Evaluating Differences in C-Section rates among Swiss Hospitals

CAS ADS Module 2 Group Project

[redacted]

09.10.2023

Outline

- Relevance of the Topic
- Research Question
- Data Acquisition & Cleaning
- Descriptive Statistics
- Part 1: Analysis & Conclusion
- Part 2: Analysis & Conclusion
- Evaluation / Discussion

Relevance

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«When medically necessary, a caesarean section can effectively prevent maternal and newborn mortality. Two new studies show that when caesarean section rates rise towards 10% across a population, the number of maternal and newborn deaths decreases**. When the rate goes above 10%, there is no evidence that mortality rates improve**.»

Source : Betran AP, Torloni MR, Zhang JJ, Gülmezoglu AM; WHO Working Group on Caesarean Section. WHO Statement on Caesarean Section Rates. BJOG. 2016 Apr;123(5):667-70. doi: 10.1111/1471-0528.13526. Epub 2015 Jul 22. PMID: 26681211; PMCID: PMC5034743.

Relevance

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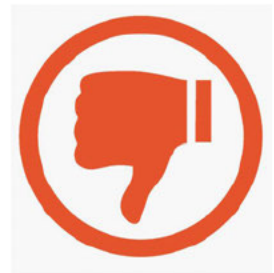
- No evidence that mortality improves
- Surgical procedure associated with risks and complications
- Inefficient use of limited healthcare resources



«Monitoring within country variation is also crucial and policy-makers should consider the use of monitoring (…) to evaluate trends on CS rates and maternal and infant outcomes in a more action-oriented and meaningful manner.»

Source:Betran AP, Ye J, Moller AB, Souza JP, Zhang J. Trends and projections of caesarean section rates: global and regional estimates. BMJ Glob Health. 2021 Jun;6(6):e005671. doi: 10.1136/bmjgh-2021-005671. PMID: 34130991; PMCID: PMC8208001.

Outline

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Research Question

Part 1:

Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

Part 2:

What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?

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Data Acquisition

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Table 1: Acquired Data

Required Data	Variables of the imported Datasets	Source	Year
C-Section Data	Hospital name	Key figures of Swiss hospitals, Federal Office of Public Health	2015 - 2021
	Hospital location (Canton)		
	Number of C-Sections per Hospital		
Hospital Deliveries	Hospital name	Key figures of Swiss hospitals, Federal Office of Public Health	2015 - 2021
	Hospital location (Canton)		
	Number of Kidney Transplantations per Hospital		
Inpatient Birth	Hospital name	Key figures of Swiss hospitals, Federal Office of Public Health	2015 - 2021
	Hospital location (Canton)		
	Number of inpatient deliveries per Hospital		
Hospital Infrastructure and Staff	Hospital name	Key figures of Swiss hospitals, Federal Office of Public Health	2015 - 2021
	Hospital location (Canton)		
	Number of Doctors		
	Number of Doctors in training		
	Number of Nurses		
	Number of other medical staff (operation technicians, physiotherapists etc.)		
	Number of Total Staff		
	Number of Operation Rooms		
	Number of Delivery Rooms		
	Private Division (y/n)		
	Number of Beds		

Data Acquisition

- All Hospitals with > 0 cases are listed
- Creation of a new variable for whether Hospitals are in latin-speaking cantons:
  - «R0» for latin speaking cantons `'GE','VD','NE','JU','FR','VS','TI'`
  - «AL» for all other cantons
- Creation of a new variable for University Hospitals
  - 1 for University Hospitals
    - Inselspital Bern, Universitätsspital Zürich, Universitätsspital Basel, CHUV Lausanne, HUG Geneva
  - 0 for Non-university Hospitals
- Creation of a new variable for Percentage C-Sections
  - Deliveries / Number of C-Sections

Data Cleaning

- Removing „Maison de Naissance“ and „Geburtshaus“ from the list of hospitals as these establishments do not carry out C-Sections
  - 96 Establishements with the string ‚Naissance‘ or ‚Geburtshaus‘ were removed from the dataframe
- Removing other institutions that do not carry out C-Sections
  - 12 Institutions were removed that do not carry out C-Sections
- Removing lines in the dataframe that do not contain the number of beds
  - 98 Lines were removed that did not contain any information on the number of beds or doctors in the hospital

