Hamburg University of Applied Sciences
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# Regional Differences between Hysterectomy Rates – A Quantitative Analysis of Routine Hospital Data in Germany, Austria and Switzerland

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# List of Abbreviations

| | |
|---|---|
| ANOVA | Analysis of variance |
| AUB | Abnormal uterine bleeding |
| BAG | Bundesamt für Gesundheit |
| BFS | Bundesamt für Statistik |
| BMGF | Bundesministerium für Gesundheit und Frauen |
| CHOP | Schweizerische Operationsklassifikation |
| DACH | Acronym commonly used for Germany (D), Austria (A) and Switzerland (CH) |
| DEGS1 | Name of a nationwide study on health status in Germany (Studie zur Gesundheit Erwachsener in Deutschland) |
| DLD | Diagnosen- und Leistungsdokumentation |
| G-BA | Gemeinsamer Bundesausschuss |
| ICD-10-GM | German Modification of International Statistical Classification of Diseases and Related Health Problems |
| LASH | Laparoscopic-assisted supracervical hysterectomy |
| LAVH | Laparoscopic-assisted vaginal hysterectomy |
| LNG-IUS | Levonorgestrel intrauterine system |
| MEL | Medizinische Einzelleistung |
| NSAID | Non-steroidal anti-inflammatory drugs |
| OPS | Operationen- und Prozedurenschlüssel |

# 1 Introduction

Hysterectomy, the removal of the uterus, is one of the most common gynaecologic surgical procedures worldwide.[1] In Germany, hysterectomies ranked fifth most performed gynaecological surgery in 2016, accounting for over 80,000 procedures.[2] There are many medical occasions that indicate a hysterectomy, e.g. the diagnosis of cancer affecting the uterus or adjacent organs of the female reproductive system. However, the surgery is also done in cases of benign diseases, in fact, the majority of hysterectomies are benign[3]. During the past decades, uterus-preserving treatments became available, which present alternatives to uterus removal for many patients with benign diseases. Although hysterectomy rates have declined, there are doubts about the potential overuse of the procedure.[4]

While providing an ultimate solution for the underlying condition and discomfort in most patients, there are several negative issues that come along with a hysterectomy, both for the patient and the healthcare system.

Previous research found that hysterectomy rates vary greatly between countries and even regions. These variations cannot be explained by mere medical reasons, but rather by a range of non-medical reasons. This entails that women are more or less likely to get a hysterectomy depending on where they live. The phenomenon of supplier-induced demand has been the focus of a body of research and it has also been researched in the field of healthcare. It assumes that certain services are induced by healthcare supply factors. A laconic expression for the phenomenon is Roemer's Law: "A bed built is a bed filled".[5]

Supplier-induced demand has been a rare subject in the field of hysterectomy research. This thesis attempts to get a clearer understanding of it in the three countries Germany, Austria and Switzerland (DACH) using routine hospital data.

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[1] Hammer et al. 2015.
[2] Statistisches Bundesamt (2016).
[3] *"Benign hysterectomy"/"malignant hysterectomy": Short for hysterectomy due to a benign/malignant disease.*
[4] Temkin, Minasian, & Noone 2016.
[5] Ginsburg & Koretz 1983.

In addition, it will examine the variation of the hysterectomy rates between the countries and their respective regions.

# 2 Objectives

Building on previous research on the topic of hysterectomy rate variations as well as on supplier-induced demand in healthcare, the objectives of this thesis are

(1) to determine whether there are differences between the hysterectomy rates of Germany, Austria and Switzerland, and if they are statistically significant,

and

(2) to investigate the phenomenon of supplier-induced demand in context of hysterectomies by examining the association of non-medical, healthcare resource factors, specifically hospital bed and physician density, with the hysterectomy rate.

Answering these research questions will give a valuable insight in the actual healthcare situation, as no paper has compared hysterectomy rates between the DACH countries with real-world hospital data in this manner yet.

# 3 Theoretical Background

## 3.1 Hysterectomy

The term hysterectomy derives etymologically from Ancient Greek *hystera*[6] (uterus, womb) and *ektomia*[7] (cutting out) and describes the surgical removal of parts or the entire uterus, which itself is part of the female reproductive system (Figure 1).

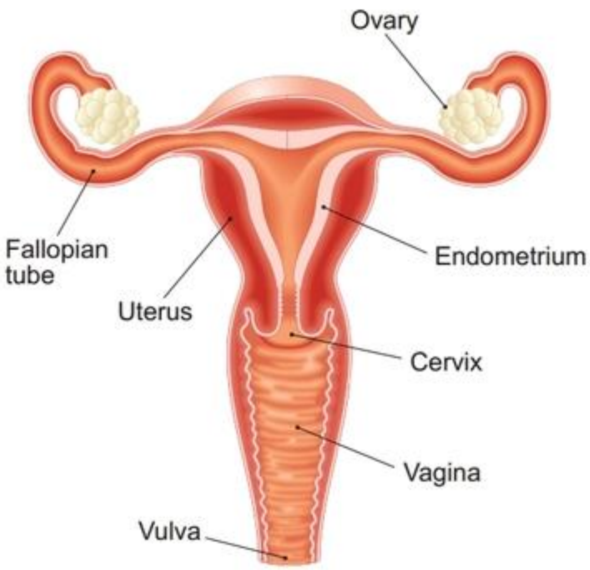


*Figure 1: Anatomy of the female reproductive system*[8]

The representative DEGS1 study showed that the prevalence of hysterectomy in Germany was 17,5 % in women aged 18 to 79. About half of those women had the surgery at the age of 40 to 49, however, the range was from as young as 24 years to 74 years.[9]

### 3.1.1 Indications for hysterectomy

A hysterectomy can become necessary in several conditions that affect the uterus or other surrounding organs. The indications can be classified in malignant and benign diseases.

[6] Online Etymology Dictionary 2018a.
[7] Online Etymology Dictionary 2018b.
[8] Leavingcertbiology.net 2018.
[9] Prütz et al. 2013.

***Malignant diseases***

When a patient is diagnosed with neoplasms (i.e. cancer) of the uterus, the cervix, the ovary or the fallopian tubes, a hysterectomy is usually inevitable.[10] Also, neoplasms of the placenta or even of neighbouring organs like the colon or the ureter can trigger a hysterectomy, when it facilitates the actual treatment. Further malignant diseases that may indicate hysterectomy are endometrial hyperplasia (i.e. the abnormal proliferation of endometrial tissue) and carcinoma in situ of any female genital organ.[11]

***Benign diseases***

One of the most common tumours of the female reproductive system is the uterine leiomyoma, also referred to as uterine fibroid.[12] Almost every third woman of reproductive age is estimated to have fibroids, however, they do not always show symptoms or cause discomfort, which is why only a part gets diagnosed.[13] The German health insurer BARMER GEK reports that one third of hysterectomies (excluding subtotal hysterectomies, see 3.1.2) in 2013 was indicated by uterine leiomyoma.[14] The second most common cause for hysterectomy is uterine prolapse, accounting for 22 % of surgeries.  Furthermore, endometriosis can indicate a hysterectomy. In women having this condition, the endometrium, the layer that lines the inside of the uterus, grows outside of it which can cause pain. Most uterine diseases, malignant or benign, can result in abnormal uterine bleeding (AUB) as a symptom, but menorrhagia (longer menstruation), hypermenorrhoea (stronger menstruation) or dysmenorrhea (painful menstruation) can also occur without any confirmed underlying conditions. The same applies for chronic pelvic pain. Not only do AUB and pelvic pain cause discomfort, but the increased blood loss in AUB can also lead to anaemia. AUB and pain can have a strong negative effect on quality of life and therefore represent an indication for hysterectomy.[15] Additionally, there are certain pelvic inflammatory diseases that can be treated with hysterectomy.[16]

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[10] Prütz & von der Lippe 2014, p. 1.
[11] Stang, Merrill, & Kuss 2011.
[12] Lefebvre et al. 2002, p. 2.
[13] Prütz & von der Lippe 2014, p. 2.
[14] Grobe, Klingenberg, Szecsenyi, & Steinmann 2015, p. 205.
[15] Neis et al. 2016.
[16] Lefebvre et al. 2002.

As with uterine leiomyomata, benign diseases of the female genital organs are often not diagnosed when they proceed asymptomatically.

German routine data showed that four out of five hysterectomies happen due to benign diseases.[17] Survey data from the DEGS1 study showed an even higher proportion of benign hysterectomies. Only 6,1 % of women with hysterectomy stated that they had a malignant uterine disease, implying that more than nine out of ten hysterectomies are benign.[18]

### 3.1.2 Types, surgical routes and setting of hysterectomies

There are three types of hysterectomy regarding the extent of tissue removed.

- A *subtotal/supracervical hysterectomy* refers to the removal of the uterine body, while the cervix is preserved.
- In a *total hysterectomy*, the whole uterus is removed.
- A *radical hysterectomy* defines the removal of the uterus, upper vagina and parametrium (tissue left and right of the cervix).[19]

In Germany, about 75 % of all hysterectomies were total hysterectomies in 2016. 20 % of the procedures were subtotal and only 5 % radical.[20] Radical hysterectomies are almost exclusively done in malignant cases and depend on the stage of the tumour. In 22 % percent of hysterectomies, regardless of the type, patients undergo a concomitant ovariectomy (also oophorectomy), which describes the removal of the ovaries.[21]

Besides classifying hysterectomies in benign vs. malignant and the three above types, they can also be characterized by their surgical route or approach.

- *Abdominal hysterectomy* describes the removal of the uterus through an incision in the abdomen of the patient. As this approach is the most invasive, it is an aim of all health systems to reduce the share of abdominal hysterectomies as much as possible.

[17] Stang et al. 2011.
[18] Prütz et al. 2013.
[19] Chmaj-Wierzchowska, Wierzchowski, Pieta, Buks, & Opala 2012, p. 394.
[20] Statistisches Bundesamt 2016.
[21] Stang et al. 2011.

- The *vaginal hysterectomy* is the most common approach in Germany. The uterus is accessed via the vagina, without any incisions.
- A *laparoscopic-assisted vaginal hysterectomy (LAVH)* is a minimally invasive method which includes laparoscopy to facilitate the removal of the uterus through the vagina. Along with the vaginal hysterectomy, these two methods account for almost 50 % of all hysterectomies in Germany. When the LAVH is performed subtotally, the method is called *laparoscopic-assisted supracervical hysterectomy (LASH)*.
- During a (*total) laparoscopic hysterectomy,* all surgery steps are performed laparoscopically.
- The above approaches can also be performed as part of a *robot-assisted hysterectomy*.[22]

Traditionally, hysterectomies take place in an inpatient setting. Since the development of minimally invasive methods, it is also possible to perform hysterectomies in an outpatient setting, also called ambulatory care. The recovery time from those procedures is much shorter than from invasive methods, so it often doesn't require the patient staying overnight. In Germany, outpatient, i.e. day-surgery hysterectomies are rare. Stang et al. estimate that less than 8 % of hysterectomies in Germany are performed outpatient.[23] Unlike with inpatient procedures, there is no monitoring in place that centrally records outpatient hysterectomies. Therefore, the share cannot be safely determined. It is certain though, that the number of outpatient hysterectomies has increased during recent years. As an example, the number of hysterectomies in a day-care clinic in Hamburg increased from 0 in 1998 to 196 in 2006.[24] Newer reports from this clinic state 231 hysterectomies in 2015.[25]

### 3.1.3 Alternative treatments for benign uterine diseases

Hysterectomy represents a definite and permanent treatment for the above-mentioned conditions.  While it is essential in most malignant cases, it is often a

[22] Neis & Schwerdtfeger 2016.
[23] Stang, Merrill, & Kuss 2012.
[24] Salfelder et al. 2007.
[25] Tageslinik Altonaer Straße 2015, p. 13.

matter of choice in benign cases. Benign hysterectomy should not be used as a first-line treatment, but rather as second- or third-line, after other treatment options have failed.[26] Personal desires of the patient and stage of family planning have to be considered, since hysterectomy entails the inability to bear children.[27] Depending on the indication and the individual medical and non-medical circumstances of each patient, there are several uterus-preserving alternatives to hysterectomy.

