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GENDER DIFFERENCES IN HEALTH-RELATED QUALITY OF LIFE IN BELGIUM IN 2013

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ADL	Activity of Daily Living
BHIS	Belgium Health Interview Survey
CERVA	Veterinary and Agrochemical Research Center
DALE	Disability-Adjusted Life Expectancy
DALY	Disability-Adjusted Life Years
EU	European Union
GALI	Global Activity Limitation Index
HALE	Health-Adjusted Life Expectancy
HLY	Healthy Life Years
ISP-WIV	Institut de Santé Publique
HRQoL	Health-Related Quality of Life
IADL	Instrumental Activity of Daily Living
LE	Life Expectancy
QALE	Quality-Adjusted Life Expectancy
QALY	Quality-Adjusted Life Years
REVES	Réseau Espérance de Vie En Santé
SILC	Survey on Income and Living Conditions
WHO	World Health Organization

1 INTRODUCTION

Life expectancy worldwide has evolved greatly throughout the last three centuries. In 1900, the life expectancy at birth was only 31 years globally. It evolved from 54 years for women in 1960 to 74 years in 2016 and from 50 years for men to 70 years (United Nations, Department of Economic and Social Affairs, Population Division 2017). This rapid increase reflects the overall improvement in health conditions worldwide. Indeed, advanced medical knowledge, better sanitation, better education and better living conditions have contributed in the reduction of mortality rates and the extension of life over the last decades, continuing a long-term trend initiated around 1850. However, improvements remain unequal. For example, the countries of the WHO European Region have on average 77.5 years of life expectancy in 2016 while countries in the WHO African Region benefit from only 61.2 years of life expectancy. Persistent inequalities in life expectancy between different socioeconomic groups, regions or ethnic groups can also be observed within countries (Chang et al. 2015). One of the main sources of variation in risks of dying is gender. Life expectancies are often presented separately for women and men due to important inequalities between genders. This separation of women and men in mortality estimates has become so natural that the interest about the differences between genders somewhat seems to dissipate (Macintyre, Hunt, and Sweeting 1996). In 2016, a difference of 4 years was observed between life expectancy in women and men worldwide. This gap varies greatly between countries and is in relation with the overall level of mortality. In 2015, it ranged from 0.1 years in Mali (58.3 years for women and 58.2 years for men) to 11.6 years in Russia (76.3 years for women and 64.7 years for men) (United Nations, Department of Economic and Social Affairs, Population Division 2017). Countries with differences in mortality rates by gender often experienced poor women's health, which reduced the women's life expectancy. The countries with large gaps are often former members of the USSR and countries that experienced wars. Inequalities in health and in life expectancy between women and men have been widely documented in the world (Lopez and Ruzicka 1983; Seifarth, McGowan, and Milne 2012).

In Europe (EU 28), the life expectancy at birth for women varied from 80.9 years in 2002 to 83.3 years in 2015. For men, the life expectancy varied from 74.5 years in 2002 to 77.9 years in 2015. In that period, the gap between women and men reduced from 6.4 years to 5.4 years. Yet, it is higher than the world average. The gaps also vary widely across countries within the EU. We observed gaps of 10.5 years in Lithuania while the Netherlands only experienced 3.3 years of difference (Eurostat, 2015). In Belgium, the life expectancy at birth for women increased from 80.5 years in 1996 to 83.7 years in 2016. For men, the life expectancy increased from 73.8 years in 1996 to 78.8 years in 2016. Hence, over the period, the gender gap reduced from 6.7 years to 4.9 years. It is also higher than the world average but lower than the European average (Statbel 2017). Obviously, the gap in life expectancy comes from differences in the mortality rates between women and men. Understanding these mortality inequalities would allow gaining a better insight into the gender inequalities in health.

However, there is also a need to go beyond age-specific mortality rates and explore the patterns of disability and diseases. The gains in life expectancy have led to concerns about the quality of these extra years lived, since ageing individuals are more at risk of disability, chronic health problems and impairments. According to some, the extension of the life expectancy is associated with the appearance and development of chronic health problems (Gruenberg 1977). As a result, the increase in the oldest-old population and uncertainties about the level of health also raised concerns about the associated costs for the health sector. Important increases in medical costs and in costs associated with disability and dependency are a source of concern (Robine 2003). These concerns generated a growing interest in the development of measures of population health that would include not only mortality but also morbidity data. Health expectancies were then developed in the 1960s as a response to these new challenges (Robine 2003). Health expectancies are using both mortality and morbidity data and are now regularly calculated in a wide range of countries when data are available. The predominant method used to calculate health expectancies is the Sullivan method (Sullivan 1971), which combines mortality data from classic life tables and prevalence of impairments from cross-sectional surveys. This method is widely recognized as robust and simple to use. It used easy to explain measures in years of life intelligible by the general population. As the concept of good health is wide and many definitions can be used, there are potentially as many health expectancies as definitions of health. However, irrespective of the definition of health which is retained, it is generally observed that inequalities remain when considering health expectancies. Socioeconomic, regional and educational inequalities are even larger with health expectancies (Mäki et al. 2013; Jagger et al. 2008; Van Oyen, Tafforeau, and Roelands 1996; Bossuyt et al. 2004). Yet, when calculating health expectancies the gap between women and men tends to narrow (Oksuzyan, Brønnum-Hansen, and Jeune 2010). In other words, the women's advantage in mortality is partly compensated by a women's disadvantage in disability. This observation and the need to explore it further in the Belgian context, are at the center of this research.

This research intends to look at gender differences in health expectancy, considering various components of health expectancies. In a same population, diverse health status data can be used and will result in substantially different health expectancies. Not only will absolute values of health expectancies be affected, but also the breadth of differences between groups, such as between women and men. The contrast is due to the fact that distinct measures of health states estimate different concepts of ill-states (Boshuizen and Perenboom 2003). One of the weaknesses of the crudest indicators of health expectancy is their binary nature, that is, indicators distinguish only between people in ill-states (0) and healthy states (1), with no intermediate state. In fact, it is hardly possible to determinate a moment of transition, a point where a healthy person become instantly an unhealthy person (Buratta and Egidi 2003). More sensitive measures, accounting for a large variety of health states, have been developed to better assess health expectancies in a nuanced way. Using one of these more detailed measures, we will establish whether the gender differences observed in binary measures will also be observed in continuous measures that better assess severity levels. In other words, this research aims to use a more detailed indicator, the Quality-Adjusted Life Expectancy (QALE), to better understand gender differences in health and life expectancies, taking Belgium as a case study. The specificity of this indicator and the lack of studies investigating the gender differences in it motivated the use of the QALE as a valuable tool to explore this field.

Our research is based on the Belgian Health Interview Survey (BHIS), a survey that covers health-related topics in the Belgian population and is coordinated by Sciensano, a federal research center, made of the former ISP-WIV (Scientific Institute of Public Health) and the CERVA (Veterinary and Agrochemical Research Center). In 2013, the survey included for the first time a multidimensional tool, the EQ-5D-5L tool, developed by the EuroQol Group, to measure the Health-Related Quality of Life

(HRQoL). The EQ-5D questionnaire evaluates the health state across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The answers to the EQ-5D questionnaire provide 3125 possible combinations of health states. Three steps can be distinguished when calculating the Quality-Adjusted Life Expectancy (QALE) based on this questionnaire. First, according to a specific method (Cleemput 2010; Van Hout et al. 2012), which will be presented further in this dissertation, an Health-Related Quality of Life (HRQoL) index score (also referred to as the disability weight) have been calculated for all respondents, and it varies from 0 to 1. Second, the mean HRQoL scores, calculated by age and by sex, provide population norms for the Belgian population (Devleesschauwer et al. in preparation). Third, the population norms can be used to calculate the Quality-Adjusted Life Years (QALYs) for different chronic diseases, and, the Quality-Adjusted Life Expectancy (QALE). This measure adjusts the life expectancy for the Health-Related Quality of Life (HRQoL) and captures more precisely the changes in severity levels.

The QALE has not been calculated for Belgium yet, despite the availability of the data to do so. This master's dissertation aims to calculate QALE for women and men at every age between 15 and 100 years. Our objective is to shed a new light on gender differences in health-related quality of life in Belgium based on this measure. The effect that the accuracy of the QALE in assessing severity levels has on the gap between women and men at every age will be investigated. To better understand and assess the gap, gender differences in QALE will be decomposed into a mortality and a morbidity effect. Indeed, as Oksuzyan et al. (2010) noticed, little has been done to investigate the gender gap in health expectancy and to investigate the contributions of mortality and disability to the gap. From a methodological standpoint, our approach is to use population norms (or population averages) based on the EQ-5D tool and derive disability-free life expectancies for the 5 dimensions of the tool (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression). This approach will allow us to identify which dimensions have the bigger impact on the HRQoL, and, which dimensions contribute most to the gap between genders in HRQoL.

This dissertation is organized as follows. In the next section, a literature review will be conducted in order to gain insight into gender differences in mortality and morbidity, with a specific focus on Belgium. This literature review will also examine the relationships between gender and mobility, self-care, performance of usual activities, pain/discomfort and anxiety/depression. The analysis of these relationships will help predict and understand the trends in the values and the gender differences in the QALE and in the life expectancy without reporting problems in mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Section 3 will present data and methods, introducing the EQ-5D tool, and explaining how the Quality-Adjusted Life Expectancy (QALE) can be computed and decomposed. Section 4 introduces our results, which are discussed in the last section.

2 LITERATURE REVIEW

In order to understand the gender differences in Quality-Adjusted Life Expectancies (QALE), this section first provides some theoretical aspects of inequalities in mortality by gender, then moves on to differences in health expectancy, and finally, introduces the concept of QALE. Lastly, the expected effect of gender on mobility, self-care, usual activities, pain/discomfort and anxiety/depression will be investigated based on the existing literature.

2.1 GENDER INEQUALITIES IN HEALTH

2.1.1 Gender differences in mortality: theoretical aspects

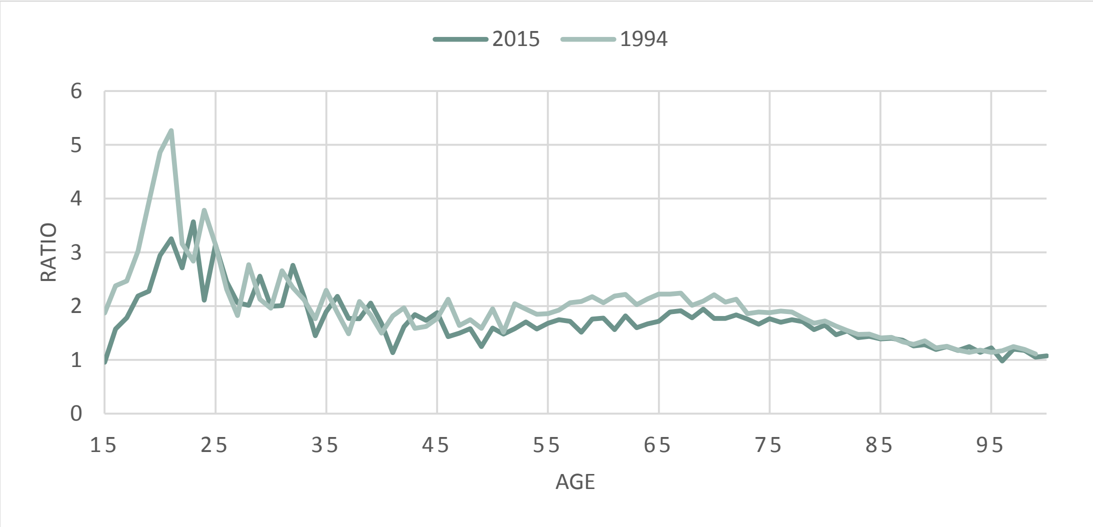
When looking at disparities in health and in mortality by gender, two effects are interacting. On one hand, we can observe biological and genetic differences between genders, and on the other hand, behavioral and environmental factors produce societal differences. It is difficult to investigate biological and genetic effects separate from societal factors, as they interact so closely together (Waldron 1983). Different types of interactions are possible. For example, the environment could influence the prevalence of a specific causes of death to which a specific gender is more vulnerable; or different environmental conditions experienced by women and men could reinforce or counteract the effects of genetic factors (Waldron 1983). However, extensive research has been conducted to investigate the reasons for the differences. Lifestyle and societal factors in interaction with biological factors will produce different outcomes, particularly concerning chronic diseases. In this section, after looking at the pattern of mortality differences between women and men, several factors likely to explain the differences are presented.

The differences between the life expectancy of men and women have been described as being linked to differences in mortality throughout the different stages of life. Inequalities in mortality start even before birth. The sex ratio at conception, even if extremely difficult to study, is estimated at 115 male conceived for 100 female conceived (Waldron 1983). Then, the embryos and the fetuses do not face the same risks of dying. The sex ratio in utero decreases as gestational age increases, indeed, between the second and the fifth month of gestational age, males have higher mortality risk (UNO 1998). The mortality risk during the first months of pregnancy is extremely difficult to evaluate, but the limited data suggest that there are more male embryos during the second month of gestational age. Moreover, in contrast with low income countries, in high income countries, no significant sex difference has been found in late fetal mortality risk (UNO 1998). At birth, the sex ratio is higher for high income countries because of better health, low fertility (high-order births have lower sex ratios) and higher life expectancy (Waldron 1983). The sex ratio at birth in Belgium hovers around 105 boys for 100 girls at birth (Statbel 2015b).

Males fetuses and babies suffer from a biological disadvantage beyond genetic factors. They are at a higher risk of congenital anomalies, of premature birth and of all perinatal conditions. After birth, male babies face higher mortality rates. They suffer from a direct genetic disadvantage with deficiencies associated with X chromosome-linked genetic defects. Men have only one copy of X-linked genes while women have two copies of them. If a mutation occurs in a X-linked gene, women have a second copy in reserve to override or mitigate the effect while men are vulnerable to the mutation (UNO 1998). The higher levels of testosterone experienced as fetus and as newborn contribute to greater risks in mortality from accidents. Even if testosterone predisposes a high energy physical activity and physical aggressiveness, the higher mortality from accidents in boys is also explained by differences in the socialization of babies. Indeed, the infant mortality, as the sex ratio at birth can also be explained by environmental and behavioral factors such as preference for boys (UNO 1998) (Waldron 1985). However, in high income countries, disparities among children account for a small part of the difference. When reaching the age of 15, children in Belgium should be quite equal in terms of survival chances since birth.

After age 15, mortality rates will continue to be higher in men for all adult ages. In Belgium, the pattern of disparities in mortality rates at adult ages is changing over time (see Figure 1). In 1994, the mortality rates between 17 and 33 years were systematically higher from 2 to more than 5 times for men than for women (Statbel 2016). This age group is characterized by risky and aggressive behaviors in males. Then, differences slightly narrow between 34 and 57 years, until being again twice higher in men between 58 and 73 years. There were 4.6 centenarian women for every man in 1994. In 2015, the pattern had evolved, with mortality rates between 18 and 33 years ranging from 2 to nearly 4 times higher among men than women. Between 65 and 75 years, the mortality rates for men rise only slightly. These differences in mortality rates will obviously be reflected in the number of centenarians. There were 6.2 centenarian women for every man in 2015. A European study showed that, in 2011, only 16.5% of the European centenarian population were men. The proportion varies from 37% in Hungary to less than 13% in Belgium (except in Lichtenstein with no male centenarians) (Teixeira et al. 2017). Thus, when compared to other countries in Europe, the number of male centenarians is particularly low in Belgium.

***Figure 1** Masculinity ratio of mortality quotients, Belgium, 2013, data from Statistics Belgium*



These differences between genders in risks of dying result from many factors interacting with each other. Firstly, women and men traditionally have different social roles in societies. The disparities in social roles influence the exposure of an individual to particular risk factors of illness or injury. Many examples of differences in lifestyle can explain why women benefit more from the progress in health. Even if women participate widely in the labor market today, they still perform different tasks and activities less prejudicial for their health. For example, women engage in less risky jobs, as illustrated by data from the United States, where 93% of fatal work injuries involved men in 2016 (U.S. Bureau of Labor Statistics 2017). Women also tend to engage in leisure activities that protect their health and their bodies. On the other hand, men tend to engage in more risky activities (Vallin 1995). They are more exposed to alcoholism, smoking and road accidents (Cameron and Bernardes 1998). Alcohol use disorders in high income countries in 2000 had a male to female ratio of 4.12 (Mathers et al. 2003). Social roles also influence greatly attitudes towards physical symptoms and the willingness and ability to take curative actions for health problems. Women are more attentive to their bodies, their health and their needs. Therefore, they are more likely to consult a doctor, more frequently in contact with health specialists due to gynecologic and pediatric care, and make more use of preventive screening. The perceived morbidity is influenced and affects the curative health actions, the long-term disability and the mortality (Verbrugge 1983).

