STATISTICS AND DATA DIRECTORATE
COMMITTEE ON STATISTICS AND STATISTICAL POLICY

Working Party on National Accounts

Quality adjustment of hospital services: Improving price and volume measures for health care

Meeting of the Working Party on National Accounts

8 November 2018
OECD Conference Centre

This paper has been prepared by Aksel Juel Clemmensen (Statistics Denmark) for the meeting of the Working Party on National Accounts of 8 November 2018, under agenda item 2.b.

JT03438813
This document is only available in pdf format.
Quality Adjustment of Hospital Services

Action 1: Improving Price and Volume Measures for Health Care

by

Aksel Juel Clemmensen

December 2017
QUALITY ADJUSTMENT OF HOSPITAL SERVICES
Action 1: Improving Price and Volume Measures for Health Care

Statistics Denmark
December 2017

Aksel Juel Clemmensen

Head of Section
National Accounts
Phone: +45 39 17 35 15
E-mail: ajc@dst.dk
Preface

This report has benefited from funding by the European Commission, Eurostat through grant agreement no. 04121.2017.001-2017.256 Action 1. The technical report was prepared in the National Accounts division of Statistics Denmark.

The author would like to thank all the people, not least the Danish health care quality experts, who have been involved with the project for their valuable contributions. A special thanks to Head of Department Charlotte Cerqueira from the Danish Clinical Registries (RKKP), chairman for the Danish Hysterectomy and Hysteroscopy Database (DHHD) Annette Settnes, Chief Adviser Laust Hvas Mortensen, Senior Adviser Lars Gustafsson and System Analyst Annelise Northved Elf from Statistics Denmark.

Further details on the report can be obtained by contacting the author.
## Contents

1. Introduction ................................................................................................... 7
2. The volume indicator for hospitals and the Danish DRG system .......... 9
   2.1. The Danish health care system ................................................................. 9
   2.2. The volume indicator for hospital services .......................................... 10
3. The project’s research approach and process ......................................... 13
4. General quality adjustment of patient treatments .................................. 15
   4.1. The approach to quality adjust the volume indicator for hospitals .......... 15
   4.2. The results ............................................................................................... 16
   4.3. Incorporation in the National Accounts ............................................... 20
5. Treatment specific quality adjustment ..................................................... 21
   5.1. Data sources and the conceptual framework ........................................ 21
   5.2. Estimation method and the quality function ....................................... 23
   5.2.1. The quality index .................................................................................. 24
   5.2.2. Estimation of the correction variables for patient characteristics ...... 25
   5.2.3. The quality function $F(q)$ - an example ........................................ 29
   5.3. The Results .............................................................................................. 30
6. Conclusion .................................................................................................... 32
7. References .................................................................................................... 34
8. Appendices ................................................................................................... 35
Summary

Health care forms a significant share of GDP in EU countries. The quality of the volume measures for health care activities thus contributes importantly to the quality of GDP volume growth data. The overall aim with the project is to improve the output volume measurement for health care, by investigating explicit quality adjustments for the volume indicator for hospital services.

The objective of this project was: First, to collect quantitative information on aspects of quality of health care. Secondly, to experiment with different models of using this information to explicitly quality-adjust the volume indicator for hospitals. Last, the explicit quality-adjusted volume indicator for hospitals can then be used, when performing constant price calculations on production of non-market services for individual consumption (the output measures).

Two types of explicit quality adjustment are accomplished. The first, the general there is applied for all treatment types. The general quality adjustment has been the somatic patient treatments, which have been quality adjusted for death during operations and for re-hospitalization within 30 days. Also, a satellite national account for non-market hospital services for individual consumption in constant prices based on the general quality-adjusted volume indicator for hospitals has been calculated.

The second is the treatment-specific quality adjustment. A model of collaboration between health care quality experts and NSI national accounts in determining the quality of patient treatments has been accomplished. The collaboration includes establishing contact and getting access to quality data from a range of patient treatments quality related databases, and for soliciting expert opinions from health care professionals. Based on the collaboration with health care quality experts, the construction of an advanced treatment specific quality adjusted volume indicator for one of the more complicated/expensive patient treatment groups has been achieved.

The project has been very successful in establish contact and getting access to quality data from a range of patient treatments quality related databases and in the health community. Due to the volume of collected data, it has not been possible to fully explore and experiment with all the data within the time and scope of this project. This provides a good platform for further research.

All in all, the comparability and quality of the experimental data used in the project is very high, and should be sustainable over time. All the results from the many different types of explicit quality adjustment of patient treatments had a positive
effect on the volume indicators. Consequently, this is a strong indication of that the quality of patient treatments in general has increased in Denmark. Moreover, including explicit quality adjustment in the output volume measurement of health care has a significant effect on the national accounts.
1. Introduction

Health care forms a significant share of GDP in EU countries. The quality of the volume measures for health care, mostly non-market, activities thus contribute importantly to the quality of GDP volume growth data. This EU action’s principle aim regarding health services is to support the research referred to methods for quality adjustment for health services.

The objective of this project was: First, to collect quantitative information on aspects of quality of health care. Secondly, to experiment with different models of using this information to explicitly quality-adjust the volume indicator for hospitals. Last, the explicit quality-adjusted volume indicator for hospitals can then be used, when performing constant price calculations on production of non-market services for individual consumption (the output measures).

The main output from the project is:

1) A volume indicator for hospitals, with general quality adjustment, for the years 2015 and 2016. The general quality adjustment has been the somatic patient treatments, which have been quality adjusted for death during operations and for re-hospitalization within 30 days. The psychiatric patient treatments have not been quality adjusted. Also, a production system for the volume indicator with explicit general quality adjustment has been developed. So, the quality adjusted volume indicator for hospitals is now ready to be applied in the annual national accounts production system.

2) A satellite national account for non-market hospital services for individual consumption in constant prices based on the general quality-adjusted volume indicator for hospitals. Moreover, a comparison is provided of the differences in the results between the national accounts calculated respectively on basis of the volume indicator with and without explicit quality adjustment, for non-market hospital services.

3) A model of collaboration between health care quality experts and NSI national accounts in determining the quality of patient treatments. The collaboration includes establishing contact and getting access to quality data from a range of patient treatments quality related databases, and for soliciting expert opinions from health care professionals. This provides a good platform for further research.
4) Construction of an advanced treatment specific quality adjusted volume indicator for one of the more complicated/expensive patient treatment groups. The treatment-specific quality adjusted volume indicator is based on a weighted index for quality of specific DRG treatments and control/correction variables for lifestyle, health conditions and age. The treatment specific indicator can be incorporated in the volume indicator for all hospital treatments.