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Descriptive Statistics

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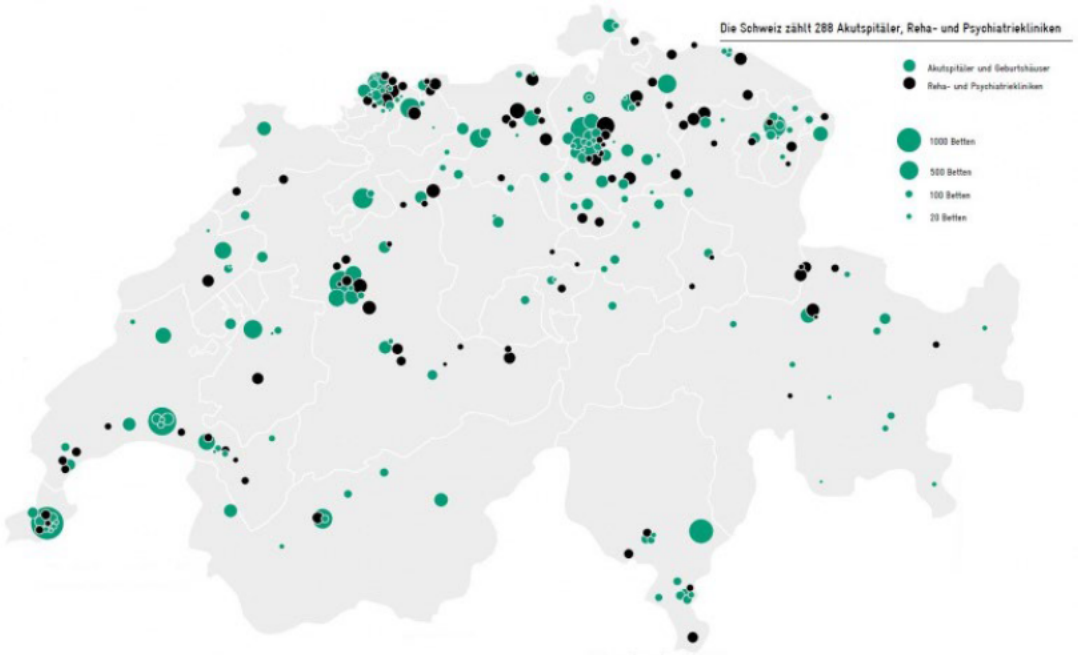
Table 2: Number of Hospitals grouped by region and year

Region \ Year	2015	2016	2017	2018	2019	2020	2021
German Speaking Cantons	43	52	52	53	57	58	59
Latin Speaking Cantons	14	18	17	17	19	18	19

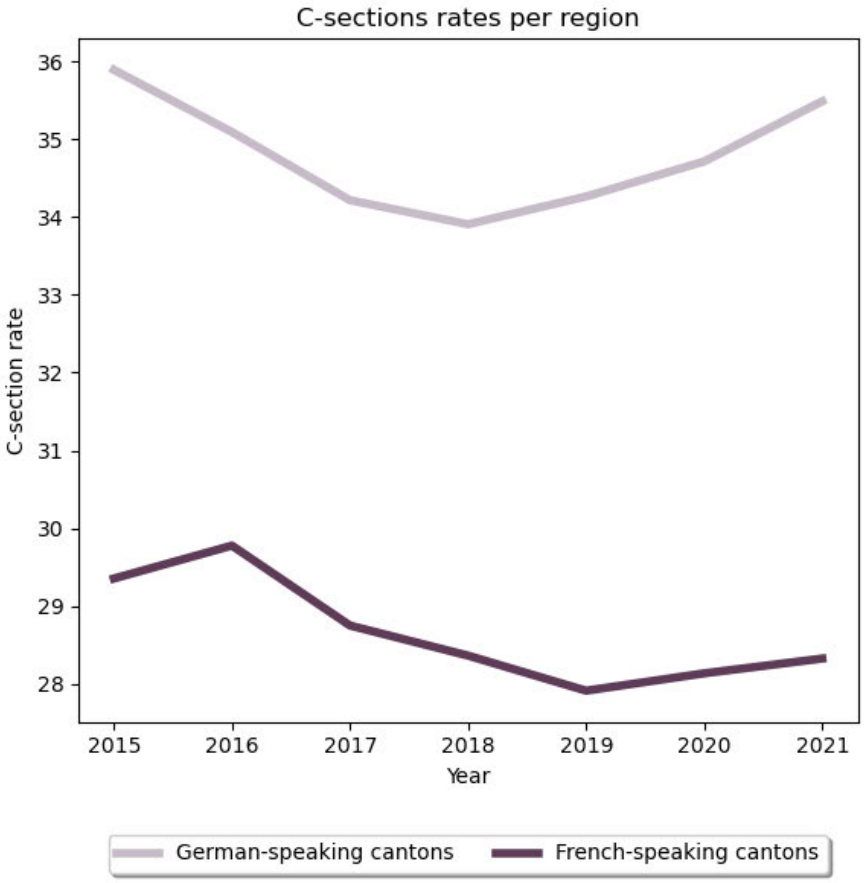
Table 3: Number of Hospitals grouped by hospital type and year