- *Myomectomy* (enucleation of the myoma) can be another surgical option for patients with uterine leiomyoma.
- *Uterine artery embolisation* offers a non-surgical approach to treat leiomyoma.
- For AUB, there are several *medical treatments* available. Non-hormonal medications include non-steroidal anti-inflammatory drugs (NSAID). Hormonal therapy includes oral contraceptives and systemic or local gestagens, e.g. Levonorgestrel intrauterine system (LNG-IUS)
- *Endometrial ablation* is a minimally invasive treatment option for AUB. There are several different ablation methods available.

For women who have not completed their family planning, only medical treatment and myomectomy ensure fertility.[28]

## 3.2 Variation in hysterectomy rates

Health and healthcare disparities are a relevant research and discussion subject in public health. Variations are seen in burden of disease, healthcare supply, access and use of healthcare, healthcare spending and more. [29,30]

Variations in healthcare can be classified as warranted (related to patients' needs and preferences) and unwarranted. These include variations related to race or

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[26] Neis & Schwerdtfeger 2016.
[27] *In isolated cases women had a live birth after uterus transplantation, however these are still considered a medical sensation and far from the norm;* Testa et al. 2018.
[28] Neis & Schwerdtfeger 2016.
[29] OECD 2014.
[30] Sundmacher 2016.

socioeconomic characteristics.[31] It is the unwarranted variations that should be reduced to achieve more equality. There are several initiatives that focus on identifying and recording variations and making them public, like the Dartmouth Atlas of Healthcare in the U.S.[32] or the NHS Atlas of Variation in the UK[33]. Another classifying element are the region units that being put in comparison. It can be variations between countries, but also within countries, which is called small area variation. Causes of small area variation have been a subject of active research for decades and still ongoing. [34]

Studies addressing variations in hysterectomy rates and routes identified the following factors that attributed unwarranted variations (non-exhaustive):

- Race[35]
- Neighbourhood[36]
- Income[37]
- Occupation of patient's partner[38]
- Gender of gynaecologist[39]
- Medical practice style[40]
- Insurance scheme[41]
- Gynaecologist density[42].

A high gynaecologist-to-population density was associated with higher hysterectomy rates. This type of physician density – procedure rate relationship is a result of a phenomenon known as supplier-induced demand.

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[31] Birkmeyer et al. 2013.
[32] The Dartmouth Institute for Health Policy & Clinical Practice 2018.
[33] Mays 2011.
[34] Cohen, Naylor, Basinski, & Ferris 1992.
[35] Price et al. 2017.
[36] Chen et al. 2017.
[37] Haas, Acker, Donahue, & Katz 1993.
[38] Domenighetti & Casabianca 1997.
[39] Domenighetti & Casabianca 1997.
[40] Roos 1984.
[41] Haas et al. 1993.
[42] Bickell, Earp, Garrett, & Evans 1994.

## 3.3 Supplier-induced demand

The term supplier-induced demand refers to the concept that physicians or other healthcare suppliers can influence, i.e. increase their patients' demand for healthcare services. It creates a demand where there was none or less demand before. It is closely linked to the above mentioned regional variations in the sense that it can provoke variations of the unwarranted kind. Reasons for physicians to manipulate the demand include their self-interest, like financial incentives, or efforts to promote their patients' health and well-being.[43] A common way to detect supplier-induced demand is to study the association of physician density and the number or rate of a specific medical service.

Evidence of supplier-induced demand, sometimes also referred to as provider-induced demand, supplier-sensitive care or supplier-induced utilisation, has been found for various medical services, like hip and knee replacement surgery[44], psychiatric admissions[45] and diagnostic tests[46].

There has been limited prior research examining the relation between healthcare supply and hysterectomy procedures. Studies that did investigate this relationship yielded inconsistent results, which makes it worthwhile examining again.[47,48,49]

[43] Bickerdyke, Dolamore, Monday, & Preston 2002, p. X.
[44] Weeks, Jardin, Dufour, Paraponaris, & Ventelou 2014.
[45] Watts, Shiner, Klauss, & Weeks 2011.
[46] Wennberg 2011.
[47] Roos 1984.
[48] Bickell et al. 1994.
[49] OECD 2014, p. 5.

# 4 Material and methods

## 4.1 Design and sample

This thesis employs routine data on an aggregated level, hence it falls in the category of ecological studies.[50] It employs a retrospective design covering the time span of one year (2015). The setting is constituted of Germany, Austria and Switzerland. Units of observation and analysis are the states and cantons of these three countries, resulting in a sample of 51 subjects (see Table 1).

| States in Germany | States in Austria | Cantons in Switzerland |
|---|---|---|
| Baden-Württemberg | Burgenland | Aargau |
| Bayern | Kärnten | Appenzell Ausserrhoden |
| Berlin | Niederösterreich | Appenzell Innerrhoden |
| Brandenburg | Oberösterreich | Basel-Landschaft |
| Bremen | Salzburg | Basel-Stadt |
| Hamburg | Steiermark | Bern |
| Hessen | Tirol | Freiburg |
| Mecklenburg-Vorpommern | Vorarlberg | Genf |
| Niedersachsen | Wien | Glarus |
| Nordrhein-Westfalen | | Graubünden |
| Rheinland-Pfalz | | Jura |
| Saarland | | Luzern |
| Sachsen | | Neuenburg |

[50] Silva & Cancer 1999, p. 92ff.

| | | |
|---|---|---|
| Sachsen-Anhalt | | Nidwalden |
| Schleswig-Holstein | | Obwalden |
| Thüringen | | Schaffhausen |
| | | Schwyz |
| | | Solothurn |
| | | St. Gallen |
| | | Tessin |
| | | Thurgau |
| | | Uri |
| | | Waadt |
| | | Wallis |
| | | Zug |
| | | Zürich |

*Table 1: States and cantons of the DACH countries*

For reasons of uniformity, the German names of all states and cantons are used.

## 4.2 Statistical analysis

Given the scope of the thesis, only secondary data that were either publicly available or available upon request, but free of charge, were used for the analysis. A prerequisite of used data sources was the availability of detailed data on state or canton level, respectively. All data refer to the year 2015. Since all data are on aggregated and not on individual patient level, neither patient consent nor ethics committee approval were required for the study.

To assess differences between the hysterectomy rates of the three countries, a one-way ANOVA is conducted. Since the ANOVA only reveals *whether* there is a difference between the rates altogether, post-hoc tests are conducted to determine which countries differ from each other. In case of violation of the homogeneity of variance assumption, the Welch's F-ration is used. Assumptions are tested before conducting the ANOVA.[51]

Regression analysis is suitable for examining associations between a number of factors and a variable of interest. It does not claim any causal relationship.

The dependent variable in the regression is the hysterectomy rate, defined as hysterectomies per 100,000 women of the respective state/canton. Men can be excluded from the denominator, as they are not part of the population at risk.

To investigate supplier-induced demand for hysterectomies while staying within the limits of the available data sources, the following factors come in line:

- Number of hospitals
- Number of hospital beds
- Number of gynaecologists

Due to large differences in hospital sizes, the number of hospital beds is a more meaningful indicator than just the number of hospitals. Hospital beds provide a measure of healthcare resources as in equipment available for delivering healthcare services.[52]

Gynaecologists as specialist doctors to perform or inform about hysterectomies provide direct care to patients and are therefore seen as an indicator of healthcare resources.[53] Both hospital beds and gynaecologists were transformed into density variables (number per 100,000 women).

It can be assumed that the frequency of (uterine) diseases as described in chapter 3.1.1 is associated with the hysterectomy rate, especially since for malignant diseases a hysterectomy is usually unavoidable. Therefore, malignant and benign diseases are used as control variables, also measured at a rate per 100,000 women. The distinction of malignant and benign diseases is intended, so the

[51] Field 2013, p. 348ff.
[52] OECD 2018a.
[53] OECD 2018b.

analysis can reveal whether benign diseases have an influence on the hysterectomy rate and how strong it is compared to malignant diseases.

Depending on the results of the ANOVA, a country variable is also used as an independent variable to control for its influence on the hysterectomy rate.

All variables, except for country (categorical), are metric, so a parametric linear regression model is used, resulting in the following equation (if country is included)[54]:

$$Y_i = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5$$

| | |
|---|---|
| $Y_i$ | Dependent variable (hysterectomy rate) |
| $b_{0\text{-}5}$ | Regression coefficients |
| $X_{1\text{-}5}$ | Independent variables (country, malignant diseases, benign diseases, hospital bed density, gynaecologist density). |

The significance threshold is set at .05, meaning all p-values < .05 indicate significance.

Before running the regression model, the following assumptions for linear regression are checked:

- Variable types (metric dependent variable and metric or categorical dichotomous predictors)
- Variance of the predictors is not zero
- No perfect multicollinearity between the predictors
- Equality of variance (homoscedasticity)
- Independent residuals (no autocorrelation)

In addition to the cross-country model, regression models are run for each country individually in order to further investigate country differences. Taking into account smaller sample sizes in these national models, results have to be treated cautiously.

Data analyses are done using the software IBM® SPSS® Statistics Version 24.

[54] Field 2013, p. 209ff.

## 4.3 Data collection

### 4.3.1 Routine hospital data

The most comprehensive, publicly available data for performed hysterectomies are hospital data. In all three DACH countries, it is mandatory for hospitals to document hospitalisations and related data and transfer this information to official institutions. Although the number of outpatient hysterectomies is increasing, there is currently no or no comparable outpatient documentation in place in any of the countries, which is why the present analysis is limited to inpatient hysterectomies. Apart from hysterectomy procedures, hospital data also include information on disease rates.

***Germany***

Since 2005, hospitals that fall within the scope of § 108 SGB V have been obliged to submit so-called quality reports. Originally this was required every other year, but since 2013 the cycle changed to every year. The Federal Joint Committee (G-BA, *Gemeinsamer Bundesausschuss*) defines the scope and structure of the reports. The purpose of these quality reports is to make hospitals and their processes more transparent to patients.[55] The reports don't only include data on diagnoses and procedures, but also on staff, medical equipment, internal quality management and more. Diagnoses are reported according to the German modification (GM) of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), which is a worldwide accepted WHO standard classification.[56] Procedures are reported according to the *Operationen- und Prozedurenschlüssel* (OPS), which is the German classification of medical procedures and also the basis for billing purposes.[57] ICD-10-GM and OPS catalogues are amended from time to time, codes in the reports refer to the respective version of the reporting year. The reports are available upon request from the G-BA in machine-readable form. Every diagnose and procedure is documented and linked to the respective hospital. It is not linked to a specific patient or case; therefore, procedures cannot be connected to their respective

[55] Gemeinsamer Bundesausschuss 2017.
[56] Deutsches Institut für Medizinische Dokumentation und Information 2018a.
[57] Deutsches Institut für Medizinische Dokumentation und Information 2018b.

diagnose or to the patient characteristics. For this thesis, the report for the year 2015 was used as a data source, which was the latest available data at the time of collecting.

***Austria***

Austrian hospitals have to document diagnoses and procedures (DLD, *Diagnosen- und Leistungsdokumentation*) and submit them to the Federal Ministry of Health and Women's Affairs (BMGF, Bundesministerium für Gesundheit und Frauen).[58] The coding of diagnoses is based on the Austrian modification of ICD-10, which is comparable to the German modification. Procedures are coded according to Individual Medical Services (MEL, *Medizinische Einzelleistung*) as listed in the *Leistungskatalog BMGF*, as amended from time to time. The full DLD contains patient- and other case-related information, like length of stay, patients' date of birth, place of residence, all associated diagnoses, procedures and services. For the purposes of the thesis, it was not possible to get access to this sensitive data. Upon direct request, the Department for Health Planning and Documentation at the BMGF provided specific diagnoses and procedures data aggregated on Austrian state level for the reporting year 2015.

