Rijksinstituut voor Volksgezondheid
en Milieu
*Ministerie van Volksgezondheid,
Welzijn en Sport*

Integrative Measures for the Public Health Foresight Study (VTV) 2018

Results and methodology

Colophon

This is a background document for the Public Health Foresight Study 2018.

RIVM experts from the following centres have contributed to the integrative measures for the Synthesis of the VTV–2018:

Environment and Safety Division:
- Centre for Sustainability, Environment and Health
- Centre for Environmental Quality

Public Health and Health Services Division:
- Centre for Nutrition, Prevention and Health Services
- Centre for Health and Society

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1 Introduction

1.1 The Public Health Foresight Study 2018 (VTV–2018)

Conducted every four years, the Public Health Foresight Study (VTV) provides insight into the most important future challenges facing society in the fields of illness and health, health determinants, prevention and health care in the Netherlands. This edition of the Public Health Foresight Study is the VTV–2018. The VTV–2018 consists of multiple products.

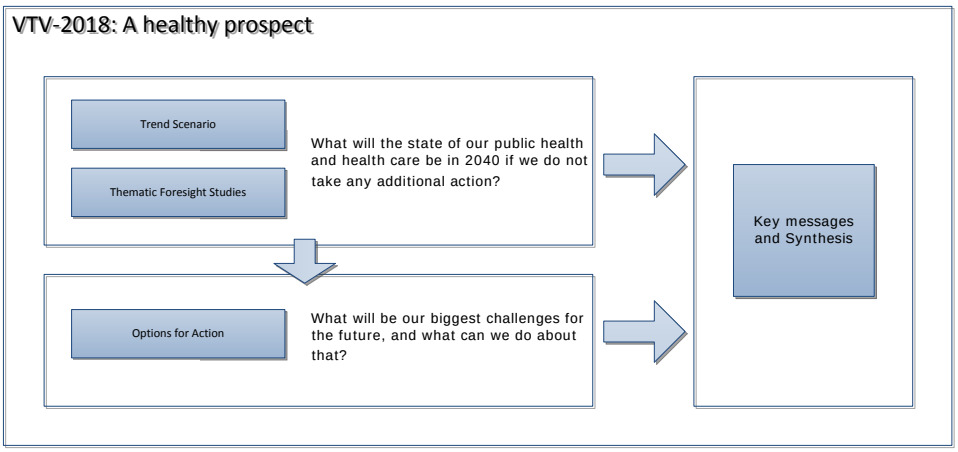

Figure 1 The elements of the VTV–2018 (see www.vtv2018.nl)

The Trend Scenario and Thematic Foresight Studies show how our public health situation and health care sector will develop over the next 25 years if we pursue our current course and do not take any additional measures. This approach makes it possible to map out the societal challenges for the future. The Trend Scenario presents quantitative projections for various indicators, while the Thematic Foresight Studies are descriptive in nature and deal with health care demand, the wider determinants of health, and technology. The Trend Scenario and Thematic Foresight Studies offer an overview of what lies ahead of us. The Options for Action section takes a closer look at what we could do about the challenges before us. The Synthesis integrates the most important conclusions of the three elements of the VTV–2018. The Synthesis includes various integrative measures, such as the extent to which determinants contribute to the burden of disease, death, and health care expenditures. This report presents the underlying results and describes the methodology and data used for calculating these integrative measures. This document is an abbreviated edition of the more extensive Dutch version. In the Dutch version, additional results are presented.

2 Population Attributable Fraction (PAF)

In addition to mapping health impacts such as death, burden of disease and costs of disease, it is also important to identify which determinants are responsible for these impacts. *Population attributable fractions* (PAF) are often used to attribute health impacts to determinants. A PAF indicates which part of health impacts can be attributed to a specific determinant. This does not always provide a realistic image of avoidable health impacts. That is because it is not always possible to completely exclude the risk factor (for instance, in the case of air pollution, there is always an unalterable background concentration due to e.g. sea salt) or because part of the current impacts come from 'accrued damage' from the past which can no longer be removed (such as smoking-related impacts caused by a history of smoking behaviour). However, the PAF does provide a good indication of the scope of the impacts that can be attributed to these risk factors. In order to calculate a PAF, information is needed about exposure(s), the relative risk of these exposure(s), and the impacts that can be associated with them. These aspects are explained in more detail in the following sections.