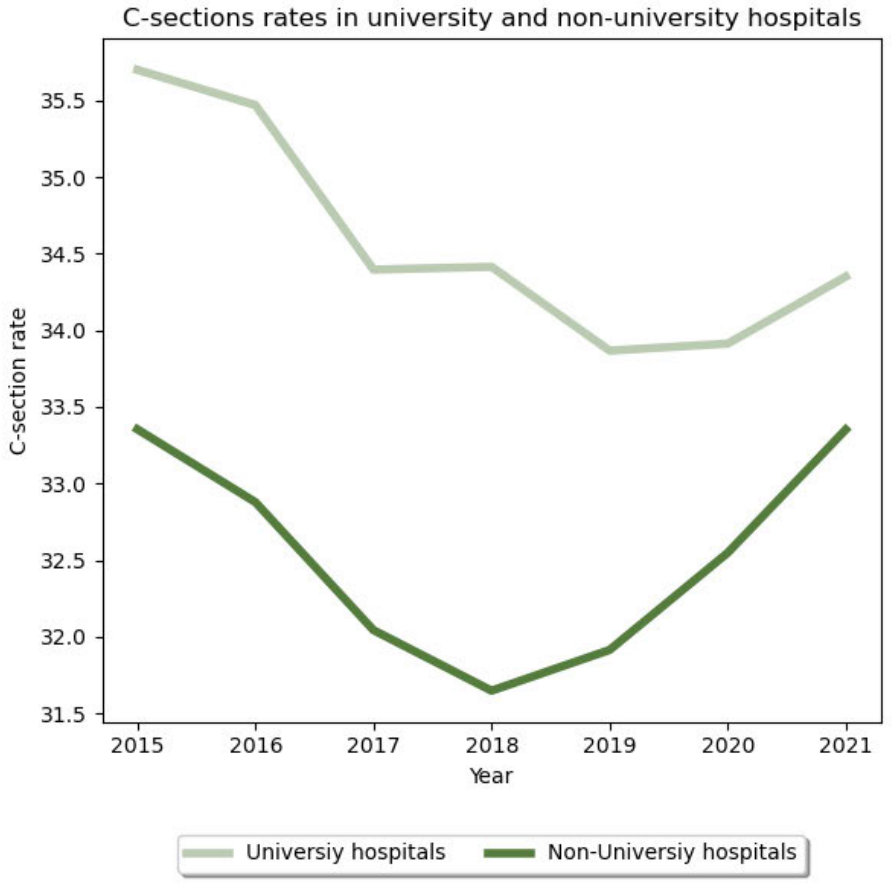
Hospital Type \ Year	2015	2016	2017	2018	2019	2020	2021
Non-university hospital	52	65	64	65	71	73	73
University Hospital	5	5	5	5	5	5	5