***Switzerland***

Switzerland introduced the obligatory submission of hospital data in its present format in 1997. All hospitals have to transport data on hospitalisations, sociodemographic characteristics of patients and diagnose and procedure codes to the Federal Statistics Office (BFS, *Bundesamt für Statistik*), where the information of all hospitals are gathered in the so-called Medical Statistics of Hospitals (*Medizinische Statistik der Krankenhäuser*).[59] Diagnoses are coded according to ICD-10-GM, procedures are coded according to the Swiss Classification of Surgical Interventions (CHOP, *Schweizerische Operationsklassifikation*).[60] Similar to Austria, it was not possible to obtain the full version of the Medical Statistics of Hospitals, but aggregated data on Swiss canton

[58] *As of Januar 8, 2018, the responsibilities of the BMGF have been taken over by the Federal Ministry of Labour, Social Affairs, Health and Consumer Protection and the Federal Chancellery.* Bundesministerium für Arbeit, Soziales, Gesundheit und Konsumentenschutz 2018a.
[59] Bundesamt für Statistik 2005.
[60] Bundesamt für Statistik 2018a.

level from 2015 was provided by courtesy of the Department of Economic Affairs, Specialist Unit for Statistics of the canton St. Gallen.

Hysterectomies were identified by the respective procedure codes in the routine hospital data.

| | | |
|---|---|---|
| Germany<br>OPS codes | 5-682* | Subtotal hysterectomy |
| | 5-683* | Hysterectomy |
| | 5-685* | Radical hysterectomy |
| Austria<br>MEL codes | JK090 | Laparoscopic supracervical hysterectomy (LASH) |
| | JK100 | Laparoscopic or laparoscopic-assisted vaginal hysterectomy (LAVH) |
| | JK110 | Abdominal hysterectomy |
| | JK120 | Vaginal hysterectomy |
| | JK130 | Laparoscopic-assisted radical vaginal hysterectomy |
| | JK140 | Extended abdominal hysterectomy with removal of the parametrium |
| | JK150 | Extended vaginal hysterectomy with removal of the parametrium |
| Switzerland<br>CHOP codes | Z68.3* | Subtotal abdominal hysterectomy |
| | Z68.4* | Total abdominal hysterectomy |
| | Z68.5* | Vaginal hysterectomy |
| | Z68.6* | Radical abdominal hysterectomy |
| | Z68.7* | Radical vaginal hysterectomy |
| | Z68.9* | Other and not elsewhere classified hysterectomy |

*Table 2: Procedure codes for hysterectomies (as of 2015)*
*The asterisk (*) signifies the inclusion of all subcodes.*

For Germany, the subcodes were available in the dataset, but for Switzerland, the data was provided only at the three-digit level as listed in Table 2. All hysterectomy codes of a country were grouped together to calculate the respective hysterectomy rates.

Main discharge diagnoses from routine hospital data were used as control variables to account for the burden of disease. Stang et al. clustered indications for (i.e. diagnoses that were linked to) hysterectomy in groups.[61] These groups were borrowed for the present analysis and are depicted in Table 3.

| Adaption for this thesis | Groups as specified by Stang et al. | ICD-10 code | Description |
|---|---|---|---|
| Malignant diseases | Group 1<br>Malignant neoplasms of female genital organs | C53 | Malignant neoplasms of cervix uteri |
| | | C54 | Malignant neoplasm of corpus uteri |
| | | C55 | Malignant neoplasm of uterus, part unspecified |
| | | C56 | Malignant neoplasm of ovary |
| | | C57 | Malignant neoplasm of other and unspecified female genital organs |
| | | C58 | Malignant neoplasm of placenta |
| | Group 2 | N85.1 | Endometrial adenomatous hyperplasia |
| | Group 3<br>Carcinoma in situ of female genital organs | D06 | Carcinoma in situ of cervix uteri |
| | | D07.0 | Carcinoma in situ of endometrium |

[61] Stang et al. 2011.

| | | | |
|---|---|---|---|
| | | D07.3 | Carcinoma in situ of other and unspecified female genital organs |
| | Group 4 | D39 | Neoplasm of uncertain or unknown behaviour of female genital organs |
| Not included | Group 5<br>Other malignant primary tumours | Codes not specified by Stang et al. | E.g. hysterectomy because of debulking of colorectal carcinoma or urothelial carcinoma |
| Benign diseases | Group 6<br>Benign diseases of female genital organs | 24 diagnoses, for full list see Appendix A1 | E.g. uterine leiomyoma, benign neoplasms, inflammatory and non-inflammatory diseases of female genital organs |

*Table 3: Grouped indications for hysterectomy*
*(Adapted from Stang et al. 2011)*

Group 5 was not included in this thesis, as the exact diagnoses were not specified by Stang et al. Since it only accounted for 0.9 % of all hysterectomies in the study by Stang et al., its impact on results can be neglected. Groups 1-4 were added together under the category "malignant diseases".

Both malignant and benign diseases were converted to rates per 100,000 women in the respective state/canton to facilitate comparability.

The German routine data does not disclose the exact number of cases if it is below four (excluding zero) due to data protection laws. Since the data is published at hospital level there are quite a few hospitals where the absolute number of cases was below four (1, 2 or 3 cases). Regarding hysterectomies, the total number of data protected cases was 8,827. If one assumes all those cases were really 1 then these cases would represent 8,827 hysterectomies. If one assumes the other extreme, meaning behind all protected cases would be three actual hysterectomies, then the 8,827 undisclosed cases would represent 26,481 hysterectomies. In reality, the number of cases is somewhere in between. With main discharge diagnoses, the total number of those data protected cases was 62,052 across all hospitals. Excluding those “missings” would falsify the results, since they each stand for at least one actual case. For this analysis, a simplifying assumption was set at the middle between 1 and 3, so all data protected cases were multiplied by 2.

In the Swiss routine data, case numbers below five (excl. zero) are not disclosed. Even though the data are on canton level already, there were still 185 missings for main diagnoses and 39 missings for hysterectomies. Analogous to Germany, the middle scenario was assumed for the present analysis, multiplying all data protected cases with 2.5 (the average of 1 and 4 as extreme scenarios).

The Austrian routine data had no protected cases, hence no assumptions had to be made.

### 4.3.2 Other data sources

The number of hospital beds was obtained from official institutions and refer to the actual setup beds for inpatients (Germany: Federal Statistical Office[62]; Austria: BMGF[63]; Switzerland: Federal Office for Public Health (BAG, *Bundesamt für Gesundheit*)[64]). The number of beds refers to all hospital types which include general and specialty hospitals, like psychological or rehabilitation institutions.

The number of gynaecologists is composed of licensed gynaecologists working in the outpatient sector (mainly practices) and gynaecologists working in the inpatient sector (hospitals). It only includes those who are actively working as gynaecologists. Data were obtained from the German Medical Association[65], Statistik Austria[66] and the Swiss Medical Association[67].

Data on the female population were obtained from the most recent census data of each country referring to the year 2015 (Germany: Federal Statistical Office[68];

[62] Statistisches Bundesamt 2015.
[63] Bundesministerium für Gesundheit und Frauen 2016.
[64] Bundesamt für Gesundheit 2016.
[65] Bundesärztekammer 2015.
[66] Statistik Austria 2017, p. 285.
[67] FMH Verbindung der Schweizer Ärztinnen und Ärzte 2015.
[68] Statistisches Bundesamt 2017a.

Austria: Statistik Austria[69]; Switzerland: Federal Statistical Office[70]). The population includes women of all ages.

[69] Statistik Austria 2018.
[70] Bundesamt für Statistik 2018b.

# 5 Results

In this chapter, the results of the statistical analyses are presented. First, a descriptive analysis of the variables is given. Additionally, the variables are illustrated on the superordinate country level, as well as on the observation level (states/cantons) for a better clarity regarding regional differences. Following the descriptive part, the ANOVA results are presented. Finally, the results from the linear regression analysis are presented.

## 5.1 Descriptive analysis

The total female population across all three countries was 50,284,851, with over 40 million women in Germany alone and Austria and Switzerland having roughly the same population size, as shown in Figure 2. The female population across the states and cantons is shown in Figure 3, sorted in descending order and separated by country.

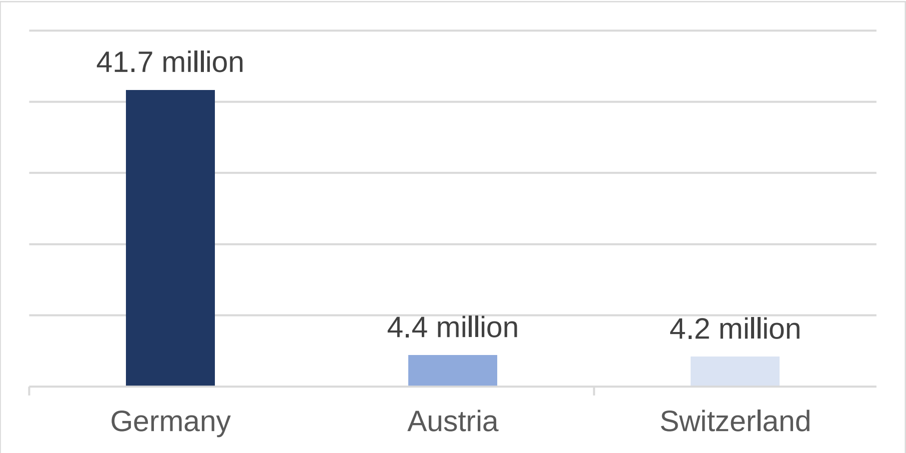


*Figure 2: Female population (country-level)*

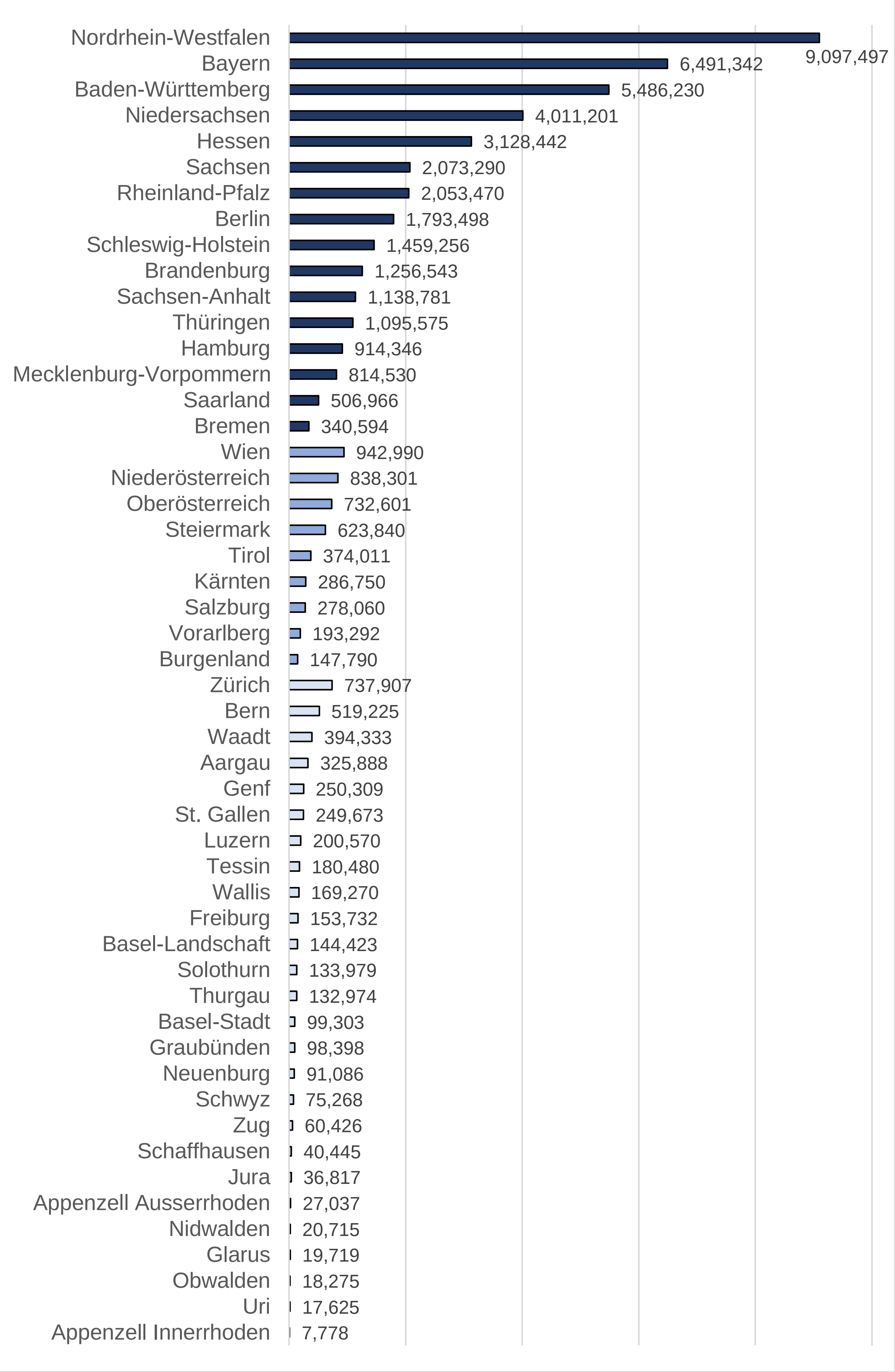


*Figure 3: Female population (state-/canton-level)*

The rate and density variables shown in Table 4 are the result of dividing the absolute number of each factor by the female population of the respective state/canton and multiplying it by 100,000. A table with absolute numbers can be found in Appendix A2. Table 4 shows the measures of central tendency and dispersion of the main variables.