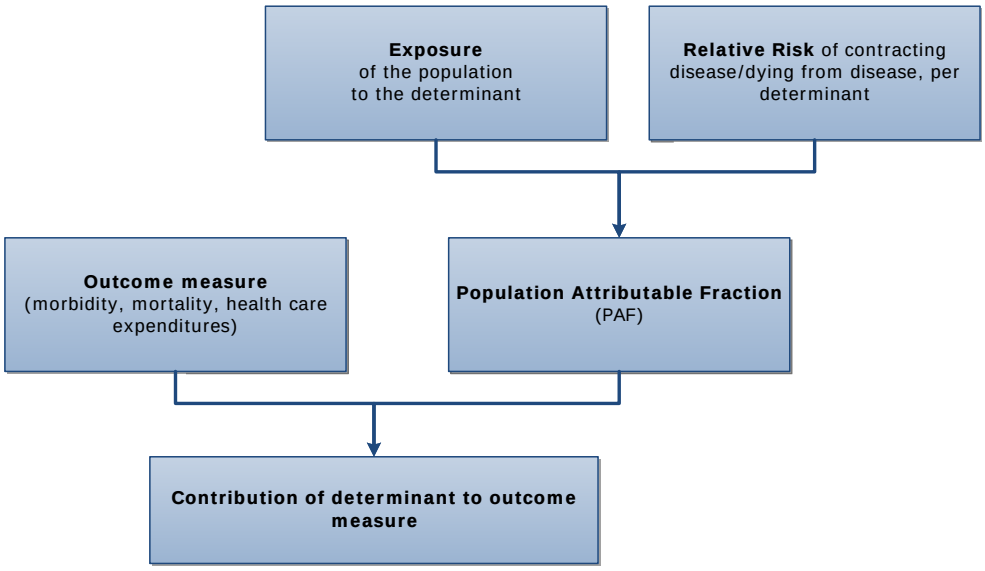

Figure 2 Schematic representation of the calculation of the extent to which determinants contribute to outcome measures

2.1 Exposure and relative risks

Calculating the PAF requires data on exposure to a determinant and the effects of this exposure, expressed in terms of relative risk (RR). RR is an indicator of the dose-response relation, i.e. the expected effects at a specific level of exposure compared to people who have not been exposed. Examples of these effects include increased frequency of occurrence or a higher death rate. The RRs may be available for specific diseases or for a group of diseases or causes of death, and may vary depending on sex and age. The choice of which RRs to use is an important decision, as it will have a substantial effect on the results. There is a constant stream of studies being published on countless RRs. These results are not always conclusive, and in many cases cannot be translated unequivocally to specific exposures in the Netherlands. This

report describes per determinant which choices have been made and offers accountability for those choices.

2.2 Determinants

Which determinants have been included in calculating the integrative measures in the VTV–2018? Obviously, it is only possible to distinguish determinants if sufficient data is available on exposure and relative risks. Much of the required information on e.g. relative risks has already been compiled in the context of chronic disease modelling at RIVM (Chronic Disease Model, DYNAMO HIA[1]). This existing evidence base was an important guiding principle in the selection of these determinants. The evidence base primarily concerns lifestyle factors. These lifestyle factors are then differentiated based on behaviour (e.g. smoking, alcohol consumption and physical activity) and metabolic factors (e.g. overweight and high blood pressure), although these two categories of factors are closely related. In addition to these factors, other determinants also play a role. For instance, the environment-related burden of disease is calculated within the environmental domain[2], and the work-related burden of disease is calculated for the Ministry of Social Affairs and Employment every two years[3]. The VTV–2018 has been clustered into four main groups of determinants: Behaviour, Metabolic, Labour and Environment. These main groups can be divided into subgroups of determinants, and sometimes those subgroups can be divided even further. These determinants can also be considered in comprehensive context. This is not simply a matter of adding things up, since many of the underlying determinants are related; considering the determinants as a whole requires a mathematical correction (see next section).

