

University of Groningen

Sport as a medicine for health and health inequalities

de Boer, Willem

DOI:
[10.33612/diss.203332155](https://doi.org/10.33612/diss.203332155)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2022

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):
de Boer, W. (2022). *Sport as a medicine for health and health inequalities: essays on the role of sport participation in socioeconomic inequalities in health and health care costs*. [Thesis fully internal (DIV), University of Groningen]. University of Groningen, SOM research school.
<https://doi.org/10.33612/diss.203332155>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Chapter 4. Socioeconomic inequalities in health care costs

What is the relationship between a neighborhood's socioeconomic status and its health care costs?³

Abstract

Objectives: There is evidence that the socioeconomic conditions of a neighborhood is related to many adverse health outcomes. However, little is known about the relationship with health care costs. The objective of this study is to identify disparities in several types of insured health care costs in the Netherlands across neighborhoods with different socioeconomic statuses and to assess the room for improvement.

Methods: Using the 2015 Dutch whole-population registry data, we estimated the age- and gender-specific cost structure by neighborhood for total, specialist, pharmaceutical, and mental health care. Classifying neighborhoods by the quintile of their neighborhood socioeconomic status (NSES), we determined differences in observed and expected health care costs for several scenarios of NSES improvement.

Results: From low to high NSES, we found a clear downward gradient in health care costs. Total health care costs would drop by 7.3% if each neighborhood's cost structure was equal to that of the most affluent neighborhoods. The potential for cost reduction appeared highest for females, age groups between 40 and 60 years, and pharmaceutical care.

Conclusions: Low NSES is associated with relatively high health care costs, and represents a considerable potential for cost savings in health care. Our research suggests that policies aimed at improving the socioeconomic determinants of health locally may be pivotal in containing health care costs.

³ Joint work with R.H. Koning, E. Buskens, J.O. Mierau and R.H. Koning. A condensed version of this chapter has been published in American Journal of Public Health as De Boer et al. (2019).

4.1 Introduction

A growing body of literature acknowledges the association between neighborhood socioeconomic conditions and many adverse health outcomes, including mortality (Daly et al., 2002), self-rated health (Venkataramani et al., 2016), and quality of life (Drukker & Van Os, 2003). Poor health has, in turn, been related to high health care costs (Muka et al., 2015). Studies have shown that socioeconomic status (SES) and living in deprived neighborhoods not only increases the odds of poor health (Diez Roux & Mair, 2010) but also the odds of high-cost health care usage (Fitzpatrick, 2015). However, few studies have researched the direct relationship between socio economic status and health care costs. Asaria et al. (2016) have used hospital episode statistics to estimate the financial consequences of neighborhood socioeconomic differences in health care costs in the United Kingdom. They documented a substantial neighborhood socioeconomic gradient in hospital admissions and estimated that, if all neighborhoods had the same number of (age- and sex-adjusted) admissions as the richest neighborhoods, annual cost savings would potentially be GBP 4.8 bn. (around € 5.6 bn.), or 11% of hospital services costs for the National Health Service (NHS). Taking a similar approach, the Public Health Agency of Canada (PHAC, 2016) estimated that the direct costs of the socioeconomic gradient amounted to CAD 6.2 bn. (around USD 4.8 bn.), or over 14% of total annual costs on acute care hospitalizations, prescription medications, and outpatient visits. For the United States, comparable patterns of health outcomes strongly associated with socioeconomic differences have been observed (Krieger et al., 2005; Braveman et al., 2010).

Thus far, research on the socioeconomic gradient in health care costs has mainly involved case studies for specific health care categories, such as inpatient hospital costs (Asaria et al., 2016) or prevalence of chronic diseases (Kivimäki et al., 2018). To the best of our knowledge, however, no study hitherto has provided a comprehensive, population wide analysis of the cost implications of the socioeconomic gradient in health. This paper aims to add to the current state of research by including total health care costs (within insured health care), as well as the major care domains, using whole population data. Specifically, we analyze the relationship between socioeconomic status of neighborhoods and pertinent health care costs, while taking into account each neighborhood's age and sex structure.

The Netherlands has a statutory health insurance system, with obligatory private insurance, which the government regulates and subsidizes (Mossialos et al., 2016). Thus, 99.8% of the Dutch population has at least basic health insurance, granting access to health care. The health care market is organized in a system of regulated competition under the Health Insurance Act, through a privatized system of health insurers and health care providers (Mossialos et al., 2016). This system encompasses more than half of total health and care costs, including primary care, hospital care, and pharmaceutical care. The remaining costs fall under different legislation

and mainly concern long-term care and supplementary insured health care, such as dental care. Health care costs constitute about 11% of Dutch GDP.

The complete data on annual insured health care costs makes it possible to identify disparities in health care costs across neighborhoods with differing socioeconomic status in the Netherlands. Our research aims to provide insights into the relationship between neighborhood socioeconomic status (NSES) and health care costs, while taking into account age and sex. By applying several policy simulations that involve improving neighborhood socioeconomic status, we were able to estimate the potential savings in annual health care costs. Jointly, these scenarios provide guidance and justification for investment and for taking a broad socioeconomic policy perspective in order to curb rising health care costs.

4.2 Methods

4.2.1 Data

Health care costs for 2015 were provided by Vektis, the health care information center established by Dutch health care insurers (Vektis, 2018). Health insurance firms are required by law to provide their health care declaration data for risk equalization. Vektis harmonizes these data, and makes them available for research and policy purposes. By design, these data cover all insured individuals (i.e., 99.8% of the population). Hence, our research is able to take advantage of what is for all intents and purposes full-population data.