The excess risk of dying in males has been particularly observed between 15 and 24 years. This excess mortality has been explained by more risky and violent behaviors, such as unsafe driving, violence, suicides and others accidents (Oksuzyan, Brønnum-Hansen, and Jeune 2010). The higher level of testosterone in men has been considered as an explanation for the more violent behavior of men, but the real extent of biological factors and the interaction with societal factors is heavily debated (UNO 1998). Social roles and socialization influence this excess mortality. In Belgium, in 2015, from all deaths between 15 and 29 years, 49.7% were deaths in men from external causes (accidents, self-harm, assaults) while only 13.7% were deaths in women from external causes (Statbel 2015a).

Secondly, differences in hormones may play a role in preventing certain diseases. Indeed, estrogen has been proved to have a protective effect against atherosclerosis (accumulation of plaque inside an artery) and against ischemia injury on the myocardium (Moolman 2006). It results in women being more protected against coronary heart disease and ischemic heart disease. After menopause, the risks become higher for women but never reach the levels observed in men (Newman and Brach 2001). Positive effects of estrogen on lipid metabolism and, correlatively the better ability to process the excess food has been linked to better protection against heart disease (Szafran and Smielak-Korombel 1998). In Belgium in 2015, between 50 and 69 years, deaths from circulatory diseases accounted for 20% of deaths in men while representing only 13.5% of deaths in women. Between 70 and 89 years, deaths from circulatory diseases represented 28.5% of deaths in men and 29% of deaths among women. Risk of death by circulatory diseases among women reaches the level of men after a certain age (Statbel 2015a).

Thirdly, the role of smoking can also be brought in as an important factor in the disparities in mortality in the last decades. Previous research has looked at the difference between women and men in life expectancy that could be attributed to smoking in Denmark, Finland, The Netherlands, Norway, and Sweden (Valkonen and Van Poppel 1997). The authors found that, on average for the 5 countries considered, 44% of the gap in life expectancy could be attributed to smoking in 1970-1974 and 31% of the difference was attributable to smoking in 1985-1989. If we only look at The Netherlands, 72% of the difference was attributed to smoking in 1970-1974 and 53% in 1985-1989. This is because smoking cigarettes is a behavior that spread in the 20th century principally among men. Smoking was socially unacceptable for women and a sign of bad reputation. Then, smoking became a symbol of emancipation and it spreads amongst women along with the desire for equality. Accordingly, studies about the causes of disparities in life expectancy reported smoking-related conditions more often in men (Case and Paxson 2005; Valkonen and Van Poppel 1997; Glei and Horiuchi 2007). In the more distant past, men were the most likely to smoke and so, they were more likely to experience mortality due to smoking-related conditions, thus the gap in life expectancy widened. Then, women started to smoke and to suffer from mortality due to smoking-related conditions while the prevalence of smoking in men started to decrease. The gap in life expectancy consequently narrowed. However, today, men are still more at risk of dying from smoking-related conditions due to their longer exposure (Valkonen and Van Poppel 1997). All in all, men suffer from a more severe form of these diseases compared to women with the same diseases due to longer exposure to tobacco and consequently, men are more likely to die from respiratory cancer, cardiovascular disease, and bronchitis. On average in Belgium in 2015, 9.6% of deaths in women and 23.7% of deaths in men were caused by tobacco use (Drope et al. 2018). 53% of Belgian men reported having smoked at least once in their lifetime while only 36% of women did so. Men have smoked on a daily basis on average during 22 years while women smoked for 19 years on average (Gisle and Demarest 2014). The pattern of discrepancies in smoking prevalence and smoking-related conditions is therefore well present in Belgium.

Fourthly, the effect of smoking is also found in the prevalence of cancer. Cancer prevalence differs between genders mainly because higher rates of lung cancer are found in men (Newman and Brach 2001). In 2000 in high income countries, trachea, bronchus and lung cancers were the third cause of deaths and had a male to female ratio of 2.8 (Colin D. Mathers et al. 2003). In 2015, 34 106 cases of cancer were recorded in women in Belgium and 39 773 cases were recorded in men. Excluding gender-specific cancers, such as breast cancer or prostate cancer, the higher disparities in Belgium were found in lung and bronchus cancer with 5711 neoplasms for men and 2658 cases of neoplasms for women in 2015 (Figure 2). Between 2011 and 2015, women had higher survival time with cancer (Figure 3) (Belgian Cancer Registry 2018).

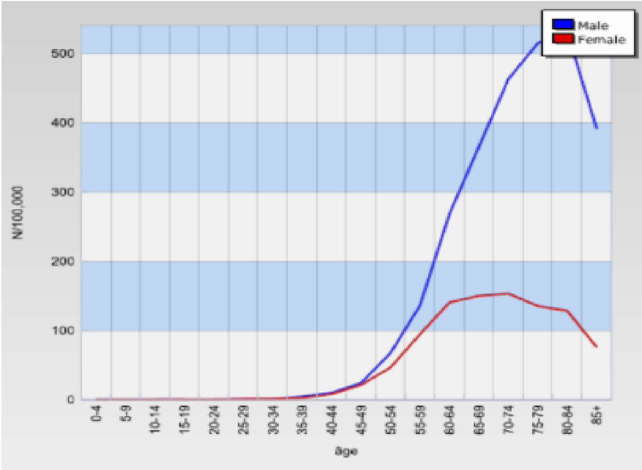


Figure 2 *Lung cancer, Belgium, 2015, Cancer registry*

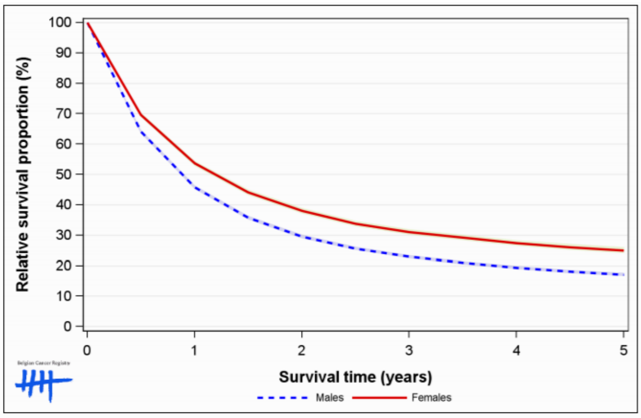


Figure 3 *Relative survival proportion in cancer by sex, Belgium, 2011-2015, Cancer Registry*

2.1.2 Gender differences in disability rates

Gender differences in life expectancy do not exist in isolation from differences in health and disability, but they do not evolve on the same direction either. There is a vast literature discussing the "men die, women suffer" paradox. Again, several explanations involving social roles, environmental factors, and biological factors have been investigated to explain the higher disability rates of women, which contrast with higher mortality rates among men.

In the first place, higher rates of limitations are often reported in women. Higher levels of overall disability in women in the US, and more frequent limitations in daily life activities or mobility were found using different indices such as the Instrumental Activity Daily Life (IADL) or Activity Daily Life (ADL) (Murtagh and Hubert 2004). As expected, limitations were found to increase with age (Rodrigues et al. 2009). Strauss et al. (2003) found gender differences in disability, in morbidity and in mortality varying with age in Sweden. Women over 90 years had a higher disability prevalence and a higher incidence of long-term disability than men of the same age. Women of 85 years had a higher morbidity prevalence while mortality in individuals with disabilities was similar for women and men. Thus, by measuring the Activity Daily Life (ADL), only women in very advanced years were more disabled than men. These results will be developed in sub-section 3.

Studies have focused more on describing patterns of differences in disability between women and men than on explaining them. The main factor introducing variations between women and men is the presence of chronic diseases. One major risk factor for functional disability, regardless of gender, was chronic conditions (stroke, arthritis, cancer, heart disease, chronic lung disease, obesity, hip fracture and systemic arterial hypertension) (Rodrigues et al. 2009). The relation between gender and chronic diseases can be differentiated by the prevalence and onset of diseases, the type of diseases, the severity and the issue of these diseases. Indeed, most research in this field reports a higher prevalence of chronic disease in women, particularly in the conditions associated with increased risks of disabilities. For example, Crimmins and colleagues (2011), using Belgian data in 2004, reported a higher prevalence of arthritis, hypertension, diabetes, and depression in women and higher prevalence of cardiovascular conditions in men. It has been reported that after a cardiovascular disease, the same degree of disability is observed in women and men, but a higher level of depression is recorded in women (Scott and Collings 2012). The conditions (musculoskeletal, neurodegenerative and psychological) and health problems correlated with a disability (such as greater medication, fractures, chronic back problems) were also the ones that were more prevalent in women (Murtagh and Hubert 2004). Gender differences are more pronounced for prolonged, mild conditions than for acute, life-threatening or severe conditions (Vlassoff 2007). At first glance, it appears that women are more at risk of non-fatal but disabling conditions whereas men are more at risk of fatal conditions. Moreover, women have been reported to be more at risk for comorbidities in chronic diseases (Öztürk et al. 2011).

It also can be noticed that diseases more prevalent in men, such as cardiovascular diseases, have received greater attention and efficient treatments. On the contrary, several diseases more prevalent in women, such as arthritis and musculoskeletal diseases, still lack an adequate treatment. The differences in treatment efficiency can lead to women suffering longer of chronic diseases. Due to lower mortality at younger ages, more women survive to advanced ages where they are at higher risk of disability (Nusselder 2003). Furthermore, due to socio-economic factors adverse to women, they are less armed to face diseases. Women, especially elderly women, tend to have lower education, lower employment rates and fewer economic resources (Hosseinpoor et al. 2012; Marmot et al. 2012). In the World Health Survey covering 57 countries, the decomposition of the differences in disability for women and men showed that 45% of these differences can be attributed to social determinants. The largest determinants were employment due to higher proportion of men in paid jobs, followed by education and marital status due to higher proportion of women with no education, divorced, widowed or separated. The household economic status also was a significant determinant (Hosseinpoor et al. 2012). Thus, due to their lower socio-economic status, women are more exposed to negative effects brought by chronic diseases. More socio-economically advantaged women lived more years in total and more years disability-free than disadvantaged women (Matthews, Jagger, and Hancock 2006).

Yokota et al. (2015) calculated disability burden and chronic diseases prevalence in Belgium based on the different waves of the Belgian Health Interview Survey (BHIS). They defined disability as a problem with one ADL item, or if the respondents reported an ability to walk without stopping that was less than 200 meters. Consistent with previous studies, they found that at age 80 or older, more than half of Belgians were disabled. In every age groups except for the 55-64 age group, women had higher rates of disability than men. Two main categories of diseases were responsible for the disability, musculoskeletal diseases, which accounted for 15 to 36% of the disability prevalence in men and 31 to 56% in women for all ages, and cardiovascular diseases, which accounted for 13 to 14% of the disability prevalence in men and 7% in women aged 55 years or older. Depression also plays a role in young individuals (15-54 years) where it represents 7% of the disability prevalence. In the elderly (65 years and older), musculoskeletal, cardiovascular, and chronic respiratory diseases represent 34 to 44%

of the disability prevalence in men and 49 to 65% in women. They further decompose disability in mild and severe disability and found a higher prevalence of mild disability in all age and gender groups, except for women aged 80 years or older, where severe disability is more common (R. T. C. Yokota et al. 2015; R. T. Yokota et al. 2015).

2.2 MEASURES OF HEALTH EXPECTANCIES

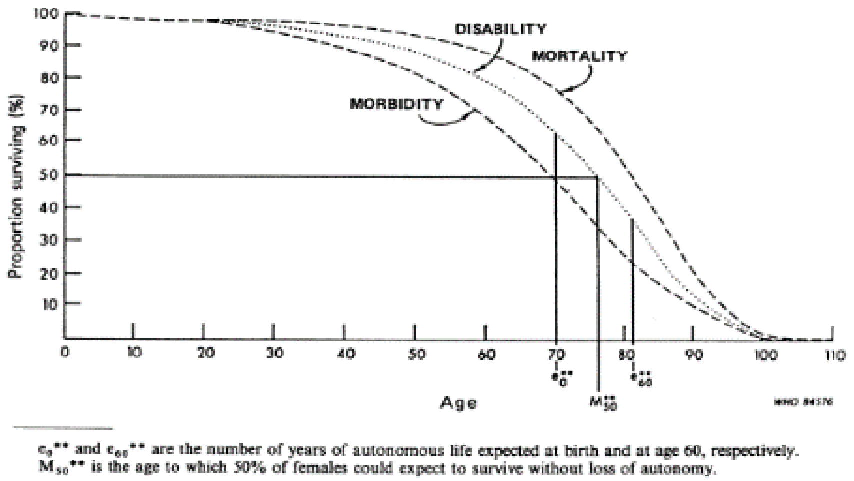
Health expectancy measures are summary measures of population health. They combine information on both mortality and morbidity and produce adjusted values of life expectancy in order to better assess the health of a population.

2.2.1 Origin

As indicated earlier, the life expectancy has been on the rise over the last 150 years and we now live much longer than before. Until recently, indicators related to life expectancy and age-specific mortality, such as under-five mortality, were sufficient to assess the health of populations. However, as life expectancy increased and mortality rates gradually declined, questions were raised concerning the quality of these extra years lived, calling for new indicators of population health. Three main hypotheses have been formulated. First, Gruenberg (1977) in his paper "The Failure of Success" tried to demonstrate how medical progress can actually deteriorate public health. His hypothesis was that with the reduction of mortality, people survived longer with diseases and limitations and are more likely to be exposed to chronic debilitating diseases. So, the increase in life expectancy could potentially provoke an increase of the time lived with disability, dementia and co-morbidities, that is the expansion of morbidity. On the contrary, Fries (1983) analyzed chronic diseases and stated that the age at the first onset of symptoms of ageing or chronic diseases was increasing faster than the corresponding increase in life expectancy. Consequently, the period lived with morbidity is compressed. Finally, Manton (1982) formulated the hypothesis of a dynamic equilibrium. He observed a reduction of mortality with a reduction of the severity of diseases. Consequently, the period of moderate limitations is extended, but the period of severe limitations is stable or diminishing. To clarify which hypothesis is unfolding, plus explore differentials across sub-groups, including by gender, the need for a measure that combines mortality and morbidity became obvious. The health expectancy indicators therefore aim to answer the question: “Is longer life accompanied by an increase in the time lived in good health (that is, the compression of morbidity scenario) or in bad health (expansion of morbidity scenario)?”

The first concept of health expectancy was introduced by Sanders in 1964 who brought together data on quantity and quality of life. The first real example was published in a report by the US Department of Health Education and Welfare in 1969 (Robine et al. 2003). In 1971, Sullivan published his method for calculating disability-free life expectancy (Sullivan 1971). The Sullivan method remains today the most widely used, due to its simplicity and the availability of the data needed. Shortly after, the health status and indicators to measure it had become a priority of the World Health Organization (WHO). The WHO declared in its 1997 World Health Report that "increased longevity without quality of life is an empty price. Health expectancy is more important than life expectancy"(World Health Organization 1997, 5). In 1984, the WHO developed the general model of health transition which allows assessing the evolution of mortality, morbidity, and disability simultaneously and hence also, the different hypotheses of the morbidity/mortality debate. In the model, the area under the mortality curve (Figure 4) represents the total life expectancy while the area under the disability curve represents the disability-free life expectancy. The area under the morbidity curve represents the life expectancy without chronic diseases (EHLEIS 2016). Apart from the WHO, academic groups have devoted a lot of attention to health expectancy. In 1989, researchers created REVES (Réseau Espérance de Vie en Santé) to harmonize health expectancy concepts, improve their calculations and promote the use of such measures. The objective was to agree on an indicator of health expectancy, in particular, a definition of disability which would meet several requirements to be easily used worldwide. More recently, the Global Burden of Disease study has taken the lead in estimating the burden of diseases, injuries and risks factors for 195 countries, including health expectancy. To quantify the burden of premature mortality and disability, the study team used two main summary measures of population health. The first one, Disability Adjusted Life Years (DALYs) combines estimates of years of life lost and years lived with disabilities and measures the health gap between the current situation and an ideal situation. The second one is the Health-Adjusted Life Expectancy (HALE), similar to the DALE described below. These two measures are computed for the 1990-2015 period for 195 countries (Kassebaum, Murray, and Lopez 2016).

__Figure 4__ The general model of health transition (WHO, 1984)



2.2.2 Definition

Health expectancies correspond to the average number of years an individual can expect to live in a given health state if the current patterns of mortality and health states continue to apply until his or her death (Robine, 1994). They are derived from the standard life expectancy, which is the number of remaining years to be lived at a particular age if the current mortality level prevailing in a country would persist (Robine 2007). Health expectancy adds a *quality* dimension to the *quantity* of life lived.