The report proceeds as follows. Chapter 2 gives a brief description of the Danish DRG system and how the volume indicator for hospitals is calculated today. Chapter 3 provides a summary of the project’s research approach, process and goals. Chapter 4 describes the volume indicator for hospitals with explicit general quality adjustment of patient treatments, and its incorporation in the national accounts. Chapter 5 presents the methods and the work put into constructing an advanced treatment specific quality adjusted volume indicator. Chapter 6 concludes and gives an assessment of the quality of the experimental data and their comparability and sustainability over time.
2. The volume indicator for hospitals and the Danish DRG system

2.1. The Danish health care system

In Denmark, all registered Danish residents are automatically given public health insurance, which provides publicly financed health care, and is largely free at the point of use. The public health care system is financed mainly through a national health tax. At the movement, the health tax is set at 8 percent of taxable income. Most of the health care services are public and public financed, for hospital services it is about 98 percent. The ministry of Health sets the regulatory framework for public health services and is in charge of general planning and supervision, but the hospitals are managed by the Regions. The public financing of the hospitals is managed by a combination of fixed-budget and activity-based funding based on Diagnosis Related Groups (DRG) System. The public provided hospital services constitute about 5 percent of the Danish GDP.

NordDRG, the Nordic Casemix system, developed through cooperation by the Nordic Countries, is now widely used. The maintenance and development of the system and the administration of the NordDRG cooperation has since 1996 been carried out by the Nordic Centre for Health care Classifications. The Centre was instituted for cooperation among the Nordic countries and more broadly with WHO and its member countries about health care classifications. The NordDRG work has been performed as collaboration of the system owners, the Nordic Countries.\footnote{Hereby, it should be relatively easy to apply the methods and results from this project in other countries, since the explicit quality adjustment is based on the DRG system.} Denmark has developed a modified DRG system based on NordDRG. The modified DRG system was introduced in 2002. From 2004 the system has been used as a general financing tool in an activity-based system, and from 2007 it has been the central instrument in financing of the public health care sector. The DRG system is used for budgeting and, particularly, as a tool for developing new methods of premises planning and management in administration and hospitals. The DRG system includes a large number of categories/codes, over 1,300 different DRG categories. Each DRG category denotes a rather homogenous service in terms of the patient treatment provided and costs of the treatment. One DRG category typically covers 10-20 different types of homogeneous patient treatments. When it is very complex/expensive patient treatments, the DRG category includes only one type of

\footnote{For more information see: www.nordcase.org/eng/}
With simple patient treatments, a DRG category can include over 20 homogeneous types of patient treatments. From year to year, there are changes in the DRG structure and prices. The prices for each DRG category/code are set by the Ministry of Health at the national level, based on average costs. There is no variation in the price of DRGs across hospitals or regions.

2.2. The volume indicator for hospital services

The output method is applied, using 18 volume indicators of general government production of services, there are incorporated into the national accounts from 2008 onwards. The 18 indicators are an integrated part of the detailed supply and use tables (SUT), which consists of more than 2,350 goods and services, including the non-market services. Of the 18 volume indicators for non-marked individual services, the volume indicator for hospitals is the largest, and account for almost 1/3 of the non-marked individual services. Today, the volume indicator for hospitals is calculated based on the DRG system and DRG cost weights to measure volumes for both outpatient (ambulatory) and inpatient (stationary) treatments at general hospitals and psychiatric hospitals. All public hospital treatments are charged within the DRG system. Hereby, the DRG turnover is straight forwardly determined as the product-sum of the DRG price*number of the respective DRG treatments provided (P x Q).

Based on the databank eSundhed, managed by the Ministry of Health, covering all Danish citizens’ hospital treatments, the volume indicator for public hospitals is calculated. The volume indicator is calculated as Laspeyres volume indices $I_{t-1,t}$ between the periods t-1 and t:

$$I_{t-1,t} = \frac{\sum_j P_{t-1,j} * Q_{t-1,j}}{\sum_j P_{t-1,j} * Q_{t-1,j}}$$

(2.1)

The DRG Price $P$ and the data for all the patient treatments performed at public hospitals $Q$ (the volume). Below an example, realistic in principle, illustrates how the volume indicator is applied inside the framework of the SUT-system, calculating the non-market product balances in constant prices.
Application of volume indicator in SUT

Example: A non-market health sector supplies the economy with two services for individuals. Hip replacements and appendectomy. The price (DKK) and production structure is as follows.

\[
P_{t}^{\text{hip}} = 100 \quad P_{t}^{\text{app}} = 200 \\
Q_{t}^{\text{hip}} = 1,000 \quad Q_{t}^{\text{app}} = 500 \\
Q_{t+1}^{\text{hip}} = 1,000 \quad Q_{t+1}^{\text{app}} = 1,000
\]

The price for a hip replacement in period \( t \) is DKK 100 and the price for an appendectomy is DKK 200. The \( Q \)'s refer to the number of operations performed in period \( t \) and \( t+1 \).

On this basis a Laspeyres' volume index is calculated:

\[
QIDX_{t,t+1}^{\text{Laspeyres}} = \frac{100 \times 1,000 + 200 \times 1,000}{100 \times 1,000 + 200 \times 500} \times 100 = 150
\]

The development in volume is an increase on 50 percent from period \( t \) to \( t+1 \). This volume indicator, named M2, is now applied to all cost components attributable to industry classification 860010 Hospitals activities.

The table below illustrates how M2 is used to calculate the corresponding deflator MIPI2 which is used to price deflate all non-market cost elements related to public hospitals.

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Industry</th>
<th>( t ) (current prices)</th>
<th>( t+1 ) (current prices)</th>
<th>( t+1 ) (constant prices)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation of employees</td>
<td>860010</td>
<td>150</td>
<td>200</td>
<td>225</td>
</tr>
<tr>
<td>Intermediate consumption</td>
<td>860010</td>
<td>70</td>
<td>100</td>
<td>105</td>
</tr>
<tr>
<td>Other production taxes, net</td>
<td>860010</td>
<td>6</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Consumption of fixed capital</td>
<td>860010</td>
<td>30</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>256</strong></td>
<td><strong>350</strong></td>
<td><strong>384</strong></td>
</tr>
</tbody>
</table>

In period \( t \) the salary at current prices paid to employees working in public hospitals is DKK 150,000. In the following period \( t+1 \) it is DKK 200,000. In period \( t \) the sum of the costs is DKK 256,000 and in period \( t+1 \) it is DKK 350,000. Prior to introducing the non-market volume indicator, the four cost components would have been calculated in constant (previous year) prices using the input method. By applying the output method the constant prices in period \( t+1 \) is calculated using the volume indicator M2. Since M2 has an index of 150 corresponding to a 50 percent development in volume, each of the cost components in period \( t+1 \) (constant prices) is equal to the value of the cost component in period \( t \) multiplied by 1.5, measured in current prices (for simplicity, it is assumed that the amount of resource input to industry 860010 is unchanged between period \( t \) and \( t+1 \)).