2.3 PAF calculation

The following formula is used to calculate the PAF:

$$PAF = \frac{\sum_{i=0}^{k} P_i \times (RR_i - 1)}{1 + \sum_{i=0}^{k} P_i \times (RR_i - 1)}$$

To calculate the PAF, a reference category is chosen. This is the group that is used to calculate the additional risk. For smoking, that group would be the non-smokers who have a relative risk of 1 (no elevated risk). It is trickier to determine the reference category for alcohol, as alcohol consumption also has a protective effect for specific cardiovascular diseases, while at the same time also leading to an increased risk for cancer (see section on alcohol).

Where possible and relevant, the PAFs have been calculated separately for morbidity (disease) and mortality (death). That is only possible when the relative risks can be divided into morbidity and mortality. If they cannot be divided, it is assumed that the PAFs for morbidity and mortality are the same. Where relevant, PAFs are also divided based on age and sex.

All PAFs that are used in this Foresight Study are available for download on the website (https://www.vtv2018.nl/en/node/991).

1 Lhachimi, S. K., W. J. Nusselder, H. A. Smit, P. v. Baal, P. Bailli, K. Bennett, E. Fernández, M. C. Kulik, T. Lobstein, J. Pomerleau, J. P. Mackenbach and H. C. Boshuizen (2012). "DYNAMO-HIA - A Dynamic Modelling tool for generic Health Impact Assessments." PLoS One 7(5).
2 Hänninen O, et al, EBoDE Working Group. 2014. Environmental burden of disease in Europe: assessing nine risk factors in six countries. Environ Health Perspect 122:439–446; http://dx.doi.org/10.1289/ehp.1206154
3 TNO (2016), Arbobalans 2016, http://www.monitorarbeid.tno.nl/nieuws/arbobalans-2016

2.4 Outcome measures

Once the PAFs have been calculated, they can be used in combination with various outcome measures, such as death, burden of disease and cost of illness. The 101 VTV diseases are used as guiding principles for these outcome measures (see Trend Scenario method). Using this selection of diseases, it is possible to present the results for the ICD main groups[4] as well as the specific diseases. Combining PAFs for mortality with the results for cause-specific deaths results in the percentage of deaths that can be attributed to the underlying determinants. For the burden of disease, the PAFs for mortality are combined with the Years of Life Lost (YLL), a measure for the number of years that people die prematurely due to a specific cause of death, and the PAFs for morbidity with the Years Lived in Disability (YLD), a measure for the occurrence of diseases, taking into account their severity. The sum of the YLL and YLD will then result in the Disability-Adjusted Life Year (DALY).

A third outcome measure is health care expenditures, based on the Costs of Illness study 2018[5]. Since the Cost of Illness study specifies health care expenditures by diagnosis, the amount that determinants contribute to health care expenditures can also be calculated by linking them with the morbidity PAFs. However, the classification of diagnosis groups in the Costs of Illness study does not always align with the list of 101 diseases which is used in VTV–2018, simply because the level of detail in the underlying data does not always allow for such detailed classification. This applies to e.g. injury and some forms of cancer. For the remaining expenditures, an additional attribution has been made in health care expenditures regarding a disease in the relevant ICD main group. This is done based on the YLD. The implicit assumption is that a disease with a high YLD will also result in high health care expenditures. Next, these expenditures have been allocated to the determinants.