To measure health expectancies, a serie of indicators have been developed, and there are potentially as many health expectancies as concepts of health, e.g., based on self-perceived health, activities of daily living, chronic morbidity, specific diseases, or activity restrictions. For example, disability-specific health states are assessed with disability-free life expectancy and disabled life expectancy. Handicap-specific health states are assessed with handicap-free life expectancy and independent life expectancy. Impairment-specific health states can also be assessed as for example, dementia-free life expectancy and life expectancy with dementia. Self-rated health states are assessed by the (un)healthy life expectancy or the life expectancy in good/poor health. These measures are mostly dichotomous; respondents go from a healthy state (1) directly to an unhealthy state (0). However, measures using continuous weights, that is, different levels of healthy/unhealthy states that can take any value between 0 and 1, are also pertinent. That is the Health-Adjusted Life

Expectancy (HALE) or the Disability-Adjusted Life Expectancy (DALE) (Robine, 1994). These health expectancies measures differ from the health gaps measures developed in the 1990s. The health gaps measures, such as the DALYs, estimate gaps between current health status and ideal status of perfect health with maximum longevity (Mathers et al. 2000). The disability measure retained in a study will of course depend on the goal of the study (Deeg, Verbrugge, and Jagger 2003).

A common indicator had to be set in Europe to ensure comparability in the wide variety of concepts of health. The EU indicator Healthy Life Years (HLY) used long-term activity restriction that can be tested by the Global Activity Limitation Indicator (GALI). The GALI ask one question: “For at least the past 6 months, to what extent have you been limited because of a health problem in activities people usually do?”. In this question, four fundamental concepts are included: activity restriction (that is, being limited), long-term for at least 6 months, comparison to peers (that is, in activities people usually do) and health-related problems (that is, because of a health problem) (Berger et al. 2015). It belongs to the family of disability-free life expectancy. This indicator is part of one objective of the EUROPE 2020 strategy. This 10-year strategy was adopted by the European Commission in 2010 to promote a sustainable social market economy with smart, sustainable and inclusive growth in Europe. It includes initiatives such as the European Innovation Partnership on Active and Healthy Ageing which aims to promote a longer life independently in good health. The goal set is to increase the healthy life years in Europe by 2 years, but many inequalities persist between European countries (Jagger et al. 2013).

2.2.3 Use

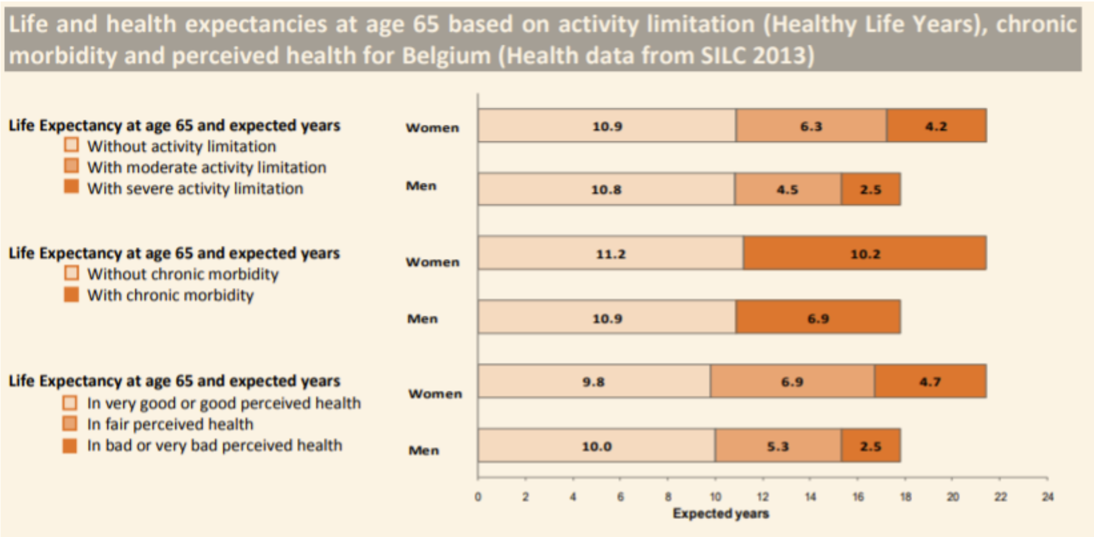
The health expectancies can monitor the interactions between health, morbidity, and mortality. For example, given the ageing of the population, the proportion of older people facing disabilities is higher and will lead to an increasing prevalence of disability overall. However, individuals are probably not more at risk than before to be disabled and health expectancies will be able to monitor the changes in mortality and in the disability condition. Health expectancies also monitor the health states of the population to answer the question regarding the quality of the extra years lived. If the health expectancy is increasing faster than the life expectancy, the years spent in good health actually increase, consistent with the compression of morbidity hypothesis. Conversely, if the life expectancy is increasing faster than the health expectancy, the years spent in good health decrease, consistent with the expansion of morbidity hypothesis.

It is also possible to explore the gains in health expectancy resulting from the elimination of specific pathologies. The definition of a target pathology allows defining public health priorities and target resources for health promotion (Robine 2007; Robine, Romieu, and Cambois 1999). Health expectancies can also monitor the changes in health status, which allows for evaluation of the impact of health policies. This is done by comparing the health states of a population at two points in time or of two different populations at the same point.

The health expectancies can also be used to evaluate inequalities within and among countries. In a country, inequalities in morbidity and mortality can be compared among gender, social group, and region. Comparisons between countries are complex, even if health expectancy is independent of the size of the population and the age structure (Robine 2007). This is because the definition of disability and the survey structure can differ between countries. In 2004, the Healthy Life Years (HLY) have been added to the set of structural indicators in Europe. The use of the healthy life years in a single survey, the Statistics of Income and Living Conditions (SILC) in 25 EU countries made comparisons possible among these countries (Jagger et al. 2008).

Healthy Life Years (HLY) using the Global Activity Limitation Index (GALI) question in the Survey on Income and Living Conditions (SILC) have been calculated for Belgium. At age 65 in 2013, women could expect to have 10.9 HLY (51% of their remaining time to live) while men could expect to have 10.8 HLY (61% of their remaining time to live) without limitations (Figure 5). These values are above the European average by 2.3 years for women and men (EHLEIS 2016). At age 65 in 2013, women could expect to live 11.2 years without chronic morbidity while men could expect 10.9 years. At age 65 in 2013, women could expect 9.8 years in good perceived health while men could expect 10 years (EHLEIS 2016). In 2016, Eurostat estimated the healthy life years at birth for all European countries at 63.8 years for women (76% of the remaining life expectancy) and at 63.7 years for men (80.7% of the remaining life expectancy). In Belgium, the estimates for women are higher than the European average with 64.2 years (76.8%) while men are slightly lower than the European average with 63.5 years (81.2%) (Eurostat 2017).

Figure 5 *Life and health expectancies at age 65 based on activity limitation, chronic morbidity and perceived health for Belgium, 2013 (EHLEIS 2016)*



As suggested earlier, most studies performed in high income countries reported that when adjusting for disability, the gap in the remaining years to live between women and men narrowed (Van Oyen et al. 2008). Data from Belgium on Healthy Life Years confirmed the hypothesis. HLY of women and men are nearly equal but, since women enjoy a longer life, their time in poor health is longer. That is the male-female health paradox.

2.2.4 Quality-Adjusted Life Expectancy

The development of the Quality-Adjusted Life Expectancy (or QALE) responds to criticisms about the binary nature of health expectancies. By allowing the use of continuous health-adjusted weights, the QALE is more precise in assessing severity levels than life expectancy or traditional measures of health expectancy (Collins 2017). It permits the insertion of detailed multi-attribute data on health-related quality of life (Love-Koh et al. 2015). Moreover, the QALE calculates quality of life by considering different dimensions of health such as mobility, self-care, usual activities, pain/discomfort and anxiety/depression.

The QALE is linked to the calculation of the Quality-Adjusted Life Years (QALYs). The QALYs are measures that combine duration and quality of life. If we live one year with a utility value of 0.9 (that is 0.9 QALY), that means that we live 90% of the year in good HRQoL, and 10% are lost due to poor quality of life. The QALE at age x is the total QALYs expected at all remaining expected ages (Jia, Zack, and Thompson 2011).

2.2.4.1 Health-Related Quality of Life

The Health-Related Quality of Life (HRQoL) is a complex and multidimensional concept which measures the impact of the health states on the quality of life. Different people will have different definitions of what a good quality of life is. WHO defines quality of life as "individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHO 2018). It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment (WHO 2018). Thus, HRQoL refers to physical, psychological, and social functioning as reported by the patients themselves (Tan et al. 2013)

This indicator was first developed for economic evaluation measures for a better rationalization in care. It was used later to describe the health-related quality of life and health status outcome of a population. It was therefore included in population surveys in various countries. In Belgium, it was included for the first time in 2013 in the Belgian Health Interview Survey (BHIS), using the EQ-5D tool. Other validated instruments exist to assess the HRQoL, but the EQ-5D is often preferred due to its simplicity. The principles of this tool will be developed further, in the next section. The answers result in an EQ-5D index score ranging from 0 to 1, 1 referring to a state of perfect health (Van der Heyden and Charafeddine 2014).

2.3 THE EXPECTED EFFECT OF AGE AND GENDER ON THE QALE AND THE 5 DIMENSIONS OF THE EQ-5D

Our objectives in this master's dissertation are to analyze gender differences in health-related quality of life in Belgium, based on the EQ-5D tool, to be able to identify which dimension has the largest effect on gender differences, when considering mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Hence, in order to formulate hypotheses on the trends and gender differences in the quality-adjusted life expectancy and these five dimensions, the different patterns in ageing, disability, and quality of life in women and men must be better understood. We will first examine the results of previous studies about the nature of the differences between women and men at different ages for the 5 dimensions included in the EQ-5D tool. Then, the effects expected on the overall quality of life will be summarized.

Many terms could be used to designate the loss of functioning or quality of life occurring in the ageing population. WHO defines disability as the difficulties experienced in three areas of functioning: (1) *impairments* are problems in body functions or structures, (2) *activity limitations* are difficulties in executing activities and (3) *participation restrictions* are difficulties in being involved in any area of life (WHO 2011). In practice, studies will often focus on measuring functional disability or limitations, which include all body functions, tasks or actions. In the elderly, functional limitations refer to acquired difficulties in performing basic everyday tasks or more complex tasks needed for independent living (Rodrigues et al. 2009). The main issue is the wide diversity of indicators used to evaluate the limitations. Indeed, if in the first health surveys, the indicators were limited to self-reported health, functioning problems and disability, today, more numerous and refined indicators have been developed to better assess morbidity across different dimensions (Crimmins, Kim, and Solé-Auró 2011). So, the quality of life does not only include body functions, but also the related activities and participation in society made possible by working functions.

The first dimension covered by the EQ-5D tool is mobility, one of the most basic functions for an independent living because it affects the physical, the psychological and social life of everyone. Mobility limitations are singular due to their early appearance before the disability process and to the lower impact of environmental factors on them. In fact, after adjusting for socioeconomic and health conditions, gender differences in mobility disability remain large while gender differences in physical performance and Activity of Daily Living (ADL) are reduced (Zunzunegui et al. 2015). Mobility limitations are also associated negatively with quality of life and depression symptoms and so, with reduced social participation and placement in nursing homes (Apinonkul et al. 2016).

Numerous studies have shown higher prevalence and incidence of self-reported mobility disability and lower physical performance on tasks in women, compared to men (Ahmed et al. 2016). Difficulties on mobility already start at younger ages. In Finland, difficulties like running have been already found in the middle-aged population. Working-aged women have more difficulties in physically demanding tasks compared to working-aged men, while elderly women reported difficulties for most mobility tasks compared to elderly men (Sainio et al. 2006). Pollard and Wagnild (2017), when looking at the walking pattern at different ages of women and men, found that women at younger ages walk more for leisure than men, in part due to walking with children and for errands. At older ages, that is, when they are 60-70 years old and above, the pattern is reversed and men tend to walk more. It is hypothesized that this shift reflects a replacement of the previous more vigorous activities of men. Generally in older age, the part of elderly walking for leisure declines due to the increase in mobility limitations, but the frequency of walking decreases faster in women. The differences in mobility limitations are age-related. Older adults are more likely to perform worse in mobility tasks, and among them, older women perform worse than older men (Butler et al. 2009). Crimmins et al. (2011) calculated the proportion of the Belgian population that self-reported disabilities for at least one of the 10 tasks related to mobility, strength, and endurance in 2004. After adjusting for age, 57.2% of women reported difficulties on one of the tasks while 41.2% of men did so. Falls in elderly is an important issue in Belgium, it was estimated that 36 027 quality-adjusted life years (1.5% of total QALY loss) were lost due to falls among the population aged 65 and above in Belgium.

On self-reported questions related to mobility limitations, women reported more difficulty with mobility tasks than men after adjusting for age. However, when comparing results of self-reported questions and performance tasks realized, disparities between genders appear. Women tend to over-report limitations while men seem to under-report limitations (Kim, Yabushita, and Tanaka 2010). The same discrepancy was observed by Sainio and colleagues (2006), who suggested that self-reporting and performance tasks assess two different phenomena. Many reasons are given to explain the lower mobility in women in advanced years: a lower muscle strength with a steeper loss, a higher body mass index, lower levels of physical activity and a higher prevalence of chronic diseases and comorbidities. Given the significant difference in the level of mobility between genders, it is not surprising that Ozturk et al. (2011) found effects on performance of daily activities and quality of life. The relationship between mobility and level of energy, pain and physical activity reduced the quality of life in women.

The second dimension of the EQ-5D concerns self-care. The question asked in the survey refers more particularly to the problems faced by individuals in washing and dressing. The third dimension of the tool concerns the problems faced doing usual activities. These two dimensions are related to the functioning measured with a scale related to Activities of Daily Living (ADL) and a scale related to Instrumental Activities of Daily Living (IADL). The ADL scale concerns more particularly self-care activities such as washing, dressing, feeding, mobility, transferring, and toileting. The IADL scale includes usual activities to be able to live independently as cooking, using the telephone, shopping, managing medication, doing housework, and laundry. These dimensions are more likely to be affected by societal and environmental factors, contrary to the mobility as seen before.

Most studies have found higher ADL and IADL score, that is higher reporting of problems in activities, in women than men. However, once adjusted for chronic diseases (Murtagh and Hubert 2004), for the socioeconomic level (Peek and Coward 1999) or both (Zunzunegui et al. 2015), the gender differences are attenuated. For example, an Australian study found that women, regardless of their partners' statuses and adjusting for chronic conditions**,** reported fewer difficulties on both scales. Unpartnered men reported higher difficulties in dressing their lower body and doing heavy housework than partnered men. Unpartnered and partnered women, when compared to partnered men, reported higher difficulties in eating, shopping and doing light or heavy housework. These activities, considered as traditional women's activities, are often still being performed by women even when they reported more severe disability. However, women reported significantly fewer difficulties in dressing their lower body, walking inside the house, using the toilet, preparing meals, taking medications, using the telephone and performing leisure activities. The effect of having a partner has been shown to have a positive impact (Pachana et al. 2011).

Several other factors influence differences in ADL and IADL levels. Arthritis, a condition known to be more common in women, has been shown to greatly contribute to difficulties in ADL. Higher rates of difficulties with physical functions, personal care, and household care are reported in arthritis patients, especially when other chronic conditions comorbid to arthritis are present (Verbrugge, Lepkowski, and Konkol 1991). Depression is also found to be associated with higher risks of activity limitations. The levels of ADL and IADL are also influenced by the behaviors used to face increasing limitations. Women are more likely to use self-care and home remedies than refer to professional care (Grzywacz et al. 2012). Crimmins and colleagues (2011) have estimated measures of ADL and IADL in the Belgian population in 2004. After adjusting for age, 15.4% of women reported difficulties in at least one of the 6 tasks of the ADL scale while 10.7% of men did so. In IADL, 23% of women reported difficulties in at least one the 7 tasks while only 14.9% of men did so.

The fourth dimension covered by the EQ-5D questionnaire is the pain and discomfort. In the ageing process, pain is often related to arthritis and osteoarthritis, both conditions have a higher prevalence in women than men, and cause pain. Verbrugge (1995) showed gender differences in the prevalence of arthritis as in the levels of disability associated with arthritis. In Belgium, Crimmins and colleagues (2011) used data from 2004 in Belgium to estimate the prevalence of arthritis at 29.2% in women and at 18.5% in men. In 2013 in Belgium, 149 548 QALYs (6.2% of total QALYs lost) were lost due to osteoarthritis and 83 625 (3.4% of total QALYs lost) due to arthritis. Osteoarthritis was the fifth leading cause of disability in high income countries in 2000 with a male to female ratio of 0.64 (Mathers et al. 2003). Not surprisingly, women tend to report more intense and frequent pain (Calvó-Perxas et al. 2016), (Rustøen et al. 2004)as well as a higher prevalence of taking analgesics and using physiotherapy for their pain. A higher percentage of men reported not receiving treatments to manage their pain (Rustøen et al. 2004). The International Association for the Study of Pain's Classification of Chronic Pain counted twice times more pain disorders with higher prevalence in women than pain disorders with similar prevalence in women and men. This includes for example, major depression, fibromyalgia, arthritis/rheumatism, back problems and migraine/headaches. Rustoen et al. (2004) found other factors that may contribute to the gender difference. Unemployed men had higher pain scores while widowed women had higher pain intensity. Different pain locations will also have different effects on women and men.

