The world has made significant progress towards wealth and health for everyone, but considerable disparities across and within countries remain. The rising burden of non-communicable diseases is partly driven by an aging population but is also linked to an increase in engagement in unhealthy behaviors. Such behaviors include smoking, unhealthy nutrition, harmful alcohol consumption and physical inactivity. The modifiable feature of health behaviors creates opportunities for health policies to stimulate healthy choices and hence improve health outcomes.

Charlotte Michèle Dieteren

Evaluating and Improving Health Behaviors, Outcomes, and Policies

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Wie vindt, heeft slecht gezocht.

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1 General introduction

1.1 THESIS RATIONALE

The world has made significant progress towards wealth and health for everyone, but considerable disparities across and within countries remain. Policymakers in low-, middle- and high-income countries are confronted with a growing burden of non-communicable diseases (NCDs) [1–3], accounting for 71% of deaths worldwide [4]. Half of these deaths are caused by cardiovascular diseases (CVD) [5]. The rise in NCDs, partly driven by an aging population [6], is linked to an increase in unhealthy behaviors including smoking, unhealthy nutrition, harmful alcohol consumption and physical inactivity (SNAP) [7, 8]. These "SNAP factors" (i.e., smoking, nutrition, alcohol consumption and physical activity) constitute important modifiable risk factors for NCDs. Changing SNAP factors may lead to prevention or postponement of the onset of age-related diseases [9, 10].

Of all NCD related deaths, 80% occur in low- and middle-income countries (LMICs) [11]. This high mortality rate is particularly challenging since communicable diseases and maternal mortality also continue to place a significant burden on the healthcare systems in LMICs [12–14]. This combined burden of communicable and non-communicable diseases in LMICs is also known as the "double burden of disease". Epidemiologic transition theory describes the long-term shift from pandemics of communicable diseases towards NCDs [15]. Countries that are confronted with this double burden of disease have not yet made this shift. In high income countries (HICs), NCDs have become the leading causes of morbidity and mortality and most communicable diseases have been eradicated. Recently, however, the world was confronted with the COVID-19 outbreak, which overwhelmed healthcare systems in both HICs and LMICs [16–18] and the World Health Organization (WHO) officially declared the outbreak as a global pandemic [19]. The COVID-19 virus has shared risk factors with common NCDs, such as obesity, smoking and hypertension [20–22]. Because the prevalence of these risk factors varies widely across and within countries, targeting of health policies to the local context is crucial.

To curb the rise in NCDs, and other diseases with shared risk factors, we must understand the distribution of unhealthy behaviors and health outcomes in the population and tackle these through the design of appropriate health policies. The following paragraphs will further elaborate on these three main themes of this thesis: health behaviors, health outcomes and health policies. Subsequently, the main objective of the thesis and corresponding research questions are presented.

1.2 HEALTH BEHAVIORS

Health behaviors are defined as actions taken by individuals that affect morbidity or mortality [23]. The traditional risk factors (SNAP) have a central position in this thesis. Globally, tobacco kills over 8 million people yearly [24]. Although smoking rates are falling in the Western world partly due to aggressive campaigns, tax increases and other regulations [24], smoking remains a persistent public health problem with 19% of the European population smoking on a daily basis [25]. However, 80% of the world's 1.3 billion smokers live in LMICs [24]. Overweight, which usually is the result of a lack of physical activity and/or an unhealthy diet, is highly prevalent around the globe. Overweight and obesity used to be most prevalent in HICs, but has become a major global concern; almost 40% of the world's population is overweight [26]. Finally, harmful alcohol use also remains a worldwide problem and contributes to 3 million preventable deaths annually [27]. Alcohol use has a profound and unequal impact on life expectancies of populations. For example, there is a 10-year gap in life expectancy between Russian men and women (68 versus 78 years) [28]. This gap has been linked to the high rate of excessive alcohol consumption among Russian men [29], although this relationship has weakened in the last decade because factors like better accessibility to healthcare have positively influenced life expectancy in Russia [30].

The definition of health behaviors may give the impression that decisions to engage in the SNAP factors occur at an individual level. However, social determinants of health (SDH), such as the conditions in which people are born, grow up, work, live, and age [31], play a considerable role in the distribution of these behaviors in the population [32, 33]. Research has shown that SDH are the main drivers of health inequities, that is, the unfair and avoidable differences in health status [34]. The SDH perspective entails that individuals may not be fully in control over their health (behavior). At the same time, driven by public health concerns and ever rising health care expenditures, there is an ongoing public and political debate regarding the role of individual responsibility for health (behavior) [35].

In the last decade, the concept of "healthy lifestyles" has emerged, which entails a more holistic perspective towards health behaviors. Health behaviors are often studied separately while most of the times they do not occur in isolation but are likely to cluster. In order to design appropriate health policies, that aim to promote health behaviors, it is important to understand the relationships between health behaviors [36]. Certain clusters of health behaviors may occur in segments of the population more frequently, for example the combination of smoking and alcohol consumption [36]. Policy makers may approach these behaviors simultaneously in order to tackle unhealthy behaviors more effectively, as the presence of multiple unhealthy behaviors in an individual has additional negative influences on health [37, 38].

1.3 FROM HEALTH BEHAVIORS TO HEALTH OUTCOMES

The above discussed health behaviors have different effects on health. While smoking has been proven to have a causal link with lung cancer and large numbers of premature deaths [24, 39, 40], obesity increases the risks for several health conditions that are not directly deadly, including diabetes and hypertension [41, 42]. Hence, unhealthy behaviors differ in their effect on morbidity and mortality.

A variety of methods exists to assess health status. A relatively simple subjective measurement of health is a visual analogue scale that ranges from 0 to 10, on which individuals can score their own health. How people perceive their own health is widely acknowledged as a valuable source for health information and there is robust evidence that it has predictive power for future health outcomes [43]. Subjective health is considered as an inclusive operationalization as it reflects aspects that may not be covered by other health indicators [44]. Disadvantages of subjective health measures are the non-sensitivity to age (e.g. older individuals tend to be more positive than younger individuals) and the lack of specificity to certain health domains [45]. Objective measurements, on the other hand, involve physical examinations leading to comparable outcomes between people (e.g., blood pressure). Financial constraints may limit the application of objective measurements as it is expensive and time consuming.

Life expectancy is a population health measure that involves solely a mortality component, while composite health measures combine morbidity and mortality into a single measure. There are two types of composite health measures that are frequently applied: health gap measures and health expectancies. The most well-known health gap measures are disability-adjusted life years (DALYs) and quality-adjusted life years (QALYs) [46, 47]. These measures represent the loss in healthy life due to disability and the years lived in perfect health, respectively, with values ranging between 0 (equivalent to dead) and 1 (equivalent to perfect health). Health expectancies are relatively easy to understand as they only reflect the number of years in full health that a person could expect to live, also known as 'healthy life expectancy'. The information is mostly derived from national population survey data. Composite health measures facilitate discussions regarding quantity and quality of life as they show the interaction between these two components [45].

1.4 HEALTH POLICIES TO IMPROVE HEALTH BEHAVIORS AND HEALTH OUTCOMES

Health policies serve as an important mechanism to improve health outcomes but also to curb rising healthcare expenditures. These two policy objectives can, however, be in contradiction. Health behaviors with a large morbidity effect induce high medical costs, while health behaviors with a stronger mortality effect place less burden on the health care budget. van Baal et al. [48] show that the lifetime health-care costs of smokers and obese people are lower compared to healthy-living people. This is because successful prevention of smoking and obesity increases life expectancy, but the extra life years gained come at a price in the form of other age-related diseases which lead to increased health care costs [48]. Hence, successfully preventing unhealthy behavior may improve health outcomes in the population but will not necessarily lead to lower healthcare costs.

As the healthcare budget is finite, and the healthcare expenditures continue to rise, rationing in healthcare is inevitable. In many countries, protocols and policies guide decisions on which treatment to reimburse from the healthcare budget, and which not. Frequently applied decision criteria for reimbursement include the necessity, effectivity and cost-effectiveness of treatment [49]. As a growing part of the disease burden can be attributed to modifiable health behaviors, individual responsibility has been suggested as an additional decision criterion to prioritize healthcare resources [50–52]. Such a criterion could imply that anyone who does not live according to the norms of a healthy lifestyle can legitimately receive lower priority [53]. When considering the SDH (introduced in paragraph 1.2), individual responsibility may be seen as a contestable criterion. Nonetheless, individual responsibility for health continues to emerge in policy documents as a possibility to incentivize healthy behavior. For instance, a policy reform document of the German healthcare system included a proposal that "insured persons may no longer claim free treatment for complications arising from certain 'lifestyle choices'" [54]. Furthermore, in the UK patients may be asked to change their health behaviors to qualify for treatment [55]. Attitudes from the public regarding the role of individual responsibility for health are not well researched yet.

To assess the acceptability and justification of health policies, the Nuffield Council on Bioethics designed an intervention ladder (Figure 1.1). This ladder characterizes the intrusiveness level of a policy intervention [56]. The lowest level is *'doing nothing or simply monitor the current situation'* and the highest level is '*eliminate choice: regulate to eliminate choice entirely*', which could restrict freedoms significantly. Justification of policies that aim for behavioral change is critical as it can threaten individual autonomy. The public health threat must be significant before the government may use intrusive health policies [56]. The threat of tobacco for public health is considered as high and governments adopted policies at high intrusiveness levels, such as the prohibition of tobacco for individuals below 18 years old. The public health treat of sugary nutrition is more complex but the health risks of e.g. obesity are well established and considered threatening [57]. However, justification and public support for interventions concerned with dietary risks placed on the higher levels of the Nuffield Intervention Ladder remain disputable and understudied. For prevention policies to be successful, they need to be accepted and adopted by the target populations. Therefore, it is important that they sufficiently align with public preferences for government intervention in health behavior. While it is to be expected that the public has heterogenous views in this area, information about policy preferences can be helpful to anticipate potential resistance among the public.

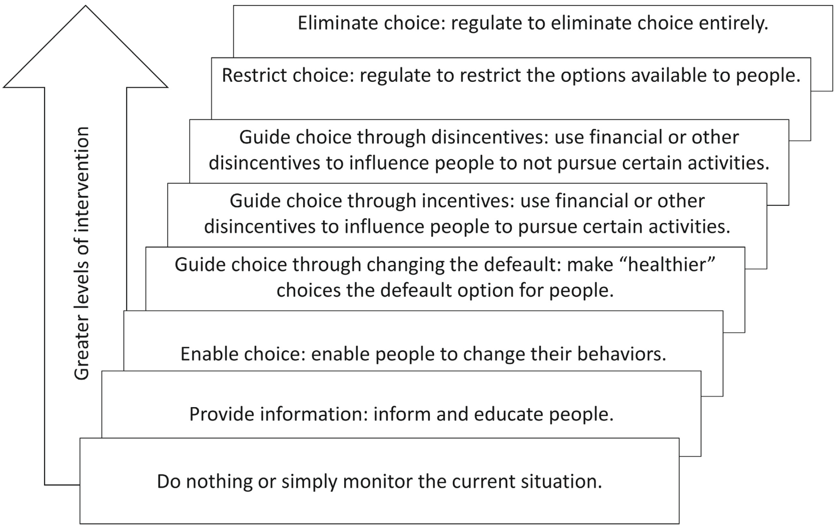

Figure 1.1 Nuffield Intervention Ladder
Source: Nuffield Council on Bioethics. Public health ethical issues. London, Nuffield Council on Bioethics, 2007)

1.5 THESIS OBJECTIVE AND RESEARCH QUESTIONS

This thesis aims to contribute to a better understanding of the relationship between *health behaviors* and *health outcomes* and explores public preferences for governmental *health policies* to improve public health while mostly considering that healthcare resources are limited. Considering the growing NCD burden and the negative consequences on public health and the healthcare budget, the modifiable feature of health behaviors creates an opportunity to prevent – or at least postpone - NCDS and related diseases.

The research questions addressed in this thesis are the following:

Regarding *health behaviors*

1. How are health behaviors distributed across the population in different regions in the world, and how do these behaviors cluster? (Chapters 2 and 3)

Regarding *health outcomes*

2. What is the current evidence on the effect of smoking on health expectancy? (Chapter 4)
3. Which healthy aging trajectories can be observed in a cohort of the general population of the Netherlands, and what are the roles of baseline sociodemographic characteristics and lifestyle factors on these trajectories? (Chapter 5)
4. To what extent are there socioeconomic inequalities in undiagnosed, untreated, and uncontrolled hypertension in Mexico, and how do people transit between these states? (Chapter 6)

Regarding *health policies*

5. Which viewpoints towards the inclusion of a lifestyle criterion in healthcare priority setting can be identified among healthcare professionals and the general population in the Netherlands? (Chapter 7)
6. What are the preferences and perceptions of effectiveness towards governmental policies to promote a healthy diet among the general population in the Netherlands? (Chapters 8 and 9)
7. Which public preferences towards the role of individual responsibility in the allocation of ICU beds during a health crisis can be identified among the general population in the Netherlands? (Chapter 10)

1.6 THESIS OUTLINE

These research questions are each answered in one of the three parts of this thesis. Below a brief outline is given for each part.

Part I - Health behaviors - includes chapters 2 and 3 and focuses on the distribution of health behaviors among different populations. Chapter 2 aims to study clustering of the health behaviors in the context of the Netherlands, while chapter 3 extends the context to low- and middle-income countries.

Part II - Health outcomes - consists of chapters 4 to 6 and studies health behaviors related to health outcomes in different settings. Chapter 4 reviews the existing literature about the effect smoking has on health expectancy to examine the compression of morbidity hypothesis. Chapter 5 is positioned in the context of the Netherlands and describes healthy aging trajectories among people aged between 30 and 70 years and the role of health behaviors in these trajectories. Chapter 6 examines socioeconomic inequality and transitions in different hypertension states in a cohort of older adults in Mexico.

Part III - Health policies - is the final part of this thesis and covers chapters 7 to 10. Chapter 7 examines viewpoints of the public and experts in healthcare regarding the inclusion of a lifestyle criterion in the context of healthcare priority setting. Chapter 8 investigates preferences among the general population of the Netherlands for governmental policy interventions to promote a healthy diet. Chapter 9 studies the same policies as in chapter 8 but adds an examination of the expected effectiveness of these policies in the general population of the Netherlands. The final chapter of this part is a study on COVID-19 that investigated public preferences for rationing criteria to be used in the allocation of ICU beds, where individual responsibility for health was also considered as a criterion.

Finally, chapter 11 discusses the main findings presented in this thesis, the overall strengths and limitations, future research opportunities and provides policy recommendations.

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I

HEALTH BEHAVIORS

2 A guilty pleasure or two? Health behaviors among the adult population in the Netherlands

Based on: Dieteren, C. M., Brouwer, W. B., & van Exel, J. (2020). How do combinations of unhealthy behaviors relate to attitudinal factors and subjective health among the adult population in the Netherlands? BMC public health, 20, 1-14.

ABSTRACT

Background
Unhealthy behaviors like smoking, unhealthy nutrition, harmful alcohol consumption and physical inactivity (SNAP) are often studied separately, while combinations can be particularly harmful. This study aims to contribute to a better understanding of lifestyle choices by studying the prevalence of (combinations of) unhealthy SNAP behaviors in relation to attitudinal factors (time orientation, risk attitude) and subjective health (self-rated health, life expectancy) among the adult Dutch population.

Methods
In total 1,006 respondents, representative of the Dutch adult population (18-75 years) in terms of sex, age, and education, were drawn from a panel in 2016. They completed an online questionnaire. Group comparisons and logistic regression analyzes (crude and adjusted) were applied to analyze (combinations of) SNAP behaviors in relation to time orientation (using the Consideration of Future Consequences scale comprising Immediate (CFC-I) and Future (CFC-F) scales) and risk attitude (Health-Risk Attitude Scale; HRAS-6), as well as subjective health (visual analogue scale and subjective life expectancy).

Results
In the analyzes, 989 respondents (51% men, average 52 years, 22% low, 48% middle, and 30% high educated) were included. About 8% of respondents engaged in four unhealthy SNAP behaviors and 18% in none. Self-rated health varied from 5.5 to 7.6 in these groups, whilst subjective life expectancy ranged between 73.7 and 85.5 years. The logistic regression models - adjusted for socio-demographic variables - showed that smoking, excessive drinking and combining two or more unhealthy SNAP behaviors were significantly associated with CFC-I scores, which increased the odds by 30%, 18% and 19%, respectively. Only physical inactivity was significantly associated with CFC-F scores, which increased the odds by 20%. Three out of the four SNAP behaviors were significantly associated with HRAS-6, which increased the odds between 6% and 12%. An unhealthy diet, excessive drinking, and physical inactivity were significantly associated with SRH, which decreased the odds by 11%. Only smoking was significantly associated with subjective life expectancy, which decreased the odds by 3%.

Conclusion
Our findings suggest that attitudinal factors and subjective health are relevant in the context of understanding unhealthy SNAP behaviors and their clustering. This emphasizes the relevance of a holistic approach to health prevention rather than focusing on a single unhealthy SNAP behavior.

2.1 BACKGROUND

The effect of lifestyle on morbidity and mortality is increasingly being recognized [1-3]. The disease burden attributed to lifestyle choices primarily consists of non-communicable diseases (NCDs). May et al.,[4] among others, have shown that making healthy choices regarding smoking, nutrition, alcohol consumption and physical activity (SNAP) (here used to define lifestyle), has a strong impact on the prevention of NCDs. However, contrary to what would be desirable from a public health perspective, studies have shown that adherence to a healthy lifestyle (making healthy choices) has decreased over the past decade [5, 6].

Adherence to a healthy lifestyle may have decreased in general, however in the last decade a strong reduction in the prevalence of smoking has been observed. Over 20% of the worldwide population smokes, which leads to high numbers of premature deaths [7]. Nutrition also plays a major role in premature deaths and disability. It has been estimated that in 2017 a poor diet was a risk factor in one in five of all deaths globally [8]. Excessive alcohol intake has been linked to 3 million deaths in 2016 [9]. Furthermore, almost a quarter of the adult population is physically inactive. Sedentary lifestyles are increasing in varying rates across countries, but seem to currently be most persistent and alarming in developed countries [10].

Healthy lifestyle promotion requires a comprehensive understanding of the way people behave. Mostly, unhealthy lifestyle choices do not occur in isolation, but in different combinations [11]. Engaging in a combination of unhealthy behaviors has been shown to have an additional negative influence on health [12, 13]. A holistic approach to lifestyle interventions may therefore result in more health gains.

Frequent combinations of unhealthy behaviors can be referred to as clusters. Noble et al., [14] conducted a systematic review of the clustering of SNAP health risk factors (referred to from now on as unhealthy SNAP behaviors). They found that the most frequently reported cluster of unhealthy SNAP behaviors was the absence of any of the behaviors, followed by a cluster of excessive alcohol consumption and smoking, a cluster including all behaviors and a cluster with an unhealthy diet and physical inactivity. To understand behavioral choices, it is relevant to have insight into the way unhealthy SNAP behaviors cluster. However, not much research has been conducted on the potential drivers of these clusters.

Our understanding of attitudinal characteristics that influence people's lifestyle choices remains limited, both in terms of underlying causes and in the way resulting consequences are perceived. Such information can be useful in the context of promoting healthy lifestyles and changing health behaviors. Here, we focus on two attitudinal concepts that may be associated with (the onset of) unhealthy behavior:

time orientation and risk attitude. Various studies show that smokers are less concerned with future consequences of their health behavior than non-smokers [15-17]. Furthermore, research shows that risk attitude is associated with risky behavioral choices, like smoking [18]. However, associations between these concepts and the engagement in multiple unhealthy SNAP behaviors have not yet been studied. People engaged in multiple unhealthy SNAP behaviors, or in certain combinations of these behaviors, might differ in their attitudinal characteristics.

Engagement in unhealthy SNAP behaviors may also result in (or result from) differences in subjective health experiences and expectations. Subjective health has been shown to be an independent predictor of morbidity and mortality [19, 20] and as such can be considered to carry relevant information in relation to health behaviors. Several studies have shown the association between self-rated health (SRH) and single lifestyle factors [21-23], however few studies have investigated the association between a number (or certain combinations) of healthy lifestyles and SRH [24]. Subjective life expectancy (SLE) is also an indicator for subjective health; it captures how old people expect to become. SLE was found to be associated with smoking behavior, which may reflect people's expectations of the increased risk of dying due to smoking , either directly or indirectly through poorer experienced health due to smoking [25]. Associations between SLE and unhealthy dietary choices have also been found [26]. Note that the causal direction between subjective health and unhealthy behavior can go in both directions. People with an ex ante low SLE may for instance be more prone to smoke, as they may expect to have less to loose from smoking. Studying these associations between subjective health and lifestyle factors, while also including behavioral characteristics, and acknowledging that unhealthy behaviors do not occur in isolation has, to our knowledge, not been done before.

Here, we present the results from a study that measured attitudinal factors, subjective health and unhealthy SNAP behaviors simultaneously in the same population. Such information can help to understand potential drivers of unhealthy lifestyle choices, both in terms of causes and consequences of unhealthy behaviors. The objectives of this study were therefore (i) to identify how unhealthy behaviors cluster in a sample representative of the adult population of the Netherlands in terms of sex, age, and education, and (ii) to associate combinations of unhealthy behaviors with attitudinal factors (time orientation, risk attitude) and subjective health (SRH, SLE).

2.2 METHODS

2.2.1 Survey design and sample

In February 2016, cross sectional data were collected through an online survey. The sample was drawn from an online panel representative of the adult population of the Netherlands in terms of age, gender and level of education, between the ages of 18 and 75 years. The survey was distributed until the study population reached an adequate representativeness of the Netherlands (quota sampling). At the beginning of the survey, respondents received information about the purpose of the study and were instructed that participation was voluntary, anonymous to the researchers, and that they could end their participation at any time. When signing up for the panel, members of the panel agreed that by submitting their data at the end of the survey, they were giving permission for the use of their data for the purpose of that study.

2.2.2 Measures

Lifestyle

Lifestyle was operationalized using unhealthy SNAP behaviors, in line with a related study in the Netherlands [27]. Smoking status was assessed, and non-smokers were distinguished from occasional smokers (not daily) and current smokers (daily). Respondents were asked to report how many days per week they ate balanced meals: the right proportion, not too much fat, sufficient fruit and vegetables. Respondents were classified as following a healthy diet when they reported eating balanced meals a minimum of six days per week. [27]. Respondents who reported eating balanced meals less than six days per week were classified as following an unhealthy diet. Respondents were asked to report their weekly alcohol consumption. Excessive drinking was defined as consuming six alcoholic drinks or more at least once a week, or when the weekly alcohol consumption exceeded 21 drinks (males) or 14 drinks (females) [28] [29]. Physical activity was measured by asking how often the respondent performed at least 30 minutes of physical activity (e.g., walking or cycling) per week. People were considered inactive if they performed 30 minutes of activity on less than five days a week [30, 31]. A lifestyle index was computed by adding the number of unhealthy SNAP behavior present (i.e., smoking, unhealthy diet, excessive alcohol consumption, physically inactive), ranging from 0 (i.e., no unhealthy SNAP behavior present) to 4 (i.e., all unhealthy SNAP behaviors present). This index has been used before [27].

Attitudinal factors

Time orientation was assessed using the consideration of future consequences scale (CFC). The CFC measures the degree to which individuals consider the potentially distant outcomes of current behavior and whether individuals are influenced by these consequences [32]. The CFC consists of 14 statements, where each statement captures either immediate or future consequences of general behavior [32, 33].

Respondents were asked to rank the statements on a 5-point Likert scale ranging from “very uncharacteristic for me” to “very characteristic for me”. The CFC score was computed by aggregating item scores (theoretical range 14-70). Research suggests a two-factor structure underlying the CFC scale [34-36]. These two factors can be labelled the CFC-Immediate (CFC-I) and CFC-Future (CFC-F) sub-scales. In this study the two-factor structure was analyzed and reported. Risk attitude in the health domain was measured by a short 6-item version of the Health-Risk Assessment Scale (HRAS-13)[37, 38], the HRAS-6. The HRAS-6 aims to predict how a person will resolve risky health decisions. Respondents were asked to rank six statements on a 7-point Likert scale ranging from “totally disagree” to “totally agree”. The HRAS-6 score was computed by aggregating item scores (theoretical range 6-42), with higher scores indicating stronger risk aversion. The statements of the CFC and the HRAS-6 were presented to respondents in a randomized order.

Subjective health

Subjective health was operationalized by eliciting SRH on a visual analogue scale (VAS) (0-10). A score of 10 refers to the best health state imaginable, while a score of 0 refers to the worst health imaginable. As in [27], SLE was obtained through the question: “What age do you expect to reach?” The continuous response scale had no minimum score but was limited to 120 years.

2.2.3 Statistical analysis

SNAP behaviors were used in the analyzes in three different ways: as individual health behaviors, as clusters with all potential combinations, and as the lifestyle index. Comparisons between socio-demographics, attitudinal factors, subjective health, and the SNAP behaviors were conducted using Chi-square-tests for categorical variables and one-way analysis-of-variances (ANOVA) for continuous variables. Because multiple tests for significance were performed, an adjusted p-value for acceptance and rejection of the null hypothesis was used [39]. A Bonferroni correction was applied, which led to a p-value of 0.001.

We continued with the single SNAP behaviors, striking combinations and the lifestyle index as the main focus. Logistic regression analyzes were performed to provide statistical associations. The lifestyle index was dichotomized (with 0 or 1 unhealthy SNAP behavior present coded as 0; and 2, 3 or 4 unhealthy SNAP behaviors present coded as 1). The lifestyle index was dichotomized for two reasons. Firstly, for ease of interpretation (given that a multinomial logistic regression without dichotomization yielded similar results), and secondly because the test of parallel lines showed that a logistic regression model was not valid for our data. A hierarchical model structure was adopted in order to provide insights into the relations between with the separate variables of interest. First, bivariate relationships were examined using attitudinal factors and subjective health as independent variables. Second, these variables were added simultaneously in the model. Third, socio-demographics were added as control variables. Odds ratios and confidence intervals were inspected and compared. The p-value for acceptance and rejection of the null hypotheses in the logistic regressions was set at $p < 0.05$. The Nagelkerke R2 and the Cox & Snell R2 and goodness-of-fit were assessed using a Likelihood Ratio chi-square test [40, 41]. The data were analyzed using STATA 15.0.

2.3 RESULTS

2.3.1 Sample characteristics

In total, 1,006 respondents completed the survey. Respondents who provided inconsistent or impossible values (e.g., SLE lower than current age) were excluded from further analyzes. This resulted in a final sample of 989 respondents. Figure 2.1 shows the prevalence of unhealthy SNAP behaviors and the number of unhealthy SNAP behaviors in this study population (i.e., presence refers to the unhealthy choice). Almost a quarter (23%) of respondents reported smoking, and half of the population did not satisfy the thresholds for a healthy diet or the guidelines of physical activity (respectively 47% and 52%). Almost half of the respondents (49.6%) were engaged in two or more unhealthy SNAP behaviors.

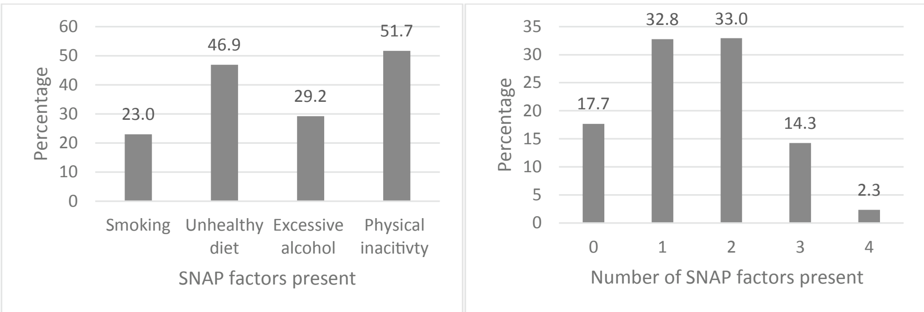

Figure 2.1 Prevalence of SNAP factors and cumulative SNAP factors present

Table 2.1 shows the socio-demographic characteristics of the study population. Smoking was significantly more concentrated among lower educated people. People with an unhealthy diet were significantly younger. Excessive drinkers were significantly more often women, younger and lower educated than other respondents. Physical inactivity was significantly more common in the youngest age group.

Table 2.1 Sociodemographic factors stratified by unhealthy SNAP behaviors, % (N)

Characteristics	Total	Smoking[1]	Diet[1]	Alcohol[1]	Physical inactivity[1]
Gender					
Men	50.7 (501)	24.2 (121)	48.7 (244)	24.6* (123)	50.5 (253)
Women	49.3 (488)	21.7 (106)	45.1 (220)	34.0 (166)	52.9 (258)
Age					
18-34 yrs	15.6 (154)	20.13 (31)	62.3* (96)	36.4 (56)	66.2* (102)
35-54 yrs	34.8 (344)	26.2 (90)	53.5 (184)	30.2 (104)	52.0 (179)
55-75 yrs	49.6 (491)	21.6 (106)	37.5 (184)	26.3 (129)	46.8 (230)
Average age (range)	51.6 (18 – 75)	51.4 (18-74)	48.5* (18-73	49.9* (18-72)	50.1* (18-74)
Highest education level					
Low	21.6 (214)	30.4* (65)	50.5 (108)	38.3* (82)	52.3 (112)
Middle	48.3 (478)	24.1 (115)	48.5 (232)	28.9 (138)	53.8 (257)
High	30.0 (297)	15.8 (47)	41.8 (124)	23.2 (69)	47.8 (142)
Sample	100 (989)	23.0 (227)	46.9 (464)	29.2 (289)	51.7 (511)

[1] Column presents characteristics of respondents engaged in the risky behavior. Numbers are compared to people who are not engaged in this behavior.
*= Significant at p <.001 level derived from chi2 and ANOVA tests.

2.3.2 Combinations of unhealthy SNAP behaviors

All possible combinations of unhealthy SNAP behaviors were present in our sample (table 2.2). Men were more frequently engaged in none of the unhealthy SNAP behaviors (19.6% vs. 15.8% in women), but the largest group of men was engaged in two or more unhealthy SNAP behaviors (36.3%), while the largest share of women was engaged in one unhealthy SNAP behavior (36.1%). People engaged in multiple unhealthy SNAP behaviors were mostly younger. People who reported physical inactivity, either alone or in combination with an unhealthy diet, were significantly higher educated. An unhealthy diet and physical inactivity was the most prevalent combination (16.5%). The frequency of other combinations of unhealthy behaviors was diffuse. Excessive alcohol consumption and smoking share that they are both addictive behaviors and are therefore regularly studied in combination. Hence, for this combination (independently from other presence of other unhealthy SNAP behaviors) we provided further characteristics concerning the attitudinal factors and subjective health in table 3, however this combination was not included in the regression analysis.

2.3.3 Unhealthy SNAP behaviors in relation to attitudinal factors and subjective health

Table 2.3 provides average scores of the attitudinal factors and subjective health. Smokers had the highest score on the CFC-I, indicating a high focus on immediate consequences. Smokers also had the highest score on the HRAS-6: they were more risk seeking in the health domain than non-smokers. SRH and SLE were significantly lower for people engaged in an unhealthy SNAP behavior. Smokers reported the lowest subjective health values.

The presence of multiple unhealthy SNAP behaviors was associated with a higher CFC-I score. The absence of an unhealthy SNAP behavior was associated with a higher CFC-F score. SRH and SLE decreased significantly when the number of unhealthy SNAP behaviors increased. A noteworthy finding is the gap of 2.1 points in SRH (scale 0-10) between people with zero and four unhealthy SNAP behaviors. Likewise, the discrepancy in SLE between zero and four unhealthy SNAP behaviors was remarkable at almost 12 years (86 versus 74).

The most prevalent combination (unhealthy diet and physical inactivity) showed values comparable to the study population averages on all characteristics. The combination smoking and excessive alcohol consumption (SA, n=16; SNA, n=14; SAP, n=21; SNAP, n=23) occurred in only 7.5% of the sample. This group is significantly more focused on immediate consequences and less on future consequences. They also appear to be relatively more risk seeking and had relatively low values on both SRH and SLE.

Table 2.2 Cumulative unhealthy SNAP behaviors present, and all possible combinations stratified by age, sex and level of education, % (n)

Cumulative unhealthy SNAP behaviors and combinations			Gender		Age, μ*	Highest educational level		
		Total	Men	Women		Low	Medium	High
0	No unhealthy SNAP behaviors	17.7 (175)	19.6 (98)	15.8 (77)	56.1	16.4 (35)	15.1 (72)	22.9 (68)
1	Smoking (S)	4.2 (42)	4.8 (24)	3.7 (18)	55.2	3.7 (8)	5.0 (24)	3.4 (10)
	Unhealthy diet (N)	7.9 (78)	6.8 (34)	9.0 (44)	49.1	6.0 (13)	8.6 (41)	8.1 (24)
	Excessive drinking (A)	7.4 (73)	5.8 (29)	9.0 (44)	51.3	4.7 (10)	7.7 (37)	8.8 (26)
	Physical inactivity (P)	13.3 (131)	12.2 (61)	14.3 (70)	54.5	8.9 (19)	14.2 (68)	14.8 (44)
	Total	32.8 (324)	29.5 (148)	36.1 (176)	52.6	23.4 (50)	35.6 (170)	35.0 (104)
2	S N	3.9 (39)	5.2 (26)	2.7 (13)	53.1	7.5 (16)	2.9 (14)	3.0 (9)
	S A	1.6 (16)	1.0 (5)	2.3 (11)	57.1	4.2 (9)	1.1 (5)	0.7 (2)
	S P	2.5 (25)	3.0 (15)	2.0 (10)	47.7	1.4 (3)	2.5 (12)	3.4 (10)
	N A	4.2 (41)	4.4 (22)	3.9 (19)	49.3	3.7 (8)	4.2 (20)	4.4 (13)
	N P	16.5 (163)	19.4 (97)	13.5 (66)	48.3	12.6 (27)	17.2 (82)	18.2 (54)
	A P	4.3 (42)	3.4 (17)	5.1 (25)	53.4	7.5 (16)	3.4 (16)	3.4 (10)
	Total	33.0 (326)	36.3 (182)	29.5 (144)	50.4	36.9 (79)	31.2 (149)	33.0 (98)
3	S N A	1.4 (14)	2.0 (10)	0.8 (4)	48.6	1.4 (3)	1.7 (8)	1.0 (3)
	S N P	4.8 (47)	4.6 (23)	4.9 (24)	47.4	5.1 (11)	5.7 (27)	3.0 (9)
	S A P	2.1 (21)	1.6 (8)	2.7 (13)	47.7	2.8 (6)	2.5 (12)	1.0 (3)
	N A P	6.0 (59)	4.4 (22)	7.6 (37)	45.3	9.8 (21)	5.7 (27)	3.7 (11)
	Total	14.3 (141)	12.6 (63)	16.0 (78)	46.7	19.2 (41)	15.5 (74)	8.8 (26)
4	S N A P	2.3 (23)	2.0 (10)	2.7 (13)	49.7	4.2 (9)	2.7 (13)	0.3 (1)
	Total	100 (989)	100 (501)	100 (488)	51.6	100 (214)	100 (478)	100 (297)

*= Significant at p <.001 level derived from an ANOVA test

2

Table 2.3 Group mean values of attitudinal factors and subjective health by unhealthy SNAP behaviors, tested for significance

Prevalence behavior		% (N)	CFC–I [1]	CFC–F [2]	HRAS-6 [3]	Self-rated health	Subjective life expectancy
S	Risky	23.0 (227)	4.0*	4.1*	20.5*	6.6*	80.4*
	Healthy	77.0 (762)	3.7	4.4	17.0	7.1	84.1
N	Risky	46.9 (464)	3.8	4.3	19.5*	6.7*	82.2*
	Healthy	53.1 (525)	3.7	4.4	16.2	7.2	84.2
A	Risky	29.2 (289)	3.9	4.4	18.0	6.7*	81.9
	Healthy	70.8 (700)	3.7	4.4	17.7	7.1	83.8
P	Risky	51.7 (511)	3.8	4.4	18.8*	6.7*	82.6
	Healthy	48.3 (478)	3.7	4.4	16.7	7.3	84.0
Lifestyle index							
0		17.7 (175)	3.6*	4.6*	14.7*	7.6*	85.5*
1		32.8 (324)	3.7	4.4	16.9	7.2	84.2
2		33.0 (326)	3.8	4.3	18.6	6.8	83.1
3		14.3 (141)	4.1	4.2	21.1	6.4	80.4
4		2.3 (23)	4.2	4.5	22.1	5.5	73.7
Prevalent combinations of unhealthy behaviors							
P N		16.5 (163)	3.6	4.4	19.2*	6.8	82.9
S A **		7.5 (74)	4.1	4.1	22.1*	6.0*	77.1*
Total		100 (989)	3.7	4.4	17.8	7.0	83.3

*= Significant at p <.001 level derived from an ANOVA test
**= Combination independent from engagement in other unhealthy SNAP behaviors
[1] Consideration of Future Consequence – Immediate; [2] Consideration of Future Consequence – Immediate;
[3] Health Risk Assessment Scale – 6 items

2.3.4 Logistic regressions

Odds ratios of the bivariate analysis, crude analysis, and adjusted associations of the individual and clustered unhealthy SNAP behaviors with the attitudinal factors and subjective health are presented in the Appendix (as models M1, M2 and M3, respectively). Table 2.4 summarizes these results and presents the adjusted associations (which coincide with the models M3 in the Appendix).

Attitudinal factors

Smoking, excessive drinking, and the lifestyle index were significantly associated with CFC-I scores, which increased the odds by 30% (95% CI; 1.08-1.56), 18% (95% CI; 1.00-1.38) and 19% (95% CI; 1.01-1.39) respectively. The combination of being physically inactive and having an unhealthy diet was significantly associated with CFC-I scores, which decreased the odds by 19% (95% CI; 0.66-0.99). Only physical inactivity was significantly associated with CFC-F scores, which increased the odds by 20% (95%

CI: 1.01-1.44). Smoking, an unhealthy diet, and physical inactivity were significantly associated with HRAS-6 scores, which increased the odds by 12% (95% CI; 1.08-1.15), 9% (95% CI; 1.06-1.12) and 6% (95% CI; 1.03-1.09), respectively. The combination of physical inactivity and an unhealthy diet, and the lifestyle index were also significantly associated with HRAS-6 scores, which increased the odds by 4% (95% CI; 1.00-1.09) and 9% (95% CI; 1.06-1.12), respectively.

Subjective health

An unhealthy diet, excessive drinking, and physical inactivity were significantly associated with SRH, which decreased the odds by 11% (95% CI; 0.81-0.98), 15% (95% CI; 0.77-0.94); and 16% (95% CI; 0.76-0.92) respectively. The lifestyle index was also significantly associated with SRH, which decreased the odds by 19% (95% CI: 0.74-0.90). Only smoking was significantly associated with SLE, which decreased the odds by 3% (95% CI: 0.95-0.99).

Sociodemographic characteristics

The socio-demographic control variables had the following associations. All SNAP behaviors except smoking, the combination of physical inactivity and an unhealthy diet, and the lifestyle index were significantly associated with age, which decreased the odds by between 1% and 3%. An unhealthy diet and the combination of physical inactivity and an unhealthy diet were significantly associated with being a female, which decreased the odds by 25% (0.57-0.99) and 42% (95% CI: 0.41-0.83), respectively. Excessive drinking was also significantly associated with being a female, which increased the odds by 45% (95% CI: 1.09-1.90). Finally, smoking and an unhealthy diet were significantly associated with high level of education compared to low level of education, which decreased the odds by 51% (95% CI; 0.30-0.80) and 42% (95% CI; 0.39-0.88), respectively. Excessive drinking and the lifestyle index were significantly associated with both medium and high level of education compared to low level of education, which decreased the odds by 33% (95% CI; 0.47-0.97) and 45% (95% CI; 0.36-0.85) for excessive drinking and decreased the odds by 47% (95% CI; 0.37 – 0.77) and 58% (95% CI; 0.28-0.64) for the lifestyle index.

Table 2.4 Odds ratio's with 95% confidence intervals for the presence of unhealthy SNAP behaviors (N=984)

Variable		SNAP behaviors[4]								Combinations of unhealthy behaviors [5]			
		Smoking		Unhealthy diet		Excessive drinking		Physical inactivity		P & N		Lifestyle index	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
CFC-I [1]		1.30*	1.08-1.56	1.11	0.95-1.30	1.18*	1.00-1.38	1.05	0.91-1.22	0.81*	0.66-0.99	1.19*	1.01-1.39
CFC-F [2]		0.95	0.77-1.18	1.04	0.87-1.25	1.09	0.90-1.31	1.20*	1.01-1.44	0.92	0.72-1.17	1.05	0.87-1.27
HRAS – 6 [3]		1.12*	1.08-1.15	1.09*	1.06-1.12	0.99	0.96-1.01	1.06*	1.03-1.09	1.04*	1.00-1.09	1.09*	1.06-1.12
Self-rated health		1.00	0.89-1.12	0.89*	0.81-0.98	0.85*	0.77-0.94	0.84*	0.76-0.92	0.92	0.82-1.04	0.81*	0.74-0.90
Subjective life expectancy		0.97*	0.95-0.99	1.00	0.98-1.01	0.99	0.97-1.00	1.00	0.98-1.01	1.00	0.99-1.02	0.99	0.97-1.00
Age		1.01	0.99-1.02	0.97*	0.86-0.98	0.98*	0.97-0.99	0.99*	0.98-0.99	0.98*	0.97-0.99	0.98*	0.97-0.99
Sex	Male		Ref		Ref		Ref		Ref	Ref		Ref	
	Female	0.86	0.62-1.19	0.75*	0.57-0.99	1.45*	1.09-1.90	1.06	0.81-1.38	0.58*	0.41-0.83	0.77	0.59-1.02
Highest educ. level	Low		Ref		Ref		Ref		Ref	Ref		Ref	
	Middle	0.74	0.50-1.10	0.75	0.52-1.06	0.67*	0.47-0.97	0.99	0.70-1.40	1.18	0.71-1.93	0.53*	0.37-0.77
	High	0.49*	0.30-0.80	0.58*	0.39-0.88	0.55*	0.36-0.85	0.79	0.53-1.17	1.22	0.70-2.11	0.42*	0.28-0.64
Nagelkerke R2		0.166		0.163		0.070		0.080		0.058		0.196	
Cox and Snell R2		0.110		0.122		0.049		0.060		0.034		0.147	

* = Significant at p <.05 level
[1] Consideration of Future Consequence – Immediate; [2] Consideration of Future Consequence – Immediate; [3] Health Risk Assessment Scale – 6 items; [4] absent (0) versus present (1)
[5] 0 or 1 unhealthy SNAP behavior present versus 2, 3 or 4 unhealthy SNAP behaviors present

2.4 DISCUSSION

In the current study, unhealthy SNAP behaviors were studied independently and in combination with each other. The prevalence of smoking, unhealthy diet and physical inactivity was comparable to figures for the general Dutch population [42]. However, the prevalence of excessive alcohol consumption (29%) was considerably higher than reported in official Dutch population statistics (9%) [42]. Half of our study population was engaged in two or more unhealthy SNAP behaviors. The most prevalent combination was an unhealthy diet combined with physical inactivity (17%). Smoking, drinking excessively and the lifestyle index were significantly associated with an increased focus on the immediate consequences of behavior (i.e., the CFC-I). On the other hand, we also found that being physical inactive was significantly associated with an increased focus on the future consequences of behavior (i.e., the CFC-F). This latter finding is contradictory to what one may expect. These findings may have implications for public health policy but need to be confirmed longitudinally.

Applying the two-factor structure of the CFC in our regression analysis revealed that smokers were significantly more oriented on immediate consequences compared to non-smokers. However, we did not find a future-oriented attitude among non-smokers. This finding underlines the added value of a two-factor structure for the CFC. Previous studies also found that smokers are more present oriented, both when using the CFC as one scale [43] or two sub-scales [17]. The CFC also has been used in relation to healthy eating, physical activity and BMI [17, 34, 43, 44]. Our results confirm previous findings, indicating that people engaged in unhealthy behavior(s) are especially oriented towards the immediate consequences of their behavior. This finding does not apply to physical activity, however. We even found a more future oriented attitude for physically inactive people. This finding is counter intuitive since physical activity typically provides gains on the long term. Doing sports is also found to bring positivity and reward just after the exercise and therefore a more present-oriented attitude may also suit athletic people [45]. In this study the question concerning physical activity not only involved “physical exercise” or “sports” but also walking or climbing stairs. Therefore, an appropriate interpretation of this finding is complicated. We found that the people who had both an unhealthy diet and were physical inactive were significantly less oriented on immediate consequences. This implies that time orientation for unhealthy SNAP behaviors can differ between a single behavior and a particular combination of behaviors. Findings regarding risk attitude were in line with the general risk attitude hypothesis. People engaged in an unhealthy SNAP behavior, except for excessive drinking, were more risk seeking than those people not engaged in this unhealthy SNAP behavior. This association was persistent when considering multiple unhealthy SNAP behaviors. The HRAS-6 (the instrument we applied for risk attitude assessment) has recently been introduced and was shown to be a valid and reliable measure of health-risks attitudes [38]. The different results found for alcohol consumption could be related to the high percentage of excessive alcohol drinkers in our population, which might be less representative of problematic drinking populations.

The presence of unhealthy SNAP behaviors was associated with significantly lower SRH, although for smoking this was not confirmed in the regression analyzes. Two potential explanations can be put forward. First, in the regression analyzes we controlled for the potential differences in SRH attributed to co-variates. It is conceivable that the co-variates (sociodemographic characteristics) explain differences in SRH more than smoking does. Second, it is suggested in the literature that smokers tend to underestimate short-term risks of smoking [46]. This phenomenon might be reflected in the current SRH status of smokers. The clustering of unhealthy SNAP behaviors and the association of these clusters to SRH has been studied before [47]. Conry et al., (2011) found that respondents with multiple unhealthy SNAP behaviors reported less good SRH scores than respondents with less unhealthy SNAP behaviors.

In the logistic regression analyzes, the association between unhealthy SNAP behaviors and SLE only remained significant for smoking. This may imply that people are aware of negative long term health consequences of smoking, which has also been found in previous studies [48-51]. Hence, reiterating long-term consequences in preventive messages may have little effect on behavior, which is emphasized by the finding that people engaged in an unhealthy SNAP behavior are more focused on immediate rather than future consequences. Two other remarks can be made about the association between SLE and unhealthy behavior. First, a person engaged in risky behavior might already experience decreased health due to the chosen lifestyle, which in turn negatively affects SLE. Second, one might expect a lower life expectancy when family members on average died relatively young [27, 52]. Unhealthy habits may then be expected to not or only marginally affect the already low life expectancy.

2.4.1 Study limitations and strengths

Several limitations of this study need to be mentioned. First, the unhealthy SNAP behaviors were operationalized through dichotomization, with people either having the risk factor or not. Cut-off points from national guidelines were used to do so. It is important to note that these cut-off points remain somewhat arbitrary, and our findings may be sensitive to the cut-off point chosen. For instance, using the national guidelines we observed a considerably higher prevalence of excessive drinking in our sample as compared to national statistics. However, this prevalence would have been even higher if we had adopted alternative, often stricter, international guidelines for excessive drinking, for example the classification defined by the National Institute on Alcohol Abuse and Alcoholism (NIAAA). Second, unhealthy SNAP behaviors were self-reported, which might result in an under- or over estimation of certain habits. Third, alcohol consumption in this study population substantially differed from that of the Dutch population (29% versus 9%). This may highlight that the panel of the sampling agency reached a particular selection of Dutch individuals. This limits the generalizability of our findings. Fourth, we do not know how many people declined to participate in the survey, or dropped out, as this information was not made available by the survey company for commercial reasons. This information is important to examine potential selection bias in the sample, and given its unavailability, we cannot rule out potential selection bias. Fifth, due to the cross-sectional design of our study, we could not investigate causal relationships. For instance, our data does not allow us to investigate whether people become more present-oriented because they smoke, or whether people become smokers more easily because they are more present-oriented. While examining this further is important, knowing the associations may already be useful for designing interventions and future research.

Several strengths of this study also deserve to be highlighted. Except for the over-representation of excessive alcohol drinkers, our sample appears to be fairly representative of the adult population of the Netherlands in terms of sex, age, educational level and unhealthy SNAP behaviors. The study sample was large with almost 1,000 respondents. Moreover, our dataset was relatively rich in terms of the wide variety of included variables. Finally, we tested different clustering techniques to identify combinations of unhealthy SNAP behaviors in the sample, but in the end opted for the simpler and more straightforward approach presented here. The results for this approach were essentially the same and had a somewhat clearer interpretation. In addition, this approach for clustering the unhealthy SNAP behaviors is easier to communicate to a general audience with a less advanced background in statistics.

2.5 CONCLUSIONS

Our findings emphasize the relevance of taking a holistic approach to health prevention rather than focusing on a single behavior only. We conclude from our study that people who were engaged in none or one unhealthy SNAP behavior differ significantly on attitudinal factors and subjective health from people engaged in multiple unhealthy SNAP behaviors. However, the specific combination of unhealthy SNAP behaviors also seems to matter, as the most prevalent combination (physical inactivity and an unhealthy diet) showed an opposite relationship with time orientation as compared to the lifestyle index. People who engage in just one unhealthy SNAP behavior may lack willingness to change because they feel they compensate for this behavior with other healthy habits. On the other hand, people engaged in multiple unhealthy SNAP behaviors might be less easily affected by health promotion messages. Policy or specific interventions targeting lifestyle could incorporate the attitudinal factors analyzed in this study to increase the probability of reaching the desired target group.

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APPENDIX

Appendix 1.

Table A1. Bivariate, crude and adjusted logistic regressions - Smoking

		Smoking					
		M1		M2		M3	
		OR (p)	CI	OR (p)	CI	OR (p)	CI
CFC		0.53* (.00)	0.43-0.66				
CFC-I		1.50* (.00)	1.28-1.76	1.37* (.00)	1.14-1.64	1.30* (.00)	1.08-1.56
CFC-F		0.66* (.00)	0.55-0.79	0.90 (.33)	0.73-1.11	0.95 (.63)	0.77-1.18
HRAS-6		1.13* (.00)	1.09-1.16	1.10* (.00)	1.07-1.14	1.12* (.00)	1.08-1.15
SRH		0.83* (.00)	0.76-0.91	0.97 (.53)	0.86-1.08	1.00 (.95)	0.89-1.12
SLE		0.96* (.00)	0.94-0.97	0.97* (.00)	0.95-0.99	0.97* (.00)	0.95-0.99
Age						1.00 (.38)	0.99-1.02
Sex	Male					1.00	
	Female					0.86 (.36)	0.62-1.19
Education level	Low					1.00	
	Middle					0.74 (.14)	0.50-1.10
	High					0.49* (.00)	0.30-0.80
Nagelkerke R2				0.151		0.166	

M1: bivariate associations of dependent variable with single characteristics
M2: characteristics corrected for each other
M3: odds ratios adjusted for socio demographic characteristics of respondents
* = significant at p <0.05 level

Table A2. Bivariate, crude and adjusted logistic regressions – Unhealthy diet

		Unhealthy diet					
		M1		M2		M3	
		OR (p)	CI	OR (p)	CI	OR (p)	CI
CFC		0.76* (.00)	0.64-0.91				
CFC-I		1.19* (.00)	1.04-1.36	1.15 (.07)	0.99-1.33	1.11 (.18)	0.95-1.30
CFC-F		0.85* (.02)	0.72-0.97	1.09 (.35)	0.91-1.30	1.04 (.66)	0.87-1.25
HRAS-6		1.12* (.00)	1.09-1.15	1.11* (.00)	1.08-1.14	1.09* (.00)	1.06-1.12
SRH		0.82* (.00)	0.75-0.89	0.90* (.02)	0.82-0.99	0.89* (.00)	0.81-0.98
SLE		0.98* (.00)	0.96-0.99	0.99 (.36)	0.98-1.00	1.00 (.53)	0.98-1.01
Age						0.97* (.00)	0.86-0.98
Sex	Male					1.00	
	Female					0.75* (.00)	0.57-0.99
Education level	Low					1.00	
	Middle					0.75 (.11)	0.52-1.06
	High					0.58* (.00)	0.39-0.88
Nagelkerke R2				0.124		0.163	

M1: bivariate associations of dependent variable with single characteristics
M2: multivariate associations of dependent variable with characteristics
M3: odds ratios adjusted for socio demographic characteristics of respondents
* = significant at p <.05 level

Table A3. Bivariate, crude and adjusted logistic regressions – Excessive drinking

		Excessive drinking					
		M1		M2		M3	
		OR(p)	CI	OR(p)	CI	OR(p)	CI
CFC		0.84 (.08)	0.70-1.02				
CFC-I		1.18* (.02)	1.02-1.37	1.21* (.01)	1.04-1.41	1.18* (.04)	1.00-1.38
CFC-F		0.96 (.64)	0.82-1.13	1.06 (.53)	0.88-1.27	1.09 (.37)	0.90-1.31
HRAS-6		1.01 (.39)	0.99-1.03	0.99 (.44)	0.96-1.02	0.99 (.35)	0.96-1.01
SRH		0.83* (.00)	0.76-0.90	0.84* (.00)	0.76-0.92	0.85* (.00)	0.77-0.94
SLE		0.98* (.00)	0.96-0.99	0.99 (.10)	0.97-1.00	0.99 (.15)	0.97-1.00
Age						0.98* (.00)	0.97-0.99
Sex	Male					1.00	
	Female					1.45* (.01)	1.09-1.90
Education level	Low					1.00	
	Middle					0.67* (.03)	0.47-0.97
	High					0.55* (.00)	0.36-0.85
Nagelkerke R2				0.039		0.070	

M1: bivariate associations of dependent variable with single characteristics
M2: multivariate associations of dependent variable with characteristics
M3: odds ratios adjusted for socio demographic characteristics of respondents
*** = significant at p <.001 level; ** =significant at p <0.005 level; *= significant at p <.05 level

Table A4. Bivariate, crude and adjusted logistic regressions – Physical inactivity

		Physical inactivity					
		M1		M2		M3	
		OR(p)	CI	OR(p)	CI	OR(p)	CI
CFC		0.93 (.41)	0.78-1.10				
CFC-I		1.08 (.25)	0.95-1.23	1.07 (.39)	0.92-1.23	1.05 (.51)	0.91-1.22
CFC-F		0.99 (.91)	0.85-1.15	1.20* (.03)	1.01-1.43	1.20* (.03)	1.01-1.44
HRAS-6		1.07*(.00)	1.04-1.09	1.01* (.00)	1.03-1.09	1.06* (.00)	1.03-1.09
SRH		0.80* (.00)	0.73-0.87	0.84* (.00)	0.76-0.92	0.84* (.00)	0.76-0.92
SLE		0.98* (.01)	0.97-1.00	1.00 (.84)	0.98-1.01	1.00 (.98)	0.98-1.01
Age						0.99* (.04)	0.98-0.99
Sex	Male					1.00	
	Female					1.06 (.67)	0.81-1.38
Education level	Low					1.00	
	Middle					0.99 (.95)	0.70-1.40
	High					0.79 (.24)	0.53-1.17
Nagelkerke R2				0.071		0.080	

M1: bivariate associations of dependent variable with single characteristics
M2: multivariate associations of dependent variable with characteristics
M3: odds ratios adjusted for socio demographic characteristics of respondents
*= significant at p <.05 level

Table A5. Bivariate, crude and adjusted logistic regressions – Physical inactivity and unhealthy diet

		Physical inactivity and unhealthy diet					
		M1		M2		M3	
		OR (p)	CI	OR (p)	CI	OR (p)	CI
CFC		1.10 (.42)	0.87-1.38				
CFC-I		0.87 (.11)	0.72-1.03	0.80* (.03)	0.66-0.98	0.81* (.04)	0.66-0.99
CFC-F		0.96 (.68)	0.78-1.17	1.00 (.96)	0.80-1.27	0.92 (.50)	0.72-1.17
HRAS-6		1.06* (.00)	1.02-1.09	1.06* (.00)	1.02-1.10	1.04* (.02)	1.00-1.09
SRH		0.91 (.09)	0.82-1.01	0.95 (.42)	0.85-1.07	0.92 (.20)	0.82-1.04
SLE		1.00 (.60)	0.98-1.01	1.00 (.66)	0.99-1.02	1.00 (.65)	0.99-1.02
Age						0.98* (.00)	0.97-0.99
Sex	Male					1.00	
	Female					0.58* (.00)	0.41-0.83
Education level	Low					1.00	
	Middle					1.18 (.52)	0.71-1.93
	High					1.22 (.48)	0.70-2.11
Nagelkerke R2				0.032		0.058	

M1: bivariate associations of dependent variable with single characteristics
M2: multivariate associations of dependent variable with characteristics
M3: odds ratios adjusted for socio demographic characteristics of respondents
*= significant at p <.05 level

Table A6. Bivariate, crude and adjusted logistic regressions – Lifestyle index

		Lifestyle index[1]					
		M1		M2		M3	
		OR (p)	CI	OR (p)	CI	OR (p)	CI
CFC		0.68* (.00)	0.57-0.81				
CFC-I		1.31* (.00)	1.14-1.49	1.25* (.00)	1.07-1.46	1.19* (.03)	1.01-1.39
CFC-F		0.79* (.00)	0.68-0.92	1.07 (.48)	0.89-1.27	1.05 (.60)	0.87-1.27
HRAS-6		1.12* (.00)	1.09-1.14	1.10* (.00)	1.07-1.13	1.09* (.00)	1.06-1.12
SRH		0.73* (.00)	0.67-0.80	0.81* (.00)	0.73-0.89	0.81* (.00)	0.74-0.90
SLE		0.97* (.00)	0.96-0.98	0.99 (.13)	0.97-1.00	0.99 (.18)	0.97-1.00
Age						0.98* (.00)	0.97-0.99
Sex	Male					1.00	
	Female					0.77 (.07)	0.59-1.02
Education level	Low					1.00	
	Middle					0.53* (.00)	0.37-0.77
	High					0.42* (.00)	0.28-0.64
Nagelkerke R2				0.157		0.196	

M1: bivariate associations of dependent variable with single characteristics
M2: multivariate associations of dependent variable with characteristics
M3: odds ratios adjusted for socio demographic characteristics of respondents
[1]: 2 0 or 1 unhealthy SNAP behavior present versus 2, 3 or 4 unhealthy SNAP behaviors present
*= significant at p <.05 level

3 Socioeconomic inequalities in health behaviors across low- and middle-income countries

Based on: Dieteren, C.M., & Bonfrer, I. (2021). Socioeconomic inequalities in lifestyle risk factors across low-and middle-income countries. BMC public health, 21(1), 1-12.