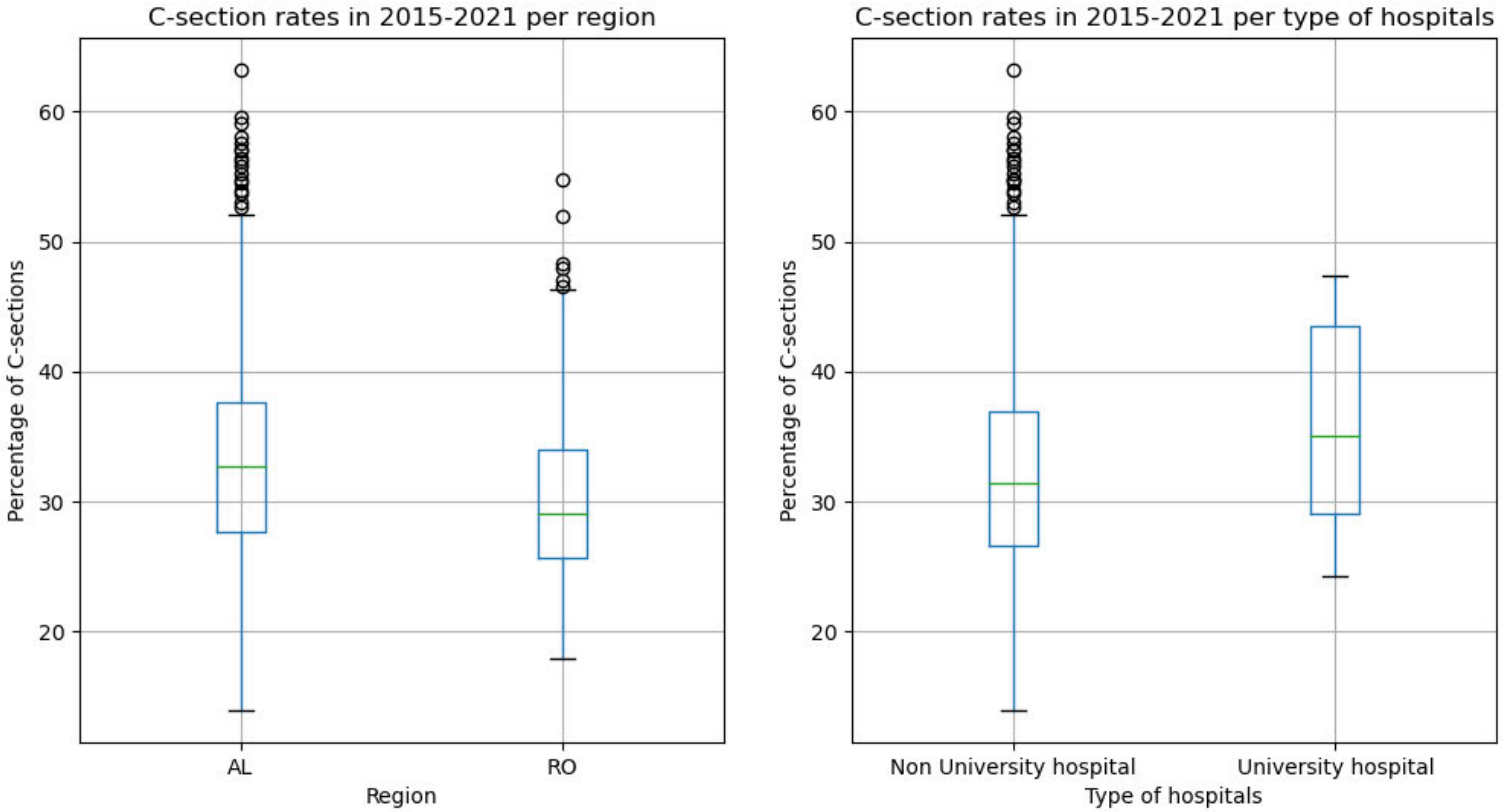
Sample Illustration of Swiss Hospitals by Avenir Suisse based on BAG Data from 2017

Descriptive Statistics





Descriptive Statistics



Descriptive Statistics

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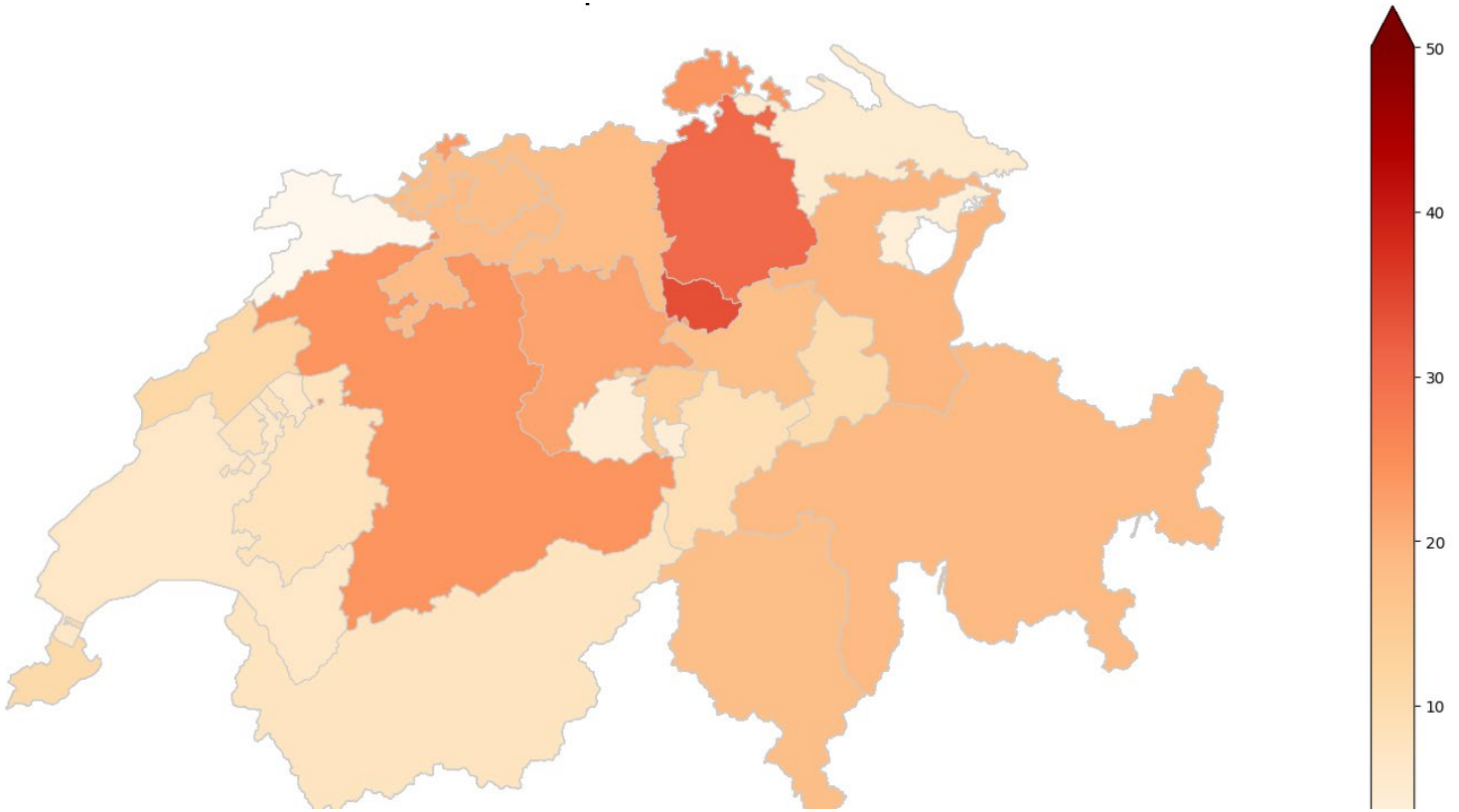
Map 1: Inpatient C-Section rates per canton in 2021



