk genotypes. Ann N Y Acad Sci 1019:141-146.

Catenacci VA, Hill JO and Wyatt HR (2009): The obesity epidemic. Clin Chest Med 30:415-444, vii.

Chelluri L, Pinsky MR and Grenvik AN (1992): Outcome of intensive care of the "oldest-old" critically ill patients. Crit Care Med 20:757-761.

Cherry KE, Hawley KS, Jackson EM, Volaufova J, Su LJ and Jazwinski SM (2008): Pictorial superiority effects in oldest-old people. Memory 16:728-741.

Christensen K and Vaupel JW (1996): Determinants of longevity: genetic, environmental and medical factors. J Intern Med 240:333-341.

Corey-Bloom J, Wiederholt WC, Edelstein S, Salmon DP, Cahn D and Barrett-Connor E (1996): Cognitive and functional status of the oldest old. J Am Geriatr Soc 44:671-674.

Cornoni-Huntley JC, Foley DJ, White LR, Suzman R, Berkman LF, Evans DA and Wallace RB (1985): Epidemiology of disability in the oldest old: methodologic issues and preliminary findings. Milbank Mem Fund Q Health Soc 63:350-376.

Corrada MM, Brookmeyer R, Berlau D, Paganini-Hill A and Kawas CH (2008): Prevalence of dementia after age 90: results from the 90+ study. Neurology 71:337-343.

Crimmins EM, Hayward MD, Hagedorn A, Saito Y and Brouard N (2009): Change in disability-free life expectancy for Americans 70-years-old and older. Demography 46:627-646.

de Jager CA, Schrijnemaekers AC, Honey TE and Budge MM (2009): Detection of MCI in the clinic: evaluation of the sensitivity and specificity of a computerised test battery, the Hopkins Verbal Learning Test and the MMSE. Age Ageing 38:455-460.

DeRijke JM, Schouten LJ, Hillen HF, Kiemeney LA, Coebergh JW and van den Brandt PA (2000): Cancer in the very elderly Dutch population. Cancer 89:1121-1133.

Di Carlo A, Baldereschi M, Amaducci L, Lepore V, Bracco L, Maggi S, Bonaiuto S, Perissinotto E, Scarlato G, Farchi G and Inzitari D; ILSA Working Group (2002): Incidence of dementia, Alzheimer's disease, and vascular dementia in Italy. The ILSA Study. J Am Geriatr Soc 50:41-48.

Eberle CM, Winsemius D and Garibaldi RA (1993): Risk factors and consequences of bacteriuria in non-catheterized nursing home residents. J Gerontol 48: M266-271.

Ebly EM, Parhad IM, Hogan DB and Fung TS (1994): Prevalence and types of dementia in the very old: results from the Canadian Study of Health and Aging. Neurology 44:1593-1600.

Elo SL and Karlberg IH (2009): Validity and utilization of epidemiological data: a study of ischaemic heart disease and coronary risk factors in a local population. Public Health 123:52-57.

den Elzen WP, Willems JM, Westendorp RG, de Craen AJ, Assendelft WJ and Gussekloo J (2009): Effect of anemia and comorbidity on functional status and mortality in old age: results from the Leiden 85-plus Study. CMAJ 181:151-157.

Evert J, Lawler E, Bogan H and Perls T (2003): Morbidity profiles of centenarians: survivors, delayers, and escapers. J Gerontol A Biol Sci Med Sci 58:232-237.

Farchi G, Brescianini S, Maggi S, Mariotti S, Scafato E, Di Carlo A, Baldereschi M and Inzitari D; ILSA Group (2004): Risk factors and health determinants in older Italians. Aging Clin Exp Res 16:3-12.

Ferri CP, Prince M, Brayne C, Brodaty H, Fratiglioni L, Ganguli M, Hall K, Hasegawa K, Hendrie H, Huang Y, Jorm A, Mathers C, Menezes PR, Rimmer E and Scazufca M (2005): Alzheimer's Disease International. Global prevalence of dementia: a Delphi consensus study. Lancet 366:2112-2117.

Fick DM, Cooper JW, Wade WE, Waller JL, Maclean JR and Beers MH (2003): Updating the Beers criteria for potentially inappropriate medication use in older adults. Results of a US consensus panel of experts. Arch Intern Med 163:2716–2724.

Folstein MF, Folstein SE and McHugh PR (1975): "Mini-Mental State": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 12:189-198.

Forman DE, Berman AD, McCabe CH, Baim DS and Wei JY (1992): PTCA in the elderly: the "young-old" versus the "old-old".J Am Geriatr Soc 40:19-22.

Formiga F, Lopez-Soto A, Sacanella E, Coscojuela A, Suso S and Pujol R (2003): Mortality and morbidity in nonagenarian patients following hip fracture surgery. Gerontology 49:41-45.

Formiga F, Ferrer A, Mascaró J, Ruiz D, Olmedo C and Pujol R (2007): Predictive items of one-year mortality in nonagenarians. The NonaSantfeliu Study. Aging Clin Exp Res 19:265-268.

Formiga F, Navarro M, Duaso E, Chivite D, Ruiz D, Perez-Castejon JM, Lopez-Soto A and Pujol R (2008): Factors associated with hip fracture-related falls among patients with a history of recurrent falling. Bone 43:941-944.

Fratiglioni L, Viitanen M, Bäckman L, Sandman PO and Winblad B (1992): Occurrence of dementia in advanced age: the study design of the Kungsholmen Project. Neuroepidemiology 11 Suppl 1:29-36.

Fratiglioni L, Forsell Y, Aguero Torres H and Winblad B (1994): Severity of dementia and institutionalization in the elderly: prevalence data from an urban area in Sweden. Neuroepidemiology 13: 79-88.

Freedman JD, Beck A, Robertson B, Calonge BN and Gade G (1996): Using a mailed survey to predict hospital admission among patients older than 80. J Am Geriatr Soc 44:689-692.

Freedman VA, Martin LG and Schoeni RF (2002): Recent trends in disability and functioning among older adults in the United States: a systematic review. JAMA 288:3137-3146.

Fries JF (1980): Aging, natural death, and the compression of morbidity. N Engl J Med 303:130–135.

Fries JF (2003): Measuring and monitoring success in compressing morbidity. Ann Intern Med 139:455-459.

Frisoni GB, Fratiglioni L, Fastbom J, Guo Z, Viitanen M and Winblad B (2000): Mild cognitive impairment in the population and physical health: data on 1,435 individuals aged 75 to 95. J Gerontol A Biol Sci Med Sci 55:M322-328.

Geerlings MI, Schmand B, Braam AW, Jonker C, Bouter LM and van Tilburg W (2000): Depressive symptoms and risk of Alzheimer's disease in more highly educated older people. J Am Geriatr Soc 48: 1092-1097.

Geerlings MI, Schoevers RA, Beekman AT, Jonker C, Deeg DJ, Schmand B, Adèr HJ, Bouter LM and Van Tilburg W (2000): Depression and risk of cognitive decline and Alzheimer's disease. Results of two prospective community-based studies in The Netherlands. Psychiatry 176:568-575.

Gonos ES (2000): Genetics of aging: lessons from centenarians. Exp Gerontol. 35:15-21.

Graham JE, Rockwood K, Beattie BL, Eastwood R, Gauthier S, Tuokko H and McDowell I (1997): Prevalence and severity of cognitive impairment with and without dementia in an elderly population. Lancet 349:1793-1796.

Haapanen N, Miilunpalo S, Pasanen M, Oja P and Vuori I (1997): Agreement between questionnaire data and medical records of chronic diseases in middle-aged and elderly Finnish men and women. Am J Epidemiol 145:762-769.

Hagberg B and Samuelsson G (2008): Survival after 100 years of age: a multivariate model of exceptional survival in Swedish centenarians. J Gerontol A Biol Sci Med Sci 63:1219-1226.

Hall CB, Verghese J, Sliwinski M, Chen Z, Katz M, Derby C and Lipton RB (2005): Dementia incidence may increase more slowly after age 90: results from the Bronx Aging Study. Neurology 65(6):882-826.

Hamel MB, Davis RB, Teno JM, Knaus WA, Lynn J, Harrell F Jr, Galanos AN, Wu AW and Phillips RS,(1999): Older age, aggressiveness of care, and survival for seriously ill, hospitalised adults. SUPPORT Investigators. Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments. Ann Intern Med 131:721-728.

Harman D (2001): Aging: Overview. Ann N Y Acad Sci 928:1-21.

Harman D (2006): Free radical theory of aging: an update: increasing the functional life span. Ann N Y Acad Sci 1067:10-21.

Hayflick L (2007): Biological aging is no longer an unsolved problem. Ann N Y Acad Sci 1100:1-13.

Hébert R, Dubois MF, Wolfson C, Chambers L and Cohen C (2001): Factors associated with long-term institutionalization of older people with dementia: data from the Canadian Study of Health and Aging. J Gerontol A Biol Sci Med Sci 56:M693-699.

Heeren TJ, Lagaay AM, Hijmans W and Rooymans HGM (1991): Prevalence of dementia in the 'oldest-old' in a Dutch community. J Am Geriatr Soc 39:755-759.

Helmer C, Barberger-Gateau P, Letenneur L and Dartigues JF (1999): Subjective health and mortality in French elderly women and men. J Gerontol B Psychol Sci Soc Sci 54: S84-92.

Henderson J, Goldacre MJ and Griffith M (1990): Hospital care for the elderly in the final year of life: a population based study. BMJ 301:17-19.

Hitt R, Young-Xu Y, Silver M and Perls T (1999): Centenarians: the older you get, the healthier you have been. Lancet 354: 652.

Hoeymans N, Feskens EJ, Kromhout D and van den Bos GA (1999): The contribution of chronic conditions and disabilities to poor self-rated health in elderly men. J Gerontol A Biol Sci Med Sci 54: M501-506.

Hovanesyan A and Rich MW (2008): Outcomes of acute myocardial infarction in nonagenarians. Am J Cardiol 101:1379-1383.

International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Version for 2007. Available at: http://www.who.int/classifications/apps/icd/icd10online/ Accessed 14 Jan, 2009.

The Italian Longitudinal Study on Aging Working Group (1997): Prevalence of chronic diseases in older Italians: comparing self-reported and clinical diagnoses. Int J Epidemiol 26:995-1002.

Jennings AG and de Boer P (1999): Should we operate on nonagenarians with hip fractures? Injury. 30:169-172.

Jensen GD and Bellecci P (1987): The physical and mental health of nonagenarians. Age Ageing 16:19-24.

John SM and Koelmeyer TD (2001): The forensic pathology of nonagenarians and centenarians: do they die of old age? (The Auckland experience). Am J Forensic Med Pathol 22:150-154.

Jylhä M (1994): Ten-year change in the use of medical drugs among the elderly - a longitudinal study and cohort comparison. J Clin Epidemiol 47:69–79.

Jylhä M and Hervonen A (1999): Functional status and need of help among people aged 90 or over: a mailed survey with a total home-dwelling population. Scand J Public Health 27:106-111.

Jylhä M, Guralnik JM, Balfour J and Fried LP (2001): Walking difficulty, walking speed, and age as predictors of self-rated health: the women's health and aging study. J Gerontol A Biol Sci Med Sci 56:M609-617.

Jylhä M, Volpato S and Guralnik JM (2006): Self-rated health showed a graded association with frequently used biomarkers in a large population sample. J Clin Epidemiol 59:465-471.

Jyrkkä J, Vartiainen L, Hartikainen S, Sulkava R and Enlund H (2006): Increasing use of medicines in elderly persons: a five-year follow-up of the Kuopio 75+Study Eur J Clin Pharmacol 62:151-158.

Kahle-Wrobleski K, Corrada MM, Li B and Kawas CH (2007): Sensitivity and specificity of the mini-mental state examination for identifying dementia in the oldest-old: the 90+ study. J Am Geriatr Soc 55:284-289.

Kannus P, Parkkari J, Sievänen H, Heinonen A, Vuori I and Järvinen M (1996): Epidemiology of hip fractures. Bone 18:57S-63S.

Katz S, Branch LG, Branson MH, Papsidero JA, Beck JC and Greer DS (1983): Active life expectancy. N Engl J Med 309:1218-1224.

Kawas C, Gray S, Brookmeyer R, Fozard J and Zonderman A (2000): Age-specific incidence rates of Alzheimer's disease: the Baltimore Longitudinal Study of Aging. Neurology 54:2072-2077.

Kehoe R, Wu S, Leske MC and Chylack LT (1994): Comparing self-reported and physician-reported medical history. Am J Epidemiol 139:813-818.

Kivinen P, Halonen P, Eronen M and Nissinen A (1998): Self-rated health, physician-rated health and associated factors among elderly men: the Finnish cohorts of the Seven Countries Study. Age Ageing 27:41-47.

Kriegsman DM, Penninx BW, Eijk JT, Boeke AJ and Deeg DJ (1996): Self-reports and general practitioner information on the presence of chronic diseases in community dwelling elderly. A study on the accuracy of patients' self-reports and on determinants of inaccuracy. J Clin Epidemiol 49:1407-1417.

Kulminski AM, Ukraintseva SV, Akushevich IV, Arbeev KG and Yashin AI (2007): Cumulative index of health deficiencies as a characteristic of long life. J Am Geriatr Soc 55:935-940.

Landis JR and Koch GG (1977): The measurement of observer agreement for categorical data. Biometrics 33:159-174.

Lee SJ, Go AS, Lindquist K, Bertenthal D and Covinsky KE (2008): Chronic conditions and mortality among the oldest old. Am J Public Health 98:1209-1214.

Leppälä JM, Virtamo J and Heinonen OP (1999): Validation of stroke diagnosis in the National Hospital Discharge Register and the Register of Causes of Death in Finland. Eur J Epidemiol 15:155-160.

Liao Y, McGee DL, Cao G and Cooper RS, (2000): Quality of the last year of life of older adults: 1986-1993. JAMA 283: 512-518.

Linjakumpu T, Hartikainen S, Klaukka T, Veijola J, Kivelä SL and Isoaho R (2002): Use of medications and polypharmacy are increasing among the elderly. J Clin Epidemiol 55:809–817.