ABSTRACT

Background

The heavy and ever rising burden of non-communicable diseases (NCDs) in low- and middle-income countries (LMICs) warrants interventions to reduce their underlying risk factors, which are often linked to lifestyles. To effectively supplement nationwide policies with targeted interventions, it is important to know how these risk factors are distributed across socioeconomic segments of populations in LMICs. This study quantifies the prevalence and socioeconomic inequalities in lifestyle risk factors in LMICs, to identify policy priorities conducive to the Sustainable Development Goal of a one third reduction in deaths from NCDs by 2030.

Methods

Data from 1,278,624 adult respondents to Demographic & Health Surveys across 22 LMICs between 2013 and 2018 are used to estimate crude prevalence rates and socioeconomic inequalities in tobacco use, overweight, harmful alcohol use and the clustering of these three in a household. Inequalities are measured by a concentration index and correlated with the percentage of GDP spent on health. We estimate a multilevel model to examine associations of individual characteristics with the different lifestyle risk factors.

Results

The prevalence of tobacco use among men ranges from 59.6% (Armenia) to 6.6% (Nigeria). The highest level of overweight among women is 83.7% (Egypt) while this is less than 12% in Burundi, Chad and Timor-Leste. 82.5% of women in Burundi report that their partner is “often or sometimes drunk” compared to 1.3% in Gambia. Tobacco use is concentrated among the poor, except for the low share of men smoking in Nigeria. Overweight, however, is concentrated among the better off, especially in Tanzania and Zimbabwe (Erreygers Index (EI) 0.227 and 0.232). Harmful alcohol use is more concentrated among the better off in Nigeria (EI 0.127), while Chad, Rwanda and Togo show an unequal pro-poor distribution (EI respectively -0.147, -0.210, -0.266). Cambodia exhibits the largest socioeconomic inequality in unhealthy household behavior (EI -0.253). The multilevel analyzes confirm that in LMICs, tobacco and alcohol use are largely concentrated among the poor, while overweight is concentrated among the better-off. The associations between the share of GDP spent on health and the socioeconomical distribution of lifestyle factors are multidirectional.

Conclusions

This study emphasizes the importance of lifestyle risk factors in LMICs and the socioeconomic variation therein. Given the different socioeconomic patterns in lifestyle risk factors - overweight patters in LMICs differ considerably from those in high income countries- tailored interventions towards specific high-risk populations are warranted to supplement nationwide policies.

3.1 BACKGROUND

The heavy and ever rising burden of non-communicable diseases (NCDs) in low- and middle-income countries (LMICs) warrants interventions to reduce their underlying risk factors, which are often linked to lifestyles. To effectively supplement nationwide policies with targeted interventions, it is important to know how these risk factors are distributed across socioeconomic segments of populations in LMICs.

An estimated 73 percent of total deaths worldwide are attributable to NCDs [1]. In LMICs NCD-related deaths are expected to increase from about 30 million currently to 41.8 million by 2030 [2]. The Sustainable Development Goal agenda [3] aims to reduce pre-mature mortality from NCDs with one-third by 2030. Progress so far has been uneven, both across and within countries [4], and the COVID-19 pandemic is eroding earlier gains [5].

The links between lifestyle risk factors or preventable factors - tobacco use, harmful alcohol use and the combination of unhealthy diet and physical inactivity resulting in overweight - and NCDs are well documented [6–8]. In high income settings, lifestyle risk factors are most prevalent among those with a lower socioeconomic status [9,10]. Less is known about socioeconomic inequalities in lifestyle risk factors across LMICs [11], which limits opportunities for targeting effective interventions on those exposed to greatest risk which is an approach that is increasingly being implemented in among others healthcare facilities [12,13]. Such targeted interventions could provide an important supplement to national policies such as taxation of unhealthy foods and tobacco to reduce consumption of these goods. An important, and sometimes underappreciated aspect of these lifestyle risk factors, is the limited choice that individuals might have in adopting and changing these unhealthy lifestyles due to structural inequalities. Overweight for example, is in many cases not simply a result of a choice to consume unhealthy foods, but a result of a food environment with limited food options available [14].

Yaya et al. [15] (2018) studied women across 33 Sub Saharan African countries and found that alcohol consumption and overweight were more prevalent among the better off, while tobacco use was more concentrated in the poor segments of the population. A systematic review by Allen et al. (2017) [16] on the association between socioeconomic status and lifestyle risk factors in LMICs, included data from 75 studies conducted between 1990 and 2015. Only two studies [17,18] reported data on more than one LMIC. Hosseinpoor et al. (2012) [17] studied 48 LMICs and found that daily smoking as well as low fruit and vegetable consumption were more prevalent among those with a lower socioeconomic status. However, their data are dated and lack information on alcohol consumption and overweight. In addition, unhealthy behaviors are likely to cluster [19] – see Chapter 2 -, and there is not much known about the prevalence of multiple lifestyle risk factors within a person or household in LMICs. In a comment on Allen et al. (2017) [16], Stringhini & Bovet (2017) [20] emphasize the lack of systematically compared data from LMICs to determine and explain socioeconomic inequality in lifestyle risk factors.

This study aims to fill part of that gap by quantifying the prevalence and socioeconomic inequalities in three lifestyle risk factors - smoking, harmful alcohol use and overweight -in 9 low-income countries (LICs) and 13 middle-income countries (MICs). This will help to identify policy priorities conducive to the Sustainable Development Goal of a one third reduction in deaths from NCDs by 2030. In this study, we use self-reported information on smoking, while overweight is determined by actual measured height and weight. Insights about harmful alcohol use are based on reports from a randomly selected subsample of women about alcohol use of their partner. We also extend the existing literature by studying cumulation of these unhealthy behaviors within households to determine which couples are most likely to jointly exhibit two or more of these three lifestyle risk factors.

We use data from 1,278,624 adults in the Demographics and Health Surveys (DHS) between 2013 and 2018. We investigate whether countries that spend more on health are less likely to exhibit large socioeconomic inequalities in lifestyle risk factors, which would be expected if several well targeted prevention programs are in place. However, it seems more likely that the better off are the first to benefit from early prevention programs, if available. We then estimate a multilevel model to associate individual characteristics with tobacco use, overweight, harmful alcohol use and the cumulation of these lifestyle risk factors within a household.

3.2 METHODS

3.2.1 Data

We exploit the Standard Demographic and Health Surveys (DHS) containing data from nationally representative, randomly selected samples of women in reproductive age (15-49) and smaller samples of randomly selected men (age 15-59) in LMICs [21]. The DHS is comparable across countries and contains data on demographics and health behavior. The DHS is publicly available for research purposes and the corresponding research protocols are reviewed and approved by an Institutional Review Board. Informed consent is obtained from each respondent before the start of the interview [22].

We include all Demographic and Health Surveys from 2013 onwards containing data on at least one of three unhealthy lifestyles: tobacco use, overweight and harmful alcohol use. Unfortunately, the data do not allow us to disentangle overweight into aspects related to unhealthy diet versus physical inactivity, but we are referring to the combination of these two when studying "overweight". Surveys collected before

2013 are excluded to ensure policy relevance. In case more than one DHS was fielded in the same country since 2013, we include the most recent one. This results in data from 9 LICs and 13 MICs covering a total of 1,029,182 women, as shown in Appendix 1. Sample sizes range from 6,116 (Armenia) to 699,686 (India) women. Most countries were African (n=16), a few Asian (n=5) and one Eastern European. Interviews with men were in most countries performed in every third household [18] resulting in a total sample of 249,442 men from 19 countries, with country-level sample sizes ranging from 2,755 (Armenia) to 112,122 (India) men as shown in Appendix 1. No data were collected among men in Chad, Egypt and Tajikistan. To estimate cumulative presence of lifestyle risk factors within a household, we use data from the subset of couples where both partners were interviewed in respectively the female and male survey. Sample sizes for each of the four outcome measures are shown in Table S1. Overweight (n = 882,820), based on height and weight measured during the interview is missing for 14 percent of women. Pregnant women were excluded from data collection on height and weight since BMI is not perceived an accurate measure of body composition during pregnancy [23]. Other women did not consent to have their measures taken. Harmful alcohol use is based on women's reports about alcohol consumption of their partner and was only collected among a randomly selected subsample of women via the "domestic violence" module of the DHS [18], resulting in a considerably smaller sample (n = 184,381). Tobacco use among men was available for virtually the entire sample (0.01% missing) and information from both partners was available for 125,393 couples.

Tobacco use was extremely low among women (ranging from only 0.1% in Tanzania to 5.2% in Rwanda) so we only included tobacco use among men. No data on husband or partner alcohol use was available for Albania, as shown in Table S1. In Egypt and Gambia less than two percent of women indicated that their husband or partner consumed alcohol. Consequently, Albania, Egypt and Gambia are excluded in the estimation of socioeconomic inequality in husband/partner's harmful alcohol consumption. In addition to these micro level data, we use the most recent macro level information (2017) on country health expenditure as percentage of GDP [24], to proxy nationwide investments in health.

3.2.2 Variables of interest

The three lifestyle risk factors are operationalized as follows. Tobacco use is based on self-reported information among men about current smoking, i.e., daily, sometimes, or never. Data on local smoking products were also collected but were excluded due to heterogeneity and low response rates. For ease of interpretation, tobacco use is dichotomized with 1 representing "daily" or "sometimes" and 0 otherwise. Secondly, the Body Mass Index (BMI) based on weight and height measured during the interview by trained surveyors, is used to define the dichotomous variable overweight with a BMI larger than 25.0 identified as overweight [25] and 0 otherwise. Height and weight measurements were only obtained among women, not among men. Thirdly, a randomly selected subset of women was asked whether their husband or partner consumed alcohol (alcohol use) and if yes, whether their husband or partner was never, sometimes or often drunk. Responses indicating that the partner was sometimes or often drunk were considered harmful alcohol use [1] and 0 otherwise. In addition to these three lifestyle risk factors at individual level, we also study the cumulation of these factors at household level. The cumulative presence of the three lifestyle risk factors was estimated within a household, using the couple's dataset. Household behavior was dichotomized into 1 unhealthy with two or the maximum of three lifestyle risk factors present in the couple, and 0 otherwise (e.g., non or one lifestyle risk factor).

To proxy socioeconomic status, we use the wealth quintiles provided in the DHS. These are derived from a wealth index ranking households based on a principal component analysis on a set of variables about household dwelling characteristics and asset ownership [26] including materials used for construction of the house, types of water access, sanitation facilities and ownership of televisions and bicycles [27]. This composite measure is considered an acceptable measure of wealth in LMICs. The lowest wealth quintile represents the 20 percent poorest part of the population while the highest quintile reflects the 20 percent best off. Filmer & Pritchett (2001) [26] have shown that that this method provides plausible and defensible weights for an asset index to serve as a proxy for wealth, even though income or expenditure data are not taken into account. To acknowledge the complexity and multidimensionality of socioeconomic status we also include education and occupation in our regression analysis.

Macrolevel country health expenditure is defined as the share of GDP spent on health i.e. health expenditure as % of GDP in 2020, the most recent data available [24]. We use health expenditure for all countries in our study sample for the same year, as opposed to the different data collection years, to allow for easier comparison. Ideally, we would have obtained information on spending earmarked for prevention and/or NCDs, but these are not available, to our knowledge.

Our multilevel models to determine individual characteristics of those using tobacco, being overweight, using harmful levels of alcohol and the cumulation of these in couples include rural/urban household, age categories, literacy, education, occupation, wealth index, household size and number of living children.

3.2.3 Analytical approach

Prevalence of lifestyle risk factors

The prevalence of the lifestyle risk factors for each country is calculated as a crude prevalence rate: dividing the total number of respondents with the lifestyle risk factor by the total number of respondents in the relevant study sample. For household unhealthy behavior the presence of two or three lifestyle risk factors in couples over the total number of couples was used as the prevalence.

Socioeconomic inequalities
We measure socioeconomic inequalities in lifestyle risk factors, i.e. variation in these factors across the wealth quintiles, with a concentration index suggested by Erreygers (2009) [28] for a dichotomous variable. This is simply the scaled covariance between the lifestyle risk factor (y_i) of individual i and their (fractional) rank (R_i) in the distribution of the wealth index:

$$EI(y) = 8\ cov(y_i, R_i) \quad \text{(Equation 1)}$$

This index takes values between -1 and 1. Positive values indicate a disproportionate concentration of the lifestyle risk factor among the better off, while negative values signal a disproportionate concentration among the poor. The STATA package "conindex" [29] is used for this analysis.

The micro level analyzes to estimate prevalence and socioeconomic inequalities in lifestyle risk factors (tobacco use, overweight, harmful alcohol use and unhealthy household behavior) are performed separately for each country.

Macro level association between inequalities and health expenditures
The within country estimations of inequalities are followed by a cross-country macro level analysis determining whether countries with smaller inequalities also tend to be those with a higher percentage of GDP spent on health. We calculate the average percentage of GDP spent on health across the countries in our sample as a reference value. Any country's spending on health above the reference value is considered "high" and otherwise "low". We map each country, differentiating between low- and middle-income countries, on a four-quadrant model of socioeconomic inequality (vertical axis) and health expenditure (horizontal axis) to identify countries with a "double disadvantage" i.e., both a skewed distribution of lifestyle risk factors towards the poor and low spending on health nationwide. This allows for identification of countries that could be prioritized by policy makers worldwide.

Multilevel analysis
We then estimate a multilevel probit model based on country fixed effects for each of the four (cumulative) lifestyle risk factors using the pooled set of data from all countries included in the study. Equation 2 describes the multilevel model.

$$y_{ic} = \beta' x_i + \gamma_c + \varepsilon_{ic} \quad \text{(Equation 2)}$$

where x_i is the set of individual characteristics, γ_c the country fixed effects and ε_{ic} the error term. This allows us to estimate the relation between individual characteristics and lifestyle risk factors while allowing for variation in these across countries. All analyzes were performed using software package StataMP 15.0.

3.3 RESULTS

3.3.1 Prevalence of lifestyle risk factors

Table A1 in the Appendix shows for each country the response rate on the lifestyle risk factors. The prevalence of the lifestyle risk factors by country (Table 3.1) indicate that tobacco use is most prevalent in Armenia and Timor-Leste: respectively 59.6% and 54.4% of men reported to smoke daily or sometimes. The highest level of overweight among women is found in Egypt (83.7%), followed by South Africa (61.6%) and Albania (58.5%). There is a wide range in the prevalence of women that reported that their partner is "often or sometimes drunk", with only 1.3% in Gambia and 82.5% in Burundi. In total, the prevalence was over 50% in three countries (Burundi, Cambodia and Rwanda). Only four countries had a prevalence below the 20% (Ethiopia, Gambia, Sierra Leone and Tajikistan), all low-income countries. The prevalence of cumulative unhealthy behavior within households (at least two lifestyle risk factors in a couple) is also diverse. Armenia and South Africa have the highest prevalence of unhealthy household behavior with 50.6% and 40.4%.

Table 3.1 Prevalence of lifestyle risk factors, N (%)

Country [code]	Income level	Tobacco use men		Overweight women		Harmful alcohol women's spouse		Unhealthy household behavior	
Albania [ALB]	MIC	2,077	(33.8)	8,617	(58.5)	*na*		*na*	
Armenia [ARM]	MIC	1,641	(59.6)	2,609	(45.5)	1,358	(38.4)	715	(50.6)
Burundi [BDI]	LIC	1,003	(12.2)	713	(9.0)	4,081	(55.4)	280	(14.3)
Cambodia [KHM]	MIC	1,652	(31.8)	2,007	(18.6)	2,885	(82.5)	871	(35.8)
Chad [TCD]	LIC	*na*		1,066	(11.0)	825	*(21.7)*	*na*	
Congo [CO]	MIC	1,837	(21.2)	1,149	(14.1)	2,291	(40.4)	106	(6.4)
Egypt [EGT]	MIC	*na*		16,197	(83.7)	*na*		*na*	
Ethiopia [ETH]	LIC	1,189	(9.7)	1,579	(11.5)	873	(18.5)	140	(4.5)
Gambia [GMB]	LIC	787	(20.6)	915	(21.9)	47	(1.3)	70	(8.0)
India [IND]	MIC	17,412	(15.5)	120,983	(18.5)	19,581	(29.7)	6,892	(13.5)
Kenya [KEN]	MIC	2,175	(17.0)	3,959	(29.4)	1,518	(33.6)	660	(19.1)
Malawi [MWI]	LIC	941	(12.6)	1,621	(21.9)	1,619	(30.0)	492	(15.2)
Nigeria [NGA]	MIC	1,144	(6.6)	8,380	(24.7)	3,523	(15.9)	503	(8.1)
Rwanda [RWA]	LIC	627	(10.1)	1,361	(21.9)	980	(51.5)	153	(16.9)
Sierra Leone [SLE]	LIC	2,002	(27.6)	1,372	(18.8)	660	(15.4)	225	(12.2)
South Africa [ZAF]	MIC	1,381	(38.2)	2,008	(61.6)	1,716	(43.0)	237	(40.4)
Tajikistan [TJK]	LIC	*na*		3,658	(36.9)	927	*(17.5)*	*na*	
Tanzania [TZA]	MIC	448	(12.8)	3,378	(28.1)	2,176	(28.6)	207	(16.3)
Timor-Leste [TLS]	MIC	2,512	(54.4)	1,094	(9.3)	1,243	(33.7)	163	(11.9)
Togo [TGO]	LIC	466	(10.4)	1,194	(27.2)	1,525	(28.4)	232	(12.9)
Zambia [ZMB]	MIC	3,014	(20.4)	3,210	(21.6)	4,270	(45.4)	1,598	(25.9)
Zimbabwe [ZWE]	MIC	1,553	(18.5)	3,307	(36.5)	2,230	(38.5)	882	(28.8)

3.3.2 Inequalities in the distribution of lifestyle risk factors

Table 3.2 shows the socioeconomic inequalities, based on the Erreygers Index (EI), for each of the lifestyle risk factors. Tobacco use is in all countries concentrated among the poor, except for Nigeria where we found a pro-rich distribution. Overweight, on the other hand, is concentrated in all countries towards those with a higher socioeconomic status. Armenia is the only country without significant inequality in overweight across socioeconomic groups. Socioeconomic inequalities in harmful alcohol use is more diverse. Four countries (Kenya, Sierra Leone, South Africa and Zimbabwe) show no wealth related inequalities in alcohol consumption. Nigeria is the only country where harmful alcohol use is most concentrated among the better off (EI 0.127), while Chad, India, Rwanda and Togo show the strongest unequal distribution towards the poor (EI respectively -0.147, -0.139, -0.210, -0.266). Accordingly, the Erreygers Indices for unhealthy household behavior show a diverse picture. Unhealthy behavior within a household is most concentrated among the poor (EI -0.253) in Cambodia. Only in Ethiopia, India, Nigeria and Timor-Leste significant positive Erreygers indices are reported, referring to a concentration among the better off (EI respectively 0.033, 0.063, 0.090 and 0.101).

The last column of Table 3.2 shows how the country average share of GDP spend on health differs (Δ) from the total average share (μ) in percentage points, indicating whether a country spends more or less than the average (6%) across these 22 LMICs. Sierra Leone spends the highest share of GDP on health (13.4%), followed by Armenia (10.4%) and Malawi (9.7%). On the other end of the spectrum, Congo, Gambia and India spend the lowest share of GDP on health, respectively 2.9%, 3.3% and 3.5%.

Table 3.2 Erreygers Indices estimates for lifestyle risk factors and national health care expenditures

Country	Income level	Erreygers Index – lifestyle risk factors				Health care expenditure[1]	
		Tobacco	Overweight	Harmful alcohol partner/husband	Unhealthy household behavior	% of GDP	Δ of μ % GDP
Albania	MI	-0.011	0.034*	na	na	6.7	0.7
Armenia	MI	-0.011	0.009	-0.062*	-0.004	10.4	4.4
Burundi	LI	-0.147*	0.073*	-0.191*	-0.071*	7.5	1.5
Cambodia	MI	-0.206*	0.053*	-0.049*	-0.254*	5.9	-0.1
Chad	LI	Na	0.061*	-0.141*	Na	4.5	-1.5
Congo	MI	-0.145*	0.074*	-0.088*	0.017	2.9	-3.1
Egypt	MI	Na	0.069*	Na	Na	5.3	-0.7
Ethiopia	LI	-0.045*	0.150*	0.082*	0.033*	3.5	-2.5
Gambia	LI	-0.028*	0.072*	Na	0.029	3.3	-2.7
India	MI	0.049*	0.210*	-0.139*	0.063*	3.5	-2.5
Kenya	MI	-0.093*	0.127*	0.005	0.010	4.8	-1.2
Malawi	LI	-0.012*	0.060*	-0.045*	-0.021	9.7	3.7
Nigeria	MI	0.072*	0.169*	0.127*	0.090*	3.8	-2.2
Rwanda	LI	-0.042*	0.094*	-0.210*	-0.071*	6.6	0.6
Sierra Leona	LI	-0.230*	0.058*	0.014	0.025	13.4	7.4
South Africa	MI	-0.053*	0.157*	0.000	-0.038	8.1	2.1
Tajikistan	LI	Na	0.071*	-0.024*	Na	7.2	1.2
Tanzania	MI	-0.053*	0.227*	-0.113*	-0.016	3.7	-2.3
Timor-Leste	MI	-0.115*	0.083*	-0.112*	0.101*	3.9	-2.1
Togo	LI	-0.091*	0.144*	-0.266*	-0.040*	6.2	0.2
Zambia	MI	-0.188*	0.179*	-0.089*	-0.096*	4.5	-1.5
Zimbabwe	MI	-0.097*	0.232*	-0.011	-0.062*	6.6	0.6
Average						6.0	

[1] Rounded based on two decimals with Δ of μ % indicating how a country's GDP spend on health differs (Δ) from the average over all countries (μ) in percentage points.
*= significant difference between wealth quintiles at p <.05 level

3.3.3 Socioeconomic inequalities and percentage of GDP spent on health

Figures 3.1 to 3.4 map each country on our four-quadrant model with socioeconomic inequality in the lifestyle risk factor of interest on the horizontal axis and average percentage of GDP spent on health on the vertical axis, distinguishing between low- and middle-income countries. The dotted reference line represents the average share of GDP (6.0%) spent on health across the countries in our sample. The top left quadrant contains countries with relatively higher shares of health expenditure, but the corresponding lifestyle risk factor concentrated among the poor where the latter is generally deemed “unfair”. The top right quadrant consists again of countries with relatively higher shares of health expenditure, but the lifestyle risk factor is concentrated among the better-off, which might suggest that these countries do not have the highest priority when it comes to reducing lifestyle risk factors among the poor, even though there is still considerable room for improvement. The bottom right quadrant shows low shares spend on health and concentration of the lifestyle risk factor among the better off. Finally, the bottom left corner contains the countries with a “double disadvantaged” population with the share spend on health relatively low and lifestyle risk factors concentrated among the poor. Countries in this bottom left quadrant should be prioritized in policies to reduce the morbidity and mortality from NCDs.

Tobacco use is mainly concentrated in the left quadrants (Figure 3.1), so among the poor (conventionally labelled as: “pro-poor”). This disadvantage is especially present for middle-income countries, where the pro-poor inequality coincides with relatively low shares of GDP spent on health. While we cannot identify an overall pattern it seems that, with the exemption of Sierra Leone, a higher share of GDP spent on health is observed in countries with less inequality i.e., a concentration index closer to zero. We observe for overweight (Figure 3.2), contrary to tobacco use, a pro-rich distribution with countries spending a higher share of their GDP on health having less inequality.

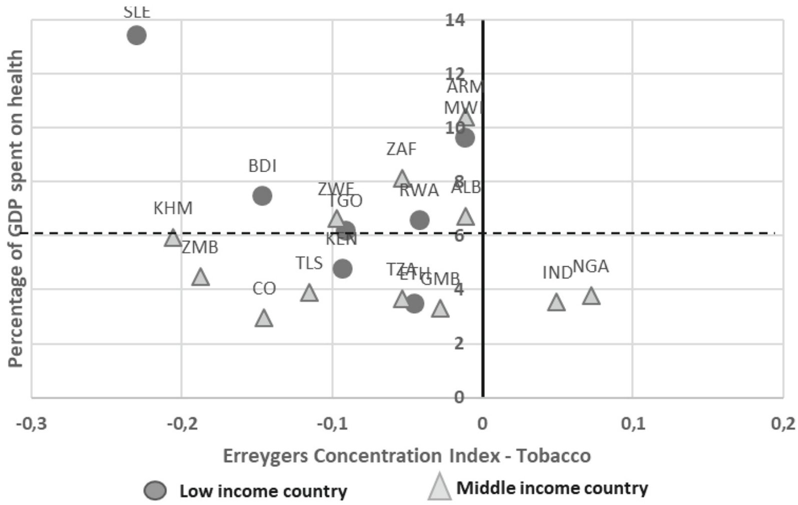

Figure 3.1 Tobacco use EI indices and percentage of GDP spent on health (with reference line for average % of GDP spent)

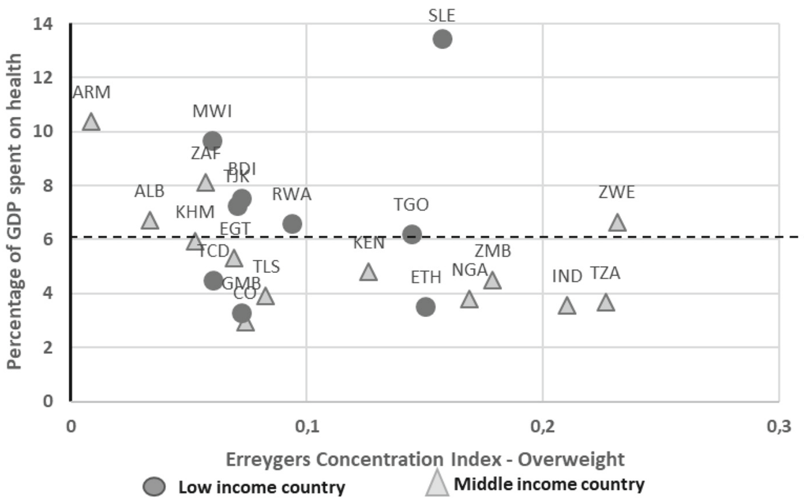

Figure 3.2 Overweight EI indices and percentage of GDP spent on health (with reference line for average % of GDP spent)

When mapping these countries in terms of harmful alcohol use (Figure 3.3), there are countries located in each of the four quadrants indicating that there is no strong association between the share of GDP spent on health and the socioeconomical distribution of harmful alcohol use. However, the countries at a "double disadvantaged" (bottom left quadrant) and thus with the most pressing need for effective interventions to reduce harmful alcohol use are Chad, Congo, India, Tanzania, Timor-Leste, Zambia and Cambodia. Figure 3.4 shows clustering of lifestyle risk factors in households (couples) and suggests that countries with a higher share of their GDP spent on health tend to have a pro-poor distribution of lifestyle risk factors within a household. Countries with a lower share of their GDP spent on health tend to have a pro-rich distribution of lifestyle risk factors within a household. As this figure shows the cumulative behavior of a household, this finding should be interpreted carefully as combinations of lifestyle risk factors within a household might differ. When comparing low- versus middle-income countries, we observe that the low-income countries more frequently have a pro-poor distribution, while the middle-income countries dominantly have a pro-rich distribution of these lifestyle risk factors. We refrain from multilevel analysis here, because of the limited sample size (n = 22 countries).

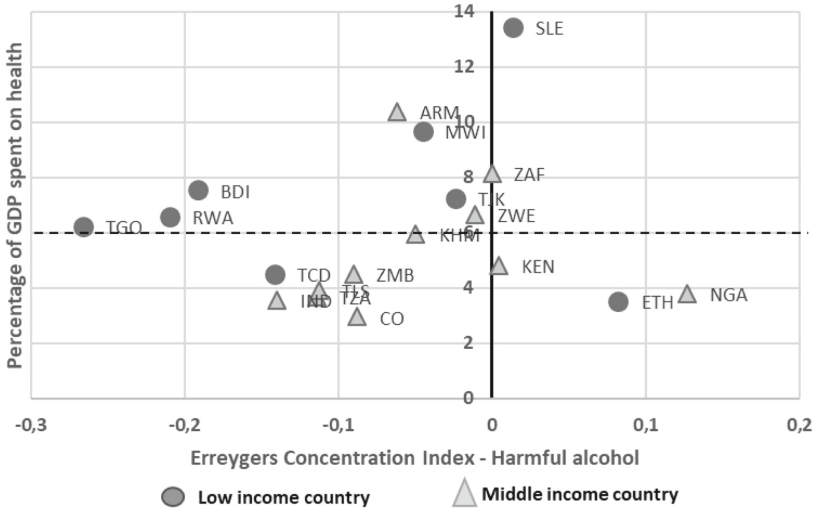

Figure 3.3 Harmful alcohol use EI indices and percentage of GDP spent on health (with reference line for average % of GDP spent)

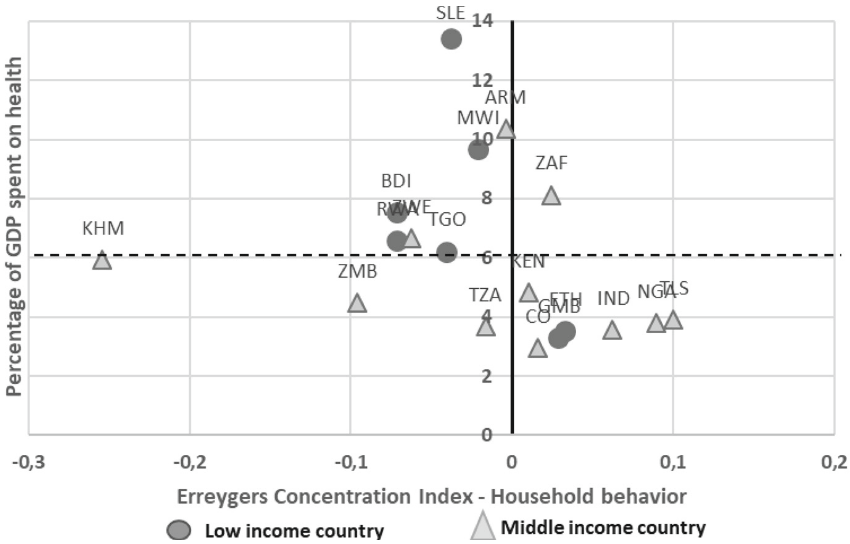

Figure 3.4 Unhealthy household behavior EI indices and percentage of GDP spent on health (with reference line for average % of GDP spent)

3.3.4 Individual characteristics and lifestyle risk factors

Table 3.3 contains descriptive statistics of the explanatory variables used in the multilevel models on the women's, men's and couples' samples. The information in Table 3.3 is based on the men and women in the couples' dataset[1]. For all countries combined, we find that a bit less than one third live in an urban area (30.1%) and half of the women indicate not to have an occupation (49.7%) compared to 4.7% among men. The average age in our sample is 37 years with an average household consisting of six members.

1 Descriptive statistics based on the women and men datasets are available from the authors upon request.

Table 3.3 Means of explanatory variables in multilevel probit regression model based on the couples' dataset[1]

	Female N (%)		Male N (%)	
Urban household	37,702	(30.1)	37,702	(30.1)
Literate	75,446	(60.2)	96,423	(77.0)
Secondary/higher educated	51,985	(41.4)	73,423	(58.6)
No occupation	61,727	(49.7)	5,838	(4.7)
White-collar	4,867	(3.9)	12,333	(9.9)
Blue-collar	22,308	(18.0)	48,524	(39.1)
Agriculture	35,342	(28.5)	57,325	(46.2)
	Mean (std. dev)		Mean (std. dev)	
Age	37.2	(8.1)	37.3	(8.6)
Household size	5.8	(2.9)	5.8	(2.9)
Number of living children	2.8	(1.9)	3.1	(2.5)
Total, N	125,393		125,393	

The results from the multilevel probit regression models (Table 3.4) confirm that tobacco and harmful alcohol use are concentrated among the poorer men, while overweight is concentrated among the better off women. When combining unhealthy behaviors among couples, as shown in the last column, we find that the probability of such clustering significantly increases with 0.07 among couples with women above 35 years old, compared to similar couples with a woman below 20 years old.

Table 3.4 Multilevel probit regression models, average marginal effects, (95% Confidence Interval)

	Tobacco[1]	Overweight[2]	Harmful alcohol use[3]	Unhealthy household behavior[4]
Rural household	Ref	Ref	Ref	Ref
Urban household	0.02* (.02 - .03)	0.02* (.02 - .03)	0.03* (.02-.03)	0.02* (.02 - .03)
Age below 20 yrs (F)		Ref	Ref	Ref
20 – 35 yrs (F)		0.17* (.16 - .17)	0.09* (.08-.11)	0.06 (.04 - .08)
above 35 yrs (F)		0.25* (.25 - .26)	0.11 (.10-.13)	0.07* (.05 - .09)
Age below 20 yrs (M)	Ref			Ref
20 – 35 yrs (M)	0.16* (.15 - .16)			0.03 (-.03 - .09)
above 35 yrs (M)	0.17* (.16 - .17)			0.06 (-.00 - .12)
Illiterate (F)		Ref	Ref	Ref
Literate (F)		0.03* (.02 - .03)	0.02* (.02-.03)	0.02 (.01 - .03)
Illiterate (M)	Ref			Ref
Literate (M)	0.00 (-.00 - .01)			0.01 (-.00 - .01)
Education: Less then primary (F)		Ref	Ref	Ref
Secondary or higher (F)		-0.02* (-.02--.01)	-0.01* (-.02--.00)	0.01
Education: Less then primary (M)	Ref			Ref
Secondary or higher (M)	-0.02* (-.03 -.01)			-0.01* (-.02 - -.00)
Occupation: none (F)		Ref	Ref	Ref
white-collar (F)		0.03* (.02 - .03)	0.04* (.03-.05)	-0.01 (-.02 - .00)
blue-collar (F)		0.01* (.01-.02)	0.09* (.09-.10)	0.02* (.01 - .02)
agriculture (F)		-0.03* (-.04--.03)	0.11* (.10-.11)	0.02 (.01 - .02)
Occupation: none (M)	Ref			Ref
white-collar (M)	0.02* (.01 - .02)			-0.02* (-.04 - -.01)
blue-collar (M)	0.06* (.05 - .06)			-0.00* (-.01 - .01)
agriculture (M)	0.04* (.03 - .04)			-0.02* (-.03 - -.00)

Table 3.4 Multilevel probit regression models, average marginal effects, (95% Confidence Interval) (continued)

	Tobacco[1]	Overweight[2]	Harmful alcohol use[3]	Unhealthy household behavior[4]
Wealth index: very poor	Ref	Ref	Ref	Ref
poor	-0.00 (-.01 - .00)	0.03* (.02 - .03)	-0.03* (-.04--.06)	0.00 (-.00 - .01)
middle	-0.00* (-.0 - .00)	0.06* (.06 - .07)	-0.05* (-.06- -.05)	0.02* (.01 - .02)
rich	-0.02* (.03 - .02)	0.11* (.11 - .12)	-0.07* (-.08 - -.07)	0.02* (.01- .03)
very rich	-0.05* (-.06--.05)	0.17* (.17 - .18)	-0.11* (-.12- -.10)	0.00* (-.01 - .01)
Household size	-0.00* (-.00--.00)	-0.00* (-.00--.00)	-0.01* (-.01 - -.01)	-0.01* (.01 - -.01)
Number of living children (F)		0.00* (.00 - .00)	0.01* (.01-.01)	0.01* (.00 - .01)
Number of living children (M)	0.00* (.00-.00)			0.00 (-.00 - .00)
Armenia	Ref	Ref	Ref	Ref
Albania	-0.17* (-.18--.15)	0.01 (-.09 - .02)	.	.
Burundi	-0.32* (-.33--.30)	0.14* (.13 - .16)	0.10* (.08 - .12)	-0.24 (-.26 - -.21)
Cambodia	-0.17* (-.18--.15)	0.02* (.01 - .04)	0.40* (.38-.42)	-0.08 (-.10 - -.06)
Chad	.	0.07* (.05 - .08)	-0.16* (-.18 -. -.14)	.
Congo	-0.25* (-.26--.23)	0.20* (.18 - .21)	-0.02* (.04 - -.00)	-0.34 (-.37 - -.31)
Egypt	.	0.42* (.41 - .44)	.	.
Ethiopia	-0.38* (-.39--.36)	-0.28* (-.29 -.26)	-0.21* (-.23 - -.19)	-0.37* (-.39 - -.35)
Gambia	-0.23* (-.24--.21)	0.28* (-.27 - .30)	Sample too small	-0.28* (-.31 - -.25)
India	-0.30* (-.31--.28)	-0.24* (-.26--.23)	-0.07* (-.08 - -.05]	-0.24* (-.26 - -.23)
Kenya	-0.29* (-.31--.28)	-0.12* (-.13--.10)	-0.08* (-.10 - -.06)	-0.21* (-.22 - -.19)
Malawi	-0.33* (-.34--.31)	0.34* (.32 - .35)	-0.11* (-.13 - -.09)	-0.22* (-.25 - -.20)
Nigeria	-0.42* (-.43--.40)	-0.13* (-.14--.11)	-0.26* (-.28 - -.25)	-0.31* (-.33 - -.29)
Rwanda	-0.37* (.39--.35)	0.19* (.18 - .21)	0.05* (.03 - .08)	-0.22* (.25 - -.20)

Table 3.4 Multilevel probit regression models, average marginal effects, (95% Confidence Interval) (continued)

	Tobacco[1]	Overweight[2]	Harmful alcohol use[3]	Unhealthy household behavior[4]
Sierra Leone	-0.19* (-.20 -.18)	0.22* (.21 - .24)	-0.28* (-.31 - -.26)	-0.24* (-.26 - -.22)
South Africa	-0.12* (-.13--.10)	0.46* (.44 - .48)	0.04* (.02 - .06)	-0.07* (-.10 - -.04)
Tanzania	-0.32* (-.34--.31)	-0.12* (-.13--.10)	-0.14* (-.16 - -.12)	-0.22* (-.25 - -.19)
Tajikistan	.	-0.06* (-.08--.05)	-0.19* (-.21 - -.17)	.
Timor-Leste	-0.00* (-.02 -.01)	-0.38* (-.39--.36)	-0.04* (.06 - -.02)	-0.26* (-.28 - -.23)
Togo	-0.36* (-.38--.35)	0.22* (.20 - .23)	-0.14* (-.16 - -.11)	-0.25* (-.27 - -.22)
Zambia	-0.25* (-.27--.24)	-0.18* (-.20--.17)	0.04* (.02 - .06)	-0.14* (-.16 - -.12)
Zimbabwe	-0.26* (-.27--.24)	-0.07* (-.08--.05)	-0.00* (-.02 - .01)	-0.13* (-.15 - -.11)
Total, N	245,835	443,528	172,450	90,578

[1]: Men's dataset; [2]: Women's dataset; [3]: Women's dataset (reporting on partner's alcohol use); [4]: Couples' dataset
*= significant at p <.05 level
F: reported in women's dataset M: reported in men's dataset

3.4 DISCUSSION

This study exploits data from the Demographic and Health Survey (DHS) collected across 22 low- and middle-income countries (LMICs) between 2013 and 2018 to analyze prevalence and socioeconomic inequality in lifestyle risk factors i.e., tobacco use, overweight and harmful alcohol use. We show that both the prevalence and the degree of socioeconomic inequality differ considerably across lifestyle risk factors and across countries. Tobacco and harmful alcohol use are largely concentrated among the poor, while overweight is heavily concentrated among the better-off in LMICs. This is contrary to findings from high income countries where all lifestyle risk factors are most prevalent among those with a lower socioeconomic status [9,10].

The largest socioeconomic inequalities across the four lifestyle risk factors were found for overweight. In developed countries low socioeconomic status is consistently associated with higher prevalence of unhealthy BMI, while our finding shows the opposite direction, in line with previous research on LMICs [17]. The largest pro-rich socioeconomic inequalities in overweight were observed in India, Tanzania and Zimbabwe. Some evidence suggests that obesity is a symbol of high social status in developing countries [30]. This contrast in socioeconomic inequality between high- versus low- and middle-income countries emphasizes the need to develop context specific policy interventions to tackle lifestyle risk factors. For most LMICs in our study, we find that harmful alcohol use is mostly a problem among the poor.

When mapping the share of GDP spend on health in each of these countries, as well as the socioeconomic inequality in lifestyle risk factors, we identified those countries with both a low share spend on health and an inequality lifestyle risk factors distributed towards the poor as “double disadvantaged”. Combining these different lifestyle risk factors, especially Zambia, Tanzania and Cambodia are at a double disadvantage and should be prioritized when implementing global policies to reduce unhealthy lifestyles among the poor.

3.4.1 Limitations

This study is based on cross-sectional data solely allowing us to examine associations. Our findings cannot be interpreted as causal. Furthermore, our findings are derived from large datasets and inferences about the nature of individuals cannot be deduced from inferences about the larger groups to which these individuals belong i.e., ecological fallacy. The response rates for the DHS are generally high, ranging from 97% to 99.9%. However, missing observations on lifestyle risk factors (Appendix 1) because respondents were unwilling to answer or to have their height and weight measured are a limitation to our study. This would be especially problematic when respondents from a specific socioeconomic group are less likely to provide this information, biasing our inequality estimates. However, we do not have reason to believe that this is the case.

The sample of women reporting on their partner's harmful alcohol use does not suffer from this potential bias, because the sample size is lower as a result of only a randomly selected subset of women being asked to answer this question. A second limitation arises from the use of BMI as a combined proxy for diet and physical activity which were not observed in the DHS. Although BMI is an objective and reliable measure it is less informative on diet composition; we cannot identify whether the poor consume less fruit and vegetables. Measuring physical activity, both work and leisure related, would be informative to policy makers aiming to reduce overweight but the DHS does not collect this information. Furthermore, because of data limitations we could not provide information on overweight in men. A third limitation arises from the reports on alcohol use in men, which are provided by the spouse and not by the consumer himself. This is likely to bias our estimates, but it is unclear whether this leads to an over- or underestimation. When alcohol consumption is collected from the consumer himself, it is possible that people who drink excessively provide an under estimation because of a perceived social stigma. However, the spouse might also under report for the same reason and her recall bias might be larger. She could also overestimate her partner's alcohol use because she does not have complete information on his alcohol consumption, especially not when this is outside of the house. Finally, socioeconomic inequality in lifestyle risk factors could be influenced by taxation policies of which the effects could differ per country and per socioeconomic group. Further research is needed to estimate the effect of such taxation schemes on the socioeconomic distribution of lifestyle risk factors. Notwithstanding these limitations, this study provides policy relevant insights into lifestyle risk factors in LMICs based on data from over a million of adults living in more than twenty LMICs.

3.5 CONCLUSIONS

This study emphasizes the importance of lifestyle risk factors in LMICs and the socioeconomic variation therein. While tobacco and alcohol use are most prevalent among males with a low socioeconomic status, it is mainly the better off females that are overweight. We identified Zambia, Tanzania and Cambodia as the countries at a "double disadvantage", implying that priority should be given to these populations when implementing policies towards the SDG target of reducing NCDs by one third. Given the different socioeconomic distribution of lifestyle risk factors, especially overweight, the targeting of interventions to reduce the burden from these lifestyles in LMICs should not be copied from high income countries but be tailored towards the high-risk populations in these countries. Below we suggest three policy implications.

3.6 POLICY IMPLICATIONS

Consistent with findings from Yaya et al. (2018) [15] among women across 33 Sub Saharan African countries, we find that tobacco use in men is most prevalent among the poor in LMICs. For HICs, increasing the price of cigarettes has been shown to be one of the most effective strategies to reduce smoking prevalence, in particular among people with a lower socioeconomic status [31]. The World Health Organization's Framework Convention on Tobacco Control (WHO FCTC) covers more than 90% of the world's population and provides its 180 collaborators to enact comprehensive, effective tobacco control measures. The findings of this study emphasize that in particular Timor-Leste, Armenia and South Africa which have the highest prevalence in tobacco use can benefit from alignment with the WHO FCTC. Second, to our knowledge, no interventions have been proven to be widely effective in sustainably reducing overweight in high income countries. So even when interventions developed in HICs, such as low caloric diets or physical activity programs, would be tailored to target the better off women in LMICs it is unlikely that these are effective. Furthermore, the food environment can limit the opportunity for the poor to switch to healthy, often more expensive, foods. As a result, overweight is not simply driven by the choice to consume unhealthy foods but can be a reflection of structural inequalities. Further research is therefore necessary to identify effective interventions to reduce overweight in LMICs. Finally, while lifestyle risk factors are generally deemed to be modifiable, support to improve lifestyles is necessary to make sustained changes. Access to this support, if even available, is likely to be smaller for those with a lower socioeconomic status. Targeting this segment of the population, for example through vouchers for support programs or cash transfers conditional on improving behavior are therefore likely to be most effective in reducing socioeconomic inequalities in lifestyle risk factors. Further research is necessary to determine the effectiveness of these policy suggestions, especially through a longitudinal approach to identify modifications in unhealthy behaviors over time.

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APPENDIX

Appendix 1

Table A1. Survey year and sample size for each lifestyle risk factor by country

Country	Year survey conducted	Men's data		Women's data			Couples' data	
		Total	Tobacco	Total	Overweight	Harmful alcohol use	Total	Unhealthy household behavior
Albania	2017-18	6,142	6,142	15,000	14,442	*na*	*na*	*na*
Armenia	2015-16	2,755	2,755	6,116	5,730	3,538	1,490	1,413
Burundi	2016-17	7,552	7,552	17,269	7,908	7,366	3,599	1,961
Cambodia	2014	5,190	5,190	17,578	10,818	3,497	3,060	2,435
Chad	2014-15	*na*	*na*	17,719	9,730	3,803	*na*	*na*
Congo DR	2013-14	8,656	8,656	18,827	8,159	5,686	4,486	1,648
Egypt	2014	*na*	*na*	21,762	19,345	6,667	*na*	*na*
Ethiopia	2016	12,688	12,688	15,683	13,781	4,720	6,141	3,124
Gambia	2013	3,821	3,819	10,233	4,176	3,534	1,388	878
India	2015-16	112,122	112,122	699,686	655,156	66,013	63,696	51,060
Kenya	2014	12,819	12,815	14,741	13,455	4,514	5,265	3,458
Malawi	2015-16	7,478	7,478	24,562	7,407	5,406	3,806	3,234
Nigeria	2013	17,359	17,344	38,948	33,894	22,247	8,658	6,212
Rwanda	2014-15	6,217	6,217	13,497	6,217	1,907	2,904	906
Sierra L.	2013	7,262	7,258	16,658	3,261	3,993	3,725	1,848
South Afr.	2016	3,618	3,618	8,514	7,305	4,303	663	587
Tajikistan	2017	*na*	*na*	10,718	9,918	5,313	*na*	*na*

Table A1. Survey year and sample size for each lifestyle risk factor by country (continued)

Country	Year survey conducted	Men's data		Women's data			Couples' data	
		Total	Tobacco	Total	Overweight	Harmful alcohol use	Total	Unhealthy household behavior
Tanzania	2015-16	3,514	3,514	13,266	12,027	7,597	1,564	1,269
Timor-Leste	2016	4,622	4,622	12,607	11,805	3,694	1,981	1,369
Togo	2013-14	4,476	4,474	9,480	4,395	5,373	2,270	1,796
Zambia	2013-14	14,750	14,772	16,381	14,833	9,410	7,198	6,183
Zimbabwe	2015	8,401	8,396	9,937	9,058	5,800	3,499	3,064
Total		249,442	249,432	1,029,182	882,820	184,381	125,393	92,445

3

II

HEALTH OUTCOMES

4 Mixed evidence for the compression of morbidity hypothesis for smoking elimination – a systematic literature review

Based on: Dieteren, C. M., Faber, T., van Exel, J., Brouwer, W. B., Mackenbach, J. P., & Nusselder, W. J. (2021). Mixed evidence for the compression of morbidity hypothesis for smoking elimination—a systematic literature review. European journal of public health, 31(2), 409-417.

ABSTRACT

Background

There is debate around the composition of life years gained from smoking elimination. The aim of this study was to conduct a systematic review of the literature to synthesize existing evidence on the effect of smoking status on health expectancy and to examine whether smoking elimination leads to compression of morbidity.

Methods

Five databases were systematically searched for peer-reviewed articles. Studies that presented quantitative estimates of health expectancy for smokers and non-/never-smokers were eligible for inclusion. Studies were searched, selected, and reviewed by two reviewers who extracted the relevant data and assessed the risk of bias of the included articles independently.

Results

The search identified 2,491 unique records, whereof 20 articles were eligible for inclusion (including 26 cohorts). The indicators used to measure health included disability/activity limitations (n=9), health-related quality of life (EQ-5D) (n=2), weighted disabilities (n=1), self-rated health (SRH) (n=9), chronic diseases (n=6), cardiovascular diseases (n=4), and cognitive impairment (n=1). Available evidence showed consistently that non-/never-smokers experience more healthy life years throughout their lives than smokers. Findings were inconsistent on the effect of smoking on the absolute number of unhealthy life years. Findings concerning the time proportionally spent unhealthy were less heterogeneous: nearly all included articles reported that non-/never-smokers experience relatively less unhealthy life years (e.g., relative compression of morbidity).

Conclusion

Support for the relative compression of morbidity due to smoking elimination was evident. Further research is needed into the absolute compression of morbidity hypothesis since current evidence is mixed, and methodology of studies needs to be harmonized.

4.1 BACKGROUND

Worldwide life expectancies are increasing, which is partly the result of new medical possibilities. We live longer, but the burden of non-communicable diseases (NCD) has never been higher. NCDs are currently the leading cause of deaths worldwide [1]. The majority of these NCDs may be the consequence of modifiable lifestyle risk factors such as smoking, physical inactivity, excessive alcohol consumption and poor diet [2]. The exact influence of prevention of lifestyle risk factors on longevity and health, including the number of life years spent in good or impaired health, remains unclear. This is in particular the case for smoking.

The past decade can be described as a public health success story in terms of smoking prevalence reduction. Joint efforts have led to substantial decreases in tobacco consumption worldwide. However, smoking is still considered as a major public health threat and this is recognized by several initiatives that aim to combat this threat. A main initiative is the world's first public health treaty: the World Health Organization (WHO) Framework Convention for Tobacco Control which is as of 2016 ratified by 180 parties [3]. Strengthening its implementation is also mentioned in the United Nations' Sustainable Development Goals [4]. Another explicit goal set by the WHO involves the 25x25 NCDs targets, which include lowering tobacco use by 30% between 2010 and 2025 [5].

There is a debate around the composition of life years gained from smoking elimination. A reduction in smoking prevalence leads to higher life expectancies because of the effect of smoking on mortality through fatal diseases [1]. However, smoking also has an effect on morbidity through a wide range of both fatal and non-fatal diseases [6]. Which effect is stronger, the morbidity or mortality effect, will determine how these life years are spent. A reduction in smoking prevalence may lead to either a compression of morbidity [7], an expansion of morbidity [8], or a dynamic equilibrium [9], implying, respectively, that less smoking leads to fewer years lived with morbidity, more years lived with morbidity, or to a shift from more severe to less severe morbidity. The third theory, a dynamic equilibrium, has never been formally defined. Morbidity and disability here not binary but are more considered as processes and therefore often proposed as the "intermediate" scenario between the other two theories [10]. Hence, in this study we merely focus on the first two theories. Consequences on morbidity can be examined as absolute and relative effects [11]. The absolute effects reflect the change of number of years lived unhealthily. When this change is interpreted as a percentage change we consider the consequences as relative effects [12]. On the individual level, distinguishing between the absolute and relative effects are not per se of an added value. However, the absolute and relative changes are both relevant to capture and estimate changes in population health.

The increased efforts that are undertaken to lower smoking prevalence's emphasize the need to understand the impact of smoking elimination on population health. This study aims to conduct a systematic literature review in order to synthesize existing knowledge on the effect of smoking status on health expectancy. Health expectancy is a measure that reflects the total life expectancy split in years lived in good health and years lived in poor health (in absolute terms and as proportion of total lifetime) [10, 13] and thus allows us to assess whether non-smokers experience a compression of morbidity or expansion of morbidity when health expectancies are compared with smokers.

4.2 METHOD

4.2.1 Search strategy

Four databases were systematically searched for peer-reviewed studies from inception up to July 2018: Embase.com (since 1971), Medline ALL via Ovid (since 1946) Web of Science Core Collection (since 1975), Cochrane Central Register of Trials via Wiley (since 1992). An additional search was performed in Google Scholar. This search engine could help in retrieving articles that have not been published yet or had no relevant search terms in their title and abstract. The search equation combined search terms (using thesaurus terms when available combined with terms in title and/or abstract) for smoking and health status indicators. We adopted a broad search strategy to cover a wide spectrum of articles. The search strategy was set up together with a librarian. The complete search strategies for all databases can be found in the Appendix table A1.

4.2.2 Eligibility criteria

We included articles based on the following eligibility criteria:

1. The article focuses on smoking and health expectancy.
2. The article estimates health expectancy for smokers and non-smokers, either prospectively or retrospectively.
3. The article focuses on a sample that aims to be representative for the general population.
4. The article is written in English.
5. The article is not a conference abstract, letter, note, or editorial.

Health status indicators can range from objective measures (e.g., disease status) to subjective measures (e.g., self-perceived health). We did not limit inclusion by a certain type of health status indicator.

4.2.3 Selection strategy

Two researchers screened the retrieved articles. The predefined eligibility criteria guided the decision process for inclusion and exclusion. When the information provided in the titles and abstracts were insufficient for a decision, a brief screening of the full-text took place to decide whether the article was eligible for inclusion. Differences in screening results, among the two researchers, were discussed and resolved by dialogue. When no consensus could be achieved, a third researcher was consulted to judge. Study selection was conducted in Endnote X6.

4.2.4 Data extraction

Extraction forms were developed to assist in the harmonization of the extracted data. Extracted data included the following information: operationalization of exposure and outcome variables, study population characteristics, applied method to estimate health expectancy and the health expectancies. Two main approaches for the estimation of health expectancy exist, which can be applied either on cross-sectional or longitudinal data [14]. Prevalence-based life tables, also known as Sullivan's Method, is applied on cross-sectional data [15]. The other approach uses multiple measurements and is based on incidence rather than prevalence and often relies on the multistate life tables [16]. The risk of bias was assessed with a quality assessment tool for observational cohort and cross-sectional studies (Appendices 2 and 3).

4.2.5 Data analysis

The study selection was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) (Figure 1) [17]. For all studies it was evaluated whether a compression or expansion of morbidity (both in relative and absolute terms) occurred by comparing the findings between non-/never-smokers and current smokers [11]. An absolute expansion of morbidity indicates an increase in the number of unhealthy life years for non-/never-smokers. This may lead to either an increase or decrease in the proportion of life spent in poor health for non-/never-smokers: relative compression or expansion of morbidity.

4.3 RESULTS

4.3.1 Study search

Figure 4.1 shows the PRISMA flow diagram of the screening process. In total, 2,488 unique records were identified and screened. We excluded 2,367 articles based on title and abstract. Thus, the full text of 121 articles were assessed of which we excluded 101 articles most of including no relevant outcomes. Moreover, one study reported health expectancies where the unhealthy and healthy life years did not add up to the total life expectancy. It was decided to exclude this paper due to inadequate results. This resulted in 20 included articles. Some articles reported health expectancies for multiple population cohorts: in total health expectancies for 26 population cohorts were reported. The quality assessment (Newcastle – Ottawa quality assessment), independently conducted by two researchers, showed that the majority of the articles were of sufficient quality (scoring at least five out of the eight stars). One article [18], showed some reason for concern with scoring three stars because the study did not control for factors in the analysis.

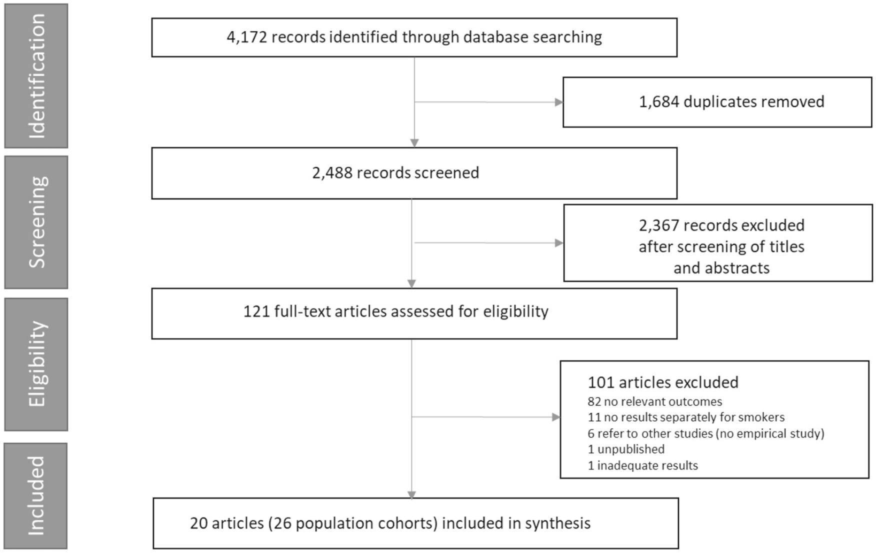

Figure 4.1 Flow diagram study search

4.3.2 Study characteristics

Table 4.1 provides characteristics of the included articles (N=20), listed by cohort (N=26). The first column in Table 1 attaches a number to each cohort. These numbers will be used for reference in the rest of this article. Data collection of the population cohorts occurred between 1948 and 2014. Sample sizes varied from 1,759 up to 42,516 respondents. Smoking status was defined in various manners, namely in two categories ((ever)smokers, non-/never-smokers); three categories (current smokers, former smokers, never smokers); or four categories (heavy smokers, moderate smokers, former smokers, never smokers). The studies that applied a dichotomous definition for smoking status could still vary by group composition due to the categorization of former smokers. The indicators for health involved disability/activity of daily living limitations (n=9), health-related quality of life (EQ-5D) (n=2), disability weights (n=1), self-rated health (SRH) (n=9), chronic diseases (n=6), cardiovascular diseases (n=4) and cognitive impairment (n=1). Some studies estimated health expectancies for different indicators for health, e.g., for both self-rated health and chronic diseases. The majority of the studies (n=11) used a longitudinal approach by applying a multi-state (Markov) transition model. The Sullivan approach (cross-sectional data) was the other main applied method (n=6). More novel methods were applied by Van Baal, Hoogenveen [19] and Mehta and Myrskylä [20]. The former adopted a dynamic population model (RIVM chronic disease model) whereas the latter applied a matrix population model (an extension of the multistate technique).

