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To what extent do the morbidity indicators in the Dutch risk equalization model for somatic care compensate for individuals with specific chronic diseases?

SUPERVISOR: DR. RICHARD VAN KLEEF
CO-READER: PROF. DR. VALESCA RETEL
WORDCOUNT: 7523

Abstract

The Dutch basic health insurance includes risk equalization to compensate insurers for predictable spending variation between individuals. The risk equalization model for somatic care was established in 1993 and has been researched ever since to improve its functioning. The model equals unevenly spread risks between healthcare insurers to prevent risk selection against specific chronic diseases. Risk selection threatens equal access to healthcare. The aim of this study is to examine to what extent the morbidity indicators in the 2025 Dutch risk equalization model compensate for the predictable high spending of somatic care for individuals with specific chronic diseases.

By simulating the risk equalization model with an ordinary least squares regression and data on diagnoses of chronic diseases from 1.2 million individuals, differences in over- and undercompensation between chronic diseases were determined. Also, identification rates of chronic diseases with morbidity indicators were established.

Results show that on average compensation is -54 euros for all chronic diseases, but large variation in over- and undercompensation, both when diseases are and are not identified, occurs. To reduce risk selection incentives for healthcare insurers the findings of this study offer insight into which diseases are identified at the lowest rate and which diseases are compensated the most below average.

By improving identification and/or compensation for the lowest identified and/or lowest compensated diseases, the risk equalization model can be improved leading to a reduction in risk selection incentives.

Acknowledgement

I am grateful to the Dutch Ministry of Health, Welfare and Sports and the Association of Health Insurers for access to (anonymized) claims data. I am also grateful to the Netherlands Institute for Health Services Research (NIVEL) for access to morbidity information registered by general practitioners. This study has been approved according to the governance code of Nivel Primary Care Database under number NZR-00322.052. The use of electronic health records for research purposes is allowed under certain conditions. When these conditions are fulfilled, neither obtaining informed consent from patients nor approval by a medical ethics committee is obligatory for this type of observational studies containing no directly identifiable data (art. 23 GDPR Implementation Act jo art. 9.2 sub j GDPR).

Whilst writing this thesis, ChatGPT has been used when the syntax for Stata was written. No information from data sources was copied into ChatGPT but only suggestions were asked from ChatGPT in order to write a functioning syntax. For example, when an error occurred ChatGPT was asked what triggered this error, or to get an idea of how the syntax could look like at the start of writing the syntax. Since the data analyses was done in the protected server of CBS it was no option to copy any information from the data source or from ChatGPT into the server. Besides ChatGPT, the website Deepl was used, which has AI functionalities. For this thesis Deepl was only used for its translation function. This made sure the writer of this thesis wrote the thesis himself.

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1. Introduction

Since the introduction of the Health Insurance Act in 2006, Dutch health insurers compete on a regulated basis for policy holders (Schut & Varkevisser, 2016). An example of this regulation is that Dutch citizens are free to switch healthcare insurers on a yearly basis, which incentivizes health insurers to offer competitive insurance plans. Insurers compete on the price and quality of their insurance plans (Enthoven & Van De Ven, 2007). Other examples of regulated competition include the requirement of open enrolment, mandatory community-rated premiums, and the mandatory basic benefit package (Zorginstituut Nederland, n.d.).

Due to the acceptance obligation and the ban on premium differentiation, it is possible for insurers to have a higher-than-average risk profile, potentially resulting in financial losses. To cover insurers with a higher-than-average risk profile, the risk equalization (RE) model was introduced, incorporating *age* and *gender* as risk adjusters. Since its introduction in 1993 in the Dutch sickness fund scheme, the model has been extended with more variables such as *region*, *pharmaceutical cost groups* and *diagnostic costs group* (Douven, 2004; Van Kleef et al., 2012). Due to differences between mental and somatic healthcare needs, separate RE models have been developed for these domains. A third risk equalization model exists to equalize out-of-pocket payments as a result from the mandatory deductible (Ministerie van Volksgezondheid, Welzijn en Sport, 2016; Van Kleef et al., 2018-a).

Recent research shows that the 2025 Dutch RE model for somatic care largely compensates insurers for predictable spending variation, though not entirely. Although somatic chronic diseases, such as cancer, diabetes and cardiovascular diseases, account for some of the most expensive types of care, a substantial portion of healthcare costs remains poorly predicted (Van Kleef & Van Vliet, 2025). If the RE model does not function adequately, insurers with a relative high share of high-risk insured individuals may incur financial losses, thereby creating incentives for risk selection. Risk selection is a form of discrimination against subgroups of individuals with specific chronic diseases that are predictably unprofitable to insurers. By avoiding contracts with known high-quality providers, or by not investing in high-quality care, insurers may attempt to

minimize financial losses by becoming unattractive for people who need high-quality care. During this process insurers may reduce financial losses, but these practices may lead to individuals in need of high-quality care to switch to insurers that offer more suitable insurance schemes. These actions are examples of risk selection (Van De Ven et al., 1994; Van De Ven et al., 2015).

Given the threats to high-quality care and equitable access, optimizing the RE model remains essential. Recent studies indicate that certain patient subgroups, particularly those with specific chronic diseases, continue to be undercompensated (Van De Ven et al., 2015; Van Kleef et al., 2019; Van Kleef & Van Vliet, 2025).

To improve the effectiveness of risk equalization, it is important to determine if chronic diseases are recognized by morbidity indicators. This study aims to identify which chronic diseases are identified and/or compensated insufficiently. Therefore, the research question of this study is: *To what extent do the morbidity indicators in the Dutch RE model for somatic care compensate for individuals with specific chronic diseases?* In the light of the study objective, the following sub-questions will be answered:

Sub-questions:

1. To what extent do the morbidity indicators in the Dutch RE model for somatic care identify individuals with specific chronic diseases?
2. To what extent does the Dutch RE model for somatic care compensate insurers for the expected spending of individuals with specific chronic diseases who are identified by a morbidity indicator?
3. To what extent does the Dutch RE model for somatic care compensate insurers for the expected spending of individuals with specific chronic diseases who are not identified by a morbidity indicator?

By addressing these sub-questions, this study aims to provide recommendations for improving the Dutch RE model for somatic care. Given that RE models are employed in several countries, including Belgium, Germany and the United States, enhancing the Dutch RE model holds significant international relevance, as elements of these models are interrelated (McGuire, 2018; Van De Ven et al., 2015).

This thesis proceeds with Chapter 2, which presents the theoretical framework and outlines the key concepts and contextual factors that influence and explain the Dutch healthcare system for somatic care. Chapter 3 describes the methodological approach used to conduct the analysis and generate the results. Chapter 4 offers a detailed presentation of the findings. Chapter 5 interprets these results, discusses their implications, gives policy recommendations and addresses the central research question.

2. Theoretical framework

This chapter discusses key concepts that are critical to understand the Dutch healthcare system. This highlights the importance of a well-functioning RE model and illustrates the potential risks associated with its shortcomings.

2.1 Health Insurance Act

The Dutch healthcare system aims to be accessible, equitable and of high quality. Risk solidarity plays a key role in achieving these goals, by ensuring that the costs of care are shared across the population, particularly benefiting those with greater healthcare needs (Companje et al.,2009).

In 2006 the Health Insurance Act came into effect, introducing regulated competition in Dutch healthcare. Since then, every person that lives or works in the Netherlands is obliged to have healthcare insurance from a Dutch health insurer (Ministerie van Algemene Zaken, 2021; Van Strien & Bhageloe-Datadin, 2015). Health insurers compete by offering different (supplementary) insurance plans, which is allowed if they at least offer the mandatory basic benefit package. Dutch citizens have the right to switch insurers on a yearly basis which incentivizes insurers to offer the “best”, or most affordable insurance plans (Van Kleef et al., 2018-a).

To guarantee access, Dutch health insurers have an acceptance obligation to anyone who applies for insurance, are not allowed to offer less than the mandatory basic benefit package and are banned from applying premium differentiation. The costs associated with unevenly spread risks are (partly) evened out by subsidies provided by the RE model. However, if the RE model does not work perfectly, insurers may be incentivized to engage in risk selection (Van Kleef et al., 2018-a).

The concept of regulated competition originates from the works of Enthoven (1988). Enthoven’s work on how healthcare systems can be financed was based on the healthcare sector in the United States, but has been applied in several countries, including Germany, Switzerland and the Netherlands (McGuire, 2018). All countries that use regulated competition can benefit from the findings of this study, as similarities in risk equalization often occurs among these countries (Van De Ven et al., 2015).

2.2 Risk selection

The ban on premium differentiation leads to predictable profits and losses for insurers. For example, young, healthy individuals typically incur lower healthcare costs compared to older individuals with chronic diseases. In an unregulated insurance market, individuals with higher risk profiles would be charged a higher premium. However, in a regulated health insurance market where insurers receive adequate ex-ante compensation, incentives for risk selection may be reduced. Ex-ante compensation means that insurers are subsidized at the beginning of the year before incurring costs, improving incentives for cost control (Van De Ven et al., 2015; Van Kleef et al., 2019). Conversely, if insurers are only compensated ex-post, meaning after the year has ended and actual costs are known, they are reimbursed for the losses they incurred, reducing incentives for risk selection but also for cost control. This mechanism is referred to as ex-post compensation (Barneveld et al., 2001; Rijksoverheid, 2017).

Risk selection embodies all actions insurers can take to attract profitable groups such as, incentivizing individuals to buy more expensive insurance schemes or actively decreasing quality of an insurance scheme, to ensure high-risk individuals will apply for other (more expensive) schemes. Both actions vary in severeness but threaten risk solidarity in the same way. By undermining risk solidarity, insurers jeopardize accessibility, equality and the quality of care (Van De Ven et al., 2015; Van Kleef et al., 2019).

When individuals in need of high-quality care are driven towards more expensive insurance plans, they are 'punished' for their chronic illness. Additional care, unrelated to their chronic disease, is then also covered by the more expensive package, despite such care not requiring that level of coverage. This situation creates inequality between groups with and without (certain) chronic diseases (Van De Ven et al., 2015).