Finally, the volume indicator-based implicit deflator MIPI2 can be calculated as:

\[
MIPI2 = \frac{350,000}{256,000 \times 1.5} \times 100 = \frac{350,000}{384,000} \times 100 = 91.15 \text{ percent}
\]

The deflator illustrates that the price of non-market hospital services has decreased by 8.85 percent from period \( t \) to \( t+1 \). The MIPI2 can now be used in the non-market volume indicator subsystem to price deflate all cost components most appropriately associated to the volume indicator, M2.

*Note: This example is inspired by an example in the publication by Statistics Denmark “General Government Output and Productivity, 2008-2014”*
The volume indicator-based deflator MIPI2 is used to deflate hospital services, as shown in the example above. Moreover, MIPI2 is also been used to deflate closely related non-market individual services provided by non-market agents. Consequently used as a proxy deflator. The underlying assumption is that the development in prices in closely related areas is the same. Hereby, all non-market services provided for individuals are covered by a suitable volume indicator, either by a volume indicator which is a perfect match, or by a proxy.

The general government activities at constant prices are calculated at a detailed level, using the output method. The four cost components at current prices (Compensation of employees; Intermediate consumption; Other production taxes, net; and Consumption of fixed capital) covering all general government activity are attributable to around 75 public industries and about 85 functions of government (COFOG). A subset of around 50 functions of government is attributable to non-market individual services provided by general government. The around 50 functions of government are calculated at constant prices using the 18 volume indicators, as illustrated with the volume indicator for hospitals in the example above. The 18 volume indicators for non-marked services are used as deflators for all areas of individual non-market services provided to the public by the general government.
3. The project's research approach and process

The general objective of the action is to improve the quality of national accounts by investigating explicit quality adjustments for health and its inclusion in the output measures. The process of investigating quality of patient treatments in the Danish health system has been the following: First, to research the literature relevant for the project. Second, to meet with the Ministry of Health (The Danish Health Data Authority) and to consult with economists and scientists (health professionals) in the field in order to establish a corporation with doctors, clinicians and health researchers and thereby determine the quality of patient treatments. Third, to establish contact and get access to quality data from a range of patient treatments quality related databases, and from other relevant databases in the Danish health community. Fourth, to collect, analyse and select/use quality variables from relevant quality databases. Fifth, to meet with the Netherlands’ NSI national accounts, who are working on a similar project, and discuss the similarities and differences of the Danish and Dutch healthcare systems and different approaches to quality adjustment of health care services. Final, to experiment with different models of using quality data to explicitly quality-adjust the volume indicator for hospitals. This has resulted in an explicit quality-adjusted volume indicator for hospitals, which can be used when performing constant price calculations on production of non-market services for individual consumption (the output measures).

The general variables for health quality, such as death or re-admission, can be used as standardised quality weights. However, this project has also another more nuanced approach to measure health quality. The project examines the hypothesis: For specific patient treatments, the doctors/clinicians who carry out the actual operations have the best knowledge and insight into to which degree a specific type of operation has been a success or gone wrong. Consequently, the selection of variables and the extent to which each quality variable should weigh on an index shall be decided by the NSI national accounts in collaboration with the doctors/clinicians for that respective type of patient treatments. Moreover, the patients’ experiences and the treatments’ long-term effect on a patient are also interesting to include. Moreover, the outcome of a specific treatment in terms of quality is not only determined by treatments characteristics, but also by patient characteristics such as age, lifestyle factors and the health conditions of the patients.

Overall, a quality function, which can capture the health professionals’ valuation of a treatment, some standard quality indicators used for all patient treatments, the patient’s assessment of the treatment and patient characteristics, seems most optimal to use as instrument for explicit quality adjustment of the volume indicator for hospital services. Although such a quality function can be difficult to construct,
in order to give a rightful valuation of the quality of a specific patient treatment, it is this challenge that this project has taken on.

The project goals

The project will be limited to the following two goals:

1) A volume indicator for hospitals with general quality adjustment for the years 2015 and 2016 ready to be implemented in the national accounts.

2) A treatment-specific quality adjusted volume indicator for one of the more complicated/expensive patient treatment groups for the years 2015 and 2016. The treatment specific indicator can be incorporated as part of the volume indicator for hospitals.

The project has been very successful in establish contact and getting access to quality data from a range of patient treatments quality related databases and in the health community. Due to the volume of collected data, it has not been possible to fully explore and experiment with all the data within the time and scope of this project. However, the project opens up for a new research project about quality adjustment, which could be very fruitful now the fundamental work is done.
4. General quality adjustment of patient treatments

Chapter 4 proceeds as follows. Section 4.1 describes the approach for general quality adjustment of patient treatments. Section 4.2 shows the results of the general quality adjustment. In section 4.3 the volume indicator for hospitals with explicit quality adjustment is incorporated in a satellite national account for hospital services.

4.1. The approach to quality adjust the volume indicator for hospitals

All information about diagnoses and operations is recorded in the National Patient Register (NPR), which is an administrative register covering all hospital procedures in Denmark. Based on the databank eSundhed, managed by the Ministry of Health, covering all Danish citizens’ hospital treatments, the volume indicator for public hospitals is calculated. Through eSundhed there is access to the DRG registered NPR.

The volume indicator for hospital services is calculated as a Laspeyres volume index. The index is directly calculated using the “turnover share weighted average of the number of DRG’s provided”, where the DRG Price is $P$ and the patient treatments performed at public hospitals is $Q$ (the volume), as illustrated in equation (2.1) in chapter 2. The volume indicator for hospital services includes all in-patient and out-patient treatments at both general and psychiatric hospitals. For more information about the Danish DRG system and how the output method is applied for hospital services in the Danish national accounts, see chapter 2.

By reviewing all of the database eSundhed’s variables, the variables that were found useful and easy to implement for general quality adjustment were selected. The result was two general variables, there can be applied to quality adjust all types of public hospital treatments. The variables applied as quality indicators are death during patient treatment/hospitalization and re-admissions within 30 days. The somatic in-patient treatments have been quality adjusted for death during hospitalization and re-admission within 30 days. The somatic out-patient treatments have only been quality adjusted for death during patient treatments, since the variable re-admission within 30 days only is available for somatic in-patient treatments. The psychiatric patient treatments have not been quality adjusted.
The volume indicator for hospitals with explicit general quality adjustment has been calculated for the years 2015 and 2016. Death during hospitalization/treatment is interpreted as 100% failure, or a treatment with quality level 0. In the quality adjusted volume indicator, these treatments do not contribute to the volume. For readmissions within 30 days, the same approach is taken. In order to be able to calculate the volume indicator with general quality adjustment for real, a production system for the volume indicator with explicit general quality adjustment has been developed. Consequently, the quality adjusted volume indicator for hospitals is now ready to be applied in the annual national accounts production system.