Table 4.1 Characteristics included articles, listed by cohort

# Cohort	Country of study	Time period*	Sample size**	Smoking status definitions	Health indicator	Estimation technique	Reference
1. DYNOPTA	Australia	1990-2006	8,111	Non-smokers (never smokers and former smokers), current smokers	Cognitive impairment (MMSE examination)	Multistate life table	Anstey, Kingston [21]
2. NPHS	Canada	1994-1996	8,009	Non-smokers (never smoked, stopped more than five years ago, or always only occasional), Smokers (daily, occasional but formerly daily, or former who had stopped within the prior five years)	Activity limitations and dependency (preparing meals, personal care, get about the house)	Multistate life table	Belanger, Martel [22]
3. DANCOS	Denmark	1991, 1994	5,811	Never smokers, former smokers, moderate smokers (1-14 gr tob. p/d), heavy smokers (>14 gr tob. p/d)	Self-rated health Longstanding illness	Sullivan's method	Brønnum-Hansen and Juel [23]
4. DANCOS	Denmark	2000	16,690	Never smokers, former smokers, moderate smokers (1-14 gr tob. p/d), heavy smokers (>14 gr tob. p/d)	Self-rated health	Sullivan's method	Brønnum-Hansen and Juel [24]
5. DANCOS	Denmark	2000	16,690	Never smokers, moderate smokers (1-14 gr tob. p/d), heavy smokers (>14 gr tob. p/d)	Self-rated Health	Sullivan's method	Bronnum-Hansen and Juel [25]
6. DANCOS	Denmark	2000	12,524	Never smokers, former smokers, moderate smokers (1-14 cig p/d), heavy smokers (>14 cig p/d)	EQ-5D (report general subjective health; report numbers of their physically unhealthy days, mentally unhealthy days and days with activity limitation during the past 30 days), Danish values	Sullivan's method	Brønnum-Hansen, Juel [26]
7. EPESE	USA	1981-1989	8,604	Never smokers, former smokers, current smokers (note: in most analyzes past and current as single group)	Activities of daily living (walking across a small room, transferring from bed to chair, bathing, dressing, eating, grooming, and using the toilet)	Multistate life table	Ferrucci, Izmirlian [27]
8. EPESE	USA	1981-1989	3,673	Never smokers, former smokers, never smokers	Activities of daily living (walking across a small room, transferring from bed to chair, bathing, dressing, eating, grooming, and using the toilet)	Multistate life table	Izmirlian, Brock [28]

Table 4.1 Characteristics included articles, listed by cohort (continued)

# Cohort	Country of study	Time period*	Sample size**	Smoking status definitions	Health indicator	Estimation technique	Reference
9. BRFSS	USA	1993-2009	n.s.	Non-smokers (never smokers and former smokers), current smokers (at least 100 cig. In entire life; now smoking)	EQ-5D (report general subjective health; report numbers of their physically unhealthy days, mentally unhealthy days and days with activity limitation during the past 30 days)	Multistate life table	Jia, Zack [18]
10. POLS	The Netherlands	1997, 1999	6,446	Never smokers, former smokers, current smokers	Disability (to walk up and down the stairs, walk outside, enter/leave the house, sit down/get up from a chair, move around on the same floor, get in/out of bed, eat/drink, get dressed/undressed, wash face/hands, and wash completely)	Sullivan's method	Klijs, Mackenbach [29]
11. ECHP	Western Europe[1]	1998-2001	66,331	Never smokers, daily smokers	Disability (hampered in daily activities by any physical or mental health problem, illness or disability)	Multistate life table	Majer, Nusselder [30]
12. HRS	USA	1998-2012	14,804	Never smokers, ever smokers	Katz activities of daily living (walking, bathing, dressing, toileting, feeding)	Matrix population model (extension of multistate technique)	Mehta and Myrskylä [20]
13. GLOBE & LSOA	The Netherlands & USA	1991-1995 1984-1990	5,107 3,270	Non-smokers, current smokers	Disability (living in an institution or indicated that they needed help or were unable to perform without any difficulty one or more activities of daily life)	Multistate life table	Nusselder, Looman [31]
14. The Framingham Heart Study	USA	1948-1989	4,634	Never smokers, former smokers, current smokers	First incidental or fatal cardiovascular disease (and death)	Multistate life table	Nusselder, Franco [32]

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Table 4.1 Characteristics included articles, listed by cohort (continued)

# Cohort	Country of study	Time period*	Sample size**	Smoking status definitions	Health indicator	Estimation technique	Reference
15. RCPH	Denmark	1982-1994	1,759	Never smokers, former smokers, current smokers	First incidental or fatal cardiovascular disease (and death)	Multistate life table	O'Doherty, Cairns [33]
16. ESTHER	Germany	2000-2010	8,482				
17. Tromso	Norway	1994-2001	9,179				
18. HRS	USA	1992-2000	12,652	Never smokers, former smokers, moderate smokers, heavy smokers	Self-rated health	Multivariate linear regression (AUC)	Østbye and Taylor [34]
19. AHEAD	USA	1993-2000	8,124	Never smokers, former smokers, current smokers			
20. HRS & AHEAD	USA	1992-2004	16,176	Never smokers, former smokers, current smokers	Katz activities of daily living (walking, bathing, dressing, toileting, feeding)	Multistate life table	Reuser, Bonneux [35]
21. ELSA	UK	2002-2013	8,805	Non-smokers (never smokers and former smokers), current smokers	Selft-rated health Longstanding illness	Multistate life table	Stenholm, Head [36]
22. FPS	Finland	1997-2013	42,516				
23. GAZEL	France	1996-2014	14,931				
24. SLOSH	Sweden	2006-2014	8,118				
25. Multiple sources [2]	The Netherlands	n.s.	n.s.	Non-smokers (never smokers and former smokers), Current smokers	Coupling disease prevalence rates to disability weights available from the Dutch burden of disease study.	Dynamic population model (extension of multistate technique)	Van Baal, Hoogenveen [19]
26. BHIS	Belgium	1997, 2001, 2004	17,148	Never smokers, daily smokers	Activities of daily living; mobility limitations (transferring in-and-out of bed or chair, dressing, washing hands and face, feeding and using the toilet; or inability to walk without stopping for ≤ 200 m)	Sullivan's method	Yokota, Nusselder [37]

[1] Nine countries: Finland, Denmark, Ireland, Austria, Belgium, Greece, Italy, Spain, Portugal
[2] Different sources were used: Dutch Burden of Disease Study, GP registrations, national registries, population surveys (STIVORO, POLS)
* Time period included in article; ** At baseline; n.s. = not stated

4.3.3 Compression of morbidity hypothesis

In order to assess the occurrence of compression of morbidity, we compared the unhealthy life years between non-/never-smokers and current smokers. Appendices 4 and 5 show the health expectancies (unhealthy life years + healthy life years = life expectancy) of the included articles. Table 4.2 shows the answers on the question whether a compression of morbidity was observed in the health expectancies. The different starting ages for the health expectancy estimations are also included in the table. The heterogeneity in the data (different health indicators, different starting ages, different smoking definitions and further stratification) hampered direct comparisons between studies. Nonetheless, we grouped the health indicators into three categories (disability, self-rated health and longstanding illness) in order to structure the findings and gain insights.

The results for the absolute compression of morbidity hypothesis are diffuse: approximately half of the studies reported an absolute compression of morbidity. This means that non-/never-smokers spent less time in poor health. Yet, this also indicates that approximately half of the studies found that non-/never-smokers spent a longer time in poor health than current, moderate and heavy smokers (absolute expansion of morbidity). This last finding was mostly found in studies that applied disability as an indicator for health. Most of the studies reported a relative compression of morbidity (except cohorts #7, #8, #26 (women), #11 (men), #19 (only from 80 years), #1). The studies that did not report a relative compression of morbidity (and thus found a relative expansion of morbidity) were prevalent in all three health categories. Further, a finding was that all studies reported that non-/never-smokers have more healthy life years compared to smokers.

Table 4.2 Compression of morbidity hypothesis overview included articles

			Compression of morbidity?					
# [a]	Health indicator		NS - CS		NS - MS		NS - HS	
			Absolute	Relative	Absolute	Relative	Absolute	Relative
Disability								
7 [b, c]	ADL	M	65: No	65: No	n.a.	n.a.	n.a.	n.a.
		F	65: No	65: No	n.a.	n.a.	n.a.	n.a.
8 [c]	ADL	M	65: No	65: No	n.a.	n.a.	n.a.	n.a.
			70: No	70: No	n.a.	n.a.	n.a.	n.a.
			75: No	75: No	n.a.	n.a.	n.a.	n.a.
	Low educated		80: No	80: No	n.a.	n.a.	n.a.	n.a.
			85: No	85: No	n.a.	n.a.	n.a.	n.a.
			90: No	90: No	n.a.	n.a.	n.a.	n.a.
		F	65: No	65: No	n.a.	n.a.	n.a.	n.a.
			70: No	70: No	n.a.	n.a.	n.a.	n.a.
			75: No	75: No	n.a.	n.a.	n.a.	n.a.
			80: No	80: No	n.a.	n.a.	n.a.	n.a.
			85: No	85: No	n.a.	n.a.	n.a.	n.a.
			90: No	90: No	n.a.	n.a.	n.a.	n.a.
	ADL	M	65: No	65: No	n.a.	n.a.	n.a.	n.a.
	High educated		70: No	70: No	n.a.	n.a.	n.a.	n.a.
			75: No	75: No	n.a.	n.a.	n.a.	n.a.
			80: No	80: No	n.a.	n.a.	n.a.	n.a.
			85: No	85: No	n.a.	n.a.	n.a.	n.a.
			90: No	90: No	n.a.	n.a.	n.a.	n.a.
		F	65: No	65: No	n.a.	n.a.	n.a.	n.a.
			70: No	70: No	n.a.	n.a.	n.a.	n.a.
			75: No	75: No	n.a.	n.a.	n.a.	n.a.
			80: No	80: No	n.a.	n.a.	n.a.	n.a.
			85: No	85: No	n.a.	n.a.	n.a.	n.a.
			90: No	90: No	n.a.	n.a.	n.a.	n.a.
26	ADL & mobility limitations	M	15: No	15: Yes	n.a.	n.a.	n.a.	n.a.
		F	15: No	15: No	n.a.	n.a.	n.a.	n.a.
12	Katz ADL	M	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
20 [c]	Katz ADL	M	55: No	55: Yes	n.a.	n.a.	n.a.	n.a.
		F	55: No	55: Yes	n.a.	n.a.	n.a.	n.a.

Table 4.2 Compression of morbidity hypothesis overview included articles (continued)

			Compression of morbidity?					
# [a]	**Health indicator**		**NS - CS**		**NS - MS**		**NS - HS**	
			Absolute	**Relative**	**Absolute**	**Relative**	**Absolute**	**Relative**
2	ADL & dependency	M	45: No	45: Yes	n.a.	n.a.	n.a.	n.a.
		F	45: No	45: Yes	n.a.	n.a.	n.a.	n.a.
6 [c]	EQ-5D	M	n.a.	n.a.	25: Yes	25: Yes	25: Yes	25: Yes
		F	n.a.	n.a.	25: Yes	25: Yes	25: Yes	25: Yes
9	EQ-5D	M	18: Yes	18: Yes	n.a.	n.a.	n.a.	n.a.
		F	18: Yes	18: Yes	n.a.	n.a.	n.a.	n.a.
10 [c]	Disability	M	55: No	55: Yes	n.a.	n.a.	n.a.	n.a.
		F	55: Equal	55: Yes	n.a.	n.a.	n.a.	n.a.
11 [d]	Disability	M	16: No	16: No	n.a.	n.a.	n.a.	n.a.
		F	16: Yes	16: Yes	n.a.	n.a.	n.a.	n.a.
13	Disability	M	30: Yes	30: Yes	n.a.	n.a.	n.a.	n.a.
			70: Yes	70: Yes	n.a.	n.a.	n.a.	n.a.
		F	30: Yes	30: Yes	n.a.	n.a.	n.a.	n.a
			70: Yes	70: Yes	n.a.	n.a.	n.a.	n.a.
25	Disability weights	M	20: Yes	20: Yes	n.a.	n.a.	n.a.	n.a.
			40: Yes	40: Yes	n.a.	n.a.	n.a.	n.a.
			60: Yes	60: Yes	n.a.	n.a.	n.a.	n.a.
		F	20: No	20: Yes	n.a.	n.a.	n.a.	n.a.
			40: No	40: Yes	n.a.	n.a.	n.a.	n.a.
			60: Yes	60: Yes	n.a.	n.a.	n.a.	n.a.
Self-rated health								
18 [c]	Self-rated health	M	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
			55: No	55: Yes	n.a.	n.a.	n.a.	n.a.
			60: Yes	60: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: Yes	50: Yes	n.a.	n.a.	n.a.	n.a.
			55: No	55: Yes	n.a.	n.a.	n.a.	n.a.
			60: No	60: Yes	n.a.	n.a.	n.a.	n.a.
19 [c]	Self-rated health	M	70: No	70: Yes	n.a.	n.a.	n.a.	n.a.
			75: Yes	75: Yes	n.a.	n.a.	n.a.	n.a.
			80: No	80: No	n.a.	n.a.	n.a.	n.a.
		F	70: Equal	70: Yes	n.a.	n.a.	n.a.	n.a.
			75: Yes	75: Yes	n.a.	n.a.	n.a.	n.a.
			80: No	80: No	n.a.	n.a.	n.a.	n.a.

Table 4.2 Compression of morbidity hypothesis overview included articles (continued)

			Compression of morbidity?					
# [a]	Health indicator		NS - CS		NS - MS		NS - HS	
			Absolute	Relative	Absolute	Relative	Absolute	Relative
21	Self-rated health	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
22	Self-rated health	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
23	Self-rated health	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
24	Self-rated health	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
3 [c]	Self-rated health	M	n.a.	n.a.	20: Yes	20: Yes	20: Yes	20: Yes
			n.a.	n.a.	65: Yes	65: Yes	65: Yes	65: Yes
		F	n.a.	n.a.	20: Yes	20: Yes	20: Yes	20: Yes
			n.a.	n.a.	65: No	65: Yes	65: Yes	65: Yes
4 [c]	Self-rated health	M	n.a.	n.a.	30: Yes	30: Yes	30: Yes	30: Yes
		F	n.a.	n.a.	30: Yes	30: Yes	30: Yes	30: Yes
5 [b]	Self-rated health	M	n.a.	n.a.	30: Yes	30: Yes	30: Yes	30: Yes
		F	n.a.	n.a.	30: Yes	30: Yes	30: Yes	30: Yes
Longstanding illness								
21	Longstanding illness	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
22	Longstanding illness	M	50-75: No	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
23	Longstanding illness	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
24	Longstanding illness	M	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
		F	50-75: Yes	50-75: Yes	n.a.	n.a.	n.a.	n.a.
3 [c]	Longstanding illness	M	n.a.	n.a.	20: No	20: No	20: Yes	20: Yes
			n.a.	n.a.	65: No	65: No	65: No	65: Yes
		F	n.a.	n.a.	20: No	20: No	20: Yes	20: Yes
			n.a.	n.a.	65: No	65: No	65: Equal	65: Yes
4 [c]	Longstanding illness	M	n.a.	n.a.	30: No	30: Yes	30: Yes	30: Yes
		F	n.a.	n.a.	30: No	30: Yes	30: No	30: No
1	Cognitive impairment	M	65: No	65: No	n.a.	n.a.	n.a.	n.a.
		F	65: No	65: No	n.a.	n.a.	n.a.	n.a.
14 [c]	Cardiovascular disease	M	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.

Table 4.2 Compression of morbidity hypothesis overview included articles (continued)

			Compression of morbidity?					
# [a]	Health indicator		NS - CS		NS - MS		NS - HS	
			Absolute	Relative	Absolute	Relative	Absolute	Relative
15 [c]	Cardiovascular disease	M	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: No	50: Yes	n.a.	n.a.	n.a.	n.a.
16 [c]	Cardiovascular disease	M	50: Yes	50: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: Yes	50: Yes	n.a.	n.a.	n.a.	n.a.
17 [c]	Cardiovascular disease	M	50: Yes	50: Yes	n.a.	n.a.	n.a.	n.a.
		F	50: Yes	50: Yes	n.a.	n.a.	n.a.	n.a.

a: Corresponds with the cohort # in Table 1.
b: Middle educational level.
c: Reports former smokers separately.
d: Normal body weight.
NS: Non/never-smoker, CS: Current smoker, MS: Moderate smoker, HS: Heavy smoker, M: Male, F: Female

4

4.3.4 Health expectancies – Disability

Figure 4.2 shows the health expectancies of the studies that are listed under the disability category in Table 4.2. The studies #6, #8, #9 and #25 are not included in this figure because they are further stratified (#8) or have the EQ-5D or disability weights as health indicator. This figure is only reported for this measure due to the great variability between the studies. The numbers in the bars indicate the healthy and unhealthy life years.

For men, the differences in unhealthy life years between non-/never-smokers and current smokers varied between -0,3 years and +1,3 years. Most studies (n=8) found more unhealthy life years for non-/never-smokers, indicating an absolute expansion of morbidity. For example, in cohort #12 it was found that non-/never-smokers would have 4,6 unhealthy life years, while current smokers would only have 3,8 unhealthy life years. The relative differences are hard to observe from this figure, but these can be found in Appendices 4 and 5. Most studies show a relative compression of morbidity, except cohorts #7 and #11.

For women, the same pattern was observed. However, the differences in the number of unhealthy life years between non-/never-smokers and current smokers were larger, ranging from -1,1 years to 2,4 years. For instance, in cohort #2 it was estimated that smokers would have 13,4 unhealthy life years while non-/never-smokers would have 15,8 unhealthy life years. A relative compression of morbidity was also found for women in most studies, except in the cohorts #7 and #26. Moreover, Figure 4.2 shows that women have on average a higher total life expectancy and more unhealthy life years compared to men.

Figure 4.2 Overview health expectancies based on disability measure

4.4 DISCUSSION

While health expectancies are central in the debate related to quantity versus quality of life, a relatively small number of studies have investigated the health expectancies for smokers and non-/never-smokers. This systematic review extracted 20 articles from the 2,488 unique retrieved records. Within these 20 articles, a total of 26 cohorts were studied. Our collected evidence showed consistently that non-/never-smokers spent more years in good health throughout their lives than smokers. In contrast, findings were inconsistent regarding the effect smoking has on the absolute number of unhealthy life years. Estimates for unhealthy life years were diffuse for all applied health indicators. Approximately half of the studies found an absolute compression of morbidity for non-/never-smokers compared to smokers. As such, the other half of the studies reported an absolute expansion of morbidity which is a finding that deserves attention in this discussion. Findings concerning the time proportionally spent unhealthy were less heterogeneous: nearly all included articles reported relative compression of unhealthy life years for non-/never-smokers compared to smokers. Caution in drawing universal conclusions of our findings is required because of the heterogeneity in the studies.

Chronic diseases mostly have an onset earlier in life than disabilities, however, the mortality effect of chronic diseases is reduced nowadays. Hence, life years after the onset of chronic diseases are likely to exceed life years after the onset of disabilities. Smokers may not reach the average age at which severe disabilities (e.g., ADL) become relevant, which might explain the reported relative small differences in unhealthy life years between non-/never-smokers and smokers. Some included articles analyzed SRH and chronic diseases for the same study population (cohorts #3, #21, #22, #23 and #24). In the majority of these cohorts the largest differences between smokers and non-/never-smokers were found for health expectancies estimated with SRH. Three of the studies reported that male smokers had less years with chronic diseases, while none of these studies reported that male smokers had less years in poor SRH. Put differently, health expectancy measured with SRH resulted in fewer healthy life years and more unhealthy life years for smokers compared to health expectancy estimated with chronic diseases. This could be because chronic diseases are stronger associated with mortality than self-rated health. Further, one study in our review had cognitive impairments as an indicator for health and reported absolute and relative expansion of morbidity for non-smokers. This health measure deviates from the other included health indicators but is an important health indicator in an aging population. Hence, the effect of smoking elimination on this health indicator is worth further exploring.

From a methodological perspective, studies differed considerably. Firstly, remaining health expectancies were estimated from a variety of ages. Health expectancy estimations from an older age (e.g., 65 years) are likely to underestimate the effect of smoking since premature deaths and early onset of reduced health are not captured. In total, eleven cohorts estimated health expectancy with a start age of 65 years and higher of which seven cohorts reported absolute expansion of morbidity and five cohorts a relative expansion of morbidity. Secondly, various categorizations for smoking were applied. Respondents belonging to a never/non-smoking group could differ from studies with a category for former smokers. Thirdly, estimation methods for health expectancy were characterized by the Sullivan's method or the multistate life table method. The multistate life table method provides a richer analysis, but for health expectancy estimations it is suggested that Sullivan's method is easier to implement and needs less assumptions [38]. Fourthly, studies used different methods to measure health status. Questionnaires, interviews, health care professionals and other sources were used.

4.4.1 Strengths & limitations

The discussed variety of methods hampered comparability and interpretation of the results. A meta-analysis was therefore not possible. Health expectancy as a measure for population health has become a standard. A call for adopting a homogeneous measure of health expectancy has frequently been made [39]. A strength of this systematic review was the applied search strategy which was comprehensive and covered a variety of databases and the consultation of experts. This creates confidence that we reached the most relevant published articles. All retrieved articles were independently double screened, and the data was extracted independently.

4.5 CONCLUSION

When a reduction in smoking prevalence delays both death and ill health, relative and absolute time spent unhealthily may still increase [40]. Relative compression of morbidity due to smoking elimination was found in most of the studies. Further research is needed to examine the effect of smoking elimination on the absolute number of years spent unhealthily since findings were mixed in all health categories. The health indicators for health expectancy should be more streamlined in future research to synthesize and understand the implications of smoking elimination on population health better.

The support found in approximately half of the studies for absolute expansion of morbidity for non-/never-smokers raises questions concerning the related consequences for public health. When society will be smoke-free, health expectancies change and thus the environment need to adapt accordingly to cope with this change. Health systems might be in need for specific adaptations in order to deal with people spending more years unhealthily. For instance, disease management programs with a particular focus on the most common NCDs will become more important [41].

4.6 REFERENCES

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APPENDICES

Appendix 1

Table A1. Search equations for systematic literature search

Database (retrieved articles)	Concept	Keywords
Embase (n=1,342)	Exposure	'smoking'/exp OR 'cigarette smoke'/de OR 'tobacco smoke'/de OR 'smoking cessation'/de OR 'smoking cessation program'/de OR 'tobacco'/de OR 'tobacco use'/de OR 'tobacco dependence'/exp OR 'nicotine'/de OR 'nicotine replacement therapy'/de OR 'nicotine gum'/de OR (smoking OR smoke* OR cigarette* OR tobacco OR nicotin*):ab,ti)
	Outcome	AND ('disability-adjusted life year'/de OR 'quality adjusted life year'/de OR ('life expectancy'/de AND disability/de) OR (((disab* OR qualit* OR healthy* OR active OR limitation* OR good-health OR mobilit*) NEXT/3 (life-year* OR years OR life-expectan* OR life-span OR lifetime)) OR qaly OR daly OR qalys OR dalys OR qale OR hale OR qale OR hale OR dale OR hly OR ylh OR hyll:ab,ti)
	Format	NOT ([Conference Abstract]/lim OR [Letter]/lim OR [Note]/lim OR [Editorial]/lim) NOT ('case report'/de OR 'case report':ti) AND [english]/lim
Medline Ovid (n=1,192)	Exposure	(exp Smoking/ OR Smoking Cessation/ OR Tobacco Products/ OR Tobacco/ OR "Tobacco Use Disorder"/ OR "Tobacco Use Cessation"/ OR "Tobacco Use Cessation Products"/ OR nicotine/ OR (smoking OR smoke* OR cigarette* OR tobacco OR nicotin*).ab,ti.)
	Outcome	AND (Quality-Adjusted Life Years/ OR (life expectancy/ AND disability/) OR (((disab* OR qualit* OR healthy* OR active OR limitation* OR good-health OR mobilit*) ADJ3 (life-year* OR years OR life-expectan* OR life-span OR lifetime)) OR qaly OR daly OR qalys OR dalys OR qale OR hale OR qale OR hale OR dale OR hly OR ylh OR hyll).ab,ti.)
	Format	NOT (letter OR news OR comment OR editorial OR congresses OR abstracts).pt. NOT (case reports/ OR case report.ti.) AND english.la.
Cochrane CENTRAL (n=78)	Exposure	((smoking OR smoke* OR cigarette* OR tobacco OR nicotin*):ab,ti)
	Outcome	AND ((((disab* OR qualit* OR healthy* OR active OR limitation* OR good-health OR mobilit*) NEXT/3 (life-year* OR years OR life-expectan* OR life-span OR lifetime)) OR qaly OR daly OR qalys OR dalys OR qale OR hale OR qale OR hale OR dale OR hly OR ylh OR hyll):ab,ti)
Web of science (n=1,360)	Exposure	TS=(((smoking OR smoke* OR cigarette* OR tobacco OR nicotin*)) AND ((((disab* OR qualit* OR healthy* OR active OR limitation* OR good-health OR mobilit*)

Table A1. Search equations for systematic literature search (continued)

Database (retrieved articles)	Concept	Keywords
	Outcome	NEAR/2 (life-year* OR years OR life-expectan* OR life-span OR lifetime)) OR qaly OR daly OR qalys OR dalys OR qale OR hale OR qale OR hale OR dale OR hly OR ylh OR hyll)))
	Format	AND DT=(article) AND LA=(english)
Google scholar (n=200)	Exposure	smoking|smoke|cigarette|tobacco|nicotine
	Outcome	"adjusted|healthy|active life years|expectan|span"|"adjusted|healthy|active years|lifetime|
Total N=4,172		

Appendix 2

Newcastle – Ottawa quality assessment for cohort studies

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability.

Selection

1) Representativeness of the exposed cohort

a) truly representative of the average _______________ (describe) in the community *

b) somewhat representative of the average ______________ in the community *

c) selected group of users eg nurses, volunteers

d) no description of the derivation of the cohort

2) Selection of the non exposed cohort

a) drawn from the same community as the exposed cohort *

b) drawn from a different source

c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure

a) secure record (eg surgical records) *

b) written self report / structured interview

c) no description

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) study controls for _____________ (select the most important factor) *
   b) study controls for any additional factor (This criteria could be modified to indicate specific control for a second important factor.) *

Outcome

1) Assessment of outcome
   a) independent blind assessment *
   b) record linkage *
   c) self report
   d) no description
2) Was follow-up long enough for outcomes to occur
   a) yes *
   b) no
3) Adequacy of follow up of cohorts
   a) complete follow up - all subjects accounted for *
   b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *
   c) follow up rate < ____% (select an adequate %) and no description of those lost
   d) no statement

Appendix 3

S3. Newcastle – Ottawa quality assessment scale adapted for cross-sectional studies

Selection

1) Representativeness of the sample:
   a) Truly representative of the average in the target population. * (all subjects or random sampling)
   b) Somewhat representative of the average in the target population. * (nonrandom sampling)
   c) Selected group of users. d) No description of the sampling strategy.

2) Sample size:
   a) Justified and satisfactory. *

   b) Not justified.

3) Non-respondents:
   a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. *

   b) The response rate is unsatisfactory, or the comparability between respondents and non-respondents is unsatisfactory.

   c) No description of the response rate or the characteristics of the responders and the non-responders.

4) Ascertainment of the exposure (risk factor):
   a) Validated measurement tool. **

   b) Non-validated measurement tool, but the tool is available or described.*

   c) No description of the measurement tool.

Comparability

1) The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.
   a) The study controls for the most important factor (select one). *

   b) The study control for any additional factor. *

Outcome

1) Assessment of the outcome:
   a) Independent blind assessment. **

   b) Record linkage. **

   c) Self report. *

   d) No description.

2) Statistical test:
   a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). *

   b) The statistical test is not appropriate, not described or incomplete.

Appendix 4

Table A4. Health expectancies as reported in included articles for men

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
6.	25		44.9	48.5	51.2	53.6	6 (13.4)	5.4 (11.1)	5.3 (10.4)	5.1 (9.5)	38.9 (86.6)	43.1 (88.9)	45.9 (89.6)	48.5 (90.5)
1.	65		13.5			17.3	1.2 (8.9)			2.0 (11.6)	12.3 (91.1)			15.3 (88.4)
18.	50-54		22.23	22.15	23.89	24.27	7.22 (32.5)	6.90 (31.2)	6.87 (28.8)	7.22 (29.7)	15.01 (67.5)	15.25 (68.8)	17.02 (71.2)	17.05 (70.3)
18.	55-59		16.08	17.41	18.36	19.20	6.92 (43.0)	7.01 (40.3)	7.19 (39.2)	7.27 (37.9)	9.16 (57.0)	10.4 (59.7)	11.17 (60.8)	11.93 (62.1)
18.	60-64		12.56	13.16	14.79	15.57	5.67 (45.1)	5.51 (41.9)	5.64 (38.1)	5.56 (35.7)	6.89 (54.9)	7.65 (58.1)	9.15 (61.9)	10.01 (64.3)
19.	70-74		8.94		9.88	11.06	3.90 (43.6)		3.99 (40.4)	3.91 (35.4)	5.05 (56.4)		5.89 (59.6)	7.15 (64.6)
19.	75-79		7.40		8.07	8.75	3.45 (46.6)		3.24 (40.1)	3.28 (37.5)	3.95 (53.4)		4.83 (59.9)	5.47 (62.5)
19.	80-84		5.32		5.54	6.33	2.29 (43.0)		2.13 (38.4)	2.77 (43.8)	3.03 (57.0)		3.41 (61.6)	3.56 (56.2)
2.	45		28.1			35.5	10.3 (36.7) (2.3=severe)			10.7 (30.3) (2.3=severe)	17.8 (63.3)			24.7 (69.7)
3.	20		49.5	54.3	55.9	56.7	13.0 (26.3)	9.5 (17.5)	10.9 (19.5)	8.0 (14.1)	36.5 (73.7)	44.8 (82.5)	45.0 (80.5)	48.7 (85.9)
	65		11.2	14.6	15.7	16.4	4.3 (38.4)	5.3 (36.3)	6.4 (40.8)	4.7 (28.7)	6.9 (61.6)	9.3 (63.7)	9.3 (59.1)	11.7 (71.3)
3.	20		49.5	54.3	55.9	56.7	20.5 (41.4)	18.3 (33.7)	20.9 (37.4)	20.1 (35.4)	29.0 (58.6)	36.0 (66.3)	35.0 (62.6)	36.6 (64.6)
	65		11.2	14.6	15.7	16.4	6.6 (58.9)	6.0 (41.1)	8.8 (56.1)	8.2 (50.0)	4.6 (41.1)	8.6 (58.9)	6.9 (43.9)	8.2 (50.0)
7.[1]	65	H	14.2			18.7	1.3 (9.2)			2.5 (13.4)	12.9 (90.8)			16.2 (86.6)
		M	11.8			17.0	1.3 (11.0)			2.6 (15.3)	10.5 (89.0)			14.4 (84.7)
		L	11.5			13.7	2.0 (17.4)			2.6 (19.0)	9.5 (82.6)			11.1 (81.0)
12.	50		25.7			32.2	3.8 (14.6)			4.6 (14.3)	22.0 (85.4)			27.6 (85.7)
20.	55		19.9		24.8	27.6	4.9 (24.6)		5.3 (21.4)	6.2 (22.5)	15 (75.4)		19.5 (78.6)	21.4 (77.5)
21,	50-75		21.86			24.19	7.92 (36.1)			5.1 (21.3)	13.95 (63.8)			19.09 (78.9)
22.	50-75		22.35			24.6	10.19 (45.5)			8.12 (32.9)	12.16 (54.4)			16.48 (67)

Table A4. Health expectancies as reported in included articles for men (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
23.	50-75		23.42			24.78	4.5 (19.2)			3.82 (15.3)	18.92 (80.8)			20.96 (84.6)
24.	50-75		24.8			25.36	7.69 (31.0)			5.83 (23.0)	17.11 (69)			19.53 (77)
21.	50-75		21.91			24.16	11.17 (51)			9.87 (40.9)	10.74 (49)			14.28 (59.1)
22,	50-75		22.17			24.56	11 (49.6)			11.66 (47.5)	11.17 (50.4)			12.9 (52.5)
23.	50-75		23.48			24.74	10.88 (46.3)			9.9 (40)	12.6 (53.7)			14.84 (60)
24.	50-75		24.66			25.37	11.49 (46.6)			10.9 (43.0)	13.17 (53.4)			14.47 (57.0)
4.[2]	30 (SRH)	H	41.7	46.2	47.9	49.2	12.0 (28.8)	9.5 (20.6)	7.9 (16.5)	5.2 (10.6)	29.8 (71.5)	36.7 (79.4)	39.9 (83.3)	44.0 (89.4)
		M	39.9	44.8	46.8	48.4	11.6 (29.1)	10.4 (23.2)	11.1 (23.7)	8.6 (17.8)	28.3 (70.9)	34.3 (76.6)	35.7 (76.3)	39.8 (82.2)
		L	38.0	43.1	45.2	46.9	13.8 (36.3)	14.1 (32.7)	12.7 (28.1)	12.5 (26.7)	24,2 (63.7)	29.0 (67.3)	32.5 (71.9)	34.4 (73.3)
	30		39.5	44.4	46.4	48.1	12.2 (30.9)	10.9 (24.5)	10.6 (22.8)	8.7 (18.1)	27.3 (69.1)	33.5 (75.5)	35.8 (77.2)	39.4 (81.9)
	30 (CHR)	H	41.7	46.2	47.9	49.2	18.6 (44.6)	18.1 (39.2)	18.2 (38.0)	17.0 (34.6)	23.1 (55.4)	28.1 (60.8)	29.7 (62.0)	32.3 (65.7)
		M	39.9	44.8	46.8	48.4	19.2 (48.1)	18.7 (41.7)	22.1 (47.2)	19.1 (39.5)	20.7 (51.9)	26.1 (58.3)	24.6 (52.6)	29.3 (60.5)
		L	38.0	43.1	45.2	46.9	18.7 (49.2)	21.9 (50.8)	22.9 (50.7)	21.1 (45.0)	19.3 (50.8)	21.2 (49.2)	22.3 (49.3)	25.8 (55.0)
	30		39.5	44.4	46.4	48.1	18.6 (47.1)	19.2 (43.2)	21.1 (45.5)	19.4 (40.3)	20.9 (52.9)	25.2 (56.8)	25.3 (54.5)	28.7 (59.7)
11.[3]	16	N	56.9			60.4	8.9 (15.6)			9.5 (15.7)	48 (84.4)			50.9 (84.3)
		O	58.8			62.4	9.5 (16.12			10.1 (16.2)	49.3 (83.8)			52.3 (83.8)
		B	56.7			60.2	11.1 (19.6)			11.8 (19.6)	45.6 (80.4)			48.4 (80.4)
13.	30		44.8			46.4	6.4 (14.2)			5.5 (11.9)	38.5 (85.9)			41.0 (88.4)
	70		10.7			11.6	4.4 (41.1)			4.1 (35.3)	6.3 (58.9)			7.5 (64.7)
14.	50		25.4		29.4	29.7	6.6 (26.0)		6.0 (20.4)	7.0 (23.6)	18.8 (74.0)		23.3 (79.3)	22.6 (76.1)

Table A4. Health expectancies as reported in included articles for men (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
10.[4]	55		23.6		26.2	27.6	3.8 (16.1)		4.0 (15.3)	3.8 (13.8)	19.8 (83.9)		22.2 (84.7)	23.8 (86.2)
	55		23.6		26.2	27.6	2.7 (11.4)		2.8 (10.7)	2.7 (9.8)	20.9 (88.6)		23.4 (89.3)	24.9 (90.2)
15.	50		19.4		25.3	25.3	2.3 (11.9)		2.7 (10.7)	2.7 (10.7)	17.1 (88.1)		22.6 (89.3)	22.6 89.3)
16.	50		26.3		31.8	34.7	6.8 (25.9)		5.7 (17.9)	6.4 (18.4)	19.4 (73.8)		26.1 (82.1)	28.3 (81.6)
17.	50		23.5		27.3	27.7	4.5(19.1)		3.7 (13.6)	3.8 (13.7)	19 (80.9)		23.6 (86.4)	23.9 (86.3)
9,	18		53.6			62.5	10.1 (18.8)			7.9 (12.6)	43.5 (81.2)			54.6 (87.4)
25.	20		55.4			63.1	8.5 (15.3)			8.3 (13.2)	46.9 (84.7)			54.8 (86.8)
	40		37.1			44.6	7.9 (21.3)			7.6 (17.0)	29.2 (78.7)			37.0 (83.0)
	65		15.4			21.0	6.0 (39.0)			4.5 (21.4)	9.4 (61.0)			16.5 (78.6)
26.	15		57.7			66.5	6.4 (11.1)			6.7 (10.1)	51.3 (88.9)			59.8 (89.9)
8.[5]	65	L	11.77		14.37	17.31	1.73 (14.7)		2.35 (16.4)	3.18 (18.4)	10.04 (85.3)		12.02 (83.6)	14.13 (81.6)
		H	12.08		14.66	17.56	1.53 (12.7)		2.08 (14.2)	2.84 (16.2)	10.55 (87.3)		12.58 (85.8)	14.72 (83.8)
	70	L	9.04		11.26	13.85	1.76 (19.5)		2.39 (21.2)	3.23 (23.3)	7.28 (80.5)		8.87 (78.8)	10.62 (76.7)
		H	9.30		11.49	14.04	1.56 (16.8)		2.12 (18.5)	2.88 (20.5)	7.74 (83.2)		9.37 (81.5)	11.16 (79.5)
	75	L	6.79		8.61	10.81	1.78 (26.2)		2.41 (28.0)	3.26 (30.2)	5.01 (73.8)		6.20 (72.0)	7.55 (69.8)
		H	6.97		8.77	10.93	1.57 (22.5)		2.14 (24.4)	2.90 (26.5)	5.40 (77.5)		6.63 (75.6)	8.03 (73.5)
	80	L	4.99		6.42	8.22	1.77 (35.5)		2.39 (37.2)	3.23 (39.3)	3.22 (64.5)		4.03 (62.8)	4.99 (60.7)
		H	5.10		6.50	8.25	1.58 (31.0)		2.14 (32.9)	2.89 (35.0)	3.52 (69.0)		4.36 (67.1)	5.36 (65.0)
	85	L	3.73		4.83	6.26	1.68 (45.0)		2.27 (47.0)	3.07 (49.0)	2.05 (55.0)		2.56 (53.0)	3.19 (51.0)
		H	3.77		4.85	6.23	1.51 (40.0)		2.04 (42.1)	2.76 (44.3)	2.26 (60.0)		2.81 (57.9)	3.47 (55.7)
	90	L	2.65		3.48	4.58	1.61 (60.8)		2.17 (62.4)	2.93 (64.0)	1.04 (39.2)		1.31 (37.6)	1.65 (36.0)
		H	2.61		3.41	4.45	1.47 (56.3)		1.98 (58.1)	2.66 (59.8)	1.14 (43.7)		1.43 (41.9)	1.79 (40.2)

Table A4. Health expectancies as reported in included articles for men (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
5.[2]	30	H	41.8	46.2		49.2	12.0 (28.7)	9.5 (20.6)		5.2 (10.6)	29.8 (71.3)	36.7 (79.4)		44.0 (89.4)
		M	39.9	44.8		48.4	11.6 (29.1)	10.4 (23.2)		8.6 (17.8)	28.3 (70.9)	34.3 (76.6)		39.8 (82.2)
		L	38.0	43.1		46.9	13.8 (36.3)	14.1 (32.7)		12.5 (26.7)	24.2 (63.7)	29.0 (67.3)		34.4 (73.3)
	30		39.5	44.4		48.1	12.2 (30.9)	10.9 (24.5)		8.7 (18.1)	27.3 (69.1)	33.5 (75.5)		39.4 (81.9)

[1]Stratified by physical activity: High – Moderate – Low, [2] Stratified by educational level: High – Medium – Low, [3] Stratified by weight (Normal weight – Overweight – Obese),
[4] Second row includes estimations with time to death, [5] Stratified by educational level (Low – High). **Age:** Life expectancy estimated from what age (report multiple lines when they estimate from multiple ages)
+: Further stratified by.**(H)S:** (Heavy) Smokers (heavy when moderate is also reported). **MS:** Moderate smokers. **F:** Former smoker. **NS:** Non-smokers. **Total LE – YRS:** total life expectancy in years
Unhealthy LE – YRS (%): unhealthy life expectancy in years, and in brackets the percentage of the total life expectancy. **Healthy LE – YRS (%):** healthy life expectancy in years, and in brackets the percentage of the total life expectancy. **SRH**: Self-rated health. **CHR**: Chronic diseases.

Appendix 5

Table A5. Health expectancies as reported in included articles for women

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
6.	25		47.0	52.2	56.0	57.4	8.5 (18.1)	8.7 (16.7)	8.5 (15.2)	7.7 (13.4)	38.5 (81.9)	43.5 (83.3)	47.5 (84.8)	49.7 (86.6)
1.	65		15.5			21.4	1.2 (7.7)			2.5 (11.7)	14.3 (92.3)			18.9 (88.3)
18.	50-54		27.16	27.55	27.77	28.60	9.03 (33.2)	8.74 (31.7)	9.02 (32.5)	8.81 (30.8)	18.13 (66.8)	18.81 (68.3)	18.75 (67.5)	19.79 (69.2)
18.	55-59		21.44	23.67	23.42	23.99	7.91 (36.9)	8.38 (35.4)	8.35 (35.7)	8.28 (34.5)	13.53 (63.1)	15.29 (64.6)	15.07 (64.3)	15.71 (65.5)
18.	60-64		17.20	17.53	18.03	18.65	6.41 (37.3)	7.09 (40.4)	6.88 (38.2)	6.88 (36.9)	10.79 (62.7)	10.44 (59.6)	11.15 (61.8)	11.77 (63.1)
19.	70-74		12.96		14.02	14.59	5.45 (42.1)		5.27 (37.6)	5.45 (37.4)	7.51 (57.9)		8.78 (62.4)	9.14 (62.6)
19.	75-79		10.79		10.38	11.49	4.52 (41.9)		3.74 (36.0)	4.04 (35.2)	6.27 (58.1)		6.64 (64.0)	7.45 (64.8)
19.	80-84		7.88		8.33	8.99	3.04 (38.6)		3.45 (41.4)	3.54 (39.4)	4.84 (61.4)		4.88 (58.6)	5.45 (60.6)
2.	45		30.4			40.8	13.4 (44.1) (3.2=severe)			15.8 (38.7) (3.9=severe)	17.0 (55.9)			25.0 (61.3)
3.	20		53.8	58.5	60.0	60.9	20 (37.2)	15.3 (26.2)	15.3 (25.5)	14.5 (23.8)	33.8 (62.8)	43.2 (73.8)	44.7 (74.5)	46.4 (76.2)
	65		13.8	17.3	18.4	19.1	9.4 (68.1)	8.4 (48.6)	8.0 (43.5)	9.1 (47.6)	4.4 (31.9)	8.9 (51.4)	10.4 (56.5)	10.0 (52.4)
3.	20		53.8	58.5	60.0	60.9	29.3 (54.2)	21.4 (36.6)	24.4 (40.7)	24.8 (40.7)	24.6 (45.7)	37.1 (63.4)	35.6 (59.3)	36.1 (59.3)
	65		13.8	17.3	18.4	19.1	12.1 (87.7)	9.2 (53.2)	10.7 (58.2)	12.1 (63.4)	1.7 (12.3)	8.1 (46.8)	7.7 (41.8)	7.0 (36.6)
7.[1]	65	H	17.5			22.2	2.2 (12.6)			3.8 (17.1)	15.3 (87.4)			18.4 (82.9)
		M	14.8			20.1	2.2 (14.9)			3.9 (19.4)	12.6 (85.1)			16.2 (80.6)
		L	14.2			16.5	3.1 (21.8)			3.8 (23.0)	11.1 (78.2)			12.7 (77.0)
12.	50		28.3			34.5	5.3 (18.7)			6.2 (18.0)	23.0 (81.3)			28.3 (82.0)
20.	55		23.8		28.8	30.4	7.0 (29.4)		7.5 (26.0)	8.4 (27.6)	16.8 (70.6)		21.3 (74.0)	22.0 (72.4)
21.	50-75		23.25			24.85	8.47 (36.4)			5.19 (20.9)	14.79 (63.6)			19.66 (79.1)
22.	50-75		23.72			25.14	10.08 (42.6)			8.21 (32.7)	13.64 (57.5)			16.93 (67.3)
23.	50-75		24.16			25.05	5.67 (23.6)			4.75 (19.1)	18.49 (76.5)			20.31 (81)

Table A5. Health expectancies as reported in included articles for women (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
24.	50-75		25.12			25.54	6.57 (26.3)			4.83 (18.8)	18.55 (73.9)			20.72 (81.1)
21.	50-75		23.3			24.76	10.65 (45.7)			9.59 (38.7)	12.66 (54.3)			15.17 (61.3)
22.	50-75		23.66			25.08	12.09 (51.1)			11.57 (46.1)	11.57 (48.9)			13.51 (53.9)
23.	50-75		24.1			25.13	11.71 (48.6)			9.7 (38.6)	12.39 (51.4)			15.42 (61.4)
24.	50-75		24.92			25.53	9.88 (39.7)			8.8 (34.5)	15.04 (60.3)			16.73 (65.5)
4.[2]	30 (SRH)	H	44.6	49.2	51.1	52.7	7.7 (17.3)	8.9 (18.1)	10.4 (20.4)	11.8 (22.4)	36.8 (82.5)	40.3 (81.9)	40.8 (79.8)	40.9 (77.6)
		M	44.1	48.8	50.8	52.4	14.7 (33.3)	15.3 (31.4)	14.1 (27.8)	14.1 (26.9)	29.3 (66.4)	33.6 (68.9)	36.7(72.2)	38.2 (72.9)
		L	42.7	47.8	49.8	51.4	18.6 (43.6)	19.7 (41.2)	20.0 (40.2)	14.4 (28.0)	24.1 (56.4)	28.0 (58.6)	29.7 (59.6)	37.1 (72.2)
	30		43.5	48.4	50.3	51.9	14.8 (34.0)	14.9 (30.8)	14.5 (28.8)	13.0 (25.0)	28.7 (66.0)	33.5 (69.2)	35.8 (71.2)	39.0 (75.1)
	30 (CHR)	H	44.6	49.2	51.1	52.7	18.7 (41.9)	23.1 (47.0)	24.7 (48.3)	21.4 (40.6)	25.8 (57.8)	26.2 (53.3)	26.5 (51.9)	31.3 (59.4)
		M	44.1	48.8	50.8	52.4	20.8 (47.2)	22.0 (45.1)	23.5 (46.43)	23.9 (45.6)	23.3 (52.8)	26.8 (54.9)	27.2 (53.5)	28.5 (54.4)
		L	42.7	47.8	49.8	51.4	24.6 (57.6)	24.9 (52.1)	25.4 (51.0)	22.1 (43.0)	18.1 (42.4)	22.8 (47.7)	24.4 (49.0)	29.4 (57.2)
	30		43.5	48.4	50.3	51.9	21.8 (50.1)	22.9 (47.3)	24.0 (47.7)	22.5 (43.4)	21.7 (49.9)	25.5 (52.7)	26.3 (52.3)	29.4 (56.6)
11.[3]	16	N	63.2			65.5	12.0 (19.0)			11.9 (18.2)	51.2 (81)			53.6 (81.8)
		O	66.4			68.4	15.7 (23.6)			15.5 (22.7)	50.7 (76.4)			52.9 (77.3)
		B	61.9			63.9	18.3 (29.6)			18.0 (28.2)	43.6 (70.4)			45.9 (71.8)
13.	30		50.8			51.6	12.4 (24.4)			11.3 (21.9)	38.4 (75.6)			40.3 (78.1)
	70		14.3			14.8	8.5 (59.4)			8.3 (56.1)	5.8 (40.6)			6.5 (43.9)
14.	50		30.4		33.2	34.5	5.6 (18.4)		6.2 (18.7)	6.3 (18.3)	24.7 (81.3)		27.0 (81.3)	28.1 (81.4)
10.[4]	55		23.6		26.2	27.6	3.8 (16.1)		4.0 (15.3)	3.8 (13.8)	19.8 (83.9)		22.2 (84.7)	23.8 (86.2)
	55		23.6		26.2	27.6	2.7 (11.4)		2.8 (10.7)	2.7 (9.8)	20.9 (88.6)		23.4 (89.3)	24.9 (90.2)

Table A5. Health expectancies as reported in included articles for women (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
15.	50		22.8		29.2	29.2	2.3 (10.1)		2.6 (8.9)	2.6 (8.9)	20.5 (89.9)		26.5 (90.8)	26.6 (91.1)
16.	50		30.9		37.0	40.1	6.6 (21.4)		5.3 (14.3)	6.0 (15.0)	24.4 (78.6)		31.5 (85.1)	34.1 (85.0)
17.	50		27.0		30.8	31.3	3.3 (12.2)		2.7 (8.8)	2.7 (8.6)	23.7 (87.8)		28.2 (91.6)	28.6 (91.4)
9.	18		53.6			62.5	10.1 (18.8)			7.9 (12.6)	43.5 (81.2)			54.6 (87.4)
25.	20		59.4			65.7	10.0 (16.8)			10.3 (15.7)	49.4 (83.2)			55.4 (84.3)
	40		40.8			47.0	9.2 (22.5)			9.5 (20.2)	31.6 (77.5)			37.5 (79.8)
	65		18.2			23.2	6.0 (33.0)			5.0 (21.6)	12.2 (67.0)			18.2 (78.4)
26.	15		64.0			69.9	9.7 (15.2)			11.3 (16.2)	54.3 (84,8)			58.6 (83,8)
8.[5]	65	L	15.14		18.07	21.30	2.81 (18.6)		3.70 (20.5)	4.83 (22.7)	12.33 (81.4)		14.37 (79.5)	16.47 (77.3)
		H	15.43		18.29	21.43	2.51 (16.3)		3.31 (18.1)	4.34 (20.3)	12.92 (83.7)		14.98 (81.9)	17.09 (79.7)
	70	L	11.80		14.40	17.33	2.80 (23.7)		3.70 (25.7)	4.83 (27.9)	9.00 (76.3)		10.70 (74.3)	12.50 (72.1)
		H	12.04		14.56	17.42	2.51 (20.8)		3.31 (22.7)	4.34 (24.9)	9.53 (79.2)		11.25 (77.3)	13.08 (75.1)
	75	L	8.96		11.15	13.73	2.76 (30.8)		3.64 (32.6)	4.77 (34.7)	6.20 (69.2)		7.51 (67.4)	8.96 (65.3)
		H	9.11		11.25	13.75	2.47 (27.1)		3.27 (29.1)	4.29 (31.2)	6.64 (72.9)		7.98 (70.9)	9.46 (68.8)
	80	L	6.61		8.41	10.57	2.65 (40.1)		3.52 (41.9)	4.62 (43.7)	3.96 (59.9)		4.89 (58.1)	5.95 (56.3)
		H	6.69		8.43	10.53	2.39 (35.7)		3.18 (37.7)	4.18 (39.7)	4.30 (64.3)		5.25 (62.3)	6.35 (60.3)
	85	L	4.95		6.35	8.10	2.47 (49.9)		3.28 (51.7)	4.32 (53.3)	2.48 (50.1)		3.07 (48.3)	3.78 (46.7)
		H	4.96		6.31	8.00	2.24 (45.2)		2.97 (47.1)	3.92 (49.0)	2.72 (54.8)		3.34 (52.9)	4.08 (51.0)
	90	L	3.51		4.58	5.93	2.25 (64.1)		3.00 (65.5)	3.94 (66.4)	1.26 (35.9)		1.58 (34.5)	1.99 (33.6)
		H	3.43		4.45	5.74	2.06 (60.1)		2.74 (61.6)	3.62 (63.1)	1.37 (39.9)		1.71 (38.4)	2.12 (36.9)

Table A5. Health expectancies as reported in included articles for women (continued)

Cohort #	Age	+	Total LE - YRS				Unhealthy LE – YRS (%)				Healthy LE – YRS (%)			
			(H)S	MS	F	NS	(H)S	MS	F	NS	(H)S	MS	F	NS
5.[2]	30	L	44.6	49.2		52.7	7.8 (17.5)	8.9 (18.1)		11.8 (22.4)	36.8 (82.5)	40.3 (81.9)		40.9 (77.6)
		M	44.1	48.9		52.4	14.7 (33.3)	15.3 (31.3)		14.1 (26.9)	29.3 (66.4)	33.6 (68.7)		38.2 (72.9)
		L	42.8	47.8		51.4	18.6 (43.5)	19.7 (41.2)		14.4 (28.0)	24.1 (56.3)	28.0 (58.6)		37.1 (72.1)
	30		43.5	48.4		51.9	14.8 (34.0)	14.9 (30.8)		13.0 (25.0)	28.7 (66.0)	33.5 (69.2)		39.0 (75.1)

[1]Stratified by physical activity: High – Moderate – Low, [2] Stratified by educational level: High – Medium – Low, [3] Stratified by weight (Normal weight – Overweight – Obese), [4] Second row includes estimations, with time to death, [5] Stratified by educational level (Low – High), **Age:** Life expectancy estimated from what age (report multiple lines when they estimate from multiple ages), **+**: Further stratified by **(H)S:** (Heavy) Smokers (heavy when moderate is also reported), **MS:** Moderate smokers, **F:** Former smoker, **NS:** Non-smokers, **Total LE – YRS:** total life expectancy in years , **Unhealthy LE – YRS (%):** unhealthy life expectancy in years, and in brackets the percentage of the total life expectancy, **Healthy LE – YRS (%):** healthy life expectancy in years, and in brackets the percentage of the total life expectancy, **SRH**: Self-rated health, **CHR**: Chronic diseases.

5 The Healthy Aging Index analyzed over 15 Years in the general population: the Doetinchem Cohort Study

Based on: Dieteren, C. M., Samson, L. D., Schipper, M., van Exel, J., Brouwer, W. B., Verschuren, W. M., & Picavet, H. S. J. (2020). The Healthy Aging Index analyzed over 15 years in the general population: The Doetinchem Cohort Study. Preventive Medicine, 139, 106193.

ABSTRACT

The Healthy Aging Index (HAI), an index of physiological aging, has been demonstrated to predicts mortality, morbidity and disability. We studied the longitudinal development of the HAI to identify aging trajectories and evaluated the role of baseline sociodemographic characteristics and lifestyle factors of the trajectories. Four measurements with intervals of 5 years were included from the Doetinchem Cohort Study. The HAI reflects levels of systolic blood pressure, non-fasting plasma glucose levels, global cognitive functioning, plasma creatinine levels and lung functioning. The HAI score ranges from 0-10: higher scores indicate a better health profile. Latent class mixture modelling was used to model within-person change and to identify aging trajectories. Area under the curve was calculated per trajectory to estimate total healthy years. In total, 2,324 women and 2,013 men were included. One HAI trajectory was identified for women, and two trajectories for men, labelled 'gradual' aging (76%) and 'early' aging (24%). Men who were medium/high educated, below 36 years at baseline, complied with guidelines on physical activity and were not obese in any round were associated with increased odds to 'gradual' aging of 1.46 (CI: 1.18-1.81), 1.93 (CI: 1.42-2.62), 1.26 (1.02-1.57) and 1.76 (1.32-2.35), respectively. Between 30 and 70 years of age, men in the 'early' aging trajectory had the least healthy years (29.6 years), followed by women (30.1 years), and 'gradual' aging men (34.7 years). This study emphasizes that 'physiological aging' is not only an issue of older ages. Between 30 and 70 years of age, 'early' aging men and women had approximately five healthy years less compared to 'gradual' aging men. Lifestyle factors (e.g., nutrition and physical activity) seem to play an important role in optimal aging.

5.1 BACKGROUND

Life expectancy continues to rise worldwide so there is an increasing interest in how aging affects health. Because health comprises a wide variety of factors, measuring the effects of aging on health is challenging [1]. Current aging indices use a range of factors related to health and are based on, for instance, comorbidity [2] [3], frailty [4] or physiological parameters [5]. One example of an aging index based on physiological parameters only is the Healthy Aging Index (HAI) [6].

The HAI is an adaptation of the “Physiologic Index of Comorbidity” (PIC) that was developed by Newman, Boudreau [7], which included measurements of carotid intima-media thickness, pulmonary vital capacity, serum cystatin-C, white matter grade, and serum fasting glucose. The PIC was sensitive to detect subclinical disease in older adults [7], but the indicators used for this index are not widely available in epidemiological studies, which limits its wider application [6]. The HAI was shown to be a reliable adaptation of the PIC, as it predicts mortality independently of chronological age and comorbidities [5, 6, 8, 9]. In addition, it was shown that the HAI is associated with the risk of incident disability, mobility limitations, slow gait speed and incident cardiovascular disease [5, 8, 10].

The HAI involves indicators for five physiologic systems that indicate both clinical and sub-clinical changes in organ structure and function [5]. Blood pressure, glucose, creatinine, lung function and cognitive functioning are used as parameters in the HAI. Due to supporting evidence, partly discussed above, the HAI is increasingly being used as a summary measure of physiological health. In addition to chronological age, these biomarkers can be used to predict future events [11]. Thus, a biomarker-based index may help to identify people who have the potential to remain healthy throughout their life course.

It is important to understand heterogeneity in health trajectories related to aging in order to understand how and why people age in the way they do. Gaining insights in the dynamics of the effect of age on health can be achieved by examining how the HAI develops over the life course in a population. Some studies have analyzed the relation between aging indices similar to the HAI with age. Studies in samples of older (50+) and elderly (70+) people [12-14] suggest that there is a sex difference in aging trajectories and that baseline HAI scores is of importance for the subsequent aging trajectory. The follow-up time in previous studies was maximum 10 years with repeated measurements up to a number of 3. To gain more insight into physiological aging over the life course, longitudinal studies with more measurements, longer follow-up time, and covering a longer span of the adult life course are desired.

In this study we used four measurement points from the Doetinchem Cohort Study (DCS) [15], spanning a period of 15 years, to study development in individual HAI scores over the life course among people aged between 30 and 70 years in the Netherlands. The objective of this study was to describe the development of the HAI with age for men and women separately, and to investigate whether different typical aging trajectories could be identified in the data. For the different trajectories, the number of years lived in full health was calculated and the role of baseline sociodemographic characteristics and lifestyle factors were evaluated.