Another way to attract low-risk groups, is by offering attractive supplementary insurance plans. Because supplementary plans are voluntary, they are not regulated in the same way as mandatory health insurance, and so insurers are therefore not obliged to accept applicants for these plans (Rijksoverheid, n.d.). Mandatory and supplementary insurance plans are often offered in combination with each other.

A possible situation is that a young adult with diabetes is not accepted for a supplementary insurance plan that covers costs related to physiotherapy, which is not included in the basic benefit package. As a result, the young adult may choose not to switch insurers for the supplementary insurance plan and remain with the same insurer for his mandatory insurance plan as well (Patiëntenfederatie Nederland, n.d.; Rijksoverheid, n.d.).

Risk selection can also have negative effects for providers who are known for delivering high-quality care. Insurers may choose not to contract these providers to be less attractive to patient groups they typically serve. Additionally, risk selection can lead to underinvesting in cost control when insurers find risk selection more profitable. These are potential consequences of risk selection that threaten the proper functioning of the healthcare system as how it is intended to operate (Van Kleef et al., 2024).

2.3 Dutch RE model

The Dutch RE model is updated annually to improve its functioning. As a result, health insurers are compensated for predictable profits and losses caused by the ban on premium differentiation, thereby reducing incentives for risk selection.

Since its introduction in 1993, the RE model has incorporated an increasing number of risk adjusters to improve the accuracy of cost predictions and enhance the compensation for predictable profits and losses (see Table 1). This way insurers receive more accurate subsidies, resulting in fewer incentives for risk selection. Risk adjusters that are prominently used to identify chronic diseases include: *diagnostic cost groups*, *pharmaceutical cost groups*, *multiple year high costs, multiple year high costs for home care, physiotherapeutic diagnostic groups* and *historical somatic morbidities*. These morbidity adjusters are referred to as morbidity-based risk adjusters (MBRA). MBRA are based on information retrieved from previous years, as reported by health insurers (Van Kleef et al., 2018-a; Zorginstituut Nederland, 2024). Each risk adjuster includes at least 2 risk classes. Individuals can be classified as having a higher risk (≥1) or do not have a higher risk (0).

Table 1: Risk adjusters in the 2025 Dutch risk equalization model for somatic care.

Risk adjusters	Description
Age/gender	42 risk classes based on age and gender.
Region	10 risk classes based on a clustering of ZIP-codes. This clustering is based on a set of regional characteristics.
Socio-Economic Status (SES)	12 risk classes for level of income in interaction with age.
Source of income	23 risk classes in which individuals are categorized based on the type of income/education level in interaction with age.
Number of persons per address	19 risk classes based on the number of residents per address in interaction with age.
Pharmaceutical Cost Groups (PCG)	48 risk classes based on specific pharmaceutical use in the previous year.
Diagnostic Cost Groups (DCG)	27 risk classes based on hospital diagnoses from the previous year.
Multiple Year High Costs (MYHC)	9 risk classes based on previous healthcare costs in the last 3 years in at least the top 30% highest costs.
Multiple Year High Costs for Home Care (MYHCN)	10 risk classes combining being in at least the top 3.5% of highest costs for homecare with one risk class combining the age group 0-17 years.
Physiotherapy Diagnostic Groups (PDG)	5 risk classes for specific physiotherapy related diagnoses in the last year.
Historical Somatic Morbidities (HSM)	2 risk classes based on whether an individual was flagged by at least one morbidity-based risk adjuster three years ago.
Indication Childbirth and Pregnancy	2 risk classes for individuals who are pregnant or give birth.
Seasonal Workers*	2 risk classes for seasonal workers.

**Note: Seasonal workers are not included in the data and are therefore not included in this study.*

**Source: (Van Kleef et al., 2018-a; Zorginstituut Nederland, 2024).*

Since 2025 the RE model uses constrained regression (CR) to predict healthcare spending for each individual. All risk adjusters, including the risk classes of MBRA, take the form of a dummy-variable. CR is a form of least-squares regression but imposes some specific constraints to the estimated payment weights (Van Kleef et al., 2018-a; Zorginstituut Nederland, 2024).

Payment weights are determined annually and are based on data from year *t*-3, which is adjusted to be representative of the current year. Once a payment weight is estimated for each risk adjuster, these weights are used to calculate the predicted costs for each individual (Van Kleef et al., 2018-a; Zorginstituut Nederland, 2024).

Compensation is calculated as the predicted costs minus the nominal premium. The nominal premium is determined by government and applies for all adults. In 2025, the nominal premium for health insurance equals 1,868 euros per year. Individuals under the age of 18 years are exempted from paying the nominal premium. Therefore, their compensation is equal to the predicted costs (Wet Open Overheid, 2025).

2.4 Measures for quantifying selection incentives

The RE model can be evaluated using various metrics that indicate how effectively it compensates insurers for predictable profits and losses. One approach to evaluate the RE model is to calculate over- and undercompensation per subgroup, which provides insight into which subgroups experience more over- and undercompensation compared to others. These results help identify which subgroups should be prioritized for improvements in the RE model (Van Kleef et al., 2018-a).

Over- and undercompensation are commonly used in research on RE models. A study of Gupta Strategists (2021) examined how often undercompensation occurred to make recommendations on whether it was necessary to address this issue in both the somatic and the mental healthcare RE model. Another study by Stam & Van De Ven (2008) used over- and undercompensation to evaluate the performance of the 2006 RE model. Van Veen (2016) conducted a literature study in which multiple studies used over- and undercompensation (Gupta Strategists, 2021; Stam & Van De Ven, 2008; Van Veen, 2016).

Another way to evaluate the RE model is by calculating the R-squared. R-squared is a value between zero and one (most often shown as a percentage) (Van Kleef, 2018-a). R-squared is a statistical measure that shows the fraction of the variance in healthcare costs explained by the model, but it does not provide any information about (the absence of) selection incentives or how well over- and undercompensation are prevented (Van de Ven & Van Kleef, 2025). Besides the R-squared, Cummings Prediction Measure (CPM) is often used to determine the functioning of predictive models. CPM presents outcomes below zero and up to one. CPM assesses the statistical performance of the RE model but is less sensitive for outliers compared to R-squared. Chapter 3 elaborates further on R-squared and CPM (Van Kleef et al. 2018-a).

Analyses of total over- and undercompensation of insurers demonstrate the accuracy of the RE model. Combined with other indicators, this can provide insight on selection incentives (Nederlandse Zorgautoriteit, 2016). Van Kleef & Van Vliet (2025) have shown that the RE model for somatic care compensates for 98% of costs incurred by chronic diseases, but also that chronic diseases incur the highest healthcare expenditures. Besides, chronic diseases generally lead to higher healthcare costs over a longer period compared to non-chronic diseases. The top 1% of individuals with the highest healthcare expenditures were found to be the most undercompensated group (Withagen-Koster et al., 2024).

3. Methods

This quantitative study aims to evaluate to what extent the morbidity indicators in the 2025 Dutch RE model for somatic care compensates health insurers for the predictable high healthcare cost of individuals with specific chronic diseases. The study used microdata on healthcare spending and characteristics of approximately 1.6 million enrollees in the Dutch basic health insurance. This chapter outlines the methodological approach used in the study.

3.1 Data Description

For this study, data from the Dutch RE model were combined with data from the Nivel Primary Care Database (Nivel-PCD), which contains diagnostic information from patients, collected by general practitioners in the Netherlands. The Nivel-PCD consists out of approximately 1.2 million Dutch citizens aged 18 years or older and was collected in 2021. This dataset has been adjusted through weighting factors to be representative for the entire Dutch population. For all 1.2 million individuals, the data contains 109 dummy variables for chronic diseases, coded as one, indicating presence of the disease, or zero, indicating absence of the chronic disease. Some examples of chronic diseases are Chronic Obstructive Pulmonary Disease (COPD), diabetes and cancer. All diseases are provided with an ICPC-code which originates from the administration system of general practitioners (Nivel, 2016; Nivel, 2022-b; Vanhommerig et al., 2025; Van Kleef et al., 2018-b).

Data of the Dutch RE model is collected annually for research aimed at evaluating and improving the RE model, commissioned by the Ministry of Healthcare, Wellbeing and Sport. The dataset includes all Dutch citizens who had mandatory health insurance in 2022 (*t*-3). To ensure anonymity, all individuals were anonymized through the assignment of pseudo citizen service numbers. The dataset of the RE model contains relevant information on risk indicators of the entire population of individuals with health insurance, except seasonal workers. On this group there is no data available. From the entire population, 1.2 million individuals who also appear in the Nivel-PCD were selected and additionally, new insured individuals since 2022 have been added, resulting in approximately 1.6 million individuals in the dataset. The Nivel-PCD data has been

enriched by the thesis supervisor to match the data from the RE model. With this dataset it is possible to recreate the RE model of 2025 and to estimate its performance for subgroups identified in the Nivel-PCD. Both datasets have been previously used and validated in prior research (Van Kleef et al., 2018-b; Van Kleef & Van Vliet, 2025).

3.2 Simulation Process

The simulation process consists of four steps, in which all three sub-questions are addressed. For each step the software program Stata was used. The outcomes of these steps form the basis for answering the main research question of this thesis, which is to give insight into what extent risk adjusters in the Dutch RE model for somatic care identify and compensate subgroups with specific chronic diseases?

Step 1: Simulating the RE model

First, this study simulated the RE model by performing an ordinary least-squares (OLS) regression, in which *somatic healthcare spending* served as the dependent variable, and all risk adjusters except seasonal workers served as independent variables. This study did not apply CR, as this method is too complex to incorporate in this thesis project. Moreover, CR is typically not included in most projects commissioned by the Ministry of Health. This approach ensures that the results from this study are comparable with results from other studies.