Lio D, Scola L, Crivello A, Colonna-Romano G, Candore G, Bonafé M, Cavallone L, Marchegiani F, Olivieri F, Franceschi C and Caruso C (2003): Inflammation, genetics, and

longevity: further studies on the protective effects in men of IL-10 -1082 promoter SNP and its interaction with TNF-alpha -308 promoter SNP. J Med Genet 40:296-299.

Lipscombe LL and Hux JE (2007): Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995–2005: a population-based study. Lancet 369:750-756.

Lönnroos E, Kautiainen H, Karppi P, Huusko T, Hartikainen S, Kiviranta I and Sulkava R (2006): Increased incidence of hip fractures. A population based-study in Finland. Bone 39:623-627.

Louhija J (1994): Finnish centenarians. A clinical epidemiological study. Academic dissertation. Helsinki: University of Helsinki.

McFadden E, Luben R, Bingham S, Wareham N, Kinmonth AL and Khaw KT (2008): Social inequalities in self-rated health by age: cross-sectional study of 22,457 middle-aged men and women. BMC Public Health 8:230.

Maggi S, Noale M, Gallina P, Bianchi D, Marzari C, Limongi F and Crepaldi G; ILSA Working Group (2006): Metabolic syndrome, diabetes, and cardiovascular disease in an elderly Caucasian cohort: the Italian Longitudinal Study on Aging. J Gerontol A Biol Sci Med Sci 61:505-510.

Maggi S, Zucchetto M, Grigoletto F, Baldereschi M, Candelise L, Scarpini E, Scarlato G and Amaducci L (1994): The Italian Longitudinal Study on Aging (ILSA): design and methods. Aging (Milano) 6:464-473.

Mahoney FI and Barthel DW (1965): Functional evaluation: the Barthel Index. Md State Med J 14:61–65.

Manton KG and Stallard E (1991): Cross-sectional estimates of active life expectancy for the U.S. elderly and oldest-old populations. J Gerontol. 46:S170-182

Manton KG, Gu X and Lowrimore GR (2008): Cohort changes in active life expectancy in the U.S. elderly population: experience from the 1982-2004 National Long-Term Care Survey. J Gerontol B Psychol Sci Soc Sci 63:S269-281.

Marengoni A, von Strauss E, Rizzuto D, Winblad B and Fratiglioni L (2009): The impact of chronic multimorbidity and disability on functional decline and survival in elderly persons. A community-based, longitudinal study. J Intern Med 265:288-295.

Matthews FE and Dening T (2002): UK Medical Research Council Cognitive Function and Ageing Study. Prevalence of dementia in institutional care. Lancet. 360:225-226.

Mayer-Oakes SA, Oye RK and Leake B (1991): Predictors of mortality in older patients following medical intensive care: the importance of functional status. J Am Geriatr Soc 39:862-868.

Menec VH, Lix L, Nowicki S and Ekuma O (2007): Health care use at the end of life among older adults: does it vary by age? J Gerontol A Biol Sci Med Sci 62:400-407.

Miyaishi O, Ando F, Matsuzawa K, Kanawa R and Isobe K (2000): Cancer incidence in old age. Mech Ageing Dev 117:47-55.

Michel SL, Stevens L, Amodeo P and Morgenstern L (1984): Surgical procedures in nonagenarians. West J Med 141:61-63.

Motta M, Bennati E, Ferlito L, Malaguarnera M and Motta L (2005): Italian Multicenter Study on Centenarians (IMUSCE). Successful aging in centenarians: myths and reality. Arch Gerontol Geriatr 40:241-251.

Murray CJ and Lopez AD (1997): Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. Lancet 349:1498-1504.

Myllykangas L, Polvikoski T, Sulkava R, Verkkoniemi A, Tienari P, Niinistö L, Kontula K, Hardy J, Haltia M and Pérez-Tur J (2000): Cardiovascular risk factors and Alzheimer's disease: a genetic association study in a population aged 85 or over. Neurosci Lett 292:195-198.

Naeim A, Keeler EB and Reuben D (2007): Perceived causes of disability added prognostic value beyond medical conditions and functional status. J Clin Epidemiol 60:79-85.

Niemi AK, Hervonen A, Hurme M, Karhunen PJ, Jylhä M and Majamaa K (2003): Mitochondrial DNA polymorphisms associated with longevity in a Finnish population. Hum Genet 112:29-33.

Nihtilä EK, Martikainen PT, Koskinen SV, Reunanen AR, Noro AM and Häkkinen UT (2008): Chronic conditions and the risk of long-term institutionalization among older people. Eur J Public Health. 18:77-84.

Nilsson SE, Johansson B, Berg S, Karlsson D and McClearn GE (2002): A comparison of diagnosis capture from medical records, self-reports, and drug registrations: a study in individuals 80 years and older. Aging Clin Exp Res 14:178-184.

Noale M, Maggi S, Minicuci N, Marzari C, Destro C, Farchi G, Scafato E, Baldereschi M, Di Carlo A and Crepaldi G; ILSA Working Group (2003): Dementia and disability: impact on mortality. The Italian Longitudinal Study on Aging. Dement Geriatr Cogn Disord 16:7-14.

Nybo H, Gaist D, Jeune B, Bathum L, McGue M, Vaupel JW and Christensen K (2001): The Danish 1905 cohort: a genetic-epidemiological nationwide survey. J Aging Health 13:32-46.

Nybo H, Gaist D, Jeune B, McGue M, Vaupel JW and Christensen K (2001): Functional status and self-rated health in 2,262 nonagenarians: the Danish 1905 Cohort Survey. J Am Geriatr Soc 49:601-609.

Nybo H, Petersen HC, Gaist D, Jeune B, Andersen K, McGue M, Vaupel JW and Christensen K (2003): Predictors of mortality in 2,249 nonagenarians--the Danish 1905-Cohort Survey. J Am Geriatr Soc 51:1365-1373.

Oeppen J and Vaupel JW. Broken limits to life expectancy. Science 2002;296:1029–1031.

Olafsdottir M, Skoog I and Marcusson J (2000): Detection of dementia in primary care: the Linkoping study. Dement Geriatr Cogn Disord 11:223-229.

Olshansky SJ and Carnes BA (1997): Ever since Gompertz. Demography 34:1-15.

Olshansky SJ, Carnes BA and Cassel C (1990): In search of Methuselah: estimating the upper limits to human longevity. Science 250:634-640.

Parker MG and Thorslund M (2007): Health trends in the elderly population: getting better and getting worse. Gerontologist 47:150-158.

Parker MG, Ahacic K and Thorslund M (2005): Health changes among Swedish oldest old: prevalence rates from 1992 and 2002 show increasing health problems. J Gerontol A Biol Sci Med Sci 60:1351-1355.

Perls T and Terry D (2003): Genetics of exceptional longevity. Exp Gerontol 38:725-730.

Perls TT, Morris JN, Ooi WL and Lipsitz LA (1993): The relationship between age, gender and cognitive performance in the very old: the effect of selective survival. J Am Geriatr Soc 41:1193-1201.

Plewa MC (1990): Altered host response and special infections in the elderly. Emerg Med Clin North Am 8:193-206.

Reischies, FM and Geiselmann, B (1997): Age-related cognitive decline and vision impairment affecting the detection of dementia syndrome in old age. British J Psychiatry 171:449-451.

Rellos K, Falagas ME, Vardakas KZ, Sermaides G and Michalopoulos A (2006): Outcome of critically ill oldest-old patients (aged 90 and older) admitted to the intensive care unit. J Am Geriatr Soc 54:110-114.

Riggs JE (1992): Aging and mortality: manifestations of natural 'non-selection'. Mech Ageing Dev 62:127-135.

Robine JM and Paccaud F (2005): Nonagenarians and centenarians in Switzerland, 1860–2001: a demographic analysis J Epidemiol Community Health 59:31-37.

Robine J and Vaupel JW (2001): Supercentenarians: slower ageing individuals or senile elderly? Exp Gerontol 36:915-930.

Rochon P and Gurwitz J (1999): Prescribing for seniors neither too much nor too little. JAMA 282:113-115.

Roos NP and Havens B (1991): Predictors of successful aging: a twelve-year study of Manitoba elderly. Am J Public Health 81:63-68.

Rosenberg IH (1997): Sarcopenia: origins and clinical relevance. J Nutr 127:990s-991s.

Rowe JW and Kahn RL (1987): Human aging: usual and successful. Science 237:143-149.

Samuelsson SM, Alfredson BB, Hagberg B, Samuelsson G, Nordbeck B, Brun A, Gustafson L and Risberg J (1997): The Swedish Centenarian Study: a multidisciplinary study of five consecutive cohorts at the age of 100. Int J Aging Hum Dev 45:223-253.

Sargent-Cox KA, Anstey KJ and Luszcz MA (2008): Determinants of self-rated health items with different points of reference: implications for health measurement of older adults. J Aging Health 20:739-761

Säynäjäkangas P, Keistinen T, Honkanen PO and Kivelä S-L (1997): Hospital discharges for pneumonia in Finland between 1972 and 1993 in the population aged 65 years or over. Age Ageing 26:269-273.

Schroll M (1992): Does increased life expectancy imply active life expectancy? Dan Med Bull 39:258-261

Skoog I, Nilsson L, Palmertz B, Andreasson L-A and Svanborg A (1993): A population-based study of dementia in 85-year-olds. N Engl J Med 328:153-158.

Smith J, Maas I, Mayer KU, Helmchen H, Steinhagen-Thiessen E and Baltes PB (2002): Two-wave longitudinal findings from the Berlin aging study: introduction to a collection of articles. J Gerontol B Psychol Sci Soc Sci 57:P471-473.

Smith PW, Roccaforte JS and Daly PB (1992): Infection and immune response in the elderly. Ann Epidemiol 2:813-822.

Sulter G, Steen C and De Keyser J (1999): Use of the Barthel index and modified Rankin scale in acute stroke trials. Stroke 30:1538-1541.

Suzman R and Riley MW (1985): Introducing the "oldest old". Milbank Mem Fund Q Health Soc 63:177-186.

STAKES (2001): Statistical Yearbook on Social Welfare and Health Care 2000. Official Statistics of Finland (SVT), Social security 2001:1, pp. 29-30, 66-68.

Stanta G, Campagner L, Cavallieri F and Giarelli L (1997): Cancer of the oldest old. What we have learned from autopsy studies. Clin Geriatr Med 13:55-68.

Statistics Finland (2008): www.tilastokeskus.fi, accessed 30 October, 2009

Strandberg TE, Pitkala KH and Tilvis RS (2009): Predictors of mortality in home-dwelling patients with cardiovascular disease aged 75 and older. J Am Geriatr Soc 57:279-284.

Struijs JN, van Genugten ML, Evers SM, Ament AJ, Baan CA and Bos GA (2005): Modeling the future burden of stroke in The Netherlands: impact of aging, smoking, and hypertension. Stroke 36:1648-1655.

Teno JM, Harrell FE Jr, Knaus W, Phillips RS, Wu AW, Connors A Jr, Wenger NS, Wagner D, Galanos A, Desbiens NA and Lynn J (2000): Prediction of survival for older hospitalized patients: the HELP survival model. Hospitalized Elderly Longitudinal Project. J Am Geriatr Soc 48:S16-24.

Terry DF, Sebastiani P, Andersen SL and Perls TT (2008): Disentangling the roles of disability and morbidity in survival to exceptional old age. Arch Intern Med 168:277-283.

Tilvis RS, Hakala SM, Valvanne J and Erkinjuntti T (1995): Urinary incontinence as a predictor of death and institutionalization in a general aged population. Arch Gerontol Geriatr 21:307-315.

Tilvis RS, Kähönen-Väre MH, Jolkkonen J, Valvanne J, Pitkala KH and Strandberg TE (2004): Predictors of cognitive decline and mortality of aged people over a 10-year period. J Gerontol A Biol Sci Med Sci 59:268-274.

Tombaugh TN and McIntyre NJ (1992): The mini-mental state examination: a comprehensive review. J Am Geriatr Soc 40:922-935.

Topinková E (2008): Aging, disability and frailty. Ann Nutr Metab 52 Suppl 1:6-11.

Valderrama-Gama E, Damián J, Ruigómez A and Martín-Moreno JM (2002): Chronic disease, functional status, and self-ascribed causes of disabilities among noninstitutionalized older people in Spain. J Gerontol A Biol Sci Med Sci 57:M716-721.

Vaillant GE and Mukamal K (2001): Successful aging. Am J Psychiatry 158:839-847.

Vallgarda S (1999): Is old age necessarily connected with high hospital admission rates? Scand. J. Public Health 27:137-142.

Walter S, Kunst A, Mackenbach J, Hofman A and Tiemeier H (2009): Mortality and disability: the effect of overweight and obesity. Int J Obes (Lond). 2009 Sep 29.

van den Akker M, Buntinx F, Metsemakers JF, Roos S and Knottnerus JA (1998): Multimorbidity in general practice: prevalence, incidence, and determinants of co-occurring chronic and recurrent diseases. J Clin Epidemiol 51:367-375.

van Doorn C and Kasl SV (1998): Can parental longevity and self-rated life expectancy predict mortality among older persons? Results from an Australian cohort. J Gerontol B Psychol Sci Soc Sci 53:S28-34.

Vaupel JW (1997): The remarkable improvements in survival at older ages. Philos Trans R Soc Lond B Biol Sci 352:1799-1804.

Wernicke TF and Reischies FM (1994): Prevalence of dementia in old age: clinical diagnoses in subjects aged 95 years and older. Neurology 44:250-253.

Williams EI, Bennett FM, Nixon JV, Nicholson MR and Gabert J (1972): Sociomedical study of patients over 75 in general practice. Br Med J 2:445-448.

von Bonsdorff M, Rantanen T, Laukkanen P, Suutama T and Heikkinen E (2006): Mobility limitations and cognitive deficits as predictors of institutionalization among community-dwelling older people. Gerontology 52:359-365.

von Faber M, Bootsma-van der Wiel A, van Exel E, Gussekloo J, Lagaay AM, van Dongen E, Knook DL, van der Geest S and Westendorp RG (2001): Successful aging in the oldest old: Who can be characterized as successfully aged? Arch Intern Med 161:2694–2700.

von Heideken Wågert P, Gustavsson JM, Lundin-Olsson L, Kallin K, Nygren B, Lundman B, Norberg A and Gustafson Y (2006): Health status in the oldest old. Age and sex differences in the Umeå 85+ Study. Aging Clin Exp Res 18:116-126.

von Strauss E, Fratiglioni L, Viitanen M, Forsell Y and Winblad B (2000): Morbidity and comorbidity in relation to functional status: a community-based study of the oldest old (90+ years). J Am Geriatr Soc 48:1462-1469.

von Strauss E, Agüero-Torres H, Kåreholt I, Winblad B and Fratiglioni L (2003): Women are more disabled in basic activities of daily living than men only in very advanced ages: a study on disability, morbidity, and mortality from the Kungsholmen Project. J Clin Epidemiol 56:669-677.