5.2 METHODS

5.2.1 Setting and participants

Between 1987 and 1991, a total number of 20,155 inhabitants (aged 20-59 years) of the city of Doetinchem, the Netherlands were invited to participate in the study named “Monitoring Project on Cardiovascular Disease Risk Factors”, based on a random selection stratified by sex and age [16]. The response rate was 62% (n=12,405). From this group, 7,769 people were randomly selected and invited for the second examination (1993-1997) and future follow-up examinations in the DCS. Appendix 1 provides an overview of the response of follow up measurements thus far. The study is approved by the Medical Ethics Committees of the Netherlands Organization of Applied Scientific Research and the University of Utrecht. The cohort profile is described in detail elsewhere [15]. Not all HAI indicators were measured in round 1 of the DCS. Therefore, we used the data from round 2 (1993-1997) as baseline (T1) until round 5 (2008-2012) (T4) for the current study. Participants were included in the study if they had at least one complete HAI score (e.g., values on all the five indicators of the HAI) in the four included measurements. In total 2,324 women and 2,013 men were included.

5.2.2 Construction of the Healthy Aging Index

The HAI used in this study is based on the study of Sanders et al., (2012) [5] and involves five indicators. Indicators were each graded at one of the three levels, with a score of 0 meaning the ‘least healthy’ outcome, a score of 1 an ‘intermediate’ outcome and a score of 2 the ‘healthiest’ outcome. Then, the HAI score was calculated by adding up all the five indicator scores. Thus, HAI scores can theoretically range between 0 and 10, with 0 indicating the least healthy and 10 the healthiest score. Cut-off points, see Table 5.1, were replicated from previous studies for systolic blood pressure (SBP), creatinine and forced vital capacity (FVC) [5, 6, 8]. Clinical cut-off points were applied for random blood glucose (RBG) and cognitive function [17] Bowen, Xuan [18]. Nooyens, Bueno-de-Mesquita [21] have described the cognitive tests in more detail. Cognition scores were transformed into z-scores to capture the decline rate over time [22, 23]. Appendix 2 provides further information about the way measurements were conducted.

Table 5.1 Cut-off off points used to categorize each indicator of the HAI

	Healthy Aging Index indicators							
Score for group	SBP, mmHg	RBG, mmol/L	Creatinine, mmol/L		FVC, L		Cognition, Z-score	
			Men	Women	Men	Women	Men	Women
0=least healthy	≥143	≥11.1	≥114.9	≥ 88.4	<3.2	<2.1	<10th percentile in T4	<10th percentile in T4
1=intermediate	126-143	5.6-11.1	97.2–114.9	70.7–88.4	3.2-3.8	2.1-2.6	10th percentile – 0 in T4	10th percentile –0 in T4
2=healthiest	<126	<5.6	<97.2	<70.7	≥3.8	≥ 2.6	> 0	> 0

5.2.3 Baseline sociodemographic characteristics and lifestyle factors

Information on several sociodemographic characteristics and lifestyle factors were collected by an interviewer or via postal survey. Age at baseline was dichotomized as ≥ 36 years and younger in order to account for a potential cohort effect. Educational level was dichotomized into low (intermediate secondary education or less) and medium/high (intermediate vocational, higher secondary education, higher vocational education or university). Work status was defined as having a formal paid job (including salaried employment and self-employed) or being unemployed. Marital status was dichotomized, being married also included registered partnership. Lifestyle was defined by the following variables: sleep, physical activity, body mass index (weight and height were assessed by a health care worker (weight (kg) / [height (m)]2), smoking status and alcohol consumption.

5.2.4 Statistical analyzes

The HAI scores were interpreted as observed representations of a latent aging process. Link functions were used to map the latent aging process (that is assumed to be Gaussian) to these observations (like in generalized linear models [25]). We expected that the population consists of a number of latent classes representing different aging trajectories. Each latent class has its own mean profile that was modelled according to age. The approach of latent class mixed models (LCMM) [26, 27] offers a unified framework and estimation process for these models. For a predefined number of latent classes, the mean class-profiles were modelled using linear mixed models on the latent scale, with a random intercept per individual. Two types of link functions were examined to map the latent scale onto the observed HAI scores: a linear transformation and a threshold function. The mean class profiles were modelled as a smooth function of age, by means of natural cubic splines with different degrees of freedom (1 to 4), defining the overall smoothness. Among the different fitted models, the model with the smallest Bayesian Information Criterion (BIC) was chosen as the best model [28], where the maximum likelihood was penalized for the number of parameters used to fit the model. All analyzes were performed in R 3.5.2 [29] with the package lcmm version 1.8.1 [30].

The number of healthy life years per trajectory was calculated by means of the area under the curve (AUC) between the ages of 30 and 70, analogous to the concept of Quality-Adjusted Life Years (QALYs), with the mean HAI score for the trajectory as a quality of life weight attached to each year. Thus, a year lived with a HAI score of 10 equals a year in full health, and receives a score of 1, whereas a year lived with a HAI score of 8 receives a score of 0.8. Scores for all years between 30 and 70 years of age are then aggregated to compute the number of healthy life years for the trajectory.

Lastly, regression analyzes were conducted to investigate which baseline sociodemographic characteristics were associated with the identified latent classes.

We accounted for the time sensitivity of the lifestyle variables by creating dummies that reflected the duration of engagement in each behavior. Appendix 3 provides detailed information about the dichotomizations. We investigated several forms of dummy variables (e.g., always, sometimes, never) to investigate how these mechanisms were associated with the identified trajectories and presented the most informative models.

5.2.5 Missing values

For each of the five indicators of the HAI, participants with missing values on two or more of the four measurements were disregarded. Data for participants with less than two missing values on an indicator were manually imputed based on values from other measurements. For SBP, RBG, creatinine and FVC we took the average value of the measurement before and after the missing data point. In case the first measurement was missing, we used the baseline values of the DCS. When this value was also missing, the value of round 3 (T2) was duplicated. In case the last SBP measurement was missing, we replicated the value at T3 for imputation. Missing data for global cognition functioning were imputed based on the assumption that global cognitive functioning will not recover after a decrease has started [24]. Therefore, in case of missing values, the value of a consecutive round was used for imputation. As cognitive tests were only performed among participants aged 45 years or older, we assumed that participants younger than 45 years were cognitively healthy [24]. We compared the imputed sample with the non-imputed sample to ensure that the values and population characteristics did not differ considerably (also see Appendices 4-9).

5.3 RESULTS

5.3.1 Sample characteristics

Table 5.2 presents the baseline (T1) sociodemographic characteristics, lifestyle characteristics and HAI values of the study sample. With a response rate of 71% the study sample consisted of 2,324 women and 2,013 men, aged 25-65 years at baseline (T1). Men were significantly older, had a higher education and were more often employed. Appendix 10 shows the characteristics of the total sample at T1. The study sample was slightly younger and consequently had somewhat healthier values for the HAI indicators.

Table 5.2 Characteristics of Doetinchem Cohort respondents, study sample at T1 (N=4,337)

Socio-demographic characteristics	**Women**	**Men**
Mean age (SD) *	42.8 (10.0)	43.7 (10.0)
Age categories, %		
26-35 yr	24.2	21.4
36-45 yr	42.0	41.4
46-55 yr	18.3	20.0
56-65 yr	15.5	17.2
Educational level, % *		
Low	59.4	44.0
Medium	25.5	32.4
High	15.1	23.6
Paid employed (yes) *	48.9	80.0
Marital status (married)	81.8	80.1
Sleep (<7 hours per night) *	11.8	18.8
Smoke status *		
Smoker	31.7	34.1
Ex-smoker	32.5	36.9
Never smoker	35.9	29.0
Physical activity (compliance with guideline)	78.6	76.1
BMI (kg/m2), mean (SD) *	25.3 (4.1)	25.9 (3.1)
Healthy Aging Index indicators	**μ (SD)**	**μ (SD)**
Systolic blood pressure, mmHg *	119.3 (15.8)	127.0 (14.9)
Random glucose, mmol/L *	5.2 (1.5)	5.4 (1.3)
Creatinine, mmol/L	72.7 (12.7)	72.5 (12)
Forced Vital Capacity (FVC), L *	4.0 (0.6)	5.4 (1.1)
Global cognitive function, z-score[1]	0.03 (0.7)	0.05 (0.8)
Healthy Aging Index *	8.3 (1.5)	8.5 (1.4)
Total, N (%)	**2,324 (54)**	**2,013 (46)**

* = Significant at p<0.05 level derived from chi2 and t-tests
[1] Scores of T2 are presented due to small sample size at T1

5.3.2 Healthy Aging Index – Descriptions

The distributions of the HAI scores for the included men and women in the different measurement rounds are presented in Figure 5.1. At T1 the study population was aged between 25 and 65 years, at T4 between 40 and 80 years. In the first measurement, at T1, the HAI scores showed a skewed distribution towards the healthy end of the spectrum, with average values of 8.5 and 8.3 for men and women respectively. Fifteen years later, at T4, there was a shift in the distribution of the HAI scores towards the unhealthy end of the spectrum (nearing a normal distribution). Only 11% of the men and 8% of the women had a HAI score of 10, with average scores of 7.2 and 6.9.

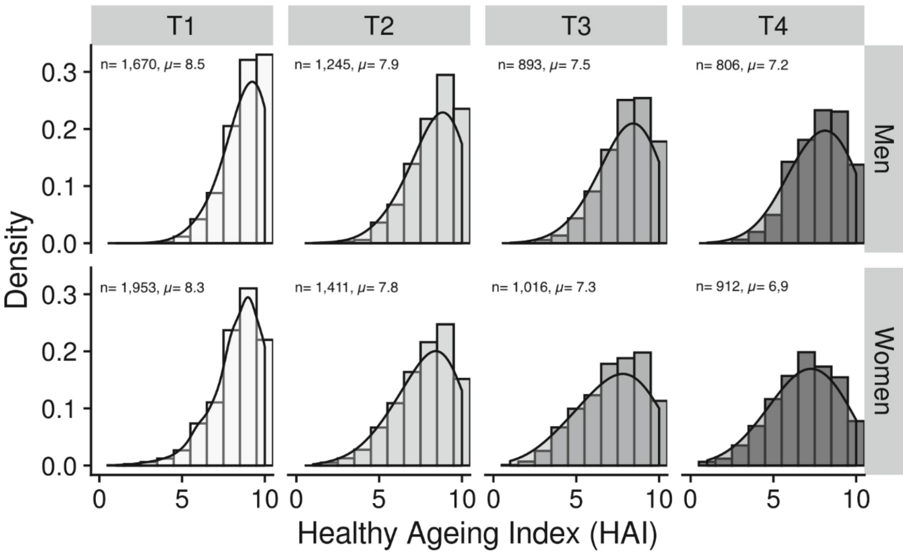

Figure 5.1 Distribution of the HAI scores at four different time points

The average population lines for the HAI scores by age stratified by gender can be found in Appendix 11. At age 30, women had an average HAI score of 8.9, while men had a slightly higher score of 9.3. The onset of decline in the HAI scores started for both men and women around the age of 40 years. Women had a 1.5 lower HAI score at the age of 70 compared to men (7.0 versus 5.5).

5.3.3 Healthy Aging Index – Latent Class Mixture Modelling

The latent class mixed models revealed two distinct HAI trajectories for men and one for women (Figure 5.2). For men, trajectory 1 included 24% (n=492) of the participants and this group was characterized by a relatively early start of decline in HAI score while it flattens later on. Accordingly, the men following this trajectory were named 'early' aging men. The mean HAI score for 'early' aging men was 9.0 at age 30, 8.4 at age 40, 7.1 at age 50 and 6.3 at ages 60 and 70. The remaining men (76%) followed a different trajectory, with on average a more gradual and consistent decline that started later with an average HAI score of 9.4 at ages 30 and 40, 8.8 at age 50, 8.2 at age 60 and 7.2 at age 70. The men following this trajectory were consequently named 'gradual' aging men. The area under the curve (AUC), as calculated for the trajectories between the ages of 30 and 70 years, was on average 29.6 for the 'early' aging men and 34.6 for the 'gradual' aging men. For women, only one latent trajectory emerged in the data. From the age of 40 years onwards, this trajectory showed a decline of 1.0 HAI score unit every 10 years which resulted in a score of 5.5 at age 70 and an AUC of 30.1, which is comparable to the AUC of the 'early' aging men trajectory. Put differently, of the potential 40 years in full health lived between the ages 30 and 70, 'gradual' aging men on average lived 34.6 healthy years, while women and 'early' aging men lost about 10 years (i.e., lost about five healthy years more than 'gradual' aging men).

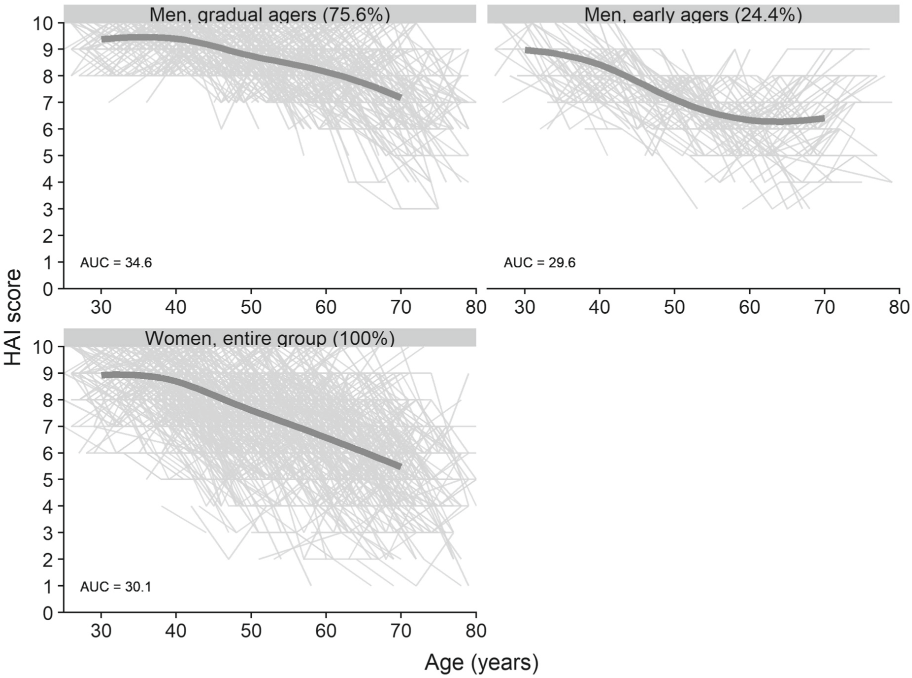

Figure 5.2 Identified trajectories of the HAI for men and women

Looking at the three identified trajectories together (Figure 5.3), it becomes clear that the 'early' aging men started with the steepest decline. However, this decline flattened around the age of 60 years while the decline for women continued. Consequently, women on average end with the lowest HAI score at age 70. The 'gradual' aging men show the most favorable HAI trajectory.

Figure 5.3 Identified trajectories of the HAI for men and women pictures together

5.3.4 Characteristics of the aging trajectories

At baseline, the 'gradual' aging men were slightly, though significantly, younger (average 43.4 years) and were higher educated than the 'early' aging men (average 44.9 years). The trajectories did not differ significantly in employment or marital status.

Table 5.3 shows the Odds Ratios (ORs) of trajectory membership for men by baseline sociodemographic characteristics and engagement in lifestyle behaviors over the four measurement rounds. Being aged below 36 years at baseline and having a medium or high level of education (versus low) were associated with increased odds of belonging to the 'gradual' aging men. Regarding lifestyle behaviors, compliance with the Dutch guideline for physical activity in all measurement rounds showed increased odds of belonging to the 'gradual' aging men (model 3). However, this association became no longer statistically significant after the addition of other lifestyle variables in the model (model 6). Not being obese in any measurement round showed increased odds of belonging to the 'gradual' aging men (model 4) and the association remained statistically significant in the model with all investigated lifestyle variables included (model 7). The association in the exact opposite direction also holds: being obese in every measurement round made it less likely to be in the 'gradual' aging trajectory. Surprisingly, the odds of belonging to the 'gradual' aging men was not statistically significantly altered with smoking status and alcohol consumption (model 5, model 6, model 7).

Table 5.3 Odds ratio's for the two identified HAI trajectories for men, 95% confidence intervals in parentheses (N=2,013)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Odds ratio	**Odds ratio**	**Odds ratio**	**Odds ratio**	**Odds ratio**	**Odds ratio**	**Odds ratio**
	Gradual Agers (reference group: Early Agers)						
Sociodemographic variables							
<36 years at baseline (reference: ≥36 years)	1.93* (1.42-2.62)	1.93* (1.42-2.62)	1.96* (1.45-2.67)	1.92* (1.41-2.61)	1.95* (1.44-2.66)	1.93* (1.42-2.62)	1.91* (1.40-2.60)
Medium & high educated (reference: low)	1.47* (1.18-1.81)	1.47* (1.19-1.82)	1.45* (1.17-1.80)	1.34* (1.07-1.66)	1.43* (1.15-1.77)	1.45* (1.17-1.79)	1.36* (1.09-1.69)
Married (reference: not married)	1.09 (0.82-1.43)	1.09 (0.82-1.44)	1.06 (0.80-1.40)	1.03 (0.77-1.37	1.07 (0.81-1.42)	1.09 (0.82-1.44)	1.03 (0.78-1.37)
Paid employed (reference: not employed)	0.92 (0.71-1.20)	0.92 (0.70-1.20)	0.90 (0.69-1.18)	0.86 (0.65-1.22)	0.91 (0.69-1.18)	0.90 (0.94-1.46)	0.86 (0.66-1.13)
Time sensitive lifestyle variables							
>7 hours sleep in all rounds (reference: ≤7 hours)		0.97 (0.78-1.22)					0.93 (0.74-1.16)
Sufficient physical activity in all rounds (reference: the rest)			1.26* (1.02-1.57)				1.08 (0.85-1.37)
Not obese in all rounds (reference: the rest)				1.69* (1.27-2.00)			1.76* (1.32-2.35)
Obese in all rounds (reference: the rest)				0.56* (0.38-0.81)			0.57* (0.39-0.83)
Non-smoker in all rounds (reference: the rest)					1.19 (0.96-1.48)		0.88 (0.67-1.16)
Alcohol consumer in all rounds (reference: the rest)						1.18 (0.95-1.46)	0.89 (0.69-1.16)
Constant	2.24* (1.61-3.11)	2.28* (1.59-3.27)	2.12* (1.52-2.96)	2.19* (1.55-3.09)	2.16* (1.55-3.01)	2.15* (1.54-3.00)	2.33* (1.60-3.41)
Nagelkerke R2	0.018	0.018	0.020	0.032	0.019	0.019	0.034
McFadden R2	0.016	0.016	0.019	0.029	0.018	0.017	0.031

*= significant at p <.05 level

5.4 DISCUSSION

This study emphasized that 'physiological aging' is not only an issue of older age, but that a much larger part of the life course is relevant in addressing physiological aging related research questions. Using the HAI, we identified two distinct aging trajectories among men and only one among women. The two trajectories among men were described as 'gradual' aging (75% of the men) and 'early' aging (25% of the men). The AUC estimates revealed that of the potential 40 years in full health (age range 30-70), 'early' aging men lost, on average, the most years in full health (10.4 years), followed by women (9.9 years), and 'gradual' aging men (5.4 years). This was the first study that investigated HAI trajectories with four time points, covering a period of 15 years.

Two other studies have investigated the HAI (or a similar index) with multiple measurements over time. O'Connell, Marron [13] found a decrease in the HAI of at least 1.0 point over a period of nine years among an older population (average age of 74 years at baseline). We modelled trajectories within the age range of 30 and 70 years, and found a decrease in HAI score of 1.0 point between the ages of 60 and 70 years for 'gradual' aging men, whereas 'early' aging men had a stable score over this same age range. Tampubolon [14] studied a very similar index over a period of nine years among people aged 50 years and older. They found a sharper decline for women than for men, while women had a more favorable score at baseline. The distribution of the index score was also wider for women than for men. These results are in line with our findings. Previously it has been suggested that sex differences may be explained by the biological variation between men and women, such as differences in hormones and the prevalence of metabolic syndrome [31]. This finding is in agreement with the 'sex paradox', i.e. the finding that women live longer than men, but tend to have worse health [32]. In our study population, men on average had a higher level of education than women, which suggests that more women in the sample had a socio-economic disadvantage for healthy aging. Since people with different educational levels tend to have different possibilities and lifestyles, and thus belong to a different study population, this might be a reason why we found two trajectories in men but only one in women.

On average, the male respondents in the two trajectories differed 1,5 years by age. We studied the change of the HAI while aging, with a method that assumes no differences between generations or birth cohorts. The regression analysis confirms a difference in age between the two trajectories, but also shows that other factors are significantly associated when there is controlled for age.

The regression analysis for the aging-trajectories among men showed associations with baseline educational level and age; and time-variant physical activity and BMI. The well-known social gradient in health outcomes [33] also seems to be present when biomarkers are used as health status indicators. Adherence to the Dutch physical activity guidelines, and not being obese increased the chance to follow the 'gradual' aging trajectory. Physical activity has been widely shown to benefit the aging process in a variety of domains, ranging from better social outcomes to a reduced risk for chronic diseases [34]. It has been suggested that "obesity disables, and smoking kills" [35]. Indeed, we found that being obese was associated with membership in the early aging trajectory. However, smoking status was not associated with one of the identified trajectories. The proportion of those who smoked was not significantly different between the total sample and our study sample, nor between the identified trajectories. Hence, a selective drop-out among smokers is unlikely. We found no other plausible explanations for this finding. In this study, alcohol consumption was also not associated with the aging trajectories. However, the data did not allow us to stratify between moderate and excessive alcohol consumption, which may explain this finding. The behaviors included in the models are sensitive to change over time (e.g., someone may start or quit smoking). We took this into account by the inclusion of dummy variables that reflected the different measurement rounds. Additional research is needed to study time-variant independent and dependent variables to gain insights in the relationship between a changing lifestyle while aging.

Two aspects are important to consider when interpreting the HAI change over time. First, the magnitude of change may be associated with the initial HAI score since participants starting with a disadvantaged score have less to lose. O'Connell, Marron [13] adjusted for the initial score to account for this impact, although they studied an already older population. In our study, trajectories had comparable HAI scores at age 30, ranging between 8.9 and 9.4 and thus differences in trajectories are unlikely to be due to these values. Second, the meaning of a change in HAI score is related to the current HAI score. Similar reductions in HAI scores in different trajectories are likely to have different effects on the (experienced) health state. People who experience a reduction in HAI score, but have a relative high HAI score, may be expected to have more reserve (e.g. they are "healthier" as defined by the HAI) compared to people with a lower HAI score. Similarly, it may matter what elements constituted the decrease in HAI scores.

5.4.1 Limitations and strengths

First, as in most prospective cohort studies, selective attrition is an obstacle in the interpretation of the results: healthy participants are more likely to remain in the study during extended follow-ups and institutionalized participants and those with (severe) health problems are more likely to drop-out [15]. Thus, participants of this study possibly represent a slightly healthier part of the population. Also, our study population is less representative of those living in more urbanized regions. Second, we had to include random blood glucose instead of fasting glucose in the HAI score. Consequently, our values for glucose were less accurate, although we took this into account in the chosen cut-off points. Third, we considered all respondents aged 45 years and younger cognitive healthy which may be an incorrect assumption. This may also explain partly why we found that 'Gradual agers' were slightly younger. The study has the following strengths. First, the long follow-up time and high participation rate provided us the opportunity to study the HAI longitudinally. Second, the wide age range (25-65 years at T1) of the respondents provided new insights in the HAI. Third, the HAI was measured consistently by trained health care professionals which ensured reliability.

5.5 CONCLUSIONS AND POLICY IMPLICATIONS

This study showed that there is significant variation in physiological aging, with a substantial difference in healthy life years: the 'early' aging men have the potential to gain approximately five healthy life years between the ages of 30 and 70 if they can transit to the 'gradual' aging trajectory. This study also showed that a large part of the life course is relevant for 'physiological aging': aging starts fairly early in life. Considering the main characteristics associated with aging trajectories, policies targeting to improve educational attainment and to promote a healthy lifestyle, leading to adequate BMI levels (i.e., to promote sufficient physical activity and a healthy diet), seem important to physiological aging. And these policies should target the whole population, not just older people, as aging seems to start early in life. Furthermore, for early identification of those at risk for 'early aging', which is needed for targeting preventive interventions, the monitoring of both lifestyle risk indicators and HAI indicators may be relevant.

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APPENDICES

Appendix 1

Table A1. Response rates in the DCS of the included rounds

Period	Invited	Participated	Response	DCS round	This study
1987 – 1991	20,154	12,404	62%	1	-
1993 – 1997	7,768	6,117*	79%	2	T1
1998 – 2002	6,581	4,918	75%	3	T2
2003 – 2007	5,783	4,520	78%	4	T3
2008 – 2012	5,136	4,018	78%	5	T4

The initial response of the random sample of the population was 62%. Two-third* of those who agreed to be measured again were approached for the second measurement 6 years later (T1 in our study). Everybody was invited for the subsequent measurements every 5 years with exclusion of those who died, moved too far away, emigrated and those who actively withdrew from the study. Respondents can skip one or more rounds and then participate again. Per round, 2% - 3% of the participants died or moved. From T2 onwards, in every round 23% of those invited did not participate with almost 50% of them mentioning that they do not want to participate again or not this time (reasons given: no time, not interested, already often medically examined) and from 50% we got no response

Appendix 2

Description HAI measurements

Systolic blood pressure
SBP was measured twice while the participant was in an upright sitting position. The two measurements were averaged. The categorization for the HAI was as follows: 2 = below 126 mmHg; 1 = 126-142 mmHg; 0 = above or equal to 143 mmHg. This is a similar to classification applied in previous studies [5, 6, 8]. Subjects who reported a physician diagnosis of hypertension, or who were taking medication for hypertension, were classified in the most unhealthy category (score = 0).

Random blood glucose
Random blood glucose (RBG) was determined in a peripheral blood plasma sample. Diabetes is diagnosed when the random glucose concentration is 11.1 mmol/L or higher. Hence, all values equal or above 11.1 mmol/L were assigned a score of 0. The International Diabetes Federation recommends additional screening for individuals with values between 5.6 – 11.1 mmol/L [17]. Moreover, Bowen, Xuan [18] showed that

a RBG ≥ 5.6 mmol/L was more strongly associated with undiagnosed diabetes than any single risk factor and remained strongly associated with undiagnosed diabetes after adjustment for traditional diabetes risk factors. Hence, values between 5.6 – 11.1 mmol/L were assigned a score of 1. Consequently, all values below 5.6 mmol/L received a score of 2. Participants who reported a physician diagnosis of diabetes or who were using medication for diabetes were coded in the highest RBG group (=0).

Creatinine

Several biochemical markers were measured in all the available samples of the follow up rounds. We used plasma creatinine levels, which are associated with renal function [19]. The cut-off points for creatinine were sex-specific and replicated from previous studies [6, 8]. The cut-off points for women were the following: 2 = below 70.7 mmol/L; 1 = 70.7 – 88.4 mmol/L; 0 = above or equal to 88.4 mmol/L. For men the cut-off points were the following: 2 = below 97.2 mmol/L; 1 = 97.2 – 114.9 mmol/L; 0 = above or equal to 114.9 mmol/L.

Forced vital capacity (FVC)

Pulmonary function measurements were performed by trained paramedics using a heated pneumotachometer. Participant's expiratory pulmonary volume was measured in a sitting position while wearing a nose clip. At least three technically acceptable attempts for measuring FVC had to be achieved, of which two had to be reproducible according to ERS criteria [20]. For comparability to other studies, the FVC was used as an indicator for lung function. Cut-off points were sex-specific, with the following values for FVC in men: 2 = above or equal to 3.84 L; 1 = 3.19-3.84 L; and 0 = below 3.19 L. For FVC in women, scores were the following: 2 = above or equal to 2.61 L; 1 = 2.14-2.61 L; 0 = below 2.14 L.

Cognitive function

Cognition was only measured in the study population aged 45 years and older. Cognitive function was measured by four neuropsychological tests: the 15 Words Verbal Learning Test (immediate and delayed recall), the Stroop Color-Word-Test, the Word Fluency Test and the Letter Digit Substitution Test. Nooyens, Bueno-de-Mesquita [21] have described these cognitive tests in more detail. From the separate test scores a summary score of global cognitive functioning was calculated. To capture the decline rate over time, the global cognitive functioning score was transformed into a z-score which was derived from the values of all the rounds together. Participants scoring below the 10th percentile on the global cognitive functioning z-score in T4 were considered cognitively frail, and assigned a score of 0 assigned for cognition. This cut-off point is consistent with the definition for cognitive frailty used in the DCS previously [22, 23]. The z-score that corresponded to the 10th percentile in T4 (z-score = -1.05) was applied as the cut-off point for cognitive frailty in the other rounds of the DCS as well. Participants with a z-score between -1.05 – 0 were assigned a score of '1', while participants with a z-score above 0 received a score of '2'. As cognitive tests were only performed among participants aged 45 years or older, we assumed that participants younger than 45 years were cognitively healthy [24], and therefore they were assigned a score of '2'.

Appendix 3

Dichotomization lifestyle factors regression analysis

Lifestyle was defined by the following variables: sleep, physical activity, body mass index (weight and height were assessed by a health care worker and were used to calculate BMI (weight (kg) / [height (m)]^2), smoking status and alcohol consumption. As these behaviors may vary over time, we accounted for this by creating dummy variables that reflected whether someone was engaged in the behavior every measurement round or not. This resulted for smoking status in the following dummy variable: non-smoker in every round versus the rest. For sleeping we took a cut-off point of 7 hours or more sleep duration per 24 hours period. Sufficient physical activity was defined as adherence to the Dutch physical activity guidelines, which recommends 30 minutes of moderate to vigorous physical activity per day on at least 5 days per week [11]. BMI was dichotomized as being obese or not (BMI ≥ 30.0). We classified someone as an alcohol consumer when the respondent indicated to consume alcohol sometimes or regularly.

Appendix 4

Table A4. Scores at T1 for respondents who had data on all four measurements for the indicator

	T1, complete cases 4 measurements				
	Women		Men		Total
	Mean (SD)	Range	Mean (SD)	Range	N
Systolic blood pressure (mm Hg)	119.9 (15.9)	79-200	127.1 (14.6)	93-191	3,439
Random glucose (mmol/l)	5.1 (1.0)	1-17.2	5.4 (1.3)	1-18.3	3,167
Creatinine	73.5 (12.6)	37-125	72.8 (12.5)	41-129	3,064
FVC (L)	4.0 (0.6)	1.9-7.4	5.4 (1.0)	2.7-27.2	2,303
Global cognitive function - T1	0.1 (0.7)	-2.2 - 1.9	0.1 (0.7)	-2.2 – 1.9	403[1]
Global cognitive function - T2	0.0 (0.7)	-2.5 – 1.9	0.0 (0.7)	-2.6 – 2.2	1,390

[1] Cognition was only measured in a sub sample at T1

Appendix 5

Table A5. Scores at T4 for respondents who had data on all four measurements for the indicator

	T4, complete cases 4 measurements				
	Women		Men		Total
	Mean (SD)	Range	Mean (SD)	Range	N
Systolic blood pressure (mm Hg)	128.5 (18.0)	84-215	134.8 (17.5)	85-240	3,439
Random glucose (mmol/l)	5.2 (1.4)	2.1-24.2	5.4 (1.4)	2.4-17.2	3,167
Creatinine	76.4 (14.4)	35-148	75.8 (15.0)	42-157	3,064
FVC (L)	3.6 (0.6)	1.6-6.7	5.0 (0.9)	2.1-8.5	2,303
Global cognitive function	-0.04 (0.8)	-2.5-1.8	-0.05 (0.7)	-2.4-1.8	1,390

Appendix 6

Table A6. Scores at T1 on the healthy aging indicators of the imputed sample

	T1, imputed sample				
	Women		Men		Total
	Mean (SD)	Range	Mean (SD)	Range	N
Systolic blood pressure (mm Hg)	120.7 (16.2)	79-200	127.4 (14.8)	92-191	4,461
Random glucose (mmol/l)	5.2 (1.2)	1-19.6	5.4 (1.3)	1-18.3	4,393
Creatinine	73.4 (12.9)	37-146	73.0 (12.6)	41-131	4,330
FVC (L)	3.9 (0.6)	1.8-7.4	5.4 (1.0)	2.4-27.2	4,002
Global cognitive function- T1	0.1 (0.7)	-2.2 -1.9	0.1 (0.7)	-2.2 - 1.9	403[1]
Global cognitive function - T2	0.0 (0.7)	-2.9 – 1.9	0.0 (0.7)	-2.6 – 2.2	3,403

[1] Cognition was in round 2 only measured in a sub sample.

Appendix 7

Table A7. Scores at T4 on the healthy aging indicators of the imputed sample

	T4, imputed sample				
	Women		Men		Total
	Mean (SD)	Range	Mean (SD)	Range	N
Systolic blood pressure (mm Hg)	128.4 (18.0)	84-215	134.6 (17.4)	85-240	3,903
Random glucose (mmol/l)	5.2 (1.3)	2.1-24.2	5.4 (1.6)	1.5-18	3,993
Creatinine	76.8 (17.3)	35-389	75.9 (16.1)	42-298	3,823
FVC (L)	3.6 (0.7)	1.1-6.7	4.9 (0.9)	2.1-8.5	3,518
Global cognitive function	-0.02 (0.8)	-2.5-2.7	-0.02 (0.7)	-2.5-2.0	3,115

Appendix 8

Table A8. Scores categories at T1 on the healthy aging indicators for complete and imputed sample

	Complete sample		Imputed sample	
	Women	Men	Women	Men
	N (%)	N (%)	N (%)	N (%)
Systolic blood pressure (mm Hg)	1,818 (47.2)	1,624 (52.8)	2,342 (52.5)	2,119 (47.5)
0 (hypertension)	11.6	16.9	12.2	16.2
1 (high – normal)	20.2	33.6	21.4	34.9
2 (optimal)	68.2	49.5	66.4	48.9
Random glucose (mmol/l)	1,656 (52.2)	1,515 (47.8)	2,301 (52.4)	2,092 (47.6)
0 (diabetes)	1.1	1.3	1.4	1.3
1 (pre stage diabetes)	20.6	30.1	20.0	32.4
2 (no diabetes)	78.3	68.6	78.6	66.3
Creatinine[2]	1,600 (52.2)	1,464 (47.8)	2,314 (53.4)	2,016 (46.6)
0 (unhealthy)	11.8	0.2	11.8	0.3
1 (pre-stage)	45.2	3.4	44.3	3.5
2 (optimal)	43.1	96.5	44.0	96.2
FVC (L)	1,216 (52.8)	1,085 (47.2)	2,102 (52.6)	1,896 (47.4)
0 (severe airway obstruction)	3.9	3.9	6.2	7.0
1 (moderate airway obstruction)	14.4	20.6	17.0	22.0
2 (good lung function)	81.7	75.5	80.8	71.0
Global cognitive function	820 (54.9)	674 (45.1)	1,804 (53.0)	1,599 (47.0)
0 (cognitive frail)	1.1	0.6	3.4	3.8
1 (moderate cognition)	5.5	5.3	18.5	20.3
2 (good cognition)	93.4	94.1	78.1	75.9

Appendix 9

Table A9. Scores categories at T4 on the healthy aging indicators for complete and imputed sample

	Complete sample		Imputed sample	
	Women	Men	Women	Men
	N (%)	N (%)	N (%)	N (%)
Systolic blood pressure (mm Hg)	1,818 (52.8)	1,624 (47.2)	2,342 (52.5)	2,119 (47.5)
0 (hypertension)	37.2	40.9	38.0	41.3
1 (high – normal)	23.1	30.3	22.9	30.6
2 (optimal)	39.7	28.8	39.1	28.1
Random glucose (mmol/l)	1,656 (52.2)	1,515 (47.8)	2,301 (52.4)	2,092 (47.6)
0 (diabetes)	6.0	7.3	6.1	7.4
1 (pre stage diabetes)	18.2	27.2	18.6	28.0
2 (no diabetes)	75.7	65.5	75.3	64.6
Creatinine[2]	1,600 (52.2)	1,464 (47.8)	2,314 (53.4)	2,016 (46.6)
0 (unhealthy)	18.8	1.6	18.7	2.0
1 (pre-stage)	43.5	5.9	42.9	5.8
2 (optimal)	37.7	92.5	38.4	92.2
FVC (L)	1,217 (52.8)	1,086 (47.2)	2,102 (52.5)	1,900 (47.5)
0 (severe airway obstruction)	1.2	1.7	1.3	3.1
1 (moderate airway obstruction)	4.4	8.0	6.0	8.8
2 (good lung function)	94.5	90.3	92.8	88.2
Global cognitive function	1,712 (52.5)	1,552 (47.5)	1,804 (53.0)	1,599 (47.0)
0 (cognitive frail)	9.9	8.1	9.0	7.3
1 (moderate cognition)	35.0	38.0	32.2	35.7
2 (good cognition)	55.1	54.0	58.8	57.0

Appendix 10

Table A10. Respondent characteristics of the total sample at T1

	Total sample (6,113)	
	Women, n=3,255 (53%)	Men, n=2,858 (47%)
Socio-demographics	**%**	**%**
Mean age (SD)	46.2 (10)	46.8 (10)
Age categories		
26-35 yr	17.5	15.4
36-45 yr	32.1	31.2
46-55 yr	28.5	31.4
56-65 yr	21.8	22.1
Educational level		
Low	63.8	47.5
Medium	22.0	29.7
High	14.2	22.9
Employed (yes)	44.4	76.0
Marital status (married)	81.4	82.1
Subjective health		
Excellent / very good	22.9	28.3
Good / moderate	62.9	59.2
Poor	14.2	12.5
Alcohol consumption (>1 per week)	48.9	76.6
Sleep (<7 hours per night)	13.2	19.0
Smoke status		
Smoker	30.7	32.2
Ex-smoker	32.4	40.5
Never smoker	36.9	27.3
Physical exercise (no)	51.3	52.8
BMI (kg/m^2), mean (SD)	25.7 (4.2)	26.1 (3.2)
Healthy Aging Index indicators (SD)		
Systolic blood pressure, mmHg	122.3 (17.2)	128.7 (15.7)
Random glucose, mmol/l	5.3 (1.5)	5.5 (1.5)
Creatinine, mmol/l	72.9 (13.0)	72.6 (12.8)
Lung function ,FVC L	3.9 (0.6)	5.3 (1.0)
Global cognitive function, z-scores[1]	0.03 (0.7)	0.03 (0.7)
Healthy Aging Index	8.3 (1.5)	8.5 (1.4)

[1] Scores of T2 are presented due to small sample size at T1

Appendix 11

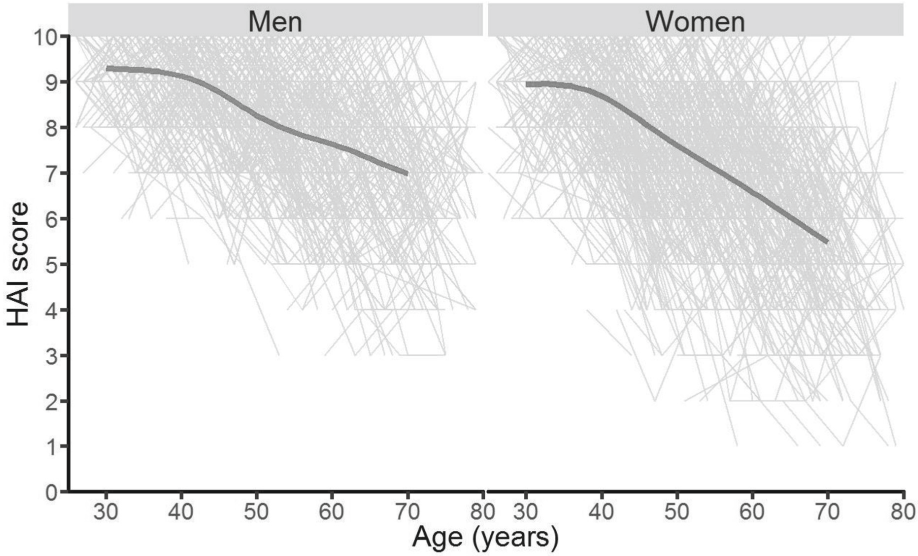

Figure A11. Development of the average HAI scores by age

6 Prevalence and inequality in persistent undiagnosed, untreated, and uncontrolled hypertension: evidence from a cohort of older Mexicans

Based on: Dieteren, C.M., O O'Donnell, Bonfrer, I. (2021). Prevalence and inequality in persistent undiagnosed, untreated, and uncontrolled hypertension: evidence from a cohort of Older Mexicans. *PLOS Global Public Health.* In press.

ABSTRACT

Background

Hypertension is the leading risk factor for cardiovascular diseases (CVDs) and substantial gaps in diagnosis, treatment and control signal failure to avert premature deaths. Our aim was to estimate the prevalence and assess the socioeconomic distribution of hypertension that remained undiagnosed, untreated, and uncontrolled for at least five years among older Mexicans and to estimate rates of transition from those states to diagnosis, treatment, and control.

Methodology

We used data from a cohort of Mexicans aged 50+ in two waves of the WHO Study on Global AGEing and adult health (SAGE) collected in 2009 and 2014. Blood pressure was measured, hypertension diagnosis and treatment self-reported. We estimated prevalence and transition rates over five years and calculated concentration indices to identify socioeconomic inequalities using a wealth index. Using probit models, we identify characteristics of those facing the greatest barriers in receiving hypertension care.

Results

More than 60 percent of individuals with full item response (N=945) were classified as hypertensive. Over one third of those undiagnosed continued to be in that state five years later. More than two fifths of those initially untreated remained so, and over three fifths of those initially uncontrolled failed to achieve continued blood pressure control. While being classified as hypertensive was more concentrated among the rich, missing diagnosis, treatment and control were more prevalent among the poor. Men, singles, rural dwellers, uninsured, and those with overweight were more likely to have persistent undiagnosed, untreated, and uncontrolled hypertension.

Conclusion

There is room for improvement in both hypertension diagnosis and treatment in Mexico. Clinical and public health attention is required, even for those who initially had their hypertension controlled. To ensure more equitable hypertension care and effectively prevent premature deaths, increased diagnosis and long-term treatment efforts should especially be directed towards men, singles, uninsured, and those with overweight.

6.1 BACKGROUND

Hypertension is the leading global risk factor for cardiovascular diseases (CVDs) [1]. Worldwide, there are substantial gaps in diagnosis, treatment, and control of hypertension [2–7], signaling failures to prevent CVDs and avert millions of premature deaths [8]. In middle-income countries, where hypertension prevalence is rising [9,10], populations are aging, and health systems are straining to cope with the double burden of disease, gaps in diagnosis and management of hypertension [5,11–13] can take a heavy toll on population health.

In high-income countries, hypertension tends to be more prevalent among lower socioeconomic groups [14]. In low- and middle-income countries (LMIC), evidence on the socioeconomic gradient in hypertension is mixed, which may reflect changes in the gradient as countries move through the epidemiological transition [2,13,15,16]. There is evidence, however, that the socially disadvantaged in LMIC have worse access to hypertension care [5,17] and so potentially suffer great ill-health as a consequence of uncontrolled hypertension. More effective and equitable targeting of hypertension screening and treatment requires improved understanding of the sociodemographic groups that face the greatest barriers in accessing these services.

In Mexico, which has the highest prevalence of overweight in the world [18] and non-communicable diseases (NCDs) account for 80% of all deaths [19], estimated hypertension prevalence in the adult population aged 18 years and older was 25.5% in 2016, and increased substantially with age with a prevalence near 50% at the age of 60 [20,21]. Among adults with hypertension, 40% were estimated to be undiagnosed, 21% were untreated, and 55% had not achieved blood pressure control in 2016 [20].

Estimates of diagnosis, treatment, and control of hypertension are valuable for monitoring and targeting of CVD prevention. However, the cross-sectional nature of most of this evidence is limiting in two respects. First, it does not provide information about persistent undiagnosed, untreated, and uncontrolled hypertension. Given that the risks of severe health consequences rise steeply with the duration of exposure to uncontrolled hypertension [22], it is important to establish prevalence of the condition that remains undiagnosed, untreated, and uncontrolled for an extended period of time and how these prevalence rates vary with sociodemographic characteristics. Second, a cross-sectional approach does not allow estimation of rates of transition from undiagnosed to diagnosed, untreated to treated, and uncontrolled to controlled hypertension, nor can it reveal reverse transitions from treated to untreated and controlled to uncontrolled, both of which indicate failures in hypertension management and treatment adherence.

These limitations can be addressed by following a cohort over time to identify the proportion and type of people who remain undiagnosed, untreated, and uncontrolled for an extended period, as well as rates of transition to more favorable states. This study aimed to estimate the prevalence and socioeconomic distribution of hypertension that remained undiagnosed, untreated, and uncontrolled for at least five years among Mexicans aged 50 years and older and to estimate rates of transition from those states to diagnosis, treatment, and control. To help target improvements in hypertension screening and management on vulnerable groups, we aimed to identify sociodemographic characteristics associated with remaining in an unfavorable hypertension state.

6.2 METHODS

6.2.1 Sample

We used longitudinal data from the Mexican sample of the World Health Organization (WHO) Study on Global AGEing and adult health (SAGE) [6]. Our study focused on adults aged 50 years and older. Mexico is the only one of six countries participating in SAGE to have made longitudinal data publicly available (as of 2021).

The sample for Wave 1 (November 2009 - January 2010) was based on the 2003 WHO World Health Survey (WHS) for Mexico (hereafter, Wave 0). A total of 96 strata were defined over 32 states and three levels of urbanicity (rural, urban, and metropolitan) [6]. A nationally representative sample was obtained in Wave 0 by conducting cluster random sampling with Basic Geo-Statistical Areas forming the primary sample units (PSUs). In total, 40,000 households were randomly sampled [24]. To obtain the Wave 1 sample, probability sampling was used to select 211 PSUs from the 797 sampled in Wave 0 [25]. In each selected rural and urban PSU, all Wave 0 individuals who had been aged 50 years or older in 2003 were included in the Wave 1 target sample (ibid). In each of the selected metropolitan PSUs, a random sample of 90% of individuals aged 50 years and older in 2003 were included. In addition, a systematic sample of 1000 individuals from Wave 0 who had been aged 18-49 across all selected PSUs were included as the primary sample.

Wave 1 had a relatively low response rate of 53%. Response was lower for middle-aged adults aged 50-59 years (42%) than for younger adults aged 18-49 years (58%). The low response rate has been attributed to the short time available for field work, which left little time to revisit sampled households that did answer during the initial visit in this wave [6], but no further information on the average characteristics of those missing has been made available. An interval of six-seven years between Wave 0 and Wave 1 also contributed to a high rate of attrition and a low response in the latter wave [6].

SAGE Wave 2 was conducted in July-October 2014. The target sample included all individuals who participated in Wave 1, plus those aged 50 years and older in 2014 who were not in the Wave 0 (or Wave 1) sample but who lived in a household that included someone from that sample [6]. The Wave 2 response rate was 83% for households and 81% for individuals.

The SAGE sample was designed, after weighting, to be nationally representative for the population aged 50 years and older at the time of each wave. We restricted the analysis sample to this age range and to respondents observed in both Wave 1 and Wave 2. To maximize the size of this cohort, we selected respondents aged 50 years and older in Wave 2 who also participated in Wave 1. Some of these respondents were therefore slightly younger than 50 in Wave 1. Then, we excluded respondents that had missing data on any of the hypertension measurements. The final step was to exclude respondents that had missing data on any of the other relevant covariates in Wave 2 (see Flow Chart Figure 1).

6.2.2 Measurements

Hypertension

Blood pressure (BP) was measured using a Boso Medistar Wrist Blood Pressure Monitor Model S during a home visit [6]. Three measurements were taken, with a minimum of one minute between each. Each participant was asked: "Have you ever been diagnosed with high blood pressure (hypertension)?" A positive response was followed with: "Have you been taking any medications or other treatment for it during a) the last 2 weeks, b) the last 12 months?" We classified a participant as having hypertension (HTN) if a) the last two measurements gave a mean systolic BP ≥140 mm Hg or mean diastolic BP ≥ 90 mm Hg, or b) they reported ever having been diagnosed with high BP [13,26]. Those classified as having hypertension were then categorized as: a) *diagnosed,* if they reported ever having been diagnosed (*HTN Diagnosed*); b) *treated,* if they reported taking medication or another treatment (*HTN Treated*); and, c) *controlled,* if they had measured systolic BP < 140 mm Hg and measured diastolic BP < 90 mm Hg (*HTN Controlled*). The other respondents, either with or without a classification of hypertension, were classified as being undiagnosed, untreated, or uncontrolled defined analogously (see Table 6.1).

Table 6.1 Definitions of hypertension states

All hypertension (HTN)	Systolic BP ≥140 mm Hg OR diastolic BP ≥ 90 mm Hg
	OR self-reported to have ever been diagnosed with high BP
HTN Diagnosed	HTN *AND* self-reported to have ever been diagnosed with high BP
HTN Undiagnosed	HTN *AND* self-reported never having been diagnosed with high BP
HTN Treated	HTN *AND* self-reported taking medication or other treatment for high BP in previous 2 weeks
HTN Untreated	HTN *AND* self-reported not taking medication or other treatment for hypertension in previous 2 weeks
HTN Controlled	HTN *AND* systolic BP < 140 mm Hg AND diastolic BP <90 mm Hg
HTN Uncontrolled	HTN *AND* systolic BP ≥140 mm Hg OR diastolic BP ≥ 90 mm Hg

While we recognized that clinically diagnosed hypertension is a chronic condition, we did not classify a participant as necessarily having hypertension in Wave 2 if they were classified with the condition in Wave 1. The reason was that we did not observe clinical diagnoses made on the basis of BP measurements on multiple occasions. Measured BP ≥140/90 mm Hg on a single occasion could be a false positive. By classifying respondents in each wave using only their measured BP and self-reported diagnoses from that wave, we avoided contaminating Wave 2 classifications with Wave 1 measurement errors.

6

Wealth index

To examine socioeconomic inequality in hypertension and its diagnosis, treatment, and control, we used a wealth index to proxy socioeconomic status. The index was the first principal component from analysis of each participant's reported possession of household durable assets and financial resources, as well as the building materials, sanitation, and water supply of their house [27]. Appendix 1 shows the list of variables included in this analysis.

Covariates

We examined associations between persistent undiagnosed, untreated, and uncontrolled hypertension and both sociodemographic and lifestyle characteristics that may plausibly have been related to the risk of hypertension or with access to health services that deliver hypertension care. Specifically, we examined associations with sex and age that are risk factors for hypertension and with cohabiting status, rural/urban location, wealth (index), and health insurance that may each be related with access to care [28,29]. In addition, we examined associations with smoking, alcohol consumption, and Body Mass Index (BMI) that may each be related to hypertension risks [28,30,31]. BMI was calculated from height and weight measured by a healthcare professional at the time of the interview. We categorized respondents as: normal weight (BMI <25.0), overweight (25.0-29.9) and obese (>29.9) [32]. Very few respondents had a BMI lower than 20.0 (n=19), we included them in the "normal weight" category.

6.2.3 Statistical analyzes

We estimated percentages of the cohort aged 50 years and older in 2014 classified as hypertensive in each wave and in both waves. We also estimated percentages of the cohort with undiagnosed, untreated, and uncontrolled hypertension, unconditionally on being classified as hypertensive. We used transition matrices and visual representations to summarize movements between hypertension states from Wave 1 to Wave 2. We also examined how the probability of having uncontrolled hypertension in Wave 2 differed between those who were diagnosed and undiagnosed in Wave 1. We did the same for those treated and untreated in Wave 1.

We measured socioeconomic inequality prevalence of each hypertension state using a concentration index equal to the (scaled) covariance between an indicator of that state and wealth index rank [33]. A positive (negative) value indicated that richer (poorer) individuals were more likely to be in that state.

We estimated probit models of persistent (from Wave 1 to Wave 2) undiagnosed, untreated, and uncontrolled hypertension and used them to obtain averaged marginal effects that indicated by how much the probability of remaining in each of these states for at least 5 years varied with covariates. We also conducted a probit regression to estimate how the probability of transitioning from undiagnosed hypertension in Wave 1 to diagnosed in Wave 2 varied with covariates. The sample used for this analysis consisted of those undiagnosed in Wave 1. We conducted analogous analyzes to examine variation in the transition probabilities between untreated and treated and between uncontrolled and controlled.

We did not apply sampling weights since these were not available at cohort level. We assessed representativeness of the cohort by comparing its sociodemographic composition with that of the full Wave 2 cross-sectional sample with sampling weights representative of the population aged 50 years and older in 2014. We took account of stratification and cluster sampling in all statistical interference. STATA 16.0 was used for all analyzes.

6.3 RESULTS

6.3.1 Sample description

Of the 2,998 Wave 2 respondents aged 50 years and older, 1,740 (58%) participated in Wave 1 (Figure 6.1). In this cohort, valid BP measures were obtained in both waves for 1,254 (72%), and 945 (54%) had full item response on all measures and variables used in the analyzes. We present results obtained from the latter, *analysis sample*. Estimates of prevalence and transition rates obtained from the larger sample with BP measures in both waves (*BP sample*) were highly consistent and are given in the Appendices 2 - 4.

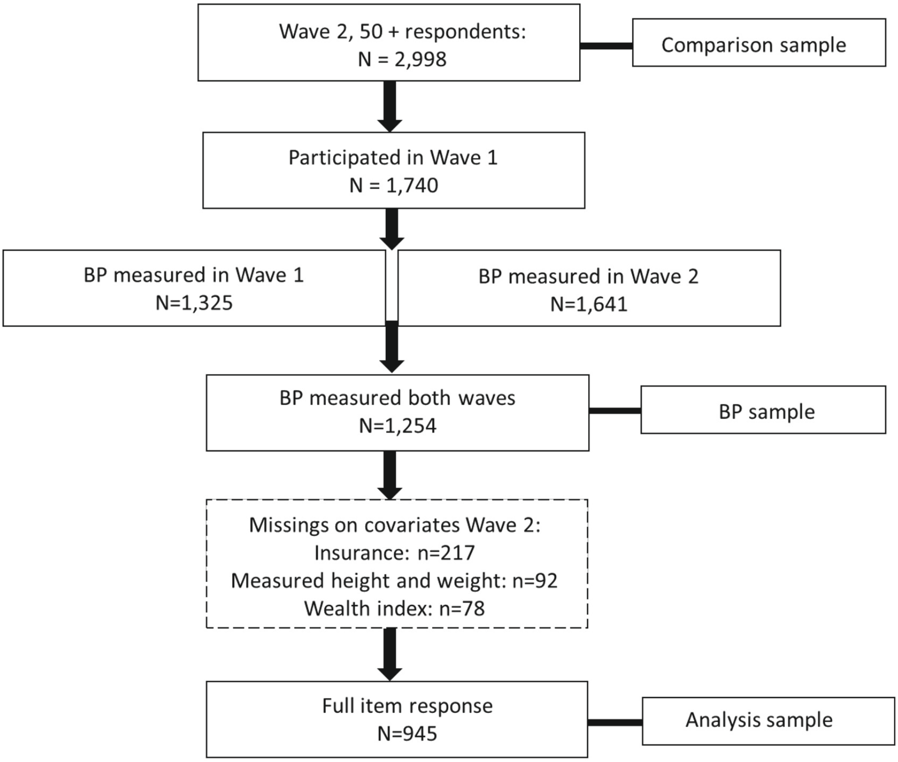

Figure 6.1 Participant flow chart
Notes: *BP measured* indicates that BP was measured, and hypertension diagnosis and treatment were reported, allowing hypertension status to be established.

Table 6.2 shows characteristics of the analysis sample of Wave 2 respondents aged 50 years and older who participated also in Wave 1 and had full item response. For comparison, the table also shows characteristics of all Wave 2 respondents aged 50 years and older that were weighted to be representative of the Mexican population in that age range [6]. On average, the analysis sample was about eight years older than the full cross-section sample, since new respondents added in Wave 2 were younger than those who had participated in Wave 1. Sample differences in BP and hypertension reflect the difference in average age. Analysis sample respondents were more likely to be rural, have health insurance and abstain from alcohol.

Table 6.2 Sample characteristics, aged 50 years and older years in 2014 (Wave 2)

	Analysis sample – observed in Waves 1 & 2	Comparison sample – observed in Wave 2
	(N=945)	(N=2,998)
	Mean (SD)	**Mean (SD)**
Age	70.7 (8.0)	62.5 (9.3)
Systolic blood pressure	141.8 (23.2)	138.8 (22.0)
Diastolic blood pressure	76.6 (11.0)	78.9 (11.0)
	N (%)	**N (%)**
Classified as hypertensive		
Yes	609 (64.4)	1,675 (55.9)
No	336 (35.6)	1,323 (44.1)
Sex		
Female	523 (55.3)	1,613 (53.8)
Male	422 (44.7)	1,385 (46.2)
Cohabiting		
Yes	625 (66.1)	2,105 (70.2)
No	320 (33.9)	893 (29.8)
Location		
Urban	645 (68.3)	2,356 (78.6)
Rural	300 (31.8)	642 (21.4)
Health insurance		
Yes	845 (89.4)	2,508 (83.7)
No	100 (10.6)	490 (16.3)
Smoker		
Yes	104 (11.0)	375 (12.5)
No	841 (89.0)	2,623 (87.5)
Drinks alcohol		
Yes	438 (46.3)	1,844 (61.5)
No	507 (53.7)	1,154 (38.5)
BMI		
Normal	270 (28.6)	670 (23.2)
Overweight	397 (42.0)	1,236 (41.2)
Obese	278 (29.4)	1,065 (35.5)

Notes. The analysis sample was observed in both waves and had full item response. The comparison sample was observed in Wave 2. Survey sampling weights were applied to the comparison sample to make it representative of the population aged 50 years and older in 2014.

6.3.2 Hypertension prevalence, diagnosis, treatment and control

Table 6.3 shows estimates of the prevalence of all hypertension and percentages of the cohort with undiagnosed, untreated, and uncontrolled hypertension in each wave. It also shows estimates of the percent of respondents with these outcomes in both waves. We estimated that 62.4% (95% CI, 58.9 to 65.9) of the cohort was classified as having hypertension in Wave 1. Around five years later when the same respondents were observed in Wave 2, 64.4% (95% CI, 61.0 to 67.7) were classified as having hypertension. The difference between the prevalence rates was not significant (P=0.364). More than half of the cohort (51.1%; 95% CI, 47.5 to 54.7) was classified as having hypertension in both waves. This percentage is lower than the prevalence in either wave because some respondents (n=107) transitioned from being classified as hypertensive in Wave 1 to normotensive in Wave 2 (see Table 6.4). These transitions arise for two reasons. First, measured BP on a single occasion, in a non-clinical setting, can be above the hypertension thresholds in Wave 1 and below the thresholds in Wave 2. If such respondents report in Wave 2 that they have never been diagnosed with high BP/hypertension, then they will not be classified as having hypertension in Wave 2. These cases may have been false positives in Wave 1. Second, a participant could report having ever been diagnosed with hypertension in Wave 1 but in Wave 2 report never having had such a diagnosis. Such reporting implies a measurement error, either in Wave 1 or Wave 2.