In our analysis, we used data aggregated at the neighborhood level, defined by the first three digits of each postcode. In 2015, the Netherlands had 790 neighborhoods of roughly 20,000 inhabitants, on average. For each of these neighborhoods, the data included the number of insured years (1 insured year equals one person insured for all 365 days) and annual health care costs, disaggregated by 91 age groups (0, 1, 2, ... up until age 89, plus age 90 and older combined) and 2 sex categories (male/female). In addition to total health care costs, three main components were discerned for further analysis: specialized, pharmaceutical, and mental health care. Specialized health care (comprising 52% of total health care costs) includes all medical-specialist care within hospitals including intramural medication, as well as extramural care by medical-specialists. Pharmaceutical care costs (11%) include all pharmaceutical aid dispensed through public pharmacies, including fees and practice costs for pharmacists. Mental health care (8%) includes treatment of basic mental health care, specialist mental care, and mental health care institutions. Apart from these three categories, total costs include other cost categories under the Health Insurance Act, such as primary, emergency, paramedical and maternity care.

Data on neighborhood socioeconomic status were obtained from the Netherlands Institute for Social Research (SCP, 2018). Bi-annually, the SCP publishes a Neighborhood Socioeconomic Status (NSES) Score, which is derived from characteristics (education, income,

and labor market status) of individuals in each neighborhood. In line with PHAC (2016) and Asaria et al (2016), we ordered the 790 neighborhoods by NSES score and divided them into roughly equal sized quintiles (with NSES1 the most deprived neighborhoods and NSES5 the most affluent). Table 4.1 shows the descriptive statistics of the data at the neighborhood level.

Table 4.1: Descriptive statistics Dutch health insurance population (at neighborhood level), 2015

Variable	Obs.	Median	Mean	Std. Dev.	Min.	Max.
Insured years	790	14,800.92	21,066.22	19,990.12	23.00	147,868.40
Sex (female = 1)	790	0.5037	0.5005	0.0249	0.3013	0.5485
NSES (status)	790	0.06	-0.03	0.83	-3.45	2.22
Total health care costs per insured year	790	€ 2,318.22	€ 2,308.32	€ 318.38	€ 1,095.24	€ 3,216.90
Specialist health care costs per ins. year	790	€ 1,231.95	€ 1,226.63	€ 158.88	€ 549.29	€ 1,787.94
Pharmaceutical costs per insured year	790	€ 258.07	€ 258.70	€ 44.12	€ 91.07	€ 431.71
Mental health costs per insured year	790	€ 133.51	€ 150.75	€ 70.78	€ 0.00	€ 661.98

4.2.2 Analysis

Following the method of Ferrer and Palmer (2004), we decomposed the variance in health care costs between, as well as within, NSES quintiles. First, we estimated the socioeconomic gradient by regressing health care on dummy variables of each of the five NSES quintiles. Next, we simulated four scenarios for reducing the variation in socioeconomic status of neighborhoods both between and within NSES quintiles. In Scenario 1, we estimate the impact of completely eliminating the socioeconomic gradient by applying the national average cost structure to all neighborhoods. The term “cost structure” stands for average costs for the (91x2=) 182 age/sex categories, which can be calculated at neighborhood, NSES-quintile, and national levels. In Scenario 2, we simulated an improvement to the cost structure of the most affluent NSES quintile for all neighborhoods. In addition to this somewhat utopian scenario, we considered two more cautious scenarios. Scenario 3 estimates the impact of each neighborhood shifting up one NSES quintile on the socioeconomic ladder. The most realistic scenario, Scenario 4, shows the impact of reducing the within-NSES quintile variation in health care cost, by assigning the within-NSES quintile average health care cost structure to each neighborhood in that quintile with health care costs above the average.

In each of the four scenarios, we calculated the differences between a neighborhood’s observed health care costs and the costs if the cost structure of the given scenario were to be applied to that neighborhood. In a simulated scenario, the neighborhood’s observed population structure (i.e., the number of insured years for each age/sex category) was multiplied with the cost structure of the given scenario (i.e., for Scenario 1, the national average costs for each

age/sex category). We then determined the absolute and relative potential cost reduction, by calculating the differences between the observed and the simulated costs for each neighborhood and NSES quintile. This analysis was performed separately for all four health care costs.

To establish the socioeconomic gradient of health care costs in the Netherlands, we performed a regression analysis. First, average health care costs were calculated for each neighborhood. Next, these average costs were then standardized: for each observed value of neighborhood average health care costs we subtracted the national mean and divided this by the standard error. These standardized average costs were regressed on the dummies for each NSES quintile, with the middle quintile (NSES3) being the baseline. The weighted regression (by number of insured years) on the standardized average costs (ac) for each neighborhood is as follows:

$$ac_j = \alpha_0 + \alpha_1 d_SES1_j + \alpha_2 d_SES2_{SES2} + \alpha_3 d_SES4_j + \alpha_4 d_SES5_j + \varepsilon_j \quad (4.1)$$

where j stands for each neighborhood (NSES, $j = 1, \dots, 790$) and d_SES1 being the dummy for neighborhoods in the first NSES quintile, etc. To analyze differences between groups (such as NSES quintiles), we performed ANOVA- and t-tests, boxplots, and regression analysis, using Stata/SE 15.0.

4.3 Results

4.3.1 Socioeconomic gradient in total health care costs

Table 4.2 shows the average total health care costs for each neighborhood and NSES quintile. A clear socioeconomic gradient in health care costs can be observed: With every subsequent NSES quintile, average costs decline by about EUR 100 (Column 3; see also boxplots of Figure A4.1 in the Appendix). One-way ANOVA tests show that average costs differ significantly ($P < 0.001$) across NSES quintiles.

Scenario 1 applies the national average cost structure to each neighborhood. Table 4.2 shows the relative difference between observed and expected outcomes in Column 4 (see also Appendix, Table A4.1). Again, the negative socioeconomic gradient is visible. While the lowest NSES quintile incurred 10% (EUR 249) more costs than expected, the highest NSES quintile incurred 8% (EUR 170) less than expected. Columns 5 of Table 4.2 show results for eliminating the socioeconomic gradient completely by assigning the age/sex-specific average health care costs of the highest NSES quintile to each neighborhood (Scenario 2). For each of the other quintiles, health care costs decline, with the greatest change being achieved in the lowest NSES group (16% per year). Aggregating over the different cost reductions provides a total potential decrease in annual health care costs of 7.3% (EUR 2.8 bn.) of total insured health care costs.