WHO (2009): http://www.who.int/ageing/en/index.html, accessed 15 March, 2009

Wikby A, Månsson IA, Johansson B, Strindhall J and Nilsson SE (2008): The immune risk profile is associated with age and gender: findings from three Swedish population studies of individuals 20-100 years of age. Biogerontology 9:299-308.

Wikipedia: http://en.wikipedia.org/wiki/Ageing, accessed Sep 15, 2009

Wilkinson TJ and Sainsbury R (1998): The association between mortality, morbidity and age in New Zealand's oldest old. Int J Aging Hum Dev 46:333-343.

Willcox DC, Willcox BJ, Wang NC, He Q, Rosenbaum M and Suzuki M (2008): Life at the extreme limit: phenotypic characteristics of supercentenarians in Okinawa. J Gerontol A Biol Sci Med Sci 63:1201-1208.

Wilmoth JR (2000): Demography of longevity: past, present, and future trends. Exp Gerontol 35:1111-1129.

Wilmoth JR, Deegan LJ, Lundström H and Horiuchi S (2000): Increase of maximum life-span in Sweden, 1861-1999. Science 289:2366-2368.

Xie J, Matthews FE, Jagger C, Bond J and Brayne C (2008): The oldest old in England and Wales: a descriptive analysis based on the MRC Cognitive Function and Ageing Study. Age Ageing 37:396-402.

Yoshikawa TT and Norman DC (1996): Approach to fever and infection in the nursing home. J Am Geriatr Soc 44:74-82.

Zhan C, Sangl J, Bierman AS, Miller MR, Friedman B, Wickizer SW and Meyer GS (2001): Potentially inappropriate medication use in the community-dwelling elderly. JAMA 286:2823–2829.

Zhu K, McKnight B, Stergachis A, Daling JR and Levine RS (1999): Comparison of self-report data and medical records data: results from a case-control study on prostate cancer. Int J Epidemiol 28:409-417

Appendix

Appendix I

Lifetime prevalences of all recorded chronic and severe diseases. Men and women.

	Prevalence			
Disease class or disease	**All** n = 822 %	**Women** n = 653 %	**Men** n = 169 %	**Sig.**
ICD Class A, Bacterial infection	18.5	17.3	23.1	0.056
Tuberculosis	4.6	4.4	5.3	0.376
Erysipelas	6.4	6.0	8.3	0.179
Gastroenteritis	6.3	5.7	8.9	0.092
ICD Class B, Viral infections	5.4	5.5	4.7	0.430
Herpes zoster	2.1	2.5	0.6	0.105
Hepatitis	0.5	0.0	2.4	0.002 *
All infections	53.6	52.4	58.6	0.087
ICD Class C, Cancer	17.6	15.8	24.9	0.005 *
Basal cell carcinoma	5.3	5.4	4.8	0.471
Cancer other than basal cell	13.8	11.7	21.7	0.001 *
Breast carcinoma	3.8	4.7	0	0.001 +
Prostate carcinoma	1.7	0	8.3	<0.001 *
ICD Class D 0-49, other tumor	9.5	10.7	4.7	0.010 +

ICD Class D 50-, blood value	18.1	17.5	20.7	0.192
Anemia	16.8	16.2	18.9	0.233
B12 deficiency	7.8	7.4	9.5	0.222
ICD Class E, Endochrinological	29.7	32.9	17.2	0.000 +
Diabetes	12.9	13.5	10.7	0.200
Thyroid disease	15.2	17.8	5.3	0.000 +
ICD Class F, Psychiatric (dem.)	33.1	35.8	22.5	0.001 +
Dementia	24.6	26.2	18.3	0.020 +
Depression	10.7	12.3	4.7	0.002 +
Psychosis	3.4	4.1	0.6	0.012 +
ICD Class G, Neurological	20.0	20.5	17.8	0.246
Transient ischemic attack	11.0	12.1	6.5	0.083
Parkinson's disease	4.3	4.3	4.1	0.567
Epilepsy	1.0	0.8	1.8	0.215
ICD Class H, Eye diseases	22.9	24.0	18.3	0.069
Glaucoma	10.2	10.7	8.3	0.218
Cataract	13.7	14.7	10.7	0.116
ICD Class H, Ear diseases	4.3	4.1	4.7	0.433
ICD Class I, Cardiovascular	78.3	79.9	72.2	0.021 +
Heart disease	72.5	74.0	66.9	0.042 +
Hypertension	36.1	39.7	22.5	0.000 +
Coronary heart disease	44.8	46.1	39.6	0.078
Heart failure	35.9	38.3	26.1	0.018 +
Stroke	16.9	17.3	15.4	0.320
Heart infarction	15.0	14.4	17.2	0.217
Atrial fibrillation	22.6	22.5	23.1	0.474
Venous thrombosis	5.2	5.7	3.6	0.184
Pulmonary embolism	5.5	4.9	7.7	0.111
Severe atherosclerosis	3.2	3.1	3.6	0.451
Varicose veins	10.0	11.2	5.3	0.013 +
Hemorrhoids	4.3	3.7	6.5	0.083

ICD Class J, Lung diseases	32.8	30.8	40.8	0.009 *
Lung infections	27.7	25.6	36.1	0.005 *
Chronic lung diseases	7.3	7.7	5.9	0.277
ICD Class K, Digestion	58.6	56.5	66.9	0.009 *
Disease of the food pipe	5.5	5.4	5.9	0.449
Peptic ulcer	9.9	8.7	14.2	0.027 *
Chronic gastritis	8.4	8.7	7.1	0.307
Appendicitis	14.1	13.2	17.8	0.083
Hernia	15.3	10.1	35.5	0.000 *
Functional bowel diseases	18.1	18.7	16.0	0.244
Diverticulosis	13.4	14.1	10.7	0.148
Gall bladder diseases	27.1	28.6	21.3	0.033 +
Pancreatic disease	0.4	0.5	0	0.501
ICD Class L, Skin diseases	5.2	5.2	5.3	0.539
ICD Class M, Connective	44.3	46.6	35.5	0.006 +
Rheumatoid arthritis	2.3	2.6	1.2	0.216
Uric arthritis	4.9	4.1	7.7	0.048 *
Osteoarthritis	22.7	24.5	16.0	0.011 +
Other connective tissue disease	4.5	4.9	3.0	0.193
Back disease	10.6	10.9	9.5	0.356
Osteoporosis	8.9	10.7	1.8	0.000 +
ICD Class N, Urinary system	41.2	38.1	53.3	0.000 *
Urinary tract infection	26.0	29.4	13.0	0.000 +
Kidney disease	3.6	3.8	3.0	0.395
Kidney stones	1.5	1.1	3.0	0.079
Prostate hyperplasia	9.9	0	47.3	0.000 *
Uterus prolapse	4.1	5.2	0	0.000 +
ICD Class P, Pregnancy problems				
	0.4	0.5	0	0.501
ICD Class Q, Congenital malformations				
	0.6	0.6	0.6	0.726

ICD Class R, Symptoms	22.7	23.7	18.9	0.109
Urinary symptoms	3.4	3.2	4.1	0.348
Vertigo	10.6	12.1	4.7	0.002 +
Collapse	0.7	0.6	1.2	0.358
ICD Classes S-Y, Injuries	46.1	49.5	33.1	0.000 +
All fractures	40.4	44.7	23.7	0.000 +
Humerus fracture	6.0	6.9	2.4	0.015 +
Wrist fracture	14.6	17.2	4.7	0.000 +
Hip fracture	17.2	19.3	8.9	0.001 +
Ankle fracture	5.7	6.4	3.0	0.054
Rib fracture	3.6	3.7	3.6	0.577
Other fractures	8.3	8.9	5.9	0.136
ICD Class W, Accidents	49.6	52.7	37.9	0.000 +
ICD Class Z, Other reason	0.6	0.8	0	0.315

* Statistically more common in men.

+ Statistically more common in women.

Appendix II

Lifetime prevalences of all recorded chronic and severe diseases. Community-living and institution-living.

	Prevalence			
Disease class or disease	**All** n = 822 %	**Home** n = 572 %	**Instit.** n = 250 %	**Sig.**
ICD Class A, Bacterial infection	18.5	15.9	24.4	0.003*
Tuberculosis	4.6	4.0	6.0	0.144
Erysipelas	6.4	5.4	8.8	0.051
Gastroenteritis	6.3	5.2	8.8	0.041*
ICD Class B, Viral infections	5.4	5.8	4.4	0.267
Herpes zoster	2.1	1.7	2.8	0.235
Hepatitis	0.5	0.7	0	0.234
All infections	53.6	47.7	67.2	0.000*
ICD Class C, Cancer	17.6	18.7	15.2	0.132
Basal cell carcinoma	5.3	5.1	5.6	0.440
Cancer other than basal cell	13.8	14.8	11.3	0.106
Breast carcinoma	3.8	4.0	3.2	0.364
Prostate carcinoma	1.7	2.4	0	0.006+
ICD Class D 0-49, other tumor	9.5	9.3	10.0	0.415
ICD Class D 50-, blood value	18.1	19.1	16.0	0.172
Anemia	16.8	17.7	14.8	0.183
B12 deficiency	7.8	8.2	6.8	0.293

ICD Class E, Endochrinological	29.7	27.3	35.2	0.014*
Diabetes	12.9	10.1	19.2	0.000*
Thyroid disease	15.2	15.4	14.8	0.460
ICD Class F, Psychiatric (dem.)	33.1	19.9	63.2	0.000*
Dementia	24.6	12.4	52.4	0.000*
Depression	10.7	7.0	19.2	0.000*
Psychosis	3.4	1.7	7.2	0.000*
ICD Class G, Neurological	20.0	17.3	26.0	0.003*
Transient ischemic attack	11.0	8.6	16.3	0.012*
Parkinson's disease	4.3	4.0	4.8	0.367
Epilepsy	1.0	1.0	0.8	0.541
ICD Class H, Eye diseases	22.9	19.9	29.6	0.002*
Glaucoma	10.2	9.1	12.8	0.070
Cataract	13.7	11.9	18.0	0.014*
ICD Class H, Ear diseases	4.3	3.5	6.0	0.077
ICD Class I, Cardiovascular	78.3	77.3	80.8	0.150
Heart disease	72.5	72.0	73.6	0.354
Hypertension	36.1	37.1	34.0	0.223
Coronary heart disease	44.8	43.0	48.8	0.072
Heart failure	35.9	32.4	43.5	0.013*
Stroke	16.9	15.0	21.2	0.020*
Heart infarction	15.0	15.9	12.8	0.148
Atrial fibrillation	22.6	23.3	21.2	0.291
Venous thrombosis	5.2	4.7	6.4	0.203
Pulmonary embolism	5.5	5.2	6.0	0.386
Severe atherosclerosis	3.2	2.8	4.0	0.241
Varicose veins	10.0	10.5	8.8	0.271
Hemorrhoids	4.3	3.8	5.2	0.240
ICD Class J, Lung diseases	32.8	29.0	41.6	0.000*
Lung infections	27.7	23.3	38.0	0.000*
Chronic lung diseases	7.3	6.6	8.8	0.171

ICD Class K, Digestion	58.6	58.9	58.0	0.432
Disease of the food pipe	5.5	4.4	8.0	0.029*
Peptic ulcer	9.9	10.0	9.6	0.492
Chronic gastritis	8.4	8.0	9.2	0.335
Appendicitis	14.0	15.6	10.8	0.043+
Hernia	15.3	16.1	13.6	0.212
Functional bowel diseases	18.1	17.1	20.4	0.154
Diverticulosis	13.4	12.8	14.8	0.247
Gall bladder diseases	27.1	26.0	29.6	0.166
Pancreatic disease	0.4	0.2	0.8	0.221
ICD Class L, Skin diseases	5.2	5.1	5.6	0.435
ICD Class M, Connective	44.3	41.8	50.0	0.018*
Rheumatoid arthritis	2.3	2.1	2.8	0.348
Uric arthritis	4.9	5.2	4.0	0.284
Osteoarthritis	22.7	20.5	28.0	0.012*
Other connective tissue disease	4.5	5.1	3.2	0.157
Back disease	10.6	10.3	11.2	0.394
Osteoporosis	8.9	7.9	11.2	0.081
ICD Class N, Urinary system	41.2	37.1	50.8	0.000*
Urinary tract infection	26.0	20.8	38.0	0.000*
Kidney disease	3.6	3.7	3.6	0.570
Kidney stones	1.5	2.1	0	0.012+
Prostate hyperplasia	9.9	11.2	6.8	0.032+
Uterus prolapse	4.1	3.0	6.8	0.011*
ICD Class P, Pregnancy problems				
	0.4	0.2	0.8	0.221
ICD Class Q, Congenital malformations				
	0.6	0.7	0.4	0.519
ICD Class R, Symptoms	22.7	20.8	27.2	0.028*
Urinary symptoms	3.4	2.3	6.0	0.008*
Vertigo	10.6	10.1	11.6	0.304

Collapse	0.7	0.9	0.4	0.411
ICD Classes S-Y, Injuries	46.1	43.2	52.8	0.007*
All fractures	40.4	37.6	46.8	0.008*
Humerus fracture	6.0	5.4	7.2	0.201
Wrist fracture	14.6	14.7	14.4	0.504
Hip fracture	17.2	14.2	24.0	0.001*
Ankle fracture	5.7	5.9	5.2	0.405
Rib fracture	3.6	3.1	4.8	0.168
Other fractures	8.3	7.9	9.2	0.305
ICD Class W, Accidents	49.6	46.9	56.0	0.010*
ICD Class Z, Other reason	14.6	14.7	14.4	0.504

* Statistically more common in institutions.

+ Statistically more common in the community.

Appendix III

Profiles of Tampere city hospitals in the treatment of 1077 90-year-olds persons.