We estimated that in Wave 1, 30.3% (95% CI, 27.2 to 33.5) of the cohort had undiagnosed hypertension, 36.0% (95% CI, 32.8 to 39.3) had untreated hypertension, and 55.7% (95% CI, 52.1 to 59.2) had uncontrolled hypertension. In Wave 2, the prevalence rates of undiagnosed, untreated, and uncontrolled hypertension were estimated to be 22.2% (95% CI, 19.7 to 24.9), 27.1% (95% CI, 24.4 to 30.0), and 48.7% (95% CI, 45.4 to 52.0) respectively. Between the two waves, there was a significant reduction in the prevalence of hypertension that was undiagnosed (P=0.000), untreated (P=0.000), and uncontrolled (P=0.000). Over one-tenth (11.3%; 95% CI, 9.5 to 13.4) were classified as having undiagnosed hypertension in both waves. We estimated that 15.3% (95% CI, 13.2 to 17.8) had untreated hypertension over the five years spanning the two waves, and more than one third (34.7%; 95% CI, 31.7 to 37.9) persistently had uncontrolled hypertension.

Table 6.3 Prevalence of hypertension and undiagnosed, untreated, and uncontrolled hypertension

	N=945					
	Wave 1		Wave 2		Both waves	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
All hypertension (HTN)	590	62.4 (58.9 – 65.9)	609	64.4 (61.0 – 67.7)	483	51.1 (47.5 – 54.7)
HTN Undiagnosed	286	30.3 (27.2 – 33.5)	210	22.2 (19.7 – 24.9)	107	11.3 (9.5 – 13.4)
HTN Untreated	340	36.0 (32.8 – 39.3)	256	27.1 (24.4 – 30.0)	145	15.3 (13.2 – 17.8)
HTN Uncontrolled	526	55.7 (52.1 – 59.2)	460	48.7 (45.4 – 52.0)	328	34.7 (31.7 – 37.9)

6.3.3 Transitions between hypertension states

Figure 6.2 and Table 6.4 show transitions between hypertension states. Panel A shows transitions between three states defined by hypertension and diagnosis. Of the 355 respondents (229+48+78) who did not have hypertension in Wave 1, 13.5% (95% CI, 10.4 to 17.4) were classified with hypertension and had been diagnosed by Wave 2. A larger percentage (22%; 95% CI, 18.3 to 26.1) of those initially not classified with hypertension were classified as having the condition in Wave 2 but had not been diagnosed. This means that more than three fifths (62%=22/(13.5+22)) of those who became hypertensive were undiagnosed. Of the 286 respondents (85+94+107) who were classified as having hypertension in Wave 1 but reported never having been diagnosed, 37.4% (95% CI, 32.7 to 42.4) remained undiagnosed five years later, while 32.9% (95% CI, 27.8 to 38.3) acquired a diagnosis and 29.7% (95% CI, 24.3 to 35.7) were reclassified, on the basis of measured BP and reported diagnosis, as not being hypertensive in Wave 2. A small fraction (8.3%; 95% CI, 5.6 to 11.9) of the 304 respondents (22+257+25) who were classified as having hypertension and reported ever having been diagnosed in Wave 1 had BP above the hypertension thresholds in Wave 2 but at that time they reported, inconsistently, that they had never been diagnosed.

Panel B shows that 11.6% (95% CI, 8.6 to 15.4) of those not classified with hypertension in Wave 1 were classified as having hypertension and in receipt of treatment in Wave 2, while 23.9% (95% CI, 20.2 to 28.2) were reclassified as having untreated hypertension. There was considerable persistence in treatment: 82.4% (95% CI, 77.3 to 86.6) of those who were being treated for hypertension in Wave 1 continued to be in treatment five years later. Over one tenth (10.4%; 95% CI, 7.3 to 14.6) of those initially under treatment were no longer treated in Wave 2 but were still classified as having hypertension. A small but sizeable percentage (7.2%; 95% CI, 4.9 to 10.6) of those who were being treated in Wave 1 were classified as not having hypertension in Wave 2, which implies that they reported in that wave, inconsistently with their previous reported treatment, never having been diagnosed with hypertension. More than two fifths (42.7%; 95% CI, 37.9 to 47.5) of those initially classified as having untreated hypertension were still untreated. Almost a third (31.2%; 95% CI, 26.6 to 36.2) of those with untreated hypertension in Wave 1 were under treatment in Wave 2.

Panel C reveals that 28.7% (95% CI, 24.7 to 33.2) of those who were free of a hypertension classification in Wave 1 had uncontrolled hypertension five years later. Among the relatively small number (64=6+28+30) identified as having controlled hypertension in Wave 1, almost half (46.9%; 95% CI, 33.7 to 60.5) moved to uncontrolled hypertension. Among the much larger number (526=101+97+328) who had uncontrolled hypertension in Wave 1, 62.4% (95% CI, 57.8 to 66.7) were still in this state in Wave 2, while only 18.4% (95% CI, 15.3 to 22.0) achieving BP control. Further analyzes revealed that those with diagnosed hypertension in Wave 1 were more than twice as likely as those initially undiagnosed to have their BP controlled in Wave 2 (Appendix 5). There was a similar difference between those initially treated and untreated in their relative likelihoods of achieving BP control by the end of the study period.

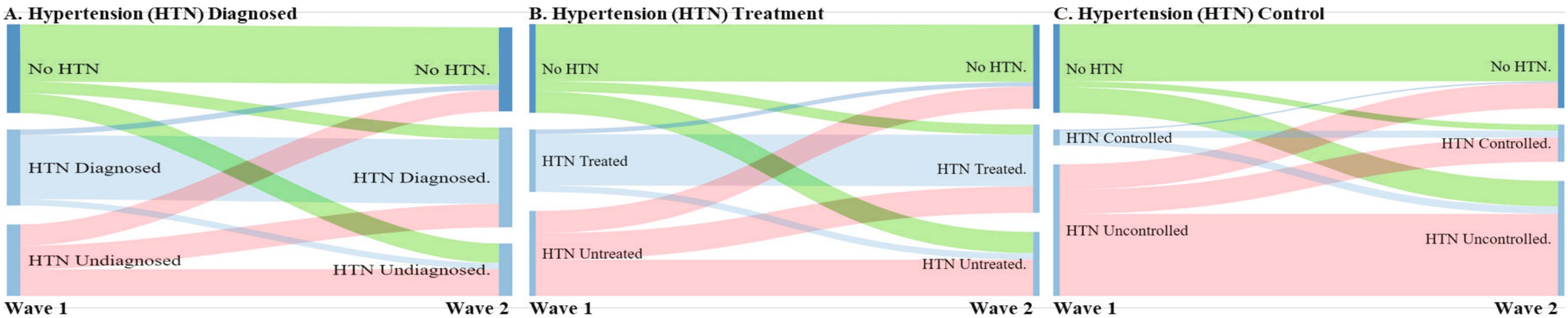

Figure 6.2 Transitions between hypertension states
Notes. Each figure in the top panel gives a visual representation of the data presented in the respective transition matrix table below it. The sample size is 945 for each panel.

Table 6.4 Transitions between hypertension states

A. HTN Diagnosed	**Wave 2**			**B. HTN Treated**	**Wave 2**			**C. HTN Control**	**Wave 2**		
Wave 1	No HTN	HTN Diagnosed	HTN Undiagnosed	**Wave 1**	No HTN	HTN Treated	HTN Untreated	**Wave 1**	No HTN	HTN Controlled	HTN Uncontrolled
	N (%) [95% CI]	N (%) [95% CI]	N (%) [95% CI]		N (%) [95% CI]	N (%) [95% CI]	N (%) [95% CI]		N (%) [95% CI]	N (%) [95% CI]	N (%) [95% CI]
No HTN	229 (64.5) [59.9, 68.8]	48 (13.5) [10.4, 17.4]	78 (22.0) [18.3, 26.1]	No HTN	229(64.5) [59,9-69,8]	41 (11.6) [8.6, 15.4]	85 (23.9) [20.2, 28.2]	No HTN	229(64.5) [59.9,68.8]	24 (6.8) [4.7, 9.7]	102 (28.7) [24.7, 33.2]
HTN Diagnosed	22 (7.2) [4.9, 0.6]	257 (84.5) [80.2, 88.1]	25 (8.3) [5.6, 11.9]	HTN Treated	18 (7.2) [4.9, 10.6]	206 (82.4) [77.3, 86.6]	26 (10.4) [7.3, 14.6]	HTN Controlled	6 (9.4) [4.4, 19.0]	28(43.8) [31.3,57.0]	30 (46.9) [33.7, 60.5]
HTN Undiagnosed	85 (29.7) [24.3, 35.7]	94 (32.9) [27.8, 38.3]	107 (37.4) [32.7, 42.4]	HTN Untreated	89 (26.2) [21.5,31.5]	106 (31.2) [26.6, 36.2]	145 (42.7) [37.9, 47.5]	HTN Uncontrolled	101(19.2) [15.6,23.4]	97 (18.4) [15.3,22.0]	328 (62.4) [57.8, 66.7]

Notes. The first number in each cell is a frequency. The second is the row percent in that cell. In parentheses is the 95% confidence interval for the row percent.

6.3.4 Socioeconomic inequality

Table 6.5 shows concentration indices that measure wealth-related inequality in each hypertension indicator. The positive concentration indices imply that a hypertension classification was more prevalent among wealthier respondents in each wave and that wealthier respondents were more likely to be classified as hypertensive in both waves. However, all of the 95% confidence intervals include zero so there was no evidence of statistically significant inequality in hypertension prevalence. The next three rows of the table show concentration indices for undiagnosed, untreated, and uncontrolled hypertension in each wave and in both waves. All the point estimates of these concentration indices are negative, indicating that poorer respondents were more likely to have undiagnosed, untreated, and uncontrolled hypertension. However, all of the 95% confidence intervals include zero, and thus the inequality apparent in the sample was not statistically significant.

Table 6.5 Concentration indices of all hypertension and undiagnosed, untreated, and uncontrolled hypertension

	N=945		
	Wave 1	**Wave 2**	**Both waves**
	Concentration index (95% CI)		
All hypertension (HTN)	0.007 (-0.06 – 0.08)	0.026 (-0.04 – 0.09)	0.028 (-0.04 – 0.10)
HTN Undiagnosed	-0.039 (-0.11 – 0.02)	-0.026 (-0.09 – 0.03)	-0.007 (-0.05 – 0.04)
HTN Untreated	-0.068 (-0.14 – 0.00)	-0.039 (-0.11 – 0.03)	-0.050 (-0.10 – 0.00)
HTN Uncontrolled	-0.029 (-0.10 – 0.04)	-0.029 (-0.10 – 0.04)	-0.047 (-0.11 – 0.02)

6.3.5 Multivariable analysis

Table 6.6 contains results of respondents' characteristics regressed on having persistent undiagnosed, untreated and uncontrolled hypertension in both waves. Men had a 10 percentage point (pp) higher probability of remaining undiagnosed. They were also significantly more likely than women to remain untreated (by 9 pp, with p-value <0.05) and uncontrolled (by 3 pp), although the 95% CI for the latter estimate includes zero. Singles were significantly more likely to remain undiagnosed (4 pp, with p-value <0.05) compared to cohabiting respondents. Rural dwellers in the sample were more likely to have persistent undiagnosed, untreated, and uncontrolled hypertension, although only their estimated 9 pp higher probability of remaining uncontrolled has a 95% CI that does not include zero. Those without health insurance were 4 pp more likely to remain undiagnosed (significant with p-value < 0.05). Those with overweight were significantly more likely to remain untreated or uncontrolled in both waves, respectively with 5 and 13 pp. Compared with abstainers, consumers of alcohol were less likely to remain undiagnosed (3 pp) and untreated (4 pp) with a p-value < 0.05. Analyzes of variation in the probabilities of transitioning from undiagnosed to diagnosed, untreated to treated, uncontrolled to controlled revealed that men were significantly less likely to make each of these transitions (Appendix 6). Smokers were significantly more likely to move from undiagnosed to diagnosed.

Table 6.6 Averaged marginal effects on probabilities of persistent undiagnosed, untreated, and uncontrolled hypertension.

	All respondents (N=945)		
	HTN Undiagnosed in both waves	**HTN Untreated in both waves**	**HTN Uncontrolled in both waves**
	ME (95% CI) (P-value)	**ME (95% CI) (P-value)**	**ME (95% CI) (P-value)**
Sex			
Female	*Ref*	*Ref*	*Ref*
Male	0.10* (0.06-0.15) (0.000)	0.09* (0.03-0.14) (0.002)	0.03(-0.04-0.11) (0.366)
Age (years)	-0.00 (-0.00-0.00) (0.900)	0.00 (-0.00-0.00) (0.068)	0.01* (0.01-0.01) (0.001)
Cohabiting			
Yes	*Ref*	*Ref*	*Ref*
No	0.04* (0.01-0.07) (0.007)	0.05 (-0.00-0.07) (0.061)	0.06 (-0.01-0.12) (0.107)
Living area			
Urban	*Ref*	*Ref*	*Ref*
Rural	0.02 (-0.00-0.05) (0.083)	0.03 (-0.1-0.07) (0.178)	0.09* (0.02-0.16) (0.013)
Health insurance			
Health insurance	*Ref*	*Ref*	*Ref*
No health insurance	0.04* (0.01-0.08) (0.046)	0.05 (-0.00-0.10) (0.103)	0.07 (-0.03-0.16) (0.171)
Wealth status			
Tercile 1	*Ref*	*Ref*	*Ref*
Tercile 2	-0.01 (-0.04-0.03) (0.710)	-0.02 (-0.06-0.03) (0.431)	-0.03 (-0.11-0.04) (0.411)
Tercile 3	0.02 [-0.02, 0.05] (0.334)	-0.02 (-0.01-0.03) (0.480)	-0.01 (-0.09-0.07) (0.766)
Body weight			
Normal weight	*Ref*	*Ref*	*Ref*
Overweight	0.02 [-0.01, 0.05] (0.284)	0.05* (0.01-0.10) (0.023)	0.13* (0.05-0.20) (0.001)
Obese	-0.00 (-0.04-0.04) (0.872)	0.04 (-0.01-0.08) (0.134)	0.16* (0.08-0.25) (0.000)

Table 6.6 Averaged marginal effects on probabilities of persistent undiagnosed, untreated, and uncontrolled hypertension. (continued)

	All respondents (N=945)		
	HTN Undiagnosed in both waves	HTN Untreated in both waves	HTN Uncontrolled in both waves
	ME (95% CI) (P-value)	ME (95% CI) (P-value)	ME (95% CI) (P-value)
Smoker			
No	*Ref*	*Ref*	*Ref*
Yes	0.00 (-0.04-0.04) (0.931)	0.02 (-0.04-0.08) (0.480)	0.07 (-0.03-0.17) (0.182)
Alcohol consumption			
No	*Ref*	*Ref*	*Ref*
Yes	-0.03* (-0.06- -0.01) (0.017)	-0.04* (-0.08- -0.00) (0.048)	-0.04 (-0.11-0.03) (0.250)

Note. Probit estimates of marginal effects averaged over the respective samples.
* = significant at p-value < 0.05

6.4 DISCUSSION

This study is among the first to provide a longitudinal perspective on diagnosis, treatment, and control of hypertension [23,34] in a middle-income country. We used data from a cohort of Mexicans aged 50 years and older in two waves of the WHO Study on Global AGEing and adult health (SAGE) collected in 2009 and 2014. We found a substantial prevalence of hypertension (64%). Prevalence of undiagnosed, untreated, and uncontrolled hypertension significantly decreased over the five-year period to reach 22%, 27%, and 49%, respectively. More than one third of those classified as having undiagnosed hypertension were still in this state five years later, more than two fifths of those initially untreated remained untreated, and over three fifths of those initially with uncontrolled hypertension failed to achieve BP control by the end of the period. The likelihood of experiencing continued uncontrolled hypertension was much higher than the chances of achieving BP control, which signals substantial losses in population health since CVD risks rise steeply with the duration of exposure to uncontrolled hypertension [35]. These estimates confirm substantial persistence of unfavorable hypertension states, ongoing failures of the health system to find patients who had fallen through the cracks of hypertension care, and lack of patient adherence to treatment. We cannot claim that these findings would necessarily extend beyond Mexico. They may, however, motivate estimation of the prevalence of persistent undiagnosed, untreated, and uncontrolled hypertension in other countries.

We are aware of two other studies that took a longitudinal approach. One study conducted in Ghana, did not assess transitions between the hypertension states but did report similar factors associated with hypertension diagnosis i.e. residing in urban areas and having health insurance [23]. The other (preprint) study is a multi-country including Mexico with similarities to our longitudinal design [34]. The transition rates from undiagnosed to diagnosed, and untreated to treated are like in our study close to 30%, while we find a tree times higher rate for treatment continuity. In line with our work, they find men and rural dwellers to be less likely to advance forward through the continuum of hypertension care. The difference in treatment continuity might be driven by differences in the average characteristics of both cohorts. The cohort used by Mauer et al. [34] is derived from the Mexican Family Life Survey which also includes those aged 40 to 49 years old and had it first wave a few years earlier (2005). The second wave was apparently collected over a prolonged period of time (2009 till 2012). Those timing differences might have resulted in a lower observed treatment continuity given that the cohort was followed over a longer and less strictly defined time period.

Our approach allowed for reclassifications from hypertensive to normotensive between waves and we found that such transitions are far from uncommon. Approximately, these are as common as moving to a diagnosed, treated, or controlled state. They do not derive from a false premise that someone with clinically diagnosed hypertension can be cured. In this study, a participant could have been reclassified as not having hypertension because their BP fell from being above the hypertension thresholds when measured (on a single occasion) at Wave 1 to below these thresholds at Wave 2 and they reported never having been diagnosed with hypertension at Wave 2. Reclassification could also occur if the participant never had BP above the thresholds but inconsistently reported having been diagnosed with hypertension at Wave 1 but never having been diagnosed at Wave 2. Each reason for reclassification derives from a measurement error – a false positive in the first case, inconsistent reporting of diagnosis in the second – that would bias cross-sectional estimates of hypertension diagnosis, treatment, and control. While these errors suggest that cross-sectional studies have likely overestimated rates of undiagnosed, untreated, and uncontrolled hypertension, this is not sufficient reason for less policy concern about these indicators of gaps in hypertension screening and management.

We compared how the probability of achieving BP control differed between those who had been diagnosed five years earlier and those who had not. The initially diagnosed were more than twice as likely to have controlled BP after five years. This supports the case for effective implementation of opportunistic or population-based screening for hypertension. The rate of persistent untreated hypertension was high and the initially treated were more than twice as likely as the untreated to have achieved BP control after five years. This points to the need for improvements in hypertension management, as well as screening. The potential health gains from such improvements are clear [37] given evidence that antihypertensives are highly cost-effective [38], as are lifestyle changes if they can be achieved. There was a high degree of persistence in treatment: more than four fifths of those who were under treatment at the beginning of the period continued with treatment five years later. Taken together, these results suggest that diagnosing people and getting them on treatment is the primary challenge, while maintaining continuity of care is arguably of a secondary order. That said, multiple studies have shown that half of patients prescribed antihypertensives stopped taking them within a year [36–38]. Lack of treatment adherence is a recognized global concern [39]. The high rate of persistent uncontrolled hypertension we find provides further support for making frequent follow-up of patients who have not achieved BP control a key component of a healthcare team's concerted effort to improve adherence [40].

In the study cohort, hypertension was slightly more prevalent among the wealthier. This adds to already conflicting evidence from Latin America regarding socioeconomic inequality since it is reported that individuals with a lower SES had a higher risk for an elevated blood pressure, while another study summarizes recent evidence from LMIC settings with the majority of the studies confirming the positive relationship between socioeconomic status and chronic conditions (including hypertension) [41,42]. Furthermore, evidence from a low-income setting in Mexico revealed that using two different aspects of SES showed an inverse association with elevated blood pressure [43]. In our sample, we found that less wealthy individuals were slightly more likely to have persistent undiagnosed hypertension and more likely to have persistent untreated and uncontrolled hypertension, however, these differences were not significant. Previous evidence showed that the performance of health systems in LMICs regarding the management of hypertension was poor: not even halve of those with hypertension were diagnosed, only one third were taking medication and 10% had their blood pressure under control [44]. Moreover, individuals with a lower household wealth were more likely to be lost to care before reaching the phase of blood pressure control [44]. The fact that, at least in the sample, the wealthier were more likely to have hypertension but less likely to have undiagnosed (as well as untreated and uncontrolled) hypertension suggests that the former positive wealth gradient in hypertension prevalence is partly due to the wealthier being more likely to get diagnosed. We found that, compared with abstainers, alcohol consumers were less likely to remain undiagnosed. The rate of alcohol consumers in our sample was lower compared to the comparison sample, therefore we have difficulties with interpreting this finding. Furthermore, we found that in the sample, men, those living alone, rural dwellers, uninsured, and those with overweight were more likely to have persistent undiagnosed, untreated, and uncontrolled hypertension. These sociodemographic groups appeared to have been most exposed to deficiencies in hypertension screening and management, and possibly most laxed in adherence to treatment. Other studies, though cross-sectional, observe similar characteristics (e.g. having health insurance, educated, married, living area) for individuals who were less likely to have (undiagnosed, untreated, uncontrolled) hypertension [16,17,45]. Previous evidence suggested that enrollees in Mexico's flagship Seguro Popular universal coverage program had better access to health care, including diagnosis and treatment of hypertension [46,47]. In line with this, we found that sample respondents that did not have health insurance were more likely to experience persistent undiagnosed, untreated, and uncontrolled hypertension, although this was only statistically significant for persistent undiagnosed hypertension. Finally, we found that women are more likely to become diagnosed, treated and controlled, and thus receive diagnoses or treatment or reach controlled hypertension.

6.4.1 Limitations

We restricted the sample to respondents who responded to both Wave 1 and Wave 2. The low response rate in Wave 1, as well as attrition between waves, potentially made the study cohort unrepresentative of the Mexican population aged 50 years and older at the time of Wave 2 (2014). Comparison with the Wave 2 cross-section sample weighted to be representative of the population aged 50 years and older showed that the cohort was older, and, consequently, had higher rates of hypertension, rural dwellers, and health insurance coverage, and it was less likely to be cohabiting and to drink alcohol. Our results should be interpreted with these differences in mind. They do not necessarily hold for the population of Mexico aged 50 years and older in 2014, although they are likely to be more representative for an older population. Selective attrition could also potentially leave the cohort unrepresentative with respect to unobserved characteristics that are related to hypertension and its management.

Respondents who had an elevated BP reading in Wave 1 were informed of this and advised to seek medical advice. Consequently, we would expect rates of persistent undiagnosed, untreated, and uncontrolled hypertension to have been lower in the study cohort than they were in the population. For this reason, the high rates we found are of even greater concern.

The main limitation of this and most hypertension awareness, treatment, and control studies, is that BP was measured on a single occasion in each wave. While it was measured multiple times on one occasion, it would have been better if there was a longer time between these two periods. Hypertension is usually diagnosed from BP measurements made on at least two occasions. This might have increased the number of false positives among those identified as having hypertension. The true rate of undiagnosed hypertension in each wave – not persistent undiagnosed hypertension between waves – is likely to be lower than estimated. However, the longitudinal perspective taken in this study provided insight into this measurement error problem that is missing from cross-sectional studies. We estimated that 30% (n=85) of those identified as having undiagnosed hypertension in Wave 1 were identified as not having hypertension in Wave 2. The respective rates for untreated and uncontrolled hypertension were 26% (n=89) and 19% (n=101). These estimates suggest that false positive may well cause substantial upward bias in cross-section estimates of these rates [48]. The focus of this study was not on a cross-sectional snapshot but on persistent gaps in hypertension diagnosis and management over a 5-year period. Classification errors, while still present, are less problematic from this longitudinal perspective.

Our study covered the period 2009-2014. Since then, the Mexican Institute of Social Security (IMSS) has tried to tilt its model of care towards prevention [49] and has introduced several integrated programs of care [50,51]. It could be that these policies have improved hypertension screening and management and corrected some of the care deficiencies suggested by our estimates.

6.4.2 Policy implications

Our estimates of substantial rates of persistent undiagnosed, untreated, and uncontrolled hypertension suggest that clinical and public health interventions are required to improve hypertension screening and care. A regular BP check during healthcare visits for other conditions may lead to more and earlier diagnoses. Our results show that this could be particularly relevant for those who are male, single, rural dwellers, uninsured or overweight. The substantial rate of transition from controlled to uncontrolled hypertension suggests that policies to improve treatment adherence care continuity would be particularly valuable. Association of persistent undiagnosed hypertension with lack of health insurance suggests that improving effective coverage for primary care, or even just making people aware of their insurance entitlement, may help close gaps in hypertension care.

6.4.3 Conclusions

Our study showed that a large proportion of the Mexican older population with hypertension remained undiagnosed, untreated, and uncontrolled for at least five years and that these hypertensive stages have a dynamic character. We show that there is room for improvement in hypertension diagnosis, long-term treatment adherence and hypertension control. To ensure more equitable hypertension management and effectively prevent premature deaths, increased diagnosis and long-term treatment efforts should be directed towards men, those living alone, rural dwellers, uninsured and those with overweight.

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APPENDICES

Appendix 1

Table A1. Variables included in this principal component analysis for the wealth index

Assets & Income	Housing
Television	Owned or rented dwelling
Security system	Type of floor dwelling
Cars	Type of wall dwelling
Electricity	Main source of drinking water
Bicycle	Type of toilet facility
Built-in kitchen sink	Type of fuel for cooking
Hot running water	
Washing machine	
Dish washer	
Refrigerator	
Housekeeper	
Mobile	
Bullock cart	
Computer	
HiFi or music centre	
Livestock	
Internet access at home	
Motorbike	
Second home	
Own land or property	
Own other valuable items	
Regular income	

Appendix 2

Table A2. Characteristics of Wave 2 participants aged 50+ years in 2014

	HTN sample	Analysis sample – observed in Waves 1 & 2	Comparison sample – observed in Wave 2
	(N=1,254)	(n=945)	(n=2,998)
Continuous	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age	71.1 (8.2)	70.7 (8.0)	62.5 (9.3)
Systolic blood pressure	142.2 (23.9)	141.8 (23.2)	138.8 (22.0)
Diastolic blood pressure	76.6 (11.3)	76.6 (11.0)	78.9 (11.0)
Categorical	**N (%)**	**N (%)**	**N (%)**
Hypertension			
Yes	818 (65.2)	609 (64.4)	1,675 (55.9)
No	436 (34.8)	336 (35.6)	1,323 (44.1)
Sex			
Female	764 (60.9)	523 (55.3)	1,613 (53.8)
Male	490 (39.1)	422 (44.7)	1,385 (46.2)
Marital status			
Married / cohabiting	713 (56.9)	625 (66.1)	2,105 (70.2)
Other	541 (43.1)	320 (33.9)	893 (29.8)
Location			
Urban	876 (69.9)	645 (68.3)	2,356 (78.6)
Rural	378 (30.1)	300 (31.8)	642 (21.4)
Health insurance			
Yes	925 (89.2)	845 (89.4)	2,508 (83.7)
No	112 (10.8)	100 (10.6)	490 (16.3)
Smoker status			
Smoker	123 (9.8)	104 (11.0)	375 (12.5)
Non-smoker	1,131 (90.2)	841 (89.0)	2,623 (87.5)
Alcohol consumer			
Yes	547 (43.6)	438 (46.3)	1,844 (61.5)
No	707 (56.4)	507 (53.7)	1,154 (38.5)
Weight			
Normal weight	336 (28.9)	270 (28.6)	670 (23.2)
Overweight	482 (41.5)	397 (42.0)	1,236 (41.2)
Obese	344 (29.6)	278 (29.4)	1,065 (35.5)

Notes. The analysis sample was observed in both waves and had full item response. The comparison sample was observed in Wave 2. Survey sampling weights were applied to the comparison sample to make it representative of the population aged 50+ in 2014.

Appendix 3

Table A3. Prevalence of hypertension and unaware, untreated and uncontrolled hypertension on HTN sample

	Wave 1		Wave 2		Both waves	
	N	% (95% CI)	N	% (95% CI)	N	% (95% CI)
All participants (n=1,254)						
Hypertension (HTN)	797	63.6 (59.2 – 68.1)	818	65.2 (60.8 – 69.9)	661	52.7 (48.7 – 56.8)
Participants with hypertension						
		(n=797)		**(n=818)**		**(n=661)**
HTN Unaware	377	47.3 (38.9 – 55.9)	276	33.7 (25.9 – 41.9)	146	22.1 (18.7 – 26.0)
HTN Untreated	458	57.5 (52.3 – 62.9)	336	41.1 (36.8 – 45.7)	234	35.4 (25.3 – 33.4)
HTN Uncontrolled	712	89.3 (79.9 – 0.99)	616	75.3 (66.3 – 84.6)	328	69.4 (63.2 – 76.0)

Notes. Top panel shows number and percentage of participants with hypertension in each wave and in both waves. Bottom panel shows number and percentage of participants with hypertension who were unaware, untreated and uncontrolled.

Appendix 4

Table A4. Transitions between hypertension states between Wave 1 and Wave 2, HTN sample

	Wave 2, N (row%)		
Wave 1	**No HTN**	**HTN Aware**	**HTN Unaware**
No HTN	300 (65.7)	63 (13.8)	94 (20.5)
HTN Aware	32 (7.6)	352 (83.8)	36 (8.6)
HTN Unaware	104 (27.6)	127 (33.7)	146 (38.7)

	Wave 2, N (row %)		
Wave 1	**No HTN**	**HTN Treated**	**HTN Untreated**
No HTN	300 (65.7)	55 (12.0)	102 (22.3)
HTN Treated	27 (7.9)	270 (79.6)	42 (12.5)
HTN Untreated	109 (23.8)	157 (34.3)	192 (41.9)

	Wave 2, N (row %)		
Wave 1	**No HTN**	**HTN Controlled**	**HTN Uncontrolled**
No HTN	300 (65.7)	36 (7.8)	121 (26.4)
HTN Controlled	10 (11.8)	39 (45.9)	36 (42.3)
HTN Uncontrolled	126 (17.7)	127 (17.8)	459 (64.5)

Appendix 5

Table A5. Transitions from hypertension awareness / treatment to control, participants with hypertension in both waves, HTN sample

Wave 1	Wave 2, N (row %)		N (column %)
	HTN Controlled	HTN Uncontrolled	Total
	(n=166)	(n=495)	(n=661)
HTN Aware	127 (32.7)	261 (67.3)	388 (58.7)
HTN Unaware	39 (14.3)	234 (85.7)	273 (41.3)
HTN Treated	107 (34.3)	205 (65.7)	312 (47.2)
HTN Untreated	59 (16.9)	290 (83.1)	349 (52.8)

Notes. The sample consists of participants who had hypertension in both waves.

Appendix 6

Table A6. Transitions from hypertension diagnosis and treatment to control

Wave 1	Wave 2, N (row%)		N (column %)
	HTN Controlled	HTN Uncontrolled	Total
	(n=125)	(n=358)	(n=483)
HTN Diagnosed	97 (34.4)	185 (65.6)	282 (58.4)
HTN Undiagnosed	28 (13.9)	173 (86.1)	201 (41.6)
HTN Treated	87 (37.5)	145 (62.5)	232 (48.0)
HTN Untreated	38 (15.1)	213 (84.9)	251 (52.0)

Notes. The sample consists of participants who had hypertension in both waves.

III

HEALTH POLICIES

7 Viewpoints among experts and the public in the Netherlands on including a lifestyle criterion in healthcare priority setting

Based on: Dieteren, C. M., Reckers-Droog, V. T., Schrama, S., de Boer, D., & van Exel, J. (2021). Viewpoints among experts and the public in the Netherlands on including a lifestyle criterion in the healthcare priority setting. *Health Expectations.*

ABSTRACT

Background

It remains unclear whether there would be societal support for a lifestyle criterion for healthcare priority setting. This study examines the viewpoints of experts in healthcare and the public regarding support for a lifestyle-related decision criterion, relative to support for the currently applied criteria, in healthcare priority setting in the Netherlands.

Methods

We conducted a Q methodology study in samples of experts in healthcare (n=37) and the public (n=44). Participants (total sample N=81) ranked 34 statements that reflected currently applied decision criteria as well as a lifestyle criterion for setting priorities in healthcare. The ranking data were subjected to principal component analysis, followed by oblimin rotation, to identify clusters of participants with similar viewpoints.

Findings

We identified four viewpoints. Participants with Viewpoint 1 believe treatments that are proven effective should be reimbursed. Those with Viewpoint 2 believe life is precious and every effort should be made to save a life, even when treatment still results in a very poor state of health. Those with Viewpoint 3 accept government intervention in unhealthy lifestyles and believe that individual responsibility should be taken into account in reimbursement decisions. Participants with Viewpoint 4 attribute importance to the cost-effectiveness of treatments; however, when priorities have to be set, treatment effects are considered most important. All viewpoints were supported by a mix of public and experts, but viewpoint 1 mostly by experts and the other viewpoints mostly by members of the public.

Conclusions

This study identified four distinct viewpoints on healthcare priority setting in the Netherlands, each supported by a mix of experts and members of the public. There seems to be some, but limited, support for a lifestyle criterion—in particular, among members of the public. Experts seem to favor the decision criteria that are currently applied. The diversity in views deserve attention when policymakers want to adhere to societal preferences and increase policy acceptance.

7.1 BACKGROUND

Unhealthy lifestyles increasingly contribute to the global burden of disease. Non-communicable diseases (NCDs) are a major public health challenge and recent research by the World Health Organization (WHO) showed that over 80% of common NCDs, such as cardiovascular diseases, can be prevented by eliminating modifiable risk factors such as unhealthy lifestyle behaviors (e.g. smoking) [1]. This suggests that—at least some part of—current healthcare expenditures could potentially be saved by promoting individual responsibility for a healthy lifestyle.

Internationally, there are several initiatives to promote healthy lifestyles and reduce NCDs. The WHO Framework Convention on Tobacco Control (WHO FCTC) is one of the most widely embraced treaties in United Nations (UN) history [2]. This led to many initiatives, such as the ambition to have a tobacco-free generation in the Netherlands by 2040 [3,4]. Furthermore, the UN have set the goal to reduce premature mortality from NCDs by one-third in 2030 [5]. Despite the increased interest in promoting healthy lifestyles, current healthcare expenditures continue to rise. Priority setting in healthcare is often subject to public and political debate. A recurring topic is the standpoint that resources allocated to treatment of avoidable disease burden (e.g., burden caused by modifiable behavior) could also be spent on interventions preventing or treating diseases that are not lifestyle-related and, in relation, that individual responsibility for health could also be used as a rationing criterion [6–8].

To allocate available healthcare resources in an equitable and efficient manner, many countries incorporated criteria into their decision-making framework that relate to the necessity, effectiveness, and cost-effectiveness of the intervention and the feasibility of reimbursing it from public funding [9, 10]. Text box 7.1 shows the reimbursement criteria of the Netherlands.

Text box 7.1 Overview of reimbursement criteria used in the Netherlands [11]

Effectiveness
How does treatment benefit a patient?
Cost-effectiveness
Effects and all cost-consequences of a (new) treatment will be set off against the treatment normally used up till that moment. Expressed in costs per QALY.
Necessity (of care and of insurance)
Is the disease burden serious? Are the treatment cost too high for an individual to pay for?
Feasibility
Is inclusion of the (new) treatment in the basic healthcare package feasible?

The increased prevalence of unhealthy lifestyles and their negative impact on health raises the question whether it would be appropriate to consider individual responsibility for health as an additional criterion for rationing healthcare. Allocating responsibility to individuals for the health effects of their lifestyle, however, is controversial [12]. There is no consensus on whether lifestyle choices can be considered as autonomous decisions and an extensive body of evidence indicates that ill health is likely caused by multiple factors [13] , both medical and non-medical [14].

Policies considering individual responsibility in the decision-making framework for reimbursement of health interventions are scarce, but there are some. A local health committee in the United Kingdom announced a policy that postpones non-urgent surgery for people who smoke or are overweight until they reach a certain health level [15,16]. This policy aims "to support patients whose health is at risk from smoking or being very overweight". In Germany, individual responsibility for health has relatively broad support as key elements from an important healthcare reform in 2007 involved: "insured persons may no longer claim free treatment for complications arising from certain 'lifestyle choices'"[17]. Policy proposals and debates about individual responsibility for health are more common, but consensus on its role in priority setting is not reached. In Sweden, the responsibility principle was first rejected in 1995, but later in 2007 it was again promoted as a potential solution for the dilemma's in the current ethical platform [18]. Considering that state responsibility is one of the main features of the welfare regimes of Scandinavian countries [19], this shift from collective state responsibility towards individual responsibility seems remarkable. In Norway, personal health responsibility has been repeatedly rejected as it seemingly challenges their core values of equality, inclusion and solidarity [20].

In 2001 in the Netherlands, following intense public debate about policy options to limit the rise in healthcare expenditures, the National Health Care Institute (ZIN) assessed the feasibility of implementing an additional decision-making criterion related to individual responsibility for a healthy lifestyle [6]. ZIN concluded that there were alternative policies in place (e.g., taxes) to compensate lifestyle-related healthcare costs, and that a lifestyle criterion would likely not alter reimbursement decisions based on the four criteria currently included in the decision-making framework (see Text box 1). Despite the public debate potentially favoring a role for individual responsibility for health, this assessment was merely conducted on a theoretical level. An empirical study from 2010, investigating public preferences in 10 European countries on general principles for healthcare priority-setting, found that taking individuals' responsibility for health was important in one of the five distinguished views [21]; approximately 11% of the public in the Netherlands supported this particular view [22]. This former study focused on viewpoints among the general population. The current study adds by also including experts, enabling a direct comparison between their viewpoints and those of the public. In addition, the former study focused on general principles regarding healthcare priority setting, of which "individual responsibility" was one. The current study looks more in-depth at the relative importance of a lifestyle criterion in the context of the decision-making framework. Finally, in the ten years since the previous study, the public debate about health lifestyle and own responsibility has continued, therefore views on the relevance of a lifestyle criterion in healthcare decision-making may have evolved.

To gain insight in the relative importance of individual responsibility for health relative to the currently applied reimbursement decision criteria, this study uses Q-methodology to examine the viewpoints on this topic among the public and experts in healthcare in the Netherlands. The results of this study provide insight into shared as well as diversity of viewpoints regarding this topic. In addition, it will help identify if there are group(s) in society that potentially support or oppose incorporating a lifestyle criterion in priority setting, in addition to the current applied decision criteria.

7.2 METHODS

7.2.1 Participants

We collected data among experts (n=37) and the public (n=44) in June 2019. The sampling strategy in Q-methodology can be compared to that of qualitative studies as the aim is to include data-rich participants [23]. Participants were recruited using convenience and snowball sampling methods to [1] obtain a varied, yet balanced sample of the public regarding age, sex, educational level, political preferences, and lifestyle (smoking status, alcohol consumption, and BMI), recruited via different informal channels at sport facilities, in specific neighborhoods and via personal connections, and [2] include a variety of experts, i.e., Master- and PhD-level students in health policy, policymakers, policy advisors, and researchers in the healthcare sector. Participants were recruited from Erasmus University Rotterdam, Erasmus Medical Center, National Institute for Public Health and the Environment (RIVM), ZIN, and the Ministry of Health, Welfare and Sport (VWS) in the Netherlands.

7.2.2 Q-METHODOLOGY

We applied Q-methodology to identify public and expert viewpoints on the importance of using a lifestyle decision criterion, relative to the currently applied decision criteria for healthcare priority setting in the Netherlands. We conducted our study in three consecutive steps that are common to Q-methodology studies [23], each further explained in the following paragraphs

7.2.3 Statement set

To arrive at a comprehensive statement set reflecting current practice and debate on healthcare priority setting, we used the decision criteria currently used by

ZIN as domains to structure the statement set development (see Text box 1). We supplemented this with a lifestyle criterion and a domain related to moral arguments that participants could deem relevant in this context.

To collect a set of statements that broadly covered our topic of interest, we reviewed the relevant literature, including previous Q-methodology studies that focused on general principles for healthcare priority-setting [21,24], policy documents, research reports, news articles, and social media. Based on this review, we identified over 100 statements on decision criteria for healthcare priority setting. In multiple iterations, these statements were structured according to the six identified domains. After removing duplicate statements and rounds of editing in order to improve clarity and balance in the phrasing of the statements, we arrived at a selection of 34 statements, with each domain represented by 4-6 statements. Appendix 1 shows the statements per domain, together with their source of origin.

The comprehensiveness and wording of the statement set were assessed by a policy maker with expert knowledge about the reimbursement process in the Netherlands and by a researcher with expert knowledge on Q-methodology. Finally, the statement set was pilot tested with five members of the public and six independent researchers. Based on these results, we made some minor changes to the wording of four statements to improve clarity. Considering that these changes were minor and did not alter the content of the statements, we merged the data collected in the pilot and main phases of the study for analysis.

7.2.4 Data collection

We conducted the interviews, during which the participants ranked and subsequently explained their ranking of the statements, either at home (the public) or work (experts). Each interview started with an introduction to the ranking exercise. Then, participants received the 34 cards with the printed statements, in randomized order, and a ranking grid (see Figure 7.1). The participants were asked to carefully read each statement and allocate them to one of three piles that indicated whether they 'agreed', 'disagreed' or were 'neutral' to the statement. Participants were then instructed to rank the statements on the grid, starting with the pile of statements with which they 'agreed', followed by 'disagreed' on the left side, and finally by placing the statements in the 'neutral' pile. Once the statements were placed on the grid, participants were given time to reflect on their ranking and make some final changes. After completing the exercise, participants were asked to explain in writing why they placed certain statements at the extreme ends of the grid. Finally, participants completed a short questionnaire on their background characteristics, amongst which their current lifestyle.

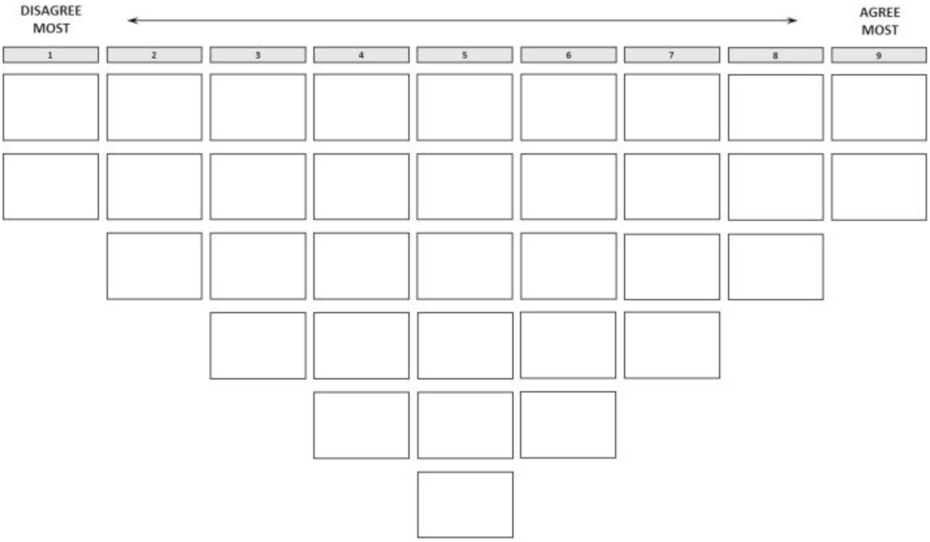

Figure 7.1 Ranking grid used during data collection

7.2.5 Data analysis

We subjected the data to a principal component analyzes (PCA), followed by oblimin rotation, to obtain insight into the viewpoints of experts and the public on the relative importance of a lifestyle decision criterion.

Different factor solutions were evaluated based on the following statistical properties: Eigenvalue of each factor >1, a low to moderate correlation between viewpoints (i.e., $\rho<0.50$), and a minimum of two non-confounded participants (i.e., exemplars) statistically significantly associated with each factor. In addition to these statistical properties, the interpretability of factors was evaluated by inspecting their coherence and distinctiveness.

For the selected factors, we computed factor arrays (i.e., weighted average ranking of the statements by exemplars), which represent how a participant perfectly correlated with a factor would rank the statements. These arrays were used for the interpretation and description of the factors as viewpoints on the relative importance of decision-making criteria in healthcare decision-making. The relative position of the statements in the array of a factor and statistically significant differences in position between factors were used to develop a narrative for each factor. Particular attention was devoted to the statements that are characterizing for the factor, i.e., those positioned on the extreme ends of the composite ranking, and the distinguishing statements for that factor, i.e., those with a statistically significantly ($p<0.01$) different position in the composite ranking of the factor as compared to the other factors. Finally, statements that did not differ statistically significantly in their position between any pair of factors were inspected. We used the qualitative data of the exemplars to verify and specify the interpretation of the factor. Exemplar quotes were used to illustrate the interpretation of the factors in the words of participants. We used Rstudio 2.2.1335 and the qmethod package for analyzing the data [25].

7.2.6 Ethics

Prior to the study, participants received information about the study objective and procedures. All participants had the opportunity to ask questions and could withdraw if desired. Participants were assured their data would be anonymized. Informed consent was provided by all participants prior to data collection. The ethical review board of the Erasmus School of Health Policy & Management assessed and waived approval of the study (20-30 Blinded).

7.3 RESULTS

7.3.1 Sample characteristics

The sample characteristics are presented in Table 7.1. The public sample was evenly distributed across age and sex, while most of the sample was highly educated. Of the experts, 81% was aged between 18 and 35 years and about 50% was Master student. Compared to general population statistics for the Netherlands in 2019, the participants more frequently had a healthy BMI (<25.0) and more often reported excessive alcohol consumption. Smoking was more prevalent among the group of experts, excessive drinking more prevalent among the group from the public.

7.3.2 Factor analysis

A four-factor solution was selected. The Eigenvalues of the factors were between 5.8 and 12.8, and 67 of the 81 participants loaded statistically significantly on one factor. Table 7.2 shows the low to moderate correlation between the factors. Factors 1 and 3 show the highest correlation (ρ=0.41) and factors 3 and 4 the lowest correlation (ρ=0.23).

Table 7.3 shows the factor loadings of participants, ordered on study sample and statistical significance. The factors were defined by 27, 22, 11 and 7 participants, respectively. Factors 1 and 4 had one participant with a negative factor loading, and hence were interpreted as being bipolar. The explained variance was 47.2%.

The automatic flagging procedure in PQ method software was used to identify defining sorts (**bold**) according to the following rule: Flag loading a: if 1) $a^2 > h^2/2$ (factor 'explains' more than half of the common variance) and 2) $a > 1.96 / \sqrt{N \text{ items}}$ (loading significant at $p < .05$).

Table 7.1 Sampling characteristics of the full sample of participants

Personal characteristics		Public	Experts	Dutch population statistics[2]
		% (n)	% (n)	%
Age	18 – 35	36.4 (16)	81.1 (30)	22.6
	36 – 55	34.1 (15)	13.5 (5)	26.7
	55 +	29.5 (13)	5.4 (2)	31.3
Gender	Female	50.0 (22)	56.8 (21)	50.0
	Male	50.0 (22)	43.2 (16)	50.0
Highest compl. educ.	Low	13.6 (6)	.	30.6
	Medium	31.8 (14)	.	37.1
	High	52.3 (23)	100 (37)	30.8
BMI	≤ 24.9	65.9 (29)	89.2 (33)	50.5
	25.0 – 29.9	31.8 (14)	2.7 (1)	34.8
	≥ 30.0	2.3 (1)	5.4 (2)	14.7
	Not stated	.	2.7 (1)	
Smoker	Yes	13.6 (6)	22.0 (8)	21.7
	No	59.1 (26)	65.0 (24)	45.7
	Ex-smoker	27.3 (12)	13.0 (5)	32.6
Excessive alc. Cons.[1]	Yes	18.2 (8)	10.8 (4)	8.5
	No	81.8 (36)	89.2 (33)	92.5
Expert type	Policymaker	.	27.0 (10)	.
	Researcher	.	32.5 (12)	.
	Master/PhD student	.	40.5 (15)	.
Total, N		44	37	

[1] Categorization based on national guidelines (for women >14 glasses p/w, excessive for men >21 glasses p/w)
[2] Source: Statistics Netherlands (https://www.cbs.nl)

Table 7.2 Correlations between factor scores

	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1	1	0.26	0.41	0.34
Factor 2	0.26	1	0.39	0.34
Factor 3	0.41	0.39	1	0.23
Factor 4	0.34	0.34	0.23	1

Table 7.3 Participants' characteristics and factor association

ID	Study sample	Factor 1 (n=27)	Factor 2 (n=22)	Factor 3 (n=11)	Factor 4 (n=7)
1	Expert	**0.70**	-0.12	0.05	0.13
2	Expert	**0.75**	-0.23	-0.25	0.34
3	Expert	**0.39**	0.12	0.08	0.27
4	Expert	**0.56**	0.01	0.29	-0.09
5	Expert	**0.64**	0.49	-0.11	0.07
6	Expert	**0.77**	-0.06	0.21	-0.06
7	Expert	**0.52**	-0.15	0.18	0.37
8	Expert	**0.67**	-0.06	0.07	-0.32
9	Expert	**0.84**	-0.06	0.09	-0.06
10	Expert	**0.66**	-0.21	0.18	0.06
11	Expert	**0.58**	0.15	0.00	0.25
12	Expert	**0.70**	0.13	0.04	-0.11
13	Expert	**0.54**	0.17	-0.06	0.07
14	Expert	**0.66**	-0.32	0.31	0.16
15	Expert	**0.68**	0.01	0.06	0.26
16	Expert	**0.59**	0.30	-0.11	0.38
17	Expert	**0.61**	0.22	0.26	-0.08
18	Expert	**0.57**	0.33	0.13	0.02
19	Expert	**0.56**	0.04	0.21	-0.20
20	Expert	**0.51**	0.42	-0.02	0.24
21	Public	**-0.56**	0.22	0.35	0.32
22	Public	**0.60**	0.52	0.00	-0.23
23	Public	**0.49**	0.11	0.25	-0.09
24	Public	**0.46**	0.03	0.01	0.26
25	Public	**0.72**	-0.24	0.10	-0.09
26	Public	**0.64**	0.24	-0.26	0.25
27	Public	**0.50**	0.18	0.18	0.20
28	Expert	0.01	**0.59**	0.42	0.11
29	Expert	0.16	**0.66**	-0.15	0.00
30	Expert	0.05	**0.56**	-0.23	049
31	Expert	0.37	**0.60**	-0.07	0.23
32	Expert	0.04	**0.63**	0.01	0.37
33	Expert	0.10	**0.45**	0.31	0.16
34	Expert	0.31	**0.41**	0.09	0.17
35	Public	-0.21	**0.62**	-0.04	-0.12

Table 7.3 Participants' characteristics and factor association (continued)

ID	Study sample	Factor 1 (n=27)	Factor 2 (n=22)	Factor 3 (n=11)	Factor 4 (n=7)
36	Public	-0.12	**0.67**	0.07	-0.29
37	Public	-0.03	**0.72**	0.09	-0.16
38	Public	-0.09	**0.81**	-0.17	-0.11
39	Public	-0.01	**0.41**	-0.14	0.21
40	Public	-0.14	**0.76**	0.16	-0.02
41	Public	-0.04	**0.70**	0.21	0.10
42	Public	-0.07	**0.50**	0.37	-0.02
43	Public	0.06	**0.64**	0.25	0.37
44	Public	-0.04	**0.75**	-0.15	0.11
45	Public	0.00	**0.74**	0.02	0.03
46	Public	0.30	**0.52**	-0.08	0.36
47	Public	0.07	**0.50**	0.02	-0.21
48	Public	0.12	**0.72**	0.28	-0.29
49	Public	0.02	**0.59**	0.20	0.09
50	Expert	0.31	-008	**0.69**	-0.10
51	Expert	0.41	0.06	**0.53**	0.09
52	Expert	0.00	0.21	**0.56**	0.08
53	Public	0.16	-0.06	**0.82**	-0.04
54	Public	0.09	0.22	**0.59**	-0.12
55	Public	0.18	0.18	**0.65**	0.08
56	Public	0.14	0.26	**0.52**	0.31
57	Public	-0.08	0.15	**0.60**	-0.34
58	Public	0.04	0.09	**0.61**	-0.02
59	Public	0.23	0.25	**0.41**	0.09
60	Public	-0.09	-0.17	**0.62**	0.33
61	Expert	0.17	0.30	0.20	**0.41**
62	Expert	-0.01	-0.08	0.04	**0.82**
63	Public	-0.29	0.32	0.02	**0.54**
64	Public	-0.06	0.36	0.02	**-0.49**
65	Public	0.20	0.27	-0.18	**0.48**
66	Public	0.27	0.03	0.21	**0.55**
67	Public	0.15	0.23	-0.15	**0.44**
68	Public	-0.01	0.19	0.32	0.11
69	Public	0.34	0.24	0.42	0.12
70	Public	-0.36	0.47	0.39	0.04

Table 7.3 Participants' characteristics and factor association (continued)

ID	Study sample	Factor 1 (n=27)	Factor 2 (n=22)	Factor 3 (n=11)	Factor 4 (n=7)
71	Public	0.27	0.47	-0.04	0.45
72	Public	0.26	0.26	0.23	0.26
73	Public	0.14	0.16	-0.05	0.29
74	Public	-0.33	0.37	0.45	0.06
75	Expert	0.29	0.38	0.11	0.22
76	Expert	0.35	-0.03	0.3	0.22
77	Expert	0.43	0.03	0.48	0.26
78	Expert	0.31	0.28	0.36	0.03
79	Expert	0.34	0.12	0.17	0.27
80	Expert	0.48	-0.21	0.23	0.4
81	Expert	0.45	0.36	-0.46	0.21
Explained variance (Sum: 47.2%)		**15.8%**	**14.6%**	**9.6%**	**7.2%**

In the following sections each factor is described with reference to the positioning of statements in the factor array (see Table 7.4). Notation is in line with previous Q-methodology studies [24] , as # indicates statement number, followed by the factor score of that statement. For instance, (#10 +3) indicates that statement number 10 had a factor score of +3 in the respective factor array. When exemplar quotes are used in the descriptions of the viewpoints, the participant's identification number is used for reference.

Table 7.4 Statement set and factor arrays

#	Statements	Viewpoints[1,2] V1	V2	V3	V4
1	Access to healthcare should be based on medical need.	**+3**	0	+1	**-4**
2	People with a severe condition should be treated with priority over people with a non-severe condition.	+1	0	+2	**+3**
3	A treatment for a non-severe condition should not be reimbursed.	*-2*	*-3*	*-2*	*-4*
4	If it is possible to save a life, every effort should be made to do so.	-2	**+3**	-2	-1
5	If there is no alternative treatment available, the only available treatment must be reimbursed.	**-4**	**+2**	+1	+1
6	Healthcare should focus on patients who need care the most.	+2	+1	+1	**-1**
7	People can pay for inexpensive treatments out of pocket.	0	**-1**	+1	***-3***
8	People with a higher income should co-pay for care more often	0	+1	**+3**	**-3**
9	Co-payment is acceptable to prevent excessive use of medication	**+2**	**0**	**+3**	**+1**
10	Patients should never have to pay themselves for treatment of a serious condition	*-1*	*+2*	*-1*	*+3*

Table 7.4 Statement set and factor arrays (continued)

#	Statements	Viewpoints[1,2]			
		V1	V2	V3	V4
11	The current basic benefits package should provide less coverage, more treatments should be included in the supplementary insurance policies	*-1*	*-1*	*-1*	*-1*
12	To ensure that patients will only use necessary care, patients can pay for the first treatments themselves.	-1	**-2**	0	**-2**
13	Priority should be given to those treatments that generate the most health.	**+1**	**0**	**0**	**+4**
14	There is no point in including treatments in the basic benefits package that do not generate considerable health benefits.	+2	**-1**	**0**	+2
15	Treatments that restore health to a level that is sufficient for participating in activities of daily living should be given priority.	0	0	-1	**+2**
16	There is no use in providing treatment when the result is still a very poor state of health.	0	**-2**	-1	**+3**
17	The improvement in quality of life is the most important.	**+3**	**+4**	+2	+1
18	A treatment should only be reimbursed if there is scientific proof that it is effective.	+3	**0**	**-2**	+2
19	When having to choose between two treatments that both cost the same, funding should be given to the treatment that results in the biggest health gain.	**+4**	+2	+2	**+4**
20	Treatments that are very costly in relation to their health benefits should not be reimbursed	**+1**	-2	**-3**	-1
21	If a treatment is very costly in relation to its health benefits, but it is the only treatment available, it should still be reimbursed.	**-4**	**+3**	0	0
22	If the total costs of treatment of a disease (for all patients) are high, this treatment should receive less priority.	**-1**	-4	-4	**0**
23	Whether or not people have caused a disease themselves should not be relevant.	0	**+2**	**-2**	0
24	Individual responsibility should not be taken into account, because people do not always have control over their way of living.	+1	+1	**-3**	**-1**
25	People who live a healthy life should be prioritized over people with an unhealthy lifestyle.	**-3**	-2	**0**	-2
26	For treatments of diseases that are the result of lifestyle choices, payment of the treatment must also be an individual responsibility.	*-2*	*-3*	*0*	*0*
27	It is more important to prevent ill health than it is to cure ill health once it occurs.	*+1*	*+3*	*+4*	*+2*
28	If people become ill through no fault of their own, they should get priority over people who are in some way to culpable for their illness.	*-3*	*-3*	*+1*	*0*
29	If there is a way of helping patients, it is morally wrong to deny them this treatment.	-1	**+4**	-1	**0**
30	Government should not interfere with the lifestyle of individuals.	**-3**	-1	**-3**	-2
31	Children's health should be given priority over adults' health.	**0**	-1	**+2**	-2
32	If a lifestyle has negative consequences for others, intervention is acceptable.	+2	+1	**+3**	+1

Table 7.4 Statement set and factor arrays (continued)

#	Statements	Viewpoints[1,2]			
		V1	V2	V3	V4
33	Poorer people should be given priority because they don't have the same opportunities in life.	-2	-4	**-4**	-3
34	Everyone has a right to healthcare, but this does not mean that everything can always be reimbursed.	**+4**	+1	**+4**	+1

[1] Bold denotes the distinguishing statements; [2] Italic denotes the consensus statements

Viewpoint 1. Access to cost-effective treatments based on need

People with this view believe that everyone has a right to healthcare, but that this does not mean that everything can always be reimbursed (#34, +4). When a treatment is very costly in relation to its health benefits, even it is the only treatment available, it should not be reimbursed (#5, -4, #21, -4). Benefits in terms of quality of life improvement are most important (#17, +3; #14, +2; #13, +1). When choices need to be made between two treatments that both cost the same, funding should be given to the treatment that results in the biggest health gain (#19, +4).