| | | Hysterectomy rate | Hospital bed density | Gynaecologist density | Benign disease rate | Malignant disease rate |
|---|---|---|---|---|---|---|
| N | Valid | 51 | 51 | 51 | 51 | 51 |
| | Missing | 0 | 0 | 0 | 0 | 0 |
| Mean | | 263.95 | 1081.50 | 39.92 | 1406.21 | 232.03 |
| Median | | 267.13 | 1113.75 | 39.81 | 1451.96 | 171.88 |
| Std. Deviation | | 90.64 | 390.43 | 11.33 | 550.19 | 217.14 |
| Variance | | 8214.98 | 152438.17 | 128.32 | 302703.75 | 47151.78 |
| Range | | 500.25 | 1714.93 | 70.73 | 2278.56 | 873.78 |
| Minimum | | .00 | 371.71 | 12.86 | 173.57 | 32.14 |
| Maximum | | 500.25 | 2086.64 | 83.58 | 2452.13 | 905.92 |

*Table 4: Descriptive statistics of the variables (measured per 100,000 women) (Adapted from SPSS output)*

### 5.1.1 Hysterectomy rate

In Germany, 130,470 hysterectomies were performed in hospitals in 2015. In Austria, there were 8,969 hysterectomies and in Switzerland 11,415 hysterectomies were performed. This leads to the following rates per 100,000 women, depicted in Figure 4. The numbers per 100,000 women in the following sections are rounded.

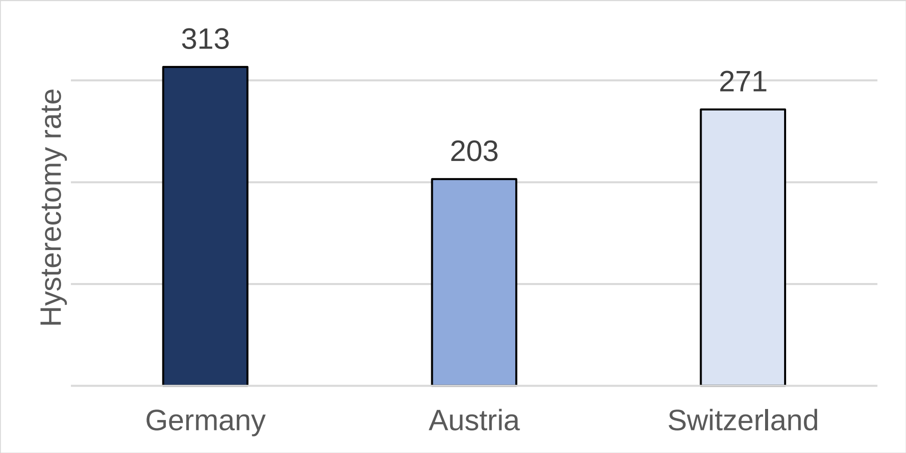


*Figure 4: Hysterectomies per 100,000 women (country-level)*

Germany has the highest hysterectomy rate with 313 procedures per 100,000 women. The rate in Austria is about one third lower. The variation between the regions is shown in Figure 5. Berlin features a very high rate of 500 procedures, followed by far by a rate of 384 in Saarland. In Austria, the different rates lie closer together. A notable canton in Switzerland is Appenzell Innerrhoden, where the hysterectomy rate is zero. This extreme value is neither a missing nor a data error. The simple explanation is that there are no (inpatient) facilities to perform hysterectomies in Appenzell Innerrhoden (see also Figure 9). Due to this fact, Switzerland has the largest range of hysterectomy rates among the countries, namely 477. However, regional variations can be observed in all the three countries, even in Austria, where the range is 126. Comparing Germany and Austria, one sees that all Austrian states, except for Kärnten, had a lower hysterectomy rate than any German state.

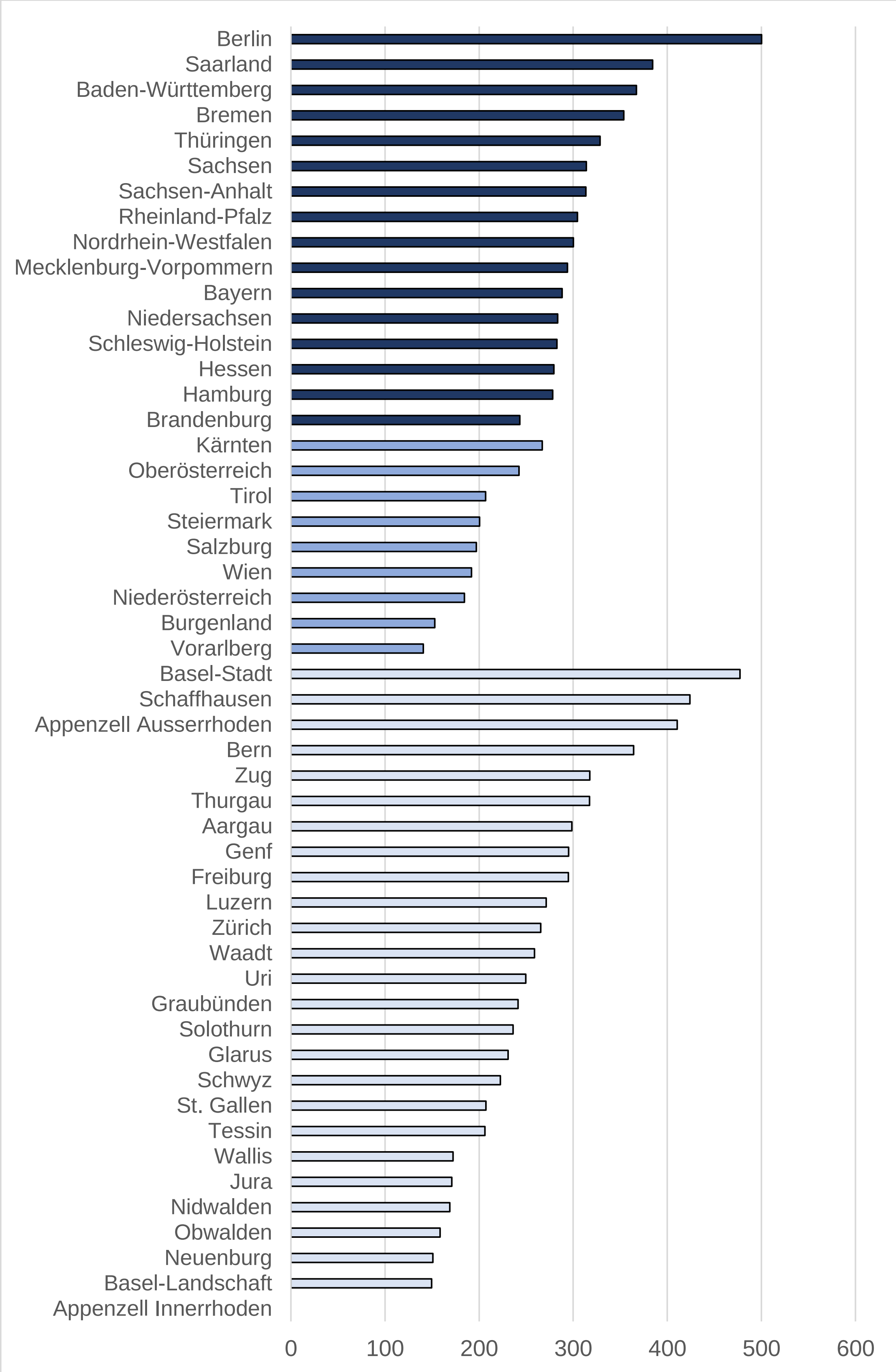


*Figure 5: Hysterectomies per 100,000 women(state-/canton-level)*

### 5.1.2 Hospital bed density

In Austria, there is the highest availability of hospital beds per woman, followed by Germany and Switzerland (Figure 6). On country average, 100,000 women have access to almost 600 more hospital beds in Austria compared to Switzerland.

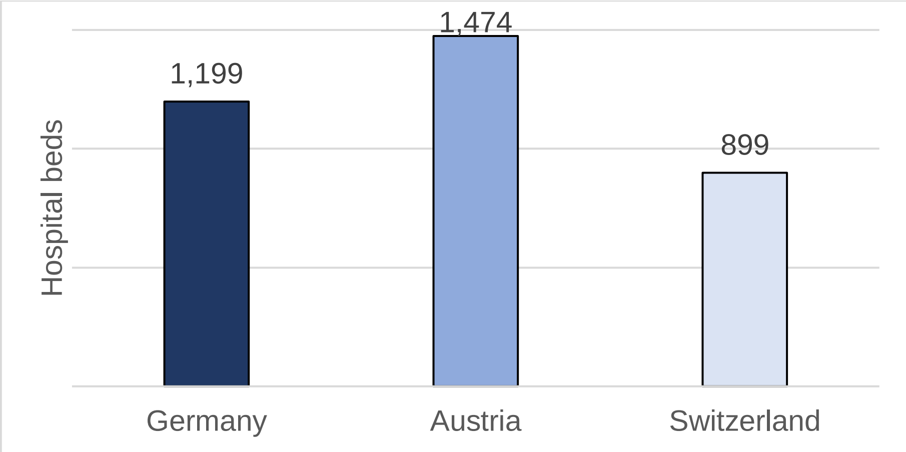


*Figure 6: Hospital beds per 100,000 women (country-level)*

Figure 7 illustrates that hospital bed density as a factor of healthcare resources varies between geographic regions in every country. This is especially true in Switzerland, where the hospital density ranges from less than 400 to over 2,000 beds per 100,000 women. Compared to Germany and Austria, the hospital bed density is generally lower in Switzerland. Only five of 26 cantons have a hospital bed density of over 1,000, whereas the states of both Germany and Austria all have bed densities over 1,000 per 100,000 women.