To evaluate and compare the RE model with previous versions, the R-squared will be calculated. The R-squared presents the fraction of the variance in healthcare costs that is explained by the model. The minimum value is zero, meaning the RE model explains none of the variance in healthcare costs and the maximum outcome is one, meaning that all variance in healthcare costs would be explained by the RE model. The maximum value of one is unattainable in practice because healthcare spending is only partially predictable (Van De Ven & Van Kleef, 2025).

$$R^2 = 1 - \frac{\sum_i (Y_i - \hat{Y}_i)^2}{\sum_i (Y_i - \bar{Y})^2} \quad (1)$$

Formula 1 presents the formula for R-squared. In this equation R^2 represents the fraction of variance explained by the model. Y_i represents the actual healthcare costs per individual, $\hat{Y}_i$ are the predicted costs of an individual and $\bar{Y}$ indicates the mean expenditure across all individuals in the sample (Layton et al., 2018).

In addition, CPM, as presented in Formula 2, is commonly used when evaluating predictive models. CPM assesses the statistical performance of the RE model but is less sensitive for outliers compared to R-squared. CPM ranges from below zero and up to one. A value of one indicates perfect prediction, a value of zero means the model performs no better than simply predicting the mean for all individuals and values below zero indicate worse performance than mean prediction (Van Kleef et al. 2018-a).

$$CPM = 1 - \frac{\sum_{i=1}^{n} |Y_i - \hat{Y}_i|}{\sum_{i=1}^{n} |Y_i - \bar{Y}|} \quad (2)$$

In formula 2, Y_i, $\hat{Y}_i$, $\bar{Y}$ have the same meaning as explained in formula 1.

Step 2: Identifying subgroups with chronic diseases

The second step aims to identify subgroups with chronic diseases. In addition to the 109 dummy variables for chronic diseases, a subgroup was added which shows if an individual has at least one chronic disease. Each subgroup will be described in terms of size and average healthcare costs.

From the original list of 109 chronic diseases, five broader disease groups were constructed to provide an overview of multiple related conditions with a relative high prevalence in the Dutch population. These groups consisted of multiple individual diseases, except diabetes, which was treated as a single group because it has a high prevalence but has no other related diseases. Other groups were COPD, cancer, cardiovascular disease (CVD) and arthrosis.

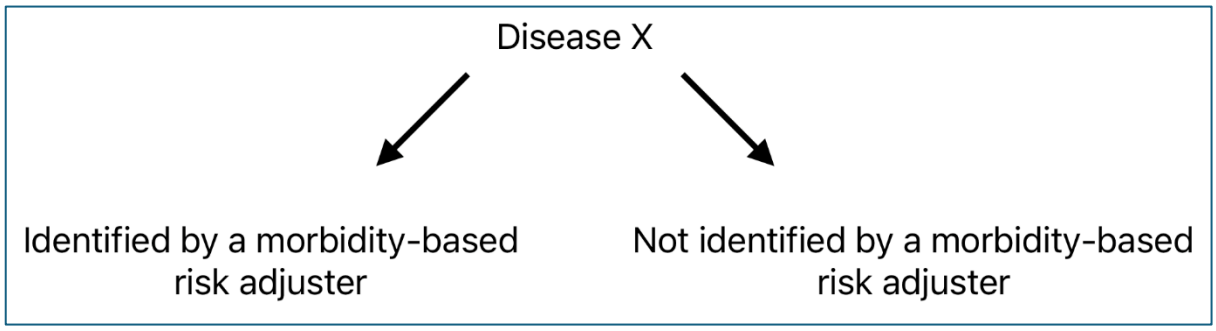
The COPD group consisted of chronic bronchitis and chronic obstructive pulmonary disease. Disease group cancer included 22 different types of cancer, CVD

exists out of seven types of heart- and vascular diseases and arthrosis exists out of three types of arthrosis.[1]

Step 3: Examine to what extent individuals with a chronic disease are identified by a morbidity-based risk adjuster

Step three examines the extent to which MBRA identifies individuals with specific chronic diseases in the Dutch RE model. MBRA which are designed to recognize chronic diseases are: DCG, PCG, PDG, MYHC, MYHCN and HSM. An individual is considered to be identified by a MBRA if they receive a positive score on at least one of these MBRA. After determining the percentage of each chronic disease subgroup that was identified by an MBRA, two groups were distinguished: subgroup A included individuals with a chronic disease which were identified by at least one MBRA, and subgroup B included individuals with a chronic disease which were not identified by a MBRA (see Figure 1).

Figure 1: Flowchart of identifying chronic diseases with morbidity-based risk adjusters.



Step 4: Calculating over- and undercompensation

After determining how MBRA identified individuals with chronic diseases, over- and undercompensation was calculated for each subgroup. Formula 3 presents the calculation of over- and undercompensation per individual for specific subgroups. By combining information about individuals who were identified by at least one MBRA and those who were not, over- and undercompensation could be evaluated for each subgroup.

[1] ICPC-codes for disease groups: COPD: r91, r95. Cancer: a79, b72, b73, b74, d74, d75, d76, d77, n74, r84, r85, s77, t71, u75, u76, u77, w72, x75, x76, x77, y77, y78. CVD: k74, k76, k77, k82, k86, k87, k91. Arthrosis: l88, l89, l90, l91. Diabetes: t90. For the entire overview of all diseases, see Appendix A.

$$\text{Over/Undercompensation}_g = \frac{\sum_{i \in g}(\hat{Y}_i - Y_i)}{n_g} \quad (3)$$

In this formula, g represents a chronic disease, Y_i represents actual healthcare costs for individual *i* with disease g, $\hat{Y}_i$ indicates predicted costs for individual *i* with disease g, and n_g shows the number of individuals within subgroup g (Layton et al., 2018). This calculation estimates over- and undercompensation per individual within a specific subgroup, expressed in absolute monetary terms (euros).

In addition to calculating over- and undercompensation per individual, total over- and undercompensation for each subgroup was calculated using Formula 4. This enabled the identification of disease groups for which over- and undercompensation is most substantial, which therefore require higher priority for improvement.

$$\text{Over/Undercompensation}_g = \sum_{i \in g}(\hat{Y}_i - Y_i) \quad (4)$$

3.3 Assessment of validity and reliability

The data used in this study was retrieved from multiple sources like general practitioners and healthcare insurers which increases the reliability of the data. The data used in this study has been used in previous studies in which weighting procedures were applied to ensure representativeness for the entire Dutch population (Van Kleef et al., 2020). Because of the large sample size random variation is less likely to influence the results, improving the reliability of the study.

As described above, this study used an OLS-regression, whereas since 2025, CR is used in the RE model. The exclusion of CR may lead to differences in the estimated performance of the RE model. However, in line with research into RE models, it is common practice to exclude CR to make the results of this study comparable with other studies. Also, the method of CR is too complex to incorporate in this thesis project.

Additional to the simulation analysis, this study conducted a sensitivity analysis to determine the effect of excluding CR. Therefore, the thesis supervisor provided

predicted cost values generated by the RE model of 2025 with CR included. To estimate the effect of excluding CR in this study, the analysis was repeated using the RE model with CR included. These results could be used to provide insight into the differences caused by including or excluding CR.

All analytical outputs were reviewed by Statistics Netherlands (CBS) to ensure all privacy protection criteria have been performed correctly. Access to the micro-data is only possible on a protected server from the CBS and accessible with double authentication by the researcher.

4. Results

Chapter 4 presents the results from the analysis. This chapter begins with a descriptive overview of the dataset, followed by results on to what extent morbidity indicators in the Dutch RE model for somatic care compensate insurers for the predictable high healthcare costs of individuals with specific chronic diseases.

4.1 Descriptive statistics

The dataset used for this study exists of 1.6 million individuals. After applying weighting factors, the sample was representative for the entire population of 17 million individuals who were insured under the Health Insurance Act in 2022. For all 1.6 million individuals' information is available on the presence or absence of chronic diseases.

Table 2 shows the prevalence of MBRA in percentages of the entire population. Risk adjusters PDG and MYHCN were relatively uncommon, each with a prevalence below 3%. In contrast, MYHC has a prevalence of 43% and HSM a prevalence of 45%. Nivel-PCD revealed that 59% of the population in 2021 was diagnosed with at least one chronic disease.

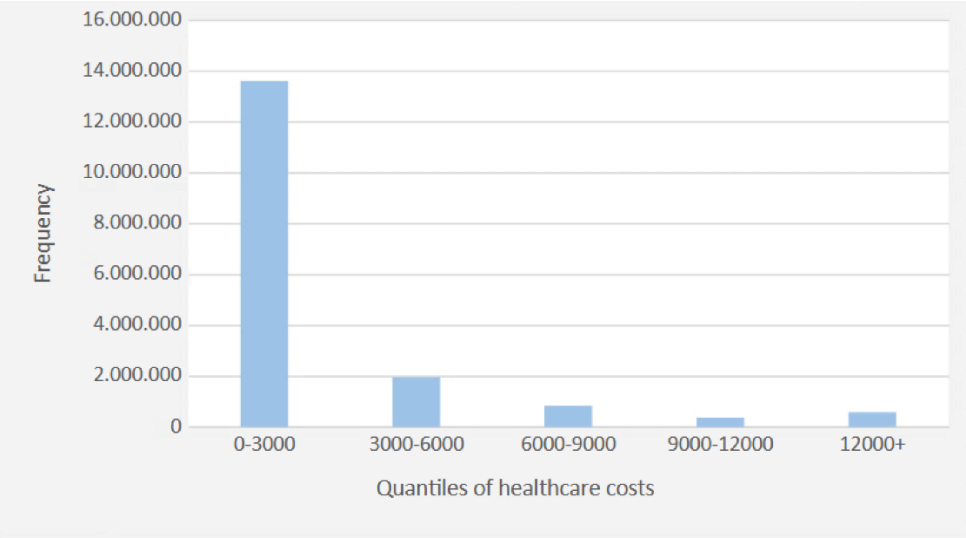
Average healthcare expenditure per individual in the dataset amounted 2,656 euros, based on actual healthcare costs in 2022. Figure 2 illustrates the distribution of these costs, which shows that 83% of the population has expenditures between 0 and 3000 euros on healthcare. The remaining cost groups represented much smaller shares of the population.