"One should always choose for the best price-quality ratio, more health gains for equal costs is always better." #ID 15

People with this view believe that treatments should only be reimbursed if scientific evidence indicates they are effective (#18, +3).

"To ensure solidarity within the [publicly financed healthcare] system, money should not be spent on treatments that don't work or are perhaps even harmful." # ID 2

Access to healthcare should be based on patients' need for care (#1, +3; #6, +2). Therefore, people who live a healthy life and those who fall ill through no fault of their own should not be prioritized over people with an unhealthy lifestyle and those who are in any way to blame for their disease (#25, -3; #28, -3). Neither should people be responsible for paying for the treatment of illnesses that result from their lifestyle choices (#26, -2). The 'access based on need' principle also implies that no particular weight is given towards prioritizing children over adults (#31, 0).

"Adults and children should be treated equally. Access to care should be based on the likelihood of successful treatment and the improvement in quality of life." # ID 16

While people with this viewpoint believe lifestyle should not play a role in reimbursement decisions, they do believe that the government holds some

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responsibility and government intervention is appropriate when people's lifestyle has negative consequences for others (#32, +2; #30, -3).

"The government has a responsibility to assist people in making an informed decision about their lifestyle behaviors." # ID 14

Viewpoint 2. Life is precious and always worth saving

People with this view attach a high value to life and believe that prevention is important (#27, +3). When it is possible to save a life, every effort should be made to do so (#4, +3) and if there is a way of helping patients, it is morally wrong to deny them treatment (#29, +4). People with this view believe that quality of life gains are important (#17, +4), but treatment should be reimbursed even when patients' quality of life after treatment is still very poor (#16, -2) or when scientific proof on a treatment's effectiveness is limited (#18, 0). Of all viewpoints, this viewpoint is most opposed to *not* reimbursing treatment if they do not generate considerable health benefits (#14, -1). Even when a treatment is very costly in relation to its health benefits, but it is the only treatment available, it should still be reimbursed (#21, +3; #5, +2; #20, -2).

"We should do whatever it takes in order to make people healthy again." # ID 35

"You never know for sure how someone will respond to treatment, thus deciding beforehand to not treat is not an option in my opinion ... every life is worth saving." # ID 36

People with this view believe that high total treatment costs (for all patients) (#22, -4) or low disease severity (#3, -3) should not affect reimbursement decisions.

"Costs should not play a role in reimbursement decisions. When there is any chance of improving someone's health, treatment should always be provided." # ID 45

Factors like the cause of a disease (#23, +2; #28, -3; #25, -2) and the socioeconomic status (#33, -4) of patients are not considered relevant in reimbursement decisions.

Viewpoint 3. Prevention and individual responsibility for health

Like people with viewpoint 1, people with this viewpoint believe that everyone has a right to healthcare but that this does not mean that everything can always be reimbursed (#34, +4). Treatments that have high total costs (for all patients) should not receive less priority (#22, -4), nor should the costs of a treatment in relation to its health benefits be decisive for reimbursement (#20, -3). In order to prevent excessive use and avoid use of unnecessary healthcare, co-payments are considered acceptable (#9, +3; #12, 0), in particular when this involves inexpensive treatments (#7, +1) and people who can easily afford this (#8, +3).

"For rich people, the costs are relatively lower and therefore they can support people with a lower socio-economic status to overcome financial obstacles in healthcare." # ID 53

People who hold this view believe that individual responsibility should play a role in reimbursement decisions (#24, -3) and in prioritizing healthcare (#23, -2), regardless of one's socio-economic status (#33, -4).

"If you have a very unhealthy lifestyle and, therefore, need extra healthcare, it simply makes sense that your financial contribution to healthcare should be higher." # ID 57

In addition, they value prevention as a means to keep the population healthy (#27, +4) and support government intervention when lifestyle choices have negative consequences for others (#32, +3; #30, -3).

"Society must not suffer from wrong choices made by others, especially when it comes to health." # ID 55

Moreover, people with this viewpoint are of the opinion that one should bear responsibility for own lifestyle choices. Therefore, individual responsibility should play a role in reimbursement decisions (#24, -3) and in prioritizing health care (#23, -2).

"If you have a very unhealthy lifestyle and therefore need extra healthcare, it simply makes sense that your financial contribution to healthcare should be higher." #Participant 57

This viewpoint distinguishes from the other viewpoints by agreeing with prioritization of children over adults in healthcare (#31, +2) and by disagreeing with the condition that treatments should only be reimbursed when there is scientific proof on their effectiveness (#18, -2).

Viewpoint 4. Treatment outcome and cost-effectiveness

People with this viewpoint believe priority should be given to treatments that are effective (#13, +4; #14, +2), substantiated with scientific evidence (#18, +2), also on their cost-effectiveness (#19, +4).

"Even though it is difficult, and almost immoral to make a cost-benefit analyzes when there are human lives at stake, I do not think that we should avoid this. When a treatment does not lead to improved quality of life, it seems that people do avoid such decisions, and this tends to be a waste of money." # ID 65

“In my opinion it does not make sense to choose for a treatment with less health gains but that has equal costs compared to another treatment. [Not reimbursing it] is a win-win situation for both the patient and the government.” # ID 61

However, when there are no other treatments available, they tend to reimbursing the only treatment that is available (#5, +1). People with this view believe that there is no use in providing treatment when the result is still a very poor state of health (#16, +3) and tend to disagree that, if it is possible to save a life, every effort should be made to do so (#4, -1). People with this view are least likely to believe that access to healthcare should be based on need for care (#1, -4). This view is also distinctive for believing that healthcare should not focus on patients who need care the most (#6, -1), nor that it would be morally wrong to deny treatment to patients (#29, 0). They deem it better to prioritize treatments that restore health to a level that is sufficient for participating in daily activities (#15, +2).

They believe that it is important to give priority to patients with a severe condition (#2, +3). However, they do not believe that treatments for non-severe diseases should not be reimbursed (#3, -4), which aligns with their focus on treatment outcome and cost-effectiveness. In this same context, they do not support individual responsibility for health (#25, -2; #24, -1) and paying for care out of pocket (#7, -3; #10, +3; 12, -2).

7.4 DISCUSSION

The aim of this study was to identify and describe viewpoints among experts and the public on applying a lifestyle decision criterion for healthcare priority setting in the Netherlands relative to support for the currently applied decision criteria of necessity, effectiveness, cost-effectiveness and feasibility. Our findings suggest that there are four viewpoints on this, each supported by a mix of experts and members of the public who participated in our study. The “Prevention and individual responsibility for health” viewpoint seems supportive of the application of a lifestyle criterion. A notable finding was that this viewpoint was largely defined by the public sample, but that also some of the expert sample were associated with this view. The majority of the experts participating in this study related more strongly to the “Access to cost-effective treatments based on need” viewpoint which most closely reflects the current decision-making framework in the Netherlands.

Three of the four viewpoints acknowledged the scarcity of resources and necessity of priority setting based on, at least, some criteria. However, people with the viewpoint “Life is precious and always worth saving” did not support rationing in healthcare, as they believed it to be morally wrong to deny treatment to patients. According to people with this view, life is priceless and always worth the effort trying to save it. Patients should be offered treatment, even when the outcomes are likely to be very poor.

People with this viewpoint and those with the viewpoint "Prevention and individual responsibility for health" believe that healthcare costs should not play a large role in healthcare priority-setting and both attribute more importance to prevention as a means to keep the population healthy and healthcare costs low. The difference between these views is that the former associated this with the responsibility to adopt a healthy lifestyle, while the latter did not favor this. Viewpoints 1 and 4 both attribute importance to the cost-effectiveness criterion, however, Viewpoint 4 favors reimbursement when there is only one treatment available while Viewpoint 1 is not in favor of this. Moreover, Viewpoint 4 attaches more value to treatment outcomes, as they do not support the provision of treatment when the result is still a very poor state of health.

To a certain degree, the results of this study are in line with previous findings. A multi-country study reported that 50% of the public in the Netherlands would support smoking as a prioritizing criterion [26]. A vignette study in the Netherlands showed that most participants were in favor of rewarding people with a healthy lifestyle instead of a punishing those with an unhealthy lifestyle [27]. In addition, two former Q studies on this topic also identified a positive attitude towards individual responsibility as a rationing criterion in one of the viewpoints [21,24]. Comparisons with these studies must be done with caution. The objectives of the studies were slightly different, and therefore also the statement sets differed. The inclusion of experts in addition to members of the public also seems to have had a particular effect on our results, since the viewpoint "Access to cost-effective treatments based on need", most closely reflects the current decision-making framework in the Netherlands and was not identified in these former studies. Rogge & Kittel [26] found that differences in attitude towards an individual responsibility criterion were best explained by rational choice theory, which suggests that people tend to prefer the distribution mechanism that is most advantageous for themselves [28]. Our study approach was not suitable for confirming this. Traina & Feiring [29] showed that clinicians were reluctant towards implementing a lifestyle criterion, mostly because they were concerned about the impact such a principle could have on the most vulnerable people in society. Our study did not include clinicians as participants. Future research could extend on our study and examine how views of clinicians relate to those of experts and the public.

Several theories of justice (e.g., luck-egalitarianism and libertarianism) favor consideration of individual responsibility as a mechanism to allocate scarce resources [30]. However, feasibility issues seem to have a pivotal position in the discussion about the application of such a decision criterion. Most objections can be categorized into problems with: i) causality; ii) efficiency; or iii) universalization. The causality problem refers to the multifactorial causes for many preventable diseases [30,31], making it difficult to establish an unambiguous causal relation at the individual level between lifestyle choices and health outcomes. The efficiency problem claims that, although incorporating a lifestyle criterion should contribute to a more efficient allocation of scarce resources, the time and resources needed to determine patients' responsibility make it far from efficient [32,33]. Finally, the universalization problem entails that applying a lifestyle criterion to its fullest means that many activities that pose health risks would need to be covered in such a mechanism, which is practically impossible [34]. While these objections should be taken seriously, it does not mean that they eradicate the potential of a lifestyle criterion completely. If a lifestyle criterion is not introduced, one could argue that in the context of a collective health insurance system, citizens with a healthy lifestyle may be disadvantaged by citizens with an unhealthy lifestyle by claiming an "unfairly" large share of the available healthcare resources for care that could perhaps have been prevented. Whether this free-riding can be mitigated by introducing a lifestyle criterion needs to be further explored. An often mentioned objection is that the free-riding argument assumes that there is a high degree of self-control in lifestyle choices, while there is strong evidence that social determinants also matter [35 36].

7.4.1 Limitations

We acknowledge some limitations of our study. First, experts were aware that they were recruited because of their expertise. This knowledge might have led to social-desirability or status-quo bias, contributing to the identification of the viewpoint "Access to cost-effective treatments based on need" that closely resembles the current decision framework in the Netherlands. Moreover, the variety in experts was limited. Second, we based our statement set on existing materials from related studies that in some way addressed the relation between lifestyle and healthcare rationing. However, we did not conduct a systematic review of the underlying literature and, hence, aspects relevant to this relation may have been overlooked. We conducted a pilot study and obtained feedback on the comprehensiveness of the statement set from experts to verify whether aspects were missing. No missing aspects were identified, suggesting that it was representative of our topic of interest. Third, factors 1 and 4 were bipolar, as both had one negative exemplar. Currently, there is no consensus on how to handle these exemplars in the analyzes of the ranking data and interpretation of viewpoints. Some argue that negatively exemplars should be excluded from the computation of the factor array as this would result in a more straightforward interpretation of the positive pole of the factor [38]. Others, however, argue that they should be included as this results in a more balanced viewpoint that reflects the views of all participants who define it [23,39]. We followed the latter approach, but also inspected the solution without the negative exemplars as a robustness check and found that the viewpoints resulting from the two approaches did not differ significantly. Fourth, our results provide no insight into the prevalence of the viewpoints, or into the strength of support for a lifestyle criterion, amongst larger samples of experts and the public in the Netherlands. Future research, in which the results of this study are integrated in a survey design [22] can shed light on this. Fifth, our data collection was finished prior to the COVID-19 pandemic. Considering the burden of the pandemic on the healthcare system, viewpoints about criteria for healthcare rationing might have changed. Individual behaviors play an important role in the spread of viruses and the course of an infection, thus the relevance of lifestyle and responsibility may also have changed in the meantime.

7.5 CONCLUSION

This study confirms findings from some previous studies indicating (some) support for a lifestyle criterion in healthcare priority setting, but we also found viewpoints indicating clear objection to such a criterion. Further research using survey methods is needed to understand the extent of the controversy around this topic better. We anticipate that the role of individual responsibility in health(care) will remain a controversial topic of debate. Accounting for heterogeneity in policies aimed at addressing responsibility in healthcare seems pivotal to increase the likelihood of policy acceptance.

7

7.6 REFERENCES

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APPENDIX

Appendix 1

Table A1. Original and used statements in the study with the source of origin and categorised by domain

Decision Criteria	Reference	Original statements	Used statements (ENG)
Necessity of care	(Wouters et al., 2017)	Access to health care should be based on need for care, not on patient characteristics, such as their gender, age or ethnicity	Access to healthcare should be based on medical need.
	(Wouters et al., 2017)	People with a severe condition should be treated with priority over people with a non-severe condition	People with a severe condition should be treated with priority over people with a non-severe condition.
	(Zorginstituut Nederland, 2017)	Een interventie voor een aandoening met een hoge ziektelast moet wel vergoed worden/een interventie voor een aandoening met een lage ziektelast moet niet vergoed worden	A treatment for a non-severe condition should not be reimbursed.
	(Wouters et al., 2017)	I fit is possible to save a life, every effort should be made to do so	If it is possible to save a life, every effort should be made to do so.
	(Reckers-Droog et al., 2020)	Als er geen alternatieve behandeling beschikbaar is voor een aandoening, dan kan dit een reden zijn om de enige beschikbare behandeling te vergoeden.	If there is no alternative treatment available, the only available treatment must be reimbursed.
	(Reckers-Droog et al., 2020)	De gezondheidszorg moet zich richten op die patiënten die de zorg het hardst nodig hebben.	Healthcare should focus on patients who need care the most.
Necessity of reimbursement	(Reckers-Droog et al., 2018)	People can pay for inexpensive treatment out of pocket	People can pay for inexpensive treatments out of pocket.
	(Reckers-Droog et al., 2020)	Vermogende patiënten zouden vaker een eigen bijdrage kunnen betalen	People with a higher income should co-pay for care more often
	(Reckers-Droog et al., 2020)	Om misbruik van medicijnen te voorkomen is in sommige gevallen een eigen bijdrage nodig	Co-payment is acceptable to prevent excessive use of medication

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Table A1. Original and used statements in the study with the source of origin and categorised by domain (continued)

Decision Criteria	Reference	Original statements	Used statements (ENG)
	(Zorginstituut Nederland, 2017)	Patiënten zouden een dure behandeling nooit zelf hoeven te betalen	Patients should never have to pay themselves for treatment of a serious condition
	(Reckers-Droog et al., 2020)	Wanneer behandelingen vanuit de aanvullende verzekering kunnen worden vergoed, hoeft deze niet in het basispakket te worden opgenomen	The current basic benefits package should provide less coverage, more treatments should be included in the supplementary insurance policies
	(Reckers-Droog et al., 2020)	Om er voor te zorgen dat patiënten alleen gebruik maken van hulp die echt noodzakelijk is en om ervoor te zorgen dat zij echt beter worden, kunnen patiënten de eerste behandelingen zelf betalen	To ensure that patients will only use necessary care, patients can pay for the first treatments themselves.
Effectiveness	(van Exel et al., 2015)	Priority should be given to those treatments that generate the most health.	Priority should be given to those treatments that generate the most health.
	(van Exel et al., 2015)	There is no point in providing treatments that do not generate considerable health benefits	There is no point in including treatments in the basic benefits package that do not generate considerable health benefits.
	(Reckers-Droog et al., 2020)	Voorkeur moet uitgaan naar het herstellen van gezondheid tot een niveau dat voldoende is voor mensen om aan hun gebruikelijke activiteiten deel te kunnen nemen.	Treatments that restore health to a level that is sufficient for participating in activities of daily living should be given priority.
	(Wouters et al., 2017)	There is no use in providing treatment when the result is still a very poor state of health.	There is no use in providing treatment when the result is still a very poor state of health.
	(Baker et al., 2014)	The amount of health and quality of life improvement is the most important. It is about getting the greatest benefit for the most people	The improvement in quality of life is the most important.

Table A1. Original and used statements in the study with the source of origin and categorised by domain (continued)

Decision Criteria	Reference	Original statements	Used statements (ENG)
	(Zorginstituut Nederland, 2014)	Een behandeling moet alleen worden vergoed als het wetenschappelijk bewezen effectief is ('evidence-based medicine')	A treatment should only be reimbursed if there is scientific proof that it is effective.
Efficiency	Van Exel et al., (2015)	When having to choose between two treatments that both cost the same, funding should be given to the treatment that results in the biggest health gain.	When having to choose between two treatments that both cost the same, funding should be given to the treatment that results in the biggest health gain.
	(Reckers-Droog., 2018).	Treatments that are very costly in relation to their health benefits should be withheld	Treatments that are very costly in relation to their health benefits should not be reimbursed
	Wouters et al., (2017)	If a treatment is costly in relation to its health benefits, but the only treatment available, it should still be provided.	If a treatment is very costly in relation to its health benefits, but it is the only treatment available, it should still be reimbursed.
	Reckers-Droog et al., (2018)	treatments that are very costly in relation to their health benefits should be withheld	If the total costs of treatment of a disease (for all patients) are high, this treatment should receive less priority.
Lifestyle	Baker et al., (2014)	Whether or not people have caused the illness themselves should not be relevant. If someone has got an illness through smoking, they are just as worthy of treatment as someone else.	Whether or not people have caused a disease themselves should not be relevant.
	Wouters et al., (2017)	Individual responsibility Lifestyle should not be taken into account because people don't always have control over their way of living.	Individual responsibility should not be taken into account, because people do not always have control over their way of living.
	Wouters et al., (2017)	People who live a healthy life should be prioritized over people with an unhealthy lifestyle.	People who live a healthy life should be prioritized over people with an unhealthy lifestyle.

Table A1. Original and used statements in the study with the source of origin and categorised by domain (continued)

Decision Criteria	Reference	Original statements	Used statements (ENG)
	(Raad voor de Volksgezondheid en Zorg, 2014)	Voor behandelingen die het gevolg zijn van eigen keuzes in de leefstijl, moet de betaling ook eigen verantwoordelijkheid zijn.	For treatments of diseases that are the result of lifestyle choices, payment of the treatment must also be an individual responsibility.
	Wouters et al., (2017)	It is more important to prevent ill health than it is to cure ill health once it occurs.	It is more important to prevent ill health than it is to cure ill health once it occurs.
	(Reckers-Droog et al., 2020)	Mensen die buiten hun schuld om een ziekte hebben gekregen moeten voorrang krijgen op mensen die zelf verantwoordelijk zijn voor hun ziekte.	If people become ill through no fault of their own, they should get priority over people who are in some way to culpable for their illness.
Moral principles	Wouters et al., (2017)	If there is a way of helping patients, it is morally wrong to deny them this treatment.	If there is a way of helping patients, it is morally wrong to deny them this treatment.
	(Raad voor de Volksgezondheid en Zorg, 2014)	Leefstijlbeïnvloedingen zijn altijd onacceptabel omdat deze interfereert met de individuele vrijheid	Government should not interfere with the lifestyle of individuals.
	Wouters e al., (2017)	Children’s health should be given priority over adults’ health.	Children’s health should be given priority over adults’ health.
	(Raad voor de Volksgezondheid en Zorg, 2014)	Als je leefstijl geen negatieve gevolgen voor andere heeft, dan is beïnvloeding ervan acceptabel	If a lifestyle has negative consequences for others, intervention is acceptable.
	Wouters et al., (2017)	Poorer people should be given priority because they don’t have the same opportunities in life.	Poorer people should be given priority because they don’t have the same opportunities in life.
	Wouters et al., (2017)	Everyone has a right to healthcare, but this does not extend beyond a certain basic level.	Everyone has a right to healthcare, but this does not mean that everything can always be reimbursed.

8 Public preferences for policies promoting a healthy diet – a discrete choice experiment

Based on: Dieteren, C.M., Bonfrer, I., Brouwer, W.B.F., van Exel, J., Public preferences for policies promoting a healthy diet – a discrete choice experiment. *Submitted*

ABSTRACT

Background

Worldwide obesity rates have nearly tripled over the past five decades. Not much is known about public support for policies that aim to promote a healthy diet. In this study, a discrete choice experiment (DCE) was used to elicit stated preferences for such policies among a representative sample of the public of the Netherlands.

Method

The choice tasks presented a hypothetical scenario of two policy packages, comprising seven attributes (i.e. potential policies). The policies were ordered based on their level of intrusiveness, We estimated mixed logit models (MXL) to estimate respondents' preferences and performed latent class analyses (LCA) to identify underlying patterns in preferences. Classes in this study refer to subgroups of respondents that largely share their stated preferences towards policies to promote a healthy diet.

Results

The MXL model showed that positive financial incentives – subsidies for vegetables and fruit – yielded most utility. A tax of 50% on sugary drinks was associated with disutility while a tax of 20% was associated with positive utility compared to no tax at all. The results indicate substantial heterogeneity in policy preferences. Hence, we identified subgroups ("against", "mixed", "pro" policies) with different preferences towards healthy diet policies.

Conclusion

Which (combination of) policies to promote a healthy diet is selected for implementation remains a policy challenge since a considerable proportion of the population negatively evaluated most measures, especially more intrusive ones. Governments should try to align with public preferences in designing health policies, while balancing the interests of different subgroups.

8.1 BACKGROUND

Worldwide overweight rates are alarmingly high and obesity rates have nearly tripled since 1975 [1] and are expected to rise further [2]. Systematic caloric overconsumption, often referred to as an "unhealthy diet", is the main cause of overweight and obesity in Western societies [3]. It is also one of the leading risk factors for morbidity and mortality from non-communicable diseases (NCDs) [4]. The COVID-19 pandemic further emphasized the importance of a healthy diet, as obesity is associated with more frequent hospital admissions after infection with COVID-19 [5]. Paradoxically, the imposed lockdowns to control the COVID-19 pandemic have resulted in further increases in overweight and obesity rates [6, 7].

Health policies that promote a healthy diet are expected to help reduce overweight and obesity. Designing and implementing these policies effectively is challenging since food choices - in addition to personal taste and appetite - are influenced by several exogeneous factors including price, accessibility, advertisement, social contacts, sociocultural determinants and the local food environment [8–12]. Hence, policies require a focus on different factors relevant to food choices and therefore implementing broader policy packages consisting of multiple policies is suggested [13].

Implementing policies may also be difficult as intervening in food choices may be viewed as limiting individual's freedom of choice and autonomy. "Intrusiveness" reflects the extent to which a policy is intervening in someone's life [15]. One of the least intrusive health policies is the dissemination of information regarding healthy food choices (i.e., via mass media campaigns), while policies that restrict the provision of certain types of food by regulation or law are more intrusive [14, 15]. Thus far, policy initiatives promoting a healthy diet have been far less intrusive than those to reduce smoking and alcohol consumption. For the latter two, many countries have implemented taxes and age restrictions [17, 18]. Public support for tobacco control policies has increased over time, also due to awareness of the toxic character of tobacco [20].

In The Netherlands, like in most European countries, most of the implemented initiatives supporting a healthy diet aim to promote informed choice, predominantly through public information campaigns and nutrition education [21]. Only a few European countries have implemented fiscal measures such as taxes and subsidies. Denmark and Finland both have a sugar/unhealthy food tax and, in addition, Denmark decreased its taxes on sugar-free soft drinks [22]. Since 2012, France has a tax on drinks with added sugar or sweetener [23]. Taxation of unhealthy food is more common in the United States. For example, the "twinkie" tax - which is the increase on prices of unhealthy food, e.g., a fat tax - have been implemented in most states [24]. Since 2010, the United States have also implemented a regulation that requires restaurant chains to display the calorie content of their servings. While this is informative and may help people in their decision-making, empirical evidence suggests that the effects on calorie consumption are relatively small [19]. One study showed that mandatory product labelling was associated with a decrease in BMI and a significantly lower probability of obesity, but this was only found among white women [25]. Furthermore, regulation on food availability is most common in schools [21]. For example, in 2005, a nationwide ban on vending machines in all secondary schools was introduced in France [26]. In addition, policies to encourage healthy eating at schools including the free provision of fruit have been implemented in many countries [27]. Denmark and Switzerland moreover regulate nutrient food content aiming to reduce trans-fatty acids [28].

While policies to promote a healthy diet in the Netherlands have been proposed, relatively few have been implemented so far. In 2018, the Dutch government and a broad coalition of parties across society and business signed the first national Prevention Agreement [29]. One of the three focus areas in this agreement was the reduction of overweight and obesity. Several goals were formulated for each focus area (e.g., reduce the overweight prevalence from 50% to 38% by 2040) and a range of policies were proposed (e.g., provision of weight loss programmes). However, the proposed policies were criticized for being insufficient to reduce the overweight rates substantially [30]. More recently, the Dutch Council for Public Health and Society (RVS) published a report urging for an integrated approach to the issue, with different parties all working together to reduce unhealthy lifestyles and recommending creating a legal basis for policies aimed at stimulating healthy choices [31]. This recommendation is based on growing evidence that low intrusive policies targeting a single behaviour, such as information dissemination, have, at best, only a modest effect on behaviour [28]

Not much is known about public support for (more intrusive) policies that promote a healthy diet. Yet, this may be a crucial factor in designing and successfully implementing effective policies. In this study, therefore, a discrete choice experiment (DCE) is used to elicit stated preferences for potential policies aiming to promote a healthy diet among a representative sample from the adult public in the Netherlands. Respondents were asked to choose between hypothetical scenarios of policy packages, consisting of several policies differing in their level of intrusiveness. The contribution of this study is twofold. Firstly, we provide insights into public preferences for policies supporting a healthy diet in the Dutch adult population. Secondly, we identify and describe subgroups among the public that have different preferences regarding the proposed policies.

8.2 METHODS

We performed a discrete choice experiment (DCE) to determine preferences, among a representative sample of the Dutch adult population, towards potential policies to promote a healthy diet. Respondents were asked to choose between different policy packages, each consisting of a combination of policies. The presented policy packages differed in the combination of policies, which were listed based on their intrusiveness level. The least intrusive policy was information dissemination, while the most intrusive policy was the elimination of food choice (see Table 8.1). Respondents were asked to select the policy package that they preferred. Consequently, preferences were revealed through the respondents' choices, also showing how respondents react to more intrusive policy measures than currently in place.

8.2.1 Respondents

In December 2020, an online survey was distributed among a representative sample of the adult population in the Netherlands. Respondents were recruited via an independent sampling company. Quota sampling was applied to obtain a sample of 600 respondents representative of the target population in terms of age, gender and level of education. Ethical approval for the study was obtained from the Internal Ethical Review Board of the Erasmus School of Health Policy & Management (reference 20-06). Written consent was obtained from all respondents before the start of the survey.

8.2.2 Attributes and levels

Respondents were asked to respond to a set of choice tasks that reflected policy packages that were aimed at promoting a healthy diet (see Figure 8.1). The Nuffield Intervention Ladder reflects how different public health policies may impact individual (freedom of) choice [15]. This ladder was used here as a theoretical framework to determine the intrusiveness level of the proposed policies (see Appendix 1). The ladder consists of seven "steps", with policies higher up the ladder (top in Table 8.1) considered more intrusive (i.e. restrictive for individual choice). The choice tasks presented seven attributes, each representing the presence or absence of a policy at one of the seven steps of the Nuffield Intervention Ladder. The attributes and their levels are shown in Table 8.1, ranked from most to least intrusive. Appendix 2 shows background information related to the attributes.

Table 8.1 Discrete choice experiment attributes and levels

Intrusiveness level	Attributes	Levels
Eliminate choice	Ban unhealthy products from specific places	No, Yes
Restrict choice	Reduce outlets for unhealthy products	No, Yes
Guide choice through disincentives	Tax on sugary drinks	No, 20%, 50%
Guide choice through incentives	Subsidy on vegetables and fruit	No, 10%, 30%
Guide choice through changing the default	Reduce serving size unhealthy products	No, Yes
Enable choice	Provide weight loss programs	No, Yes
Provide information	Show calorie content on all products/menu's	No, Yes

Including many attributes in a choice task can be burdensome for a respondent. De Bekker-Grob et al. [32] reviewed the literature and found that the vast majority of DCE studies (75%) included four to nine attributes. We included seven attributes, three of which were based on the recently proposed policies in the Netherlands (i.e., the bottom three in Table 8.1) [31, 33], while the remaining four (i.e., the top four in Table 8.1) were based on policies that were suggested in the literature as having the potential of being effective [28, 34–37]. As shown in Table 8.1, five of the seven attributes had dichotomous levels, which also reduced the complexity of the choice tasks. For the two remaining attributes (taxes and subsidies) three levels were used, that were based on the literature [38, 39].

8.2.3 Choice tasks

The choice tasks consisted of two unlabelled policy alternatives: Policy A and Policy B. The design had a two-step approach to account for potential disutility for all proposed policies. First, respondents had to choose between one of the two presented policies by answering the question: "*Which policy do you prefer?*" Second, respondents had to choose between the selected policy or the absence of the listed policies by answering the question: *"You chose Policy [A/B]. If you could choose between* [the selected] *Policy [A/B] or no policy, what would you choose?"* The first step of the choice task is reflected in Figure 8.1.

Which policy do you prefer: policy A or policy B?

	Policy A	Policy B
Ban unhealthy products from certain places	No	Yes
Reduce outlets for unhealthy products	Yes	No
Tax on sugary drinks	No	No
Subsidy on vegetables and fruit	-30% on price	No
Reduce serving size unhealthy products	No	No
Provide weight loss programmes	No	Yes
Show calorie content on all products	No	No

Figure 8.1 Example of a choice task presented to respondents

We used colour coding to help respondents identify differences between the policies included in the two policy alternatives without nudging respondents to focus on specific interventions [40]. Shades of purple were applied, as these have been shown to be useful in reducing cognitive burden without steering respondents in a specific direction [41]. All choice tasks had three overlapping attributes such that respondents only had to inspect the four other attributes in terms of their differences. The colour coding and the overlapping attributes were expected to reduce drop-out of respondents and to increase the likelihood that respondents evaluated all policies, i.e. attribute attendance [41].

8.2.4 Experimental design

A full factorial design, where respondents rate all possible combinations, would be unrealistic since this would result in 288 possible choice tasks (2^5 x 3^2: five attributes with two levels and two attributes with three levels). A Bayesian efficient design algorithm with four attributes overlap was used to create a manageable number of 12 choice tasks [32, 42, 43]. This approach takes into account the prior parameter distributions in generation of the design [44]. The D-efficiency criterion, which leads to the minimalization of the generalized variance of the parameter estimates, was used to optimize the design [45]. To maximize the precision of the parameter estimates, heterogenous DCE designs were used [46]. This means that multiple sub-designs were simultaneously optimized. Each respondent was asked to complete only a single sub-design (consisting out of 12 choice tasks) [47]. Sandor and Wedel [46] showed that as compared to homogenous DCE designs, heterogenous DCE designs can be much more efficient. The different sub-designs of the survey were randomly allocated to respondents. The Bayesian design optimization algorithms were implemented with C++ programming language.

8.2.6 Survey administration

Sawtooth software version 9.7.2 (Sequim, WA) was used to create the survey. Respondents received a personalized link allowing them to access the survey. The survey could be completed on any digital device. Respondents first received background information on each attribute (i.e. policy) separately (see Appendix 2) to allow them to familiarize themselves with the different policies. To start with, the first three attributes were introduced and respondents were presented a trial fixed choice task consisting of these attributes. Next, the same approach was applied for the remaining four attributes. The warming-up ended with a fixed choice task consisting of all seven attributes. The attributes were presented to all respondents following the order of the Nuffield Intervention Ladder (see Table 8.1), that is, from low intrusiveness at the bottom to high intrusiveness at the top in order to reduce the complexity of the choice tasks. A block of six choice tasks was administered, followed by evaluation questions regarding the choice tasks and five other independent questions to reduce respondent fatigue, and concluded with a second block of six choice tasks.

8.2.7 Pilot testing

We carried out a think-aloud exercise with six respondents before the start of the data collection. Respondents were asked to fill out the entire survey while thinking out loud with a researcher (CD) present. This resulted in minor changes in wording of the survey and provided an indication of how much time respondents would need to complete the survey. After this exercise, we conducted a pilot study among 100 respondents. The data from this pilot was used to optimize the priors (i.e., best guesses for the parameters) of the design, which were initially set at 0.00.

8.2.8 Other variables

We presented respondents with six evaluation questions about complexity and design of the choice tasks (Appendix 3). Respondents were asked to respond on a five-point Likert scale (fully disagree – fully agree). In addition, we monitored the completion time of each choice task and could thus also calculate the total completion time for the twelve choice tasks.

Three background characteristics – age, sex and highest completed level of education - were collected at the start of the survey. In between the two blocks of the choice tasks, data on household composition, employment status and financial situation were obtained. After the choice tasks, we presented the respondents with six statements regarding governmental interventions (see Figure 8.2) and asked them to respond on a five-point Likert scale (fully disagree – fully agree). Statements 1, 3 and 6 were formulated specifically for this study, and statements 2, 4 and 5 were derived from previous studies [48, 49].

We also collected lifestyle characteristics and self-reported height and weight. Respondents self-reported *smoking status*, weekly alcohol consumption to identify *alcohol consumers* – consuming alcohol at least one day a week - and *physical activity* based on self-reported number of days with at least 30 minutes of physical activities per week. Based on the Dutch guidelines for physical activity, sufficient physical activity was defined as 150 minutes or more per week [50]. *Nutrition intake* was based on the self-reported number of days a week that respondents ate a balanced meal: appropriate portion size, not too much fat and sufficient fruit and vegetables. Sufficient variation in diet was identified as reporting to have balanced meals for at least six days a week [51]. We calculated *Body Mass Index (BMI)* with the self-reported height and weight using weight (kg) / height (m)^2. We defined the following categories: normal weight (BMI 18.5-25.0), overweight (BMI 25.0-30.0) and obese (BMI ≥ 30.0) [52]. None of the respondents had a BMI below 18.5.

8.2.9 Statistical analyzes

To assess the quality of the data, we started with the examination of the evaluation questions (Appendix 3) and assessed the completion time per choice task and of the entire survey. Respondents were excluded from the analyzes when their average time spent on the twelve choice tasks was unrealistically short i.e., below six minutes. Subsequently, we generated descriptive statistics of the background characteristics.

MXL model

We analyzed the DCE tasks under a random utility theory framework [53]. In choice task t, the utility U of respondent i, associated with choosing alternative j can be expressed as follows:

$$U_{ijt} = X_{ijt}\, b_{i} + \varepsilon_{ijt} ,$$

Where X reflects a vector of the alternative specific attribute levels, b represents the coefficients and ε the error term. The coefficients are indexed by individuals, thus acknowledging preference heterogeneity, and we assume specific distributions from the individual parameters. We estimate mixed logit (MXL) models allowing for different coefficients by respondent [54]. The random error term adjusts for individual-level variations in preferences for the corresponding attributes [55]. MXL models thus account for differences in preferences among the respondents by estimating both a mean effect and a standard deviation of effects across the sample [55]. All attributes were coded binary, with the absence of a policy as the reference category. The model estimation was conducted with 500 Halton draws with multiple starting points (random seeds) to ensure model stability [55, 56].

Latent class model
In addition to the MXL model, we estimated a latent class model. As we assumed heterogeneity in our sample, we wanted to assess whether this could be captured in a set of classes. Classes in this study refer to subgroups of respondents that largely share their stated preferences towards policies to promote a healthy diet. The latent class model assumes that attributes can have heterogenous effects across a predetermined number of classes [55]. This type of heterogeneity is reflected in preference weights that are identical within a class and differ systematically from preference weights estimated in the other classes [55]. The conditional logit model is used to estimate the preference weights within each class. To determine the optimal number of classes, the model diagnostics of models with 2 up to 10 classes were compared. The Akaike Information Criterion (AIC) of the models was compared to assess performance and determine the optimal number of classes [57]. The model with the lowest AIC was considered superior to other models, but also class size and predicted and conditional probability were included to assess quality of the models [58]. The selected model was inspected for interpretability of the classes, and the classes were related to background characteristics of respondents and their opinion about governmental interventions. Statistical significance of the differences in these characteristics across classes was assessed using the chi^2-test and Analysis of Variance (ANOVA).

All analyses were performed in Stata 15.0. The gllamm procedure was used for the latent class analyses. The mixlogit command was used to estimate the MXL models, and the mixlbeta command was used to calculate individual-level coefficients.

8.3 RESULTS

8.3.1 Study sample description
A total of 755 respondents started with the survey and 599 completed the entire survey (see Table 8.2) and took more than the minimum required amount of 6 minutes time. In total, 93 percent of the respondents indicated that the choice tasks were clear and that they considered all policy initiatives while answering the choice tasks (see Appendix 3). The study sample was representative for the adult population of the Netherlands in terms of age and sex, but people with a middle level education were slightly overrepresented in the sample. Furthermore, most lifestyle characteristics were close to those of the reference population, with approximately one-fifth of the sample reporting to smoke (21 percent), and about half of the sample reporting sufficient variation in nutrition intake (47 percent), consuming alcohol (46 percent), reporting insufficient physical activity levels (51 percent) and being overweight or obese (53 percent).

Table 8.2 Individual characteristics (N=599)

Demographic characteristics		n (%)
Age, mean (sd)		48.2(15.0)
Sex	Female	301 (50.2)
	Male	298 (49.8)
Education level[1]	Low	122 (20.4)
	Middle	291 (48.6)
	High	186 (31.1)
Financial status	Very difficult to make ends meet	23 (3.8)
	Rather difficult to make ends meet	174 (29.1)
	Rather easy to make ends meet	258 (43.1)
	Very easy to make ends meet	144 (24.0)
Children	Yes	329 (54.9)
	No	270 (45.1)
Lifestyle characteristics		**n (%)**
Smoking	Yes	125 (20.9)
	No	474 (79.1)
Nutrition intake	Insufficient variation	320 (53.4)
	Sufficient variation	279 (46.6)
Alcohol consumption	Yes	277 (46.2)
	<1 day p/w	322 (53.8)
Physical activity	Insufficient	307 (51.3)
	Sufficient	292 (48.8)
Weight	Normal weight	284 (47.4)
	Overweight	210 (35.1)
	Obese	105 (17.5)
Body mass index, mean (sd)		26.3 (6.3)

Dutch population reference values for education: low: 26%, medium: 38%, high: 35% (www.opendata.cbs.nl)
[1] Categorization based on Statistics Netherlands (www.cbs.nl)

8.3.2 Respondents' policy preferences – MXL model

The results of the MXL model with random effects are presented in the first two columns of Table 8.3. All standard deviations from the coefficients were statistically different from zero indicating heterogeneity in preferences across respondents. As the reference levels of the attributes refer to an absence of the policy, positive coefficients indicate a preference for (or positive utility derived from) the corresponding policy while negative coefficients indicate a negative evaluation (or negative utility). Most utility (1.19) was derived from *30% subsidy on vegetables and fruit* (see Table 8.3), followed by a *10% subsidy on vegetables and fruit* (0.61). In addition, a *20% tax on sugary drinks* yielded utility, on average, while a *50% tax on sugary drinks* was associated with a disutility. Policies with lower levels of intrusiveness were generally preferred over policies with higher levels of intrusiveness, although the (differences in) coefficients were relatively small. The two most intrusive policies, *ban unhealthy products from certain places* and *reduce outlets for unhealthy products*, were not associated with significant (dis)utility, indicating that, in the overall sample, on average respondents did not significantly derive (dis)utility from these policies.

8.3.3 Identification of three classes – Latent class model

We found the model with three classes to have the best fit of all estimated latent class models with random coefficients. Appendix 4 shows the model diagnostics of the models with 2-10 classes. The jump from two to three classes showed the largest decrease in AIC, CAIC and BIC values. While these values still decrease slightly with an increased number of classes, the differences are small. Next, models with two, three and four classes were examined regarding their interpretability and the model with three classes was considered as the most intuitive solution. The conditional probabilities (Appendix 5) showed promising values for three classes: the mean predicted probabilities of the allocated classes were all close to 99 percent, suggesting little uncertainty regarding the class that respondents were assigned to as an average score greater than 90 percent is considered as ideal [58]. Hence, our model performs well in distinguishing between different underlying patterns in the preferences for policy interventions to promote a healthy diet.

The final three columns of Table 8.3 show the class specific preference estimates. Class 1 includes respondents that derive a negative utility from all policies promoting a healthy diet. Relative to the other classes, these respondents derive most disutility from negative financial incentives (*tax on sugary drinks*) and the most intrusive policies (*reduce outlets for unhealthy products* and *ban unhealthy products from certain places*). Positive financial incentives (*subsidy on vegetables and fruit*) were not significantly associated with utility in Class 1. Class 2 contains a mixture of positive and negative utility associated with policies to promote a healthy diet; negative for a *tax on sugary drinks* and positive for *subsidy on vegetables and fruit*. Class 3 contains the largest group (56%) of respondents and represents a group that derives positive utility from all proposed policies. The policies that were most preferred were the financial incentives, both in the form of a subsidy and a tax. The least preferred policy was to *reduce serving size unhealthy products*, although its coefficient was still positive and significant.

Table 8.3. Results of mixed logit regression model (MXL) and latent class analysis (LCA)

	MXL		LCA		
			Class 1	Class 2	Class 3
Attributes	**Mean[1] (SE)**	**SD (SE)**	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**
Ban unhealthy products from specific places	0.07 (0.05)	0.89 (0.05) **	-0.85 (0.09) **	-0.03 (0.06)	0.64 (0.05) **
Reduce outlets for unhealthy products	0.08 (0.04)	0.64 (0.06) **	-0.61 (0.08) **	0.06 (0.06)	0.51 (0.05) **
50% tax on sugary drinks	-0.55 (0.08) **	1.69 (0.09) **	-1.92 (0.15) **	-1.13 (0.11) **	1.04 (0.07) **
20% tax on sugary drinks	0.12 (0.05) *	0.96 (0.06) **	-1.09 (0.10) **	-0.40 (0.07) **	0.97 (0.05) **
30% subsidy on vegetables and fruit	1.19 (0.05) **	1.05 (0.06) **	-0.04 (0.09)	0.98 (0.08) **	1.69 (0.06) **
10% subsidy on vegetables and fruit	0.61 (0.04) **	-0.30 (0.07) **	-0.18 (0.09)	0.52 (0.07) **	0.97 (0.06) **
Reduce serving size unhealthy products	0.10 (0.04) *	0.57 (0.05) **	-0.40 (0.08) **	0.04 (0.06)	0.39 (0.05) **
Provide weight loss programs	0.33 (0.04) **	0.57 (0.08) **	-0.20 (0.08) *	0.33 (0.06) **	0.70 (0.05) **
Show calorie content on all products/menu's	0.16 (0.04) **	0.61 (0.06) **	-0.23 (0.08) **	0.10 (0.06)	0.46 (0.05) **
Total N, (%)	599 (100)		104 (17.4)	160 (26.7)	335 (55.9)
Model diagnostics					
Number of choice sets	28,752				
Log-likelihood	-7881				
Likelihood ratio X^2	1943.32				

[1] Mean β coefficients show estimated utility of each attribute, where positive coefficients indicate positive preference , * = Significant with *p-value* * < .05, ***p* < .01

8.3.4 Latent class membership characteristics

We examined the three identified classes on demographic and lifestyle characteristics (Table 8.4). Class 1, the group that derived disutility from any form of policy, had the highest rates of smokers and people with overweight and obesity, but these differences were not statistically significant. We only observed significant differences across classes in sex, with more females present in Class 3 and less in Class 1. Figure 8.2 shows the proportion of respondents per class that (strongly) agreed with the statements regarding government intervention. These findings generally coincide with the interpretations of the classes. The majority (67%) of Class 1 agreed with the statement *Government should not interfere with the lifestyle of individuals* (S1), while only 17% of respondents in Class 3 agreed with this statement. The proportion of people that believes that *the government is responsible for the health of the population* (S3) was four times larger in Class 3 as compared to Class 1. Furthermore, the responses to the statement: *Due to the COVID-19 crisis I am more positive about governmental interventions to protect the public health* (S6) in Class 3 showed a relatively positive attitude towards governmental policies to protect the public's health, while Class 1 had a rather negative attitude to such policies (38% and 11% agreement, respectively). The three classes can thus be characterized as being "*against*" (Class 1), "*mixed*" (Class 2) and "*pro*" (Class 3) policies to promote a healthy diet.

Table 8.4 Individual characteristics by class

Demographic characteristics		**Class 1**	**Class 2**	**Class 3**
		n (%)	**n (%)**	**n (%)**
Age, mean (SD)		48.3 (12.9)	45.6 (14.6)	49.4 (15.6)
Sex	Female	43 (41.4)	76 (47.5)	182* (54.3)
Education level	Low	27 (26.0)	32 (20.0)	63 (18.8)
	Middle	52 (52.0)	76 (47.5)	163 (48.7)
	High	25 (24.0)	52 (32.5)	109 (32.5)
Financial status	Very difficult	5 (4.8)	9 (5.6)	9 (2.7)
	Rather difficult	30 (28.9)	50 (31.3)	94 (28.0)
	Rather easy	40 (38.5)	73 (45.6)	145 (43.3)
	Very easy	29 (27.9)	28 (17.5)	87 (26.0)
Children	Yes	55 (52.9)	84 (52.5)	190 (56.7)
Lifestyle characteristics				
Smoking	Yes	29 (27.9)	33 (20.6)	63 (18.8)
Nutrition intake	Insufficient variation	58 (55.8)	95 (59.4)	167 (49.9)
Alcohol consumption	Yes	48 (46.1)	71 (44.4)	158 (47.2)
Physical activity	Insufficient	48 (46.2)	81 (50.6)	178 (53.1)
Weight	Normal weight	43 (41.4)	80 (50.0)	161 (48.1)
	Pre-obesity	38 (36.5)	50 (31.3)	122 (36.4)
	Obesity	23 (22.2)	30 (18.8)	42 (15.5)
BMI, mean (sd)		27.1 (7.4)	26.5 (7.4)	26.0 (5.3)
Total		17.4% (N=104)	26.7% (N=160)	55.9% (N=335)

* p-value ≤ 0.05 between groups

S1. Government should not intervene with the lifestyle of individuals

S2. If a lifestyle has negative consequences for others, the government should intervene.

S3. The government is responsible for the health of the population

S4. People with a healthy lifestyle should be prioritized over people with an unhealthy lifestyle.

S5. Lifestyle is an autonomous choice, and therefore consequences of lifestyle choices an individual's own responsibility

S6. Due to the COVID-19 crisis I am more positive about governmental interventions to protect the public health.

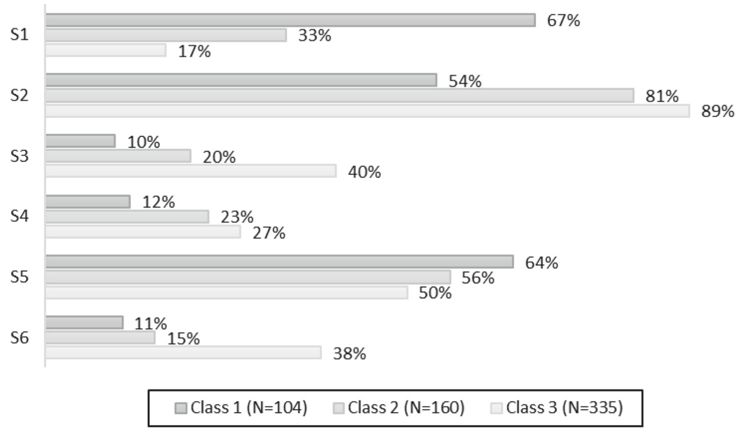

Figure 8.2 Per class the proportions that (strongly) agree with statements

8.4 DISCUSSION

An "unhealthy diet" is the main cause of overweight in Western societies [3] and one of the leading risk factors for morbidity and mortality from non-communicable diseases (NCDs). So far, policy initiatives to promote a healthier diet have remained less intrusive than those to reduce tobacco and alcohol consumption. We performed a discrete choice experiment (DCE) to elicit stated preferences for potential policies aiming to promote a healthy diet among the public in the Netherlands.

Several studies have explored public preferences for policies to promote a healthy diet before. This is one of the first DCE studies that assessed preferences for policies that support a healthy diet in relation to their level of intrusiveness. The DCE was completed by 599 respondents. We estimated Mixed Logit (MXL) models to estimate respondents' preferences. We found, on average, that *subsidies on vegetables and fruit* yielded most utility, while a high *tax on sugary drinks* was associated with disutility. The MXL model showed clear heterogeneity in preferences across respondents. Subsequently, we estimated a latent class model and identified three distinct classes among the respondents, which were characterized as being "against" (class 1), "mixed" (class 2) and "pro" (class 3) government intervention in this context. Two classes showed statistically significant coefficients for *the reduction of outlets for unhealthy products* and to *ban unhealthy products from specific places*: class 1 ("against") in the form of disutility, while class 3 ("pro") in the form of positive utility for these two most intrusive policies.

Previous studies mostly used a cross-sectional design including a single-item measure for public support for policies to promote a healthy diet. These studies showed that support for overweight and obesity prevention generally is high when it concerns information provision to individuals [19, 59]. These types of policies, such as mass public information campaigns, are also the most common types of action across Europe [21]. While these policies have been successful in raising awareness about unhealthy eating, their actual effect on healthy eating appears to be small [19, 28]. Public support for regulation and taxation mostly is limited [60]. Our results confirmed the negative evaluation of more intrusive policies in a substantial part of the respondents, but also highlighted that a small majority of our sample (56%) evaluated all the listed policies positively, including the most intrusive ones. Lanscar and colleagues [61] conducted a similar study in the Australian context, involving eight policies to reduce and prevent obesity presented together with the additional related costs and the impact on obesity rates. Interestingly, their results also revealed three classes showing a heterogeneity in policy preferences. Financial incentives to exercise were least preferred in their study [61] which contrasts somewhat with our finding that positive financial incentives were most preferred, although in our study they did not concern exercising, but subsidizing fruits and vegetables.

Public beliefs about the causes of obesity are reported to be major predictors for public support for policies to promote a healthy diet. Studies have shown that public support for policies was highest when causes for obesity were considered beyond the control of the individual (e.g. the obesogenic environment, genes) [60, 62]. Other factors, such as the lack of willpower or political view, were less relevant for policy support [59, 60, 63]. While we did not assess the beliefs about the causes of obesity, we did assess the attitude towards governmental interference with the lifestyle of individuals. This may serve as a proxy for the extent to which people believe the adoption of a healthy lifestyle is (fully) an individual's own responsibility. We found that more than two-thirds (67%) of the "against" class believed that the government should not intervene with the lifestyle of individuals, versus only 16% of the "pro" class. This statement seems to align with a libertarian belief, emphasizing freedom of choice.

Another relevant indicator for public support is the stage of policy implementation. Currently, intrusive polices to promote a healthy diet are not common, while intrusive tobacco policies are more prevalent. Previous research showed that public support for tobacco policies has increased over time, in particular after the introduction of smoking bans in certain areas [64, 65]. Our finding that a small majority of respondents (56%) was in favour of policies that promote a healthy diet at all levels of intrusiveness might therefore be explained by the fact that these policies are increasingly mentioned and are explicit topics in public and political debates [31]. The COVID-19 pandemic may also have strengthened the belief that a healthy lifestyle is important and may also have influenced the policy preferences we observed.

It is important to note that obesity is sometimes stigmatized and, therefore, how obesity is perceived and described in policy measures, may influence the acceptance of those measures. For instance, obesity can be seen as mostly the result of environmental factors on the one hand, or as mostly due to conscious choices on the other [66]. Cawley [67] introduced an economic framework for understanding physical activity and eating behaviour and argued that individuals may fully rationally accept a higher body weight in order to gain utility derived from eating or leisure. Different perceptions regarding behavioural factors, autonomy and rationality may influence acceptability of policy measures and the type of measures considered to be necessary if the aim is to reduce obesity. Similarly, policy actions targeted at obesity reduction may be taken in order to improve health or to improve welfare, which may not necessarily lead to the same policy choices.

8.4.1 Limitations

We highlight several limitations of this study. First, data were collected during a lockdown imposed by the Dutch government to prevent the spread of COVID-19. This means that at the time of data collection respondents were confronted with invasive measures taken by the government. This extraordinary situation may have affected our results in two directions. First, some respondents may have considered the government as capable of forcefully handling the difficult public health crisis posed by COVID-19, leading to an increased recognition that government intervention may improve or protect public health. On the other hand, other respondents may have disliked the imposed measures by the government and subsequently also be more prone to disfavour other measures by the government. Responses to the statement "*Due to the COVID-19 crisis I am more positive about governmental interventions to protect public health*" (S6) show that the of the "pro" class 38% agreed with this statement, while of the "against" the proportion of agreement was much less (11%). We cannot exclude the possibility that he COVID-19 crisis may have had some effect on the attitude towards interventions to protect public health, although the exact impact of this remains unclear. To shed more light on this, this study could be repeated in a period without such drastic measures imposed by the government.

Second, our choice tasks did not involve the potential effects on public health nor did we present the opportunity costs of the policies (e.g. who pays the subsidies for fruits). In another study [68], we explored other factors deemed relevant as a predictor for support, such as perceived effectiveness and familiarity. In the current choice tasks we deliberately focused solely on the intrusiveness levels. Future research could further explore potential determinants for the identified preferences. Lanscar et al. [61] did include the costs and expected impact on obesity rates in a similar study and found that a large majority (78%) of their sample would choose new policy and accept the increased taxation. This is important since, for instance, policy measures like subsidizing vegetables and fruit would come at a price that arguably would be ultimately paid by citizens, e.g. through higher general taxes. Whether or not support remains equally high in our study when confronted with the related costs we cannot ensure. Likewise, different expectations may exist as to the (health) impact of different policy measures, which may be more or less accurate.

Third, our sample is representative of the Dutch adult population on a range of background and lifestyle characteristics. The data was collected via an online panel hosted by an independent company, and respondents received a small reimbursement for the completion of the survey. It needs noting that online data collection may lead to a certain selection, with specific segments of the population not reached via this channel and thus not represented in this study.

Finally, the DCE approach is considered as an advanced method for eliciting preferences, but a drawback is that choice tasks can be cognitively challenging for respondents. We have used a variety of methods to reduce the complexity, e.g., with colour coding and attribute overlap, but cannot exclude the possibility that a part of the respondents experienced difficulties with evaluating the choice tasks.

8.5 CONCLUSIONS

This study showed that preferences for policies to promote a healthy diet have a heterogenous character. Information campaigns that aim to raise awareness of the obesity pandemic may be helpful for increasing public support for policies that promote a healthy diet. However, in order to actually change dietary habits, more intrusive policies may be required. More than half of the respondents (56%) favoured policies to promote a healthy diet at all intrusiveness levels. This may be explained by the increased recognition that external factors like an obesogenic environment may importantly contribute to high overweight and obesity rates. Financial incentives to change behaviour could be considered, either in the form of a tax on sugary drinks or a subsidy on vegetables and fruit. However, which (combination of) policies to promote a healthy diet is selected for implementation remains a policy challenge since a considerable proportion of the population negatively evaluated most measures, especially more intrusive ones.

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APPENDICES

Appendix 1

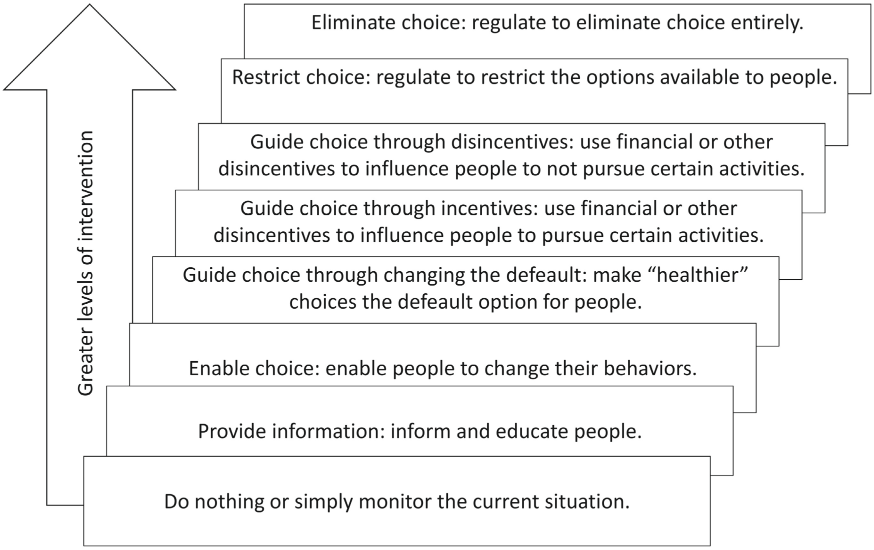

Figure A1. Nuffield Intervention Ladder. Source: Nuffield Council on Bioethics. Public health ethical issues. London, Nuffield Council on Bioethics, 2007.

Appendix 2

Table A2. Background information presented with the attributes

Attributes	Background information
Ban unhealthy products from certain places	At sports clubs and public transport stations unhealthy products will be removed from their range and will therefore no longer be available at these locations.
Reduce outlets for unhealthy products	The number of outlets for unhealthy products in your municipality will be reduced. This entails that no new outlets may be opened, or that a number of existing outlets need to be closed.
Tax on sugary drinks	Impose a sugar tax on all drinks that contain added sugars (e.g., soft drinks, energy drinks, sweetened water), both in supermarkets and in the catering sector. For example, a sugar tax of 20% will raise the price of a bottle of coke that costs €2,50 to €3,00.
Subsidy on vegetables and fruit	Give subsidy on all vegetables and fruits, both in supermarkets and in the catering sector. For example, a subsidy of 20% will lower the price of a bag of apples that costs €2,50 to €2,00.
Reduce serving size unhealthy products	The serving size of unhealthy products will be reduced. The price and serving size will change at the same rate. For example, a chocolate bar of 100 grams that costs 99 cents, will be reduced in size to 60 grams at a price of 59 cents.
Provide weight loss programs	Each municipality offers support to people with overweight to help them loose weight by changing their behavior.
Show calorie content on all products	Everywhere (for example in restaurants, cafeterias, supermarkets) the calorie content of menus or products will be shown.