However, Hairi et al. (2013) state that the relationship between pain and disability is partly mediated by psychological factors and self-rated health. Gender difference in pain-related disability was only found in self-rated measures and no gender difference is found in the association between pain and objective physical disability in older people. This is consistent with extensive research on the link between pain and depression. In Canada, the prevalence of depression in individuals with chronic pain conditions was 11.3%, and the prevalence was 5.3% in individuals without (Munce and Stewart 2007). Numerous studies showed that depression and chronic pain are closely intertwined (Munce and Stewart 2007; Calvó-Perxas et al. 2016; Rustøen et al. 2004; Tsai 2007). In individuals suffering from fibromyalgia, arthritis, back problems and migraine headaches, the prevalence of depression was higher in women than male. Depressed women tend to rate their pain as more severe than depressed men, consistent with indications that the pain of men and women have different characteristics (Munce and Stewart 2007). Indeed, while in men, treated and untreated pain are associated with depression, only treated pain is associated with depression in women. If the treatment of pain is a proxy of its severity, depression in women is more closely associated with the severity of pain while in men, depression is more closely associated with the frequency of pain (Calvó-Perxas et al. 2016). Similar results are found by Munce and Steward (2007). It is reported that women not only take more analgesics but also more anxiolytics and anti-depressants (Calvó-Perxas et al. 2016).

The fifth dimension of the EQ-5D concerns anxiety and depression. In general, the prevalence of depression is higher in women than in men. The gender difference is even higher for anxiety and for anxiety in combination with depression than for depression alone (Simonds and Whiffen 2003). Unipolar depressive disorders were the leading cause of disability in 2000 in high income countries and had a male to female ratio of 0.6 (Mathers et al. 2003). In Belgium in 2004, a prevalence of depression of 33.1% in women and of 17.4% in men was found in individuals aged 50 years and over (Crimmins, Kim, and Solé-Auró 2011). In 2013 in Belgium, 207 703 QALYs (8.6% of total QALY lost) were lost for depressive disorders and 148 434 QALYs (6.1% of total QALY lost) were lost for anxiety disorders. The difference already emerges in adolescence. More girls start to present symptoms early in adolescence while boys will experience an acceleration in symptoms later. The discrepancy that is caused by an earlier and faster rate of increase for girls will produce inequalities in rates in adulthood. At age 20, there are no differences in intensity since depressed boys and depressed girls will have spent a similar number of days clinically depressed. (Salk et al. 2016; Simonds and Whiffen 2003). The gender disparities in depression for adolescents have been explained through the *ABC* model. There are affective, biological and cognitive factors that confer vulnerabilities to depression. These factors when in interaction with negative life events or stress increase girls' rates of depression in early adolescence leading to the gender difference in depression (Hyde, Mezulis, and Abramson 2008). Later on, women report more episodes of major depressive disorders and have longer episodes. Symptoms are also reported to be different in women and men with, for example, more somatic symptoms such as more appetite and weight changes in women. Bebbington et al. (2003) reported that this higher prevalence of anxiety and depression in women is only significant before 55 years. After that, the prevalence of depression in women fell while in men it stayed stable, consequently differences between women and men disappeared. The hypothesis is that since depression increased with puberty in women, a decrease after menopause is consistent. However, Cairney and Wade (2002) using data on Canada do not find convergence in the gender gap in depression after 55 years.

Factors explaining the difference in depression prevalence in women and men have been investigated. Besides biological and psychological risks factors, differences in social roles and positions in private as in social life have been recognized to put a different burden on individuals. The higher exposure to violence that women are victims of and the increasing risks of depression linked to violence could be a likely factor for higher depression. Adjusting for violence exposure especially for sexual assault and rape attenuated the association between gender and depression (Dunn et al. 2012). Other significant factors of the relation between gender and depression have been found. Being married or having a partner is associated with lower risk of depression in both women and men. However, being single or a widow is a more significant risk factor for men than women. A good socioeconomic condition has also been related to a lower risk of depression (Van de Velde, Bracke, and Levecque 2010).

Similarly, the prevalence of depression decreased for women and men after adjusting for sociodemographic factors (Cairney and Wade 2002).

To sum up, when the reporting of problems is comparable in women and men, the life expectancy without problems will have a higher gap in favor of women since only the difference in mortality rates will be playing a role. When women will report more problems, the gap in life expectancy without problems will decrease and, if the higher reporting of women is substantial, the gap could grow in favor of men. The prevalence of mobility problems is expected to increase with age and the rate of increase is expected to be faster in women. The size of the gap depend on the life expectancy without mobility problems combining mortality data and the expected prevalence of mobility problems and their levels at each age for women and men. Since the prevalence of mobility problems is expected to be higher in women but not with a huge difference, we can expect a low gender difference in life expectancy without mobility problems. The prevalence of problems with self-care and usual activity is expected to be low at younger ages and to increase with age, especially at the oldest ages after 85 years. Women are expected to have fewer years due to certain conditions such as osteoarthritis, back and neck disorders, which have been pointed out as high contributors to the Quality Adjusted Life Years (QALY) loss in Belgium. The life expectancy without self-care and usual activities problems is expected to have a higher gap in favor of women at younger ages because of a low prevalence of reporting problems by both genders. Then, at older age, the gap is expected to decrease because of higher reporting of problems from women. The prevalence of problems reported on pain and discomfort is expected to be higher for women at every age and to increase with age. Pain has been related to chronic diseases particularly prevalent in women. Since reported pain and discomfort are expected to be largely more prevalent in women, the life expectancy without pain and discomfort is expected to have a low gap or a gap in favor of men. Then, with the increase in men's mortality rates and the increase in reporting for both men and women, the gap is expected to decrease. The prevalence of reporting problems in anxiety and depression is expected to be higher for women at every age despite possible reduced disparities after 55 years. Since the difference in prevalence is expected to be high, the life expectancy without problems in anxiety and depression is also expected to have a low gap or a gap in favor of men. Then, this gap is expected to decrease due to higher mortality of men.

The quality-adjusted life expectancy is expected to tend to a low gender gap in favor of women at all ages, especially at the oldest age compared to the life expectancy. However, it is expected that a gap persists due to higher men's mortality at younger ages and higher women's morbidity especially due to pain/discomfort and anxiety/depression. Since the higher male mortality and the higher female morbidity will interact to reduce the gender gap in quality-adjusted life expectancy, finding a way to investigate the two effects separately is needed. Nusselder et al. (2004) suggested to decompose the gap into a mortality effect and a morbidity effect. It would allow us to understand the roles played by the mortality and by the morbidity in the gender gap.

3 DATA AND METHODS

3.1 DATA

As previously stated, in order to calculate health expectancy, two types of data are needed. First, we will use prevalence data concerning the definition of health used, the Health-Related Quality of Life (HRQoL), and then analyze data on mortality.

3.1.1 Data on Health-Related Quality of Life (HRQoL)

The calculation of the Quality-Adjusted Life Expectancy (QALE) requires data on the Health-Related Quality of Life (HRQoL). These data have been collected by the EQ-5D tool in the Belgian Health Interview Survey (BHIS) in 2013. Understanding the organization and the specific design of the survey is important for analyzing the results and their limitations. In the last sub-section, the specific tool used to assess the HRQoL is presented, as well as primary results.

3.1.1.1 Belgian Health Interview Survey

The main objective of the Belgian health interview survey was to provide an overview of the health of the Belgian population. It examined the main health problems and their determinants, the health-related attitudes and behaviors, the use of healthcare facilities and preventive health and social services. Having a survey that focuses only on health issues allows for the deeper investigation of health-related topics without being in competition with other modules. I discuss further information about the development of the survey, the advantages of it, the sampling frame, the survey design and questionnaires.

In the nineties, the lack of quality health data in Belgium led to the development of a new tool capable of gathering new information necessary for decision makers designing public health programs and policies. The health interview survey was created and investigated five areas: health status, health determinants, medical prevention, health consumption and health and society. In the health status section, the focus is on chronic diseases. This question is important due to long duration and the high burden of these conditions on health expenditures. The survey is also essential to complete routine statistics and be able to assess the health status of the population as recommended by WHO.

Using the survey method has several advantages. First, it allows gathering several types of data simultaneously for the same individuals and based on a representative sample of the population. Second, since the data are collected periodically over time, changes in health status and the effects of health policies and interventions can be assessed. The rich database created, can then be used by the authorities, scientists and also international instances to inform and influence health programs. The survey is realized by Sciensano (former ISP-WIV), a scientific institute commissioned by the different Belgian authorities. The authorities in charge and co-financing include the Federal Government, the Flemish Community and Region, the Walloon Region, the French Community, the German Community and Brussels' Capital Region.

The sampling frame consisted of all households listed in the National Register. The survey is presumed to assess the health of the population in Belgium, which means ‘'all people residing in Belgium, regardless of their place of birth, nationality or any other characteristic". However, individuals without an address, living in a prison, in a religious community with more than 8 persons and in an institution (except elderly living in old people's homes and nursing homes) have been excluded from the survey. Elderly living in a collective household have been considered as a one-person household. Individuals not listed in the National Register, such as homeless, illegal immigrants or newly created households not yet included in the Register were also not included in the sampling frame. In the BHIS 2013, the basic sampling size was 10 000 respondents (3 500 in Flanders, 3 500 in Wallonia, 3 000 in Brussels). However, this sample size is too small for analysis at the provincial level. Therefore, provinces are entitled to ask for an oversampling if they finance this extra sample. In the BHIS 2013, only the Luxemburg province asked for over-sampling (600), thus the official sample size was 10 600.

The design chosen for the survey was a stratified clustered multi-stage design. First, a regional stratification between the 3 regions was completed. Then, a stratification at the level of the provinces was performed. The sample size was proportional to the population size of the province, except for provinces financing an oversampling. Another special case is the province of Liege which was split into 2 strata, the German community with a predetermined sample size (300) and the rest of the province. Then, in each stratum, we had 3 stages. The primary sampling units selected municipalities.

Within the latter, the secondary sampling units selected 50 individuals. For the tertiary sampling units, a maximum of 4 individuals was selected in each household. Moreover, to ensure that the sample remains representative over time, the interviews in the survey year were split into four quarters and the sampling procedure for each quarter was accomplished one month before data collection. At the end of the year, 10 829 individuals have been interviewed, in which 3 512 were interviewed in Flanders, 3 103 in Brussels region and 4 214 in Wallonia. Overall, more than 200 interviewers were involved in establishing contact with the households and conducting interviews.

The BHIS survey is not a mandatory survey, selected households can refuse to participate. In that case, or if there is an impossibility to conduct the survey, non-participant households are replaced with a predefined household by a substitution process. In BHIS 2013, 43% of the selected households refused to participate in the survey and were substituted. This high rate of refusal could potentially introduce biases in our results, since households refusing to take part in the survey could be negatively selected based on health characteristics.

The survey was based on two questionnaires. The first one, the face-to-face questionnaire was administered by the interviewers assisted by a computer to all the selected persons in the household. The information given by the national register about gender was verified in this step, people could only be women or men, no additional categories were possible. The second one, the self-administered questionnaire was printed and completed by all respondents aged 15 years or older. It allows for more reliable answers to sensitive questions such as mental health and alcohol consumption. The EQ-5D tool was included in this questionnaire. The face-to-face questionnaire could be answered by a proxy but the self-administered questionnaire, including the EQ-5D tool, not. A proxy interview is used for respondents under 15 years. Some modules are only asked to the reference person of the household since they concern characteristics of the household (Demarest et al. 2013).

3.1.1.2 EQ-5D and population norms

The EuroQol Group is a network of international multidisciplinary researchers created in 1987 and working on the measurement of health status. It includes researchers from all over the world and its main achievement is the development of the EQ-5D. The EQ-5D is a preference based standardized measure of health status. It has become one of the most popular tools to measure Health-Related Quality of Life (HRQoL) in a survey because of its simplicity, but it is also widely used in clinical trials and for economic evaluations. It provides a descriptive profile of the health state (the scores on each dimension) and an index value (a summary score) for health status (The EuroQol Group 1990).

The first version, the EQ-5D-3L, was created in 1990. This version consisted of two parts, the EQ-5D descriptive system and the EQ visual analog scale (EQ-VAS). The EQ-5D descriptive system covered 5 dimensions: mobility, self-care, usual activities, pain/discomfort, anxiety/depression. Each dimension had 3 levels: no problems, some problems, extreme problems. Thus, this system produced 243 different health states. For the EQ-VAS, the respondents had to rate their health on a vertical scale from best imaginable health state to worst imaginable health state (Reenen and Janssen 2015).

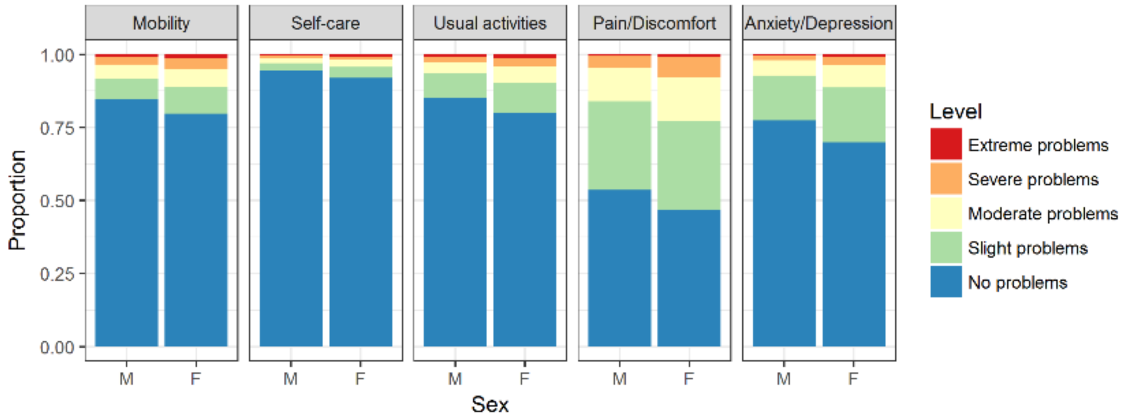
The second version, the EQ-5D-5L, was introduced to address some critiques of the first version, such as ceiling effects that is the high proportion of “no problems” answers. There are still 5 dimensions, but each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. In total, 3125 different health states are possible, based on all the possible combinations of answers, versus the 243 different health states in the previous version. Some wording of the previous version has also been improved. The complete questionnaire can be found in the Annexe 1. The health states are expressed by a 5-digit number consisting of the 5 dimensions. The numbers represent the levels in each dimension, so level 1 indicates no problems while level 5 indicates extreme problems. Thus, each unique health state is the combination of 1 level/number from each of the 5 dimensions. For example, 11111 indicate no problems on the five dimensions while 55555 indicate extreme problems on the five dimensions (Reenen and Janssen 2015).

The 3125 different health statuses obtained from the descriptive system of the EQ-5D-5L can be converted into a single index value to facilitate further analysis. The index value is the most interesting characteristic of the tool, making it possible to calculate Quality-Adjusted Life Years (QALYs) and Quality-Adjusted Life Expectancy (QALE). In order to transform the health states in a single index score, country-specific value sets are needed. The value sets are derived from a study, conducted at the country level, that elicit preferences from the general population for different health states. Thus, it allows us to know the preference of a specific population for health states and makes it possible to convert the 3125 health states in a single index (Reenen and Janssen 2015). Studies to generate the value sets for the EQ-5D-3L have been conducted in Belgium as in other countries. Cleemput (2009) in her study, calculated preference valuation set for EQ-5D-3L health states from the general Flemish population in Belgium. This value set is the one currently used for the general population in Belgium. However, even if this is used among those working with EQ-5D in Belgium, it presents several limitations. First, the study was done in the Dutch-speaking region of Belgium only. Second, the response rates were extremely low (35%) and a significant part of respondents had to be excluded of the study, meaning that only 20% of the initial sample was kept (Cleemput 2010). It is therefore likely that selection biases plague this value set.