4.2. The results

Figure 4.1 shows the results of the explicit general quality adjustment of the volume indicator for hospitals, as described in section 4.1. Without explicit quality adjustment, the development from 2014 to 2015 has a growth on 2.43% and the development from 2015 to 2016 has a growth on 1.69%. Overall, a solid growth in output of hospital services in both 2015 and 2016. By explicit quality adjustment, the volume indicator increases to 3.07% in 2015 and 2.40% in 2016. Overall, significant effects from explicit quality adjustment of hospital treatments, indicating the quality of patient treatments has increased from 2014 to 2016.

The next figures will illustrate the different patient groups included in the volume indicator for hospitals contribution to the quality adjustment. Figure 4.2 and figure 4.3 shows the volume indicator for somatic in-patients with and without quality adjustment. Figure 4.4 displays the volume indicator for somatic out-patients with...
and without quality adjustment. Finally, Figure 4.5 sums up the general quality adjustments effect on the volume indicator for hospitals, and the effect for somatic in-patient and out-patient treatments.

In figure 4.2, the volume indicator for in-patient treatments is 0.27 % in 2015 and – 0.43 % in 2016. The results indicate that the volume growth is rather modest in 2015, and even slightly negative in 2016 for in-patient treatments. By adjusting for death during hospitalization, the volume indicator increases to 0.34 % in 2015 and – 0.3 % in 2016. By adjusting for re-admissions within 30 days, the volume indicator growth for in-patient treatments increases to 0.4 % in 2015 and - 0.22 % in 2016. The combined explicit quality adjustment of death and re-admission for in-patient treatments are 0.48 % in 2015 and -.0.07 % in 2016
Figure 4.3 shows that the percentage point effect of explicit quality adjustment of in-patient treatments are respectively 0.07 %, 0.13 % and 0.27 % from adjusting for death, re-admission, and the combined effect in 2015. In 2016 the percentages point effect of explicit quality adjustment are even larger, for death 0.13 %, for re-admission 0.21 % and combined 0.35 %. All in all, the quality adjustment of in-patient treatments has a relatively large effect on the volume indicator.

In figure 4.4, the volume indicator for out-patient treatments is 5.58 % in 2015 and 4.96 % in 2016. The results indicate that the volume growth is large in both 2015 and 2016 for out-patient treatments. By adjusting for death during hospitalization, the volume indicator increases even further to 6.78 in 2015 and 6.11 % in 2016. Overall, there is a significant effect from explicit quality adjustment of out-patient treatments.

Figure 4.5 below summaries the percentage point effects explicit quality adjustment has on the volume indicator for hospitals, and for in-patient treatments and out-patient treatments. The percentage point effects are respectively 0.64 %, 0.21 % and 1.20 % in 2015 and 0.71 %, 0.35 % and 1.16 % in 2016 for the volume indicator for hospitals, in-patient treatments and out-patient treatments. Consequently, explicit quality adjustment has a positive effect on the output of hospital treatments. The results indicate that the quality of the patient treatments in general has been improved over the timespan from 2014 to 2016.
Figure 4.5

The Percentage Point effect of quality adjustment of the volume indicator for respectively hospitals, in-patient treatments and out-patient treatments
4.3. Incorporation in the National Accounts

In order to see the effect of the explicit quality adjustment of hospital services in the national accounts, a satellite account is calculated. Table 4.1 shows a satellite national account for non-market hospital services for individual consumption in constant prices, based on the general quality-adjusted volume indicator for hospitals. Moreover, the differences in the results between the national accounts calculated respectively on basis of the volume indicator with and without explicit quality adjustment, for non-market hospital services for individual consumption is also included in table 4.1.

Table 4.1 shows that when the non-marked health care services are deflated with the volume indicator for hospitals with explicit quality adjustment the output increases. The increase is 596 (79.5) million Danish Kroner (Euro) in 2015 and 1,274 (170) million Danish Kroner (Euro) in 2016. The growth in non-marked health care secrecys provided for the Danish citizens was 1.5 % in 2015 and 1.3 % in 2016, by the output method. By applying explicit quality adjustment, when deflating non-marked health care services, the output increased to 2 % in 2015 and 1.9 % in 2016. Consequently, by quality adjust for death during hospitalization and re-admission within 30 days, the total output of public health care services increased with 0.5 percentage points in 2015 and 0.6 percentage points in 2016. All in all, quality adjustment really matters, when calculating the output of health care services.

### Table 4.1

#### Non-marked health care services (individual consumption)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current prices</strong></td>
<td>3142</td>
<td>06000</td>
<td>117,817</td>
<td>121,667</td>
<td>125,135</td>
</tr>
<tr>
<td><strong>Constant prices (the output method), 2014=100</strong></td>
<td>3142</td>
<td>06000</td>
<td>117,817</td>
<td>119,604</td>
<td>121,190</td>
</tr>
<tr>
<td><strong>Constant prices (the output method) quality adjusted, 2014=100</strong></td>
<td>3142</td>
<td>06000</td>
<td>117,817</td>
<td>120,200</td>
<td>122,464</td>
</tr>
</tbody>
</table>

#### Non-marked health care services (individual consumption)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current prices</strong></td>
<td>3142</td>
<td>06000</td>
<td>15,709</td>
<td>16,222</td>
<td>16,685</td>
</tr>
<tr>
<td><strong>Constant prices (the output method), 2014=100</strong></td>
<td>3142</td>
<td>06000</td>
<td>15,709</td>
<td>15,947</td>
<td>16,159</td>
</tr>
<tr>
<td><strong>Constant prices (the output method) quality adjusted, 2014=100</strong></td>
<td>3142</td>
<td>06000</td>
<td>15,709</td>
<td>16,027</td>
<td>16,329</td>
</tr>
</tbody>
</table>
5. Treatment specific quality adjustment

This chapter discusses some important aspects of the quality of health care services and proposes some indicators and the methods and the work put into constructing an advanced treatment-specific quality adjusted volume indicator.

5.1. Data sources and the conceptual framework

The objective is to construct an advanced treatment specific quality adjusted volume indicator for one of the more complicated/expensive patient treatment groups. The treatment specific quality adjusted volume indicator will be based on a weighted index for quality of specific DRG treatments and control variables for lifestyle, health conditions and age. The data sources are from the Danish Clinical Registries (RKKP). More precisely, from the group of RKKP databases, we have been in contact with. The members of these RKKP databases national boards have also contributed to the weighting of the quality index, by advising on the selection and weighting of the most relevant quality variables from their databases. Hereby, striving to include the most significant quality measures in the treatment specific quality adjusted volume indicator.