Profile	Periods	Days	Length of stay	% of 90-y. -old died	%of 90-years -old are men	Most common diagnoses
General hospital	433	6,752	16	18.9	27.5	Hip fracture Chronic heart failure Coronary heart disease Respiratory infections Atherosclerosis
Geriatric	377	13,191	35	31.6	16.2	Coronary heart disease Stroke Dementia Social reason Chronic heart failure
Geriatric for the city's nursing home residents	179	12,533	70	48.4	9.0	Dementia Coronary heart disease Respiratory infections Chronic heart failure Functional bowel dis.
Psycho-geriatric	35	6,919	198	40.0	12.4	Dementia Psychosis Depression

						Stroke
Geriatric for bedridden patients	18	4,156	231	38.9	0.0	Dementia Coronary heart disease Stroke Breast cancer
All hospitals	**1,042**	**43,551**	**42**	**31.7**	**18.3**	**Hip fracture** **Dementia** **Coronary heart dis.** **Chronic heart failure** **Respiratory infections**

Appendix IV

Recorded medical conditions and 4-year survival (%) of nonagenarians.

	Survived until 94		
Disease class or disease	**All**	**Women**	**Men**
All	36.4	38.6	32.0
ICD Class A, Bacterial infection	30.9	32.7	25.6
Tuberculosis	26.3	27.6	22.2
Erysipelas	28.3	30.8	21.4
Gastroenteritis	38.5	40.5	33.3
ICD Class B, Viral infections	40.9	38.9	50.0
Herpes zoster	35.3	37.5	0
Hepatitis	25.0	38.6	25.0
All infections	28.1	29.5	23.2
ICD Class C, Cancer	29.7	33.0	21.4
Basal cell carcinoma	41.9	42.9	37.5
Cancer other than basal cell	26.8	30.3	19.4
Breast carcinoma		29.0	
Prostate carcinoma			28.6
ICD Class D 0-49, other tumor	30.8	32.9	12.5
ICD Class D 50-, blood value	28.2	28.1	28.6
Anemia	28.3	28.3	28.1
B12 deficiency	32.8	29.2	43.8
ICD Class E, Endochrinological	27.0	27.9	20.7
Diabetes	19.8	20.5	16.7
Thyroid disease	28.8	29.3	22.2
ICD Class F, Psychiatric (dem.)	24.3	26.1	13.2
Dementia	17.8	19.9	6.5

Depression	36.4	35.0	50.0
Psychosis	32.1	33.3	0
ICD Class G, Neurological	32.3	32.8	30.0
Transient ischemic attack	26.9	26.1	33.3
Parkinson's disease	34.3	35.7	28.6
Epilepsy	12.5	0	33.3
ICD Class H, Eye diseases	37.8	39.5	29.0
Glaucoma	34.5	35.7	28.6
Cataract	39.8	42.1	27.8
ICD Class H, Ear diseases	25.7	33.3	0
ICD Class I, Cardiovascular	31.5	33.1	24.6
Heart disease	30.5	31.9	24.8
Hypertension	33.7	34.4	28.9
Coronary heart disease	29.3	29.9	26.9
Heart failure	21.9	21.4	25.0
Stroke	19.4	18.6	23.1
Heart infarction	27.6	26.6	31.0
Atrial fibrillation	27.3	25.9	15.4
Venous thrombosis	27.9	39.0	0
Pulmonary embolism	28.9	28.1	30.8
Severe atherosclerosis	15.4	20.0	0
Varicose veins	46.3	47.9!	33.3
Hemorrhoids	28.6	25.0	36.4
ICD Class J, Lung diseases	29.3	29.4	29.0
Lung infections	26.3	26.9	24.6
Chronic lung diseases	31.7	32.0	30.0
ICD Class K, Digestion	35.5	36.9	31.0
Disease of the food pipe	26.7	25.7	30.0
Peptic ulcer	34.6	31.6	41.7
Chronic gastritis	26.1	26.3	25.0
Appendicitis	37.1	38.4	33.3

Hernia	37.3	36.4	38.3
Functional bowel diseases	28.9	30.3	22.2
Diverticulosis	32.7	32.6	33.3
Gall bladder diseases	35.0	37.4	22.2
Pancreatic disease	100	100	
ICD Class L, Skin diseases	30.2	26.5	44.4
ICD Class M, Connective	36.0	37.5	28.3
Rheumatoid arthritis	42.1	41.2	50.0
Uric arthritis	25.0	33.3	7.7
Osteoarthritis	38.5	39.4	33.3
Other connective tissue disease	24.3	25.0	20.0
Back disease	31.0	32.4	25.0
Osteoporosis	32.9	31.4	66.7
ICD Class N, Urinary system	27.1	27.7	25.6
Urinary tract infection	21.5	24.0	0
Kidney disease	13.3	16.0	0
Kidney stones	50.0	57.1	40.0
Prostate hyperplasia			28.4
Uterus prolapse		32.4	
ICD Class P, Pregnancy problems			
		0	
ICD Class Q, Congenital malformations			
	20.0	25.0	0
ICD Class R, Symptoms	39.6	39.4	40.6
Urinary symptoms	25.0	33.3	0
Vertigo	41.4	40.5	50.0
Collapse	33.3	50.0	0
ICD Classes S-Y, Injuries	34.0	34.4	32.1
All fractures	33.4	33.9	30.0
Humerus fracture	32.7	31.1	50.0
Wrist fracture	39.2	38.4	50.0

Hip fracture	28.4	30.2	13.3
Ankle fracture	29.8	31.0	20.0
Rib fracture	30.0	37.5	0
Other fractures	32.4	31.0	40.0
ICD Class W, Accidents	35.0	35.8	31.3
ICD Class Z, Other reason		60.0	

Original Communications

Medical history, cognitive status and mobility at the age of 90. A population-based study in Tampere, Finland

Sirkka Goebeler[1,2], Marja Jylhä[1], and Antti Hervonen[1]

[1]School of Public Health, University of Tampere, and [2]Department of Forensic Medicine, Tampere University Hospital, Tampere, Finland

ABSTRACT. ***Background and aims:*** *The oldest-old population is expanding rapidly. There is a new need for clinical information about this group, which is actively using social and health care. We studied the population of people born in 1907-1910 and living in the city of Tampere (Finland) at the age 90 (N=916, 79.4% women, 20.6% men); 71.7% of the population lived in the community and 28.3% in institutions.* ***Methods:*** *Medical records of 832 (90.8%) nonagenarians were obtained. We registered diagnoses of chronic diseases or diseases that required hospitalization at any time of their lives, as well as physicians' notes on their memory and mobility. Diseases were coded and grouped according to ICD-10.* ***Results:*** *The most common diagnosis groups were cardiovascular diseases (78.3%), gastrointestinal diseases (58.6%), infections (53.6%) and trauma (49.6%). There was an average of 8 chronic or severe diseases mentioned in patient records. The diagnosis of dementia was mentioned in 26.7% of cases, most of them living in institutions; a problem with memory – from forgetfulness to dementia – was mentioned in 35.9% of cases; 37.5% were able to move using no or a light support, 8.3% were bedridden.* ***Conclusions:*** *We conclude that this age group suffers from numerous chronic diseases influencing mobility and cognition. Dementia seems to be the most important symptom leading to institutionalization.*

(Aging Clin Exp Res 2003; 15: 154-161)

INTRODUCTION

The oldest-old are the fastest growing group in the Western population (1). Research on the oldest-old has concentrated on centenarians as a model of successful aging and as a curiosity (2-4). However, there is a significantly large group of very old people who are 90 and over, and most of them still have years to live, even though only a few will reach the age of 100 years. This historically "young" group of the oldest-old have far exceeded the life expectation of their contemporaries, and there is not much systematic epidemiologically relevant information available about them. Many studies on the very old have been carried out in the form of mailed questionnaires or interviews and testing of a selected group. Earlier studies are almost entirely either community-based (5-7) or use a selected institutionalized group of people. Studying an unselected normal population of the oldest-old is rare. Further, community studies are likely to give a too optimistic picture of the health of the population. Several studies indicate that not participating in a research project is a good predictor for impaired health and mortality (5, 8). However, some studies with large and representative samples have recently been published, such as the Italian Longitudinal Study on Aging – a longitudinal study on a large sample of 65-84-year-old Italians (9); the Sardinia Study of Extreme Longevity, in which all Sardinian centenarians were originally included in the study and most of them were interviewed and tested (10); the Danish Study of Centenarians and Older Twins, which focuses on all centenarians and twins aged 75-94 in Denmark (11); and the Kungsholmen project – a community-based survey of all Stockholm residents of age 90 and older (12).

There are several stereotypes for the oldest-old. Some studies indicate that they are exceptionally healthy and robust, and have avoided the common killers such as cancer, stroke, or myocardial infarction (2-4); others show that the very old are all frail and more or less demented (2, 13). However, the prevalence of major geriatric diseases has not been systematically investigated. For example, the reported prevalence of dementia varies considerably among the oldest-old (7, 14-17).

This study is a part of an ongoing multidisciplinary pro-

Key words: Chronic disease, cognition, geriatric disease prevalence, institutional care, longevity, mobility, nonagenarians.

Correspondence: S. Goebeler, School of Public Health, University of Tampere, Tampere 33014, Finland.
E-mail: sirkka.goebeler@uta.fi

Received November 14, 2001; accepted in revised form October 2, 2002.

ject, "Vitality 90+", which focuses on the health and social situation of 90-year-old people in Tampere, Finland. Thanks to accurate population and medical records, practically every person reaching 90 years of age could be traced for the study. In this paper, the aim was to explore the history of 90-year olds from the medical perspective, to learn about the type of diseases they suffer from and what chronic diseases they have. In the "Vitality 90+" project, we decided to study the group of 90-year olds. Characteristically, this group is old enough to give a picture of exceptional longevity, represents a less selected group than centenarians, and – being a narrow age cohort – is free from heterogeneity caused by age differences. People at 90 and over form 0.5% of the population in the city of Tampere, which is similar to the proportion of nonagenarians in, for example, the USA (18). We wanted to design a study based on records that would include people of different backgrounds and people living more or less dependently on the support of their families or the social and health care system. Ideally, the study would cover the basic population completely. For these reasons, we chose to use public health physicians' records to understand subjects' medical history and the current state of their health.

METHODS

Health care system and health records in the region

Tampere is a growing technology and industrial city of about 193000 inhabitants, located in Southern Finland. The public health care system in Finland is divided into hierarchical levels that work closely together. The city of Tampere has one university, one general and three geriatric hospitals. The city health centers with outpatient clinics are connected with the general hospital; two of the geriatric hospitals also provide outpatient services. Only a nominal fee is collected for seeing a doctor at outpatient and health centers. Public health benefits cover everyone living in the region. There are no private inpatient hospitals in the region. However, there are several private outpatient clinics in Tampere. The city hospitals and health centers combined systematic patient registry goes back to 1972. Since 1972, physicians have been required to keep records of each patient visit by law, and all records since then are archived. Records must report the reason for each patient's visit, medical history, symptoms, diagnosis, and treatment. The clinic secretary ascertains that the physician has properly completed the records, which then follow the patient in the city health care system. The university hospital sends a copy of its records after each treatment to the primary care physician, unless the patient has specifically refused this, and these copies are attached to the city health care records. As there are no private hospitals, any disease leading to hospitalization in Tampere after the year 1972 shows up in the public health records. It is common practice that earlier illnesses, such as severe infections or operations, are also recorded. However, if a person chooses to use only private health care physicians, information about chronic diseases and earlier hospitalizations is not available from the city records.

Sample

The target population consisted of people born in 1907-1908 and living in Tampere in January 1999, and of people born in 1909-1910 and living in Tampere in January 2000. The basic population was 916, 189 men (20.6%) and 727 women (79.4%). The source of the study population was the population register of the city of Tampere, covering the whole population and updated biweekly.

We studied a total of 832 cases using public health care physicians' records, corresponding to 90.7% of the basic population. The missing 9.3%, 84 people altogether, fell into two categories: 1) 44 people did not have health records in the city hospitals or health centers; and 2) 40 people had records which were not available at the time of the study. There was no significant difference between community-dwelling and institutionalized groups (10.8 and 8.9%, respectively) or between men and women (7.9 and 9.5%, respectively) in the proportion of drop-outs. To study further the 44 subjects who had no health records, we examined currently unpublished data on them. For two related studies within the framework of the Vitality 90+ project, 30 of the missing 44 subjects had returned a mailed questionnaire focusing on health and medication (10 and 20 cases). The questions for these two studies were not identical but, combining the data, at least 23 of the missing subjects reported one or more chronic diseases, most often a heart disease, dementia or rheumatoid arthritis (9 of 10), or daily use of 3 or more prescription medicines (14 of 20). This suggests that the missing subjects had health problems comparable with subjects with available records. The study protocol was reviewed and accepted by the Tampere City Ethical Committee (permission number 1592/403/96).

Data collection

We collected our data manually from the records of the city hospitals and health centers. Information on the diseases leading to a visit to the university hospital was obtained from the period of rehabilitation in the city hospital or outpatient clinics onwards. The university hospital sends a copy of its records after each treatment to the primary care physician, unless the patient has specifically refused this, and these copies are attached to the city health care records. Diagnoses of chronic diseases or diseases that required hospitalization at any time in the subjects' lives, as well as physicians' notes on their memory and mobility, were manually registered by the first author. Manual registering by a clinician was chosen, as coding for diagnoses was varying and overlapping. The diagnostic background was not further confirmed. When diagnoses were made in the health center, diagnostic criteria were normally

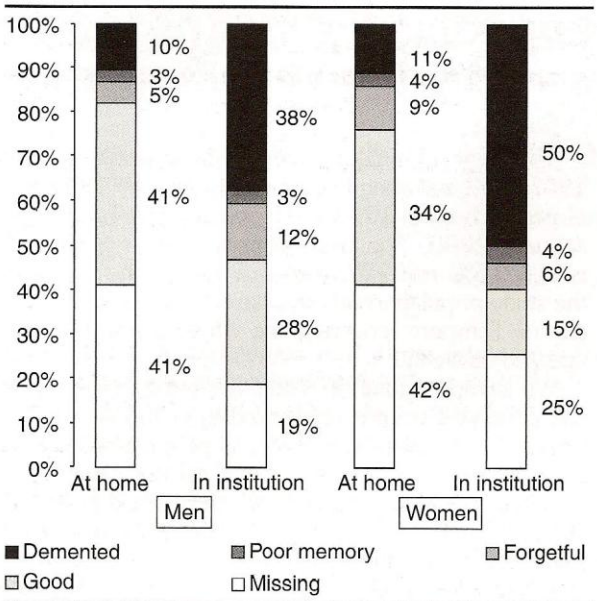

Figure 1 - *Memory problems in 90-year olds living at home or in institutions (%).*

available. However, if diagnoses were made in the university hospital or by a specialist from the private sector, no diagnostic criteria appeared in the records. Thus, for example, the diagnosis of dementia or depression was accepted without any further statements of neuropsychological testing. A plain description of symptoms of common geriatric diseases was not recorded as a diagnosis. Thus, a note commenting on forgetfulness was not recorded as "dementia" without an explicit diagnosis of dementia. The medical history was listed as follows: diagnosis, year when diagnosed, and year when mentioned if the year of diagnosis was not mentioned. All data were coded according to the International Classification of Diseases, 10th Revision (ICD-10) (19). Henceforth, we use the term 'lifetime prevalence' for current and past diseases which appeared in the public health records since 1972. Most records mentioned some major illnesses prior to 1972, such as appendicitis, gall stones, or scarlet fever.