In addition to disease of burden and health care expenditures, there are also effects in relation to other outcomes. Examples of these outcomes are sleep disturbance due to excessive noise and annoyance due to odours. As far as excessive noise is concerned, the effects on cardiovascular disease have been included, but not the effects on sleep disturbance as such. Moreover, health care expenditures only indicates part of the economic impact. Costs due to absenteeism or reduced productivity are not included, for instance.

2.5 Combining PAFs

A person can be exposed to multiple risk factors or determinants. These determinants can have an influence on the same endpoints and the PAFs cannot just be casually added up without further processing. A simple sum would attribute too much impact to specific determinants (sometimes adding up to more than 100%). For instance, lung cancer is associated with many different determinants (smoking, secondary smoke, nutrition, air pollution and occupational factors). To correct for these factors, the PAFs are multiplicatively combined with the same endpoints according to the following formula. This is done on the assumption that the effects of determinants occur independently at the same endpoints. This correction is applied in order to calculate the totals

4 International Statistical Classification of Diseases and Related Health Problems http://apps.who.int/classifications/icd10
5 https://www.volksgezondheidenzorg.info/kosten-van-ziekten

at the various different levels (see Figure 3). The formula to calculate such a combined PAF is therefore:

$$PAF_{combi} = 1 - \prod_i (1 - PAF_i)$$

2.6 Global Burden of Disease (GBD)

The Institute for Health Metrics and Evaluation (IHME) also generates estimates for the burden of disease and for the attribution to the underlying determinants[6]. They do so for every country, including the Netherlands. As their primary goal is to reach worldwide estimates in their Global Burden of Disease project, generic methods are used to ensure that the data and results between countries are comparable. These methods include e.g. processing data regarding disease and death based on various background variables, such as income and education level. For instance, the IHME has applied a substantial reallocation of causes of death in the Netherlands. This has changed the deaths in 2015 due to coronary disease from 9,000, as listed in the VTV, to 17,500 after correction. It is sometimes hard to retrace the exact figures and calculations applied in the GBD, such as exposure levels in the Netherlands. What does set the GBD study apart, though, is the way in which it includes the underlying studies for relative risks and reports back on the results. A user-friendly data tool for accessing the results is also very helpful for viewing and analysing the results. A wide range of determinants was also considered. By making our own PAF calculations for the VTV, we ensure that they are more closely aligned with Dutch data for specific determinants (for instance the Dutch Physical Activity Guidelines) and that additional relevant categories can be identified (for instance, not only smokers, but ex-smokers as well). It is also important to keep these calculations consistent with the Trend Scenario from the VTV–2018 as well as with other RIVM products, such as VZinfo.nl, the gateway to information about health and disease, risk factors, care and prevention in the Netherlands, and Staatvanvolksgezondheid.nl, an overview of consistent statistics on public health and health care in the Netherlands. Accordingly, the VTV generates its own calculations wherever possible. In situations where that is not possible, or where it would result in incomplete calculations, GBD estimates are used. That is the case for dietary risks, low bone density and high blood pressure (see Figure 3), for which original calculations were not available regarding exposure. To that end, we have included the morbidity and mortality PAFs from the GBD and combined them with the outcome measures from the Trend Scenario. That means the reallocation of disease and death has not been incorporated from the GBD.

The underlying GBD data sources are available in a searchable data bank http://ghdx.healthdata.org

6 Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2016 (GBD 2016) Burden by Risk 1990-2016. Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2017.