Appendix 3

Table A3. Evaluation statements

Questions	Neutral/agree, n (%)
The choice tasks were clear	554 (92.5)
The choice tasks became easier after answering a few	532 (88.9)
I compared all the policies before I made my choice	567 (94.7)
The colors made the choice tasks easier	513 (85.6)
There were too many choice tasks	331 (55.2)
It was difficult to remain focused during all choice tasks	281 (46.9)

Appendix 4

Table A4. Model diagnostics for 2-10 classes from latent class analysis

Classes	LLF	AIC	Δ AIC	CAIC	Δ CAIC	BIC	Δ BIC
2	-7459.794	14957.59		15060.10		15041.10	
3	-7216.350	14490.70	-466.89	14647.16	-412.94	14618.16	-422.94
4	-7124.739	14327.48	-163.22	14537.89	-109.27	14498.89	-119.27
5	-7071.297	14240.59	-86.89	14504.96	-32.93	14455.96	-42.93
6	-7017.031	14152.06	-88.53	14470.38	-34.58	14411.38	-44.58
7	-6972.392	14082.78	-69.28	14455.06	-15.32	14386.06	-25.32
8	-6948.326	14054.65	-28.13	14480.88	25.82	14401.88	15.82
9	-6928.414	14034.83	-19.82	14515.01	34.13	14426.01	24.13
10	-6895.439	13988.88	-45.95	14523.01	8	14424.01	-2

Appendix 5

Table A5. Conditional probabilities for 2 - 4 classes derived from latent class analyzes

Variable	Obs	Mean	Std. Dev	Min	Max
Max cond. prob. 2 classes	599	0.9798242	0.0726824	0.5246402	1
Max cond. prob. 3 classes	599	0.9569972	0.1020432	0.5046849	0.999999
Max cond. prob. 4 classes	599	0.9570256	0.090794	0.5144748	0.999998

9 Policy interventions to reduce overweight: “effective for others, but not for me”

Based on: Dieteren, C. M., Brouwer, W. B., & Bonfrer, I. (2021). Overheidsmaatregelen om overgewicht tegen te gaan. *TSG-Tijdschrift voor gezondheidswetenschappen, 99*(3), 120-124.

ABSTRACT

Promoting healthy behavior features high on the policy agenda. However, policy interventions towards a healthy diet are still in their infancy. The Council for Public Health and Society recently called for increased government action to prevent unhealthy diets. Designing interventions that are both acceptable and effective is complex. We surveyed 700 Dutch adults and presented them with five statements regarding government intervention to stimulate healthy diets. We asked them what effect they expect for themselves and for others from the interventions suggested in the National Prevention Agreement and by the Council for Public Health and Society. We found that respondents estimate efficacy among *others* higher than efficacy for *themselves.* This finding seems to be valid for each level of the Nuffield Intervention ladder, expect the lowest one (providing information). When taking the effect that they expect for themselves as the starting point, this could mean that the expected efficacy of interventions at population level are overestimated when these are based (partly) on expectations for others. The expected efficacy of more intrusive interventions seems higher, but acceptance of such interventions is essential and not a given. Further research into public support for such interventions as well as into the actual effectiveness of these interventions in practice should, therefore, be high on the research agenda.

9.1 BACKGROUND

In late 2018, the first-ever Dutch National Prevention Agreement was sealed [1]. A broad coalition of parties from across society, business, and the government has formulated a set of interventions that are intended to make the population healthier. This set of interventions seeks to tackle the three pillars of an unhealthy lifestyle: smoking, problematic alcohol use, and overweight. Jointly, these three risk factors lead to an annual disease burden of roughly 35,000 deaths by preventable causes and are linked to 9 billion euros in healthcare spending [1]. Interventions focused on a healthy diet and combating overweight and obesity are still in their infancy, while over half of all adults in the Netherlands are overweight [2]. The urgency to change Dutch people's eating habits is, therefore, only growing. In a recent report, entitled 'A fair chance of a healthy life', the Council for Public Health and Society calls for structural and legal obligations to reduce health deficits and disparities [3]. One of their recommendations is to give local authorities the power to keep fast food restaurants and snack bars out of their municipalities, so as to create a healthier living environment. The interventions from the Prevention Agreement mentioned above are considerably less drastic, including interventions such as a suitable healthcare offering to help people with weight problems change their lifestyle, encouraging food companies to sell biscuits, chocolate, and candy in smaller portions, and using nudging tactics in supermarkets to get individuals to buy healthy products.

The British Nuffield Intervention Ladder ranks public health interventions by level of government intrusiveness [4]. As shown in Figure 1, the lowest level contains the least intrusive interventions, while the seventh and therefore highest level contains the most intrusive forms of government intervention. In the Netherlands, government intervention to promote a healthy diet have been limited so far and do not go beyond the lower levels of the Nuffield Intervention Ladder. More intrusive interventions, such as implementing a sugar tax or reducing outlets of unhealthy food, have been on the table for quite some time, but have not yet been implemented in a generally binding way [5]. This may change due to the recent report from the Council for Public Health and Society, which is now calling for interventions that are on the higher levels of the Nuffield Intervention Ladder. The Council for Public Health and Society's makes a recommendation to the Ministry of Health, Welfare and Sports to empower local authorities to keep fast food shops out of their municipalities, to introduce a sugar tax, to lower the rate of VAT on healthy food, and to ban advertising for unhealthy food. Such more intrusive policy interventions have been taken previously in relation to other kinds of unhealthy behaviors: smoking is prohibited in many public places (level 7) and petrol stations are not allowed to sell alcohol (level 6).

Interventions on the intermediate levels (levels 4 and 5 in Figure 1) of the Nuffield Intervention Ladder include financial incentives. Interventions such as a sugar tax are generally considered to be a potentially effective way of influencing people's behavior [6]. They might, therefore, be a logical extension to the Dutch government policy to stimulate a healthy diet. However, Nobel Prize winners Esther Duflo and Abhijit Banerjee recently showed that while people often believe that financial incentives are an effective way to change *others'* behavior, they do not consider financial incentives equally effective as a way to change *their own* behavior [7]. This distinction suggests that people expect financial incentives to have a greater effect on other people than on themselves. This leads to the question whether the effectiveness expectations for this kind of intervention a reliable indicator of the actual effectiveness. If everyone expects the intervention to be more effective for others than for themselves, while their assessment with respect to themselves is the most accurate, this could lead to an overestimation of the expected effect. Albert Bandura introduced the very commonly used 'self-efficacy theory' [8], a theory that says that belief in one's own capabilities is essential for successful behavior change. Self-efficacy can be increased when seeing someone else achieve success similar to what one is trying to achieve for oneself. And yet, what has thus far never been studied, as far as we know, is whether self-effectiveness and other- effectiveness differ from each other when it comes to diet interventions. In this survey, we analyze whether this difference between expected effectiveness for oneself and expected effectiveness for others exists in the Dutch context regarding policy interventions from the Prevention Agreement and the Council for Public Health and Society's advice on food and diet. The proposed interventions are likely to achieve the biggest gains among overweight people, we will in this survey also stratify the results by respondents who are overweight and respondents who are not overweight (BMI based on self-reported height and weight ≥25).

9.2 METHODS

In December 2020, an online questionnaire was sent to 700 adults in a panel that was compiled by an independent research firm. These 700 adults are representative of the Dutch population in terms of age, gender, and education. Data collection had a duration of one week. We first measured acceptance of governmental interference with lifestyle in general of individuals by asking respondents to respond to five statements (Textbox 9.1). Next, we presented the respondents seven possible policy interventions to promote a healthy diet (Figure 1). These interventions were taken from the Dutch National Prevention Agreement (level 1: '*show calorie content on all products/meals*', level 2: '*provide weight loss programs*', level 3: '*reduce serving size unhealthy products*'), and are aligned with interventions suggested by the Council for Public Health and Society (level 4: '*subsidy on vegetables and fruit*', level 5: '*tax on sugary drinks*', level 6: '*reduce outlets for unhealthy products*'), while the final one is derived from the literature (level 7: '*ban unhealthy products from certain places'*). For all seven interventions, we asked respondents to indicate how effective they expect the interventions to be by responding to the following two statements: 1) '*This intervention would make <u>me</u>*

eat fewer unhealthy products/drinks', 2) '*This intervention would make* *others* *eat fewer unhealthy products / drinks'*. Sub-group analyzes were conducted on the statements and the expected effectiveness among people with and without overweight to see whether these groups differ significantly from each other. Significance was tested using the chi^2 test.

Textbox 9.1 Five statements to measure acceptance of government intervention

1. The government should not intervene with the lifestyle of individuals.
2. If a lifestyle has negative consequences for others, the government should intervene.
3. The government is responsible for the health of the population.
4. People with a healthy lifestyle should be prioritized over people with an unhealthy lifestyle.
5. Lifestyle is an autonomous choice, and therefore consequences of lifestyle choices are an individual's own responsibility.

9.3 RESULTS

9.3.1 Support for government interventions to promote healthy behavior

In total, 698 respondents completed the questionnaire, Table 9.1 describes the characteristics of this study population. The average age is 50 years and just over half of the study population is female (52%). A total of 52 percent of the respondents are overweight (BMI ≥ 25.0).

Table 9.1 Description of the study population (N=698)

Background characteristics		%
Age	18-35	23.4
	36-50	26.1
	51-70	50.5
Sex	Female	52.0
	Male	48.0
Level of education[1]	Low	16.9
	Medium	53.0
	High	30.1
Body Mass Index, average (sd)		26.3 (6.0)
Weight[2]	Not overweight	47.1
	Overweight	52.9

[1] Low: primary school, lower vocational education (profession-oriented)/senior secondary vocational education (level 1), lower vocational education (theory/mixed)/Junior general secondary education; Medium: senior secondary vocational education levels (2, 3, and 4)/pre-1998 senior secondary vocational education, senior general secondary education/pre-university secondary education; High: First year in higher vocational education/university, Bachelor from higher vocational education/university, Master from higher vocational education/university, post-doctorate
[2] Not overweight: BMI < 25.0, Overweight: BMI ≥ 25.0

Figure 9.1 details the findings regarding the five statements presented to the respondents. In total, 30 percent of the survey population is opposed to governmental interference in the lifestyle of individuals, 26 percent is neutral, and 44 percent does not agree with the statement ('*The government should not intervene with the lifestyle of individuals*'). A vast majority of respondents (81%) favors government intervention if the behavior has negative consequences for others, while only 4 percent are against this. Smoking is a prime example of behavior that is harmful to third persons, and there does indeed seem to be great public support for government intervention in this area. When asked whether the government can be held responsible for the health of the population, over a quarter of respondents (28%) agree, while 34 percent disagree, and a slightly larger group (38%) is neutral. This topic is relevant for recent discussions regarding a statutory basis for health objectives [9]. Prioritizing people with a healthy lifestyle over people with an unhealthy lifestyle for treatment at healthcare institutions is something that nearly half of the population (46%) objects to, while 22 percent is in favor. However, 56 percent of respondents consider the consequences of an unhealthy lifestyle to be an individual's own responsibility, while only 17 percent think otherwise. These figures show that there is no unanimity on the acceptance of government intervention, except when it targets behavior that is harmful to third parties, which is where government intervention can count on large public backing.

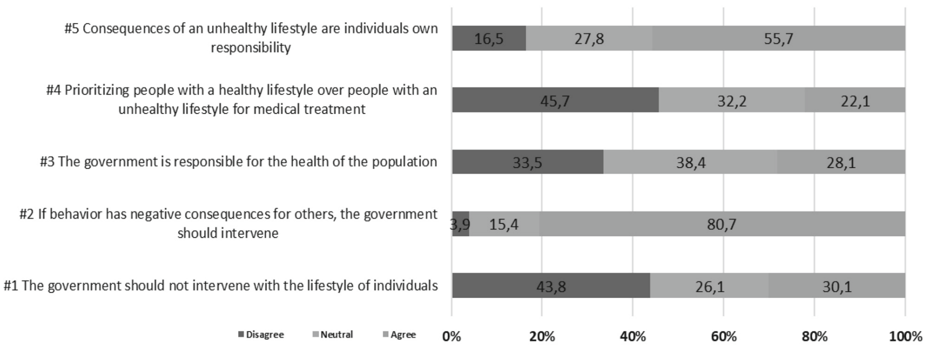

Figure 9.1 Acceptance of government intervention in the area of lifestyle (N=698)

9.3.2 Effective for others but not for me

The right half of Figure 9.2 shows for all interventions, arranged based on the Nuffield Intervention Ladder, the percentage of respondents who believe the intervention will have an actual effect on the consumption levels of unhealthy products. This has been broken down into the expected effect on *themselves* and the expected effect on *others*. The final column shows the difference between expected *self-efficacy* and expected *other-efficacy* in percentage points (pp).

A general trend that seems to emerge from Figure 9.1 is that the expected efficacy is greater the higher up on the ladder the interventions are. These interventions can at the same also have a lower acceptance rate. One exception, and outlier, seems to be the positive incentive in the form of a subsidy (level 4), which respondents expect to have a considerably greater effect than the other interventions, both for *themselves* (58%) and for *others* (65%).

The observation that respondents estimate effectiveness among *others* higher than effectiveness for *themselves* seems to be valid for each level of the Nuffield Intervention ladder, expect the lowest one (providing information). When taking the effect that they expect for themselves as the starting point, this could mean that the expected effectiveness of interventions at population level are overestimated when these are based (partly) on expectations for others.

In line with Duflo and Banerjee, we find that people consider financial incentives to be more effective for *others* than for *themselves* (7 pp difference). This goes for both positive incentives (subsidy) and negative incentives (tax). In a more general sense, the picture that emerges is that the more drastic the government intervention (i.e., the higher up the ladder), the greater the difference between the expected effect on oneself and the expected effect on others. On the highest level, i.e., a ban on unhealthy products, the difference is 22 pp. Compared to the six other classes of interventions, respondents do not expect such a ban to have a great effect on their own consumption of unhealthy products (34%), while they think it will have a relatively great effect on others (34%).

Stratification by age showed significant variation in the expected effectiveness of financial incentives. Young people (18-35) expect a positive incentive to have a greater effect (65%) on their behavior than older people do (51-70) (52%). Older people expect a negative incentive to be the most effective for others (47%).

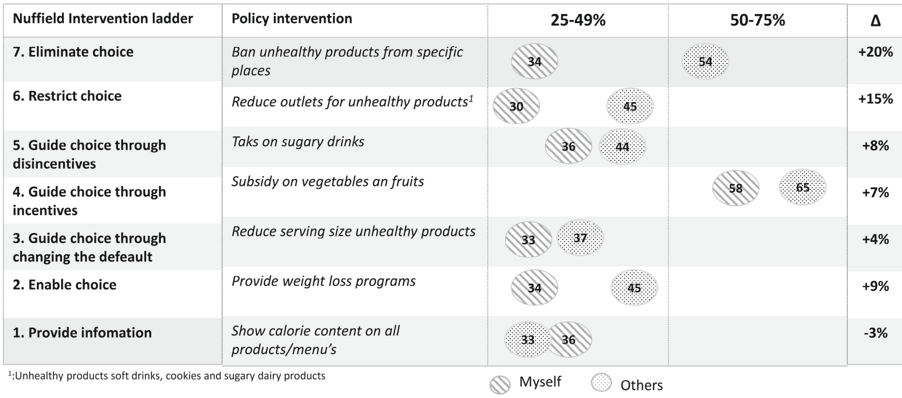

Figure 9.2 Possible policy interventions around healthy weight and the percentage that believes in the efficacy for the respondent himself/herself versus efficacy for others

9.3.3 And among overweight people?

One would expect for various reasons that respondents who are overweight themselves differ from respondents who are not overweight in terms of their acceptance and estimation of the effectiveness of interventions. For the group of respondents who are not overweight, the effect on their eating habits would perhaps by definition be estimated to be lower. In our study population, 53 percent of people are overweight (BMI of ≥25.0), based on self-reported height and weight, while the other 47 percent have a BMI of under 25, with some even being underweight (BMI under 18.0, n=13) (see table 9.1).

A distinction based on overweight shows that a third of respondents who are not overweight (34%) believe that the government is responsible for the health of the population, compared to only 22 percent of people with overweight. Aside from that, over a quarter (27%) of respondents who are not overweight find that people with a healthy lifestyle should be given priority in healthcare, while overweight people are considerably less in favor of such preferential treatment (17%). The other statements did not show any significant differences.

In relation to the expected effectiveness, we do not see any major differences between overweight respondents and respondents who are not overweight (Appendix 1). Only for the intervention of '*providing weight loss help*', 39 percent of respondents with overweight expect this intervention to be effective for *themselves* and 44 percent expect it to be effective for *others,* compared to 27 and 45 percent respectively among respondents who are not overweight. A possible explanation for this is that respondents who are not overweight will only have a limited need or no need at all for weight loss help for themselves in the short term.

9.4 CONCLUSION AND POLICY RECOMMENDATIONS

Various parties recently proposed the studied policy interventions aimed at supporting the Dutch population in achieving and maintaining a healthy weight to policymakers. Our findings suggest that people are more optimistic about the expected effectiveness of these interventions for others than for themselves. This goes specifically for interventions involving a high degree of government intrusion, such as a ban on the sale of unhealthy products in certain places (such as the canteens of sports clubs). This may lead to overestimation of interventions' expected effect on public health, especially when these interventions are more intrusive. The actual efficacy of the possible policy interventions for a healthy weight in the Dutch context is, however, still largely unknown and requires further research. According Bandura's self-efficacy theory, this heightened expected effectiveness for others could have a positive effect on self-efficacy [8]. When other people succeed in buying less unhealthy food due to a sugar tax, this can have a positive effect on others and boost self-efficacy.

Given our findings, there does not seem to be unequivocal public support for government intervention in the area of people's lifestyle. The expected effectiveness of more intrusive interventions seems higher, but acceptance of such interventions is essential and not a given. An exception to this seems to be the positive financial incentive of making fruit and vegetables cheaper. Not only do our respondents consider this to be the potentially most effective of all interventions, it is also more likely to be accepted. We found that the expected effectiveness of this intervention was greatest among young people (18-35 years). When it comes to other interventions higher up the ladder, some of which were also mentioned by the Council for Public Health and Society, respondents also expect a higher level of effectiveness. However, acceptance seems to be more doubtful for these interventions. Further research into public support for such interventions as well as into the actual effectiveness of these interventions in practice should, therefore, be high on the research agenda.

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9

APPENDICES

Appendix 1

Nuffield Intervention ladder	Policy intervention	25-49%	50-75%	Δ
7. Eliminate choice	*Ban unhealthy products from specific places*	32	52	+20%
6. Restrict choice	*Reduce outlets for unhealthy products*[1]	29 42		+13%
5. Guide choice through disincentives	*Taks on sugary drinks*	37 43		+6%
4. Guide choice through incentives	*Subsidy on vegetables an fruits*		54 63	+9%
3. Guide choice through changing the defeault	*Reduce serving size unhealthy products*	32 34		+2%
2. Enable choice	*Provide weight loss programs*	29 44		+15%
1. Provide infomation	*Show calorie content on all products/menu's*	33 38		-5%

[1]:Unhealthy products soft drinks, cookies and sugary dairy products

Myself Others

Figure A1. Possible policy interventions around healthy weight and the percentage that believes in the efficacy for the respondent himself/herself versus efficacy for others, for people who are overweight (N=368)

9

10 How should ICU beds be allocated during a crisis? Evidence from the COVID-19 pandemic

Based on: Dieteren, C.M., van Hulsen, M.A.J., Rohde, K.I.M., van Exel, J. (2021) How should ICU beds be allocated during a crisis? Evidence from the COVID-19 pandemic. *Submitted.*

ABSTRACT

Background

The first wave of the COVID-19 pandemic overwhelmed healthcare systems in many countries, and the rapid spread of the virus and the acute course of the disease resulted in a shortage of intensive care unit (ICU) beds. We studied preferences of the public in the Netherlands regarding the allocation of ICU beds during a health crisis.

Methods

We distributed a cross-sectional online survey at the end of March 2020 to a representative sample of the adult population in the Netherlands. We collected preferences regarding the allocation of ICU beds, both in terms of who should be involved in the decision-making and which rationing criteria should be considered. We conducted Probit regression analyzes to investigate associations between these preferences and several characteristics and opinions of the respondents.

Results

A total of 1,019 respondents returned a completed survey. The majority favored having physicians (55%) and/or expert committees (51%) play a role in the allocation of ICU beds and approximately one-fifth did not favor any of the proposed decision-makers. Respondents preferred to assign higher priority to vulnerable patients and patients who have the best prospect of full recovery. They also preferred personal characteristics, including age, play no role.

Conclusion

Our findings show that current guidelines for allocating ICU beds that include age as a criterion are not consistent with societal preferences; rather, age seems to be accepted as a criterion merely because of its relation to vulnerability and a prospect of full recovery. There is not a single value alone that is able to determine which patients should be prioritized, a multi-value ethical framework should be applied.

10.1 BACKGROUND

During the first quarter of 2020, there were more than 118,000 confirmed cases of COVID-19 in at least 114 countries [1]. Consequently, the WHO officially declared the international COVID-19 outbreak a pandemic in March, 2020 [1]. The first wave of the COVID-19 pandemic overwhelmed healthcare systems in many of these countries [2–4]. The acute course of the disease, which includes respiratory conditions that sometimes require admission to an intensive care unit (ICU), revealed that even some of the better equipped healthcare systems faced a shortage of ICU beds.

Resource scarcity in healthcare is not a new phenomenon. In most countries, the demand for healthcare exceeds the capacity for delivery within the available budget. As a consequence, choices must be made about how to spend these resources optimally. Although countries are thus familiar with rationing scarce health care resources, the scarcity due to the COVID-19 outbreak had a different character. The pandemic led to situations of acute shortages of both medical devices, such as high-filtration N-95 masks and ventilators, and specialized staff. Italy, the European epicenter of the COVID-19 pandemic in February 2020, initially faced an extreme shortage of ICU beds and staff, which forced physicians to allocate critical resources to the patients who would benefit most [5]. Italian physicians were supported with recommendations by an Italian expert team (SIAARTI) on how to prioritize patients in times of ICU bed scarcity [6]. The criteria to be considered for admitting patients to ICUs included age, comorbidities, and pre-existing functional status. However, these recommendations were strongly criticized by the media and the public as ageist and discriminatory against elderly patients [7]. Other countries had similar experiences during the first wave [8].

Decisions about who to treat and who not to treat sometimes lead to intense societal and political debates. Aligning decisions with societal preferences may help increase public acceptance and support for such decisions. However, previous research has shown that societal preferences are heterogeneous; along with broader ethical notions such as fairness, solidarity, and equity, members of the public care about the effectiveness of the treatment, the severity of the disease, patients' capacity to benefit, and the size of the gains in terms of quality of life [9–11]. Moreover, such societal preferences may well be different in crisis situations where the consequences of allocation decisions are more salient because they affect more people and are more ambiguous due to uncertainties about the nature of the crisis. It is well known from research in psychology and behavioral economics that salience and ambiguity affect people's preferences [12–14]. However, it is unclear whether these societal preferences are affected by crisis situations that strongly impact healthcare systems, such as catastrophes and epidemics. Catastrophes (e.g., natural disasters, airplane crashes) mostly have courses that are easier to predict than those of epidemics (e.g., Ebola, SARS). In addition, the magnitudes of pandemics like the COVID-19 outbreak place such heavy burdens on healthcare systems that they also affect other patients. For instance, the capacity for regular care must be scaled down and the treatment of other patients displaced [15, 16]. The Netherlands' National Institute for Public Health and the Environment estimated that, during the country's first wave alone, at least 50,000 healthy years of life were lost as a consequence of delayed or cancelled appointments with medical specialists [17]. Hence, rationing during a pandemic requires careful understanding of the overall situation.

The current COVID-19 pandemic makes it possible to investigate public support for rationing decisions made during a health crisis. During the first wave of the pandemic, by the end of March 2020, hospitals in the Netherlands experienced a critical shortage of medical equipment and staff, and in some regions of the country a shortage of ICU capacity was imminent [18]. Experts and healthcare professionals in several hospitals raised concerns about the escalating situation, some patients were deferred to hospitals in other parts of the country and also to Germany, and the national government commissioned the development of guidelines for prioritizing patients in need of intensive care [18]. The public debate about this crisis situation in the healthcare system and about the need for prioritizing among patients also intensified. The present study aimed to investigate preferences among the public in the Netherlands regarding allocation of ICU beds in times of healthcare crises, looking both at who should be involved in the decision-making and which rationing criteria should be considered. In addition, we explored the relation between these preferences and respondents' demographic characteristics as well as their opinions about the government's response to the pandemic. These additional analyzes provide more insight into the heterogeneity of the measured preferences and will help identify the groups in a society who will potentially support or oppose different policies or guidelines proposed by different stakeholders. As a consequence, allocation guidelines can be aligned with societal preferences, which will increase the policy acceptance rate among the public. In addition, information about the heterogeneity within the public can also be used to more effectively inform the public about why such allocation policies are needed.

10.2 METHODS

10.2.2 Survey design and sample

In this study, we used data collected at the end of March 2020 to investigate the compliance of citizens in the Netherlands with government measures to contain and mitigate the spread of the coronavirus [19]. At the time, which was one month after the first confirmed case of COVID-19, the Netherlands experienced exponential growth in the number of infections and hospital admissions, and the imminent scarcity of ICU beds was starting to become a topic of public debate. To collect the data, we developed a survey that was distributed online by a survey sampling company. Respondents were recruited using a quota-sampling approach, which aimed for the respondents being comparable to the Netherlands' adult population in terms of age, sex and level of education. At the beginning of the survey, respondents were given information about the purpose of the study and were instructed that their participation was voluntary and anonymous to the researchers and that they could end their participation at any time.

10.2.3 Measures

Who should be involved in making decisions about the allocation of ICU beds?

To assess who members of the public believe should be involved in decision-making regarding the allocation of ICU beds, we presented respondents with a list of ten decision-makers that could potentially have a role in developing guidelines for prioritizing patients for ICU beds in the Netherlands (see Table 10.1). We asked respondents to indicate on a 5-point Likert scale the extent to which they believed that each of these decision-makers should play a role in developing these guidelines (ranging from 1 = *completely disagree* to 5 = *completely agree*). For the analyzes, we organized the decision-makers into five categories, as shown in the right-hand column of Table 10.1. These categories were based on the similarity in importance attached to the different types of decision-makers by respondents, by inspecting the Spearman correlations between the Likert scores (see Appendix 1). Despite moderate correlation, the decision-makers "population of the Netherlands" and "lottery" were placed into separate categories on substantive grounds. The decision-maker "hospital management" was not included into one of the categories and excluded from further analysis as the observed correlations did not allow for a meaningful and unambiguous classification into any one of these categories. Within the identified categories with more than one decision-maker, the Likert scores were moderately to highly correlated (i.e., between 0.47 and 0.89).

Table 10.1 Potential decision makers for the allocation of ICU beds

Decision-maker		Category
1.	Physician on duty	Physicians
2.	Physicians from the hospital making a joint decision	
3.	National association of intensive care physicians	Expert committees
4.	Team of experts	
5.	The House of Representatives	Government
6.	The Cabinet	
7.	The Ministry of Health, Welfare and Sports	
8.	Population of the Netherlands (for instance, through a referendum)	The public
9.	Lottery (giving all patients an equal chance for an ICU bed)	Lottery
10.	Hospital management	–

The five decision-maker categories were then organized as dummy variables that take the value 1 for a respondent if the respondent's average agreement score on the 5-point Likert scale for the decision-makers in that category was at least 4, corresponding to a '(completely) agree' score that these decision-makers should play a role in developing guidelines, and the value 0 otherwise. For example, respondents who were positive that the "physician on duty" and "physicians from the hospital making a joint decision" should play a role in making allocation decisions (by giving these two potential decision-makers an average score of 4 or higher) were assigned the value 1 for the category *physicians,* while those who were negative or neutral about such a role for them (by giving them an average score of less than 4) were assigned the value 0 for this category.

Respondents were also asked whether they had additional suggestions for decision-makers that should be involved in developing the guidelines. The answers in this open text field were categorized as "no," "don't know," "protest answer," and "a specific recommendation."

Allocation criteria for the rationing of ICU beds

Next, we presented respondents with a list of 18 criteria that might be considered in the development of guidelines for the allocation of ICU beds (see Table 10.2). These criteria were selected from previous research that has investigated societal preferences for the distribution of health and healthcare [10, 20, 21], combined with the most salient criteria mentioned in the public and political debates in the Netherlands at the time of the survey development. Each criterion reflects a distinct potential reason for a rationing choice. Although these criteria are not necessarily independent (e.g., age and vulnerability), we included them as separate criteria in order to try to disentangle the relevance of each criterion for priority setting in the view of the public. We asked respondents to indicate on a 5-point Likert scale whether each of these criteria should have a role in guidelines for allocating ICU beds (ranging from 1 = *completely disagree* to 5 = *completely agree*).

Table 10.2 Potential criteria for rationing ICU beds

1. The most vulnerable patient should receive priority
2. Younger patient should receive priority
3. Patient who has been to the hospital for care before should receive priority
4. Patient who arrives at the hospital first should receive priority
5. Patient who had a higher risk of becoming infected because of working in a crucial profession during the coronavirus outbreak (such as health care, police, grocery stores) should receive priority
6. Patient who had a higher risk of becoming infected because of working on the development of a treatment against the coronavirus should receive priority
7. Patient who had a higher risk of becoming infected because of providing care to people with the coronavirus should receive priority
8. Patient with the highest chances of full recovery should receive priority
9. Patient who are breadwinners should receive priority
10. Patient who provides informal care to family members should receive priority
11. Patient who is parent of school-going children should receive priority
12. Patient who has not used much healthcare in the past should receive priority
13. Patient who was completely healthy before becoming infected should receive priority
14. Patient who complied with precautionary measures should receive priority
15. Patient with urgent needs based on a reason other than coronavirus should receive priority
16. Patient with coronavirus should receive priority
17. Patient who lives near the hospital should receive priority
18. Personal characteristics of patients should play no role in deciding who gets an ICU bed

Opinion variables

We also collected data on respondents' opinions about the government's response to the pandemic. We asked respondents whether they considered the government's response to the pandemic to be highly insufficient, insufficient, appropriate, exaggerated, or highly exaggerated, as well as whether they believed that the measures taken by the government were very effective, effective, neutral, ineffective, or very ineffective in combating the pandemic. We also asked whether respondents had been stockpiling food and household goods, as a proxy for the experienced uncertainty about the development of the COVID-19 crisis. The rapid spread of this novel virus came with great uncertainty about its health effects and its impact on the economy and society at large. Such uncertainty in a time of crisis has been shown to affect household consumption and stockpiling [22]. The exact wording of these questions can be found in Appendix 2.

Demographic characteristics

Finally, we asked respondents about several demographic characteristics, including age, sex, employment status, and highest achieved level of education.

10.2.4 Analytical approach

We only included respondents who completed the survey. After cleaning and recoding the variables of interest for this study, we examined the sociodemographic characteristics of the sample and their answers to the two central questions. We first recoded the answers to the question about who should be involved in the development of the allocation guidelines into five categories, as described above. Next, we further analyzed these answers in terms of the number of decision-maker categories respondents thought should be involved in the development of the guidelines, distinguishing in particular the group of respondents who assigned a score of 3 or less to all categories. For the question about the criteria that should be used in decision-making, we computed the mean score for each of the 18 decision-making criteria, based on the scores of respondents on the 5-point Likert scale, and their difference from the overall mean score across criteria.

Second, we estimated a series of binary response models to examine the relationship between the respondents' preferences and their demographic characteristics and opinions. First, we examined the relationships between the demographic characteristics of respondents (i.e., age, sex, level of education, and employment) and their probability of being in favor of the involvement of each decision-maker category (i.e., physicians, expert committee, government, the public, lottery). Then we added opinions about the government's response to the COVID-19 pandemic (i.e., whether the response was sufficient, whether the measures were effective, and whether respondents engaged in stockpiling) to these models. The following model structure was applied:

$$Y_i = \begin{cases} 1 & \text{if } X_i\theta + \varepsilon_i > 0 \\ 0 & \text{otherwise} \end{cases}$$

Next, we estimated models for the six decision-making criteria that were the most relevant according to the respondents or were the most heavily discussed in public and political debates in the Netherlands at the time of data collection. To do this, we first examined the relationships between the respondents' demographic characteristics (i.e., age, sex, level of education, and employment) and the probability of being in favor of each of the six decision-making criteria. Then we added the preferences for the five decision-maker categories to the models. We used STATA 16.0 to analyze the data.

10.2.5 Ethical approval

This study was approved by the Internal Review Board of the Erasmus School of Economics (ESE IRB-NE application 2020-04). Participants could only continue with the survey once they provided written informed consent.

10.3 RESULTS

10.3.1 Study sample

Table 10.3 shows the demographic characteristics of the 1,019 respondents who returned completed surveys. The final column shows the percentages of the reference population during the data collection. The mean age was 48 years and 53% of the sample were female. The sample is slightly higher educated than the reference population.

Table 10.3 Demographic characteristics and COVID-19-related opinions of the study sample (N = 1,019)

Demographic characteristics		**N (%)**
Age	18–34	248 (24.3)
	35–59	474 (46.5)
	60–77	297 (29.2)
Sex	Female	542 (53.2)
	Male	477 (46.8)
Education level	Low	288 (28.3)
	Medium	370 (36.3)
	High	361 (35.4)
Employed	No	471 (46.2)
	Yes	548 (53.8)
COVID-19 related opinions		**N (%)**
Government response	(Highly) Insufficient	266 (26.1)
	Appropriate	657 (64.5)
	(Highly) Exaggerated	96 (9.4)
Government measures	(Highly) Ineffective	132 (13.0)
	Neutral	314 (30.8)
	(Highly) Effective	573 (56.2)
Stockpiling	No	687 (67.4)
	Yes	332 (32.6)

10.3.2 Who should be involved in decisions about the allocation of ICU beds?

Figure 10.1 shows that large majorities of between 55% and 70% of the respondents completely agreed that physicians from the hospital making a joint decision, the physician on duty, the national association of intensive care physicians, or a team of experts should play a role in developing guidelines for the allocation of ICU beds. Much smaller proportions of between 20% and 30% thought the Ministry of Health, Welfare and Sports, the Cabinet, the House of Representatives, or hospital management should play a role. When aggregating these decision-makers into the categories defined earlier, the majority of the sample were in favor of a role for physicians (55%) or an expert committee (51%), while about 18% considered government to be an appropriate decision-maker. Only 12% of the respondents were in favor of a role for the public, and only 12% were in favor of a lottery (see Appendix 3).

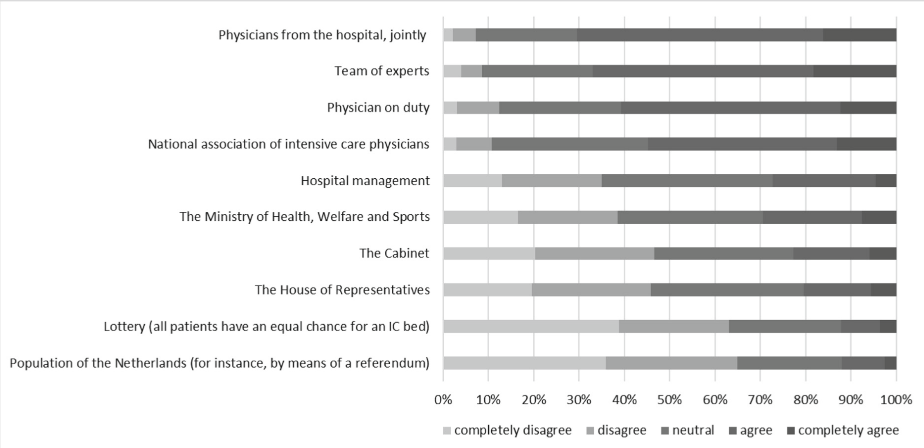

Figure 10.1 Support for decision-making categories, ranked by agreement

Overall, about one-third of the respondents (34.3%) had a clear preference for a single decision-maker category, while 43.9% were in favor of shared responsibility between two or more of the proposed decision-maker categories (see Appendix 3 and 4). Approximately one out of five respondents (21.8%) did not support a role for any of the five decision-maker categories, as indicated by an average score of less than 4 for all categories. About half of this group (114 respondents; 11.2% of the total sample) even had an average score of less than 3 for all categories. These results could be interpreted as protest responses, because the majority of these respondents (74%) did not provide an alternative suggestion for who should be involved in decisions about the allocation of ICU beds. Moreover, many of these respondents expressed dissatisfaction with the government and the shortage of ICU beds in a wealthy country such as the Netherlands (example: "*The shortage of ICU beds is simply the result of all the cutbacks implemented by the current and previous governments*"; resp100). Some characterized having anyone play a role in allocating ICU beds as inhumane and expressed relief that they themselves did not bear the responsibility for such decisions (example: "*Everything should be done to avoid having physicians and patients ending up in these sorts of situations*"; resp31). This "protest group" had a slightly lower mean age than the rest of the sample (45 years versus 48 years) and was less educated. No differences were found regarding sex or employment status.

The results of the models investigating the associations between the preferences regarding who should be involved in decisions about the allocation of ICU beds and the demographic characteristics and opinions of respondents are presented in Table 10.4. We found that people aged 60–77 years were 16 percentage points more likely to be in favor of a role for physicians, while younger people were more likely to be in favor of a role for government or a lottery. Female respondents were more likely than male respondents to be in favor of a role for an expert committee. Compared to respondents with a low level of education, respondents with a medium level of education were 9 percentage points less likely to be in favor of an expert committee, and those with a high level of education were 7 percentage points less likely to be in favor of a role for the public. Being employed increased the likelihood of being in favor of a role for the government or the public. In addition, compared to the respondents who considered the government's response to the COVID-19 pandemic (highly) insufficient, those who believed it was (highly) exaggerated were more likely to be in favor of a role for the public or a lottery, and less in favor of an expert committee. Compared to respondents who considered the measures the government took in response to the pandemic (highly) ineffective, those who thought they were (highly) effective were more likely to be in favor of a role for physicians, an expert committee, and the government. Finally, stockpiling during the initial stages of the COVID-19 pandemic was positively associated with a role for the public or a lottery, and to a smaller extent also with a role for the government.

Table 10.4 Probit regressions preferences for decision-makers; average marginal effect (95% confidence interval)

	Who should decide who gets an ICU bed?									
	Physicians		Expert committees		Government		The public		Lottery	
Age										
18-34	ref		Ref		ref		Ref		ref	
35-59	0.12**	(.03 - .19)	0.03	(-.05 - .11)	-0.04	(-.10 - .02)	-0.01	(-.06 - .03)	-0.07*	(-.12 - -.01)
60-77	0.16**	(.06 - .25)	-0.06	(-.15 - .03)	-0.08*	(-.15 - -.00)	-0.01	(-.07 - .04)	-0.07*	(-.13 - .00)
Sex										
Male	Ref		Ref		Ref		Ref		Ref	
Female	0.05	(-.01 - .11)	0.07*	(.01 - .13)	-0.04	(-.09 - .00)	-0.04	(-.07 - .00)	-0.03	(-.07 - .00)
Education level										
Low	ref		Ref		Ref		Ref		Ref	
Middle	0.06	(-.02 - .13)	-0.09*	(-.17 - -.01)	-0.05	(-.11 - .01)	-0.02	(-.07 - .03)	0.00	(-.04 - .05)
High		(-.08 - .09)	0.00	(-.08 - .08)	-0.06	(-.12 - .00)	-0.07*	(-.11 - -.01)	-0.04	(-.09 - .01)
Employed										
No	ref		Ref		ref		Ref		Ref	
Yes	-0.05	(-.12 - .02)	-0.04	(-.11 - .03)	0.06*	(.00 - .10)	0.07**	(.02 - .10)	0.02	(-.02 - .06)
Government response										
(Highly) Insufficient	ref		Ref		ref		Ref		Ref	
Appropriate	-0.02	(-.09 - .05)	-0.07	(-.14 - .00)	0.01	(-.04 - .06)	-0.00	(-.04 - .04)	0.02	(-.02 - .05)
(Highly) Exaggerated	0.01	(-.11 - .12)	-0.15*	(-.27 - -.03)	0.05	(-.05 - .13)	0.12**	(.03 - .21)	0.09*	(.00 - .17)
Government measures										
(Highly) Ineffective	Ref		Ref		Ref		Ref		Ref	
Neutral	-0.00	(-.09 - .05)	-0.00	(-.10 - .10)	0.05	(-.01 - .11)	-0.02	(-.09 - 0.4)	-0.00	(-.06 - .06)

Table 10.4 Probit regressions preferences for decision-makers; average marginal effect (95% confidence interval) (continued)

	Who should decide who gets an ICU bed?									
	Physicians		Expert committees		Government		The public		Lottery	
(Highly) Effective	0.14**	(.04 - .25)	0.19***	(.09 - .29)	0.10**	(.03 - .16)	-0.05	(-.11 - .01)	-0.00	(-.06 - .05)
Stockpiling										
No	Ref		Ref		ref		Ref		Ref	
Yes	-0.01	(-.07 - .06)	0.06	(-.00 - .13)	0.05*	(.00 - .11)	0.10***	(.05 - .15)	0.10***	(.04 - .14)
McFadden's R2	0.034		0.041		0.034		0.093		0.066	
Observations	1019		1019		1019		1019		1019	

* p < 0.05, ** p < 0.01, *** p < 0.001

10.3.3 Which criteria should be considered in deciding on the allocation of ICU beds?

The left panel of Figure 10.2 shows the mean score for each of the 18 criteria presented to respondents. The overall mean score was 3.12 (on a scale ranging from 1 to 5). The right panel of Fig 2 shows the difference between the mean score for each criterion and the overall mean score.

The highest mean score (3.8) was observed for the criterion [18] stating that personal characteristics should play no role in the allocation of ICU beds. This criterion representing the equality of patients was followed by criteria [1] and [8], favoring patients who are vulnerable or have the highest chance of full recovery, and criteria [5], [6], and [7], favoring those with higher risks related to working in a crucial profession, caring for infected patients, or working on development of a vaccine or treatment. Prior healthcare use [12] and the hospital-related criteria [3] and [17], which received the lowest mean scores, were thus least preferred for consideration in guidelines for the allocation of ICU beds. Compliance with the safety measures advised by the government [14], which involves notions of own responsibility and culpability, also received a lower-than-average score. Preference for prioritizing patients infected with the coronavirus [16] was only slightly higher than for patients with other urgent needs for an ICU bed [15].

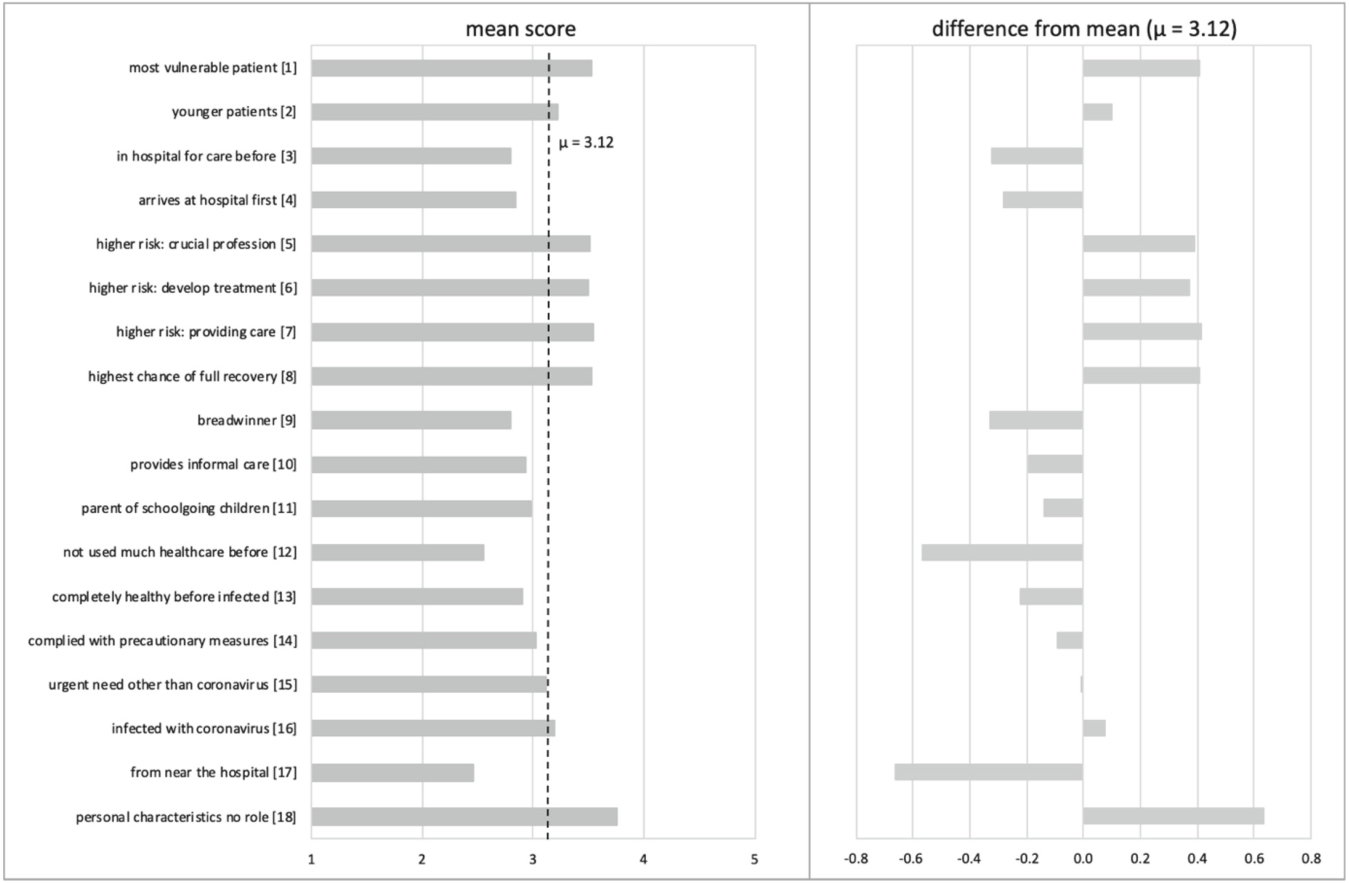

Figure 10.2 Preferences for decision-making criteria for the allocation of ICU beds (mean score and difference from overall mean)

We further investigated how the six allocation criteria that either came out as the most relevant in our data ([1], [5], [8] and [18]) or were most prolific in the public debate in the Netherlands at the time of analysis ([2] and [14]) associated with respondents' demographic characteristics and preferences for decision-maker categories, see Table 10.5 for model estimations. We found that age, education level, and employment status affected the likelihood of being in favor of certain criteria. For example, people aged 35–77 were more likely than young people to support prioritizing based on vulnerability [1] and less likely to support prioritizing based on age [2]. The oldest age group was less likely to support prioritizing based on patients' personal characteristics [18], while people aged 35–59 were less likely to support the culpability criterion [14]. More highly educated people were more likely to be in favor of prioritizing based on the capacity to benefit [8]. Employed people were less likely than unemployed people to be in favor of the vulnerability criterion [1] and more likely to be in favor of the culpability criterion [14] and the capacity to benefit [8].

Moreover, people in favor of a role for physicians were more likely to support the criteria related to vulnerability [1], work-related risk [5], and capacity to benefit [8] but against discrimination based on personal characteristics [18]. People in favor of a role for an expert committee were more likely to support all of the allocation criteria other than the one specifying that personal characteristics should play no role [18]. People in favor of a role for the government were likely to support the age [2] and crucial profession [5] criteria, which the government in the Netherlands actually does, but also the chance of full recovery [8] and culpability [14] criteria, which it does not. As one would perhaps expect, people in favor of a role for a lottery were against discrimination based on personal characteristics [18], yet they showed support for the crucial profession [5] and culpability [14] criteria.

Table 10.5 Probit regressions decision-making criteria; average marginal effect (95% confidence interval)

Demographic characteristics	What should determine the allocation of ICU beds?											
	Vulnerability [1]		Age [2]		Crucial profession [5]		Chance of full recovery [8]		Compliance with measures [14]		Personal characteristics no role [18]	
Age												
18-34	ref		ref		ref		Ref		ref		ref	
35-59	0.08*	(-.00 - .17)	-0.12**	(-.20- -.04)	-0.05	(-.13 - .03)	-0.04	(-.12 - .04)	-0.09*	(-.16 - .01)	-0.03	(-.11 - .05)
60-77	0.11*	(-.01 - .20)	-0.13**	(-.22 - -.04)	0.05	(-.05 - .14)	0.03	(-.07 - .13)	-0.08	(-.16 - .01)	0.13**	(.04 - .22)
Sex												
Male	ref		Ref		Ref		Ref		Ref		Ref	
Female	-0.02	(-.08 - .04)	0.03	(-.03 - .09)	-0.01	(-.07 - .06)	0.02	(-.04 - .08)	-0.01	(-.06 - .05)	0.05	(-.01 - .12)
Education level												
Low	ref		Ref		Ref		Ref		Ref		Ref	
Middle	-0.04	(-.12 - .04)	-0.04	(-.11 - .04)	-0.06	(-.14 - .02)	0.04	(-.04 - .12)	-0.07	(-.15 - .00)	-0.05	(-.13 - .03)
High	-0.06	(-.14 - .03)	0.05	(-.03 - .14)	-0.02	(-.11 - .06)	0.13**	(.04 - .21)	-0.03	(-.11 - .04)	-0.04	(-.12 - .05)
Employed												
No	ref		Ref		Ref		Ref		Ref		Ref	
Yes	-0.09*	(-.16 - -.01)	0.02	(-.05 - .09)	-0.01	(-.08 - .06)	0.08*	(.00 - .15)	0.07*	(.01 - .14)	0.01	(-.06 - .08)
Physicians												
Neutral/disagree	ref		Ref		Ref		Ref		Ref		Ref	
Agree	0.16***	(.09 - .22)	0.04	(-.03 - .10)	0.12***	(.05 - .19)	0.15***	(.08 - .21)	-0.01	(-.07 - .05)	0.16***	(.10 - .23)
Expert committee												
Neutral/disagree	ref		Ref		Ref		Ref		Ref		Ref	
Agree	0.07*	(.00 - .14)	0.11**	(.04 - .17)	0.18***	(.11 - .24)	0.13***	(.07 - .20)	0.13***	(.07 - .19)	0.06	(-.01 - .12)

Table 10.5 Probit regressions decision-making criteria; average marginal effect (95% confidence interval) (continued)

Demographic characteristics	What should determine the allocation of ICU beds?											
	Vulnerability [1]		Age [2]		Crucial profession [5]		Chance of full recovery [8]		Compliance with measures [14]		Personal characteristics no role [18]	
Government												
Neutral/disagree	ref		Ref		Ref		Ref		Ref		Ref	
Agree	0.04	(-.05 - .13)	0.12*	(.03 - .21)	0.09*	(.00 - .19)	0.14**	(.05 - .23)	0.11*	(.02 - .19)	-0.03	(-.13 - .06)
The public												
Neutral/disagree	Ref		Ref		Ref		Ref		Ref		Ref	
Agree	0.08	(-.02 - .20)	0.09	(-.02 - .20)	0.03	(-.08 - .15)	-0.09	(-.21 - .02)	0.10	(-.00 - .20)	-0.00	(-.11 - .11)
Lottery												
Neutral/disagree	ref		Ref		Ref		ref		Ref		Ref	
Agree	0.10	(-.00 - .20)	0.04	(-.06 - .15)	0.20***	(.11 - .30)	0.09	(-.02; -.19)	0.15**	(.04 - .25)	0.15**	(.05 - .24)
McFadden's R2	0.054		0.053		0.076		0.061		0.081		0.051	
Observations	1019		1019		1019		1019		1019		1019	

* p < 0.05, ** p < 0.01, *** p < 0.001

10

10.4 DISCUSSION

The data for this study were collected at the end of the first quarter of 2020, when the first wave of the COVID-19 outbreak in the Netherlands was nearing its peak. Hence, this study took place against the backdrop of public and political debates about the increasing pressure the pandemic placed on the healthcare system. In this context, we wanted to investigate societal preferences regarding the allocation of scarce ICU beds during a health crisis. We assessed the societal preferences for various types of decision-makers being involved in the development of guidelines for the allocation of ICU beds and the rationing criteria that should be considered in this allocation process.

The results of our study suggest that the majority of the sample believed that physicians or an expert committee should be involved in developing guidelines for the allocation of scarce ICU beds during a health crisis. The preferred allocation criteria for guiding these decisions mostly related to the health and risk profiles of patients in need of an ICU bed. Priority for the most vulnerable patients and those with the highest chance of full recovery was supported, as well as priority for those with a higher work-related risk of becoming infected. Interestingly, it was generally preferred that personal characteristics should play no role, and priority for younger patients was only weakly supported. The age criterion has been criticized more generally before, both by experts and in the public debate, as connected with ageism or even racism [7]. One of the arguments against an age-related criterion, which may also have played a role in our study, is that research shows significant differences between biological and chronological age [23]. The weak support for using age as a decision criterion seems to stand in contrast with international guidelines, where age appears to be a leading criterion for prioritizing patients when there is a shortage of ICU beds [6, 18]. However, other criteria considered important in our study are in part age-related, for example, vulnerability and the chance of full recovery. Based on our findings, we anticipate that guidelines based on age may be met with opposition from the public, although the clinical reasoning for using age as a criterion may not be so different from the priorities of the public. Presenting respondents separately with the different criteria previously identified in the literature enabled us to disentangle the various criteria that may otherwise be conflated as an age-related criterion. However, we recognize that there is not a single value alone that is able to determine which patients should be prioritized. Rather a multi-value ethical framework should be applied [24]. As suggested also by others, a utilitarian perspective (e.g., greatest benefit), individual patient preferences, social contexts, and operability should be included in the decision-making process [25].

We found that respondents who were 35 years and older were more positive about a role for physicians in developing allocation guidelines, while respondents who were younger than 35 more strongly supported a lottery. We also found that people who were positive about how the Netherlands' government is handling the pandemic, that is, who were satisfied with the government's response to the COVID-19 outbreak and considered the measures taken by the government to be effective, were more likely to be in favor of a role for the government. They were also more positive about a role for an expert committee, which, considering the government's strong reliance on such a committee (called the "outbreak management team") in the development of their policies for handling the pandemic, seems to make sense. Not surprisingly, people who were positive about how the government was handling the current health crisis also tended to prefer a role for government in the development of guidelines for the allocation of ICU beds, and people who considered the government response as exaggerated were more likely to be in favor of a role for the public or a lottery. Finally, people who experienced more uncertainty in relation to the pandemic, as revealed by self-reported stockpiling behavior, showed stronger support for a role for the government, the public, and a lottery, but not for physicians or an expert committee. One possible interpretation of this finding is that people who experienced more uncertainty generally do not trust or understand or feel insufficiently represented in the advice of experts as much as others do and would therefore like to shift influence away from experts and make the government more accountable for their decisions, or, alternatively, leave it to the public or a lottery.

Approximately one out of every nine respondents was neutral or (strongly) disagreed with a role for any of the proposed decision-makers, but also did not provide alternative suggestions. In the open follow-up question, some of these respondents expressed the belief that rationing ICU beds is inhumane, with the government to blame for the capacity shortage, and that they were glad they were not—and also did not want to be—responsible for such difficult choices. This "protest response" could also be interpreted as *decision avoidance*. When respondents perceive themselves to be personally responsible if they state being in favor of something, they may more likely anticipate regret about the possible outcomes of their choices and hence may prefer not to choose [26]. Avoidance of a decision, in particular deferral, is more likely among decision-makers who hope to postpone or escape the responsibility of making a decision [26].

Societal preferences for healthcare priority setting have previously been assessed in the Netherlands, although under ordinary circumstances [10, 11, 20, 27]. Across these studies, an egalitarian view with respect to decision-making in healthcare was found to be most common, emphasizing the importance of equal opportunities and access to healthcare services for those in need of care. This is in line with our finding that vulnerability should play a role in the prioritization of patients for ICU beds, while personal characteristics, including age, should not. These previous studies also found that the effectiveness of the care and the quality of life after treatment are considered important by members of the public in the Netherlands, which seems to be consistent with the strong support for prioritizing those with a chance of full recovery in our study.

In the context of limited ICU bed capacity, preference for those who would benefit most relates to a concern for the efficiency of healthcare. Hence, also in the context of a health crisis, people seem to trade off concerns about equity and about efficiency. These trade-offs differ for different people; in our study, more highly educated people in particular seemed more in favor of considering efficiency in the allocation of ICU beds.

Some limitations of our study need to be acknowledged. First, we collected our data by means of an online survey, and the answers to certain questions may be sensitive to a social desirability bias [28]. Second, our data collection took place at the start of the COVID-19 outbreak. Although the shortage of ICU beds was a realistic threat for the country's healthcare system at the time of data collection, it did not materialize because of intensive investments in capacity and deferral of patients to a neighboring country, Germany. In addition, the data collection took place in the early days of the pandemic, and since then much has changed regarding the patient flow within and between hospitals and the ICU treatment capacities and efficiency. Therefore, public opinion may also have changed in the interim. Repeating this study today, a year later, while the Netherlands is facing a third wave of COVID-19 infections, could generate additional insights about societal preferences for rationing healthcare during a health crisis. Some criteria might have become less or more relevant in the eye of the public. One could hypothesize that after months of experience with the social and economic consequences of lockdown measures, and now that people are better informed and more aware about the behavioral component in preventing contamination, the culpability criterion may have gained popularity. Finally, although our data were collected from a sample that was intended to be representative of the adult population of the Netherlands (in terms of age, sex, and level of education), caution is required in generalizing our findings. The sample ended up being slightly older and more highly educated than the reference population, and it cannot be ruled out that certain subgroups of the overall population were less likely to accept the invitation to participate or to finish completing the survey. Moreover, although the COVID-19 pandemic is an international concern, generalization of our findings beyond the Netherlands is limited by differences between countries in the organization and capacity of their healthcare systems, the measures taken by governments to contain and mitigate the coronavirus, and more general value orientations in the population (such as equality and solidarity).