RKKP constitutes the infrastructure of National Clinical Quality Databases, and Danish Multidisciplinary Cancer Groups (DMCG). RKKP’s primary objective is to ensure a continued improvement in the utilization of the Danish clinical registries in a clinical as well as managerial-, and research oriented sense. RKKP designs new clinical registries, and facilitates re-use of available data in hospitals and GP-surgeries. The formation of a registry can be initiated either top-down – RKKP asking clinicians to collect data on a given topic – or bottom-up with clinicians asking RKKP to manage a database on a topic of their interest. The registries vary to some extent with respect to the variables that are stored.

The relevance of conducting a database on a given topic is decided on by weighing; disease severity, incidence/ prevalence, quality problems/ possibility for improvement, resources and appropriateness, political and patient preferences etc. At the moment, RKKP manages 70 clinical registries, containing information about individual patients, used for improvement of quality, research and surveillance purposes. RKKP is exempt from patient consent to data-collection.

The Data-collection is as follows: Data is registered by clinical personnel, gathered and reported through data-collection systems. The databases store information of the patients on a wide array of quality related outcomes. Then, accumulated and analysed by epidemiologists, to be discussed and concluded on at regional and na-
tional audits. At these audits clinicians determine indicators and standards for good clinical quality, and recommendations are reported back to clinical personnel for quality improvement, and released in public for transparency and accountability. Each individual clinical registry has a professional board appointed by professional medical and nursing societies, representing the main clinical stakeholders.²

**Conceptual framework**

The aim is a treatment specific adjustment, using information from the RKKP database, the Danish Hysterectomy and Hysteroscopy Database (DHHD). For this type of adjustment, a weighted quality index is constructed from a selected set of quality related variables. The selection of variables and the extent, to which each variable should weight in the index, is decided on in collaboration with the steering committee of DHHD. Since the outcome of a specific treatment in terms of quality is not only determined by treatments characteristics, but also by patient characteristics, such as life style factors, age and health condition, they will also be included in the quality function, used for quality adjustment. Accordingly, we assume that the quality of a patient treatment also dependent on these other factors. Consequently, the quality function consists of the following: A quality index that contains variables there evaluates the operation. In addition, correction variables for lifestyle, health conditions and age that will reduce the negative effects in the quality index, if it is due to the patient have a very high age, an unhealthy lifestyle and/or critical health condition.

The choice of database was in cooperation with RKKP. The DHHD database was selected, based on the volume of patient treatments and its medium size type of operations. As such, being a representative database for the RKKP databases. The DHHD database objective is the following: For the first, to reduce complications, readmissions, reoperations. Secondly, specify the needs for hospitalization after hysterectomy. Thirdly, secure quality assessment of hysterectomy and hysteroscopy by setting standards and national guidelines. Finally, monitoring of laparoscopic surgery and explore long-term side effects after hysterectomy.

The database includes all women in Denmark who have had elective benign uterine surgery since 2003. The surgery includes hysterectomy and operative hysteroscopy. The database contains detailed information about the hysterectomy and hysteroscopy operation techniques, operations, and indications, as well as relevant lifestyle factors. It is mandatory to register information about complications and readmissions in the register. Since the establishment of the database in 2003, over 50,000 hysterectomies have been registered. These types of treatments/operations

² For more information, see: [www.rkkp.dk](http://www.rkkp.dk)
are most commonly performed due to abnormal menstrual bleeding, leiomyomas, descensus of the uterus, or abdominal pain.

5.2. Estimation method and the quality function

This section describes the estimation of the quality function used for calculating the volume indicator with explicit treatment specific quality adjustment. The purpose is to estimate the quality function $F(q)$ and then calculate a quality-adjusted volume index. $F$ is assumed to be a function of $q$ (quality) and depends on many quality indicators and their weights. The different quality indicators will be weighted according to their relevance for the output. The volume index is considered to have dimensions of quantity and quality.

Output = Quantity $\times$ Quality \hfill (5.1)

The volume indicator with explicit quality adjustment is calculated as a Laspeyres volume index $I_{t-1,t}$ between the periods $t-1$ and $t$:

$$I_{t-1,t} = \frac{\sum_{j} P_{t-1,j} \times Q_{t-1,j} \times F(q_t)}{\sum_{j} P_{t-1,j} \times Q_{t-1,j} \times F(q_{t-1})} \hfill (5.2)$$

In equation (5.2), the DRG Price $P$ and the DHHD patient treatments performed $Q$ (the volume) is the first expression of equation (5.1), which is the cost-weighted volume index (measure of the quantity). The last expression of equation (5.2) $F(q)$, is the quality measurement part of equation (5.1).

$F(q)$ is the function of quality, and quality is supposed to consist of different indicators, which are selected and weighted according to their importance. $F(q)$ has a value between 0 and 1 for each treatment $Q$. The value 0 means that the treatment has failed. The value 1 means that the treatment has been a success. The values in between 0 and 1 means that the treatment has to some extent been a success. Since the volume index measures growth, and not the level, a scale of between 0 and 1 is assessed as being most optimal for the quality function. The quality function $F(q)$ consists of a quality index there evaluates the respective operation/treatment and correction variables for the respective patient’s lifestyle, health condition and age. The following describes in details how the quality function for health care services is measured.
5.2.1. The quality index

The selection of variables and the extent to which each variable should weight in the index is decided by the NSI national accounts in collaboration with the steering committee of DHHD. The project for quality adjustment of patient treatments in the national accounts was presented at the national clinical audits annual conference for The Danish Hysterectomy and Hysteroscopy Database 2017. At the conference, the clinical audits discussed, after the presentation of the project, relevant quality variables and how much each quality variable should weight in a quality index. Based on the DHHD database’s recommendations regarding the selection and weighting of the most relevant quality variables from their database, a weighted quality index was constructed. Nine variables measuring the quality of the operations were chosen. Two positive variables which measure good quality of operation technics and type of treatments provided during the operation. Seven negative variables, which cover complications from the operation, re-operations and mortality. Table 5.1 below, describes in details the nine quality variables that constitute the quality index.