Comments on memory and mobility were recorded from the time of ±2 years from the 90th birthday, preferably at the age of 90. Memory was coded as follows: good, forgetful, poor, demented. This classification was chosen according to the notes in the doctors' status descriptions. MMSE scores were rarely available. We accepted clear statements about memory or notes referring to cognitive skills such as: "the patient discusses daily politics intelligently" for 'good memory'. Comments such as: "active and cheerful patient" or "in good health for his/her age" were coded 'missing', as they did not directly indicate good cognitive state.

Mobility was coded as follows: good ('moves with no support', or 'uses light support as a walking stick'), moderate support ('uses rollator'), heavy support ('uses wheel chair', or 'needs supporting persons to move') and bedridden. This coding was based on the doctors' most common remarks. Mobility testing scales were rarely used.

Whether the person was living at home or in an institution was traced from the city population register, according to the address.

Statistical methods

Medical histories are presented in frequency tables showing lifetime prevalences. Comparisons between groups were performed using the Pearson corrected *t*-test, analysis of variance for continuous variables, and χ^2 test for distribution of categorical variables. The two birth cohorts of 1907-1908 and 1909-1910 were first studied separately. They had very similar variable frequencies, and the data were pooled for further analysis. We used SPSS version 6.1 for statistical analysis (SPSS Inc., Chicago, USA).

RESULTS

The study population totalled 832, consisting of 174 men (20.9%) and 658 women (79.1%). Of these, 71.3% lived at home in the community and 28.7% in institutions. More men (83.1%) than women (68.8%) lived at home ($p<0.0001$). The mean number of diagnoses of severe or chronic diseases in the medical records was 7.8±4.0 (mean±SD) for men, and 8.3±4.4 (mean±SD) for women (range 0-20). This difference was not significant in the

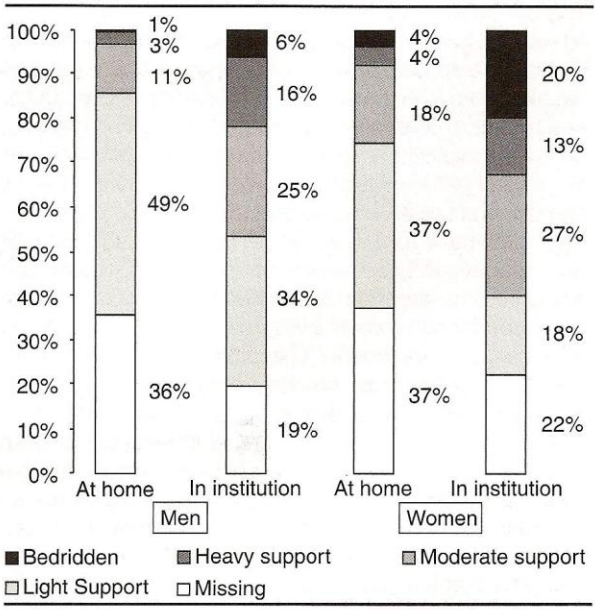

Figure 2 - *Mobility status in 90-year olds living at home or in institutions (%).*

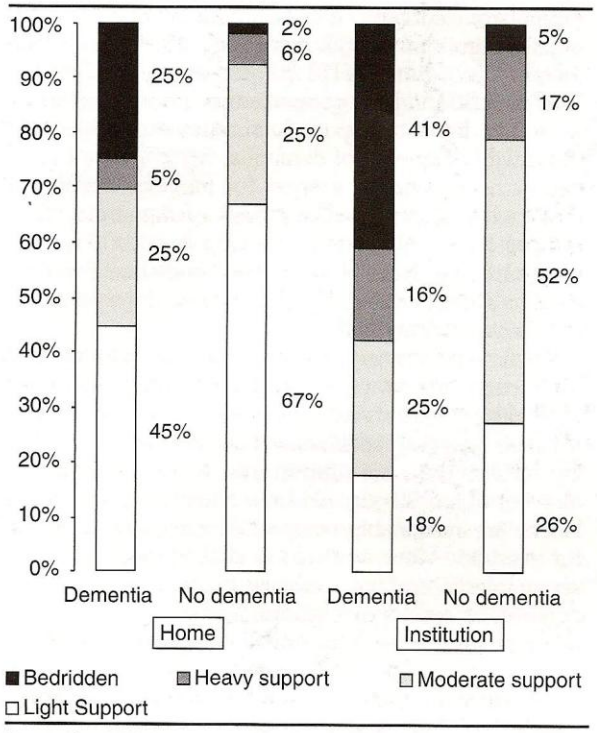

Figure 3 - *Mobility status for demented and non-demented at home and in institutions (%).*

analysis of variance. However, the number of diagnoses was significantly higher among institutionalized subjects. The means and SD were 7.6±4.1 for home, and 9.7±4.4 for institution ($p<0.0001$).

Physicians' recent comments regarding memory were available for 578 subjects. About half of these had good memory (48.3%) and one-third of them (33.7%) had the statement "demented". Figure 1 shows records for memory, including missing remarks. It is possible that most of those who had no records regarding their cognitive state had no problems with memory, which would considerably increase the proportion of those with good cognitive skills. Based on these data, we could not verify this. Expressions such as 'forgetful' or 'poor memory' were used in the records when either the patient or a caregiver had brought up a memory problem, but the doctor had not recorded a diagnosis. Including these statements, the data indicated a memory problem in at least 35.9% of the study population. This minimum number assumes that all subjects with no notes regarding memory had a good cognitive state.

Physicians' recent notes regarding mobility were available for 616 subjects. Just over one-tenth of them (11.2%) were bedridden, but half (49.6%) needed no or only light support such as a walking stick to move, and four out of five could move independently with aid (79.3%). Using a rollator was very common (28.7%). Figure 2 shows records for mobility including missing remarks. It is possible that most of those who had no records for mobility had no problems in moving although, based on these data, we could not verify this. Including subjects with no note of mobility, about 8.3% were bedridden, whereas a minimum of 58.8% could move independently.

Ninety-year olds living in institutions had significantly more problems with memory and mobility than those living in the community (Figs. 1 and 2). As expected,

Table 1 - *Lifetime prevalence of diseases. Left column: main class of diagnoses. Central column: diagnoses with frequency more than 3% in sample.*

Class	Disease	Frequency (%)
A Bacterial infections		**18.5**
B Viral infections		**5.4**
Infections, including urinary tract infections and respiratory infections		**53.6**
	respiratory infections	27.7
	urinary tract infections	26.0
	gastroenteritis	6.3
	erysipelas (skin infection)	6.3
	tuberculosis	4.6
	herpes zoster	4.3
C Malignant tumors		**17.6**
	basal cell carcinoma	5.3
	other than basalioma	13.8
	breast carcinoma	3.8 (4.3% of women)
	prostate carcinoma	1.7 (7.4% of men)
	colorectal carcinoma	3.4
D0-48 Benign tumors		**9.5**
D50-99 Hematological diseases		**18.1**
	anemia	16.8
	thiamine deficiency	7.8
E Endocrinological diseases		**29.7**
	thyroid disease	15.2
	diabetes	12.9
F Psychiatric diseases		**33.1**
	dementia	24.6
	depression	10.7
	psychosis	3.4
G Neural diseases		**20.0**
	transient ischemic attack	10.1
	Parkinson's disease	4.3
H0-59 Eye diseases		**22.9**
	cataract	13.7
	glaucoma	10.2

(Continued)

Table 1 - *(Continued)*

H60-99 Ear diseases		**4.3**
I Cardiovascular diseases		**78.3**
	coronary heart disease	44.8
	chronic heart failure	36.7
	hypertension	36.1
	atrial fibrillation	22.6
	stroke	16.9
	myocardial infarct	15.0
	varicose veins	10.0
	atherosclerosis	5.4
	thrombosis in lower leg	5.2
	hemorrhoids	4.3
	pulmonary embolism	3.4
J Respiratory diseases, including infections		**32.8**
	respiratory infections	27.7
	chronic respiratory diseases	7.3
K Gastrointestinal diseases		**58.6**
	gall stones	27.1
	functional bowel disease	18.1
	hernia	15.3
	appendicitis	14.1
	diverticulosis	13.4
	peptic ulcer	9.9
	chronic gastritis	8.4
L Skin diseases		**5.2**
M Musculoskeletal diseases		**44.3**
	arthrosis	22.7
	diseases of back	10.6
	osteoporosis	8.9
	gout	4.9
	systemic collagenosis	4.5
N Urinary tract diseases, including infections		**41.2**
	urinary tract infections	26.0
	prostate hyperplasia	9.9 (42.9% of men)
	uterus prolapse	4.1 (4.7% of women)
	kidney disease	3.6
O-Q Diseases during pregnancy, perinatal diseases and malformations		**1.0**
R Symptoms		**22.7**
	vertigo	10.6
	urinary symptoms	3.4
S-Y Trauma		**49.6**
	all fractures	40.4
	hip fracture	17.2
	wrist fracture	14.6
	humerus fracture	6.0
	ankle fracture	5.7
	rib fracture	3.6
W Other reasons for using health care		**0.6**

there were clearly more demented and bedridden people in institutions (53.0% demented, 19.9% bedridden) than in the community (11.9% demented, 3.8% bedridden, $p<0.001$ in both comparisons). Poor mobility correlated to dementia especially in institutions (Fig. 3). Of those with diagnoses of dementia, 39.2% were bedridden or needed heavy support for moving, whereas of those with no recorded diagnosis of dementia, 7.8% needed heavy support for moving ($p<0.0001$). This may partly be due to the fact that end-state dementia leads to physical inability, and that most of the bedridden people were demented.

Lifetime prevalences of diseases according to the medical records are shown in Table 1. Assuming that dropouts with no records were healthy, prevalences drop to 4% unit. However, additional information about the missing subjects does not support this. As we have data for nine out of ten 90-year olds in the region, shown prevalences are reasonably near actual prevalences, if data for everyone were available. Including operations and severe infections at younger ages, the mean number of diagnoses of severe or chronic diseases in the medical records was 8.2±4.3 (mean±SD, range 0-20). Of the study population, only 0.2% had no recorded diagnosis of any chronic disease or other severe earlier disease, and 14.6% had 1-3 recorded diseases, most commonly a cardiovascular disease. Surprisingly, 36.4% had 10 or more recorded diseases indicating common comorbidity among 90-year olds. Institutionalized patients had had significantly more infections ($p<0.0001$), endocrinological diseases ($p<0.05$), psychiatric diseases ($p<0.0001$), neurological disorders ($p<0.05$), musculoskeletal and connective tissue diseases ($p<0.05$), non-diagnosed symptoms ($p<0.05$) and traumas ($p<0.05$) than community-dwelling ones. Specific diagnoses mainly seen among institutionalized nonagenarians were dementia, diabetes, urinary tract infections, depression, and hip fracture. Their prevalences are listed in Table 2. There was no significant difference in the prevalence of cancer, hematological diseases, cardiovascular diseases or gastrointestinal diseases between the types of dwelling.

As described above and shown in Figures 1 and 2, the

Table 2 - *Lifetime prevalence of diseases that were more frequent in institution-dwelling population.*

Disease	Frequency (%)		
	Home	Institution	Significance
Dementia	14.5	54.2	$p<0.0001$
Urinary tract infections	20.6	39.4	$p<0.0001$
Depression	6.8	20.3	$p<0.0001$
Hip fracture	14.7	23.3	$p=0.0030$
Diabetes	10.6	18.6	$p=0.0018$
Stroke	15.2	21.2	$p=0.038$

better health of 90-year-old men compared with women was obvious: a smaller percentage of men were living in institutions, men had slightly fewer chronic illnesses, and more men than women had good memory functions and independent mobility.

DISCUSSION

The setting for the study was favorable in Tampere. The study population was large enough to give a good estimate of the general health status for nonagenarians, but small enough to reduce tedious data collection. Since 1972, every doctor has been obliged to enter data at each patient's visit on patient records, which are then available at the successive call for the next physician, even if the reason for the call is not the same. City hospitals and health centers use the same patient records which follow the patient. The hospital outside the records is the university hospital, which sends a copy of its records to the city hospital after each treatment, unless the patient refuses this. The high degree of use of public health services in the nonagenarian population, the uniform manner of creating patient records, and the accessibility of records for scientific research have all resulted in the more than sufficient coverage of the population (90.7%). This type of setting usually favors people living in institutions, where health inspections are frequently carried out. In our study, this was not the case; there was no significant difference in the number of drop-outs between the types of living arrangement. However, it is possible that, for institutionalized patients, there is more detailed information available about their skills of daily living such as memory and mobility because, for many institutions, a doctor's referral is needed for admission.

The records go back to 1972 and occasionally further back. Compulsory patients records have been kept since 1972. Most records mention some major illnesses in youth, such as appendicitis, gall stones, or scarlet fever. Earlier hospitalizations are recorded. Our aim was to discover the medical history of 90-year olds using information recorded as early as possible. Using the records from as early as the 1970s, we could obtain data recorded at that time of subjects' lives when there were not so many comorbidities, dementia was not biased, and taking history and medical histories was short and easy to remember and record.