Canton	C-Section Rate
Zug	41.5
Zürich	39.1
Bern	36.2
Schaffhausen	36.0
Basel-Stadt	35.7
Lucerne	35.2
Valais	34.4
Sankt Gallen	34.0
Graubünden	33.6
Solothurn	33.5
Aargau	33.3
Basel-Landschaft	33.2
Schwyz	32.9
Nidwalden	31.3
Ticino	31.2
Neuchâtel	29.6
Genève	29.3
Glaurs	29.0
Uri	28.4
Fribourg	27.8
Vaud	27.1
Thurgau	26.3
Obwalden	25.6
Appenzell Ausserrhoden	25.5
Jura	23.6

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Part 1: Analysis - Distribution

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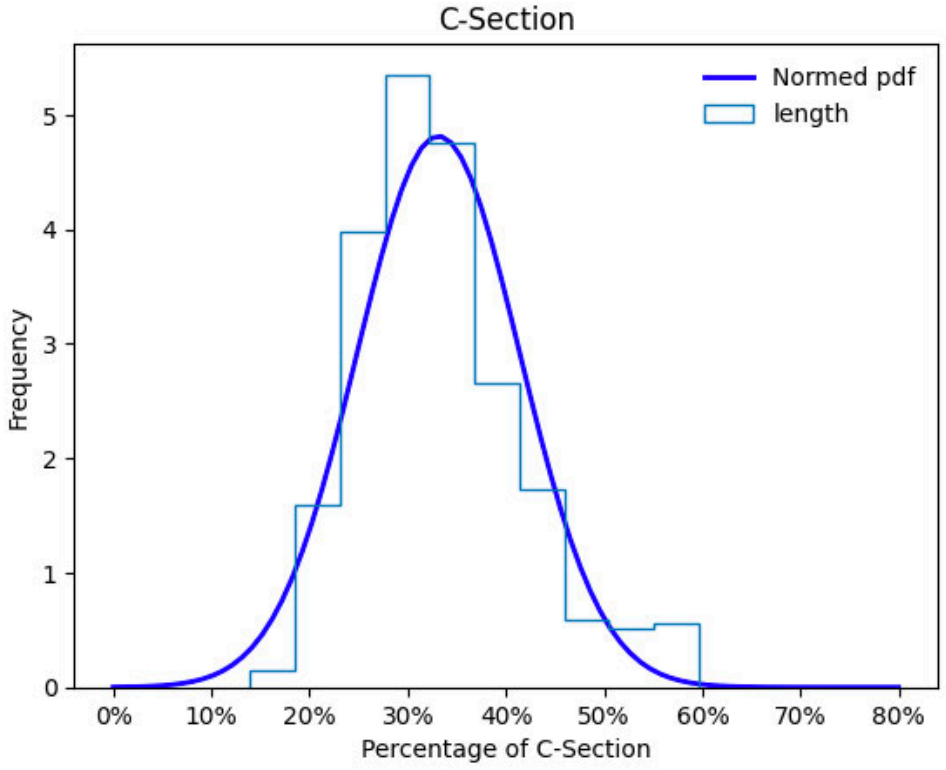
Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?