Since studies developing national preference valuation sets for the EQ-5D-5L are still in process, bypass from EQ-5D-3L value sets to EQ-5D-5L had to be set in the meantime. The EQ-5D-5L Crosswalk Project was charged with the development of a function to link the two descriptive systems. This crosswalk function used the existing value sets for the EQ-5D-3L to calculate index values for the EQ-5D-5L. This function and the methodology used can be found in Van Hout et al. (2012).

The EQ-5D-5L was introduced for the first time in 2013 in the Belgian Health Interview Survey. An overview of the answers given by the respondents to the EQ-5D-5L questions in BHIS 2013 is presented in Figure 6. The most prevalent dimension is the pain/discomfort with more than half of the respondents reporting problems (50%), followed by problems of anxiety/depression (26%), mobility (18%), usual activities (18%) and self-care (7%). Women always reported more problems than men. This is particularly striking for the anxiety/depression (30% vs 22%) and the pain/discomfort (53% vs 46%).

Figure 6 *The survey-weighted probability of reporting problems on the five EQ-5D dimensions, by sex, for the Belgian population aged 15 years and older, 2013 (Devleesschauwer et al. in preparation)*

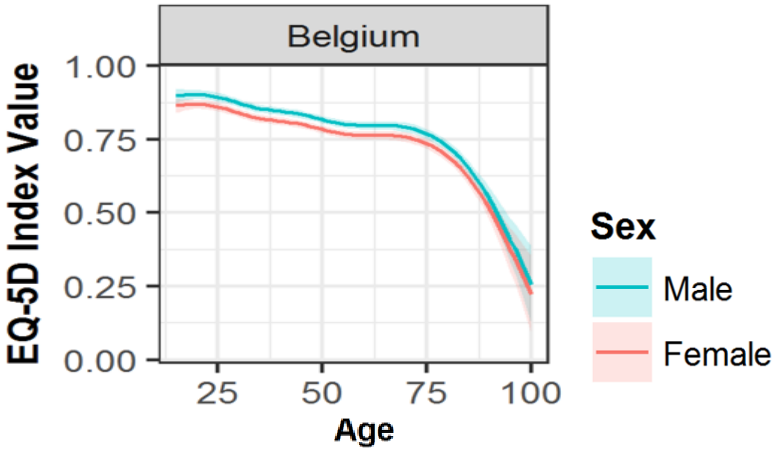


The answers of 6061 respondents at the five questions of the tool needed to be converted in three steps to permit the calculation of the quality-adjusted life expectancy and the life expectancy without problems on the dimensions. The first step is to compute for each health states (e.g. 11111, 23423, 55545), an index value, or HRQoL score which summarizes in one number the health state, based on the population preference value set. In Belgium, thanks to the population preferences for different health states calculated (Cleemput 2010) and the crosswalk function developed to adjust for the 5 levels (Van Hout et al. 2012), an index value for each health states has been calculated. These index values range from -0.518 to 1 (perfect health state). Each individual gets an index value corresponding to her health state. The second step is to calculate populations norms, which are the average index values by age and sex for the Belgian population. These calculations have been realized previously by Devleesschauwer et al. (in preparation). The population norms are needed to evaluate a loss due to a specific disease and to monitor population health with measures as the QALE.

The average Health-Related Quality of Life (HRQoL) values by age and sex are presented in Figure 7, with 1 indicating a perfect HRQoL while 0 indicates the worst HRQoL. The average index value for the Belgian population aged 15 years and older was 0.8, and men had a higher value (0.82) than women (0.78). At the age of 15, men have an index value of 0.9 while women have an index value of 0.87. That means that women aged 15 spent on average 87% of the year separating their 15th and their 16th

birthday living in good HRQoL. The gender gap is constant at 0.03 throughout the lifetime with men having higher index value. A sharp decrease in the index value is observed after 75 years. At age 100, about 25% of the time is spent in a state of good HRQoL.

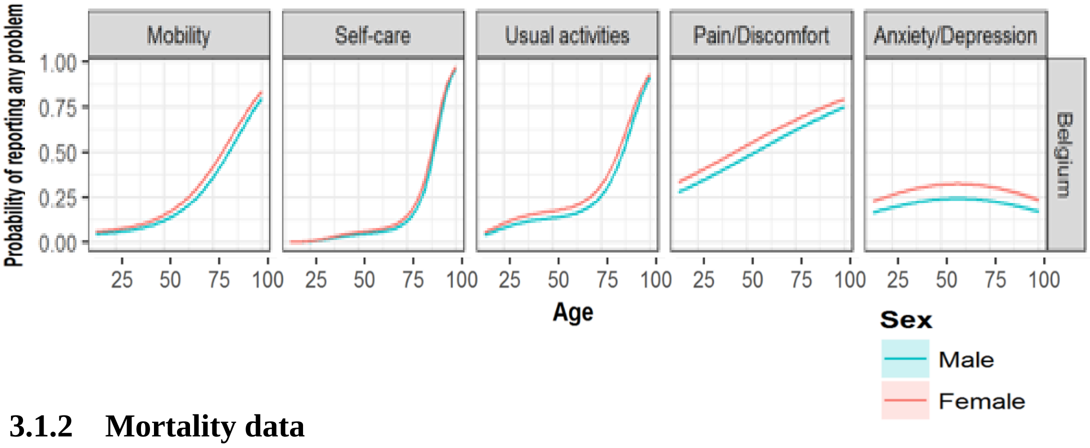
Figure 7 EQ-5D-5L index value population norms by age and sex for the Belgian population aged 15 years and older, 2013 (Devleesschauwer et al. in preparation)



While the second step enables the calculation of the quality-adjusted life expectancy, the third step enables the calculation of the life expectancy without problems on mobility, on self-care, on usual activities, on pain/discomfort and on anxiety/depression. The population norms or mean index values by age and sex for individuals reporting no problems on mobility, on self-care, on usual activities, on pain/discomfort and on anxiety/depression were computed.

The average probability by age and sex or population norms to report any problem are presented in Figure 8. As already seen before, women have a higher probability of reporting problems in all dimensions. While the dimension self-care gap is tiny, the gender difference is the most important for dimensions related to pain/discomfort and anxiety/depression. Dimensions related to self-care and usual activities show similar patterns with a sharp increase in reporting problems after the age of 75. The mobility dimension presents a moderate increase, but the increase starts earlier after 45 years. The pain/discomfort dimension shows a high prevalence and a steady increase throughout the lifetime. The anxiety/depression dimension has a non-monotonic relation with age, with a maximum observed between the ages of 50-70.

Figure 8 Population norms for the probability of reporting any problem per EQ-5D dimension, by age and sex, for the Belgian population aged 15 years and older, 2013 (Devleesschauwer et al. in preparation)



3.1.2 Mortality data

The second type of data needed in order to calculate the health expectancy is classic life tables. Life tables of Statistics Belgium for the year 2013 by sex were used in this study (Statbel 2016). It has been decided to start the life table at age 15 and to close it at age 100.

3.2 CALCULATION

3.2.1 Sullivan method of life table calculation

The health expectancies are calculated using a method developed by Sullivan in 1971 (Sullivan 1971). The health expectancy calculated by Sullivan is the number of remaining years, at a particular age, which an individual can expect to live in a healthy state (Jagger, Van Oyen, and Robine 2014). The method is widely used today in health expectancy calculation due to its simplicity. Indeed, the data needed are readily available in most of high-income countries. First, we need the age-specific prevalence of the population in healthy or unhealthy states, depending on the definition given to health. These data are often obtained from cross-sectional surveys. Then, we need period life table (complete or abridged) and in particular age-specific mortality rates (Jagger, Van Oyen, and Robine 2014).

Practically, the number of life-years lived in successive age intervals by a hypothetic cohort who would experience the age-specific mortality rate of today (L_x) is multiplied by the age-specific proportion in healthy states (i). This results in the number of person-years lived in good health in the age interval ($_nL_{xi}$). Then, values for T_{xi} and e_{xi} are obtained as in a classic life table. The e_{xi} column gives the health expectancy i.e., the number of years in good health an individual would experience if the current age-specific rates of mortality and disability do not change (Sullivan 1971). In other words, the Sullivan method deflates the number of person-years ($_nL_{xi}$) according to health states, and then proceeds to summing those person-years and generates the life expectancy as in the standard life table.

The method developed by Sullivan presents several advantages. First, it is applicable to all definitions of health expectancies. Second, because of the use of the life table, the health expectancies are independent of the age structure of the population and adjusted for mortality levels. Finally, as indicated earlier, it is a simple method using data that are easily available and easy to interpret.

In this research, the Sullivan life table is started at age 15 and closed at age 100. This is because data on quality of life cannot be assessed for children and due to the long survival of the Belgian population, pursuing the table until 100 years allows to better understand the high number of individuals surviving longer. To apply the method, the index value population norms calculated thanks to the EQ-5D tool in the BHIS 2013 are multiplied by the age-specific mortality rate (L_x) of the life tables developed by Statistics Belgium. This generates estimates of the Quality-Adjusted Life Expectancy (QALE) for women and men in the Belgian population. Further, standard errors are calculated based on the method developed by the EURO-Reves team (Jagger, Van Oyen, and Robine 2014). In a second step, we proceed to the same calculation, but with the population norms for each dimension, again with the Sullivan method. This second step is needed to generate estimates of life expectancy free of problems on the 5 dimensions providing insights on the importance of each dimension taken separately.

3.2.2 Decomposition

In the previous section, we explained how the health expectancy was obtained by the Sullivan method. This health expectancy, the quality-adjusted life expectancy, was the basis of our decomposition, which is a second step of our analysis. The decomposition method used in this second step has been developed by Nusselder and Looman (2004). The Arriaga method, used to decompose the life expectancy into specific diseases or age groups, is modified to decompose the difference in health expectancy calculated by the Sullivan method into (1) a mortality effect and (2) a disability effect. In the Arriaga method, the changes in life expectancy are the result of the increase or decrease in the mortality rate only, whereas in the decomposition of health expectancy, the changes will result from changes in the mortality and/or in the proportion disabled. Changes are formed of two components (Equation 1). First, the *mortality effect* (${}_iMOR_x$) is the change in the number of person-years with disability due to the change in mortality rates. Second, the *disability effect* (${}_iDIS_x$) is the change in the number of person-years with disability due to a change in the proportion disabled. The total of both effects corresponds to the change between two health expectancies (Nusselder and Looman 2004).

Equation 1 *Formulas of the decomposition method developed by Nusselder and Looman (2004)*

$$ {}_iMOR_x = \left[\frac{{}_i\pi_{x(t)} + {}_i\pi_{x(t+n)}}{2} \right] \cdot \Delta_i L_x $$

and

$$ {}_iDIS_x = \left[\frac{{}_iL_{x(t)} + {}_iL_{x(t+n)}}{2} \right] \cdot \Delta_i \pi_x . $$

In this research, the decomposition method is used to assess the difference in the Quality-Adjusted Life Expectancy (QALE) for women and men. At different ages, the differences between the QALE of women and the QALE of men is decomposed. The morbidity or disability effect refers here to the reporting of problems on different levels in the dimensions of the EQ-5D tool.

The calculation was performed using Excel and R. A R function have been developed to compute health expectancies with the Sullivan method and to decompose it into a mortality effect and a disability effect with the method of Nusselder and Looman. A R package will be created.

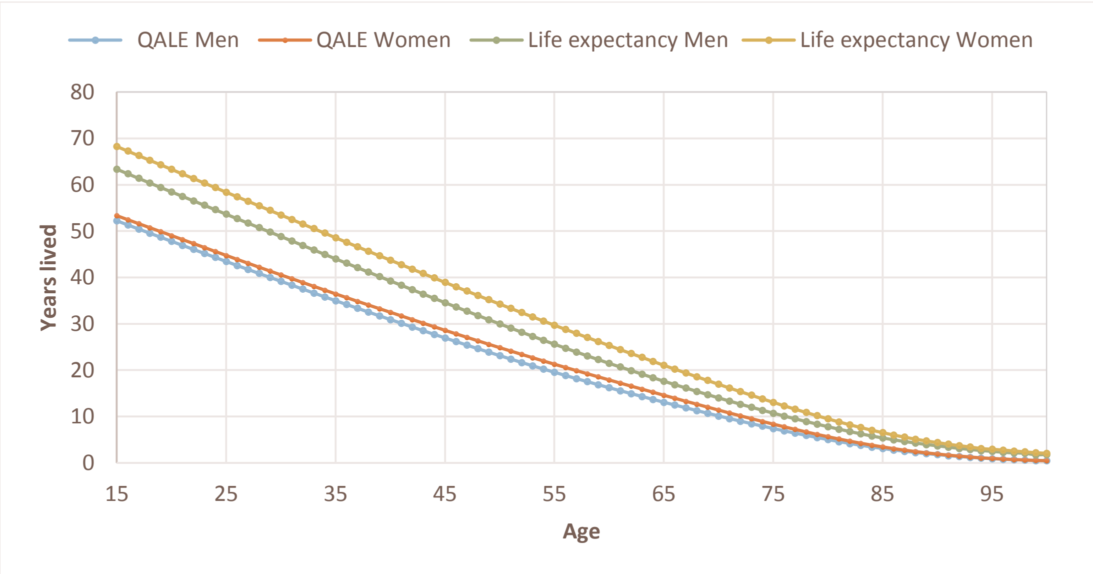
4 RESULTS

This section is organized as follows. Firstly, I report on the value of the Quality-Adjusted Life Expectancy (QALE) obtained for each sex, discuss the gap between genders and then decompose this gap by age. Secondly, the values for the life expectancies adjusted for the 5 dimensions of the EQ-5D and the gender differences associated with these are presented.

4.1 QUALITY-ADJUSTED LIFE EXPECTANCY

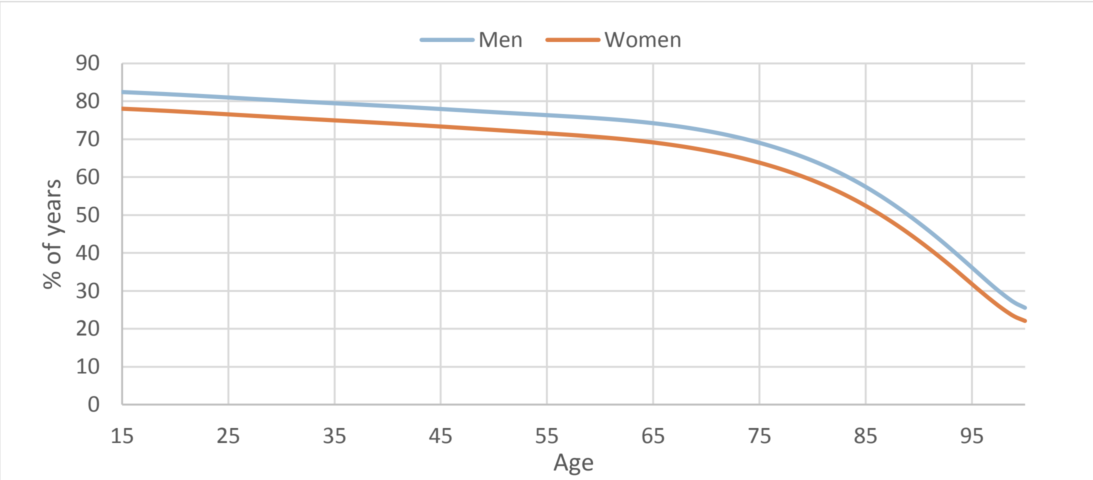
In 2013, based on estimates from Statistics Belgium, the life expectancy at age 15 was of 68.5 years for women and of 63.5 years for men (Figure 9). Hence, the gender difference in life expectancy at age 15 was around 5 years. As expected, this gap between men and women narrowed when adjusting life expectancy for quality. The Quality-Adjusted Life Expectancy (QALE) at age 15 was 53.3 years for women and 52.3 years for men. So, women lose 15.2 years of life expectancy when adjusting for the health-related quality of life while men lose only 11.2 years. The gender difference in QALE is estimated at 1.1 years at age 15 and reaches its maximum of 1.7 years at 54 years. At the oldest ages, the differences in life expectancy and in quality-adjusted life expectancy narrowed and nearly disappeared.