Choosing medical records as the source of data assumes that study subjects have had a reason to visit a doctor at some point in their later lives. The 44 drop-outs with no records were all from the home-dwelling population only. They may have used private doctors, but any severe recent disease is not probable, because the private sector offers only outpatient services. The fact that subjects had no hospital stays within the past 28 years gives us good reason to estimate that these people were among the healthiest in their cohort. Nevertheless, information through mailed questionnaires showed that most of them had at least one chronic condition, such as dementia or heart disease. Therefore we could not include them in the study group as "healthy". The 40 drop-outs who had records that were not accessible at the time of the study had recently seen a doctor or were on a physician's waiting list, and the records were at the physician's office. Most of them came from the community-dwelling population as well, but the visit to a doctor or stay at a hospital indicated a health problem.

Based on number of chronic and severe diseases, type of dwelling, memory and mobility, men were generally healthier than women in the study population. This finding is consistent with earlier studies on the health of old generations (19, 20). And yet life expectation for men is lower than for women: 73.7 and 81.0 years at birth, and 86.6 and 88.2 years for 80-year olds in the Finnish population in 2000 (21). The men in the community more often have spouses or other caregivers than women, and this may explain the difference in the type of living arrangement between genders (5).

It appears that, based on physicians' records, the prevalence of dementia is very high in the population living in institutions and relatively low among those living at home. This may partly be due to not diagnosing dementia at home before it causes severe problems of daily living. However, for very old patients, it is common practice for doctors to record their good or poor state of memory, to indicate attention to their cognitive state. Analyzing statements of memory, we gained further support for the lower prevalence of dementia among the community-dwelling individuals. We did not directly study the causes of institutionalization but, based on the very high prevalence of dementia in institutions it seems that, among the very old, dementia is the most common reason for institutionalization. It has been reported earlier that the stages of dementia at home and in institutions are different: most demented patients in institutions suffer from severe dementia, whereas those living at home have a relatively mild form of the disease (22). Other psychiatric disorders like depression were also significantly more common in the institutionalized population. The prevalence of depression may be higher than our data show. Unlike dementia, it is not common practice to record statements on life satisfaction or depression. Whether depression is the cause for institutionalization or the result of it cannot be judged from this study. Depression has been reported to be related to early dementia (23, 24). In our study, depression is seen with mostly non-demented subjects with good or only mildly impaired memory. It is possible that depression in severely demented patients was not recorded.

Infections are very common in the institutionalized population. This is probably rather the result of poor mobility and poor resistance to diseases in an environ-

ment where pathogens circulate easily, than symptoms leading to institutionalization. The high prevalence of infections may be related to the weakened immune system of the old (25, 26).

In addition to dementia, other diseases and traumas requiring special treatment or causing difficulties in daily living may lead the oldest-old to live in institutions. Diabetes causing secondary diseases of the arteries and impairing vision is common in people in institutions. The proper care of diabetes may also be difficult to provide at home, even though insulin is rarely used in the very old population (27). Hip fractures commonly happen to the demented in institutions, but may also lead to institutionalization because of the long rehabilitation time in hospital that is often needed (28). There are no clear differences in the prevalence of cardiovascular or gastrointestinal diseases between community-dwelling and institutionalized populations. These groups of diseases are common in the whole nonagenarian population, and our study does not classify their severity. There may be a significant difference in cardiovascular status and symptoms between the two sub-populations. Similarly, functional bowel diseases such as diverticulosis and constipation may give rise to more symptoms in bedridden subjects in institutions.

Patients' histories with numerous diseases indicate that 90-year olds are not exceptionally healthy. The diseases they have are not less dangerous than diseases in the main population. Even the oldest-old are affected by common diseases, and prevalences seem to increase with age. A well-known example is cancer, which has been extensively recorded among people of all ages, and data analyses show that its prevalence increases with age (29).

Most of our nonagenarians were able to live at home with the support of their families and society. Many of them had good cognitive status and good mobility, despite numerous diseases, and they were therefore able to live independently. Dementia is common in institutions among 90-year olds, and this may indicate that it is also the final reason for moving to an institution from home. In the future, we are interested in studying factors related to the oldest-old managing at home and those which are likely to lead to institutionalization. Further information is also needed about the influence of different types of diseases, especially dementia, on the life satisfaction of the oldest-old.

ACKNOWLEDGEMENTS

We thank the city of Tampere for providing us with access to the health record database and for assisting us in collecting data about the population.

REFERENCES

1. World Health Organization Report 1998. Available at: http://www.who.int/whr/1998/whr-en.htm Accessed February 25, 2002.
2. Louhija J. Finnish centenarians. A clinical epidemiological study (Academic dissertation). Helsinki: University of Helsinki, 1994.
3. Gonos ES. Genetics of aging: lessons from centenarians. Exp Gerontol 2000; 35: 15-21.
4. Hitt R, Young-Xu Y, Silver M, Perls T. Centenarians: the older you get, the healthier you have been. Lancet 1999; 354: 652.
5. Jylha M, Hervonen A. Functional status and need of help among people aged 90 or over: a mailed survey with a total home-dwelling population. Scand J Public Health 1999; 27: 106-11.
6. Bild DE, Fitzpatrick A, Fried LP, et al. Age-related trends in cardiovascular morbidity and physical functioning in the elderly: the Cardiovascular Health Study. J Am Geriatr Soc 1993; 41: 1047-56.
7. Henderson AS, Korten AE, Jacomb PA, et al. The course of depression in the elderly: a longitudinal community-based study in Australia. Psychol Med 1997; 27: 119-29.
8. Kawas C, Gray S, Brookmeyer R, Fozard J, Zonderman A. Age-specific incidence rates of Alzheimer's disease: the Baltimore Longitudinal Study of Aging. Neurology 2000; 54: 2072-7.
9. Maggi S, Zucchetto M, Grigoletto F, et al. The Italian Longitudinal Study on Aging (ILSA): design and methods. Aging Clin Exp Res 1994; 6: 464-73.
10. Deiana L, Ferrucci L, Pes GM, et al. AKEntAnnos. The Sardinia Study of Extreme Longevity. Aging Clin Exp Res 1999; 11: 142-9.
11. Andersen-Ranberg K, Christensen K, Jeune B, Skytthe A, Vasegaard L, Vaupel JW. Declining physical abilities with age: a cross-sectional study of older twins and centenarians in Denmark. Age Ageing 1999; 28: 373-7.
12. von Strauss E, Fratiglioni L, Viitanen M, Forsell Y, Winblad B. Morbidity and comorbidity in relation to functional status: A community-based study of the oldest old (90+ years). J Am Geriatr Soc 2000; 48: 1462-9.
13. Haavisto M, Heikinheimo RJ, Mattila KJ, Rajala SA. Living conditions and health of a population aged 85 or over: a five-year follow-up study. Age Ageing 1985; 14: 202-8.
14. Ebly EM, Parhad IM, Hogan DB, Fung TS. Prevalence and types of dementia in the very old: results from the Canadian Study of Health and Aging. Neurology 1994; 44: 1593-1600.
15. Skoog I, Nilsson L, Palmertz B, Andreasson L-A, Svanborg A. A population-based study of dementia in 85-year olds. N Engl J Med 1993; 328: 153-8.
16. Olafsdottir M, Skoog I, Marcusson J. Detection of dementia in primary care: the Linkoping study. Dement Geriatr Cogn Disord 2000; 11: 223-9.
17. Heeren TJ, Lagaay AM, Hijmans W, Rooymans HGM. Prevalence of dementia in the 'oldest-old' in a Dutch community. J Am Geriatr Soc 1991; 39: 755-9.
18. US Bureau of the Census. International Data Base 1998. Available at: http://www.census.gov/population/projections Accessed February 25, 2002.
19. The International Classification of Diseases, 10th Revision. Available at: http://www.cdc.gov/nchs/icd9.htm Accessed February 25, 2002.
20. Guralnik JM, Simonsick EM. Physical disability in older Americans. J Gerontol 1998; 48: 3-10.
21. Tilastokeskus: Suomen tilastollinen vuosikirja 2000, 95:s vuosikerta (Statistical Yearbook of Finland, 95th Annuum). Hämeenlinna: Karisto, 1999.
22. Fratiglioni L, Forsell Y, Aguero Torres H, Winblad B. Severity of dementia and institutionalization in the elderly: prevalence data from an urban area in Sweden. Neuroepidemiology 1994; 13: 79-88.

23. Geerlings MI, Schmand B, Braam AW, Jonker C, Bouter LM, van Tilburg W. Depressive symptoms and risk of Alzheimer's disease in more highly educated older people. J Am Geriatr Soc 2000; 48: 1092-7.

24. Geerlings MI, Schoevers RA, Beekman AT, et al. Depression and risk of cognitive decline and Alzheimer's disease. Results of two prospective community-based studies in The Netherlands. Br J Psychiatry 2000; 176: 568-75.

25. Plewa MC. Altered host response and special infections in the elderly. Emerg Med Clin North Am 1990; 8: 193-206.

26. Smith PW, Roccaforte JS, Daly PB. Infection and immune response in the elderly. Ann Epidemiol 1992; 2: 813-22.

27. Glynn RJ, Monane M, Gurwitz JH, Choodnovskiy I, Avorn J. Aging, comorbidity, and reduced rates of drug treatment for diabetes mellitus. J Clin Epidemiol 1990; 52: 781-90.

28. Jäntti PO, Pyykko I, Laippala P. Prognosis of falls among elderly nursing home residents. Aging Clin Exp Res 1995; 7: 23-7.

29. DeRijke JM, Schouten LJ, Hillen HF, Kiemeney LA, Coebergh JW, van den Brandt PA. Cancer in the very elderly Dutch population. Cancer 2000; 89: 1121-33.

Self-reported medical history and self-rated health at age 90. Agreement with medical records

Sirkka Goebeler[1,2], Marja Jylhä[1], and Antti Hervonen[1]

[1]School of Public Health, University of Tampere, [2]Department of Forensic Medicine, Medical School of University of Tampere and Tampere University Hospital, Tampere, Finland

ABSTRACT. ***Background and aims:*** *Taking medical history from a very old patient for either clinical or research purposes raises the question of the reliability of the information obtained. We ascertained whether the self-reported medical history and self-rated health of 90-year-olds would be in agreement with their medical records.* ***Methods:*** *Information on chronic diseases and self-rated health was collected using medical records and a mailed questionnaire in a population sample of community-living 90-year-old subjects in Tampere, Finland. The results were compared with earlier studies on self-reported medical history.* ***Results:*** *The inter-source agreement of the reported diseases was relatively good. As expected, many of the diseases diagnosed were under-reported in the mailed questionnaire. However, dementia, depression and arthritis were reported more often than doctors had recorded them. Of the respondents, 78% reported their current health as good or average. Subjects with heart disease, stroke, rheumatoid arthritis, Parkinson's disease or depression reported poor health more often than those not having these diseases.* ***Conclusions:*** *The agreement between medical records and self-reported medical history obtained by questionnaire showed a similar pattern to earlier studies in younger old populations, but in the 90-year olds, the differences became larger. In future studies, special attention should be paid to the oldest old who under-report certain diagnosed medical conditions.*

(Aging Clin Exp Res 2007; 19: 213-219)

INTRODUCTION

Taking medical history from an aged patient for either clinical or research purposes raises the question of the reliability of the information obtained.

Information received about past medical history by interviewing may already be unreliable among the young old (1), and under-reporting diagnosed diseases tends to increase with age (2). In very old age, problems may arise with memory disorders and impaired cognitive functions. In addition, it is possible that physicians have not informed their aged patients about their medical condition (3).

A Swedish study on very old subjects indicated that, while morbidity was best viewed from medical records, self-reports gave additional information, especially for less objective health problems such as osteoarthritis or minor infections (4). Selecting the best source of information may be difficult, as the inter-source agreement of medical data can vary significantly. In an earlier Finnish study, the agreement of self-reported diseases with medical records was between 75-98% in younger elderly in certain clearly defined medical conditions (5), whereas in a Taiwanese study, sensitivity of reported medical history was only 20.5% for cardiovascular diseases (6).

Reported medical history may be complemented using self-rated health, which is known to be a good indicator of morbidity and mortality (7-10). However, among the very old, self-rated health and physician-rated health are not necessarily in agreement (11). Centenarian studies have shown that the oldest old often estimate their health as good or satisfactory when interviewed (for a review, see 12), even though they suffer from several chronic conditions (12, 13). In the case of chronic diseases, relatively good self-rated health may reflect the low expectation of health in very old age (14).

We studied 1) to what extent the self-reported medical condition and self-reported health of 90-year-olds are in agreement with medical records, and 2) if the findings were consistent with earlier reports in younger populations. This study is part of the multidisciplinary project "Vitality 90+" which focuses on the health and social situation of 90-year-old subjects in Tampere, Finland (15-17).

Key words: Geriatric disease, medical records, oldest-old, self-rated health.

Correspondence: Sirkka Goebeler, Department of Forensic Medicine, Medical School, Bldg. B, 33014 University of Tampere, Finland. E-mail: sirkka.goebeler@uta.fi

Received June 1, 2005; accepted in revised form August 10, 2006.

Aging Clin Exp Res 19: 213-219, 2007

METHODS

Subjects

We studied community-living people born in 1907-1908 living in Tampere, Finland. According to the comprehensive population register, at the starting point of the study, in January 1999, there were 382 people born in 1907-1908, of whom 273 (71.5%) were living in the community and formed our study group. Their mean age was 90.9 years; 74.7% were women.

Data

Data of the home-dwelling population was collected using two sources: 1) a mailed questionnaire and 2) medical records from city hospitals and health centers. Altogether, 232 people responded to our questionnaire (87.0% of men and 84.3% of women). In 31.7% of cases, some other person had assisted the 90-year-olds in filing the questionnaire. In Finland, public health benefits cover everyone and the system is highly appreciated by people from all social classes. Additionally, there are no private hospitals in the Tampere region. Thus, the use of city health centers and hospitals is very common. Full medical records were available for 90.1% of the respondents, with their informed consent. With a participation rate of 85.0%, the final data cover 76.6% of the population of the home-dwelling 90-year-olds (n=209). The study protocol was reviewed and accepted by the Tampere City Ethical Committee (permit number 1592/403/96).