The outcomes of Scenario 3 are shown in Column 6 of Table 4.2. If neighborhoods were to reach the cost structure of the next NSES quintile, a savings of 3.6% (EUR 1.4 bn.) of total insured health care costs would be achieved.

Column 7 of Table 4.2 shows the outcomes of a decrease in health care costs of the neighborhoods that have costs above the average of their own NSES quintile to match that average within-NSES quintile cost structure (Scenario 4). In total 306 (out of 790) neighborhoods, or about 8.6 million insured years, have health care costs above their within-NSES quintile average. The potential reduction in total health care costs equals 2.4% of total insured health care cost (EUR 958 mln.), or 4.6% of the costs for these neighborhoods alone. The cost saving potential was quite evenly distributed over the NSES quintiles. Additionally, *within* NSES quintiles we also observed a negative relationship between health care costs and NSES.

Table 4.2: Real and expected average total health care costs and potential savings for 4 scenarios, 2015

NSES quint.	n (neighb.)	Insured years	Obs. average costs	Cost saving Scen. 1	Cost saving Scen. 2	Cost saving Scen. 3	Cost saving Scen. 4
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NSES1	112	3,346,924	€ 2,554	9.8%	16.3%	7.3%	2.4%
NSES2	153	3,301,725	€ 2,469	2.6%	9.7%	4.2%	2.3%
NSES3	170	3,331,801	€ 2,350	-1.7%	5.7%	2.8%	2.5%
NSES4	184	3,335,400	€ 2,250	-4.7%	2.9%	2.9%	2.6%
NSES5	171	3,326,467	€ 2,159	-7.9%	0.0%	0.0%	2.5%
Total	790	16,642,317	€ 2,356	0.0%	7.3%	3.6%	2.4%

Notes: Table 4.2 shows for each neighborhood socioeconomic status (NSES) quintile the number of neighborhoods (column 1), insured years (2) and the observed average health care costs (3). NSES1 are the most deprived areas, NSES5 the most affluent. Columns 4-7 show the relative potential costs saving (i.e., the percentage difference between the simulated health care costs in each of the four scenarios and the observed costs). In Scenario 1 (column 4) the health care cost structure for each neighborhood is equal to that of the national average. In Scenario 2 (5) costs are equal to that over the most affluent NSES quintile. In Scenario 3 (6) costs are equal to that of the next NSES category. In Scenario 4 (7) each neighborhoods' costs are held to at most the within-NSES-quintile average.

4.3.2 Cost categories

Costs and cost saving potentials differ considerably over the cost categories. While total health care costs were over 10% higher in the lowest NSES1, as compared to the national average (Scenario 1), this number was considerably less for specialist care (6.6%; see Appendix Table A4.2). By contrast, for pharmaceutical care and especially mental health care, these differences were much higher: 17% and 23% for NSES1, respectively. Bonferroni tests showed that, with the exception of specialist care, average costs drop significantly when moving upward on the NSES quintile ladder. However, the differences between NSES4 and NSES5 were not significant for any of the cost categories. Table 4.3 shows the relative difference between observed and expected

costs in the scenario that shows the cost saving potential (Scenario 2) and the most realistic scenario (Scenario 4) for total, specialist, pharmaceutical, and mental health care.

There are large differences between the cost groups when it comes to the potential cost savings if each neighborhood was to have the NSES5 cost structure (Scenario 2). This is especially the case for NSES1 in pharmaceutical care and mental health, with potential cost reductions of 27% and 34%, respectively. The relationship between deprivation and health care costs is mainly positive for most cost types (greater deprivation means higher costs). However, for mental health care, the fourth quintile (NSES4) would have had 5.6% *higher* costs with the cost structure of NSES5. A similar pattern is visible for Scenario 3 (see Appendix Table A4.2).

Scenario 4 paints a different picture, since within-NSES-quintile improvements show similar sized cost cutting potentials across the NSES groups. Relative cost-saving potentials in this scenario are higher for mental health (11.6%) and pharmaceutical care (4.5%) than for total health care (2.4%).

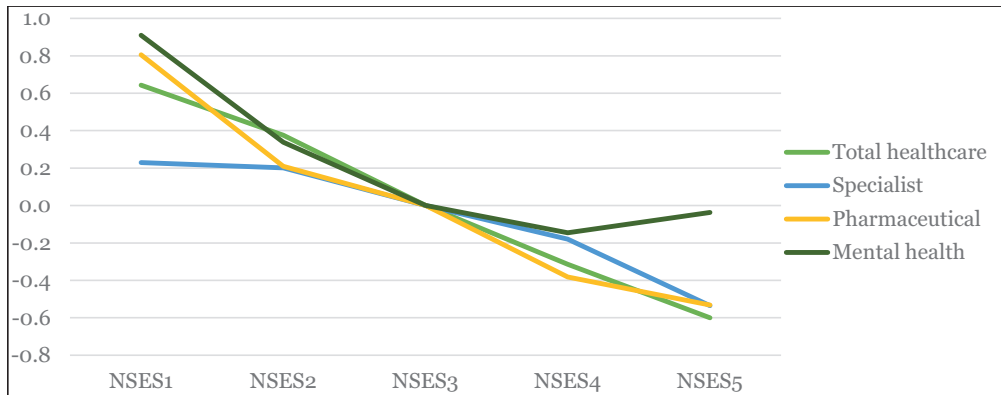
Table 4.3: Cost effects of Scenarios 2 and 4 for total, specialist, pharmaceutical, and mental health care, 2015

Scenario 2						
NSES quintiles (1 most deprived, 5 least deprived)		Total health care	Specialist	Pharmaceutical	Mental health	
		(1)	(2)	(3)	(4)	
	NSES1	16.3%	10.9%	21.1%	25.1%	
	NSES2	9.7%	6.2%	8.6%	12.8%	
	NSES3	5.7%	4.0%	5.8%	-0.1%	
	NSES4	2.9%	3.0%	0.8%	-5.9%	
	NSES5	0.0%	0.0%	0.0%	0.0%	
	Total	7.3%	4.9%	7.9%	8.1%	
	Scenario 4					
		Total health care	Specialist	Pharmaceutical	Mental health	
	(5)	(6)	(7)	(8)		
NSES1	2.4%	3.0%	4.5%	8.1%		
NSES2	2.3%	2.7%	3.8%	11.8%		
NSES3	2.5%	3.0%	4.7%	13.3%		
NSES4	2.6%	2.7%	3.9%	12.4%		
NSES5	2.5%	3.0%	5.3%	14.1%		
Total	2.4%	2.9%	4.5%	11.6%		