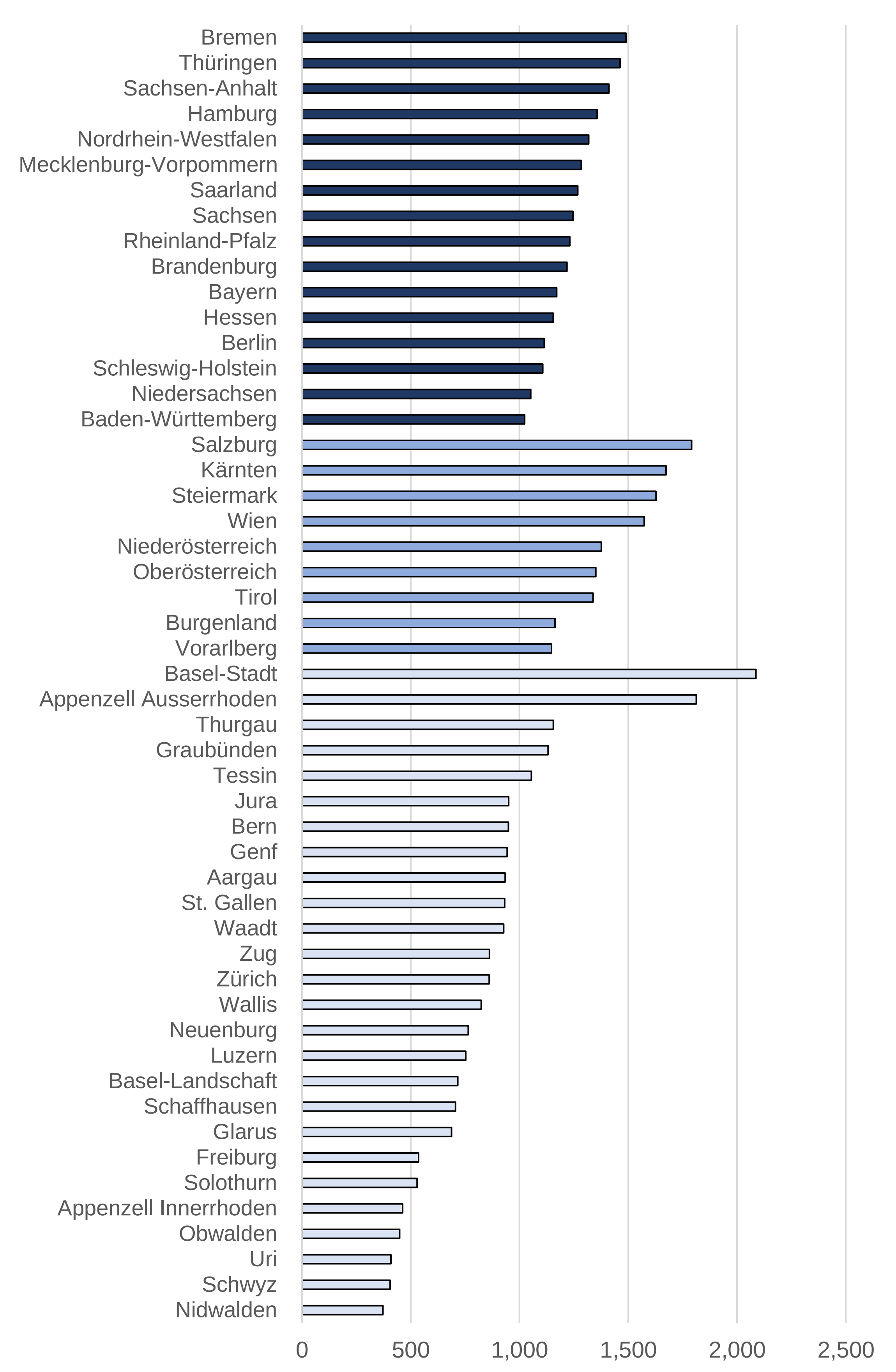


*Figure 7: Hospital beds per 100,000 women (state-/canton-level)*

### 5.1.3 Gynaecologist density

The number of gynaecologists is the sum of the medically active outpatient and the medically active inpatient gynaecologists. Although, the individual rates were not used for the statistical analyses, the following two figures visualize how the compound rates are made up.

In Figure 8, no apparent differences between the country rates can be found. The gynaecologist density is close to 41 per 100,000 women in each country. When considering the individual sectors, there is still almost no difference between Germany and Switzerland. Austria, however, has a slightly different ratio of inpatient to outpatient gynaecologists, having a higher proportion of outpatient gynaecologists.

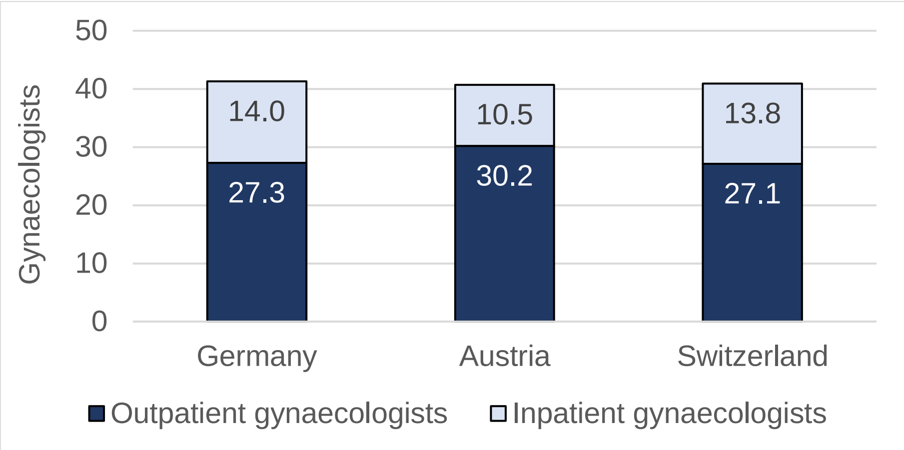


*Figure 8: Gynaecologists (with medical activity) per 100,000 women (country-level)*

Figure 9 shows how the gynaecologist rates vary across regions. In Germany, the gynaecologist density was relatively balanced across states, except for the city states of Hamburg, Berlin and Bremen, where the gynaecologist availability was close to 60. In Austria, there is not a big regional variation either. But again, Wien, as the only city state, featured the highest density. The Swiss city canton of Basel-Stadt had an extremely high gynaecologist density of over 80. All other cantons had densities of less than 60. The lowest gynaecologist density was in Appenzell Innerrhoden. Per 100,000 women, there were only 13 gynaecologists. Though it needs to be considered that this canton only featured a population of roughly 7,800 women. Moreover, Appenzell Innerrhoden is the only region where there were no inpatient gynaecologists. This is the reason for the lack of hysterectomies in this canton (see Figure 5).

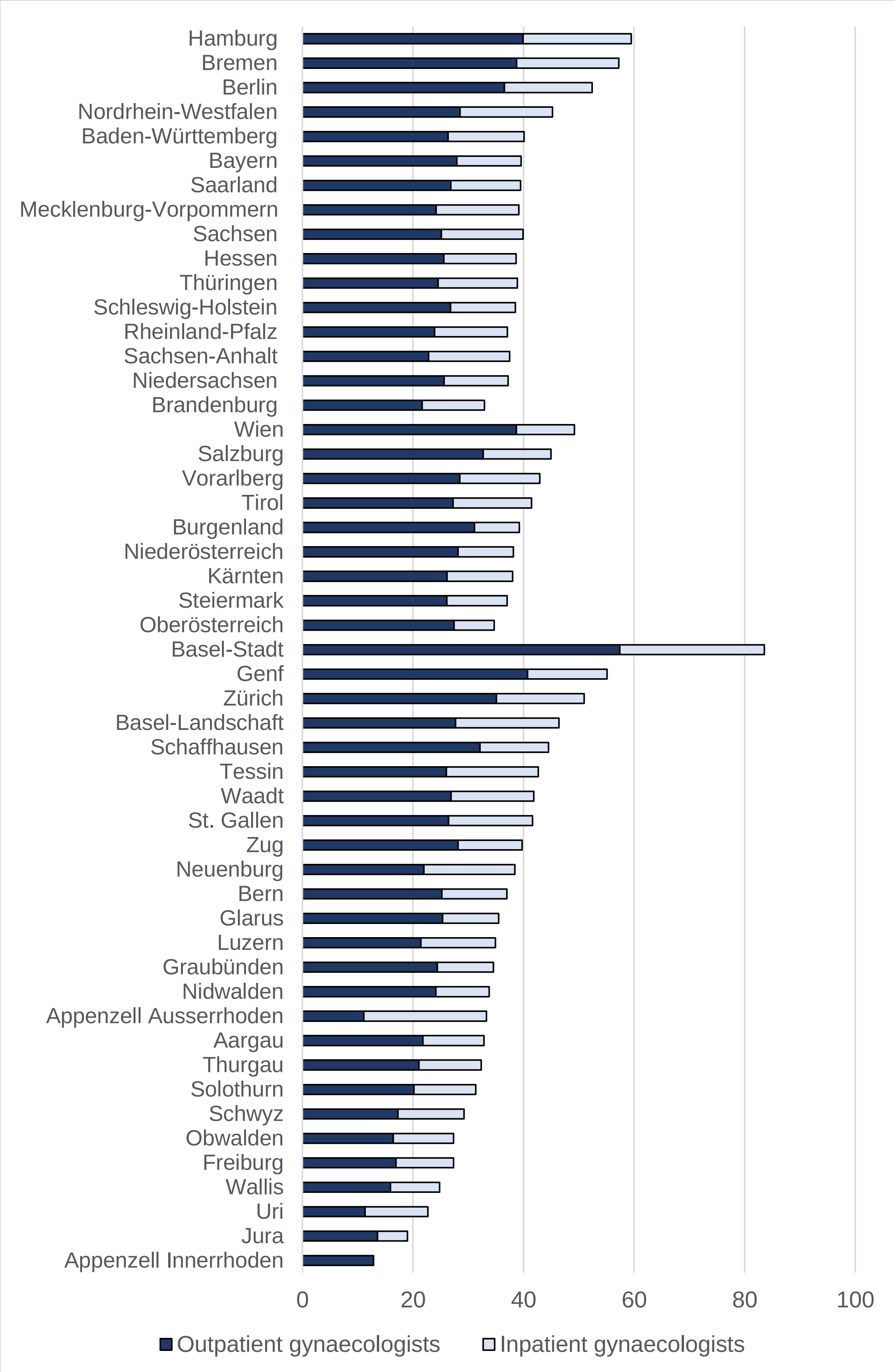


*Figure 9: Inpatient and outpatient gynaecologists per 100,000 women (state-/canton-level)*

### 5.1.4 Benign and malignant disease rates

The country rates of benign and malignant diseases of the female genital organs extracted from main hospital discharge diagnoses are shown in Figure 10. Austria has the highest rates in both benign and malignant diseases. The difference in malignant diseases is particularly striking, with Austria having a disease rate 4.6 times as high as Switzerland and three times higher than Germany.

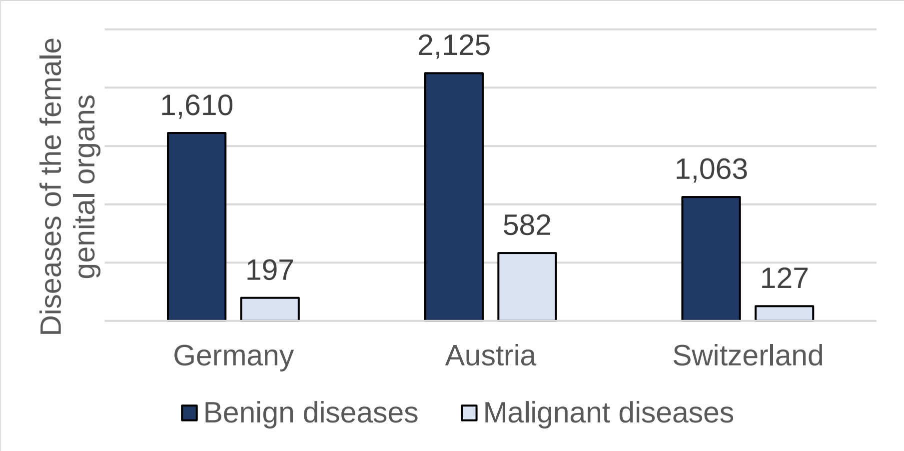


*Figure 10: Diagnoses of benign and malignant diseases of the female genital organs per 100,000 women (country-level)*

When looking at the regional differences in Figure 11, the special position of Austria becomes even more evident. While the rate of malignant diseases was rather consistent among regions in Germany and Switzerland, in Austria the rates were not only higher, but also much more dispersed, ranging from 292 malignant diseases per 100,000 women in Niederösterreich to 906 in Salzburg.