Figure 9 Life expectancy and quality-adjusted life expectancy by gender, Belgium, 2013



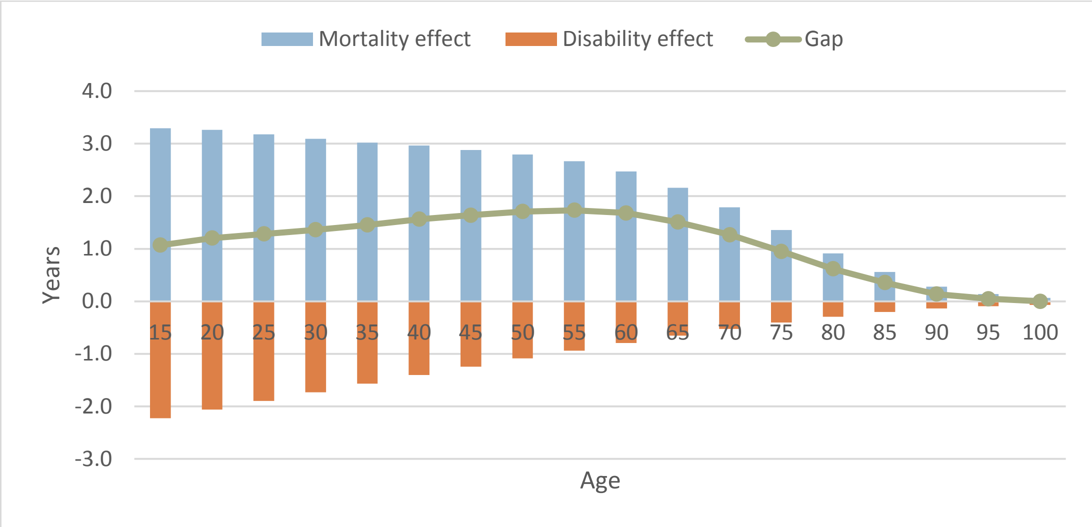
The ratio of the QALE to the total life expectancy is a relative measure useful to compare values and differences across genders. This ratio decreases with age. At age 15, since the life expectancy of women was of 68.5 years and the QALE was of 53.3 years, 78% of their remaining years will be spent without reporting any problems on the 5 dimensions of the EQ-5D while this proportion declines to 22% at age 100 (Figure 10). For men at age 15, 82% of the remaining years are expected without reporting problems, it drops to 25% at age 100. Thus, women have a higher number of years remaining to live in good quality while men spend a higher proportion of their remaining years to live in good quality.

Figure 10 *Ratio QALE to Life expectancy, Belgium, 2013*



The gender difference in the Quality-Adjusted Life Expectancy (QALE) can be explained by a mortality effect and a disability effect. At the age of 15, the gap of 1.07 years is explained by a mortality bonus of 3.3 years for women and a disability advantage of 2.2 years for men, resulting in a gain in women (Figure 11). Then, when the gap widened, the relative part explained by the mortality is increasing. At the end of life, the gap tended to 0 and is increasingly explained by more disability in women. Over all ages, the gap is explained by an advantage in mortality for women and an advantage in disability for men, consistent with our hypotheses and the literature review.

Figure 11 Decomposition of difference in quality-adjusted life expectancy for women and men, Belgium, 2013



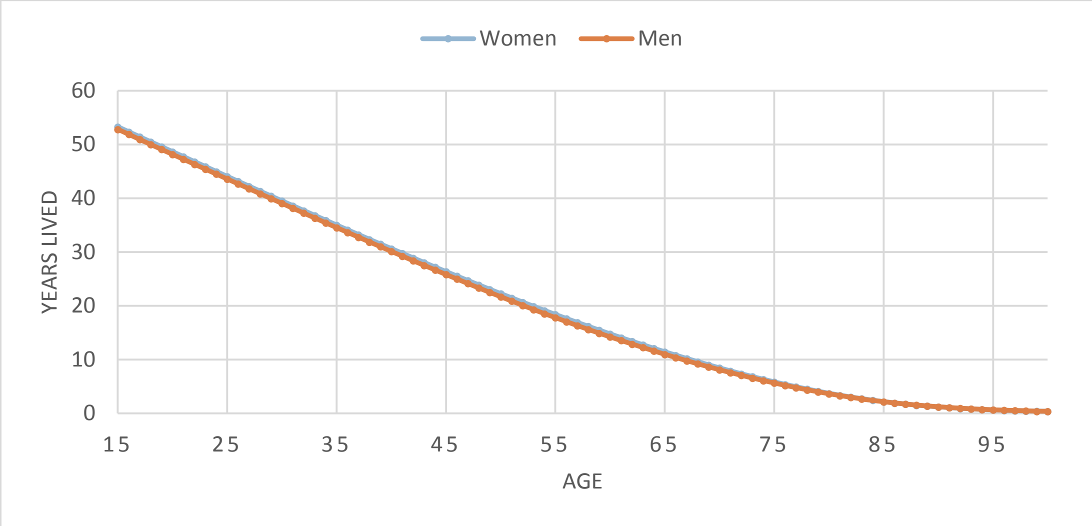
4.2 Dimensions of the EQ-5D

Life expectancies adjusted for problems on mobility, on self-care, on usual activities, on pain/discomfort and on anxiety/depression are presented here.

4.2.1 Mobility

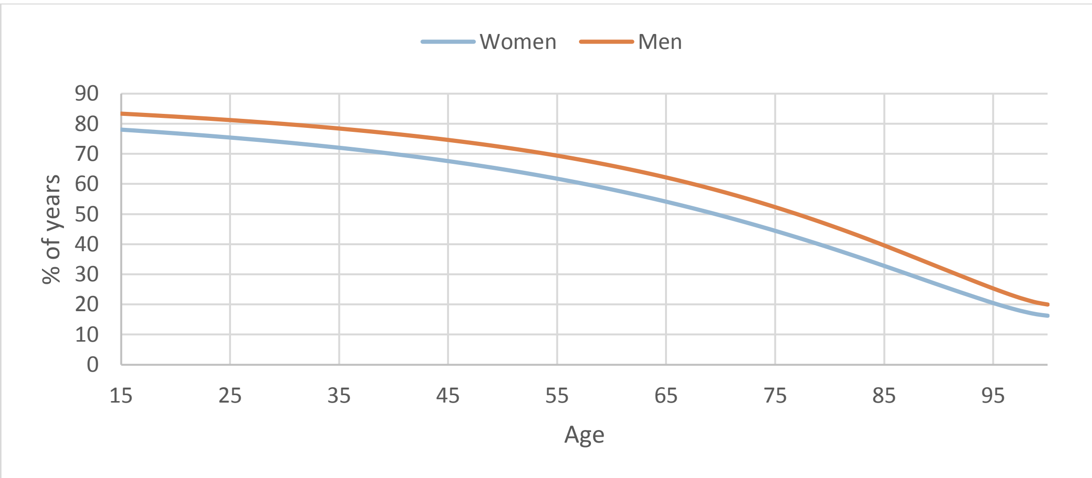
The life expectancy free of mobility problems at 15 years is equal to the QALE for women (53.3 years) and is slightly higher than the QALE for men (52.8 >< 52.3 years) (Figure 12). At the age of 15 years, mobility problems are a good predictor of health-related quality of life. At age 65, women could expect 11.4 years without mobility problems while men could expect to live 11 additional years. Hence, women and men could expect to live a similar number of years free of mobility problems. As expected and in accordance with the literature review, the gender gap is tiny and nearly disappears at the oldest age.

Figure 12 Life expectancy without mobility problems, Belgium, 2013



The ratio of the life expectancy without mobility problems to the remaining overall life expectancy, as illustrated in Figure 13, shows similar trends in both sexes, but a larger fraction of time spent without mobility problems among men. Women at age 15 were expected to spend 78% of their remaining years without mobility problems, and at age 65, only 54% of their life expectancy remained free of mobility problems (Figure 13). Men at age 15 could expect to live 83.3% of their remaining years free of mobility problems while at age 65, they could still expect 62.2% of their years free of mobility problems.

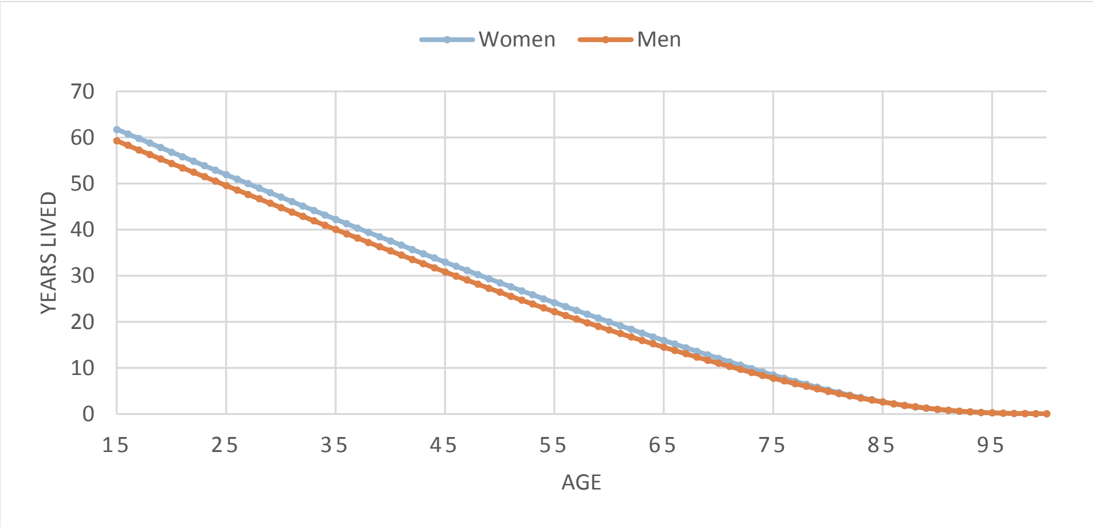
Figure 13 Ratio life expectancy without mobility problems to life expectancy, Belgium, 2013



4.2.2 Self-care

At age 15, women were expected to live 61.8 years without self-care problems while men were expected to live 59.3 additional years (Figure 14). These observed values are higher than the quality-adjusted life expectancy. At age 65, women were expected to live 16 years without self-care problems while men were expected to live 14.5 additional years. Within the 5 dimensions studied, the self-care dimension had the higher number of remaining years at 65 years since the problems on the self-care dimension are compressed at the oldest ages. This dimension also presents the highest disparity between genders at the age of 15 and at the age of 65. The gap is estimated at 2.5 years at age 15 and 1.5 years at age 65 and will decrease as the population gets older to approximately 0 from 86 years onwards, consistent with our expectations and the literature review.

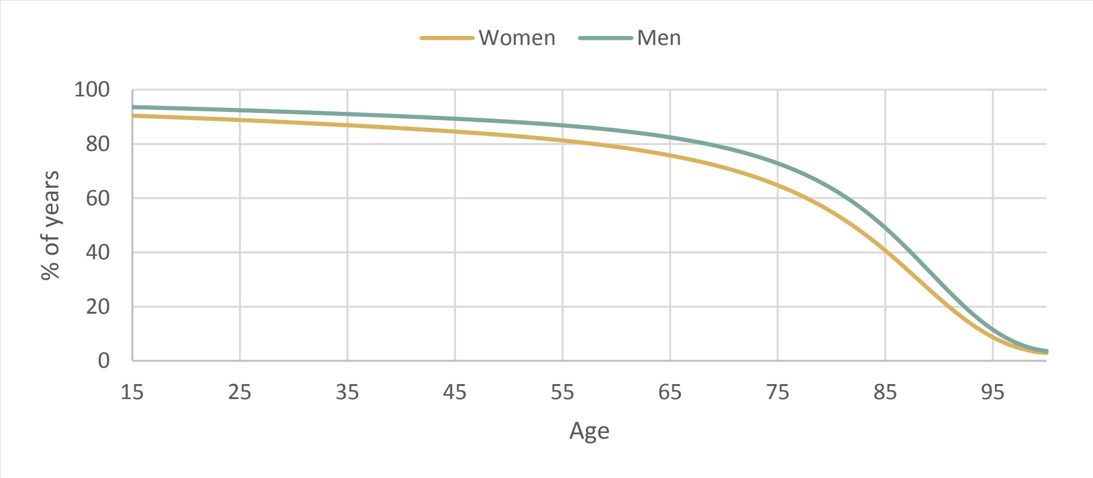
Figure 14 *Life expectancy without self-care problems, Belgium, 2013*



Again, comparing the remaining total life expectancy to the life expectancy without self-care problems reveals interesting patterns. Women at 15 were expected to spend 90.5% of their remaining years without self-care problems, and at 65, 75.8% of their remaining life expectancy was still free of self-care problems (Figure 15). Men at age 15 could expect to live 93.6% of their remaining years free of self-care problems while at age 65, they could still expect to spend 82.4% of their remaining years free of self-care problems. Thus, as seen before, the onset of self-care problems is delayed until older age, where we observed a sharp increase in the time spent with problems after

75 years. At 100 years, the life expectancy is nearly in totality spent with self-care problems.

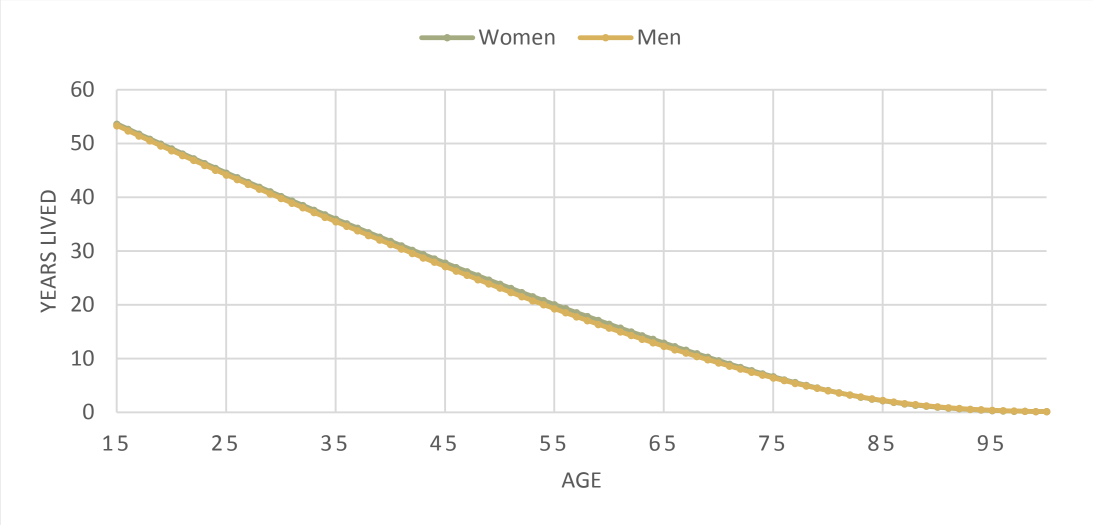
Figure 15 *Ratio life expectancy without self-care problems to life expectancy, Belgium, 2013*



4.2.3 Usual activities

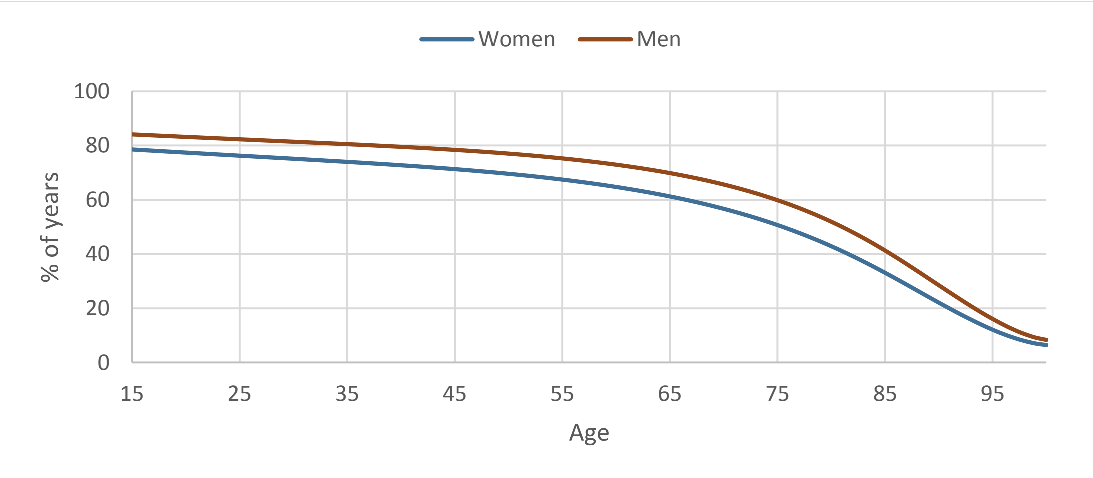
The values of the life expectancy free of problems in usual activities are similar to the values of the QALE. They are estimated at 53.6 years for women and 53.3 years for men at age 15 and therefore present a reduced gender gap (Figure 16). At the age of 65, women and men could respectively expect 12.9 years and 12.3 years. Thus, women and men could expect to live a similar amount of time without problems in self-care. This is not fully consistent with our expectations of a higher gap in favor of women at younger ages. Younger individuals, in particular women but also men, already reported problems with usual activities before 50 years. Accordingly, a gender gap in reporting is well present and produces a low gender gap in the life expectancy without problems in usual activities.