Note: Table 4.3 shows the relative potential cost reduction for each of the Neighborhood Socioeconomic Status (NSES) quintiles (Column 1) for Scenarios 2 and 4 for total health care, specialist care, pharmaceutical care, and mental health care. NSES1 are the most deprived areas, NSES5 the most affluent. In Scenario 2 (columns 2-4) costs are equal to that over the most affluent NSES quintile. In Scenario 4 (5-8) costs are held to at most the within-NSES-average.

We performed linear regressions of standardized health care costs on dummy variables for each NSES quintile. Figure 4.1 shows the predicted standardized health care cost difference from the benchmark NSES3. All cost categories have a negative slope, implying that a higher NSES quintile is associated with lower than expected health care costs. The slope is steepest for pharmaceutical costs. The curve for mental health care shows an upward slope at the end, indicating that NSES4 performs relatively better than NSES5 (although this difference is not statistically significant).

Figure 4.1: Standardized differences in health care costs between neighborhood socioeconomic status quintiles (NSES3 benchmark), 2015



This figure shows the standardized (i.e., the values on the y-axis show the difference to the benchmark in terms of standard errors) differences between neighborhood socioeconomic status (NSES) quintiles in health care costs, with NSES1 the most deprived neighborhoods and NSES5 the most affluent. The middle NSES quintile (NSES3) serves as the benchmark.

4.3.3 Effects of sex and age

Differentiating the scenarios by age revealed the typical upward sloping profile of health care costs over the life cycle, with a peak in health care costs for women during childbearing years (see Figure A4.2 in the Appendix). Concerning the NSES quintiles, we observed that the most deprived neighborhoods almost consistently displayed higher health care costs over the life cycle. Table A4.3 of the Appendix shows the potential total impact of reducing the socioeconomic gradient in health care costs, for Scenarios 2-4 (by definition, the impact of Scenario 1 equals zero). For Scenario 2, the total cost reduction is 8.0% for females (EUR 1.7 bn.) and 6.4% for males (EUR 1.1 bn.). This relative potential decreases to 3.6% for both sexes in Scenario 3. By contrast, the potential for health cost savings within NSES quintiles (Scenario 4) is relatively higher for males (2.7%) than for females (2.3%).

Differentiating by age groups, the 41-50 and 51-60 year-olds have the highest saving potential in relative terms, and in absolute terms for 51-60 year-olds. The potential for these age

groups is over 10% for Scenario 2, and 3.5% for Scenario 4. By contrast, the potential for teenagers (11-20 year-olds) is just 1.4% and 1.6%, respectively.

Sensitivity analysis using alternative socioeconomic status measurements

The previous analysis revealed that there is a substantial socioeconomic gradient in insured health care expenditures and that even a conservative reduction in socioeconomic gradient can lead to quite substantive reductions in health care expenditures. Looking at alternative measurements of socioeconomic status may function as a kind of sensitivity analysis. By definition, composite measurements of neighborhood socioeconomic status (NSES) such as the one for the SCP aim to project a variety of underlying components onto a single number or index. To address the sensitivity of our results vis-à-vis alternative modes of assessing NSES, we performed a similar analysis on total health care costs for two alternatives: the average household income and the average property value of a neighborhood. For both these measurements, specific new quintiles were constructed based on the average values for each neighborhood. The results of this exercise are shown in Tables 4.4a-c. As with the analysis for NSES, the analysis of both these indicators shows very similar patterns and effect sizes. Average neighborhood health care costs show a (significantly) negative relationship for both household income and property value (Scenario 1). The potential relative cost reductions for Scenarios 2, 3, and 4 are very close for the income and property-value quintiles as for the NSES groups.

Table 4.4: Sensitivity analysis for potential savings in 4 scenarios, with original NSES, average household income, and average property value, 2015

(a) Health care costs and potential savings (%) for neighborhood socioeconomic status (NSES) quintiles

NSES quintile	N (1)	Insured years (2)	Total costs (3)	Sc. 1 (4)	Sc. 2 (5)	Sc.3 (6)	Sc. 4 (7)
NSES1	112	3,346,924	€ 8,549,609,241	9.8%	16.3%	7.3%	2.4%
NSES2	153	3,301,725	€ 8,152,880,687	2.6%	9.7%	4.2%	2.3%
NSES3	170	3,331,801	€ 7,828,779,340	-1.7%	5.7%	2.8%	2.5%
NSES4	184	3,335,400	€ 7,503,827,262	-4.7%	2.9%	2.9%	2.6%
NSES5	171	3,326,467	€ 7,180,839,376	-7.9%	0.0%	0.0%	2.5%
Total	790	16,642,317	€ 39,215,935,906	0.0%	7.3%	3.6%	2.4%

(b) Health care costs and potential savings (%) for quintiles based on average household income per neighborhood

Income quintile	N (1)	Insured years (2)	Total costs (3)	Sc. 1 (4)	Sc. 2 (5)	Sc.3 (6)	Sc. 4 (7)
1	128	3,338,457	€ 8,393,821,335	9.5%	16.5%	6.7%	2.6%
2	139	3,325,181	€ 8,174,648,468	3.0%	10.6%	3.9%	2.6%
3	136	3,364,873	€ 7,884,048,840	-1.0%	7.0%	3.3%	2.4%
4	191	3,289,810	€ 7,498,559,095	-4.4%	3.9%	3.9%	2.3%
5	196	3,323,996	€ 7,264,858,170	-8.7%	0.0%	0.0%	2.3%
Total	790	16,642,317	€ 39,215,935,908	0.0%	7.9%	3.6%	2.4%