The questionnaire consisted of 32 questions. For 31 of them, respondents were asked to select from 2-5 predetermined answers, and one question, asking for occupation, was open-ended. We designed the questionnaire with attention to clarity and readability. Most questions were about managing daily life. Respondents were asked to evaluate their current health on the scale 'very good', 'fairly good', 'average', 'fairly poor', and 'very poor'. Subsequently, eleven common geriatric conditions were asked, as follows: "Has a doctor detected any of the following diseases in you?" The selected diseases were hypertension, heart disease, stroke, diabetes, cancer, dementia, depression, Parkinson's disease, hip fracture, osteoarthritis, and rheumatoid arthritis.

Medical records were manually studied by a physician, the first author. We recorded diagnoses of chronic diseases and diseases that had required hospital treatment at any time during the subjects' life. The records went back to 1972, but they customarily contained summaries of diseases that had occurred earlier. All physician-recorded remarks were included, if the disease was identified. Thus, a description of symptoms or test results alone did not qualify. The data was coded and grouped according to the International Classification of Diseases, 10th Revision (ICD-10) (18). Mini-Mental scores were rarely available, but we recorded physicians' remarks on memory within 2 years from the 90th birthday, preferably at the age of 90. Memory was coded as follows: good, forgetful, poor memory, demented. This classification was chosen according to commonly expressed remarks in the doctors' status description. We accepted a clear statement about the memory or a remark referring to cognitive skills as 'good memory.' General phrases such as "active and cheerful patient" or "in good health for his/her age" were coded 'missing'. Self-rated health was re-classified for analysis into three groups instead of the original five, combining 'fairly good' with 'good' and 'fairly poor' with 'poor'. Physicians' remarks on memory were re-classified into two groups, 'good' or 'impaired'.

The data from the two sources were collected separately, to ascertain that medical record data were recorded without prior expectations.

Statistical methods

Comparisons between the groups were performed by the χ^2-test for distribution of categorical variables and the *t*-test for continuous variables. Agreement between data from the two sources was evaluated using Cohen's κ-test, in which coefficient values below 0.40 were considered poor to fair accuracy, 0.40-0.60 moderate accuracy, 0.60-0.80 substantial accuracy, and 0.80-1.00 almost perfect accuracy, as earlier suggested by Landis and Koch (19). We used SPSS version 6.1 for statistical analysis (SPSS Inc., Chicago, U.S.A.).

RESULTS

Our study covered 76.6% of the home-dwelling 90-year-olds. There were no significant gender differences in responses to the questionnaire or in the availability of medical records (p=0.376 and p=0.239, respectively). Of the selected 11 diseases, men reported 1.6±1.1 diseases (mean ± SD), whereas women reported 2.3±1.4 diseases (mean ± SD). In medical records, men had an average of 1.6±1.3 (mean ± SD) and women 2.5±1.5 (mean ± SD) of the selected diseases. Gender differences were significant (p=0.002 and p=0.001, respectively).

Of the respondents, 77.5% evaluated their current health good or average. Gender difference was also significant: 91.6% of men reported their health good or average, whereas only 72.5% of women did (p=0.028). Poor self-rated health was associated with a higher num-

Table 1 - *Association of self-rated health in 90-year-olds with the number of medical conditions.*

	Diagnosed			Self-reported		
	0-1	2	3+	0-1	2	3+
Self-rated health						
Good	47.2	45.8	29.2	46.4	37.7	24.4
Average	36.1	37.0	40.4	40.6	42.0	38.5
Poor	16.7	17.3	30.4	13.0	20.3	37.1
Column per cent	100	100	100	100	100	100
N	72	46	89	69	69	78

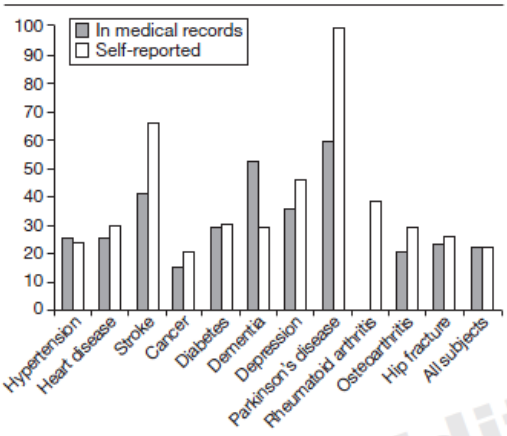

Fig. 1 - *Association of poor self-rated health with self-reported or physician-recorded diseases.*

ber of selected conditions recorded in medical records or questionnaire (Table 1).

Subjects reporting the following diseases rated their health as fairly poor or poor significantly more often than those without the diseases: Parkinson's disease (100.0% fairly poor or poor, p=0.0001), stroke (66.6% fairly poor or poor, p=0.0002), depression (46.3% fairly poor or poor, p=0.0006), rheumatoid arthritis (38.7% fairly poor or poor, p=0.0384), and heart disease (29.4% fairly poor or poor, p=0.0370).

Of physician-recorded diseases, Parkinson's disease, stroke, and depression were associated with poor self-rated health. Additionally, a diagnosis of dementia was closely related to poor self-rated health (52.5% fairly poor or poor, p=0.0004). (Fig. 1; Table 2)

Table 3 shows the prevalence of the common geriatric diseases based on medical records (column D+) and self-reports (column P+), source-dependent prevalence of the diseases, concordance and discordance of data, and κ-statistics for agreement of data. Inter-source agreement showed substantial accuracy in three clearly defined conditions: diabetes, hip fracture and Parkinson's disease. In these diseases, 19.0%, 29.6% and 40.0%, of diagnosed patients reported negative ([D+P-]/ [D+P+] + [D+P-]), but only 4.0% of all subjects reported diabetes and 6.5% a hip fracture that was not visible in the medical records (D-P+). Many diseases were reported less often than the medical records indicated – for example, only half the patients with diagnosed cardiovascular diseases or cancer reported them. Agreement was independent of physician-recorded impaired memory ($0.157 \leq p \leq 0.709$), indicating that

Table 2 - *Self-rated health in 90-year-olds: association with diagnosed and self-reported diseases.*

Self-rated health	Very good n (%)	Good n (%)	Average n (%)	Poor n (%)	Very poor n (%)	n
Heart disease D+	3 (2)	54 (35)	58 (37)	31 (20)	10 (6)	156
Heart disease P+	1 (1)	37 (34)	39 (36)	22 (20)	10 (9)	109
Hypertension D+	1 (1)	29 (33)	35 (40)	18 (21)	4 (5)	87
Hypertension P+	0 (0)	22 (35)	26 (41)	11 (18)	4 (6)	63
Stroke D+	0 (0)	8 (28)	9 (31)	11 (38)	1 (3)	29
Stroke P+	0 (0)	0 (0)	4 (33)	7 (59)	1 (8)	12
Cancer D+	1 (3)	10 (30)	17 (52)	5 (15)	0 (0)	33
Cancer P+	1 (4)	7 (29)	11 (46)	5 (21)	0 (0)	24
Diabetes D+	0 (0)	7 (42)	5 (29)	5 (29)	0 (0)	17
Diabetes P+	1 (4)	9 (39)	6 (26)	5 (22)	2 (9)	23
Dementia D+	0 (0)	4 (17)	6 (29)	9 (37)	4 (17)	23
Dementia P+	1 (2)	20 (33)	22 (36)	12 (20)	6 (10)	61
Depression D+	0 (0)	3 (21)	6 (43)	4 (29)	1 (7)	14
Depression P+	0 (0)	8 (19)	14 (34)	15 (37)	4 (10)	41
Parkinson's disease D+	0 (0)	0 (0)	4 (40)	4 (40)	2 (20)	10
Parkinson's disease P+	0 (0)	0 (0)	0 (0)	4 (67)	2 (33)	6
Arthritis, combined D+	1 (2)	19 (37)	22 (42)	7 (13)	3 (6)	52
Arthritis, combined P+	1 (1)	23 (27)	36 (42)	20 (24)	5 (6)	85
Hip fracture D+	1 (3)	7 (21)	18 (52)	7 (21)	1 (3)	34
Hip fracture P+	0	8 (21)	20 (54)	9 (24)	1 (3)	38

D+ diagnosed by physician. P+ self-reported. n (%)

Aging Clin Exp Res 19: 213-219, 2007

Table 3 - *Comparison between medical records and reports by 90-year-olds: prevalence of diseases and agreement of sources.*

	D+P+	D+P-	D-P+	D-P-	Total	PreM	PreP	C	Disc	κ
	1	2	3	4		1+2	1+3	1+4	2+3	
Heart disease	44.1	31.7	4.5	19.8	100	75.8	48.6	63.9	36.1	0.288
Hypertension	21.4	20.5	5.9	52.2	100	41.9	27.3	73.6	26.4	0.432
Stroke	5.4	8.3	0.5	85.7	100	13.7	5.9	91.1	8.9	0.509
Cancer	8.4	7.9	3.4	80.2	100	16.3	12.8	88.6	11.4	0.532
Diabetes	6.4	1.5	4.0	88.1	100	7.9	10.4	94.5	5.5	0.673
Dementia	9.5	2.5	18.5	69.5	100	12.0	28.0	79.0	21.0	0.369
Depression	2.5	4.0	16.5	77.0	100	6.5	19.0	79.5	20.5	0.110
Parkinson's disease	3.0	2.0	0.0	95.0	100	5.0	3.0	98.0	2.0	0.740
Rheumatoid arthritis	1.5	0.5	10.4	87.6	100	2.0	11.9	89.1	10.9	0.187
Osteoarthritis	12.0	10.5	21.0	56.5	100	22.5	33.0	68.5	31.5	0.225
Arthritis, combined	14.1	11.2	23.9	50.7	100	25.3	40.0	64.8	35.2	0.204
Hip fracture	11.9	5.0	6.5	76.6	100	16.9	18.4	88.5	11.5	0.607

D+ recorded by doctor, D- not recorded, P+ reported by 90-year-old, P- not reported. PreM prevalence using medical records, PreP prevalence using subject reports, C concordance, Disc discordance.

mismatching answers were not mainly a result of poor cognition. Neither was under-reporting diagnosed diseases associated with good self-rated health ($0.274 \leq p \leq 0.864$). This opposes the hypothesis that good self-rated health may be associated with ignoring one's medical condition.

The common joint diseases osteoarthritis and rheumatoid arthritis were commonly reported by subjects who did not have these diseases mentioned in their medical records, and *vice versa*. To check whether confusion in identifying the conditions was causing this, we combined the groups. However, this did not remove the disagreement of the data (κ=0.20).

Subjects reported dementia (28.0%) and depression (19.0%) more often than their medical records did (12.0% and 6.5%, respectively), suggesting that physicians had ei-

Table 4 - *Comparison between medical records/physician-reported information and self-reports. Agreement of sources in three studies.*

Diagnosis	D+P+	D+P-	D-P+	D-P-[1]	Total	κ	Study[2]	Age
Heart disease	44.1	31.7	4.5	19.8	100	0.29	Current	90
Cardiac disease	15.6	6.3	3.7	74.3	100	0.69	LASA	55-85
Coronary disease	12.9	7.4	3.5	76.1	100	0.64	LOCCS	66 (median)
Coronary disease	13.6	1.9	3.8	80.7	100	0.80	UKK	45-73
Stroke	5.4	8.3	0.5	85.7	100	0.51	Current	90
Cerebro-vascular dis.	2.9	2.1	2.1	92.9	100	0.56	LASA	55-85
Stroke or TIA[3]	3.5	1.5	1.6	93.4	100	0.66	UKK	45-73
Cancer	8.4	7.9	3.4	80.2	100	0.53	Current	90
	6.3	3.7	2.4	87.5	100	0.64	LASA	55-85
	6.7	2.8	9.6	80.9	100	0.45	LOCCS	66 (median)
Diabetes	6.4	1.5	4.0	88.1	100	0.67	Current	90
	6.6	1.4	0.6	91.3	100	0.85	LASA	55-85
	13.7	2.5	2.7	81.1	100	0.78	LOCCS	66 (median)
	6.0	1.5	2.0	90.5	100	0.75	UKK	45-73
Arthritis	14.1	11.2	23.9	50.7	100	0.20	Current	90
	12.5	6.1	21.8	59.5	100	0.31	LASA	55-85
	24.3	8.1	22.8	44.9	100	0.37	LOCCS	66 (median)
Osteoarthritis	12.3	7.6	10.0	70.1	100	0.48	UKK	45-73

[1]D+ recorded by doctor, D- not recorded, P+ reported by 90-year-old, P- not reported. [2]Longitudinal Aging Study Amsterdam (LASA) (2), Lens Opacities Case-Control Study (LOCCS) (20), UKK Institute (UKK) (5). [3]TIA = Transient ischemic attack

ther failed to recognize these conditions in the 90-year-olds or did not consider recording them essential.

Comparison of inter-source agreement with earlier reports

We evaluated our results by comparing them with the following earlier studies that investigated the inter-source agreement of health-related data in the old, partially using the same variables: 1) Kriegsman et al. compared self-reports obtained via face-to-face interview and general practitioner information obtained via a questionnaire in community-dwelling 55-85-year-olds (LASA) (2); 2) Kehoe et al. studied self-reports obtained in an interview and information obtained from primary physicians with a questionnaire in cataract cases and controls whose median age was 66 (LOCCS) (20); 3) Haapanen et al. evaluated the agreement between self-reports in a mailed questionnaire and medical records in a follow-up study of a population sample of 45-73-year-olds (UKK Institute, UKK) (5). The common variables were heart disease or coronary disease (LASA, LOCCS, UKK), stroke (LASA, UKK), cancer (LASA, LOCCS), diabetes (LASA, LOCCS, UKK), and arthritis or osteoarthritis (LASA, LOCCS, UKK). These data are shown in Table 4. For comparisons, results were transformed into percentages (LOCCS) and group percentages were calculated (UKK). Most of the categories were identified with the same title. However, Kriegsman et al. use the category 'any cerebro-vascular disease' including stroke, which is compared here with the category 'stroke'; Haapanen et al. combined stroke with transient ischemic attacks; Kehoe et al. and Haapanen et al. did not include the category 'coronary disease' which, for the purpose of the present study, was compared with 'heart disease' or 'cardiac disease' in the study of Kriegman et al.