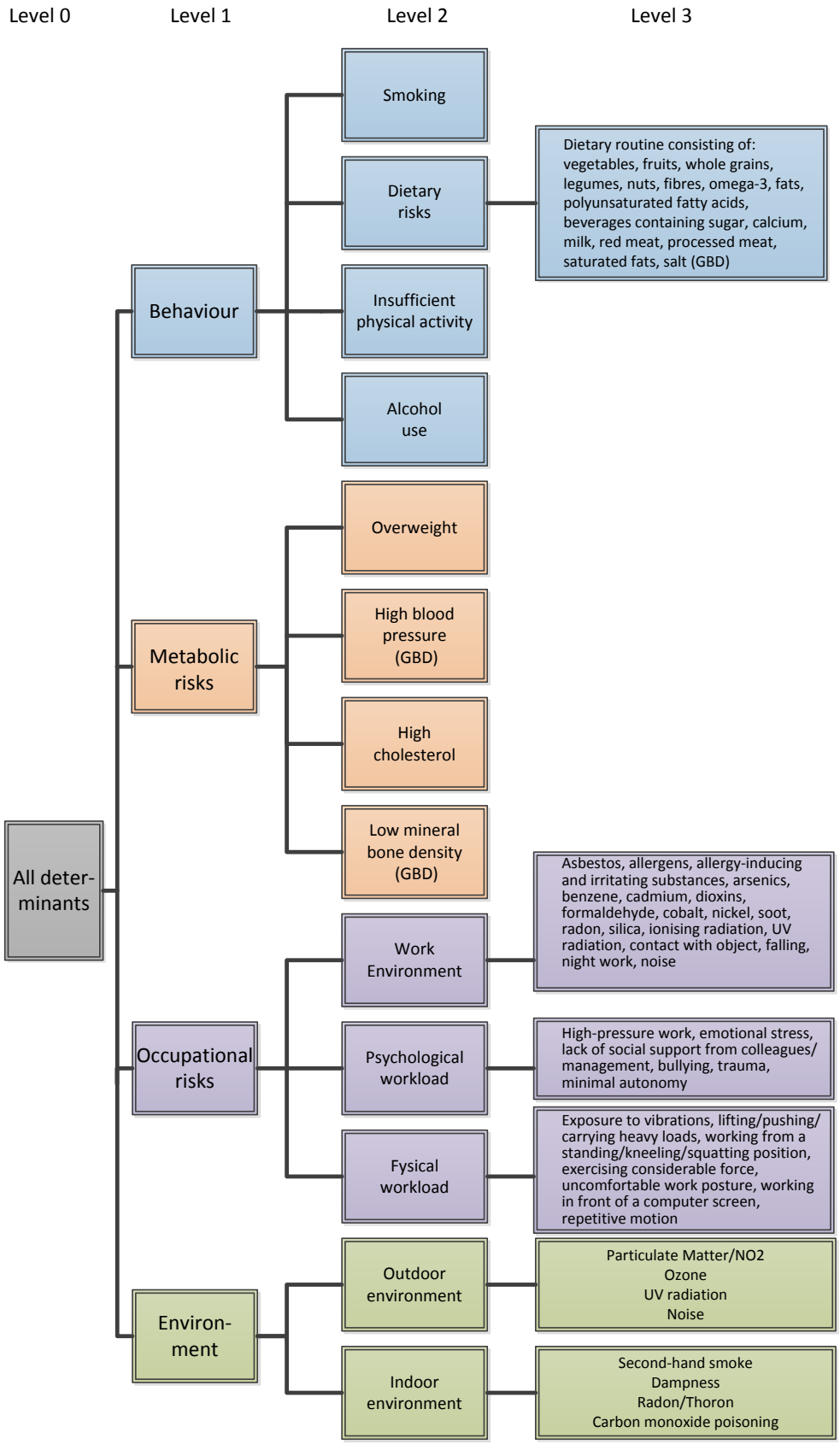

Figure 3 Determinants and determinant groups at various levels

Contribution of determinants to death and burden of disease

The method applied in the VTV–2018 is different than methods used in previous Public Health Foresight Studies. For instance, there are more overarching groups of determinants; in case of some determinants, the effects on more diseases have been included. The percentages of the burden of disease attributable to the determinants have also been calculated based on the *total* burden of disease. Previous Public Health Foresight Studies were often based on 59 diseases, which covered approximately two-thirds of the total burden of disease. The current VTV is based on a more comprehensive burden of disease. This makes the percentages non-comparable to previous publications.