Table 4.4 (continued)**(c) Health care costs and potential saving (%) for quintiles based on average property value per neighborhood**

Prop. value quintile	N (1)	Insured years (2)	Total costs (3)	Sc. 1 (4)	Sc. 2 (5)	Sc.3 (6)	Sc. 4 (7)
NSES1	120	3,336,801	€ 8,501,795,535	8.2%	15.0%	5.2%	2.9%
NSES2	127	3,326,274	€ 8,005,981,736	3.2%	10.4%	3.4%	2.8%
NSES3	157	3,348,980	€ 7,858,833,819	-0.2%	7.3%	4.0%	2.7%
NSES4	174	3,305,115	€ 7,500,627,896	-4.5%	3.4%	3.4%	2.7%
NSES5	212	3,325,146	€ 7,348,696,921	-8.1%	0.0%	0.0%	2.5%
Total	790	16,642,316	€ 39,215,935,907	0.0%	7.5%	3.3%	2.7%

Notes: Tables 4.4a-c show for each quintile of three socioeconomic indicators the number of neighborhoods (Column 1), insured years (2), total health care costs (3) and the potential health care costs saving for the four scenarios (4-7). The socioeconomic indicator is Neighborhood Socioeconomic Status for Table A5a, average household income per neighborhood for Table A5b and average property value per neighborhood in Table A5c. In Scenario 1 the health care cost structure for each neighborhood is equal to that of the national average (Column 4). In Scenario 2 costs are equal to that over the most affluent NSES quintile (5). In Scenario 3 costs are equal to that of the next NSES category (6). In Scenario 4 each neighborhoods' costs are held to at most the within-NSES-quintile average (7).

4.4 Discussion

Our analyses are not without limitations. First of all, while we used rich, full-population data, this data only includes insured health care costs. These make up about 50% of total health care costs, and it is unclear if a socioeconomic gradient will also be present in the remaining care costs.

Second, we measured only the direct costs of health care, and cannot assess the impact of the indirect and intangible costs of ill health. As highlighted by Mackenbach et al. (2011), indirect and intangible costs of health also display a socioeconomic gradient, indicating that our estimates are best viewed as lower bounds.

Third, since we use data, aggregated at the neighborhood level, this may lead to an ecological inference fallacy (Simpson's paradox) and we may have over- or underestimated the socioeconomic gradient at less aggregated levels. Our analysis shows, however, that a negative socioeconomic gradient was present between as well as within NSES quintiles. Future research may look deeper into the role of subpopulations on these gradients.

Fourth, because we use a cross-sectional approach, the socioeconomic gradients in health care costs that we find are associations and not necessarily indicative of a causal relationship between NSES and health care costs. However, applying Hill's criteria, we are confident that the outcomes are strong, consistent, and coherent, and therefore this causal relationship may be considered plausible. We performed robustness checks on NSES with average household income and the average property value as alternative measurements, which show results similar to our analysis (see Appendix). Our results also show that, although Bhavsar et al. (2018) argue that neighborhood socioeconomic variables may not add information to

explain socioeconomic differences in health outcomes, these variables can be very valuable, at least in the absence of individual data. Indeed, individual data would have been preferable and may in future research yield more precise estimates and insights.

We further acknowledge that the relationship between the socioeconomic environment and health outcomes is not simple, direct, or mono-causal. Moreover, it is likely that several bi-directional mechanisms are at work here, as has been suggested by others (Cutler et al., 2016)

Finally, due to the unavailability of detailed data, our analysis does not take into account mortality. Low SES groups tend to have a higher mortality rate. We addressed this issue indirectly by keeping the population structure for each neighborhood constant. However, mortality also has an influence on the cost structure, and future analysis should, ideally, incorporate mortality rates.

Future research needs to focus on elucidating the general and regional specifics of the socioeconomic gradient in health care costs and understanding the underlying mechanisms. Knowledge of these mechanisms provides essential information on the type of policies that may be developed to achieve the cost reductions indicated by our analysis. Future research could test hypotheses that local characteristics, such as access to green and recreational areas (Mitchell et al., 2015) or sport facilities (Mueller et al., 2018), along with lifestyle characteristics, such as nutrition and physical activity, affect health care costs.

4.5 Conclusion

In this paper, we demonstrated a clear socioeconomic gradient for insured health care costs using full-population data from the Netherlands. We discerned a substantial negative relationship between socioeconomic status and health care costs, with health care costs in the lowest socioeconomic neighborhoods being over 10% higher than expected, based upon national averages, and those in the most prosperous neighborhoods being 8% less than expected. Simulations show that if each neighborhood's cost structure was equal to that of the most affluent quintile of neighborhoods, health care costs would drop by 7.3%. Interestingly, if the neighborhoods with above-average costs *within* each NSES quintile just dropped back to the average in that quintile, total health care costs could still be reduced by 2.4%.

Our findings confirm the findings of a negative socioeconomic gradient for health care costs that others have found for more specific cost categories (Asaria, et al., 2016; PHAC, 2016), but the sizes of the effects (i.e., the relative cost saving potential) are more modest. This could be due to the fact that we are using full-population data (without a selection bias), or to specifics of Dutch society and its health care system. Our research show that the highest savings would be achieved by improving socioeconomic conditions and outcomes, which is consistent with the findings on actual (Braveman, Cubbin, Egerter, Williams, & Pamuk, 2010) and perceived health in the US (Venkataramani et al., 2016; PHAC, 2016). Future research should consider into the

mechanisms that relate low NSES to higher costs. Perhaps the neighborhood socioeconomic gradient in health care costs is a reflection of relatively poorer lifestyles, since smoking (Barbeau et al., 2004) and heavy drinking (Brenner et al., 2015) are generally found to be more prevalent among persons with a lower socioeconomic status.