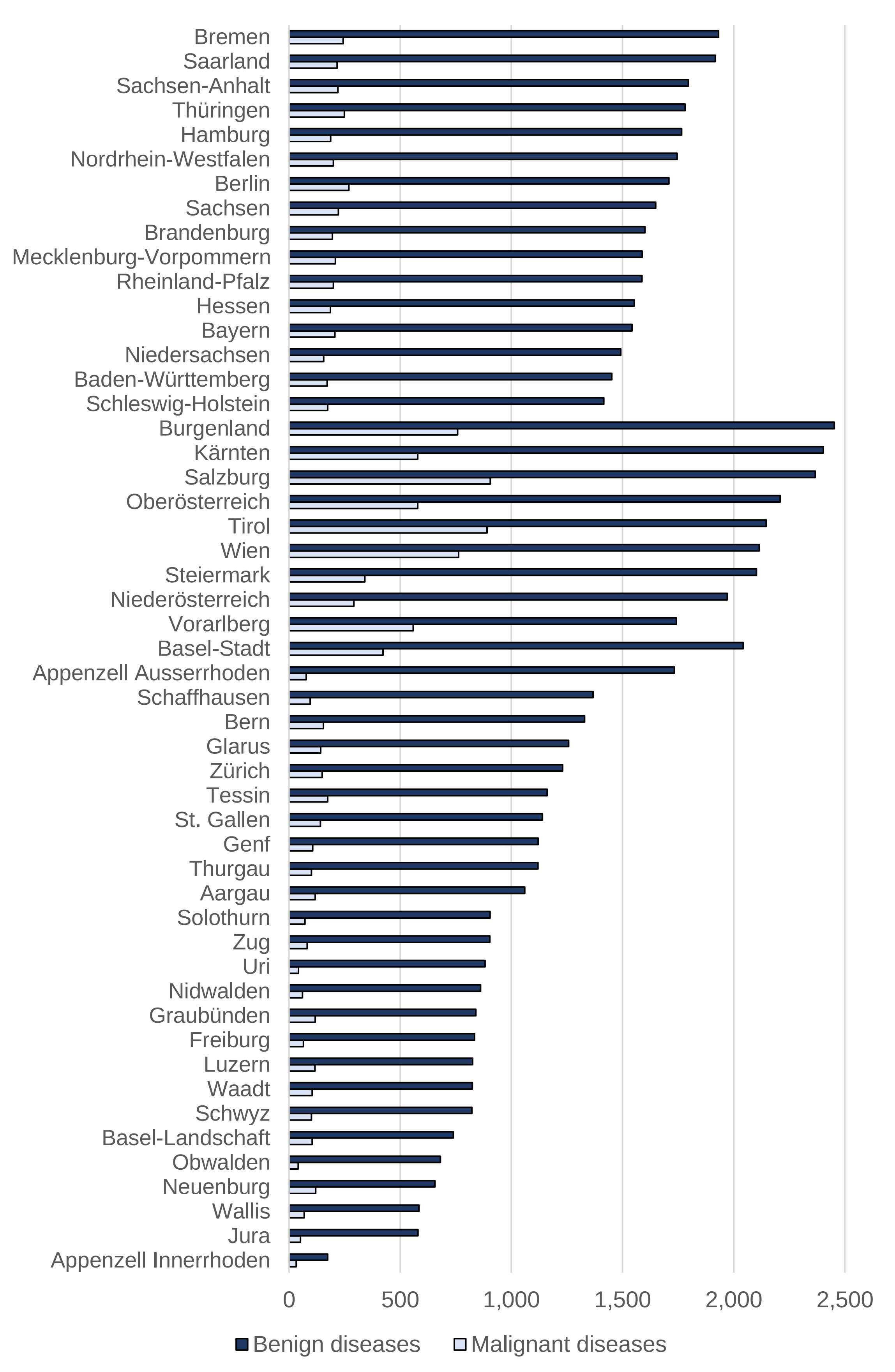


*Figure 11: Diagnoses of benign and malignant diseases of the female genital organs per 100,000 women (state-/canton-level)*

## 5.2 One-way ANOVA: Cross-country differences

The question to be answered by the ANOVA was: Are there significant differences between the hysterectomy rates of Germany, Austria and Switzerland? And if yes, between which countries exactly?

Before conducting the ANOVA, the following assumptions were tested:

| Assumption | Result |
|---|---|
| Independence of measurements | Yes, no repeated measurements with the same subjects |
| Dependent variable at least on interval scale | Yes, hysterectomies per 100,000 women is on ratio scale |
| Independent variable on nominal scale and independent groups | Yes, country is categorical and the groups (Germany, Austria, Switzerland) are independent of each other |
| Normality of dependent variable within the groups | Based on the Shapiro-Wilk-Test ($\alpha = .05$), the hysterectomy rate was normally distributed in Austria and Switzerland, but not in Germany. |
| Homogeneity of variances in each group (homoscedasticity) | This assumption was tested during the analysis as part of the SPSS output (Levene's Test) |

*Table 5: Assumptions of the One-way ANOVA*

Even though the normality assumption was violated, the ANOVA was still conducted. One-way ANOVA has shown to be quite robust against this type of violation.[71] The violation of the last assumption is

[71] Lix, Keselman, & Keselman 1996.

The hysterectomy rate was highest in Germany (*M* = 319.75, *SD* = 60.26), followed by Switzerland (*M* = 252.35, *SD* = 100.34) and lowest in Austria (*M* = 198.24, *SD* = 39.33).

Levene's Test was used to assess homogeneity of variances. It was significant ($p = .045$), hence equal variances could not be assumed. This means one could not interpret the regular ANOVA table but had to use the more robust Welch ANOVA. The hysterectomy rates varied significantly between the three countries, Welch's $F(2, 29.18) = 18.10$, $p < .001$.

This result indicates that at least two of the countries have statistically significant different hysterectomy rates. To find out which countries these are, post-hoc analyses were conducted. Considering the violation of the homoscedasticity assumption, the Games-Howell Test was interpreted instead of Tukey.

Games-Howell Post-hoc Test showed that the German hysterectomy rate was significantly higher than the Austrian rate (121.52, 95%-CI [71.40, 171.63], $p < .001$). Additionally, the German rate was significantly higher than the Swiss rate (67.40, 95%-CI [7.08, 127.72], $p = .026$). No significant difference in hysterectomy rates was found between Austria and Switzerland (-54.11, 95%-CI [-112.20, 3.97], $p = .072$).

## 5.3 Linear Regression: Determinants of the hysterectomy rate

By running regression models, the aim was to find out which factors determine the hysterectomy rate, with special focus on healthcare supply and resources. First, the results of the full model (N=51) are presented. Afterwards the individual models of each country are shown.

The following assumptions were tested to justify the regression method:

| Assumption | Result |
| --- | --- |
| Metric dependent variable and categorical dichotomous independent variables | Yes, all variables are metric except country, which was dummy-coded |
| Variance of predictors is not zero | Yes, as shown in Table 4, no variable has a variance of zero. |
| No perfect multicollinearity between the predictors | This assumption was tested during the analysis as part of the SPSS output (Tolerance, Variance Inflation Factor) |
| Equal variance at each level of the predictors (homoscedasticity) | This assumption was tested during the analysis as part of the SPSS output (scatterplot standardised residuals against standardised predicted values). |
| Normally distributed residuals | Based on the Shapiro-Wilk-Test ($\alpha = .05$), the residuals were normally distributed |
| No influential outliers | This assumption was tested during the analysis as part of the SPSS output (Casewise diagnostics, Cook's distance, Central Leverage Value) |
| Independent residuals (no autocorrelation) | This assumption was tested during the analysis as part of the SPSS output (Durbin-Watson Statistic) |

*Table 6: Assumptions for Linear Regression*

Since none of the assumptions tested beforehand was violated, we could proceed with the analysis.

### 5.3.1 Cross-country model

The One-way ANOVA revealed a significant difference between the hysterectomy rates of Germany and Austria, as well as Germany and Switzerland. To take these differences into account, dummy variables were created for both Austria and Switzerland setting Germany as the reference country.

Variance Inflation Factor values are < 10 for all included variables and all Tolerance values are > 0.1, therefore we could confirm the assumption of multicollinearity. The Durbin-Watson-Statistic is close to 2 (Durbin-Watson = 1.87), which meant we could rule out autocorrelation. Residuals were not arranged in a distinctive pattern, homoscedasticity was hence given. Lastly, casewise diagnostics pointed out one case (Berlin), where the standardized residual was > 3. The average Leverage in our sample was 0.14 (6 predictors + 1 divided by the sample size 51) and there was one case (Basel-Stadt) where the Central Leverage Value was higher than three times the average Leverage, which indicates a potential outlier. However, the maximum Cook's distance in our sample was 0.23, which is well below 1 and suggests that there is no case with an overly strong influence on the model.

Since all assumptions were met, we proceeded with the model.

Adjusted $R^2$ was .65 ($R^2 = 0.69$), which means that about 65 % of the variance in the hysterectomy rate can be explained by the model. The model is a significant improvement to the basic model ($F = 16.57$, $p < .01$).

As we can see from Table 7, the country factor has a significant influence on the hysterectomy rate. This result was already anticipated by the previously done One-way ANOVA. Its inclusion in the model allowed for better representation of other influence factors. The negative sign indicates that Austria is associated with a smaller rate of hysterectomies than Germany, whereas Switzerland is associated with a higher rate. Of the remaining independent variables, only benign disease rates significantly influenced the hysterectomy rate. In fact, benign diseases are the factor with the highest influence (Beta = 1.27). The hysterectomy rate increases by 0.21 per 100,000 women with every unit increase of benign diseases per 100,000 women.

Consequently, we can fill in the regression equation:

Hysterectomy rate = - 36.50 – 178.42*Austria + 66.86*Switzerland + 0.21*Benign disease rate – 0.11*Malignant disease rate – 0.003*Hospital bed density + 0.83*Gynaecologist density

| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. | 95.0% Confidence Interval for B Lower Bound | 95.0% Confidence Interval for B Upper Bound |
|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | -36.501 | 45.537 | | -.802 | .427 | -128.276 | 55.273 |
| | Austria | -178.420 | 43.900 | -.758 | -4.064 | .000 | -266.896 | -89.944 |
| | Switzerland | 66.860 | 25.398 | .372 | 2.633 | .012 | 15.675 | 118.046 |
| | Benign disease rate | .209 | .041 | 1.266 | 5.089 | .000 | .126 | .291 |
| | Malignant disease rate | -.110 | .086 | -.265 | -1.279 | .208 | -.284 | .064 |
| | Hospital bed density | -.003 | .036 | -.012 | -.078 | .938 | -.075 | .069 |
| | Gynaecologist density | .833 | .951 | .104 | .876 | .386 | -1.084 | 2.750 |
| a. Dependent Variable: Hysterectomy rate | | | | | | | | |

*Table 7: Coefficients for cross-country regression*
*(Adapted from SPSS output)*

The cross-country model presupposes that associations between hysterectomy rate and the independent variables are constant across countries. The slope coefficients are the same for every country. Since the countries vary on a multitude of factors (e.g. the organisation of healthcare), we have reason to believe that the slope coefficients vary between countries. To address this issue, we ran separate regression models for each country. Since the results are limited in validity due to smaller sample sizes anyway, we neglected discussing all assumptions again, and just focused on the regression coefficients.

### 5.3.2 German regression model

The German model included 16 states as subjects and reached significance ($F = 15.67$, $p < .01$). About 80 % of the variance in hysterectomy rate could be explained (Adj. $R^2 = 0.80$, $R^2 = 0.85$).

| Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. | 95.0% Confidence Interval for B Lower Bound | 95.0% Confidence Interval for B Upper Bound |
|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | 122.497 | 75.128 | | 1.631 | .131 | -42.859 | 287.853 |
| | Benign disease rate | .229 | .092 | .593 | 2.502 | .029 | .028 | .431 |
| | Malignant disease rate | 1.480 | .317 | .734 | 4.666 | .001 | .782 | 2.178 |
| | Hospital bed density | -.441 | .086 | -1.021 | -5.104 | .000 | -.631 | -.251 |
| | Gynaecologist density | 1.376 | .940 | .197 | 1.464 | .171 | -.693 | 3.445 |

*Table 8: Coefficients for the German Regression*
*(Adapted from SPSS output)*

Table 8 shows that the rate of benign diseases is still a significant positive predictor for the hysterectomy rate. Moreover, malignant diseases and hospital bed density are shown to be significant predictors. Malignant diseases are an even stronger predictor than benign diseases. According to the model, for every malignant disease per 100,000 women the hysterectomy rate grows at 1.48 per 100,000 women. Interestingly, more hospital beds seem to be associated with less hysterectomies.