Table 2: Frequency/percentage of population distribution based on age, gender, chronic diseases and identification by morbidity-based risk adjusters.

		Frequency/Percentage
N weighted		17,310,264
N unweighted		1,614,109
Men		49.5%
Women		50.5%
0-17	***Men***	19.5%
	Women	18.2%
18-34	***Men***	21.7%
	Women	20.9%
35-44	***Men***	12.1%
	Women	12.0%
45-54	***Men***	13.4%
	Women	13.3%
55-64	***Men***	14.0%
	Women	13.9%
65+	***Men***	19.3%
	Women	21.7%
≥1 chronic disease according to Nivel-PCD		59.0%
≥1 PCG		26.3%
≥1 DCG		11.3%
≥1 MYHC		43.6%
≥1 FDG		2.8%
≥1 MYHCN		2.3%
≥1 HSM		45.3%

**Note: Observations are based on weighted results as described in paragraph 3.1. Prevalence is presented as percentage of the entire population. PCG = Pharmaceutical Cost Groups. DCG = Diagnostic Cost Groups. MYHC = Multiple Year High Costs. PDG = Physiotherapeutic Diagnostic Groups. MYHCN = Multiple Year High Costs for Home Care. HSM = Historical Somatic Morbidities. Nivel Primary Care Database = Nivel-PCD.*

Figure 2: Distribution of actual healthcare costs



**Note: Observations are based on weighted results as described in paragraph 3.1. Costs are calculated in euros.*

4.2 Estimation of the risk equalization model

This paragraph presents results from the simulation of the RE model for somatic care, which was done by using an OLS-regression. Besides the OLS-regression, the R-squared and CPM were calculated to estimate the statistical accuracy.

The analyses revealed a value of 0.3198 for the R-squared, meaning that the RE model explains 32% of the variance in healthcare costs. Besides the R-squared, CPM was calculated. The result for CPM is 0.3542, which shows that the RE model compensates for 35% of the absolute differences in costs on individual level.

The OLS regression presents results on compensation based on the RE model. The results from the OLS regression show average predicted healthcare costs of 2,656 euros per individual per year and a distribution of healthcare costs similar to the distribution of actual healthcare costs. With results from the regression, over- and undercompensation were calculated per disease. Appendix A shows the results for each specific disease.

Table 3: Prediction of the 2025 risk equalization model for somatic care.

R-squared	0.3198
Cummings Prediction Measure	0.3542
Mean predicted somatic healthcare costs	2,656
Mean actual somatic healthcare costs	2,656

**Note: Observations are based on weighted results as described in paragraph 3.1. Costs are calculated in euros.*

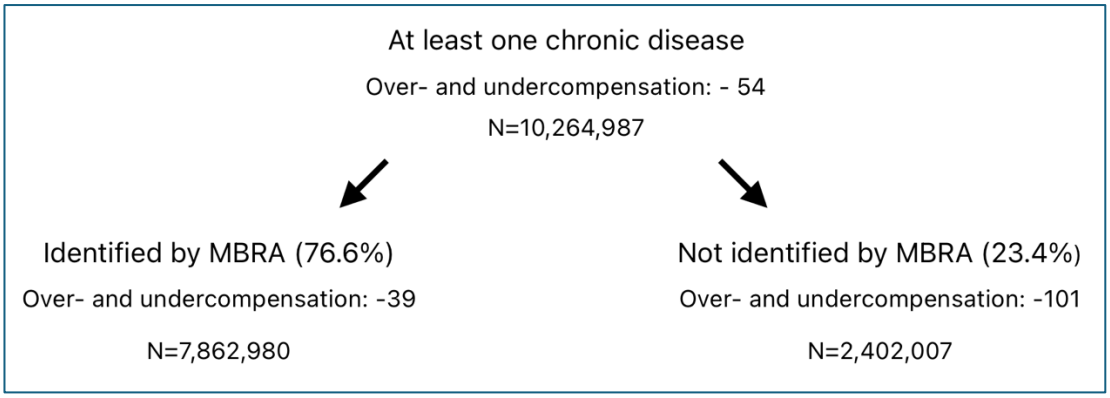
4.3 Which fraction of individuals with chronic disease X is identified

This section addresses the question: to what extent do the morbidity indicators in the RE model identify (individuals with) chronic diseases? To evaluate the performance of MBRA, five subgroups were defined. These subgroups represent a large share of the population with a chronic disease, with prevalences for disease groups ranging from 3% up to 22% of the entire population. Further on in this chapter, differences between identification and no identification are presented combined with results from the sensitivity analyses and effects on over- and undercompensation.

Not all diagnosed chronic diseases were identified by an MBRA. To be identified, one MBRA needs to identify the chronic disease, but overlap from multiple MBRA is possible. Over- and undercompensation does not change if multiple MBRA identify the same chronic disease. Figure 3 presents the outcomes of identification by MBRA of individuals with at least one chronic disease. Out of every individual who was diagnosed with a chronic disease, 77% was identified by at least one MBRA, meaning that the remaining 23% of individuals was not identified by a MBRA. Between these two groups, a difference of 62 euros in over- and undercompensation was found, with a negative effect for individuals diagnosed with a chronic disease who were not identified by a MBRA. These results reaffirm that not every individual with a chronic disease was identified by a MBRA. Figure 4 presents the distribution in identification and over- and undercompensation for all 109 chronic diseases. Each dot represents a chronic disease, and the dotted line shows that diseases which were undercompensated were generally identified better. The dotted line shows that approximately 87% of all diagnosed chronic

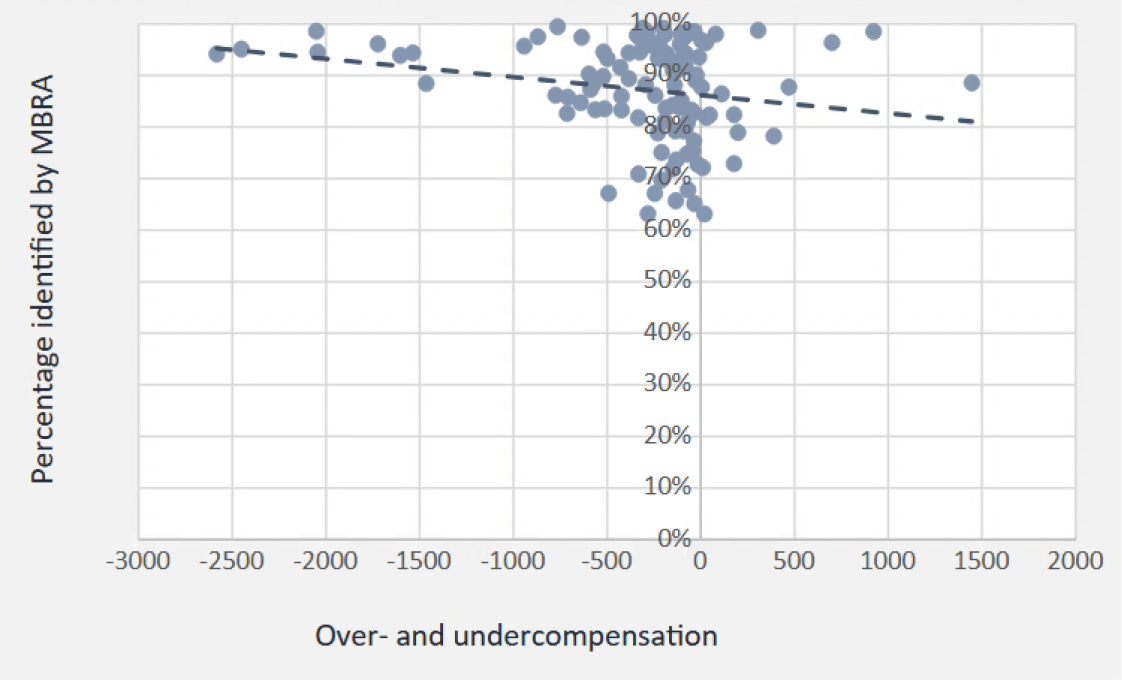
diseases were identified, against an identification-rate of 77% for all individuals with at least one chronic disease.

Figure 3: (Percentage) of individuals (not) identified by MBRA and difference in over- and undercompensation.



**Note: Morbidity-based risk adjuster (MBRA). Observations are based on weighted results as described in paragraph 3.1. Compensation is calculated in euros. Prevalence is presented as percentage of the entire population.*

Figure 4: Identification-percentage, and over- and undercompensation of the 109 chronic diseases in Nivel-PCD.



**Note: Morbidity-based risk adjuster (MBRA). Observations are based on weighted results as described in paragraph 3.1. Over- and undercompensation is calculated in euros.*

Table 5 presents five diseases with the lowest identification-rates besides the five chronic diseases with the highest identification-rates. The five chronic diseases with the highest identification-rates were identified approximately 99% and diseases with the lowest rates were identified around 65%. The highest rate of identification is found for decompensation cordis and other ischemic heart diseases, Parkinsonism and HIV/aids. Actual healthcare costs are higher for the five highest identified diseases compared with the five lowest identified diseases. For the entire overview with identification percentages, see Appendix A.

Table 5: Diseases with the lowest and highest identification-rates by morbidity-based risk adjusters

Code	Disease	Identification percentage	Compensation	Prevalence	Actual healthcare costs
	Lowest identification rate				
y84	Congenital anomaly male other	63.1%	20	0.1%	1,570
y82	Hypospadias	63.2%	-282	0.1%	2,089
s87	Dermatitis/atopic eczema	65.1%	-34	12.1%	2,448
l82	Congenital anomaly musculoskeletal	65.7%	-133	1.4%	2,504
d81	Congenital anomaly digestive system	67.1%	-245	0.5%	2,386
	Highest identification rate				
b90	HIV-infection/aids	98.8%	306	0.1%	12,266
k87	Hypertension complicated	98.8%	-303	1.9%	8,556
k76	Acute myocardial infarction	99.1%	-201	1.1%	8,686
n87	Parkinsonism	99.2%	-310	0.3%	11,866
k77	Heart failure/Decompensation Cordis	99.5%	-764	1.2%	13,761

**Note: Observations are based on weighted results as described in paragraph 3.1. Codes refer to ICPC-codes related to general practitioners' registration system and are used in the Nivel-PCD. Compensation is calculated in euros. Prevalence is presented as percentage of the entire population.*

4.4 Over- and undercompensation when chronic disease X is or is not identified

This paragraph shows results for the five created disease groups on differences between identified and not identified groups combined with information about compensation and actual healthcare costs.