Inter-source agreement followed a similar pattern in all four studies, showing a high κ-value for diabetes (0.67-0.85), moderate for cancer (0.45-0.64) and stroke (0.51-0.66), and low for arthritis (0.20-0.48). However, inter-source accuracy was low in heart disease in the 90-year-olds (0.29) but high in the other three studies (0.69-0.80). The κ-statistics used in this analysis are sensitive to the prevalence of each disease, so that a rare disease with a large negative/negative (D-P-) class will yield more conformed results. The prevalence of a cardiac disease in 90-year-olds is very high – up to 75% according to the medical records – so that the disagreement of positive cases weighs more in the analysis.

The Finnish study (UKK) on middle-aged subjects using medical records and a mailed questionnaire reached a better agreement than the other referred studies. In spite of an identical method of collecting data in the UKK study, inter-source disagreement in the 90-year-olds was overall greater than in any of the younger populations, the largest difference being found in the groups of diagnosed patients reporting negative (D+P-). Table 5 compares the sensitivity and specificity of self-reports from the standpoint of medical records or physician reports, as the gold standard. Sensitivity is poorer in 90-year-olds, but the specificity of the self-reports was very similar in all studies.

Table 5 - *Comparison between medical records/physician-reported information and self-reports. Sensitivity and specificity of self-reports.*

Diagnosis	Sensitivity	Specificity	Study[1]	Age
Heart disease	58.2	95.5	Current	90
Cardiac disease	71.2	96.3	LASA	55-85
Coronary disease	63.5	96.5	LOCCS	66 (median)
Coronary disease	88	96	UKK	45-73
Stroke	39.4	99.5	Current	90
Cerebro-vascular dis.	58.0	97.9	LASA	55-85
Stroke or TIA[2]	69	98	UKK	45-73
Cancer	51.5	96.6	Current	90
	63.0	97.6	LASA	55-85
	70.5	90.4	LOCCS	66 (median)
Diabetes	81.0	96.0	Current	90
	82.5	99.4	LASA	55-85
	84.6	97.3	LOCCS	66 (median)
	80	98	UKK	45-73
Arthritis	55.7	76.1	Current	90
	67.2	78.2	LASA	55-85
	75.0	77.2	LOCCS	66 (median)
Osteoarthritis	62	88	UKK	45-73

[1]Longitudinal Aging Study Amsterdam (LASA) (2), Lens Opacities Case-Control Study (LOCCS) (20), UKK Institute (UKK) (5). [2]TIA = Transient ischemic attack.

DISCUSSION

Three-quarters of the community-living 90-year-olds in Tampere participated in this study, and hence the data represent the home-dwelling population well. However, as in many other studies, analysis in the same population suggests that non-respondents in the survey on average had somewhat poorer health status than respondents (16).

Most 90-year-olds estimated their health as good or average, in spite of numerous diseases. Good self-rated health in cases of disease may reflect adjustment of health expectations in old age (14). Certain diseases, such as stroke and depression, were related to poor self-rated health, which is consistent with earlier studies (8, 11). An interesting finding was the close association of poor self-rated health with diagnosed dementia (54% poor) and only a moderate association with reported dementia (30% poor), which may indicate false-positive self-reports of dementia in cases with minor memory problems without clinical importance.

Another possible explanation is physicians' failure to detect dementia in the very old, when the patient otherwise appears relatively healthy. One-third of the 90-year-olds had received assistance from a family member

Aging Clin Exp Res 19: 213-219, 2007

or a caregiver to complete the questionnaire. Although there were no clear differences in the inter-source agreement of data connected with the use of assistance, some of the replies – especially those concerning self-rated health – may have been modified by the caregiver or after a discussion between participant and caregiver.

There was considerable inter-source disagreement as regards the selected medical conditions. It was more usual to fail to report diseases than physicians had recorded. A similar phenomenon, to a lesser extent, has been described earlier for younger populations (2, 4, 5, 20). There may be several underlying reasons for this. Among reasons for commonly under-reporting diagnosed diseases may be impaired cognition, missing information about the diseases, or simply poor attention in filing the questionnaire. Patients' self-awareness of certain medical conditions may be influenced by physicians. Especially if there are no disturbing symptoms, people do not necessarily find out about some conditions, such as hypertension, unless their doctor informs them properly. Identifying medical conditions may also be unclear – for example, in the case of rheumatoid arthritis, which can be confused with osteoarthritis or other joint diseases.

The differences in inter-source agreement between various diseases are consistent in several studies, including our study. Only cardiac disease shows a different pattern, with low inter-source agreement in 90-year-olds.There are several possible explanations: 1) the prevalence of cardiac diseases increases from 15-20% in middle age to 75% at age 90. The data disagreement increases with prevalence, as answering negative (true and false negatives) is more common than answering positive (true and false positives); 2) the heart disease of a 90-year-old person may mean several conditions, some of which are intermittent or do not in themselves recall symptoms – such as atrial fibrillation or congestive heart failure. It is also possible that symptoms do not influence daily life, if there are other physical limitations preventing stress for the heart. In younger people, symptoms may be more disturbing with angina pectoris or arrhythmias, which restrict normal activities.

In addition to the studies compared above, the OCTO-Twin study on Swedish octogenarian twins showed a similar pattern, with high agreement in diabetes, moderate in stroke and Parkinson's disease, and low in arthrosis (4). This study was left out of the comparison because of its different statistical approach. The consistent results suggest that the definition or nature of a medical condition may be more important than recorder-related differences. For example, therapy-requiring diabetes was always reported more accurately than joint problems. Some differences between the studies may be explained by the definitions of conditions and diagnostic criteria. For example, if in one study a subject is thoroughly examined for medical conditions to be identified, physicians' awareness increases, whereas subjects' awareness is not necessarily changed. The opposite situation occurs when a study uses past medical records and asks subjects to describe their medical condition later. In our study, an interesting finding supporting this was that failing to report a diagnosed disease did not depend on cognitive state. However, in our study, in 31.7% of cases, some other person assisted the 90-year-olds in filing the questionnaire, and this may have compensated for memory problems.

Subjects reported dementia, depression and arthritis more often than these diseases were recorded in their medical records. Medical records may emphasize acute severe diseases, at the cost of chronic conditions such as osteoarthritis or depression (21). In addition, depression or dementia may be underdiagnosed, even when the patient has clearcut symptoms (22-25). For example, Nygaard and Ruths showed in their study that one-third of demented nursing home residents had not been previously diagnosed as such according to the nursing home medical records (26). Thus, medical records are not necessarily an accurate source of information. In the case of dementia, on one hand it is common for very old healthy individuals to be worried and to complain about memory deficits (27). On the other hand, the early stages of dementia are often better identified by the patients themselves (23), and primary health care physicians may fail to detect dementia in very old patients (24, 25). This significant over-reporting of certain diseases suggests that medical records are not always a reliable source for the oldest-old. In our study, some of the respondents may also have had conditions diagnosed in other medical locations, and this information would not necessarily be available to us. This may slightly lower the inter-source agreement.

We used a mailed questionnaire for the study group and medical records as the second source of data – an approach different from that of some other studies which used a questionnaire addressed to the primary physician. The slightly lower data agreement in the 90-year-olds may partly be explained by this methodological difference. However, the study with the highest agreement of data used the same method of data collection, although in a younger population (5). We preferred to exploit these data sources, as they are commonly used in both medical research and health care. The use of mailed questionnaires in the oldest-old population has already been validated by Jylhä and Hervonen, and showed that the specificity of self-reported results against medical records was almost identical to findings in earlier studies with younger subjects, indicating that attention had been applied in completing the questionnaire (17). We found sensitivity to be lower in our study, and this may be due to the higher prevalence of diseases in the oldest-old population. Medical records are commonly used as the gold standard, although their completeness has been questioned (4). By manually checking each record thoroughly, we tried to obtain a comprehensive medical history of our subjects. Due to manual processing, the results may be comparable to physicians' reports in other studies. Unfor-

tunately, this approach is very labor-intensive, and cannot be carried out for vast population studies.

In comparison with earlier data, the disagreement between self-reports and medical records or physician-reported data in the 90-year-olds showed a pattern similar to that of earlier studies in younger-old populations, but in most cases the differences grew larger with our 90-year-olds. Under-reporting of medical conditions increases with prevalence. In addition, also facts like patients not being informed by doctors, and doctors not recording everything, increase data discordance.

In future studies, attention should be paid especially to the oldest-old under-reporting certain diagnosed medical conditions, which may be one source for the overly positive image of health status in the very aged.

CONCLUSIONS

Compared with earlier studies in younger-old populations, the agreement between medical records and self-reported medical history obtained via questionnaires was poorer in 90-year-olds. Both under-reporting of diagnosed medical conditions and reporting undiagnosed diseases were common, the latter phenomenon being typical of this age group. Although most diseases were under-reported, dementia and depression were typically reported more often than they were mentioned in the medical records.

ACKNOWLEDGMENTS

We thank the city of Tampere for providing us with access to the health record database and for assisting us in collecting data about the population.

REFERENCES

1. McCusker J, Bellavance F, Cardin S, Trepanier S. Screening for geriatric problems in the emergency department: reliability and validity. Identification of Seniors at Risk (ISAR) Steering Committee. Acad Emerg Med 1998; 5: 883-93.
2. Kriegsman DM, Penninx BW, Eijk JT, Boeke AJ, Deeg DJ. Self-reports and general practitioner information on the presence of chronic diseases in community dwelling elderly. A study on the accuracy of patients' self-reports and on determinants of inaccuracy. J Clin Epidemiol 1996; 49: 1407-17.
3. Caruso A, Di Francesco B, Pugliese P, Cinanni V, Corlito A. Information and awareness of diagnosis and progression of cancer in adult and elderly cancer patients. Tumori 2000; 86: 199-203.
4. Nilsson SE, Johansson B, Berg S, Karlsson D, McClearn GE. A comparison of diagnosis capture from medical records, self-reports, and drug registrations: a study in individuals 80 years and older. Aging Clin Exp Res 2002; 14: 178-84.
5. Haapanen N, Miilunpalo S, Pasanen M, Oja P, Vuori I. Agreement between questionnaire data and medical records of chronic diseases in middle-aged and elderly Finnish men and women. Am J Epidemiol 1997; 145: 762-9.
6. Wu SC, Li CY, Ke DS. The agreement between self-reporting and clinical diagnosis for selected medical conditions among the elderly in Taiwan. Public Health 2000; 114: 137-42.
7. Bosworth HB, Siegler IC, Brummett BH, et al. The association between self-rated health and mortality in a well-characterized sample of coronary artery disease patients. Med Care 1999; 37: 1226-36.
8. Hoeymans N, Feskens EJ, Kromhout D, van den Bos GA. The contribution of chronic conditions and disabilities to poor self-rated health in elderly men. J Gerontol A Biol Sci Med Sci 1999; 54: M501-6.
9. van Doorn C, Kasl SV. Can parental longevity and self-rated life expectancy predict mortality among older persons? Results from an Australian cohort. J Gerontol B Psychol Sci Soc Sci 1998; 53: S28-34.
10. Helmer C, Barberger-Gateau P, Letenneur L, Dartigues JF. Subjective health and mortality in French elderly women and men. J Gerontol B Psychol Sci Soc Sci 1999; 54: S84-92.
11. Kivinen P, Halonen P, Eronen M, Nissinen A. Self-rated health, physician-rated health and associated factors among elderly men: the Finnish cohorts of the Seven Countries Study. Age Ageing 1998; 27: 41-7.
12. Louhija J. Finnish centenarians. A clinical epidemiological study. Academic dissertation. Helsinki: Helsinki University Press, 1994.
13. Andersen-Ranberg K, Christensen K, Jeune B, Skytthe A, Vasegaard L, Vaupel JW. Declining physical abilities with age: a cross-sectional study of older twins and centenarians in Denmark. Age Ageing 1999; 28: 373-7.
14. Jylhä M. Oman terveyden kokeminen eläkeiässä (Self-perceived Health of the Elderly) Acta Universitatis Tamperensis Ser A Vol. 195. Tampere: Tampere University Press, 1985.
15. Goebeler S, Jylhä M, Hervonen A. Medical history, cognitive status and mobility at the age of 90. A population-based study in Tampere, Finland. Aging Clin Exp Res 2003; 15: 154-61.
16. Jylhä M, Hervonen A. Vitality 90+: stories of complete lives. Gerontologist 1997; 1: 25.
17. Jylhä M, Hervonen A. Functional status and need of help among people aged 90 or over: a mailed survey with a total home-dwelling population. Scand J Public Health 1999; 27: 106-11.
18. The International Classification of Diseases, 10th Revision. Available at: http://www.cdc.gov/nchs/icd9.htm Accessed Jan 8, 2005.
19. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33: 159-74.
20. Kehoe R, Wu S, Leske MC, Chylack LT. Comparing self-reported and physician-reported medical history. Am J Epidemiol 1994; 139: 813-18.
21. Jencks SF, Williams DK, Kay TL. Assessing hospital-associated deaths from discharge data. The role of length of stay and comorbidities. J Am Med Assoc 1988; 260: 2240-6.
22. Garrard J, Rolnick SJ, Nitz NM, Luepke L, Jackson J, Fischer LR, Leibson C, Bland PC, Heinrich R, Waller LA. Clinical detection of depression among community-based elderly people with self-reported symptoms of depression. J Gerontol A Biol Sci Med Sci 1998; 53: M92-101.
23. Schofield PW, Jacobs D, Marder K, Sano M, Stern Y. The validity of new memory complaints in the elderly. Arch Neurol 1997; 54: 756-9.
24. Harwood DM, Hope T, Jacoby R. Cognitive impairment in medical inpatients. II: Do physicians miss cognitive impairment? Age Ageing 1997; 26: 37-9.
25. Olafsdottir M, Skoog I, Marcusson J. Detection of dementia in primary care: the Linkoping study. Dement Geriatr Cogn Disord 2000; 11: 223-9.
26. Nygaard HA, Ruths S. Missing the diagnosis: senile dementia in patients admitted to nursing homes. Scand J Prim Health Care 2003; 21: 148-52.
27. Riedel-Heller SG, Matschinger H, Schork A, Angermeyer MC. Do memory complaints indicate the presence of cognitive impairment? Results of a field study. Eur Arch Psychiatry Clin Neurosci 1999; 249: 197-204.