Figure 16 Life expectancy without problems in usual activities, Belgium, 2013



The ratio of the life expectancy without problems in usual activities to the total life expectancy showed that women at age 15 were expected to spend 78.5% of their remaining years without problems in usual activities, and at the age of 65, 61.2% of their life expectancy would remain free of problems (Figure 17). Men at the age of 15 could expect to live 84.1% of their remaining years free of problems in usual activities while at the age of 65, this percentage had declined to 69.9%. Most of the remaining life expectancy at the age of 100 will be spent with problems in usual activities.

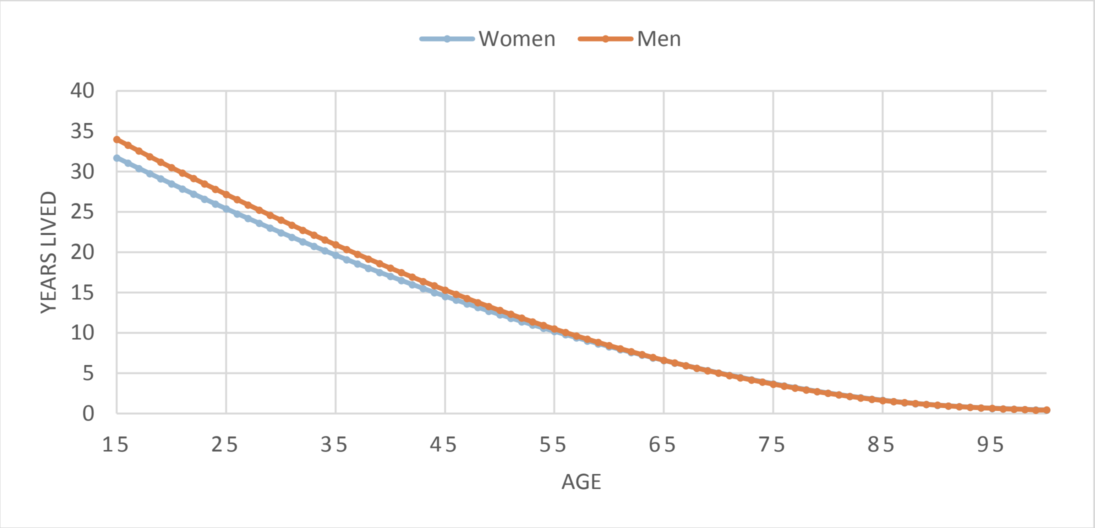
Figure 17 Ratio life expectancy without problems in usual activities to life expectancy, Belgium, 2013



4.2.4 Pain and discomfort

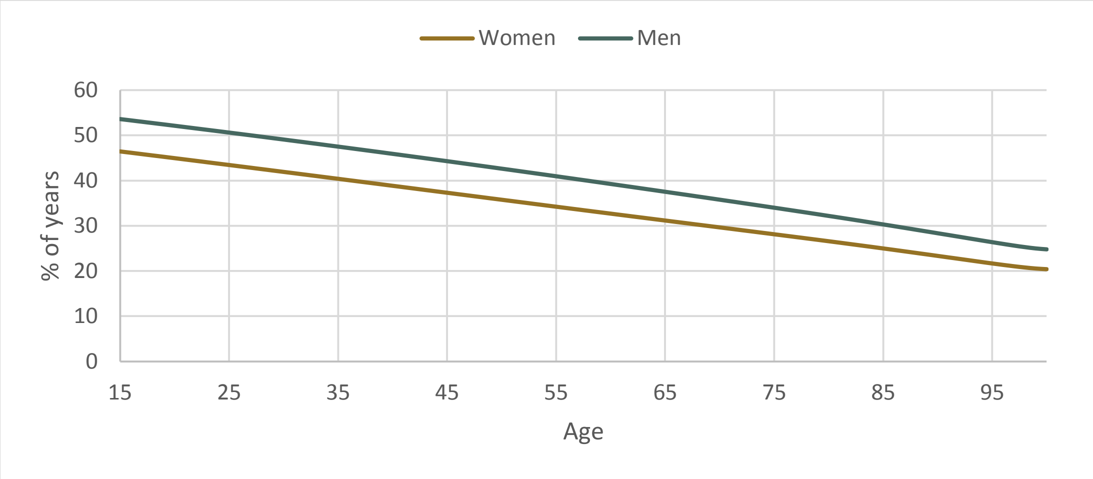
Women at the age of 15 were expected to live 31.7 additional years without any reported pain or discomfort and only 6.6 years at the age of 65 (Figure 18). On the other side, men at the age of 15 were expected to live 34 years without any reported pain or discomfort and only 6.6 additional years at age 65. Contrary to the total life expectancy, to the QALE and the three previous dimensions, men have a higher life expectancy without pain or discomfort problems. Values at 65 years are already considerably low. These facts are consistent with our expectations and caused by a level of reporting substantially higher in women and already at younger ages.

Figure 18 *Life expectancy without problems in pain and discomfort, Belgium, 2013*



The low absolute values of the life expectancy without problems in pain and discomfort predict a small portion of the remaining total life expectancy without problems. Women at age 15 were expected to spend 46.4% of their remaining years without problems in pain or discomfort, and at age 65, 31.1% of their life expectancy would remain free of problems (Figure 19). Men at age 15 could expect to live 53.6% of their remaining years free of problems in pain or discomfort while at age 65 they could still expect to live 37.5% of their years free of problems. However, contrary to previous dimensions, individuals at the age of 100 years could still enjoy more than 20% of their remaining years free of problems in pain and discomfort. Thus, the life expectancy without problems in pain and discomfort is low but declines slowly with age.

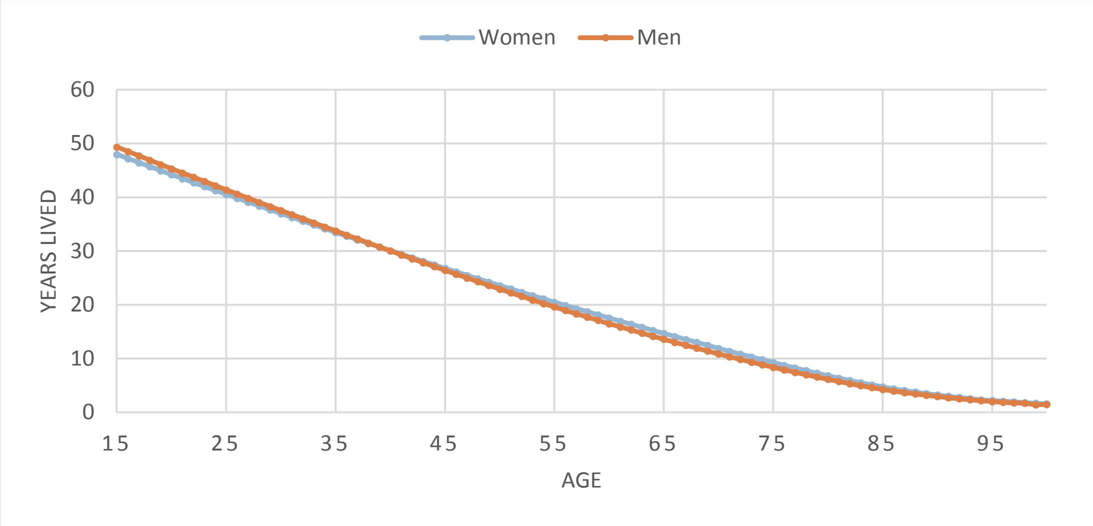
Figure 19 Ratio life expectancy without problems in pain and discomfort to life expectancy, Belgium, 2013



4.2.5 Anxiety and depression

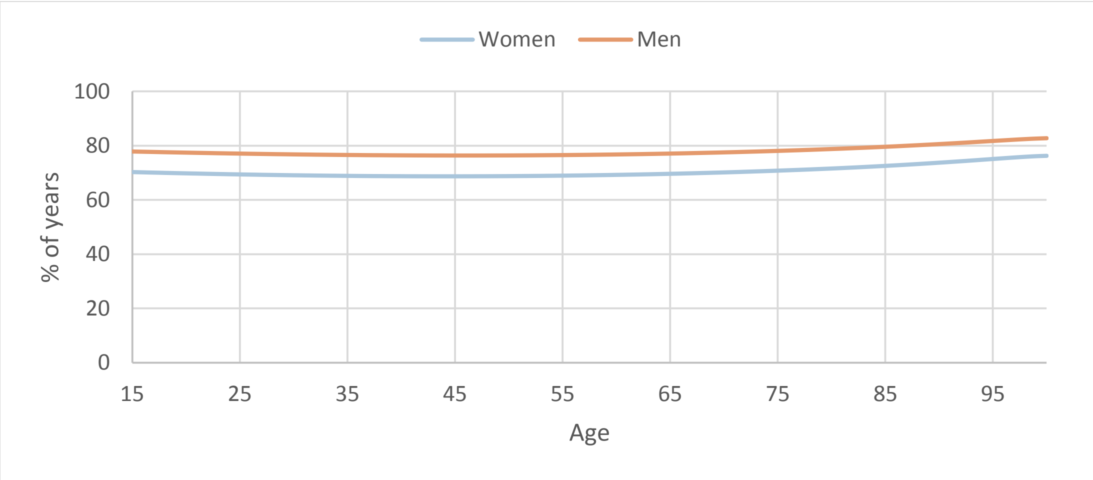
As in the previous dimension, at younger ages, men have more expected years without problems in anxiety and depression than women (+1.3 years) (Figure 20). Women at age 15 could expect to live 48 years without anxiety or depression while men could expect 49.3 years. These values lie below the quality-adjusted life expectancy. However, this advantage of men will reduce and reverse at the age of 40. Then, the gap will increase again but it is now in favor of women until around 65 years (+1.1 years), afterwards the trend will converge. At the age of 65, women could expect to spend 14.7 years free of anxiety and depression while men could expect 13.6 years. The life expectancy without anxiety and depression is the second highest expectancies at age 65 in our five dimensions. These results meet our expectations.

Figure 20 Life expectancy without problems in anxiety and depression, Belgium, 2013



The pattern observed in Figure 21 is particularly interesting. The comparison of the remaining total life expectancy to the life expectancy without anxiety or depression showed that women at the age of 15 were expected to spend 70.2% of their remaining years without problems in anxiety or depression, and still 69.2% at the age of 65. Men at the age of 15 could expect to live 78% of their remaining years free of problems in anxiety or depression while at 65 they could still expect 74.2%. It is noticeable that the proportion of years remaining to live without anxiety and depression problems, after a slight decrease in working ages, is high and increasing with age.

Figure 21 Ratio life expectancy without problems in anxiety and depression to life expectancy, Belgium, 2013

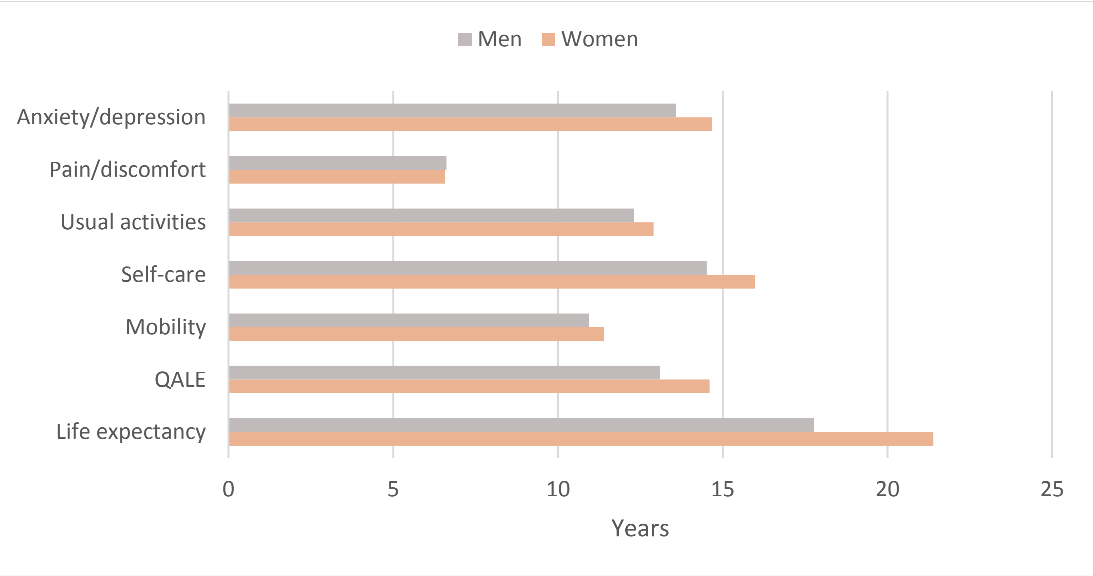


The following table and figure summarize the results. Table 1 displays the life expectancy, the QALE and the life expectancy without problems on the five dimensions for women and men at the age of 15 and 65 years. Figure 22 represents the indicators at the age of 65 years and offers a global view of the ageing of the Belgium population.

Table 1 *Life expectancy, QALE and life expectancy without problems on the five dimensions at age 15 and 65 for women and men, Belgium, 2013*

AGE	SEX	Life Expectancy (LE)	QALE	LE without mobility problems	LE without self-care problems	LE without problems in usual activities	LE without problems in pain and discomfort	LE without problems in anxiety and depression
15	Women	68.6	53.1	53.1	61.4	53.4	31.7	48.2
	Men	63.5	52.1	52.7	59	53.1	34	49.5
	Gap	5.1	1	0.4	2.4	0.2	-2.2	-1.3
65	Women	21.4	14.6	11.4	16	12.9	6.6	14.7
	Men	17.7	13.1	10.9	14.5	12.3	6.6	13.6
	Gap	3.6	1.5	0.5	1.5	0.6	0	1.1

Figure 22 *Life expectancy, QALE and life expectancy without problems on the five dimensions for women and men aged 65, Belgium, 2013*



5 DISCUSSION

5.1 ANALYSES

5.1.1 Quality-Adjusted Life Expectancy (QALE) and its decomposition into the mortality and disability effect

In accordance with our objectives of investigating the gender differences in health with a more precise measure of health population, the Quality Adjusted Life Expectancy (QALE) was calculated for the first time in Belgium thanks to the data collected by the EQ-5D tool in the Belgian Health Interview Survey (BHIS) 2013. This allowed for the assessment and monitoring of population health and inequalities across different social groups, such as between men and women. To push the analysis further, the gap between women and men was decomposed into a mortality and a disability effect.

Obviously, the life expectancy adjusted for the quality is lower than the total life expectancy. However, it remains higher than the Healthy Life Years (HLY) calculated in Belgium by the Global Activity Limitation Indicator (GAPI) measure. The life expectancy at 15 years was respectively 68.5 years and 63.5 years for women and men in 2013. At the age of 15, women enjoyed 53.3 additional years in QALE while men enjoyed 52.3 years. An important result here relates to the gender gap, which is reduced in the QALE compared to the gender differences in life expectancy. As expected, the higher disability rates of women on different dimensions contribute to reduce the advantage of women. From a difference of 5 years in life expectancy at age 15, the gap in QALE at 15 years is reduced to only 1 year.

In 2015 at the age of 65, women can still expect to live 10.9 years of Healthy Life Years (HLY) while men can count on 10.8, hence the gender difference has virtually disappeared. At the age of 65, women could expect 14.6 years in QALE while men could expect 13.1 additional years in QALE. In other words, adjusting for the Health-Related Quality of Life (HRQoL) results in higher life expectancy than adjusting for disability with the Healthy Life Years (HLY). In addition, because the index value is made up of several components, the HRQoL has a higher sensitivity than basic disability measures. Indeed, by accounting for the 5 dimensions on 5 levels rather than "yes/no" questions, it allows for a more precise assessment of the problems. Moreover, by using population preferences for each health states, the severity of the different health states is better assessed, accounting for cultural norms. Thus, assessing problems by their severity and the preference of the population reduces the disability burden estimated for Belgium.

Looking at the decomposition between the disability and the mortality effect in the gender difference in QALE gives additional insight. At age 15, the gender gap in QALE is estimated at 1.07 years and is mostly explained by a difference in disability rates. Women at age 15 already tend to report more problems on depression/anxiety and pain/discomfort while the difference in mortality rates between women and men is low. Then, mortality for men increases and the gap in mortality widens while the disability rates tend to stay constant. As a consequence, the gender gap in QALE will rise to 1.74 years at age 54, and the contribution of mortality to the gender differences has increased. At age 55, we observe a gender difference of 1.73 years, made of 2.7 additional years for women, due to their mortality advantage, and reduced by 0.9 due to their disability disadvantage. Next, between 55 and 75 years, the gap in QALE decreases from 1.73 to 0.95 years. This is mostly explained by a larger difference in mortality due to men's mortality rates starting their sharp increase earlier than women. At older ages, the gender gap decreases almost until 0 and is increasingly explained by a disadvantage in disability of women. As expected, at the oldest ages, the gender difference is very tiny due to convergence in health statuses.