3 Contribution of determinants to health care expenditures

In addition to death and burden of disease, it is also relevant to calculate the contribution to health care expenditures. Just like with the DALYs and death rate, this indicates the theoretical contribution to health care expenditures. It is not always possible to reduce exposure to zero. Moreover, effects from exposure in the past may play a role, or the effect of one determinant may be increased by removing another determinant. Nevertheless, these calculations provide an overview of the health care expenditures associated with the underlying determinants. These calculations are made using the morbidity PAFs, categorised according to age, sex and disease, combined with health care expenditures in relation to age, sex and condition. The results are presented here in less detail.

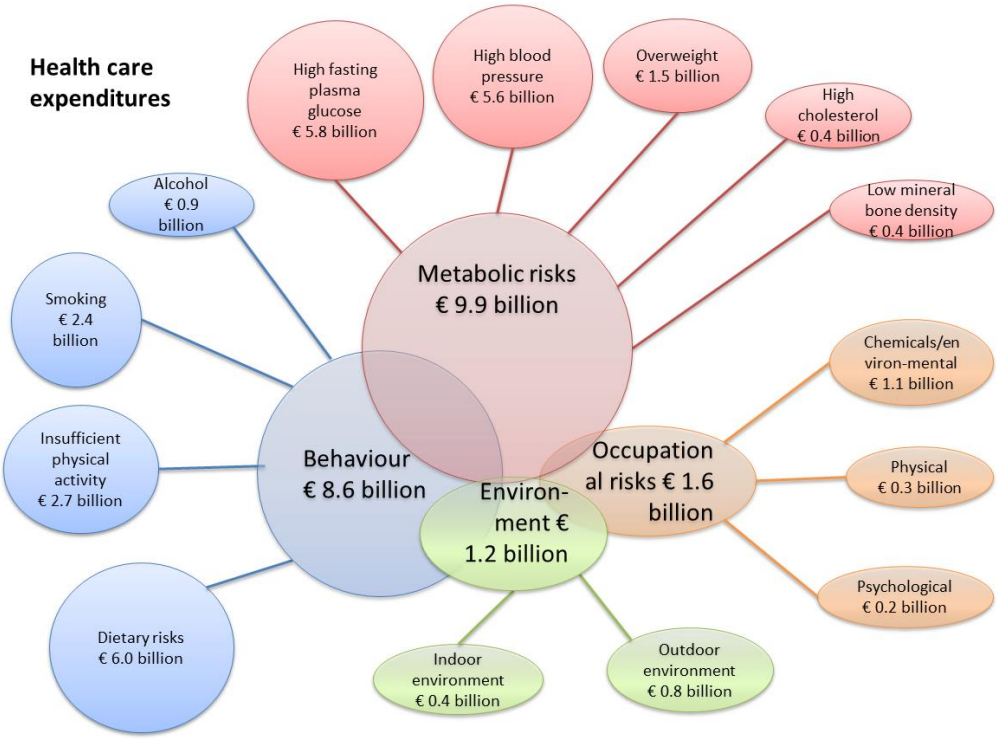

Figure 4 Results for contribution of determinants to health care expenditures

4 Other integrative measures

In addition to the contribution of determinants to burden of disease, death and health care expenditures, the underlying PAFs for mortality and morbidity can also be used to generate analyses for (healthy) life expectancy.

4.1 Health-adjusted Life Expectancy (HALE)

Within the family of population health metrics (integrative public health measures), the commonly used Disability-Adjusted Life Years (DALY) metric is a significant supplement to the Health-Adjusted Life Expectancy (HALE). Both of these measures assess health gaps that indicate how significant the 'loss of health' is. This loss of health is thus a combination of premature death and the prevention of diseases. But where the DALY, and specifically the YLD (Years Lived in Disability) component of the DALY, is a reflection of the absolute loss – the bigger an age group, the bigger the contribution in the DALY – the HALE is a relative metric which looks at structural changes within age groups. Life expectancy will then indicate how many years are lost on average due to death, while HALE shows how many healthy years of that life expectancy (LE) are lost on average due to disease. The HALE, just like the DALY, also takes into account the severity of the diseases.