### 5.3.3 Austrian regression model

In the Austrian model, the sample size was even smaller with 9 states. The model was not significant in predicting the hysterectomy rate, for that reason the further results of the regression cannot be interpreted ($F = 2.18$, $p = .23$). The coefficients are shown in Table 9.

| Model | | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. | 95.0% Confidence Interval for B Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | 295.261 | 214.327 | | 1.378 | .240 | -299.806 | 890.327 |
| | Benign disease rate | -.019 | .078 | -.107 | -.240 | .822 | -.234 | .197 |
| | Malignant disease rate | .066 | .084 | .367 | .782 | .478 | -.168 | .299 |
| | Hospital bed density | .119 | .059 | .687 | 2.026 | .113 | -.044 | .281 |
| | Gynaecologist density | -6.465 | 3.611 | -.770 | -1.790 | .148 | -16.491 | 3.562 |

*Table 9: Coefficients for the Austrian regression (Adapted from SPSS output)*

### 5.3.4 Swiss regression model

The number of subjects in the Swiss analysis was 26 cantons. The model is a good fit for the prediction of the hysterectomy rate ($F = 17.25$, $p < .01$). It explained about 72 % of the variance (Adj. $R^2 = 0.72$, $R^2 = 0.77$).

| Model | | Unstandardized Coefficients B | Std. Error | Standardized Coefficients Beta | t | Sig. | 95.0% Confidence Interval for B Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|---|---|
| 1 | (Constant) | 4.475 | 39.234 | | .114 | .910 | -77.116 | 86.066 |
| | Benign disease rate | .245 | .048 | .924 | 5.100 | .000 | .145 | .345 |
| | Malignant disease rate | -.382 | .306 | -.281 | -1.246 | .226 | -1.019 | .255 |
| | Hospital bed density | .021 | .042 | .083 | .494 | .627 | -.067 | .109 |
| | Gynaecologist density | .818 | 1.617 | .110 | .505 | .618 | -2.546 | 4.181 |

*Table 10: Coefficients for the Swiss regression (Adapted from SPSS output)*

In the Swiss model, the hysterectomy rate was only significantly predicted by the benign disease rate. As shown by Table 10, the association was positive, that is for every unit increase of benign diseases, the hysterectomy rate increases by 0.25.

# 6 Discussion

***Hysterectomy rate variation***

The main question of this thesis was if there were regional differences between hysterectomy rates and we compared Germany, Austria and Switzerland. We found that there are differences between the hysterectomy rates of Germany, Austria and Switzerland. The ANOVA showed that these differences are significant when Germany vs. Austria and Germany vs. Switzerland are compared. Germany had the highest number of hysterectomies per 100,000 and Austria had the lowest rate. This roughly resonates with results from other studies where individual countries were examined.[72,73] In comparison to international hysterectomy rates, Germany and Switzerland are positioned in the middle, strikingly higher rates are found in the U.S. with over 500 hysterectomies per 100,000 women.[74] Austria is in line with countries such as Denmark where the rate was found to be as low as 182 per 100,000 women.[75]

A look at Figure 5: Hysterectomies per 100,000 women(state-/canton-level), where the hysterectomy rates were broken down to regions within the countries, showed that these rate numbers are far from consistent. In Berlin or Basel-Stadt, the rates were almost high as in the U.S. However, we did not statistically validate the significance of these small-area variations, nor do we have proof of what caused the variation.

An important data factor that needs to be taken into account is that diagnosis and procedure data are based on the location of the hospital and not the residence of patients. As mentioned earlier, the total lack of hysterectomies in Appenzell Innerrhoden is probably not due to perfectly healthy women. The canton is so small in size and population, it is rather comparable to a small town. Understandably, not every town has a fully equipped hospital and all services that are needed for standard healthcare. Consequently, people go to other towns or cities where the service they need can be provided. This explanation is also likely

[72] Stang et al. 2011.
[73] Edler et al. 2017.
[74] Whiteman et al. 2008.
[75] Gimbel, Settnes, & Tabor 2001.

to be true for the lower number of benign and malignant diseases. Not just the procedures, but also the diagnoses were made in other cantons.

Even when there are healthcare facilities in the same canton of a patient, it is still possible that women went to other cantons for diagnosis and procedures. In all DACH countries there is the principle of free choice of hospital. The biggest hospitals and the most supply is usually in the big cities and at teaching hospitals, which could explain the high rate in Berlin. To give an example of the so-called patient migration: In 2015, there were 865,372 total diagnoses in hospitals in Berlin. Of these, 729,771 were linked to patients living in the state Berlin.[76]This amounts to 16 % of diagnoses that were of patients from other German states or to a small extent from other countries. This means that at least a small part of the variation is likely due to patient migration.

The much larger part of the variation is caused by other factors that were not included or examined in this thesis, hence we cannot quantify the actual impact. As mentioned in chapter 3.2, reasons for variation in hysterectomy rates can be patients' needs and preferences, socioeconomic characteristics, attitudes and gender of the treating gynaecologist, co-payment schemes and others.

Another factor that is probably minor in accounting for variations, yet worth mentioning, is the inpatient data source. We know that outpatient hysterectomies exist, but we don't know the share compared to inpatient procedures and more importantly, in respect to variation, we don't know if the share of outpatient hysterectomies is different among regions.

***Interpretation of the regression models***

The full model where all countries were included was a good fit for predicting the hysterectomy rate. Of the control variables both country dummies, significantly predicted the hysterectomy rate.

Furthermore, benign diseases significantly influenced the number of hysterectomies per 100,000 women. A very thought-provoking result is that malignant diseases were not a significant predictor of the hysterectomy rate. It is exactly this variable where we would assume a direct association, because a

[76] Statistisches Bundesamt 2017b.

hysterectomy is usually medically indicated when a woman is diagnosed with a malignant disease of the genital organs. In the model though, when accounting for all the other variables, this expected influence was reduced to the point of insignificance. Due to the aggregated nature of the data, we cannot say how many hysterectomies were attributed to malignant or benign diseases, respectively. But this result still demonstrates that benign diseases play a crucial role in the decision for hysterectomy as therapy. This is also consistent with other studies that did have patient data and linked hysterectomies to underlying diagnoses.[77]

The sample size of 51 subjects is very small for the number of independent variables. In fact, the recommended sample size would be 50 + 8 * the number of predictors. It is still just about enough if we expect a large effect.[78]

In the full model, slopes for the regression coefficients are presupposed to be equal for each country. Therefore, a separate regression model was run for each country.

The influence of benign diseases on the hysterectomy rate in the German and Swiss model was significant and consistent with the full model. The Austrian model was not significant, so we could not interpret the results. Germany was the only country where the model showed a significant influence of malignant diseases, which, as mentioned above, was actually expected in all models. Besides, the German model was the only one where a factor representing healthcare supply, namely hospital bed density, was a significant predictor of the hysterectomy rate. However, the direction of the association was opposite to what is meant by supplier-induced demand, i.e. a higher gynaecologist density was associated with a lower rate of hysterectomies. This could be explained by better and better access to preventive care, which leads to earlier detection of diseases and as a result to lower need for hysterectomies.

Even though the individual models were significant in the case of Germany and Switzerland, the sample sizes are too small (Germany = 16, Austria N = 9, Switzerland N = 26) for sound interpretation of the results.

[77] Stang et al. 2011.
[78] Field 2013, p. 223.

The factors that are possible causes for variation are accordingly predictors of the hysterectomy rate. In the regression models in this thesis, it was not possible to adjust for these known individual factors, because of the nature of the databases. Although it is not certain to what extent they influence the hysterectomy rate, it is possible that these factors vary systematically which makes it an important limitation when interpreting the results.

***General limitations***

The hospital data used was hospital stay-related and should not be seen as epidemiologically valid. This means that there can be several diagnoses per patient, because every time the patient is released from an inpatient stay, there is one main discharge diagnosis. Often, patients have many hospitalisations per year, especially in more severe cases. For example, five cervical cancer diagnoses do not necessarily mean that there were five patients with that diagnose. It could have been the same patient, who has had five hospitalisations in 2015 due to the cervical cancer. Although the same principle applies for procedures, in case of hysterectomies each procedure definitely represents a distinct patient, as it is in the nature of removing an organ that such a procedure can only be performed once. This leads to a probable overestimation of diagnoses and therefore the burden of disease in our dataset.

This overestimation might not be so bad if the extent were the same in all regions. Austria, however has a special position regarding number of hospital stays and thereby discharge diagnoses. In international comparison, the number of inpatient stays is high and continuously increasing. One reason for this is the allocation of day hospital stays (zero- and one-day care) and even some outpatient treatments to the inpatient area for billing purposes. This also applies to day care follow-up treatments, like chemotherapy, so each time a patient comes in it is counted as a new diagnose and procedure. And even a single stay is sometimes divided if required by billing regulations. To make this even more complex, different Austrian states have different regulations.[79] Yet, overall Austria has a higher number of benign and malignant disease diagnoses (but not necessarily higher burden of disease) than Germany and Switzerland, which is clearly visible in Figure 11. This

[79] Bundesministerium für Arbeit, Soziales, Gesundheit und Konsumentenschutz 2018b.

overestimation might have also biased the results of the cross-country regression model.

Apart from that, there might also be other, unknown differences in hospital coding practices which limit the comparability of the data used.

Like with all secondary data, collection errors, here coding errors, are possible. If the dataset included falsely coded diagnoses or procedures, they could not be identified. Since hospitals are regularly audited, those errors, if existent, should be irrelevant.

A general limitation of routine data is that it is gathered for billing purposes. This leads to various problems when trying to use the data for anything other than the actual purpose. For this thesis, we did not have insurance data where diagnoses and procedures are linked to a single patient. The data was aggregated, which made contextualising impossible.

An age-adjustment, like it is standard in other similar studies, could only have been done if the dataset were on individual patient level and included patient characteristics like age at procedure.

The definition of “hospital”, or rather which hospital types are included in the routine data varies by country. For example, the hospital quality reports in Germany are not mandatory for every institution. Many day clinics as well as all practice clinics do not have to submit these reports. In Austria, as mentioned above, there are different regulations and billing standards from state to state.

Again, it should not be forgotten that only inpatient data were used in this thesis. A minor but increasing share of hysterectomies are performed in outpatient settings and of course many diagnoses are made by licenced gynaecologists. The reason why outpatient data are not included is simple: None of the DACH countries have a data monitoring system in the outpatient sector in place.

***Implications and ideas for further research***

For women’s health, it would be beneficial to reduce the overuse of hysterectomy to treat benign diseases. Hysterectomy has been associated with a number of adverse side effects, including higher risk of cardiovascular disease[80], problems with sexual functioning[81], urinary incontinence[82] and earlier onset of menopause[83].