All created subgroups, arthrosis, diabetes, COPD, cancer and CVD, are presented in Table 6, which presents identification rates from MBRA and the amount of over- and undercompensation per subgroup. The results show over- and undercompensation when the disease was identified and when the disease was not identified. The created disease groups had identification-rates between 92% and 99%. When a disease group was not identified by a MBRA, different amounts of undercompensation were found varying per disease group. Undercompensation increased varying between 77 euros and 240 euros for different disease groups when these were not identified. When someone with cancer is identified, the amount of undercompensation is higher compared to when the disease is not identified, with a decrease in undercompensation of 155 euros.

Actual healthcare costs are lower for every disease when it was not identified. Actual healthcare costs range between 6,424 euros up to 8,830 euros when diseases are identified and between 1,120 euros up to 1,436 euros when diseases were not identified.

Table 6: Disease groups' compensation when (not) identified and their actual healthcare costs.

Disease subgroups	Percentage not identified by MBRA	Compensation when not identified	Actual healthcare costs when not identified	Percentage identified by MBRA	Compensation when identified	Actual healthcare costs when identified
Arthrosis	7.5%	-251	1,360	92.5%	-174	6,681
Diabetes	1.9%	-341	1,436	98.1%	-101	7,969
COPD	5.7%	-307	1,193	94.3%	-309	8,830
Cancer	7.2%	-104	1,120	92.8%	-259	7,865
CVD	1.4%	-272	1,310	98.6%	-101	6,424

**Note: Observations are based on weighted results as described in paragraph 3.1. Compensation is calculated in euros. Prevalence is presented as percentage of the entire population. Chronic Obstructive Pulmonary Disease (COPD). Cardiovascular Disease (CVD). Morbidity-based risk adjuster (MBRA).*

4.5 Sensitivity analysis

To examine the effect of excluding CR in this study, a sensitivity analysis was executed. With results from the model including CR added to the dataset by the supervisor of this thesis, it was possible to run analysis with these values.

Results from the sensitivity analysis show that on average, undercompensation decreased with 91 euros per person with a chronic disease when CR was included. Differences up to 900 euros comparing different diseases were found between both models, but 95% of differences between diseases were found between -115 and -67 euros. Table 7 presents differences in over- and undercompensation for the created subgroups. This shows that including CR has a positive effect on compensation for all five subgroups and even increases compensation for diabetes and CVD to a level of overcompensation.

Table 7: Difference in over- and undercompensation for disease groups in- and excluding constrained regression.

Disease	Compensation	Compensation CR	Difference compensation
Diabetes	-105	92	-197
CVD	-110	35	-145
Arthrosis	-180	-42	-138
Cancer	-248	-119	-129
COPD	-310	-221	-89

**Note: Observations are based on weighted results as described in paragraph 3.1. Compensation is calculated in euros. Chronic Obstructive Pulmonary Disease (COPD). Cardiovascular Disease (CVD). Constrained Regression (CR).*

Differences in over- and undercompensation between both models are presented in Table 8, together with different outcomes when diseases were, or were not identified. The average range in difference of over- and undercompensation when a disease was or was not identified became smaller when CR was included. The range excluding CR was between -139 up to -311 euros (172 euros difference) and between -214 up to -290 euros (76 euros difference) for the model including CR. No difference in identification rates were found during the analysis. Results for each disease are

presented in Appendix B: Sensitivity Analysis. Besides these changes, CPM increased from 0.3434 to 0.3455 and R-squared decreased from 0.3198 to 0.3159.

Table 8: Difference in over- and undercompensation when disease groups were or were not identified, including constrained regression.

Disease	Compensation identified	Compensation including CR identified	Compensation not identified	Compensation including CR not identified
Diabetes	-101	102	-341	-459
CVD	-101	58	-272	-391
Arthrosis	-174	-17	-251	-367
Cancer	-259	-111	-104	-219
COPD	-310	-209	-307	-424

**Note: Observations are based on weighted results as described in paragraph 3.1. Compensation is calculated in euros. Chronic Obstructive Pulmonary Disease (COPD). Cardiovascular Disease (CVD). Constrained Regression (CR).*

5. Discussion

5.1 Summary of findings

To evaluate how effectively the Dutch RE model compensates health insurers for individuals with specific chronic diseases, its functioning was assessed based on statistical tests such as R-squared and CPM. Combined with identification-rates and calculating over- and undercompensation for all chronic diseases, it was possible to compare the results with each other and with results from prior research.

After calculating R-squared it was found that the 2025 RE model explains 32% of the variance in healthcare costs. R-squared has been subject to change over time but generally found values between 30% and 35% since 2017 (Van Casteren et al., 2025). Besides R-squared, CPM was calculated, for which a result of 0.3542 was found, indicating that the 2025 RE model for somatic care compensates for 35% of the absolute differences in costs on individual level. The result of 0.3542 is in line with prior studies (Van Kleef et al., 2018-a).

MBRA identified individuals with a chronic disease for 77% of all cases, which leaves 23% of people with chronic diseases not identified. A different identification-rate was found for all diagnosed chronic diseases separately. It is possible that this difference occurs because the total amount of diagnosed chronic diseases is higher than the number of individuals with a chronic disease. Besides calculating identification rates for chronic diseases, the results show the extent to which the RE model compensates for people with chronic diseases which are or are not identified by MBRA. On average, individuals with chronic diseases which are identified by MBRA are better compensated with an average of -39 euros undercompensation. Diseases which are not identified have an average undercompensation of -101 euros.

Four out of five created disease groups showed a decrease in undercompensation when the disease was identified by at least one MBRA. Only cancer showed an increase in undercompensation when the disease was identified. A possible reason can be that not identified cases received the diagnose long ago and do not make high healthcare costs anymore, also being the reason that MBRA do not identify these

cases (anymore). Besides, the sensitivity analysis showed that when CR is included, undercompensation does not increase for disease group cancer when it is identified. In total 59 out of 109 chronic diseases showed similar results such as cancer within the model using an OLS regression (see Appendix A). This kind of results are not unprecedented. Gupta Strategists (2021) found similar differences between subgroups based on diagnostic data and over- and undercompensation.

Over- and undercompensation has existed since the introduction of the RE model as shown in multiple studies (Gupta Strategists, 2021; Stam & Van De Ven, 2008; Van Veen, 2016). Findings from this study are in line with prior research and show that undercompensation still occurs regularly. Besides these previously known outcomes, identification-rates of (individuals with) chronic diseases show new insights in the effect of identification and not identification on over- and undercompensation. Results from the sensitivity analysis show that over- and undercompensation on average becomes more accurate when CR is included, with a decrease in undercompensation of 91 euros.

5.2 Strengths, limitations and directions for future research

This study has several strengths that increase the validity and reliability of the results. Data from the Dutch RE model contains information about 1.6 million Dutch individuals. Additionally, Nivel-PCD offers real diagnostic information of 1.2 million Dutch individuals. As these datasets were combined and enriched with weighting factors that have been tested and validated in prior research, the data used in this study is reliable and representative for the Dutch population and the Dutch RE model for somatic care.

Besides these strengths, this study is subject to several limitations that may affect its validity and reliability. First, the dataset was made representative for the Dutch population through weighting factors based on the entire Dutch population. However, these weighting factors were not specifically tailored to the subgroups analyzed in this study. This may lead to discrepancies between the observed results and actual population-level patterns. These factors should be considered when interpreting the results. Also, diagnostic data from Nivel-PCD is inserted by many different general practitioners, incurring the possibility for variance in data, threatening its reliability.

The conducted sensitivity analyses resulted in differences in (total) over- and undercompensation and small changes in R-squared and CPM. Identification rates did not change when CR was included. When CR was included, differences in over- and undercompensation increased when diseases were or were not identified. This shows that CR lowers undercompensation when diseases are identified but increases undercompensation when a disease is not identified. These factors should be considered when interpreting the results of this study. Future research can benefit from the use of data from the entire population of individuals insured under the Health Insurance Act. Also, using outcomes on over- and undercompensation from the model including CR can give more accurate results when the RE model is evaluated in future research.

5.3 Policy implications

The results of this study have shown that undercompensation remains prevalent, both in the model with and without CR. Undercompensation for specific chronic diseases may negatively affect equal accessibility and affordability of care for individuals with these specific chronic diseases. Diseases with higher undercompensation have an increased risk for risk selection. When undercompensation is low whilst prevalence of the disease is high, undercompensation may reach high levels. This could incentivize insurers to apply risk selection for these specific diseases. Risk selection can occur in the form of contracting lower quality care then possible, or by not investing in types of care these specific groups would attract. This can cause individuals with chronic diseases in need of high-quality care to select a more expensive insurance plan. To reduce risk selection incentives, chronic diseases with the most (total) over- and undercompensation need high priority in adjustments of the acknowledged risk to reduce (total) over- and undercompensation.

The results of this study show that over- and undercompensation reaches levels closer to zero when diseases are identified by MBRA. However, between identified diseases, discrepancies over 3,000 euros per individual per year between specific diseases still exist. Such large differences may incentivize insurers to apply risk selection, undermining equal access to healthcare. Reducing differences in

compensation between different chronic diseases may reduce incentives for risk selection. Also, (re)introducing ex-post risk equalization can reduce incentives for risk selection but will also reduce incentives for cost control. Therefore, when (re)introducing ex-post risk equalization is considered, this should be done with caution.