5.1.2 Dimensions of the Health-Related Quality of Life

Given the relevance of assessing health population measures combining mortality and morbidity on different dimensions, the life expectancy free of problems adjusted for the 5 dimensions of the EQ-5D tool was assessed. I discuss below the main results obtained from this approach.

5.1.2.1 Mobility

When considering gender differences in life expectancy without mobility problems, we observe that women benefit from 0.45 additional years at the age of 15, then this advantage will increase slightly to reach 0.7 at the age of 54 years, before decreasing again until approximating 0. This gain is small due to the higher levels of reporting problems on mobility in women, especially between 55 and 85 years. The higher level of mortality in men and the higher level of morbidity in women interact to produce a modest gender gap. The slight increase in the gender gap before 55 years is likely to be caused by the increase in men's mortality rates while the decrease after 55 years is likely to be due to the increased reporting of problems in mobility of women. As already seen, the gender gap tends to disappear at the oldest ages.

We can put our results in perspective with the situation in France (Table 2). Life expectancy without mobility difficulties at 65 years assessed by self-reporting has been calculated in France for the period 2000-2002 (Cambois et al. 2008). The results show higher absolute and relative life expectancy without mobility difficulties in France than in Belgium. As mentioned before, relative measures are particularly pertinent to compare measures across countries. Even higher absolute and relative values are found in Singapore in 2005 (Yong, Saito, and Chan 2010). The study design and the sensibility of the scales used are likely to influence these substantial disparities. However, irrespective of the differences in levels between countries, women consistently benefit from a higher life expectancy without mobility limitations, but the percentage of the remaining time without mobility difficulties is lower than in men.

Table 2 *Remaining years free of mobility difficulties at 65 years, in Belgium, France and Singapore*

65 years	Belgium 2013	France 2000-2002	Singapore 2005
Women	11.4 (54%)	14.7 (69%)	18.6 (91%)
Men	10.9 (62%)	12.9 (76%)	16.1 (95%)

(%) designate the percentage of the remaining life expectancy without mobility limitations

5.1.2.2 Self-care

At the age of 15, the gender gap is the highest, at 2.5 years, due to few individuals reporting problems with self-care at young ages and nearly no gender difference between them. Thus, the mortality advantage of women is the only at play. Then, slowly more individuals are reporting problems with self-care and the rate of increase in reporting is greater in women than men. As a consequence, the gap between women and men in reporting problems increases. Since the gender gap in reporting is increasing, the gap in the life expectancy free of self-care problems decreases, first at a slow path and then faster. At the oldest ages, the gender gap is gone and nearly the totality of the remaining life expectancy is expected to be spent with self-care problems.

The self-care question in the EQ-5D-5L tool is composed of two elements, the ability of individuals to wash themselves and to dress themselves. The life expectancy without washing difficulties has been estimated in France in the period 2000-2002 for individuals aged 65. French women could expect to live 18.3 years without washing issues (corresponding to 86% of their remaining years) while men could count on 15.4 years (91%). The absolute and relative values are, not surprisingly, higher than our values estimated at 16 years for women aged 65 (76%) and 14.5 years in men (82%). This is because the French study only took in consideration one of the two dimensions enclosed in our question. They have also computed in 2002-2003 the life expectancy without restrictions in activities related to personal care at 65 years, which included getting dressed, feeding him/herself, getting in/out of bed, washing/bathing, going to the toilet. They found values consistent with our results; the life expectancy without restrictions for women is estimated at 17.1 (80%) years for women and at 14.8 (87%) years for men (Cambois et al. 2008).

5.1.2.3 Usual activities

The life expectancy without problems in usual activity present a low gender difference. The gap of 0.3 years at 15 years increases slightly as the population gets older to reach a maximum of 0.77 years at age 54, before decreasing to 0 at age 80. The increase in the gap between 15 and 54 years is likely due to the excess mortality in men. Then, the decrease in the gap between 55 and 80 years is likely to be caused by the increased reporting of problems in usual activities in women. Finally, the gap is constant around 0 from 80 to 100 years because of small differences in mortality rates and in the prevalence of problems with usual activities.

5.1.2.4 Pain and discomfort

The values of the life expectancy free of problems in pain and discomfort are particularly low compared to other dimensions. They range from 31.7 years for women to 34 years for men at age 15. It is worth noticing here that men have a higher life expectancy free of problems in pain and discomfort than women. Indeed, women are much more likely to report problems in pain and discomfort than men and the gap between men and women reporting problems is invariant with age. At younger ages, given the higher prevalence of reporting of women and a low difference in mortality level between women and men, the life expectancy free of problems is higher in men, by 2.3 years. Then, as mortality rates start to increase in men, the gender gap decreases until reaching 0 at 67 years, at which point it will remain marginal.

5.1.2.5 Anxiety and depression

The life expectancy free of problems in anxiety and depression is again higher in men than in women at the age of 15. At younger ages, women are much more likely to report problems with anxiety and depression and since the mortality rates are quite similar for women and men, the life expectancy free of problems is higher in men. However, as observed for pain and discomfort, the mortality rates in men will increase and this reduces the gender gap in the QALE which will drop at 0 at the age of 40. After that point, women will enjoy a higher life expectancy free of anxiety and depression than men. The gender gap in the reporting of problems is constant over the period and the levels of reporting raise only a bit during the 50-70 age range. At the oldest ages, the gap is negligible.

5.2 LIMITATIONS AND AREAS FOR FURTHER RESEARCH

Our study has several limitations, discussed below in terms of data, and methods.

5.2.1 Data

Firstly, our results are likely to be affected by limitations of the Belgian Health Interview Survey (BHIS). The survey has the advantage of including people living in nursing homes and hence the population of more dependent elderly, mostly women who are likely to have poor health states. However, it still excluded individuals from other institutions like prisoners and people residing in mental hospitals. Even if it represents a small portion of the population, it is a population likely to report poor health status. Notwithstanding, including institutionalized population may also presents drawbacks. For the population living in communities the disability scale used need to have more variation in the mild disability and for the institutionalized population the scale need more variation in the severe disability. Measures such as Activities of Daily Living (ADL) become a choice and individuals do not have to perform Instrumental Activities of Daily Living (IADL) tasks anymore (Deeg, Verbrugge, and Jagger 2003). Moreover, the sampling frame is the National Population Registry and this source excluded the population not officially registered, such as homeless people and unofficial migrants or asylum seekers. These populations also present more risks of being in poor health states.

The sampling procedure is robust in the BHIS 2013. However, selection biases are always possible. From a sample, results are extrapolated to the entire Belgian population, it is likely that the results obtained in our sample would be the ones obtained if we had asked the entire population, but it is not a certainty. Thus, the results obtained are only estimates. The assumption that the observations were selected independently and that each observation has the same selection probability is not fully met due to the regional stratification, the clusters on a limited number of municipalities and the sub-sample in the household. The weighting factors correct for the non-responses and adjust the sample distribution to fit the total Belgian population (Demarest et al. 2013). Potential bias can also come from educational differences in the survey participation and in the willingness and ability to answer the self-administered questionnaire. Lower participation rates in lower educated households were found (S. Demarest et al. 2013). Van der Heyden et al. (2017) investigated the use of education in the survey weight of the BHIS and recommended to adjust for education to improve the accuracy of estimates.

The BHIS is not a compulsory survey, the non-participation of households, non-contactable or refusals, must be underlined. The participation rate was 57% in 2013 (Van der Heyden and Charafeddine 2014). In 2008, 14.438 households were activated to finally conduct 11.254 individual interviews. For 0.7% of the households, the address did not exist, for 16.1% of the households, the selected respondents did not live anymore at the address, 10% of households could not be contacted and 30% refused to participate. As indicated earlier, when a household cannot be interviewed, it is substituted by a replacement household with same characteristics (living in the same municipality, with the same number of people and the same age for the reference person). This technic, even if contested, have shown its efficiency and reliability in the Belgian context (Demarest et al. 2013).

Secondly, different aspects of the construction, collection and analysis of answers of the EQ-5D-5L can be underlined. First, the EQ-5D questionnaire has not been validated for the children under the age of 15, therefore information about the health status of children could not be collected. Assessing HRQoL in children is delicate due to the use of proxy respondents especially for the youngest children. However, a new version of the tool, the EQ-5D-Y, adapted to children from 8 years has been tested in several countries, including Germany, Spain and South Africa (Wille et al. 2010). Another aspect of the EQ-5D-5L worth mentioning is that the question is self-reported and thus the subjective nature of the reporting must be acknowledged. The main advantage of self-rated health status is also its main disadvantage. Individuals can consider the cultural, economic, social, environmental and health-related factors that influence their health. It gives information directly about the health status as experienced by individuals. Notwithstanding, the reporting is affected by the willingness to state the situation perceived, to perceive the first signs of diseases and to seek health services as well as the availability of suitable health structures and the ability to choose the most appropriate structures (Deeg, Verbrugge, and Jagger 2003). Individuals with comparable levels of a disease can have substantially different HRQoL scores because of different treatments. In fact, some efforts to standardize instruments and measurements have had an adverse effect. The same health-related question will have different answers in different groups depending on culture, education, the frequency and quality of contact with doctors and individuals' sensitivity toward health issues (Buratta and Egidi 2003).

An important factor influencing reporting biases is the differences in socioeconomic status. On one side, individuals from higher socioeconomic groups have more sedentary and less risky jobs and may be less limited in their usual activities by illness or injury. On the contrary, individuals with lower socioeconomic status may have more manual occupations and more physically demanding activities for which ill states may affect their ability to perform their daily activities more. But individuals from more deprived areas may also have lower expectations in health and consequently report less disability compared to equivalent health status in less deprived areas. It may result in higher utility score for people with lower socioeconomic status compared to people with higher status with the same objective clinical status. This could underestimate the degree of health inequalities (Love-Koh et al. 2015; Collins 2017).

There have been concerns that the higher disability rates self-reported by women result from potential differences in health-reporting behaviors. Women know more about their health and would be more likely to report disabilities. Many studies investigated this effect by comparing self-reported measures of disability with objectively observed chronic diseases and functional limitations (Merrill et al. 1997; Orfila et al. 2006; Case and Paxson 2005). Consistent results showed accuracy in the reporting of disability by men and women, and acknowledged women's higher prevalence of reported disability or functional problems as likely reflection of true disability. It has been observed that older people tend not to report slight declines in function or mild disability, but that they only report more severe limitations. The prevalence of disability is underestimated, but gender differences have not been reported in this respect. It is often reported that men may not report as much disability in performing households tasks because they do not need to perform these tasks (Newman and Brach 2001). The EQ-5D has the advantage of using dimensions that are not specifically associated to social roles specific to a gender.

5.2.2 Methods

The method of calculating can also present weaknesses. First, the HRQoL data are based on the EQ-5D tool and on national values sets that are weights representing population preferences for health states. The distribution of answers on the EQ-5D is non-standard because of a highly right-skewed distribution caused by most people reporting a score of 1, a perfect HRQoL. Value sets or population preferences are needed to calculate the index score. As already mentioned, the Belgian value set has several drawbacks. On the top of that, differences in value sets can lead to large differences in quality-adjusted life expectancy as reported by Heijink et al. (2011) investigating the cross-country comparison of the QALE calculated with HRQoL information from the EQ-5D tool. They found that comparisons between countries are highly influenced by differences in value sets. Indeed, for example, the German value set create a QALE seven years higher than the UK value set. Finally, value sets are generated based on the general population. Yet, it has been shown that the general population attaches more HRQoL loss to some health states than patients do.

Then, the Sullivan method can present some limitations. All individuals, healthy or unhealthy, are assumed to have the same mortality. Indeed, the method is simple and is underpinned by an oversimplification of reality. Mortality and health deterioration processes are considered to be independent. Unhealthy individuals cannot go back to healthy states, there is no recovery possible. Prevalence life tables, such as the Sullivan method, grab only information about the current population structure (Laditka and Hayward 2003). Other methods exist as the increment-decrement life table or the multistate life tables, but they required incidence data, which are rarely available. The Sullivan method and the multistate life table method using longitudinal data have been compared by Mathers and Robine (1997). They show that the Sullivan method is not capable of detecting a sudden change in disability rates. However, they also highlight that the method approximates the multistate values if there are smooth and relatively regular changes over the long term. Hence, if the prevalence or the incidence rates vary, these variations can cause an underestimation or overestimation of health expectancy because the results are based on past probabilities of becoming unhealthy (Pongiglione, Stavola, and Ploubidis 2015).

Then, the decomposition method has been critiqued by Shkolnikov and Andreev (2017). They compare the decomposition method suggested by Andreev, Shkolnikov and Begun (2002) and the method developed by Nusselder and Looman (2004). They state that the formulas by Nusselder and Looman are correct only for the mortality component contrary to the formulas by Andreev, Shkolnikov and Begun, which are correct for the health and the mortality components.

Finally, our question could benefit from further developments. First, as previously stated, socio-economic levels influenced greatly the participation to the survey and the answers to health-related self-reported questions. Thus, the research could benefit from the addition of significant factors such as education. Next, the data collection of the Belgian Health Interview Survey for the year 2018 is currently undergoing. When these results are ready, time trends will be possible to explore by comparing the quality-adjusted life expectancy for the year 2013 and 2018. The analysis of changes would gave us insight in the question of which scenario of morbidity (compression, expansion, or dynamic equilibrium) is unfolding in Belgium.

6 CONCLUSIONS

Our objectives have been to analyze the gender differences in health in Belgium by using a new measure, the Quality-Adjusted Life Expectancy (QALE). As expected, the gender difference was smaller in quality-adjusted life expectancy than in life expectancy. However, decomposing the gap showed that a reduced gap does hide substantial inequalities. It is the result of an interaction between a high disadvantage in disability of women and a high disadvantage in mortality of men. Moreover, the life expectancy without problems on the 5 dimensions of the EQ-5D showed that the higher levels of disability of women are more present in pain/discomfort and in anxiety/depression. The higher levels of reporting were not only found in the elderly but also in younger individuals. Disabilities in the elderly have received a greater interest but the Health-Related Quality of Life (HRQoL) showed that younger individuals should not be forgotten. These results need to be further and could be used for a better allocation of healthcare resources.

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ANNEXE 1: EQ-5D-5L QUESTIONNAIRE

Under each heading, please tick the ONE box that best describes your health TODAY

MOBILITY

I have no problems in walking about ❑
I have slight problems in walking about ❑
I have moderate problems in walking about ❑
I have severe problems in walking about ❑
I am unable to walk about ❑

SELF-CARE

I have no problems washing or dressing myself ❑
I have slight problems washing or dressing myself ❑
I have moderate problems washing or dressing myself ❑
I have severe problems washing or dressing myself ❑
I am unable to wash or dress myself ❑

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

I have no problems doing my usual activities ❑
I have slight problems doing my usual activities ❑
I have moderate problems doing my usual activities ❑
I have severe problems doing my usual activities ❑
I am unable to do my usual activities ❑

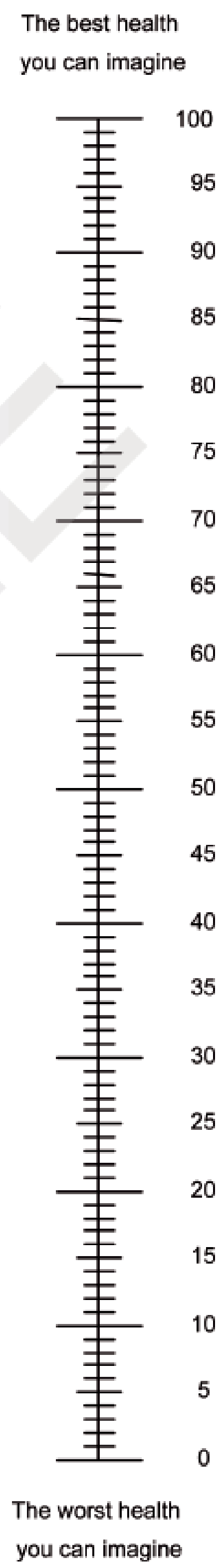
PAIN / DISCOMFORT

I have no pain or discomfort ❑
I have slight pain or discomfort ❑
I have moderate pain or discomfort ❑
I have severe pain or discomfort ❑
I have extreme pain or discomfort ❑

ANXIETY / DEPRESSION

I am not anxious or depressed ❑
I am slightly anxious or depressed ❑
I am moderately anxious or depressed ❑
I am severely anxious or depressed ❑
I am extremely anxious or depressed ❑

- We would like to know how good or bad your health is **TODAY**.
- This scale is numbered from **0** to **100**.
- **100** means the <u>best</u> health you can imagine.
  0 means the <u>worst</u> health you can imagine.
- Mark an **X** on the scale to indicate how your health is **TODAY**.
- Now, please write the number you marked on the scale in the box below.



YOUR HEALTH TODAY = $\boxed{}$