- Skew: 0.87 → Our distribution is skewed toward the left
- Kurtosis: 0.80 → Our distribution is more heavy-tailed compared to the normal distribution

Part 1: Analysis – Normality

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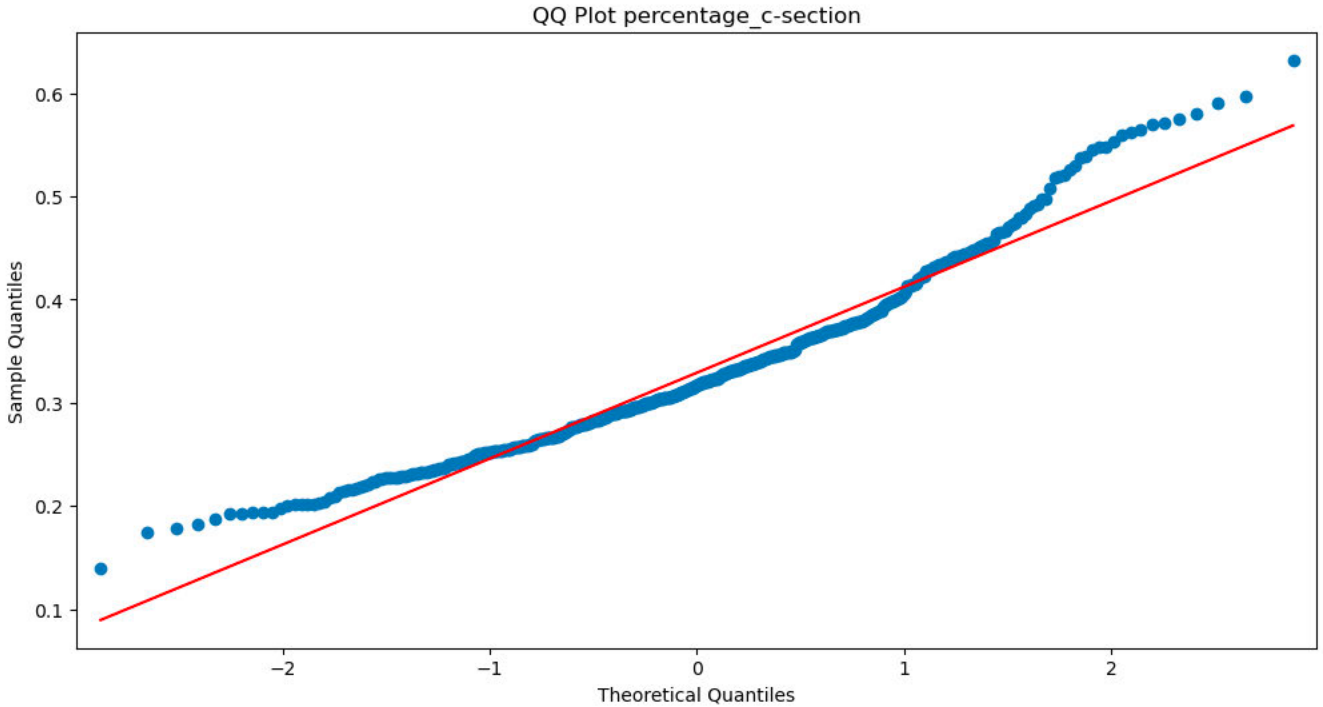
Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