Next to over- and undercompensation, identification-rates were calculated for each chronic disease. Results on identification-rates show big differences between diseases ranging from 63% up to 99%. Table 5 shows that chronic diseases with the lowest identification-rates have lower actual healthcare costs compared to diseases with the highest identification-rates. It is possible that patients may remain not identified by MBRA because they do not use healthcare which activates MBRA. By developing new MBRA which target specific features in the treatment of diseases that are not targeted by existing MBRA, low identification rates could improve. This can prevent these diseases to be targeted with risk selection. Further research on low identification rates can improve existing MBRA to better identify chronic diseases with low identification-rates.

If low identification rates cause more undercompensation, insurers might be incentivized to apply risk selection against these specific chronic diseases. Contrarily, there are chronic diseases that receive less compensation when they are identified, compared to when they are not identified. For disease group cancer, when it is not identified, average actual healthcare costs are 6,756 euros lower compared to when the disease is identified. This might explain a difference in undercompensation. Additional research can study if this is the case or that other factors are of influence. This can also give insight in other diseases which are compensated better when they are not identified. This might answer the question how these differences occur and if it causes subgroups with low healthcare expenditures with a specific disease to receive more, or less compensation than necessary. The discrepancy in compensation and actual healthcare costs within the same disease, asks for adaptation in the acknowledged risk on high costs which health insurers face when their insures are diagnosed with specific diseases. By enhancing the prediction of costs incurred by individuals with a chronic disease in different stages of the disease, more accurate compensation can be offered.

The sensitivity analyses presented an average reduction in undercompensation of 91 euros, which is a reduction of 30% compared to the model without CR. Besides this reduction, CR results in higher undercompensation for diseases which are not identified. This shows that CR affects the accuracy of the RE model but not only with better results. If CR keeps being used in the RE model for somatic care, it could be preferable to apply this in future research which studies the functioning of the RE model for somatic care, as these results reflect the actual performance of the RE model and highlight potential flaws.

5.4 Conclusion

The results found in this study show that the 2025 Dutch RE model for somatic care on average results in -54 euros undercompensation per individual with a chronic disease and identifies individuals with a chronic disease with a rate of 77%. Differences between chronic diseases of more than 3,000 euros undercompensation still occur. These differences can incentivize insurers to apply risk selection for chronic diseases which are undercompensated more than average. Large differences in compensation exist when chronic diseases are, or are not identified, sometimes even with less undercompensation when a disease is not identified. These findings ask for careful adaptions of MBRA to improve identification-rates and the introduction of new MBRA that target characteristics which are not yet targeted. Further improvements of the RE model to reduce or remove existing differences when people are, or are not identified, can improve the performance of the RE model. If improvements are executed correctly this can reduce incentives for risk selection and so, improve equal access to healthcare.

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Appendix

Appendix A: Complete list of diseases and outcomes

Code	Disease	Compensation	% prevalence	Prevalence	Total compensation	Actual costs	Identification	Compensation when identified	Compensation when not identified
a28	Limited functioning/disability	-514	0.16	27,504	-14126880	6323	83.54%	-668.15	270.39
a79	Malignancy NOS	-1536	0.06	9,664	-14846417	16417	94.37%	-1632	62
a90	Congenital anomaly OS/	-714	0.22	37,377	-26676339	5443	82.65%	-821	-1033
b28	Limited functioning/disability blood and/or blood forming organs	-574	0.03	4,354	-2497063	7003	88.27%	-1894	-14
b72	Hodgkin's Disease/lymphoma	-1603	0.22	38,768	-62157897	11347	93.90%	-2714	388.13
b73	Leukemia	-181	0.16	26,904	-4875005	15482	94.16%	1280	-596
b74	Malignant neoplasm blood other	-2051	0.10	17,376	-35646516	26099	98.58%	-2078	-200
b78	Hereditary hemolytic anemia	-209	0.32	55,758	-11668477	3691	75.07%	-263	-45
b79	Congenital. Anomaly. Blood/lymph other	178	0.05	8,669	1539441	7456	82.39%	223	-34
b83	Purpura/coagulation defect	-37	0.86	148,505	-5448648	6264	82.77%	-14	-145
b90	HIV-infection/aids	306	0.13	23,313	7135876	12266	98.76%	315	366
d28	Limited functioning digestion	-1465	0.06	9,965	-14597330	9279	88.44%	-1696	300
d74	Malignant neoplasm stomach	5	0.05	8,980	40769	11206	96.75%	-7	348
d75	Malignant neoplasm colon/rectum	79	0.80	138,664	11015468	8895	98.00%	80	50
d76	Malignant neoplasm pancreas	-869	0.04	6,395	-5558534	16149	97.50%	-846	1776
d77	Malignant neoplasm digest other/NOS	-2451	0.21	36,013	-88268223	12564	95.11%	-2505	-1405
d81	Congenital. Anomaly. Digestive system	-245	0.47	81,450	-19991903	2386	67.13%	-279	-177
d92	Diverticular disease	-228	2.18	378,209	-86386718	6442	93.40%	-231	-186
d94	Chronic enteritis/ulcerative colitis	-498	0.99	170,781	-85091633	6890	93.28%	-532	-28
d97	Liver disease NOS	-429	1.08	186,330	-79989606	6406	91.57%	-453	-176
f28	Limited functioning eye	-82	0.28	49,012	-4017514	4916	79.53%	-92	-44
f81	Congenital. Anomaly. Eye other	-333	0.26	44,444	-14785185	3190	70.90%	-351	-287
f83	Retinopathy	-100	0.79	136,926	-13637830	9959	98.04%	-101	-50
f84	Macular degeneration	-85	0.78	135,429	-11566991	9141	97.57%	-90	94
f91	Refractive Error	-68	5.19	898,731	-61374340	2824	67.81%	-47	-114
f93	Glaucoma	-24	1.98	342,083	-8155259	5609	90.09%	-20	-59
f94	Blindness	-423	0.21	36,268	-15351156	6187	83.30%	-446	-310

Code	Disease	Compensation	% prevalence	Prevalence	Total compensation	Actual costs	Identification	Compensation when identified	Compensation when not identified
h28	Limited functioning ear	-110	0.14	25,089	-2756779	4698	83.72%	-151	103
h80	Congenital anomaly ear	-491	0.15	26,177	-12864687	3040	67.15%	-666.58	-134
h83	Otosclerosis	-104	0.09	15,811	-1641024	4187	85.12%	-68	-310
h84	Presbyacusis	-111.0	1.73	300,093	-33313324	7498	96.04%	-109	-154
h85	Acoustic trauma	-50	0.37	64,843	-3214916	4702	83.28%	30	-447
h86	Deafness	-243	2.54	439,835	-107077831	5327	86.16%	-269	-85
k28	Limited functioning cardiovascular	-213	0.07	12,384	-2641136	7309	93.34%	-231	31
k73	Congenital anomaly cardiovascular	47	0.44	75,743	3592490	3985	82.35%	108	-235
k74	Ischemic heart disease w. angina pectoris	-34	2.31	400,420	-13610276	8161	98.48%	-32	-145
k76	Acute myocardial infarction	-201	1.14	196,930	-39563237	8686	99.12%	-199	-360
k77	Heart failure/Decompensation cordis	-764	1.15	199,026	-152137465	13762	99.46%	-769	110
k82	Pulmonary heart disease	-942	0.05	9,468	-8918951	16134	95.69%	-928	-1251
k86	Hypertension uncomplicated	-81	14.36	2486443	-201401883	5687	94.26%	-69	-282
k87	Hypertension complicated	-303	1.89	327,081	-99174230	8556	98.81%	-304	-201
k90	Stroke/CVA	-61	1.98	342,788	-20858650	8935	98.53%	-53	-620
k91	Atherosclerosis	-79	1.13	195,057	-15409503	7106	97.73%	-68	-532
k92	Cardiovascular disease other	-521	2.38	412,842	-215202149	7902	89.81%	-561	-172
l28	Limited functioning musculoskeletal	-710	0.45	77,842	-55232791	7064	85.78%	-806	-127
l82	Congenital anomaly musculoskeletal	-133	1.38	239,236	-31904513	2503	65.70%	-156	-89
l84	Back syndrome w/o radiation pain	-173	1.72	297,013	-51427801	6636	92.94%	-165	-274
l85	Acquired deformity spine	-130	1.00	173,742	-22614259	3814	73.62%	-150	-74
l88	Rheumatoid/seropositive arthritis	-98	1.46	253,094	-24737408	7095	93.68%	-88	-244
l89	Osteoarthritis hip	-274	2.63	455,511	-125024104	7270	95.89%	-262	-569
l90	Osteoarthritis knee	-326	4.14	717,459	-233654873	6916	94.51%	-322	-396
l91	Osteoarthritis other	-82	3.68	636,892	-52358891	5847	91.75%	-80	-110
l95	Osteoporosis	-205	3.02	523,278	-107261524	7161	94.74%	-325	56
l98	Acquired deformity of limb	-55	4.81	833,025	-46074613	3565	75.11%	-33	-120