<table>
<thead>
<tr>
<th>Hysterectomy</th>
<th>Weight</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minimal invasive hysterectomy</td>
<td>0.25</td>
<td>Good quality of operations technics</td>
</tr>
<tr>
<td>2. Antibiotic prophylaxis</td>
<td>0.25</td>
<td>If this type of treatment has been provided during the operation</td>
</tr>
<tr>
<td>3. The number of days hospitalized</td>
<td>-0.1</td>
<td>If 2 days or more</td>
</tr>
<tr>
<td>4. Vaginaltop rupture ≤6 months</td>
<td>-0.4</td>
<td></td>
</tr>
<tr>
<td>5. General indicator for complications from or during patient treatment</td>
<td>-0.2</td>
<td>Includes minor and major complications, mortality, re-admissions and re-contacts</td>
</tr>
<tr>
<td>6. Major and serious complications</td>
<td>-0.4</td>
<td>Major complications such as, postoperative bleeding complication, Infections directly surgically derived, organ lesions and surgical wound complications</td>
</tr>
<tr>
<td>7. All re-admissions and/or re-contacts (≤ 30 days post-operatively)</td>
<td>-0.1</td>
<td></td>
</tr>
<tr>
<td>8. Re-operation ≤ 30 days postoperatively</td>
<td>-0.4</td>
<td></td>
</tr>
<tr>
<td>9. Mortality</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

The quality index for each operation / treatment has a value between 0 and 1. Starting value is 0.5. Depending on which of the quality variables the treatment has fulfilled, a value of maximum 1 and minimum 0. There is a floor on the index, so the treatment at a minimum has the value 0. In other words, it cannot be negative. If the patient dies during the operation, the quality index is in any case 0 for this patient treatment.
5.2.2. Estimation of the correction variables for patient characteristics

It is assumed that a number of patient characteristics, which can affect the quality of the patient treatment, are independent of the health service provided. The patient characteristics must therefore be controlled for. The hypothesis for correction variables for patient characteristics is as follows: There is a close correlation between how successful an operation is and the patient’s health condition such as age, unhealthy lifestyle and medical history.

In order to estimate the correction variables for life style, critical health condition and age, the Ordinary Least Square (OLS) regression method has been used. The OLS estimation method is chosen because it is a simple and generally recognised estimation method that is easy to apply. In order to estimate the coefficients of the correction variables, the quality index is used as the explained variable and the correction variables are the explanatory variables in this “auxiliary” OLS regression. The OLS regression is applied in order to construct the correction variables used for adjustment of patient characteristics.

The following approach has been used to modelling the regression model. The correction variables have been adjusted to the quality index to obtain the most statistically significant regression model that contains explanatory variables for lifestyle, age and health conditions. The explanatory/correction variables have been adjusted by working with the functional form of the variables and by modelling the most optimal dummy variables for lifestyle.

Then, the construction of the quality function $F(q)$ can be made based on the weighted index for quality of specific DRG treatments (quality indicator) and correction variables for patient characteristics. The quality function $F(q)$ is:

$$F(q) = \text{Quality index} - \text{correction indicators for patient characteristics} \quad (5.3)$$
The data and model

The regression model used to estimate the correction indicators for patient characteristics contain the following explanatory variables:

- The dummy variable $BMI_{obeses}$, patients with a body mass index ≥ 30
- $age$ and $age^2$, the patients age, when operated.

- The dummy variables $ASA3$ and $ASA4$, is indicators for the patient’s health condition. ASA 3 is the second most critical level. Serious systemic disease - Limited functional impairment. Eg. moderate to severe degree of respiratory insufficiency, diabetes with late complications or angina pectoris. ASA IV is the most critical level: Severe systemic disease, which is constantly life threatening

- The dummy variable $alcohol_{BIG}$, patients who drinks more than 9 units of alcohol per week.

- The dummy variable $smoking_{BIG}$, patients who smokes ≥ 30 gram of tobacco per day.

The data used for the explanatory variables is from DHHD database for the years 2014 to 2016. Table 5.2 shows the variables’ summary statistics.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Min</th>
<th>Max</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUALITY index</td>
<td>0.8301</td>
<td>0.2516</td>
<td>0</td>
<td>1</td>
<td>11,368</td>
</tr>
<tr>
<td>BMI_OBESE</td>
<td>0.2236</td>
<td>0.4167</td>
<td>0</td>
<td>1</td>
<td>9,808</td>
</tr>
<tr>
<td>AGE</td>
<td>49.8048</td>
<td>10.7029</td>
<td>14</td>
<td>93</td>
<td>11,368</td>
</tr>
<tr>
<td>AGE2</td>
<td>2,595.059</td>
<td>1,181.520</td>
<td>196</td>
<td>8,649</td>
<td>11,368</td>
</tr>
<tr>
<td>ASA3</td>
<td>0.0180</td>
<td>0.1331</td>
<td>0</td>
<td>1</td>
<td>9,644</td>
</tr>
<tr>
<td>ASA4</td>
<td>0.0006</td>
<td>0.0249</td>
<td>0</td>
<td>1</td>
<td>9,644</td>
</tr>
<tr>
<td>ALCOHOL_BIG</td>
<td>0.0450</td>
<td>0.2072</td>
<td>0</td>
<td>1</td>
<td>9,698</td>
</tr>
<tr>
<td>SMOKING_BIG</td>
<td>0.0056</td>
<td>0.0748</td>
<td>0</td>
<td>1</td>
<td>9,776</td>
</tr>
</tbody>
</table>
The results of the OLS regression model:

\[
\text{Quality indicator} = 1.0868 - 0.0151 \text{BMI obeses} - 0.0103 \text{age} + 0.0001 \text{age}^2 - 0.0914 \text{ASA3}
\]

\[
\begin{align*}
& (0.0509) \quad (0.0064) \quad (0.0019) \quad (0.0002) \quad (0.0203) \\
& -0.3165 \text{ASA4} - 0.0332 \text{alcohol BIG} - 0.1283 \text{smoking BIG} \\
& (0.1106) \quad (0.0129) \quad (0.0374)
\end{align*}
\]

(5-4)

\[N = 8,854 \quad R^2 = 0.132\]

In regression model (5.4): The dataset used is unbalanced for the years 2014-2016, with 8,854 observations. The quantities in parentheses below the coefficient estimates are the std. errors. All the explanatory variables have the expected sign, and is statistical significant on a 1 percent significance level. However, \( \text{BMI obeses} \) is only almost, with a P-value on 0.0173, but all the coefficients in the regression model are highly statistical significant. The R-squared is on 1.32 percent, which is acceptable, considering it is micro data.

The regression model (5.4) was tested for multicollinearity, heteroscedasticity and normal distribution of the residuals. There is almost non multicollinearity except between the variables age and age-squared, which is as expected. However, there is evidence of heteroskedasticity. By use of White-Hinkley heteroskedasticity consistent standard errors and covariance, when estimating regression model (5.4) the results are less statistical significant, but all variables is statistical significant at a 5 percent significance level. Thus, the heteroskedasticity issue is no serious problem for the regression model (5.4). For more test details, see the Appendices. The test for normality showed the regression model's residuals are not normal distributed. Although normality of the residuals would have been preferable, it is not unexpected given the way the variables are constructed. Moreover, it is not unexpected because it is micro data on patient’s relation to the quality of their operation and many other factors than patient characteristics influence the quality of an operation.