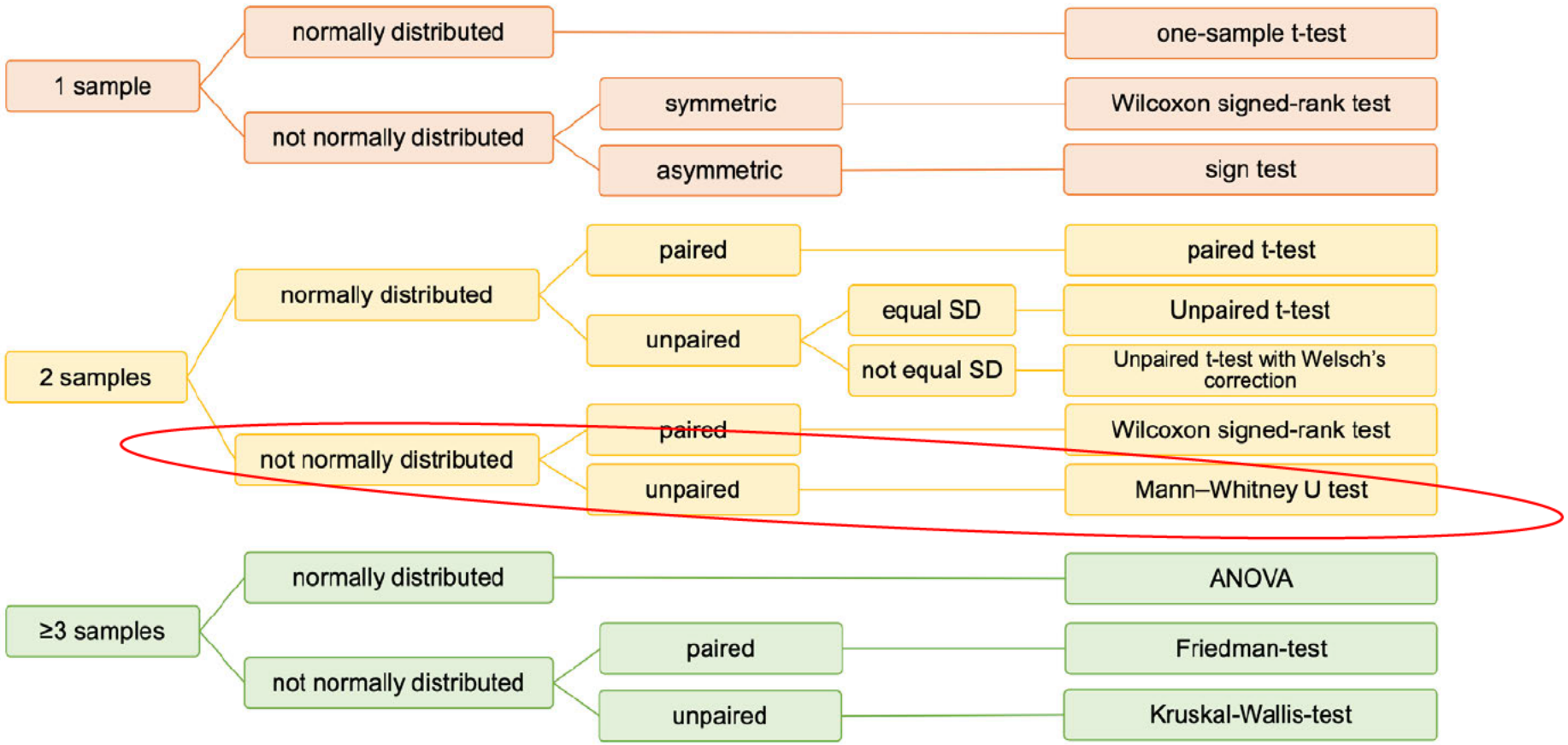


D'Agostino Pearson Test:

- H_0 = Data follows a normal distribution
- Alpha = 0.001
- P = 2.93×10^{-13}
- H_0 can be rejected

Our data is **not normally distributed**

Part 1: Analysis – Hypothesis testing



Part 1: Analysis – Hypothesis testing

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Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

Mann-Whitney U Test

- Chosen significance Level = 0.05

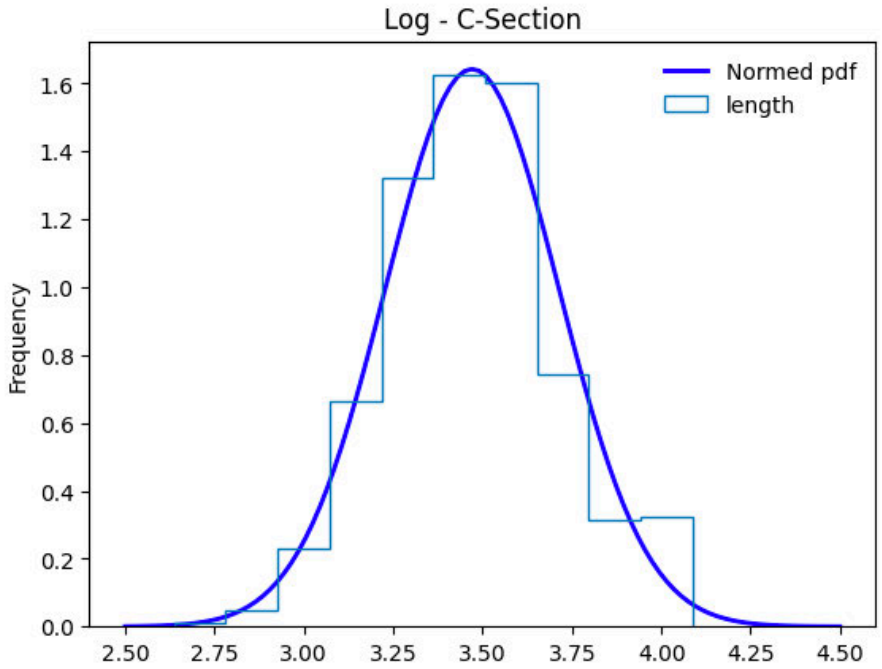
- Comparing the German to the Latin speaking cantons
- P-value = 0.00567
- We reject the null hypothesis and conclude that there is a statistically significant difference between the two groups.