The HALE is calculated using a life table based on the Sullivan method[7], which is used to calculate life expectancy. Health prevalences are used in the life table, making it possible to calculate life expectancy as well as healthy life expectancy. The various healthy life expectancies in the Trend Scenario include e.g. occurrence of activity limitations and perceived health as health prevalences. The Years Lived in Disability (YLD) figure, one of the components of the DALY, is used to calculate those figures for the HALE. The per capita YLDs, i.e. the YLDs divided by the population by age and sex, are used as health prevalences for the life table. Since the YLDs have now been corrected for multimorbidity (see Trend Scenario method), the YLDs per capita do not exceed 1. The method used to calculate burden of disease has also been improved, so it is now possible to generate an estimate for all YLDs, including the residual categories. Consequently, this result may be the most accurate representation of the HALE.

4.2 Loss of healthy years and years of life due to premature death

As discussed above, (HA)LE can be used to calculate health loss, expressed in the number of years lost due to disease and the number of years lost to premature death. By taking a look at disease and death with a focus on the underlying diseases or groups of diseases, it is also possible to calculate how many (healthy) years are lost per disease or group of diseases. The underlying life tables combined with the YLDs per capita are used to calculate these figures. As the VTV also provides projections per disease and death with regard to underlying causes, they can be calculated for each year from 2015 to 2040. The life table applicable to that year is used for that purpose.

7 Sullivan D.F. A single index of mortality and morbidity. HSMHA Health Reports 1971;86: 347–354.

Since PAFs can also be used to attribute death and disease to underlying risk factors, the same exercise can be used to calculate the number of lost (healthy) years attributable to the determinants.

5 Considerations

1. The PAF methodology is a static approach used to attribute death and disease to risk factors. Such a static approach does not always provide a realistic impression of avoidable burden of disease, death or health care expenditures. For instance, in case of smoking, considerable damage has already been accrued, which means that ex-smokers will continue to experience increased risks. When the effect of one determinant is reduced, it may also increase the impact of another determinant. When interpreting and using these results, that needs to be taken into account.
2. The relative risks and PAFs used here reflect the current state of affairs regarding the relationship between determinants and diseases. However, science does not stand still and new insights are frequently published. These updates address changes in insights regarding existing relationships as well as new relationships between determinants and diseases. The results of various studies are not always unambiguous either, or cannot be applied indiscriminately. The relative risks, and therefore also the results, are thus subject to change over time.
3. A number of determinants make use of the GBD (Global Burden of Disease, IHME). This study is a rich source of underlying data, some of which is used in the VTV. The GBD also makes it possible to compare VTV results. There are similarities, but also quite a few differences between the GBD and the VTV. This indicates that there are various ways to interpret data and methods. We stand to benefit from insights into these differences and how they can influence the end results.
4. The purpose of these calculations is to provide estimates of the extent to which determinants contribute to various outcome measures. Findings 2) and 3) indicate that these estimates are subject to uncertainties, which can be both statistical and structural in nature. Addressing these uncertainties would require a huge investment in terms of time and capacity, which is why they are not made more explicit in the VTV. It is recommended to pay more attention to these uncertainties in future Public Health Foresight Studies.
5. The outcome measures for death, burden of disease and health care expenditures do not reflect all of the ways that the determinants affect health. Effects also include severe sleep disturbance, absenteeism, loss of productivity, perceived health, participation in activities (as well as limitations on participating in activities) that are not covered by these outcome measures. As a result, not all health effects of these determinants have been included in the calculations for this VTV.
6. The determinants in the VTV only partially explain the health impacts. Even though the most important determinants have been

included – to the extent that they are known and quantifiable – the majority of health impacts are not (demonstrably) attributable to these determinants.