10.5 CONCLUSIONS

In conclusion, it appears that during a health crisis, the public attaches the most value to rationing criteria that are related to the health status and prospects of patients and to their risk profiles and not to personal characteristics such as their age. The majority of our sample shared the opinion that physicians and experts should be responsible for the development of guidelines for the allocation of scarce ICU beds. The considerable size of the "protest group" that did not support any of the decision-makers or did not want to bear any responsibility for this type of decision signals that any healthcare rationing decision in the context of a health crisis may face considerable opposition. Hence, policy makers should devote extra attention to disseminating information regarding the importance of rationing criteria in the context of healthcare. Moreover, allocation guidelines that involve criteria related to the health and risk profiles of patients as well as those that favor patients that have the highest chances of full recovery are likely to receive the most support from the public.

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APPENDICES

Appendix 1

Table A1. Decision-makers; spearman correlation matrix agreement scores

		1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	Physician on duty	1.00								
2.	Physicians from the hospital jointly	0.56	1.00							
3.	National association of intensive care physicians	0.26	0.44	1.00						
4.	Population of the Netherlands (for instance by means of a referendum)	-0.08	-0.12	0.07	1.00					
5.	Hospital management	0.02	0.12	0.25	0.43	1.00				
6.	The House of Representatives	-0.10	-0.07	0.22	0.50	0.52	1.00			
7.	The Cabinet	-0.07	-0.02	0.24	0.46	0.49	0.89	1.00		
8.	The Ministry of Health, Welfare and Sports	-0.06	0.02	0.31	0.40	0.49	0.75	0.80	1.00	
9.	Team of experts	0.19	0.36	0.47	-0.03	0.24	0.18	0.21	0.31	1.00
10.	Lottery (all patients have an equal chance to an ICU bed)	-0.13	-0.11	-0.02	0.48	0.29	0.31	0.29	0.24	-0.02

Appendix 2

Table A2. COVID-19 related questions

Question	Response categories
What do you think of the response of the government to the COVID-19 outbreak in the Netherlands?	highly exaggerated; exaggerated; appropriate; insufficient; highly insufficient
How effective do you consider current measures taken by the government in order to slow down the spread of the COVID-19 virus?	very ineffective; ineffective; neutral; effective; very effective
During the last three days, have you bought more of certain things than you would do in normal circumstances?	yes, of many things; yes, of some things; no

Appendix 3

Table A3. Preferences for who should be involved in the allocation of ICU beds (N=1,019)

Decision-maker category	Preferred	Preferred as only decision-maker	Also a role for…				
			Physicians	Expert committee	Government	The public	Lottery
	N (%)	N (% of category)	N (% of category)				
Physicians	560 (55.0)	181 (32.7)	-	357 (63.8)	113 (20.2)	78 (13.9)	67 (12.0)
Expert committees	520 (51.0)	104 (20.0)	357 (68.7)	-	151 (29.0)	85 (16.3)	79 (15.2)
Government	179 (17.6)	19 (10.6)	113 (63.1)	151 (84.4)	-	65 (36.3)	52 (29.1)
The public	122 (12.0)	17 (13.9)	78 (63.9)	85 (69.7)	65 (53.3)	-	61 (50.0)
Lottery	124 (12.2)	16 (21.8)	67 (54.0)	79 (63.7)	52 (41.9)	61 (49.2)	-
None	222 (21.8)	-	-	-	-	-	-

Appendix 4

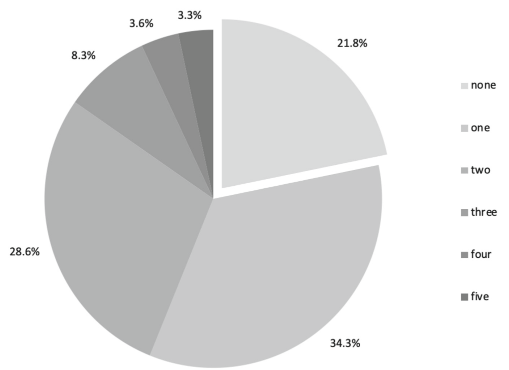

Figure A4. Number of decision-maker categories preferred

11 General discussion

11.1 GENERAL OVERVIEW

Unhealthy behaviors like smoking, unhealthy nutrition, harmful alcohol consumption and physical inactivity (SNAP) can have a profound negative effect on health. These SNAP factors, for example, substantially increase the risk of individuals developing non-communicable diseases (NCD) [1]. NCDs cover almost three-quarter (73%) of the disease burden and are the leading cause of death worldwide [2]. Therefore, NCDs and associated risk factors are a major public health concern. There is an opportunity to prevent, at least partly, or postpone NCDs and related diseases because these SNAP factors are modifiable. Designing health policies to improve health behaviors is challenging and public support for such policies has been understudied.

This thesis aimed to contribute to a better understanding of the relation between health behaviors and health outcomes and explored public preferences for health policies to improve public health while mostly acknowledging that healthcare resources are limited. The following paragraphs discusses the main findings of the chapters and provide an answer to each of the research questions. Subsequently, the overall strengths and limitations of this thesis, future research opportunities and recommendations for policy will be provided.

11.2 Main findings

This thesis was divided in three parts – Health behaviors, Health outcomes, Health policies – and the results are presented accordingly. Research question 1 is covered in Part I, research questions 2 – 4 answered in Part II, and the results to research questions 5-7 are presented in Part III.

11.2.1 Part I Health behaviors

The first part of the thesis aimed to contribute to a better understanding of the distribution of health behaviors in populations across regions globally and addressed the following research question:

1. How are health behaviors distributed across the population in different regions in the world, and how do these behaviors cluster? (Chapters 2 and 3)

The results of the study in chapter 2, involving the general population of the Netherlands, showed that half of the study population was engaged in two or more of the four SNAP factors (smoking, unhealthy nutrition, harmful alcohol consumption, physical inactivity). The most prevalent combination was an unhealthy diet combined with physical inactivity. Furthermore, almost one fifth of the study sample did not report to partake in any of the four unhealthy behaviors and one third only in one unhealthy behavior. We found that lower educated people more often are engaged in unhealthy behaviors. Especially smoking and harmful alcohol consumption were concentrated among people with a lower educational level. Those who engaged in these two unhealthy behaviors were found to be more likely to have an increased focus on immediate results of their behavior. This implicates that those who smoke are vulnerable for the instant pleasure derived from smoking and are less vulnerable for the long-term negative health effects due to smoking. A gap of twelve years in subjective life expectancy was found between people who behaved healthily and those engaged in all unhealthy behaviors (85.5 versus 73.7 years).

Chapter 3 is a cross-country comparison of 22 low- and middle-income countries (LMICs) in terms of prevalence and socioeconomic distribution of unhealthy behaviors, also in relation to the countries' share of their gross domestic product (GDP) spent on health. We found that both the prevalence and the degree of socioeconomic inequality differed considerably across health behaviors and countries. Prevalence rates for excessive alcohol consumption, smoking and overweight were respectively lower than ten percent in Gambia, Nigeria and Burundi, while the highest prevalence rates were observed in Armenia (60%), South Africa (62%) and Cambodia (83%). Note that in Chapter 3, the clustering of unhealthy behaviors was assessed at household level as opposed to the individual level analyzes in Chapter 2. For one country (Armenia), we found that more than half of the households in the study were engaged in multiple unhealthy behaviors, while in all other countries this was less. In almost all countries smoking and harmful alcohol usage was concentrated among the poor. We found that overweight was concentrated among the better-off across all 22 LMICs, contrary to high-income countries where overweight is mostly observed among the poorer segments of the population. We identified countries – especially Zambia, Tanzania and Cambodia - that had a low share of GDP spent on health and relatively large socio-economic inequalities in the distribution of health behaviors. These countries should be prioritized when implementing global policies to reduce unhealthy behaviors among the poor.

11.2.2 Part II Health outcomes

In part II of this thesis, the relationship between health behaviors and health outcomes was assessed by employing a variety of methods. The following research questions were addressed:

2. What is the current evidence on the effect of smoking on health expectancy? (Chapter 4)
3. Which healthy aging trajectories can be observed in a cohort of the general population of the Netherlands, and what are the roles of baseline sociodemographic characteristics and lifestyle factors on these trajectories? (Chapter 5)
4. To what extent are there socioeconomic inequalities in undiagnosed, untreated, and uncontrolled hypertension in Mexico, and how do people transit between these states? (Chapter 6)

Chapter 4 addressed research question 2 and synthesized existing evidence for the effect of smoking on health expectancy. Smoking affects health through a wide range of both fatal and non-fatal diseases. We conducted a systematic literature review to examine the compression and expansion of morbidity hypothesis for smoking cessation, and finally included 20 articles (covering 26 population cohorts). The health indicators used to estimate health expectancy in these studies included disability/ activity limitations, self-rated health, chronic diseases and cardiovascular diseases, but also health-related quality of life (EQ-5D), weighted disabilities, and cognitive impairment. The results consistently showed that non-/never-smokers spent more life years in good health compared to smokers, indicating that the life expectancy of non/never-smokers is higher and includes more healthy years. However, the estimates for the number of unhealthy life years varied considerably. Half of the studies reported an absolute compression of morbidity for non-/never-smokers compared to smokers, while the other half of the studies reported an absolute expansion of morbidity. Furthermore, nearly all included studies reported relative compression of unhealthy life years for non-/never-smokers. The indicators to estimate health expectancy should be more harmonized to enhance the comparability of future research. For instance, national surveys for population health surveillance generally include a single question to measure health. Other large cohort studies could include similar measures to increase comparability between studies. A multidimensional measure of health provides a more complete assessment and especially in the context of smoking cessation this may be helpful to better understand the implications of smoking elimination on population health.

Chapter 5, addressing the third research question, exploits the Doetinchem Cohort Study to identify trajectories of health outcomes and assessed the relationship with sociodemographic and health behaviors among this sample of the general population. Health outcomes were defined by means of a Healthy Aging Index that involves five indicators: systolic blood pressure, random glucose, creatinine, forced vital capacity and global cognitive function. These five indicators together represent the five physiological systems of the body. Based on this index, we identified two distinct aging trajectories among men (“*Gradual agers*” and “*Early agers*”) and only one among women. This was done by using data obtained during a follow-up period of 15 years (1998 - 2012). Women as well as *early aging* men lost 10 years in full health, within the age range of 30-70 years, while *Gradual aging* men lost 5 years in the same time period. Hence, the aging trajectory of the *Gradual aging* men was postponed as compared to the *Early aging* men and women. Men who met the Dutch guidelines for physical activity were more likely to follow the *Gradual aging* trajectory. Moreover, having a body mass index below 30.0 was also positively associated with this more favorable aging trajectory.

The final Chapter of the part on Health outcomes, Chapter 6, estimated the prevalence, transitions, and socioeconomic distribution of hypertension that remained undiagnosed, untreated, and uncontrolled for at least five years among older persons in Mexico. This Chapter has a focus on hypertension, a health outcome which was one of the indicators of the Healthy Aging Index developed in Chapter 5. The prevalence rates of undiagnosed, untreated and uncontrolled hypertension decreased significantly over the five-year period, but transition analyzes showed that of those identified with undiagnosed, untreated and uncontrolled hypertension, a substantial group up to 60% for uncontrolled hypertension were still in this state after five years. We found that men, singles, rural dwellers, uninsured and those with overweight were more likely to be in a persistent unfavorable hypertension state. Hypertension was found to be more prevalent among the rich, while undiagnosed, untreated and uncontrolled hypertension were more concentrated among the poor. To ensure more equitable hypertension care and effectively and equitably prevent premature deaths, increased diagnosis and long-term efforts should be targeted towards high-risk populations.

11.3.3 Part III Health policies

The final part of this thesis explored public preferences for health policies to improve public health while mostly acknowledging that healthcare resources are limited. A particular focus was put on the role of individual responsibility for health. These chapters addressed research questions 5 to 7, listed below:

5. Which viewpoints towards the inclusion of a lifestyle criterion in healthcare priority setting can be identified among healthcare professionals and the general population in the Netherlands? (Chapter 7)
6. What are the preferences and perceptions of effectiveness towards governmental policies to promote a healthy diet among the general population in the Netherlands? (Chapters 8 and 9)
7. Which public preferences towards the role of individual responsibility in the allocation of ICU beds during a health crisis can be identified among the general population in the Netherlands? (Chapter 10)

Chapter 7, covering research question 5, examined viewpoints regarding support for decision criteria in the context of healthcare priority setting in the Netherlands, among members of the general population and experts in healthcare in the Netherlands. We assessed the support for a lifestyle-related decision criterion, relative to the currently applied reimbursement criteria in priority setting, i.e., effectiveness, cost-effectiveness, necessity of care and of insurance, and feasibility. Using Q-methodology, we identified four distinct viewpoints: 1 "*Access to cost-effective treatments based on need*", 2 "*Life is previous and always worth saving*", 3 "*Prevention and individual responsibility for health*", and 4 "*Treatment outcome and cost-effectiveness*". Each viewpoint was supported by a mix of experts and members of the public, however, most experts related strongly to viewpoint 1, which most closely reflects the current decision-making framework in the Netherlands. Viewpoint 3 supported the application of a lifestyle criterion in priority setting, while the other viewpoints clearly objected to such a criterion. The viewpoint supporting a lifestyle criterion was largely defined by the general population sample and less prevalent among healthcare experts. Viewpoint 2 did not support rationing in healthcare at all, as they believed that it would be morally wrong to deny treatment to patients. The other viewpoints acknowledged the scarcity of resources and necessity of priority setting based on, at least, some criteria. Heterogeneity in policy preferences is inevitable, and thus acknowledging this in policy communication seems pivotal to increase the likelihood of policy acceptance. Individual responsibility in health(care) is likely to remain a controversial topic and further research in this area is required.

Chapters 8 and 9 addressed research question 6 and focused on policies to promote a healthy diet. Chapters 2 and 3 showed that overweight and obesity are highly prevalent worldwide, and Chapters 5 and 6 identified relationships between overweight and obesity and long-term health outcomes. Hence, policies to reduce overweight and obesity rates can help to improve health. Chapter 8 showed results regarding the preferences of the Dutch general population towards potential policies supporting a healthy diet, with varying levels of intrusiveness. A discrete choice experiment (DCE) was conducted, involving seven policies (ranging from solely information provision to the ban of unhealthy products at certain places). A mixed logit model showed that preferences for these policies were heterogenous. On average, subsidies for vegetables and fruit (either 10% or 30%) and a tax of 20% on sugary drinks were most preferred, while a tax of 50% on sugary drinks was disfavored. We continued with a latent class model and identified three distinct classes. These classes were labeled as 1 "*Against*" (17%), 2 "*Mixed*" (27%), and 3 "*Pro*" (56%) policies to promote a healthy diet. Which combination of interventions to select for promoting a healthy diet remains a challenge, since a considerable proportion of the population (17%) is opposed to most measures, especially the more intrusive ones. Important to note is that we did not involve the potential effects on public health of the policies, nor did we present the opportunity costs of the interventions. We deliberately focused solely on the intrusiveness levels. The seven policies described in Chapter 8, were further explored in Chapter 9. We examined the expected effectiveness of the policies among a representative sample of the Dutch population. Respondents were asked what effect they expected these policies to have on themselves and others. The expected effectiveness increased for policies with a higher intrusiveness level. However, an exception is the expected effectiveness for subsidy on vegetables and fruit: the policy with the highest expected effectiveness. For all policies, except the one with the lowest intrusiveness level, we found a gap between the perceived "self"-effectiveness and "others"-effectiveness. A larger effectiveness was expected for others. A sub-group analysis on people with and without overweight revealed no major differences between these two groups. If expectations of effectiveness of policies are based on their expected effects on others, this could imply that their effectiveness may be overestimated.

The final study, presented in Chapter 10, assessed public preferences towards allocation of intensive care unit (ICU) beds among the Dutch adult population in times of a healthcare crisis, looking both at who should be involved in the decision-making and which rationing criteria should be considered (research question 7). Data was collected via an online survey during the first wave of the COVID-19 pandemic, when even some of the better equipped healthcare systems faced a shortage of ICU beds. Participants were presented a list of potential decision makers (e.g., physicians, government, the public) and rationing criteria (e.g., age, risk profile, profession). A large majority (70%) completely agreed that physicians or a team of experts should develop the guidelines for the allocation of ICU beds. The criterion stating that individual characteristics should play no role in the allocation of ICU beds was most preferred, followed by criteria related to the risk profile of the patient. Prior healthcare use and living near the hospital were least preferred. Compliance to the precautionary measures taken by the government, involving notions of own responsibility and culpability, as a rationing criterion was scored slightly lower-than-average compared to the other criteria. Age, educational level, and employment status were associated with the likelihood of being in favor of criteria that were considered most relevant according to the respondents or were the most heavily discussed in public and political debates at the time of data collection. While international guidelines seem to support an age criterion, our results show that during a health crisis the Dutch public attaches most value to rationing criteria related to the health status of patients and not to their personal characteristics.

11.3 STRENGTHS AND LIMITATIONS

This section highlights the overarching strengths and limitations of this thesis. The application of diverse methodologies across chapters is considered as a major strength of this thesis, as this contributes to a comprehensive analysis of the research topic. While most studies in this thesis have a quantitative character – except chapter 4 and 7, respectively a mixed-methods approach and a systematic literature review - the applied statistical research techniques vary greatly between the chapters. Moreover, besides the exploitation of existing datasets (either previously collected by others or publicly available data), this thesis also included studies (chapters 7- 10) for which a questionnaire was specifically designed, and data was collected. Finally, this thesis utilized a comprehensive approach towards understanding the role of health behaviors to address the complexity of the subject. Hence, different perspectives were included - the distribution among the population; the relationship with health outcomes; the role in health policies- and low-, middle- as well as high-income countries were studied to acknowledge the global magnitude of the increasing burden of unhealthy behaviors.

The research presented in this thesis also has limitations. While we did attempt to portray the complexity of health behaviors, many areas related to health behaviors remain uncovered. For example, the cost-effectiveness of proposed policies to promote health behaviors are of importance before proceeding to actual implementation. The effect of improved health behaviors on public health - will we live longer, but also healthier? – is essential to account for in the future health system. We have assessed health behaviors on the individual-engagement level, but health behaviors studied on the individual decision-making level are also crucial to understand *how* individuals make decisions. In such a context the discipline of behavioral economics is relevant, to acknowledge that health behaviors are not (always) rational [3]. Besides other areas that require attention, there are five main limitations to acknowledge when considering the findings of this thesis.

First, while some health indicators (weight and height to estimate BMI, systolic and diastolic blood pressure to estimate hypertension, and all indicators of the Healthy Aging Index) were measured by a healthcare professional (Chapters 5 – 6), most data in the other chapters were self-reported, potentially introducing reporting bias. For self-reported weight and heigh this leads to an overestimation of BMI values at the low end (BMI < 22) and to an underestimation of BMI values at the high end (BMI > 28) [4]. Health behaviors were solely self-reported, and for physical activity this is likely to be less accurate compared to an objective measurement by means of, for instance, an activity tracker, as self-report is more likely to overestimate actual physical activity- [5]. Hence, our results should be interpreted with caution.

Second, the application of diverse methods and data sets is considered as a strength of this thesis, however, it is also a limitation since findings across chapters are sometimes difficult to compare. For instance, chapters 2 and 3 both study the distribution of unhealthy behaviors, but the behavior clustering in the two studies is determined differently (i.e., at the household or individual level) which hampers comparability. The preferred method for the estimation of behavior clustering depends on the goal of the research or policy. Policies that are targeted on an individual level will benefit from data that is collected at an individual level.

Third, the respondents in chapters 2, 8 and 9 were recruited via an online panel - hosted by an independent research company - and therefore certain groups of the population may not have been reached. Although a quota-sampling approach on age, sex and educational level was applied, it may be the case that people that participate in an online panel differ on certain characteristics compared to people who do not participate in such a panel, e.g., in digital skills, cognitive ability or time availability. This might limit the generalizability of our findings in those Chapters.

Fourth, the use of mainly quantitative methods in this thesis does not allow for interaction between the researcher and participants during the data collection. Most data were collected via online questionnaires which is an efficient method to reach large samples, which adds to the validity of statistical techniques by improved power [6]. Nonetheless, "the story behind the data" is not obtainable which is a disadvantage of survey data. A qualitative approach, such as individual interviews or focus groups, would be complementary to quantitative data and might enrich the (interpretation of) the findings. For example, in chapter 2 we utilized a risk attitude measurement instrument (the HRAS-SF) and a time orientation scale (the CFC) resulting in numerical values for these measures. Complementing these data with interviews for a sub-group of the study population could lead to deeper understanding of the relations between these measures and SNAP factors.

Finally, Part I and II of this thesis were conducted before the outbreak of the COVID-19 pandemic (March 2020), while the data collection for the studies in Part III took place during an imposed lockdown by the Dutch government. The pandemic arguably emphasized the importance of a healthy lifestyle, as hospital admission after infection with COVID-19 was associated with overweight. Peoples' views towards (intrusive) health policies (chapter 8) might be different during a health crisis. Moreover, the imposed lockdown may also have influenced the prevalence and socio-economic distribution of unhealthy behaviors. While this pandemic has further increased the relevance of studying unhealthy behaviors and health policy, the findings should be interpreted in relation to the COVID-19 pandemic.

Notwithstanding these limitations, this thesis provides policy makers important insights about the distribution of unhealthy behaviors in various populations and preferences for different policies to modify behavior and in turn to curb the rise in NCDs.

11.4 FUTURE RESEARCH OPPORTUNITIES

These limitations, the results of this thesis and remaining gaps in the literature create opportunities for future research. First, a study design that considers objective measurements of unhealthy behaviors, e.g., an activity tracker for physical activity, salivary thiocyanta as a chemical estimator for smoking and transdermal alcohol sensors [7, 8], may lead to more accurate results and an improved understanding of the distribution of unhealthy behaviors among the population. In addition, instead of the body mass index a possible better predictive measure related to weight is the waist-to-hip ratio. Second, a qualitative approach that further disentangles the reasons why people begin, maintain, or give up unhealthy behaviors can generate additional insights for policy makers. While studies assessing barriers for behavior change are not uncommon, a multidisciplinary approach considering the irrational component of behavioral decision making may also generate new findings. Finally, replication of the studies in this thesis that assessed policy preferences (chapters 7-10) after the current health crisis would be useful. The data collection for these studies took place during a period of extraordinary government intervention due to the COVID-19 pandemic, which may obviously have affected the results. Replication could shed some light on the validity of these results. Moreover, given that the relation between health behaviors and health outcomes is of interest around the globe, replicating these studies in other countries may highlight interesting communalities and differences in support for policy measures aimed at improving health behaviors. Also, a re-assessment of behavior clustering is encouraged, as the COVID-19 pandemic may also have affected the prevalence and distribution of unhealthy behaviors.

The findings of this thesis may also encourage future research. We reported large heterogeneity in the distribution of unhealthy behaviors in the countries included. We studied the relationship between attitudinal factors (risk attitude and time orientation) and unhealthy behaviors in the Netherlands (chapter 2), but this relationship could also be assessed in other HICs and LMICs. Findings of these studies may benefit the development of targeted policies that aim to lower the prevalence of unhealthy behaviors in each of these countries. Furthermore, the healthy aging trajectories identified in chapter 5 could be assessed using other (national and international) datasets to confirm these aging trajectories and their relations to SNAP factors in other contexts or identify alternative trajectories and mechanisms. Moreover, trajectories based on health behaviors could generate additional insights in aging as these behaviors are dynamic. Health behaviors are dynamic in the sense that they can change every day, however, behavioral changes analyzed over an extend period can be helpful in the understanding of why and when individuals modify their behavior. Finally, in chapter 8 we have assessed the societal preferences for governmental policies that support a healthy diet. As the "obesogenic environment" is clearly visible in everyday life, governments that wish to reduce obesity rates in the population may consider intervening in this environment. Future research could further explore the societal views on this topic and assess the effect of the potential policies on the public health and healthcare costs.

11.5 POLICY RECOMMENDATIONS

The findings from the nine studies presented in this thesis together hopefully serve as a motivation and input for the development of policy to promote healthier lifestyles in HICs and LMICs. These findings emphasize the presence of heterogeneity in society in terms of behavior, health (outcomes) and preferences, which requires special attention in developing and communicating policies that are accepted and supported by the public when implemented. Several policy recommendations following from this thesis are highlighted below.

In chapter 2, clustering of unhealthy behaviors was found to be highly prevalent, with more than half of the Dutch population being engaged in two or more unhealthy behaviors. Policies can acknowledge such clustering by adopting a more holistic approach. Instead of approaching unhealthy behaviors in isolation, one at a time, policies could take a more comprehensive “lifestyle lens”. The combination of an unhealthy diet and physical inactivity was shown to be prevalent and thus policies that promote a healthy diet may also incorporate an aspect that places emphasis on physical activity. For example, sport clubs could be encouraged to promote nutritious food or schools could be subsidized to provide (only) healthy options in their canteens and more physical exercise, and such policies could even be anchored in national regulations. Furthermore, policies could be more focused on specified sub-populations. Anti-smoking policies are often on a population-level, e.g., through public mass campaigns, which adds to the collective awareness of the dangers of smoking, but targeted policies may better reach segments of the population where (starting with) smoking is still highly prevalent. For example, schools may introduce education on health behaviors and ban smoking on school grounds by pupils and staff as prevention should start early in life. This thesis also shows that unhealthy behaviors have a different socio-economic distribution in high-income and low- and middle-income countries and therefore it is recommended to tailor policies on a national level.

The indicators of the Healthy Aging Index applied in chapter 5 – systolic blood pressure, forced vital capacity, creatinine, cognitive function, glucose – are valuable in detecting and preventing future adverse health outcomes. In this thesis it was found that physiological aging starts early in life, already around the age of 40 years. Monitoring individuals on these indicators may add to signaling those that need to adapt their lifestyle or receive medication to postpone adverse health outcomes. The findings of this thesis also show that persistent undiagnosed, untreated and uncontrolled hypertension is a common phenomenon in Mexico. In this context it is specifically recommended for the Mexican government to design policies that aim to increase screening uptake by targeting men, singles, uninsured and those with overweight. However, also for other LMICs it is of increased importance to further strengthen monitor systems to detect NCDs across the whole of the population in an early phase as a major part of the premature mortality due to NCDs occur in LMICs [9]. Specifically, Sustainable Development Goal 3.4 aims to “reduce by on-third premature mortality from NCDs through prevention and treatment and promote mental health and well-being”. Hence, screening individuals in an early stage may add to reach this goal.

Individual responsibility towards one’s own health remains a controversial topic in both public and political debates. Chapters 7, 8 and 10 studied the role of individual responsibility in different contexts. Each of those studies showed that most of the respondents thought that individual characteristics should play no role in the allocation of resources in healthcare. Instead, respondents indicated that the risk profile and medical need of individuals should be more important in healthcare decision-making. Additionally, chapter 9 showed that the majority of the respondents supported government intervention in the context of health behaviors. A minority favored a role for individual responsibility in rationing in healthcare. Social determinants of health – e.g., income, type of job - play an important role in the adoption of health behaviors which undermines to a certain extent the individual responsibility argument. In addition, there are many actions the government may undertake to improve the health behaviors among its population. For example, a sugar tax and subsidy on fruit and vegetables may be a first step to promote healthy choices. Moreover, placing more responsibility at the municipality level – by e.g., restricting the number of fast-food chains per given area - leads to a healthier -i.e., less "obesogenic"- living environment creating less temptations to give in to unhealthy behavior and more opportunities for adopting healthy behaviors.

11.6 CLOSING WORDS

This thesis contributes to the existing body of scientific work by providing evidence about health behaviors and health outcomes and suggesting policy recommendations. Worldwide, figures on health behaviors show that there is considerable room for improvement. Socioeconomic inequality was found to be persistent in health behaviors, which in turn leads to socioeconomic differences in health outcomes. Health policy makers should adopt a stronger focus on prevention to promote public health and lower socioeconomic inequalities.

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SUMMARY, SAMENVATTING, PHD PORTFOLIO, ABOUT THE AUTHOR, DANKWOORD

& Summary

SUMMARY

Non-communicable diseases (NCDs) by now account for approximately 70% of all deaths worldwide. The ongoing rise in NCD rates is partly driven by aging populations but is also linked to an increase in unhealthy behavior such as smoking, unhealthy nutrition, harmful alcohol consumption and physical inactivity (in short, the SNAP factors). These SNAP factors so far have often been studied separately, while these behaviors mostly occur in combination The presence of multiple unhealthy behaviors in an individual has been shown to have an additional negative influence on health. At the same time, the modifiable character of the SNAP factors creates opportunities for health policies to stimulate healthy choices and hence improve public health.

The NCD burden is a global problem. Healthcare systems worldwide are confronted with an increasing demand for health care against limited budgets. To curb the rise in NCDs, we must understand the distribution of unhealthy behaviors and health outcomes in different populations. This could contribute to the development of more tailored health policies to improve health outcomes and reduce health inequalities.

This thesis aims to contribute to a better understanding of the relationship between health behaviors and health outcomes and explores public preferences for governmental health policies to improve public health. Considering the growing NCD burden and their negative consequences on public health and healthcare costs, preventing or postponing NCDs and related diseases is important both for public health and the financial sustainability of healthcare systems. The results of the studies in this thesis are presented in three parts: Part I – Health behaviors; Part II – Health outcomes; Part II – Health policies.

Part I – Health behaviors

Chapters 2 and 3 present results on the distribution of health behaviors in different populations. **Chapter 2** examined the clustering of health behaviors in a representative sample of the adult population in the Netherlands. Half of the study population engaged in two or more of the SNAP factors. The most prevalent combination was unhealthy nutrition combined with physical inactivity. Respondents with unhealthy behaviors reported lower scores on subjective health and subjective life expectancy. In addition, attitudinal factors (time orientation and risk attitude) were found to be associated with the SNAP factors. Smokers had the highest focus on the immediate consequences of their behavior (i.e., pleasure due to smoking) and they exhibited higher risk seeking behavior in the health domain than non-smokers. **Chapter 3** focused on unhealthy behaviors in low- and middle-income countries (LMICs) and presented results on the prevalence and socioeconomic distribution of health behaviors for 22 LMICs. The results showed a large diversity in the prevalence and socioeconomic distribution of unhealthy behaviors across and within these countries. For example, the prevalence of

smoking among men ranged from 7% in Nigeria to 60% in Armenia. The results further indicated that smoking is predominantly concentrated among people with a low socio-economic status, which is comparable to high-income settings. The results also showed that overweight is concentrated among people with a higher socio-economic status, which is contradictory to the distribution in high-income countries. Therefore, tailored interventions for improving health are warranted that consider these socioeconomic patterns in (combinations of) unhealthy behaviors.

Part II – Health outcomes

Next, the thesis focuses on the relationship between health behaviors and health outcomes. **Chapter 4** reported a systematic literature review investigating the compression of morbidity hypothesis, which stipulates that less smoking leads to fewer years lived with morbidity. In total, 20 articles comprising 26 population cohorts were eligible for inclusion. The results showed that non- and never-smokers experienced more healthy life years throughout their lives than smokers, confirming relative compression of morbidity. However, the findings regarding absolute compression of morbidity were diffuse. Chapter 4 also highlighted that the diversity of indicators used to measure health in different studies hindered comparability of findings and that more standardization would be beneficial for future comparative studies.

Chapter 5 used data from the Doetinchem Cohort Study to develop and describe the Healthy Aging Index (HAI). The study investigated whether different typical aging trajectories exist for women and men aged between 30 and 70 years. The HAI reflects five important physiologic systems measured by the following indicators: systolic blood pressure, creatinine, forced vital capacity, random blood glucose and cognitive function. Based on observations in 2,325 women and 2,013 men over a follow-up period of 20 years, one typical HAI trajectory for women and two trajectories for men were identified. The latter two were labelled as gradual aging (76% of men) and early aging (24% of men). Between the ages of 30 and 70 years, men in the early aging trajectory had the least healthy years (29.6 years), followed by women (30.1 years), and gradually aging men (34.7 years). Men who complied with guidelines for physical activity and were not obese were more likely to follow the gradual aging trajectory. Chapter 5 emphasized that physiological aging, estimated with the HAI, already starts at a relatively young age and health behaviors play an important role in aging trajectories.

Globally, there are substantial gaps in diagnosis, treatment, and control of hypertension to prevent premature deaths. **Chapter 6** focused on the care continuum related to hypertension in Mexico, an upper middle-income country with the highest overweight prevalence in the world and where NCDs account for 80% of all deaths. Hence, the objective of the study presented in Chapter 6 was to estimate the prevalence and socioeconomic distribution of hypertension that remains undiagnosed, untreated, and uncontrolled for at least five years, and to estimate transition rates between these hypertension states. Data from the WHO Study on Global AGEing and adult health (SAGE) were used. The results showed that of the 945 included Mexicans of 50 years and older, 60% were classified as hypertensive. The hypertension care continuum estimates reveal substantial rates of persistent undiagnosed, untreated, and uncontrolled hypertension. For example, of those with uncontrolled hypertension in Wave 1, more than half (62%) continued to be in this state five years later. While being classified as hypertensive was more concentrated among people with a higher socio-economic status, missing diagnosis, treatment and control were more prevalent among people with a lower socio-economic status. Chapter 6 showed that clinical and public health interventions are required to improve hypertension screening and care in Mexico.

Part III – Health policies

Chapters 7 to 10 discuss public preferences for health policies to improve public health, with a particular focus on individual responsibility for health. **Chapter 7** examined views among experts and the public in the Netherlands regarding inclusion of a lifestyle-related decision criterion in healthcare priority setting. Four distinct viewpoints were revealed, which were all supported by a mix of members of the public and experts. These viewpoints emphasized different elements such as effectiveness of treatments, the value of (saving a) life also in poor health states, individual responsibility and government intervention in unhealthy lifestyles, and the importance of cost-effectiveness of treatments. Overall, the results show some but overall limited support for a lifestyle criterion, and this support was only found among members of the public.

Chapters 8 and 9 focus on broadly advocated policies aiming at promoting a healthy diet. **Chapter 8** assessed preferences for seven policies with different levels of intrusiveness among a representative sample (N=599) of the public of the Netherlands, using a discrete choice experiment. The results showed that subsidies for vegetables and fruit and a moderate tax on sugary drinks were most preferred. Latent class analyses identified three classes with distinct preferences: the majority (56%) of respondents were positive about all proposed policies, while 27% had mixed opinions and a minority of 17% was against all proposed policies. This highlighted important heterogeneity in preferences. **Chapter 9** subsequently assessed the expected effectiveness of the seven policies also used in Chapter 8. Dutch adults (N=700) were asked what effect they expected from these policies for themselves and for others. The results showed that respondents in general estimated the efficacy of the policies higher for others than for themselves, except for the policy of providing information. In addition, more intrusive policies (e.g., banning unhealthy products from certain places) were expected to be most effective. Given these results, the effectiveness of policies aiming to improve people's lifestyle may be overestimated when these are (partly) based on expectations of their effects in others.

Chapter 10 deals with COVID-19. The rapid spread of the COVID-19 virus overwhelmed healthcare systems in many countries and resulted in a shortage of intensive care unit (ICU) beds. Hence, we investigated the preferences regarding the allocation of ICU beds during a health crisis. A representative sample of the Dutch population (N=1,019) was surveyed, focusing on who should decide regarding the allocation of ICU beds and which rationing criteria should be considered in doing so. The majority of respondents favored involving physicians and/or expert committees in the development of guidelines for the allocation of scarce ICU beds during a health crisis. However, a part of the respondents did not support any of the decision-makers in doing this, or did not want to bear any responsibility for these types of decisions. Respondents preferred rationing criteria related to the health status and prospects of patients, and their risk profiles. Criteria related to personal characteristics such as their age or adherence to safety measures advised by the government received little support.

The findings of the nine studies presented in this thesis highlight considerable heterogeneity in health behaviors, outcomes, and policy preferences in different populations. Figures on health behaviors show considerable room for improvement and socioeconomic inequality in health behaviors and health outcomes remain persistent. This thesis provides important insights about the distribution of unhealthy behaviors in various populations and the preferences for policies to modify health behavior and curb the rise in NCDs.

& Samenvatting

SAMENVATTING

Niet-overdraagbare ziekten zijn inmiddels verantwoordelijk voor ongeveer 70% van alle sterfgevallen wereldwijd. De aanhoudende stijging van deze ziektelast wordt deels veroorzaakt door vergrijzing, maar wordt ook veroorzaakt door toenemend ongezond gedrag zoals roken, ongezonde voeding, schadelijk alcoholgebruik en lichamelijke inactiviteit (kortweg de SNAP-factoren). Deze SNAP-factoren zijn tot nu toe vaak afzonderlijk bestudeerd, terwijl deze gedragingen meestal in combinatie voorkomen. Het is aangetoond dat de aanwezigheid van meerdere ongezonde gedragingen bij een individu grotere negatieve gevolgen heeft op de gezondheid. Tegelijkertijd creëert het aanpasbare karakter van de SNAP-factoren kansen voor zorgbeleid om gezonde keuzes te stimuleren en daarmee de volksgezondheid te verbeteren.

De niet-overdraagbare ziektelast is een wereldwijd probleem. Zorgstelsels worden belast met een toenemende vraag naar zorg, tegen beperkte budgetten. Om de toename van niet-overdraagbare ziekten te beteugelen, moeten we de verdeling van ongezond gedrag en gezondheid in verschillende populaties begrijpen. Dit zou kunnen bijdragen aan de ontwikkeling van meer op maat gesneden zorgbeleid om de gezondheid te verbeteren en ongelijkheid in gezondheid te verminderen.

Dit proefschrift heeft als doel bij te dragen aan een beter begrip van de relatie tussen gezond gedrag en gezondheid en onderzoekt de voorkeuren van het publiek voor het gezondheidsbeleid van de overheid om de volksgezondheid te verbeteren. Gezien de toenemende niet-overdraagbare ziektelast en de negatieve gevolgen daarvan voor de volksgezondheid en de kosten van de gezondheidszorg, is het voorkomen of uitstellen van niet-overdraagbare ziekten en aanverwante ziekten belangrijk, zowel voor de volksgezondheid als voor de financiële houdbaarheid van de gezondheidszorgstelsels. De resultaten van de onderzoeken in dit proefschrift worden gepresenteerd in drie delen: Deel I – Gezond gedrag; Deel II – Gezondheid; Deel II – Zorgbeleid.

Deel I – Gezond gedrag

Hoofdstukken 2 en 3 presenteren resultaten over de verdeling van ongezonde gedragingen in verschillende populaties. **Hoofdstuk 2** onderzocht de clustering van ongezond gedrag in een representatieve steekproef van de volwassen bevolking in Nederland. De helft van de onderzoekspopulatie hield zich bezig met twee of meer van de SNAP-factoren. De meest voorkomende combinatie was ongezonde voeding en lichamelijke inactiviteit. Respondenten met ongezond gedrag rapporteerden lagere scores op subjectieve gezondheid en subjectieve levensverwachting. Daarnaast bleken attitudefactoren (tijdsoriëntatie en risicoattitude) geassocieerd te zijn met de SNAP-factoren. Rokers waren het meest gericht op de directe gevolgen van hun gedrag (bijvoorbeeld plezier door roken) en vertoonden een hoger risicozoekend gedrag in het gezondheidsdomein dan niet-rokers. **Hoofdstuk 3** richtte zich op ongezond gedrag in lage- en middeninkomenslanden en presenteerde resultaten over de prevalentie en sociaaleconomische verdeling van gezondheidsgedrag voor 22 landen. De resultaten lieten een grote diversiteit zien in de prevalentie en sociaaleconomische verdeling van ongezond gedrag in en binnen deze landen. Zo varieerde de prevalentie van roken onder mannen van 7% in Nigeria tot 60% in Armenië. De resultaten gaven verder aan dat roken voornamelijk geconcentreerd is bij mensen met een lage sociaaleconomische status. Dit is vergelijkbaar met de verdeling hiervan in hoge-inkomens landen. De resultaten laten ook zien dat overgewicht zich concentreert bij mensen met een hogere sociaaleconomische status, wat in tegenspraak is met de verdeling in hoge-inkomenslanden. Daarom zijn op maat gesneden interventies die deze sociaaleconomische patronen in beschouwing nemen van belang.

Deel II – Gezondheid

Vervolgens richt het proefschrift zich op de relatie tussen gezond gedrag en gezondheid. **Hoofdstuk 4** rapporteerde een systematisch literatuuronderzoek naar de compressie van de morbiditeitshypothese, die stelt dat minder roken leidt tot minder jaren met morbiditeit. In totaal kwamen 20 artikelen met 26 populatiecohorten in aanmerking voor inclusie. De resultaten toonden aan dat niet- en nooit-rokers gedurende hun hele leven meer gezonde levensjaren ervoeren dan rokers, wat de relatieve compressie van morbiditeit bevestigt. De bevindingen met betrekking tot absolute compressie van morbiditeit waren echter diffuus. Hoofdstuk 4 benadrukte ook dat de diversiteit aan indicatoren die gebruikt worden om gezondheid te meten in verschillende studies, de vergelijkbaarheid van bevindingen belemmerde en dat meer standaardisatie gunstig zou zijn voor toekomstige vergelijkende studies.

Hoofdstuk 5 gebruikte gegevens uit de Doetinchem Cohort Study om de Healthy Ageing Index (HAI) te ontwikkelen en te beschrijven. De studie onderzocht of er verschillende typische verouderingstrajecten bestaan voor vrouwen en mannen tussen de 30 en 70 jaar. De HAI weerspiegelt vijf belangrijke fysiologische systemen gemeten door de volgende indicatoren: systolische bloeddruk, creatinine, geforceerde vitale capaciteit, bloedglucose en cognitieve functie. Op basis van observaties bij 2.325 vrouwen en 2.013 mannen gedurende een follow-upperiode van 20 jaar, werden één typisch HAI-traject voor vrouwen en twee trajecten voor mannen geïdentificeerd. De laatste twee werden gelabeld als geleidelijke veroudering (76% van de mannen) en vroege veroudering (24% van de mannen). Tussen de leeftijd van 30 en 70 jaar hadden mannen in het vroege verouderingstraject de minst gezonde jaren (29,6 jaar), gevolgd door vrouwen (30,1 jaar) en geleidelijk ouder wordende mannen (34,7 jaar). Mannen die voldeden aan de richtlijnen voor lichamelijke activiteit en niet zwaarlijvig waren, hadden meer kans om het geleidelijke verouderingstraject te volgen. Hoofdstuk 5 benadrukte dat fysiologische veroudering, geschat met de HAI, al op relatief jonge leeftijd begint en dat gezond gedrag een belangrijke rol speelt in verouderingstrajecten.

Wereldwijd zijn er aanzienlijke hiaten in de diagnose, behandeling en controle van hypertensie om vroegtijdige sterfte te voorkomen. **Hoofdstuk 6** concentreerde zich op het zorgcontinuüm met betrekking tot hypertensie in Mexico, een hoog midden-inkomensland met de hoogste prevalentie van overgewicht ter wereld en waar niet-overdraagbare aandoeningen verantwoordelijk zijn voor 80% van alle sterfgevallen. Het doel van de studie gepresenteerd in Hoofdstuk 6 was dan ook om de prevalentie en sociaaleconomische distributie van hypertensie te schatten die ten minste vijf jaar ongediagnosticeerd, onbehandeld en ongecontroleerd blijft, en om de transities tussen deze hypertensietoestanden te schatten. Er werden gegevens gebruikt uit de WHO Study on Global aging and adult health (SAGE). De resultaten toonden aan dat van de 945 Mexicanen van 50 jaar en ouder, 60% geclassificeerd was met hypertensie. De schattingen van het continuüm van hypertensiezorg onthullen aanzienlijke percentages van aanhoudende, niet-gediagnosticeerde, onbehandelde en ongecontroleerde hypertensie. Van degenen met ongecontroleerde hypertensie bij de eerste meting, bleef meer dan de helft (62%) vijf jaar later in deze toestand. Hoewel de classificatie hypertensie meer voor kwam bij mensen met een hogere sociaaleconomische status, kwamen ontbrekende diagnose, behandeling en gecontroleerde hypertensie vaker voor bij mensen met een lagere sociaaleconomische status. Hoofdstuk 6 liet zien dat klinische en volksgezondheidsinterventies nodig zijn om screening en zorg voor mensen met hypertensie in Mexico te verbeteren.

Deel III – Zorgbeleid

Hoofdstukken 7 tot 10 bespreken de voorkeuren van het publiek voor zorgbeleid om de volksgezondheid te verbeteren, met bijzondere aandacht voor de individuele verantwoordelijkheid voor gezondheid. **Hoofdstuk 7** onderzocht de opvattingen van experts en het publiek in Nederland over het opnemen van een leefstijlgerelateerd-besliscriterium bij het stellen van prioriteiten in de gezondheidszorg. Er werden vier verschillende visies onthuld, die allemaal werden ondersteund door een mix van leden van het publiek en experts. Deze standpunten benadrukten verschillende elementen zoals de effectiviteit van behandelingen, de waarde van (het redden van een) leven ook in slechte gezondheidstoestanden, individuele verantwoordelijkheid en overheidsingrijpen bij ongezonde leefstijlen en het belang van kosteneffectiviteit van behandelingen. Over het algemeen laten de resultaten enige maar over het algemeen beperkte steun zien voor een levensstijlcriterium, en deze steun werd alleen gevonden bij leden van het publiek.

Hoofdstukken 8 en 9 richten zich op veel besproken beleid gericht op het bevorderen van gezonde voeding. **Hoofdstuk 8** evalueerde de voorkeuren voor zeven beleidsmaatregelen met verschillende mate van opdringerigheid onder een representatieve steekproef (N=599) van het Nederlandse publiek, met behulp van een discreet keuze-experiment. Uit de resultaten bleek dat subsidies voor groenten en fruit en een gematigde belasting op suikerhoudende dranken de meeste voorkeur hadden. Latente klassenanalyses identificeerden drie klassen met verschillende voorkeuren: de meerderheid (56%) van de respondenten was positief over alle voorgestelde beleidsmaatregelen, terwijl 27% gemengde meningen had en een minderheid van 17% tegen alle voorgestelde beleidsmaatregelen was. Dit benadrukte belangrijke heterogeniteit in voorkeuren. **Hoofdstuk 9** evalueerde vervolgens de verwachte effectiviteit van de zeven beleidsmaatregelen die ook in hoofdstuk 8 zijn onderzocht. Aan Nederlandse volwassenen (N=700) werd gevraagd welk effect zij van dit beleid voor zichzelf en voor anderen verwachtten. Uit de resultaten bleek dat respondenten in het algemeen de effectiviteit van het beleid hoger inschatten voor anderen dan voor zichzelf, behalve voor het voorlichtingsbeleid. Bovendien werd verwacht dat meer opdringerig beleid (bijvoorbeeld het verbieden van ongezonde producten op bepaalde plaatsen) het meest effectief zou zijn. Gezien deze resultaten kan de effectiviteit van beleid gericht op het verbeteren van de levensstijl van mensen worden overschat wanneer deze (mede) gebaseerd zijn op verwachtingen van hun effecten bij anderen.

Hoofdstuk 10 gaat over COVID-19. De snelle verspreiding van het COVID-19-virus overspoelde de gezondheidszorgstelsels in veel landen en resulteerde in een tekort aan bedden op de intensive care (IC). Daarom onderzochten wij in dit hoofdstuk de voorkeuren met betrekking tot de toewijzing van IC-bedden tijdens een gezondheidscrisis. Een representatieve steekproef van de Nederlandse bevolking (N=1.019) is bevraagd, waarbij de nadruk ligt op wie moet beslissen over de toewijzing van IC-bedden en met welke besliscriteria daarbij rekening moet worden gehouden. De meerderheid van de respondenten was voorstander van het betrekken van artsen en/of commissies van deskundigen bij de ontwikkeling van richtlijnen voor de toewijzing van schaarse IC-bedden tijdens een gezondheidscrisis. Een deel van de respondenten steunde echter geen van de beslissers hierin, of wilde geen verantwoordelijkheid dragen voor dit soort beslissingen. Respondenten gaven de voorkeur aan besliscriteria die betrekking hadden op de gezondheidstoestand en vooruitzichten van patiënten en hun risicoprofielen. Criteria met betrekking tot persoonlijke kenmerken zoals hun leeftijd of het naleven van door de overheid geadviseerde veiligheidsmaatregelen kregen weinig steun.

De bevindingen van de negen onderzoeken die in dit proefschrift worden gepresenteerd, laten een aanzienlijke heterogeniteit zien in gezond gedrag, gezondheid en beleidsvoorkeuren in verschillende populaties. Cijfers over gezond gedrag laten zien dat er veel ruimte is voor verbetering en de sociaaleconomische ongelijkheid in gezond gedrag en gezondheid blijft hardnekkig. Dit proefschrift biedt belangrijke inzichten over de verdeling van gezond gedrag in verschillende populaties en de voorkeuren voor beleid om ongezond gedrag aan te passen en de toename van niet-overdraagbare ziekten te beteugelen.

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PhD portfolio

PHD PORTFOLIO

Training

2019	Choice modelling and stated choice survey design, Choice Modelling Centre, University of Leeds, London, United Kingdom
2018	Speak up my dear! – Presentation and profiling training for women, Zeist, the Netherlands
2018	Q Methodology, Caledonian University, Glasgow, United Kingdom
2018	Great thinkers of the 20th century, Erasmus Graduate School of Social Sciences and Humanities, Rotterdam, the Netherlands
2018	Advanced Behavioral Economics, Erasmus School of Economics, Erasmus University Rotterdam, Rotterdam, the Netherlands
2018	Doctoral course: "Methods for Life course epidemiology", Karolinska Institutet & the Swedish Interdisciplinary Graduate School in register-based research, Stockholm, Sweden
2018	English Academic Writing for PhD Students, Erasmus Graduate School of Social Sciences and Humanities, Rotterdam, the Netherlands
2018	Making an academic poster that stands out, Erasmus Graduate School of Social Sciences and Humanities, Rotterdam, the Netherlands
2018	How to manage your PhD, Erasmus Graduate School of Social Sciences and Humanities, Rotterdam, the Netherlands
2017	Effective communication, Aletta Wubben, Human- and Organization development, Rotterdam, the Netherlands
2017	Group Dynamics, Risbo institute, Erasmus University Rotterdam, Rotterdam, the Netherlands
2017	Basic didactics and group dynamics for PhD students, Risbo institute, Erasmus University Rotterdam, Rotterdam, the Netherlands
2017	Searching, finding and managing your literature, Erasmus Graduate School of Social Sciences and Humanities, Rotterdam, the Netherlands
2017	Social Epidemiology, Erasmus Summer Programme, Erasmus Medical Centre, Netherlands Institute for Health Sciences, Rotterdam, the Netherlands
2017	Primary and Secondary Prevention Research, Erasmus Summer Programme, Erasmus Medical Centre, Netherlands Institute for Health Sciences, Rotterdam, the Netherlands

Teaching

2020 – 2021	Thesis supervision, course in Master programmes in Health Economics, Policy and Law, Erasmus University Rotterdam
2020 – 2021	Global Health Economics, course in Master programmes in Health Economics, Policy and Law and Health Economics, Erasmus University Rotterdam
2020 – 2021	Choices & Dilemma's, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam
2019 – 2020	Thesis supervision, course in Master programmes in Health Economics, Policy and Law and Health Economics, Erasmus University Rotterdam
2019 – 2020	Thesis supervision, course in European Master programme in Health Economics & Management, Erasmus University Rotterdam & University of Bologna
2019 – 2020	Choices & Dilemma's, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam
2019 – 2020	Healthcare Ethics, course in Master programmes in Health Economics, Policy and Law and Health Care Management
2019 – 2020	Global Health Economics, course in Master programmes in Health Economics, Policy and Law and Health Economics, Erasmus University Rotterdam
2018 – 2019	Thesis supervision, course in Master programmes in Health Economics, Policy and Law and Health Economics, Erasmus University Rotterdam
2018 – 2019	Thesis supervision, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam
2018 – 2019	Healthcare Ethics, course in Master programmes in Health Economics, Policy and Law and Health Care Management
2018 – 2019	Global Health Economics, course in Master programmes in Health Economics, Policy and Law and Health Economics, Erasmus University Rotterdam
2018 – 2019	Quantitative research in healthcare, course in Pre-Master programme in Health Policy & Management, Erasmus University Rotterdam
2017 – 2018	Thesis supervision, course in Master programme in Health Economics, Policy and Law, Erasmus University Rotterdam
2017 – 2018	Thesis supervision, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam
2017 – 2018	Quantitative research in healthcare, course in pre-master programme in Health Policy & Management, Erasmus University Rotterdam
2017 – 2018	Introduction to Health Sciences, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam
2017 – 2018	Mentorship new students, course in Bachelor programme in Health Policy & Management, Erasmus University Rotterdam

Research grants

2021	Ter Meulen beurs, Dutch Royal Institute of Sciences
2021	Research grant Erasmus Trustfonds

Invited presentations

2021	Guest Lecture – African Dynamics, minor course in Bachelor programmes, Leiden University, Technical University of Delft, Erasmus University Rotterdam
2018	Dutch Ministry of Health, Welfare and Sport, The Hague, the Netherlands. Research presentation.

Conference and symposium presentations

2021	European Health Economics PhD-Supervisor (online edition), Rotterdam, the Netherlands. Discussant.
2019	Interdisciplinary Global Health Master Classes, Amsterdam, the Netherlands. Paper presentation.
2019	WEON Healthy Ageing, Groningen, the Netherlands. Poster presentation.
2019	International Association of Gerontology and Geriatrics European Region (IAGG ER), Gotenburg, Sweden. Poster presentation.
2018	Lowlands Health Economics Study Group (LOLA HESG), Hoenderloo, the Netherlands. Paper presentation.
2018	International Society on Priorities in Health (ISPH), Linkoping, Sweden. Poster presentation
2018	European Health Economics Association (EuHEA), Maastricht, the Netherlands. Paper presentation.
2017	International Health Economics Association (iHEA), Boston, United States of America. Paper presentation.

Miscellaneous

2021 - 2022	World Health Organization – Consultancy project: Health seeking and non-communicable diseases in low- and middle-income countries
2019 – 2021	Member Erasmus Choice Modelling Centre (ECMC)
2018 – 2021	Member Rotterdam Global Health Initiative (RGHI)
2019 – 2021	Referee for: *BMC Geriatrics, BMJ Open, Gerontology, Global Health Research and Policy, PLOS ONE, Population Health Metrics, Frontiers in Health*
2019 – 2020	External researcher at National Institute for Public Health and the Environment (RIVM), de Bilt, the Netherlands.
2018	Prevention of Dementia: invited meeting with Secretary of State Paul Blokhuis. Ministry of Health, Welfare, and Sport. The Hague, the Netherlands.

List of publications

Dieteren, C. M., O'Donnell, O., & Bonfrer, I. (2021). Prevalence and inequality in persistent undiagnosed, untreated, and uncontrolled hypertension: Evidence from a cohort of older Mexicans. *PLOS Global Public Health*, *1*(12), e0000114.

Dieteren, C. M., Reckers-Droog, V. T., Schrama, S., de Boer, D., & van Exel, J. (2021). Viewpoints among experts and the public in the Netherlands on including a lifestyle criterion in the healthcare priority setting. *Health Expectations*.

Dieteren, C. M., Brouwer, W. B., & Bonfrer, I. (2021). Overheidsmaatregelen om overgewicht tegen te gaan. *TSG-Tijdschrift voor gezondheidswetenschappen*, 1-5.

Dieteren, C.M. & Bonfrer, I. (2021). Socioeconomic inequalities in lifestyle risk factors across low-and middle-income countries. *BMC public health*, *21*(1), 1-12.

Dieteren, C. M., Faber, T., van Exel, J., Brouwer, W. B., Mackenbach, J. P., & Nusselder, W. J. (2021). Mixed evidence for the compression of morbidity hypothesis for smoking elimination—a systematic literature review. *European journal of public health*, *31*(2), 409-417.

Dieteren, C. M., Samson, L. D., Schipper, M., van Exel, J., Brouwer, W. B., Verschuren, W. M., & Picavet, H. S. J. (2020). The healthy aging index analyzed over 15 years in the general population: the Doetinchem cohort study. *Preventive Medicine*, *139*, 106193.

Dieteren, C. M., Brouwer, W. B., & van Exel, J. (2020). How do combinations of unhealthy behaviors relate to attitudinal factors and subjective health among the adult population in the Netherlands?. *BMC Public Health*, *20*(1), 1-14.

Other academic work

Dieteren, C.M., Patty, N., Reckers-Droog, V., van Exel, J. (2021) Q Methodology – A Systematic Review. *Under review.*

de Veer, A., Dieteren, C., & de Groot, K. (2017). Cliëntgebonden samenwerking over organisatiegrenzen heen: Verpleegkundige voelt zich onvoldoende competent. *TVZ-Tijdschrift voor verpleegkundige experts*, *127*(4), 32-33.

Dieteren, C. M., de Veer, A. J. E., & Groot, K. D. (2017). Cliëntgebonden samenwerking over de grenzen van organisaties: tabellen.

de Veer, A. J., Dieteren, C. M., & Francke, A. L. (2017). Goed voorbeeld, goed volgen? Evaluatie van het Verbeterprogramma Palliatieve Zorg.

Testa, M., Dieteren, C., Tavoschi, L., & Lopalco, P. (2015). Burden, costs and prevention measures for communicable diseases among inmates in EuropeMarco Testa. *European Journal of Public Health*, *25*(suppl_3).

& About the author

ABOUT THE AUTHOR

Charlotte Dieteren followed the bachelor Health Sciences at Maastricht University from 2010 - 2013. She specialized in Policy, Management and Evaluation of Health Care. For her thesis project she went to Ghana to study the phenomenon "brain drain" of health professionals. Thereafter she started with the Research Master Global Health at Vrije Universiteit (VU) Amsterdam. Charlotte went for several months to South Africa to contribute to a transdisciplinary research project focusing on pregnant women living in slums. For her master thesis she was selected for an internship at the European Centre for Disease Control (ECDC) based in Stockholm, Sweden. She assessed the vaccination policies for healthcare workers in European hospitals. After she obtained her first MSc Degree at the VU she wanted to specialize further in health economics and successfully finished her second master (Health Economics, Policy and Law) at the Erasmus University Rotterdam.

After her studies, Charlotte started working as a junior researcher at the Netherlands Institute for Health Services Research (NIVEL). One year later, Charlotte had the opportunity to start a PhD trajectory at the Erasmus School of Health Policy and Management (ESHPM). Currently she is working as a post-doctoral researcher in the field of global health economics at ESHPM. The final two months of 2021 she was in India to conduct an impact evaluation of a smartphone application to improve maternal knowledge and behaviors among pregnant women. In June 2022, she will start working as a Research Advisor Health Economics at PharmAccess. Their goal is to make inclusive health markets work in sub-Saharan Africa.

& Dankwoord

DANKWOORD

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