From an economic perspective, a shift from inpatient to outpatient procedures would be desirable. This would also include hysterectomy types and routes that are able to be done in an outpatient setting, but especially alternative methods. Outpatient procedures offer several advantages, e.g. prevention of costly hospitalisations and subsequent sick leave of patients, which varies between a few days and several weeks. In a recent U.S. study, costs of inpatient hysterectomy were compared to costs of outpatient hysterectomy and endometrial ablation. Costs were defined as total healthcare costs in the first year after invention (including the procedure, complications and any necessary reinterventions).[84]

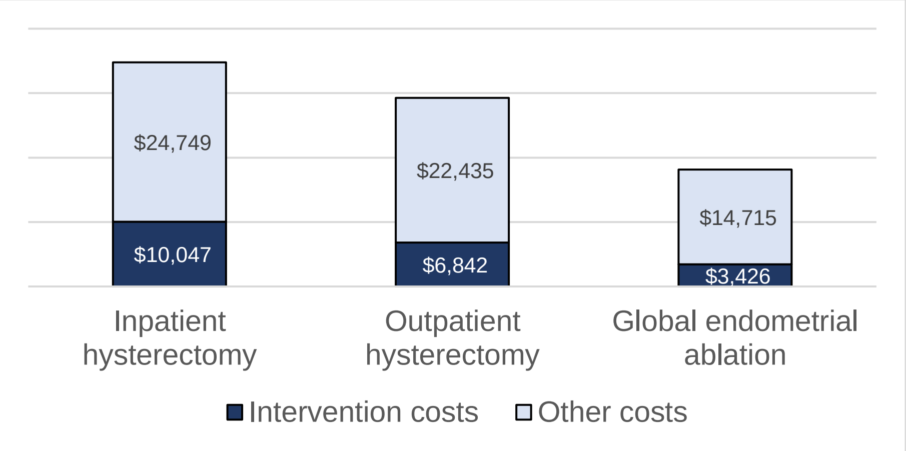


*Table 11: Costs comparison of inpatient and outpatient hysterectomies and endometrial ablation (Adapted from Miller et al. 2018)*

As seen in Table 11, inpatient hysterectomies are the most expensive of the three. They cost almost twice as much as endometrial ablations. There is no such study about costs in the DACH countries, which is why their applicability is limited.

Possible ways to tackle the overuse of benign hysterectomies include setting the right incentives for healthcare providers by the health insurance. In Germany, statutory health insurers reimburse more than 3,000 Euros as flat-rate payment for

80 Ingelsson, Lundholm, Johansson, & Altman 2011.
81 Rodríguez, Chedraui, Schwager, Hidalgo, & Pérez-López 2012.
82 Brown, Sawaya, Thom, & Grady 2000.
83 Farquhar, Sadler, Harvey, & Stewart 2005.
84 Miller et al. 2018.

a hysterectomy without posing further questions. However, modern uterus-preserving alternatives are not reimbursed at all in the outpatient sector and in the inpatient sector only up to 1,500 Euros are reimbursed.[85] This current practice is not supporting the shift from hysterectomies to minimally-invasive uterus-preserving alternatives. Needless to say, a co-payment for a treatment of a painful condition is rarely paid when there is another treatment available that is free of co-payment. Women who are insured with a private insurer can usually get another treatment method if indicated.

Measures also include raising physicians' awareness about minimally-invasive and even uterus-preserving alternatives that are less risky and more cost-effective at the same time.[86]

Other countries such as India and Denmark have started health policy initiatives to reduce the overuse of hysterectomies and to gather more detailed data to get a better understanding of why overuse exists. In 2011, Danish authorities have created a database called *Danish Quality Database for Hysterectomy and Hysteroscopy* for collecting data on women who have benign hysterectomies and who have had a hysteroscopic examination of the uterus. The declared aims of the database are

- to reduce complications, readmissions, reoperations
- to specify the need for hospitalization after hysterectomy
- to secure quality assessment of hysterectomy and hysteroscopy by setting standards and national guidelines
- to intensify the monitoring of laparoscopic surgery and explore long-term side effects after hysterectomy.[87]

A similar database could be established in Germany in order to reach for the same aims as the Danish database.

To get a better understanding of variations in hysterectomy rates, why they exist and what influences them further research should be placed on a smaller regional level, i.e. with smaller units than states. This could be towns or postcode clusters.

[85] Initiative Rettet die Gebärmutter 2018.
[86] Jakovljevic et al. 2016.
[87] Topsoee, Ibfelt, & Settnes 2016.

By having more subjects, more statistical analyses are possible, e.g. urban-rural comparisons, and also results have a higher validity.

A way to do research on individual patient level is to use claims data. For individual researchers it is difficult to get access to such sensitive data, but if initiated by an insurer or an authority, it would not constitute a problem. With these data, patient characteristics like demographic or socioeconomic factors could be included in regression models. It would even allow to include information on previous diagnoses and procedures to better explain hysterectomy rates. Another benefit of claims data is the availability of outpatient records. This would enable studies where hysterectomies and alternatives like endometrial ablation could be compared by rate and even costs. Of course, data that is not recorded anywhere, like weight (obesity), occupation and personal preferences, cannot be adjusted for. The only way to include those factors is by doing primary research by means of surveys or interviews or the like. However, with this form of research it is a trade-off between more information and big populations or even nation-wide samples.

# 7 Conclusion

This thesis demonstrated that the number of hysterectomies per 100,000 women in Germany is significantly higher than the rates in Austria and Switzerland. Even within the countries, there was great variation between the rates. In international comparison, Germany and Switzerland rank midrange, whereas Austria has a relatively low hysterectomy rate.

There was no evidence found for supplier-induced demand for hysterectomy procedures, represented by gynaecologist density and hospital bed density, at least not with consistence and statistical validity. The hysterectomy rate was significantly predicted by the rate of benign diseases of the female genital organs (defined by hospital main discharge diagnoses). The more benign diseases per 100,000 women, the higher the hysterectomy rate. Malignant diseases of the female genital organs, on the other hand, were not found to be a significant predictor of the hysterectomy rate in the model, despite their obvious connection.

Following international models, Germany could implement programs and initiatives to tackle overuse of benign hysterectomies. Examples include setting up a national database for gathering patient characteristics of women getting benign hysterectomies to better understand patterns and determining factors and consequently derive measures to reduce the amount of benign hysterectomy needs in favour of modern, uterus-preserving alternatives.

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# Declaration of Independent Work

I hereby declare that I wrote this thesis without any assistance and used only the aids listed. Any material taken from other works, either as a quote or idea have been listed under “References”.

Stuttgart, 31 July 2018

# Appendix

## A1: List of benign indications associated with hysterectomy

| ICD-10 code | Description |
|---|---|
| D25 | Leiomyoma of the uterus |
| D26 | Benign neoplasms of the uterus |
| D27 | Benign neoplasm of ovary |
| D28 | Benign neoplasm of other and unspecified female genital organs |
| K57 | Diverticular disease of intestine (mainly of the large intestine, K57.2, K57.3) |
| K66 | Other disorders of peritoneum (mainly peritoneal adhesions, K66.0) |
| N39 | Other disorders of urinary system (mainly stress incontinence, female, N39.3, and incontinence of urine, N39.4) |
| N70 | Salpingitis and oophoritis |
| N71 | Inflammatory disease of uterus, except cervix |
| N72 | Inflammatory disease of cervix uteri |
| N73 | Other female pelvic inflammatory diseases |
| N80 | Endometriosis |
| N81 | Genital prolapse |
| N83 | Noninflammatory disorders of ovary, fallopian tube and broad ligament |

| | |
|---|---|
| N84 | Polyp of female genital tract |
| N85 | Other noninflammatory disorders of uterus (excluding precancerous N85.1, which constitutes group 2) |
| N87 | Dysplasia of cervix uteri |
| N92 | Excessive, frequent & irregular menstruation |
| N93 | Other abnormal uterine & vaginal bleeding |
| N94 | Pain & other conditions associated with female genital organs and menstrual cycle |
| N95 | Menopausal & other perimenopausal disorders |
| O72 | Postpartum haemorrhage |
| R87 | Abnormal findings in specimens from female genital organs (mainly abnormal Papanicolaou smear, R87.6) |
| T81 | Complications of procedures, not elsewhere classified (mainly haemorrhage and hematoma complicating a procedure, not elsewhere classified, T81.0) |

*Table 12: A1: List of benign indications associated with hysterectomies*
(adapted from Stang et al 2011)

# A2: Absolute numbers of hysterectomies, hospital beds, gynaecologists, benign and malignant diseases of the female genital tract

| Region | Hysterectomies | Hospital beds | Gynaecologists with med. activity | Benign diseases | Malignant diseases |
|---|---|---|---|---|---|
| Baden-Württemberg | 20,147 | 56,154 | 2,324 | 79,658 | 9,430 |
| Bayern | 18,711 | 76,000 | 2,682 | 100,155 | 13,383 |
| Berlin | 8,972 | 19,975 | 1,035 | 30,645 | 4,828 |
| Brandenburg | 3,057 | 15,305 | 426 | 20,121 | 2,456 |
| Bremen | 1,205 | 5,074 | 205 | 6,579 | 828 |
| Hamburg | 2,544 | 12,407 | 584 | 16,147 | 1,716 |
| Hessen | 8,744 | 36,130 | 1,266 | 48,569 | 5,820 |
| Mecklenburg-Vorpommern | 2,394 | 10,458 | 332 | 12,937 | 1,697 |
| Niedersachsen | 11,373 | 42,178 | 1,548 | 59,856 | 6,257 |
| Nordrhein-Westfalen | 27,314 | 119,900 | 4,262 | 158,854 | 18,195 |
| Rheinland-Pfalz | 6,254 | 25,282 | 813 | 32,610 | 4,108 |
| Saarland | 1,949 | 6,427 | 207 | 9,719 | 1,097 |
| Sachsen | 6,510 | 25,825 | 844 | 34,194 | 4,604 |
| Sachsen-Anhalt | 3,570 | 16,069 | 444 | 20,460 | 2,502 |
| Schleswig-Holstein | 4,126 | 16,150 | 581 | 20,661 | 2,531 |
| Thüringen | 3,600 | 16,017 | 441 | 19,520 | 2,725 |
| Burgenland | 226 | 1,719 | 61 | 3,624 | 1,121 |
| Kärnten | 766 | 4,799 | 110 | 6,891 | 1,661 |
| Niederösterreich | 1,546 | 11,536 | 337 | 16,525 | 2,448 |
| Oberösterreich | 1,776 | 9,895 | 256 | 16,180 | 4,243 |
| Salzburg | 548 | 4,980 | 127 | 6,582 | 2,519 |
| Steiermark | 1,251 | 10,153 | 237 | 13,114 | 2,131 |
| Tirol | 774 | 5,004 | 159 | 8,029 | 3,331 |
| Vorarlberg | 272 | 2,217 | 85 | 3,367 | 1,080 |
| Wien | 1,810 | 14,835 | 478 | 19,942 | 7,195 |
| Aargau | 974 | 3,042 | 107 | 3,456 | 384 |
| Appenzell Ausserrhoden | 111 | 490 | 9 | 469 | 21 |
| Appenzell Innerrhoden | 0 | 36 | 1 | 14 | 3 |
| Basel-Landschaft | 216 | 1,035 | 67 | 1,068 | 151 |
| Basel-Stadt | 474 | 2,072 | 83 | 2,029 | 420 |
| Bern | 1,892 | 4,927 | 192 | 6,904 | 803 |
| Freiburg | 454 | 824 | 42 | 1,284 | 100 |
| Genf | 739 | 2,360 | 138 | 2,805 | 266 |
| Glarus | 46 | 136 | 7 | 248 | 28 |
| Graubünden | 238 | 1,114 | 34 | 827 | 116 |

| | | | | | |
|---|---|---|---|---|---|
| Jura | 63 | 350 | 7 | 214 | 19 |
| Luzern | 544 | 1,510 | 70 | 1,656 | 235 |
| Neuenburg | 138 | 696 | 35 | 598 | 110 |
| Nidwalden | 35 | 77 | 7 | 179 | 13 |
| Obwalden | 29 | 82 | 5 | 125 | 8 |
| Schaffhausen | 172 | 286 | 18 | 553 | 39 |
| Schwyz | 168 | 305 | 22 | 619 | 76 |
| Solothurn | 317 | 709 | 42 | 1,212 | 96 |
| St. Gallen | 518 | 2,327 | 104 | 2,847 | 353 |
| Tessin | 372 | 1,904 | 78 | 2,097 | 315 |
| Thurgau | 422 | 1,536 | 43 | 1,489 | 135 |
| Uri | 44 | 72 | 4 | 156 | 8 |
| Waadt | 1,021 | 3,654 | 165 | 3,253 | 410 |
| Wallis | 292 | 1,395 | 42 | 989 | 115 |
| Zug | 192 | 521 | 24 | 546 | 50 |
| Zürich | 1,959 | 6,347 | 376 | 9,085 | 1,103 |