The variables BMI_obese, ASA3, ASA4, alcohol_BIG and smoking_BIG are all dummy variables, as such, the intercept should not be included among the correction variables for quality. Because the overall intercept is common to all groups of dummy variables, we can ignore that (the intercept) in finding the differences. However, this is not the case for the variables age and \( \text{age}^2 \), since they are not dummy variables. In order to adjust for the part of the age and \( \text{age}^2 \) effects contained in the intercept, the effects from a patient’s age on the quality of the operation will first be included, when the patient is above the average age for this type of operation/treatment. The average patient age is 49. The adjustment is made based on the assumption that if the patient is under 50, age should not have a significant effect on the outcome of the treatment, if the operation has been successful or not.
To correct for the part of the age's effect on quality contained in the intercept, age and \( \text{age}^2 \) are adjusted for average age in the following way:

\[
IF \begin{cases} 
\text{age} \leq 49 & \text{then} \quad 0 \\
\text{age} > 49 & \text{then} \quad \text{age} - 49 
\end{cases}
\] (5-5)

Figure 5.1 below illustrates the combined effect from the age and \( \text{age}^2 \) variables on the quality function with and without adjustment for average age. Figure 5.1 shows the quality effects depending on the patient’s age from 1 to 100 years old patient.
### 5.2.3. The quality function F (q) - an example

To show how the quality function is calculated, it is here illustrated with an example including two patients, patient A and patient B. Both patient A and patient B have had a Hysterectomy operation with a quality value from the quality index on 0.4. This means that both patient A and patient B did not have a special successful operation.

**Patient A** is 45 years old, has a BMI on 25, drinks less than 9 units of alcohol per week, doesn’t smoke and has no critical health condition.

**Patient B** is 64 years old, has a BMI above 30, drinks more than 9 units of alcohol per week, smokes over 30 grams of tobacco per day and has a critical health condition.

Based on the above information, we can now calculate the quality function for patient A and patient B:

\[
F(q) = \text{Quality index} - \text{correction indicators for patient characteristics} \\
= 0.4 - (-0.0151*1 - 0.0103*0 + 0.0001*0^2 - 0.0914*0 - 0.3165*0) \\
= 0.4
\]

\[
F(q) = \text{Quality index} - \text{correction indicators for patient characteristics} \\
= 0.4 + 0.0151 + 0.1545 - 0.2225 + 0.0914 + 0.0332 + 0.1283 \\
= 0.8
\]

By taking into account the patient characteristics, patient B now has twice as good/successful a patient treatment than patient A with respect to quality. The results show that patient characteristics can have a large effect on the output of an operation, if the operation is successful or not. Consequently, an unsuccessful operation shall not be reduced so much in quality value if it is a patient with unhealthy patient characteristics who is treated than if it is a healthy patient. However, the quality values from the quality function have a ceiling on 1 and a floor on 0. Since, the assumption for the quality function F (q) is that the value 1 meaning a successful operation and the value 0 a failed operation, given the patient characteristics and the quality index.
5.3. The Results

Almost all of the Hysterectomy operations performed from 2014 to 2016 have been given the Danish DRG code 1311, but a few haven’t. For simplicity of the calculation of this volume indicator with treatment specific quality adjustment, the assumption has been made that all of the Hysterectomy operations performed from 2014 to 2016 have the DRG code 1311. However, it is possible to link the respective Hysterectomy operations to their correct DRG codes. Although, it will demand the development of an IT solution, in order to make these links correctly, and is beyond the scope of this pilot project. The DRG price for treatment code 1311 was 39,341 Danish kroner or about 5,250 Euro in 2014, and 31,846 Danish kroner or about 4,250 Euro in 2015.

Figure 5.2 shows the results for the volume indicator for Hysterectomy operations (DHHD) with and without explicit quality adjustment. The volume indicator is calculated, as illustrated in equation (5.2), for the development from 2014 to 2015 and 2015 to 2016. The results are a volume growth on $-6.88\%$ and $-8.54\%$ without explicit quality adjustment, respectively $-6.05$ and $-6.90$ with explicit quality adjustment, for the years 2015 and 2016. Consequently, as illustrated in figure 5.3 below, treatment specific quality adjustment has a significant effect on the volume indicator. The treatment specific quality adjustment increased the volume growth with 0.83 percentage points in 2015, and 1.64 percentage points in 2016.
Figure 5.3

The effect of quality adjustment

<table>
<thead>
<tr>
<th>Year</th>
<th>Pct</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>0.80</td>
</tr>
<tr>
<td>2016</td>
<td>1.80</td>
</tr>
</tbody>
</table>
6. Conclusion

The overall aim with the project is to improve the output volume measurement for health care, by investigating explicit quality adjustments for the volume indicator for hospital services. The project has resulted in an explicit quality-adjusted volume indicator for hospitals, which can be used when performing constant price calculations on production of non-market services for individual consumption (the output measures). Two types of explicit quality adjustment are accomplished. The first, the general there is applied for all treatment types. The second, more advanced is the treatment-specific. The chapter proceeds by concludes on all the main results accomplished from the project.

The result of the explicit general quality adjustment of the volume indicator for hospitals was an increase in the volume indicator from 2.43 % to 3.07 % in 2015 and from 1.69 % to 2.40 % in 2016. Overall, significant effects from quality adjust for death during hospitalization and re-admission within 30 days. The quality adjusted volume indicator for hospitals is also been applied in the calculation of a satellite national accounts. By applying explicit quality adjustment, when deflating non-marked health care services, the output growth for these services increased from 1.5 % to 2 % in 2015 and from 1.3% to 1.9 % in 2016. The quality adjusted volume indicator for hospitals effect on the national accounts is an increase on 596 (79,5) million Danish Kroner (Euro) in 2015 and 1,274 (170) million Danish Kroner (Euro) in 2016. Consequently, explicit general quality adjustment of hospital treatments has a significant effect on the national accounts.

A model of collaboration between health care quality experts and NSI national accounts in determining the quality of patient treatments has been accomplished. The collaboration includes establishing contact and getting access to quality data from a range of patient treatments quality related databases, and for soliciting expert opinions from health care professionals. Based on the collaboration with health care quality experts, the construction of an advanced treatment specific quality adjusted volume indicator for one of the more complicated/expensive patient treatment groups has been achieved.

The treatment-specific quality adjusted volume indicator is based on a weighted index for quality of specific DRG treatments and control/correction variables for lifestyle, health conditions and age. The treatment specific indicator can be incorporated in the volume indicator for all hospital treatments. The results for the volume indicator for Hysterectomy operations (DHHD) with explicit quality adjustment showed that lifestyle, health conditions and age have a large effect on if an operation is successful or not. The treatment specific quality adjustment patient characteristics and the quality index for Hysterectomy operations have a significant
effect on the volume indicator for DHHD. The treatment specific quality adjustment increased the DHHD volume indicator’s growth with 0.83 percentage points in 2015, and 1.64 percentage points in 2016.