Code	Disease	Compensation	% prevalence	Prevalence	Total compensation	Actual costs	Identification	Compensation when identified	Compensation when not identified
n28	Limited functioning neurological system	-192	0.07	11,614	-2225475	5375	81.20%	-381	624
n70	Poliomyelitis	470	0.04	7,785	3660351	6169	87.75%	547	-80
n74	Malignant neoplasm nervous system	-2045	0.07	11,912	-24354560	11899	94.53%	-2122	-702
n85	Congenital anomaly neurological	-774	0.13	21,767	-16852229	7896	86.18%	-868	-189
n86	Multiple Scleroses (MS)	-519	0.20	34,742	-18031098	13936	94.55%	-561	208
n87	Parkinsonism	-310	0.29	50,380	-15613266	11866	99.15%	-294	-2200
n88	Epilepsy	4	1.17	201,951	854253	5646	87.72%	4	8
p28	Limited functioning psychological	389	0.11	18,960	7384598	3757	78.25%	354	519
p70	Dementia	700	0.68	117,553	82286395	6414	96.38%	735	-230
p72	Schizophrenia	-148	0.28	47,838	-7084760	4745	91.03%	735	-258
p80	Personality disorder	-230	1.37	236,496	-54369011	3708	78.85%	-243	-183
p85	Mental retardation	177	0.68	117,525	20836712	3304	72.91%	53	511
r28	Limited functioning respiratory system	-641	0.09	15,627	-10019564	8430	84.72%	-714	-237
r84	Malignant neoplasm bronchus/lung	-286	0.28	49,321	-14121096	18260	98.36%	-260	-1841
r85	Malignant neoplasm respiratory other	-1723	0.07	12,412	-21387614	11780	96.13%	-1770	-558
r89	Congenital anomaly respiratory	198	0.05	7,951	1574059	6862	78.95%	241	-48
r91	Chronic bronchitis/bronchiectasis	-423	0.71	123,576	-52333200	6636	85.97%	-479	-82
r95	Chronic Obstructive Pulmonary Disease (COPD)	-319	2.34	404,235	-129060108	9108	97.10%	-309	-673
r96	Asthma	-37	9.53	1,650,172	-60924350	3464	77.29%	-15	-113
s28	Limited function disability skin	-136	0.06	10,681	-1448237	4442	79.25%	-155	-61
s77	Malignant neoplasm of skin	-134	4.29	742,533	-99692481	6101	90.79%	-148	-1
s81	Hemangioma/lymphangioma	11	1.24	215,454	2320440	2929	72.14%	48	-86
s83	Congenital skin anomaly other	-210	0.33	56,841	-11920695	2956	69.72%	-235	-152
s87	Dermatitis/atopic eczema	-34	12.11	2,095,567	-71123544	2448	65.14%	0	-98
s91	Psoriasis	-70	2.83	489,595	-34281442	4602	80.95%	-76	-44
t28	Limited functioning endocrine system	-596	0.01	2,081	-1241296	7093	90.27%	-692	292
t71	Malignant neoplasm thyroid	-340	0.07	12,883	-4382539	6729	97.78%	-340	-346

Code	Disease	Compensation	% prevalence	Prevalence	Total compensation	Actual costs	Identification	Compensation when identified	Compensation when not identified
t78	Thyroglosal duct	-17	0.11	19,259	-320470	2912	72.76%	-13	-25
t80	Congenital anomaly endocrine/metabolic	-562	0.13	21,993	-12367104	6880	83.36%	-644	-153
t81	Goitre	-295	0.57	99,059	-29210518	5323	88.21%	-326	-60
t86	Hypothyroidism/myxoedema	-10	2.85	493,283	-5120278	5080	93.56%	-6	-70
t90	Diabetes	-105	6.25	1,082,125	-113980226	7874	98.14%	-101	-341
t92	Gout	-384	2.93	507,651	-194826301	7048	89.38%	-418	-96
t93	Endocrine/metabolic/nutritious. Dis. Other	-28	8.53	1,475,964	-41061318	5045	88.99%	-23	-66
u28	Limited functioning urinary system	-2583	0.08	13,857	-35787365	16685	94.16%	-2757	232
u75	Malignant neoplasm kidney	28	0.14	23,757	654030	12192	96.39%	70	-1117
u76	Malignant neoplasm bladder	-636	0.32	54,938	-34924087	10632	97.41%	-648	-158
u77	Malignant neoplasm urinary other	922	0.02	3,828	3530335	12103	98.50%	940	-249
u85	Congenital anomaly urinary tract	-334	0.21	36,730	-12253495	5481	81.80%	-387	-93
u88	Glomerulonephritis/nephrosis	-588	0.15	26,618	-15660168	8468	87.30%	-685	79
w28	Limited functioning due to pregnancy	-150	0.16	27,644	-4147706	2431	84.20%	-176	-9
w72	Malignant neoplasm due to pregnancy	1446	0.001	231	334058	1896	88.55%	1535	858
w76	Congenital anomaly complicate pregnancy	-75	0.02	2,940	-220059	2401	74.73%	-50	-147
x28	Limited functioning female genital	111	0.01	1,411	156819	3790	86.44%	-80	311
x75	Malignant neoplasm cervix	-187	0.25	44,100	-8246700	4670	83.68%	-241	87
x76	Malignant neoplasm breast female	-222	1.47	254,949	-56506896	6912	96.41%	-215	-394
x77	Malignant neoplasm female genital other	-384	0.28	48,862	-18759099	8011	94.38%	-377	-498
x83	Congenital anomaly female genital	-42	0.07	12,185	-516400	2672	75.36%	-54	-5
x88	Fibrocystic disease breast	-94	1.62	281,180	-26312824	3240	79.26%	-101	-64
y28	Limited functioning male genital	-140	0.13	21,711	-3036500	6156	88.13%	-101	-425
y77	Malignant neoplasm prostate	-190	0.69	120,208	-22822691	9517	97.96%	-194	-1
y78	Malign neoplasm male genital other	30	0.13	22,380	682366	4008	81.86%	20	78
y82	Hypospadias	-282	0.12	20,028	-5651501	2089	63.19%	-111	-576
y84	Congenital anomaly male other	20	0.07	12,943	255883	1570	63.14%	118	148

Code	Disease	Compensation	% prevalence	Prevalence	Total compensation	Actual costs	Identification	Compensation when identified	Compensation when not identified
z28	Limited function social	-150	0.01	88,671	-13313951	3976	71.92%	-179	-76
	CVD	-110	22.04	3,814,425	-419586750	6,163	0		
	Diabetes	-105	6.25	1,082,125	-113623125	7,847	1.9%	-341	
	COPD	-310	3.05	527,811	-163621410	8,397	5.7%	-307	
	Cancer	-248	9.63	1,667,702	-413590096	7,380	7.2%	-104	
	Arthrosis	-180	11.92	2,062,956	-371332080	6,306	7.50%	-251	

**Note: Observations are based on reweighted results as described in paragraph 3.1. Codes refer to ICPC-codes related to general practitioners' registration system and are used in the Nivel-PCD. Compensation is calculated in euros.*

Appendix B: Sensitivity Analysis

Code	Disease	Compensation	Compensation SA	Compensation when identified	Compensation when not identified	Percentage prevalence	Prevalence	Total compensation	Total compensation SA
a28	Limited functioning/disability	-513.63	-367	-479	197	0.16	27,504	-4032911.52	-10093968
a79	Malignancy NOS	-1536.26	-1629	-1723	-48	0.06	9,664	896239.36	-15742656
a90	Congenital anomaly OS/	-713.71	-675	-763	-256	0.22	37,377	-1446863.67	-25229475
b28	Limited functioning/disability blood and/or blood forming organs	-573.51	-438	-510	109	0.03	4,354	-590010.54	-1907052
b72	Hodgkin's Disease/lymphoma	-1603.33	-1551	-1573	-1202	0.22	38,768	-2028729.44	-60129168
b73	Leukemia	-181.2	-725	-727	-689	0.16	26,904	14630395.2	-19505400
b74	Malignant neoplasm blood other	-2051.48	-2466	-2497	-256	0.10	17,376	7202699.52	-42849216
b78	Hereditary hemolytic anemia	-209.27	-216	-234	-159	0.32	55,758	375251.34	-12043728
b79	Congenital. Anomaly. Blood/lymph other	177.58	-4	25	-143	0.05	8,669	1574117.02	-34676
b83	Purpura/coagulation defect	-36.69	60	126	-258	0.86	148,505	-14358948.5	8910300
b90	HIV-infection/aids	306.09	905	314	-366	0.13	23,313	-13962388.8	21098265
d28	Limited functioning digestion	-1464.86	-1348	-1696	300	0.06	9,965	-1164509.9	-13432820
d74	Malignant neoplasm stomach	4.54	35	-7	348	0.05	8,980	-273530.8	314300
d75	Malignant neoplasm colon/rectum	79.44	234	80	50	0.80	138,664	-21431907.8	32447376
d76	Malignant neoplasm pancreas	-869.2	-420	-846	-1776	0.04	6,395	-2872634	-2685900
d77	Malignant neoplasm digest other/NOS	-2451.01	-2287	-2326	-1405	0.21	36,013	-5906492.13	-82361731
d81	Congenital. Anomaly. Digestive system	-245.45	-279	-279	-278	0.47	81,450	2732647.5	-22724550
d92	Diverticular disease	-228.41	-101	-86	-303	2.18	378,209	-48187608.7	-38199109
d94	Chronic enteritis/ulcerative colitis	-498.25	-372	-388	-147	0.99	170,781	-21561101.3	-63530532
d97	Liver disease NOS	-429.29	-341	-346	-295	1.08	186,330	-16451075.7	-63538530
f28	Limited functioning eye	-81.97	-43	-14	-158	0.28	49,012	-1909997.64	-2107516
f81	Congenital. Anomaly. Eye other	-332.67	-332	-302	-404	0.26	44,444	-29777.48	-14755408
f83	Retinopathy	-99.6	105	111	-161	0.79	136,926	-28015059.6	14377230
f84	Macular degeneration	-85.41	120	123	-19	0.78	135,429	-27818470.9	16251480
f91	Refractive Error	-68.29	-73	3	-231	5.19	898,731	4233023.01	-65607363
f93	Glaucoma	-23.84	83	111	-178	1.98	342,083	-36548147.7	28392889