Analysis for three large cost categories reveals that, by moving up on the NSES ladder, high relative cost reductions in pharmaceutical and mental health care may be achieved, but much less so in specialist care. Since low SES is more associated with mental disorders (Hudson, 2005) and chronic diseases (Kim et al., 2018), for example, these may provide an explanation for higher mental and pharmaceutical health care costs. Meanwhile stress is more common in the highest SES groups (Damaske et al., 2016), which could offer an explanation for the U-shaped curve in mental health care costs. Ideally, future research should expand to other types of health care costs, including primary health care, which has many direct and indirect linkages to other types of care, and zoom in on deeper levels of health care, such as specific treatments and the consumption of medicine. Currently, the possibilities for this research are restricted due to availability of data, as well as the compensation structure (for primary care) in the Netherlands. The limited data available on primary care indicate similar trends that would need explicit and additional study.

Females account for a relatively large portion of total health care cost differences between the NSES quintiles, while inequality within NSES quintiles is relatively higher among men. Importantly, neighborhood socioeconomic differences seem to contribute to comparatively large health cost effects for persons aged between 40 and 60, but are relatively limited for younger persons (below the age of 20). This age pattern confirms earlier research on SES and general health outcomes (House et al., 1990), and may reflect the fact that non-communicable diseases (NCDs), for example, are more prevalent at an early age in lower SES classes (Forouzanfar et al., 2016). Hence, the occurrence of the (perceived) burden of NCDs may also take place much earlier. However, age-specific outcomes should be treated with caution, since they could reflect age as well as cohort- or period-specific characteristics.

4.5.1 Public health implications

Curbing ever-increasing health care costs is an important public health goal. Our research suggests that, in line with other research (Carlin et al., 2017; Kivimäki et al., 2018), improving socioeconomic conditions, public policies, and facilities in neighborhoods is likely to contribute to this goal, especially for the most deprived areas. Additionally, the within-NSES-quintile potential for cost reductions suggests that local characteristics and more locally focused policies may decrease health care costs for deprived as well as affluent neighborhoods. It would seem, however, that a national public policy should start with the most deprived neighborhoods (NSES1), because these areas have the highest potential for health gain and cost savings.

Our analysis indicates that health and health care costs should become a more integral part of socioeconomic policies, and vice versa. Effective strategies need to take into account a neighborhood's population and social structure. Additionally, differences in potential cost gains between age groups may signal a generational effect, which may have implications for future health care cost developments between socioeconomic groups, as others have suggested for specific health indicators (Hurst et al., 2013).

Our research provides a clear indication that taking a broad view of future policies aimed at curbing health care costs, and either directly or indirectly decreasing the socioeconomic gradient in health and subsequent cost of care, is required. As such, there obviously is no "cure" or intervention to alleviate the SES of an individual or neighborhood. Yet, this is no reason not to claim that our results provide clear support for the development of policies that address SES-associated disparities in health.

To conclude, while not having presented experimental evidence about interventions that were designed to reduce health differences associated or mediated by SES, we have been able to present strong arguments for developing integral approaches focused on target populations. This development would require solid theoretical underpinning as well as appropriate confirmatory research.

Appendix

Figure A4.1: Boxplots for the average costs of total, specialist, pharmaceutical, and mental health care, per NSES quintiles, 2015

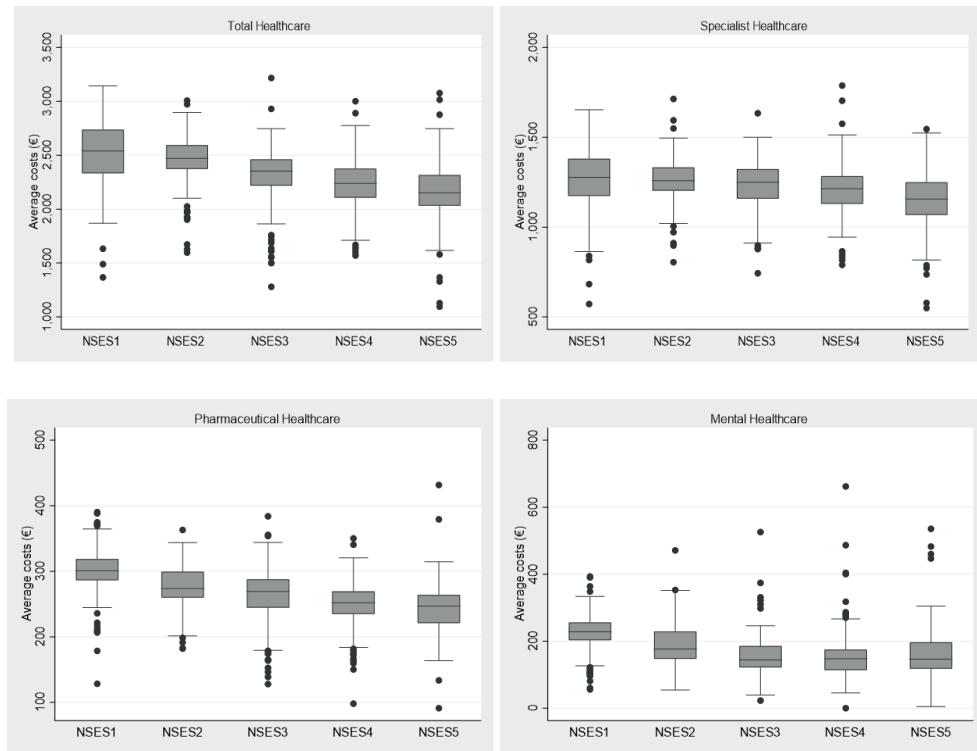


Figure A4.2: Average total health care costs per insured year over age, by NSES quintile, for males and females, 2015