The project has been very successful in establishing contact and getting access to quality data from a range of patient treatments quality related databases and in the health community. Due to the volume of collected data, it has not been possible to fully explore and experiment with all the data within the time and scope of this project. This provides a good platform for further research.

All in all, the comparability and quality of the experimental data used in the project is very high, and should be sustainable over time. All the results from the many different types of explicit quality adjustment of patient treatments had a positive effect on the volume indicators. Consequently, this is a strong indication of that the quality of patient treatments in general has been increased from 2014 to 2016 in Denmark. Moreover, including explicit quality adjustment in the output volume measurement of health care has a significant effect on the national accounts.
7. References

The Eurostat Handbook on price and volume measures in national accounts

European System of Accounts (ESA2010): final version:
http://ec.europa.eu/eurostat/web/esa-2010/overview

“General Government Output and Productivity, 2008-2014”
www.dst.dk/publ/GovernOutProd

The Nordic DRG system
www.nordcase.org/eng/

The Danish Clinical Registries (RKKP)
www.rkhp.dk

The Danish Hysterectomy and Hysteroscopy Database (DHHD)
www.dsog.dk/koder-og-kvalitetssikring/dansk-hysterektomi-og-hysteroskopi-database

eSundhed
www.sst.dk
8. Appendices

Regression model (5.4), from chapter 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.086826</td>
<td>0.050890</td>
<td>21.35652</td>
<td>0.0000</td>
</tr>
<tr>
<td>BMI_OBESE</td>
<td>-0.015125</td>
<td>0.006352</td>
<td>-2.381049</td>
<td>0.0173</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.010279</td>
<td>0.001909</td>
<td>-5.385737</td>
<td>0.0000</td>
</tr>
<tr>
<td>AGE^2</td>
<td>0.000107</td>
<td>1.73E-05</td>
<td>6.147804</td>
<td>0.0000</td>
</tr>
<tr>
<td>ASA3</td>
<td>-0.091392</td>
<td>0.020253</td>
<td>-4.512462</td>
<td>0.0000</td>
</tr>
<tr>
<td>ASA4</td>
<td>-0.316473</td>
<td>0.110615</td>
<td>-2.861022</td>
<td>0.0042</td>
</tr>
<tr>
<td>ALCOHOL_LARGE</td>
<td>-0.033245</td>
<td>0.012903</td>
<td>-2.576477</td>
<td>0.0100</td>
</tr>
<tr>
<td>SMOKING_HIGH</td>
<td>-0.128344</td>
<td>0.037396</td>
<td>-3.432056</td>
<td>0.0006</td>
</tr>
</tbody>
</table>

R-squared        | 0.013239    | Mean dependent var | 0.843794 |
Adjusted R-squared| 0.012459    | S.D. dependent var  | 0.248755 |
S.E. of regression| 0.247201    | Akaike info criterion | 0.043672 |
Sum squared resid | 540.5637    | Schwarz criterion   | 0.050077 |
Log likelihood    | -185.3358   | Hannan-Quinn criter. | 0.045853 |
F-statistic       | 16.95540    | Durbin-Watson stat  | 1.984686 |
Prob(F-statistic) | 0.000000    |                      |          |

Regression model (5.4), from chapter 5 corrected for heteroskedasticity

White-Hinkley (HC1) heteroskedasticity consistent standard errors and covariance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.086826</td>
<td>0.047261</td>
<td>22.99619</td>
<td>0.0000</td>
</tr>
<tr>
<td>BMI_OBESE</td>
<td>-0.015125</td>
<td>0.006850</td>
<td>-2.208007</td>
<td>0.0273</td>
</tr>
<tr>
<td>AGE</td>
<td>-0.010279</td>
<td>0.001752</td>
<td>-5.867929</td>
<td>0.0000</td>
</tr>
<tr>
<td>AGE^2</td>
<td>0.000107</td>
<td>1.56E-05</td>
<td>6.820876</td>
<td>0.0000</td>
</tr>
<tr>
<td>ASA3</td>
<td>-0.091392</td>
<td>0.024563</td>
<td>-3.720790</td>
<td>0.0002</td>
</tr>
<tr>
<td>ASA4</td>
<td>-0.316473</td>
<td>0.147161</td>
<td>-2.150525</td>
<td>0.0315</td>
</tr>
<tr>
<td>ALCOHOL_LARGE</td>
<td>-0.033245</td>
<td>0.013514</td>
<td>-2.460026</td>
<td>0.0139</td>
</tr>
<tr>
<td>SMOKING_HIGH</td>
<td>-0.128344</td>
<td>0.050578</td>
<td>-2.537546</td>
<td>0.0112</td>
</tr>
</tbody>
</table>

R-squared        | 0.013239    | Mean dependent var | 0.843794 |
Adjusted R-squared| 0.012459    | S.D. dependent var  | 0.248755 |
S.E. of regression| 0.247201    | Akaike info criterion | 0.043672 |
Sum squared resid | 540.5637    | Schwarz criterion   | 0.050077 |
Log likelihood    | -185.3358   | Hannan-Quinn criter. | 0.045853 |
F-statistic       | 16.95540    | Durbin-Watson stat  | 1.984686 |
Prob(F-statistic) | 0.000000    | Wald F-statistic    | 18.51044 |
Prob(Wald F-statistic) | 0.000000   |                      |          |
Test for multicollinearity of regression model (5.4), from chapter 5

Variance Inflation Factors (VIF)

<table>
<thead>
<tr>
<th>Auxiliary Regression</th>
<th>R-squared</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI_OBESE</td>
<td>0.0142</td>
<td>1.0144</td>
</tr>
<tr>
<td>AGE</td>
<td>0.9828</td>
<td>58.2683</td>
</tr>
<tr>
<td>AGE^2</td>
<td>0.9828</td>
<td>58.2717</td>
</tr>
<tr>
<td>ASA3</td>
<td>0.0155</td>
<td>1.0158</td>
</tr>
<tr>
<td>ASA4</td>
<td>0.0006</td>
<td>1.0006</td>
</tr>
<tr>
<td>ALCOHOL_LARGE</td>
<td>0.0107</td>
<td>1.0108</td>
</tr>
<tr>
<td>SMOKING_HIGH</td>
<td>0.0019</td>
<td>1.0019</td>
</tr>
</tbody>
</table>

Normality test of regression model (5.4), from chapter 5

Series: Residuals
Sample 1 11367
Observations 8854

Mean 1.98e-16
Median 0.139429
Maximum 0.460978
Minimum -0.904556
Std. Dev. 0.247103
Skewness -1.753184
Kurtosis 5.532081

Jarque-Bera 6900.972
Probability 0.000000