Code	Disease	Compensation	Compensation SA	Compensation when identified	Compensation when not identified	Percentage prevalence	Prevalence	Total compensation	Total compensation SA
f94	Blindness	-423.27	-320	-297	-436	0.21	36,268	-3745396.36	-11605760
h28	Limited functioning ear	-109.88	-40	-46	-19	0.14	25,089	-1753219.32	-1003560
h80	Congenital anomaly ear	-491.45	-516	-651	-241	0.15	26,177	642645.35	-13507332
h83	Otosclerosis	-103.79	-38	29	-425	0.09	15,811	-1040205.69	-600818
h84	Presbyacusis	-111.01	48	61	-262	1.73	300,093	-47717787.9	14404464
h85	Acoustic trauma	-49.58	32	151	-563	0.37	64,843	-5289891.94	2074976
h86	Deafness	-243.45	-158	-152	-200	2.54	439,835	-37583900.8	-69493930
k28	Limited functioning cardiovascular	-213.27	-93	-93	-85	0.07	12,384	-1489423.68	-1151712
k73	Congenital anomaly cardiovascular	47.43	99	193	-338	0.44	75,743	-3906066.51	7498557
k74	Ischemic heart disease w. angina pectoris	-33.99	121	127	-271	2.31	400,420	-62061095.8	48450820
k76	Acute myocardial infarction	-200.9	-35	-31	-490	1.14	196,930	-32670687	-6892550
k77	Heart failure/Decompensation cordis	-764.41	-642	-645	-10	1.15	199,026	-24362772.7	-127774692
k82	Pulmonary heart disease	-942.01	-873	-850	-1378	0.05	9,468	-653386.68	-8265564
k86	Hypertension uncomplicated	-81	60	88	-400	14.36	2486443	-350588463	149186580
k87	Hypertension complicated	-303.21	-113	-110	-319	1.89	327,081	-62214077	-36960153
k90	Stroke/CVA	-60.85	121	134	-727	1.98	342,788	-62335997.8	41477348
k91	Atherosclerosis	-79	93	111	-657	1.13	195,057	-33549804	18140301
k92	Cardiovascular disease other	-521.27	-380	-391	-285	2.38	412,842	-58322189.3	-156879960
l28	Limited functioning musculoskeletal	-709.55	-629	-694	-239	0.45	77,842	-6270173.1	-48962618
l82	Congenital anomaly musculoskeletal	-133.36	-154	-130	-202	1.38	239,236	4937831.04	-36842344
l84	Back syndrome w/o radiation pain	-173.15	-32	-4	-393	1.72	297,013	-41923385	-9504416
l85	Acquired deformity spine	-130.16	-118	-96	-182	1.00	173,742	-2112702.72	-20501556
l88	Rheumatoid/seropositive arthritis	-97.74	46	73	-357	1.46	253,094	-36379731.6	11642324
l89	Osteoarthritis hip	-274.47	-124	-100	-678	2.63	455,511	-68540740.2	-56483364
l90	Osteoarthritis knee	-325.67	-186	-166	-514	4.14	717,459	-100207499	-133447374
l91	Osteoarthritis other	-82.21	55	81	-224	3.68	636,892	-87387951.3	35029060
l95	Osteoporosis	-204.98	-156	-162	-52	3.02	523,278	-25630156.4	-81631368

Code	Disease	Compensation	Compensation SA	Compensation when identified	Compensation when not identified	Percentage prevalence	Prevalence	Total compensation	Total compensation SA
l98	Acquired deformity of limb	-55.31	-15	57	-233	4.81	833,025	-33579237.8	-12495375
n28	Limited functioning neurological system	-191.62	-51	-195	571	0.07	11,614	-1633160.68	-592314
n70	Poliomyelitis	470.18	598	710	-204	0.04	7,785	-995078.7	4655430
n74	Malignant neoplasm nervous system	-2044.54	-1999	-2067	-809	0.07	11,912	-542472.48	-23812088
n85	Congenital anomaly neurological	-774.21	-698	-766	-273	0.13	21,767	-1658863.07	-15193366
n86	Multiple Scleroses (MS)	-519	-282	-304	104	0.20	34,742	-8233854	-9797244
n87	Parkinsonism	-309.91	-7	13	-2318	0.29	50,380	-15260605.8	-352660
n88	Epilepsy	4.23	128	160	-99	1.17	201,951	-24995475.3	25849728
p28	Limited functioning psychological	389.483	476	473	476	0.11	18,960	-1640362.32	9024960
p70	Dementia	699.994	967	1010	-176	0.68	117,553	-31387356.3	113673751
p72	Schizophrenia	-148.099	-9	-366	1010	0.28	47,838	-6654217.96	-430542
p80	Personality disorder	-229.894	-164	-285	-132	1.37	236,496	-15583667.4	-38785344
p85	Mental retardation	177.296	239	447	162	0.68	117,525	-7251762.6	28088475
r28	Limited functioning respiratory system	-641.17	-705	-769	-352	0.09	15,627	997471.41	-11017035
r84	Malignant neoplasm bronchus/lung	-286.31	-5	27	-1934	0.28	49,321	-13874490.5	-246605
r85	Malignant neoplasm respiratory other	-1723.14	-1539	-1576	-643	0.07	12,412	-2285545.68	-19102068
r89	Congenital anomaly respiratory	197.97	159	243	-156	0.05	7,951	309850.47	1264209
r91	Chronic bronchitis/bronchiectasis	-423.49	-346	-370	-199	0.71	123,576	-9575904.24	-42757296
r95	Chronic Obstructive Pulmonary Disease (COPD)	-319.27	-226	-209	-792	2.34	404,235	-37702998.5	-91357110
r96	Asthma	-36.92	22	94	-226	9.53	1,650,172	-97228134.2	36303784
s28	Limited function disability skin	-135.59	-85	-62	-170	0.06	10,681	-540351.79	-907885
s77	Malignant neoplasm of skin	-134.26	-21	-12	-118	4.29	742,533	-84099287.6	-15593193
s81	Hemangioma/lymphangioma	10.77	36	127	-200	1.24	215,454	-5435904.42	7756344
s83	Congenital skin anomaly other	-209.72	-203	-177	-263	0.33	56,841	-381971.52	-11538723
s87	Dermatitis/atopic eczema	-33.94	-47	42	-212	12.11	2,095,567	27368105.02	-98491649
s91	Psoriasis	-70.02	-3	33	-159	2.83	489,595	-32812656.9	-1468785
t28	Limited functioning endocrine system	-596.49	-468	-538	189	0.01	2,081	-267387.69	-973908

Code	Disease	Compensation	Compensation SA	Compensation when identified	Compensation when not identified	Percentage prevalence	Prevalence	Total compensation	Total compensation SA
t71	Malignant neoplasm thyroid	-340.18	-210	-204	-474	0.07	12,883	-1677108.94	-2705430
t78	Thyroglosal duct	-16.64	16	72	-135	0.11	19,259	-628613.76	308144
t80	Congenital anomaly endocrine/metabolic	-562.32	-309	-319	-260	0.13	21,993	-5571266.76	-6795837
t81	Goitre	-294.88	-198	-201	-174	0.57	99,059	-9596835.92	-19613682
t86	Hypothyroidism/myxoedema	-10.38	102	121	-180	2.85	493,283	-55435143.5	50314866
t90	Diabetes	-105.33	92	102	-459	6.25	1,082,125	-213535726	99555500
t92	Gout	-383.78	-260	-265	-218	2.93	507,651	-62837040.8	-131989260
t93	Endocrine/metabolic/nutrition. Dis. Other	-27.82	83	116	-186	8.53	1,475,964	-163566330	122505012
u28	Limited functioning urinary system	-2582.62	-2334	-2486	111	0.08	13,857	-3445127.34	-32342238
u75	Malignant neoplasm kidney	27.53	226	280	-1216	0.14	23,757	-4715051.79	5369082
u76	Malignant neoplasm bladder	-635.7	-497	-503	-257	0.32	54,938	-7619900.6	-27304186
u77	Malignant neoplasm urinary other	922.24	1027	1048	-379	0.02	3,828	-401021.28	3931356
u85	Congenital anomaly urinary tract	-333.61	-299	-319	-206	0.21	36,730	-1271225.3	-10982270
u88	Glomerulonephritis/nephrosis	-588.33	-469	-534	-22	0.15	26,618	-3176325.94	-12483842
w28	Limited functioning due to pregnancy	-150.04	-148	-153	-123	0.16	27,644	-56393.76	-4091312
w72	Malignant neoplasm due to pregnancy	1446.14	1559	1673	680	0.00	231	-26070.66	360129
w76	Congenital anomaly complicate pregnancy	-74.85	-67	2	-272	0.02	2,940	-23079	-196980
x28	Limited functioning female genital	111.14	172	167	206	0.01	1,411	-85873.46	242692
x75	Malignant neoplasm cervix	-187	-124	-143	-29	0.25	44,100	-2778300	-5468400
x76	Malignant neoplasm breast female	-221.64	-204	2	-501	1.47	254,949	-4497300.36	-52009596
x77	Malignant neoplasm female genital other	-383.92	-204	-180	-609	0.28	48,862	-8791251.04	-9967848
x83	Congenital anomaly female genital	-42.38	-25	6	-119	0.07	12,185	-211775.3	-304625
x88	Fibrocystic disease breast	-93.58	-50	-17	-177	1.62	281,180	-12253824.4	-14059000
y28	Limited functioning male genital	-139.86	25	101	-540	0.13	21,711	-3579275.46	542775
y77	Malignant neoplasm prostate	-189.86	-21	-19	-106	0.69	120,208	-20298322.9	-2524368
y78	Malign neoplasm male genital other	30.49	90	120	-41	0.13	22,380	-1331833.8	2014200
y82	Hypospadias	-282.18	-320	-111	-680	0.12	20,028	757458.96	-6408960

Code	Disease	Compensation	Compensation SA	Compensation when identified	Compensation when not identified	Percentage prevalence	Prevalence	Total compensation	Total compensation SA
y84	Congenital anomaly male other	19.77	-21	114	-252	0.07	12,943	527686.11	-271803
z28	Limited function social	-150.15	-109	-80	-183	0.01	88,671	-3648811.65	-9665139
	Diabetes	-105	92	102	-459	11.92	2,062,956	-406402332	189791952
	CVD	-110	35	58	-391	6.25	1,082,125	-156908125	37874375
	Arthrosis	-180	-42	-17	-367	3.05	527,811	-72837918	-22168062
	Cancer	-248	-119	-111	-219	9.63	1,667,702	-215133558	-198456538
	COPD	-310	-221	-209	-424	22.04	3,814,425	-339483825	-842987925

**Note: Observations are based on reweighted results as described in paragraph 3.1. Codes refer to ICPC-codes related to general practitioners' registration system and are used in the Nivel-PCD. Compensation is calculated in euros.*