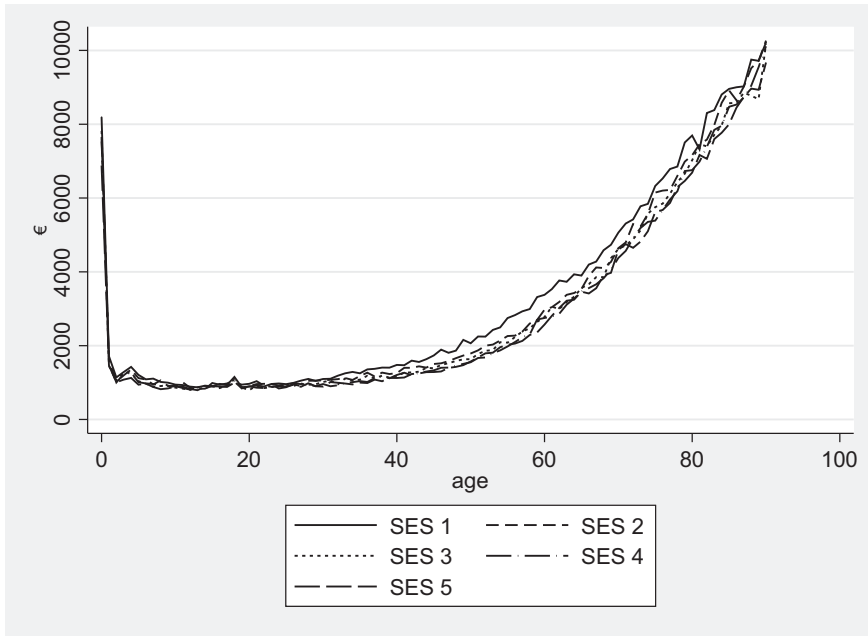


Figure A4.2a: male

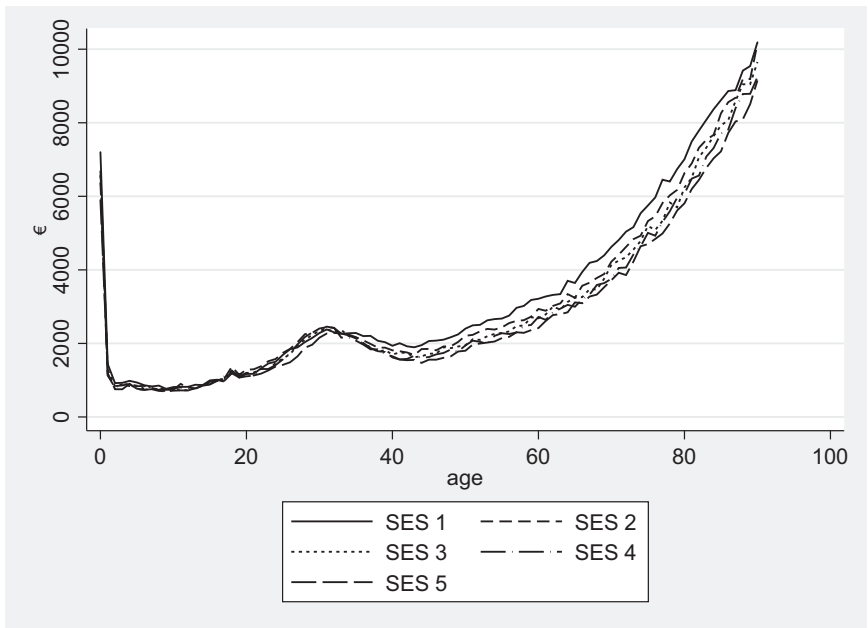


Figure A4.2b: female

Table A4.1: Real and expected average total health care costs and potential savings for 4 scenarios, 2015

NSES quintile	n (neighbb.) (1)	Insured years (2)	Average costs (3)	Scenario 1: avg. exp. costs (4)	Scenario 1: diff. (%) (5)	Scenario 2: avg. exp. costs (6)	Sc.2: saving potential (7)
NSES1	112	3,346,924	€ 2,554	€ 2,305	9.8%	€ 2,138	16.3%
NSES2	153	3,301,725	€ 2,469	€ 2,404	2.6%	€ 2,230	9.7%
NSES3	170	3,331,801	€ 2,350	€ 2,389	-1.7%	€ 2,216	5.7%
NSES4	184	3,335,400	€ 2,250	€ 2,355	-4.7%	€ 2,183	2.9%
NSES5	171	3,326,467	€ 2,159	€ 2,329	-7.9%	€ 2,159	0.0%
Total	790	16,642,317	€ 2,356	€ 2,356	0.0%	€ 2,185	7.3%

Table A4.1 (continued)

NSES quintile	Scen. 3: avg. exp. costs (8)	Scenario 3: saving potential (%) (9)	Scenario 4: n (neighborh.) (10)	Scenario 4: insured years (11)	Scenario 4: avg. costs (12)	Scenario 4: avg. exp. costs (13)	Scenario 4: saving potential (%) (14)
NSES1	€ 2,369	7.3%	49	1,736,024	€ 2,688	€ 2,569	2.4%
NSES2	€ 2,365	4.2%	61	1,835,388	€ 2,540	€ 2,439	2.3%
NSES3	€ 2,283	2.8%	58	1,626,814	€ 2,426	€ 2,305	2.5%
NSES4	€ 2,183	2.9%	76	1,807,536	€ 2,339	€ 2,232	2.6%
NSES5	€ 2,159	0.0%	62	1,623,421	€ 2,173	€ 2,063	2.5%
Total	€ 2,272	3.6%	306	8,629,183	€ 2,437	€ 2,326	2.4%

Notes: Table A4.1 shows, for each neighborhood socioeconomic status (NSES) quintile, the number of neighborhoods (column 1), insured years (2) and the observed average health care costs (3). NSES1 are the most deprived areas, NSES5 the most affluent. Columns 4-9 and show the expected average costs and relative potential costs savings, or the percentage difference between the simulated health care costs in each of the four scenarios and the observed costs, for Scenarios 1, 2 and 3. In Scenario 1 the health care cost structure for each neighborhood is equal to that of the national average (4-5). In Scenario 2 costs are equal to that over the most affluent NSES quintile (6-7). In Scenario 3 costs are equal to that of the next NSES category (8-9). In Scenario 4 each neighborhoods' costs are held to at most the within-NSES-average (10-14).