7. The method for calculating the PAFs has improved compared to previous Public Health Foresight Studies. More determinants and diseases have now been included in the calculations, the method for calculating burden of disease has been improved, and a more systematic approach has been adopted by distinguishing between different groups of determinants. As a result, it will not be possible to compare the outcomes of the 2018 study to previous years.

6 Appendix: Tables of relative risks

All PAFs are available for download on the website (www.vtv2108.nl/methoden). The relative risks for a selection of determinants have also been included there. This appendix has not presented the relative risks for PM_{10}/NO_2, secondary smoke and dampness, as they are not included in the PAFs.

Table 1 Relative risks of air pollution based on DUELS 2-component model

DUELS 2-component model	Component	RR (per 10 ug/m3) RR	PAF	Threshold limit (ug/m3)
total mortality (including natural deaths) ICD-10: A00–R99	NO2	1.019	0.1036	0
	PM10	1.043		0
	NO2	1.019	0.0771	5
	PM10	1.043		5
mortality due to cardiovascular causes ICD-10: I00-I99	NO2	0.983	0.1223	0
	PM10	1.093		0
	NO2	0.983	0.0884	5
	PM10	1.093		5
mortality due to respiratory causes ICD-10: J00–J99	NO2	0.990	0.2154	0
	PM10	1.155		0
	NO2	0.990	0.1596	5
	PM10	1.155		5
mortality due to lung cancer ICD-10: C33–C34	NO2	1.080	0.2511	0
	PM10	1.093		0
	NO2	1.080	0.1940	5
	PM10	1.093		5

Table 2 Relative risks of secondary smoke included in the calculations

Diseases	Age risk groups	OR/RR (95 percent Bi)	Source
Ischaemic heart disease	15+	1.27 (1.19-1.36)	(USSG 2006)
Lung cancer	15+	1.21 (1.13-1.30)	(USSG 2006)
Stroke	15+	1.25 (1.12-1.38)	(USSG 2014)
Asthma, children	0-18 years	1.32 (1.24-1.41)	(Cal-EPA 2005)
Infectious diseases of the lower respiratory tract, children	0-2 years	1.55 (1.42-1.69)	(USSG 2006)
	2-5 years	1.18	(Li, Peat et al. 1999)

USSG (2006). The health consequences of involuntary exposure to tobacco smoke: a report by the Surgeon General. . Atlanta US Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease
Prevention and Health Promotion, Office on Smoking and Health.
USSG (2014). The health consequences of smoking: 50 years of progress. : U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. Atlanta, GA, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention.
Cal-EPA (2005). Proposed identification of environmental tobacco smoke as a toxic air contaminant. . Sacramento, California, Californian Environmental Protection Agency.
Li, J. S., J. K. Peat, W. Xuan and G. Berry (1999). "Meta-analysis on the association between environmental tobacco smoke (ETS) exposure and the prevalence of lower respiratory tract infection in early childhood." Pediatr Pulmonol **27**(1): 5-13.

Table 3 Relative risks of dampness included in the calculations

Disease	Age risk groups	OR/RR (95 percent bi)	Source
Asthma, children and adults	All	1.37 (1.23-1.53)	(Fisk WJ, et al. 2007)
Infectious diseases of the lower respiratory tract, children	0-15 years	1.45 (1.32-1.59), for bronchitis	(Fisk WJ, et al. 2010)

Fisk WJ, Lei-Gomez Q and Mendell MJ (2007). "Meta-analyses of the associations of respiratory health effects with dampness and mold in homes." Indoor Air 17(4): 284-296.
Fisk WJ, Eliseeva EA and Mendell MJ (2010). "Association of residential dampness and mold with respiratory tract infections and bronchitis: a meta-analysis." Environmental Health 9(72).