Table A4.2: Cost effects of four scenarios for total, specialist, pharmaceutical, and mental health care, 2015

NSES quintile	Scenario 1: potential cost reduction (in millions euros and %)				Scenario 2: potential cost reduction (in millions of euros and %)			
	Total Costs (1)	Specialist Care (2)	Pharmac. Care (3)	Mental Healthc. (4)	Total Costs (5)	Specialist Care (6)	Pharmac. Care (7)	Mental Health care (8)
NSES1	€ 834.2 9.8%	€ 264.4 6.2%	€ 147.1 14.4%	€ 142.6 18.5%	€ 1,392.3 16.3%	€ 464.9 10.9%	€ 215.3 21.1%	€ 193.3 25.1%
NSES2	€ 214.0 2.6%	€ 57.9 1.4%	€ 7.6 0.8%	€ 32.6 5.2%	€ 790.1 9.7%	€ 258.6 6.2%	€ 79.1 8.6%	€ 80.2 12.8%
NSES3	-€ 132.5 -1.7%	-€ 38.3 -0.9%	-€ 20.2 -2.3%	-€ 48.0 -8.7%	€ 445.6 5.7%	€ 165.4 4.0%	€ 51.7 5.8%	-€ 0.3 -0.1%
NSES4	-€ 350.5 -4.7%	-€ 82.6 -2.0%	-€ 64.4 -7.7%	-€ 77.9 -15.0%	€ 221.0 2.9%	€ 121.4 3.0%	€ 6.7 0.8%	-€ 30.5 -5.9%
NSES5	-€ 565.1 -7.9%	-€ 201.4 -5.2%	-€ 70.1 -8.6%	-€ 49.3 -9.1%	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%
Total	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%	€ 2,849.0 7.3%	€ 1,010.3 4.9%	€ 352.8 7.9%	€ 242.7 8.1%

Table A4.2 (continued)

NSES quint.	Scenario 3: potential cost reduction (in millions of euros and %)				Scenario 4: potential cost reduction (in millions of euros and %)			
	Total Costs (9)	Specialist Care (10)	Pharmac. Care (11)	Mental Healthc. (12)	Total Costs (13)	Specialist Care (14)	Pharmac. Care (15)	Mental Health care (16)
NSES1	€ 621.8 7.3%	€ 204.8 4.8%	€ 139.4 13.7%	€ 106.8 13.9%	€ 206.2 2.4%	€ 129.2 3.0%	€ 45.3 4.5%	€ 62.5 8.1%
NSES2	€ 345.3 4.2%	€ 96.3 2.3%	€ 27.2 3.0%	€ 80.2 12.8%	€ 184.3 2.3%	€ 114.0 2.7%	€ 35.3 3.8%	€ 73.8 11.8%
NSES3	€ 221.0 2.8%	€ 44.5 1.1%	€ 44.3 5.0%	€ 29.9 5.4%	€ 196.1 2.5%	€ 125.4 3.0%	€ 42.5 4.7%	€ 73.5 13.3%
NSES4	€ 221.0 2.9%	€ 121.4 3.0%	€ 6.7 0.8%	-€ 30.5 -5.9%	€ 193.0 2.6%	€ 107.2 2.7%	€ 33.2 3.9%	€ 64.1 12.4%
NSES5	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%	€ 0.0 0.0%	€ 178.6 2.5%	€ 115.6 3.0%	€ 43.6 5.3%	€ 76.4 14.1%
Total	€ 1,409.1 3.6%	€ 467.1 2.3%	€ 217.7 4.9%	€ 186.4 6.2%	€ 958.3 2.4%	€ 591.4 2.9%	€ 199.9 4.5%	€ 350.3 11.6%

Notes: Table A4.2 shows the potential cost reduction for each NSES quintile in costs for total health care, specialist care, pharmaceutical care, and mental health care for the four scenarios. The savings are visible in both absolute (€) and relative (%) terms. NSES1 are the most deprived areas, NSES5 the most affluent. In Scenario 1 the health care cost structure for each neighborhood is equal to that of the national average (columns 1-4). In Scenario 2 costs are equal to that over the most affluent NSES quintile (5-8). In scenario 3 costs are equal to that of the next NSES category (9-12). In scenario 4 each neighborhoods' costs are held to at most the within-NSES-quintile average (13-16).

Table A4.3: Total health care costs and potential reduction for sex and age groups, 2015

	Total costs (millions of euros)	Potential cost reduction (millions of euros and %)		
	(1)	Scenario 2 (2)	Scenario 3 (3)	Scenario 4 (4)
Sex				
Female	€ 21,257.3	€ 1,695.2 8.0%	€ 763.2 3.6%	€ 481.9 2.3%
Male	€ 17,958.7	€ 1,153.8 6.4%	€ 645.9 3.6%	€ 476.4 2.7%
Age				
0	€ 584.8	€ 57.3 9.8%	€ 22.1 3.8%	€ 15.7 2.7%
1-10	€ 1,743.4	€ 124.0 7.1%	€ 58.3 3.3%	€ 38.3 2.2%
11-20	€ 1,863.6	€ 26.9 1.4%	€ 11.5 0.6%	€ 30.0 1.6%
21-30	€ 2,705.1	€ 196.3 7.3%	€ 45.0 1.7%	€ 37.0 1.4%
31-40	€ 3,179.9	€ 168.4 5.3%	€ 90.4 2.8%	€ 58.6 1.8%
41-50	€ 4,016.7	€ 432.8 10.8%	€ 219.5 5.5%	€ 147.2 3.7%
51-60	€ 5,603.6	€ 561.4 10.0%	€ 309.1 5.5%	€ 186.2 3.3%
61-70	€ 7,194.1	€ 479.6 6.7%	€ 280.3 3.9%	€ 186.7 2.6%
71-80	€ 6,697.1	€ 466.9 7.0%	€ 232.8 3.5%	€ 164.4 2.5%
81 and over	€ 5,627.5	€ 335.4 6.0%	€ 140.0 2.5%	€ 94.2 1.7%

Notes: Table A4.3 shows total health care cost costs (Column 1) and the potential cost reduction for each sex and 10-year age group, for Scenarios 2-4. The savings are visible in both absolute (€) and relative (%) terms. In Scenario 2 costs are equal to that over the most affluent NSES quintile (2). In Scenario 3 costs are equal to that of the next NSES category (9-3). In Scenario 4 each neighborhoods' costs are held to at most the within-NSES-quintile average (4).