- Comparing university hospitals to non-university hospitals
- P-value = 0.01161
- We reject the null hypothesis and conclude that there is a statistically significant difference between the two groups.

Part 1: Analysis – Normality

Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

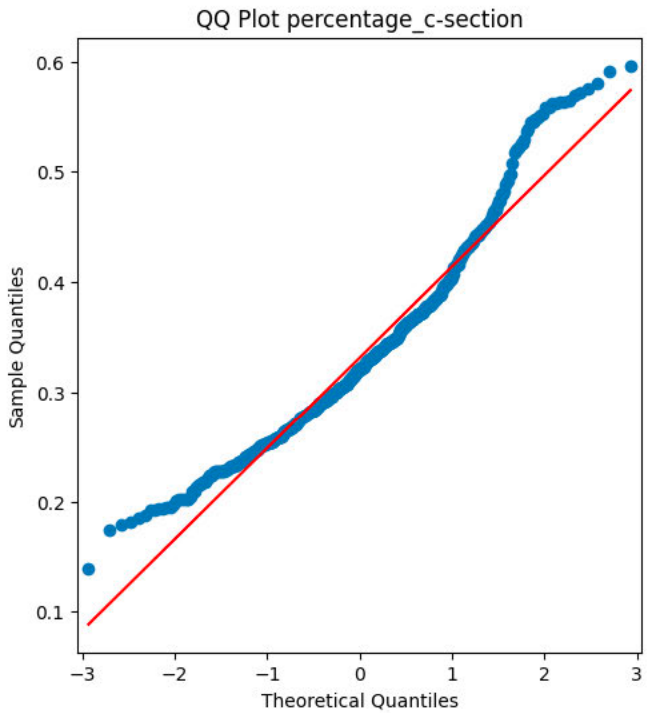
What if we take the log of the C-Section rate?

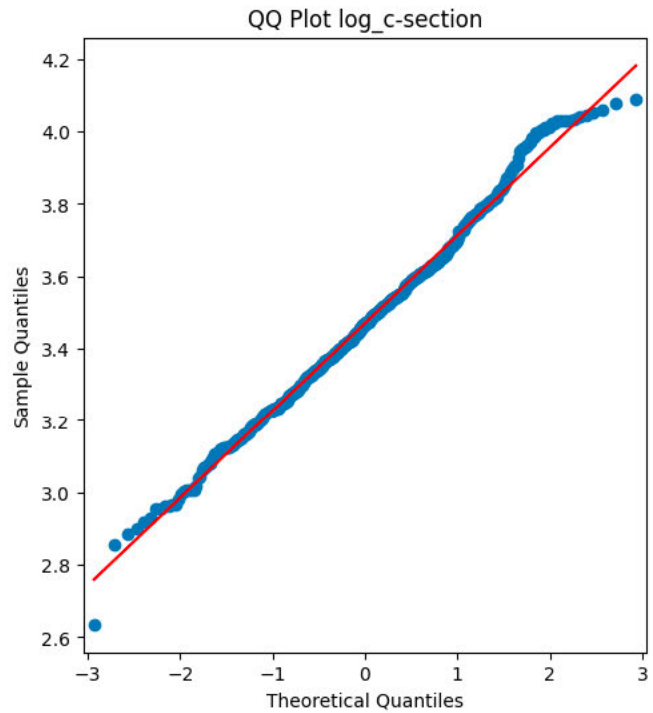


- Skew: 0.16 → Our distribution is skewed toward the left
- Kurtosis: 0.01 → Our distribution is slightly more heavy-tailed compared to the normal distribution

Part 1: Analysis – Normality

Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?





D'Agostino Pearson Test:

- H_0 = Data follows a normal distribution
- Alpha = 0.001
- P = 0.335
- H_0 can not be rejected

Using the log we created a normally distributed dataset

Part 1: Analysis - Variance

Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

Do we have equal or unequal standard deviations?

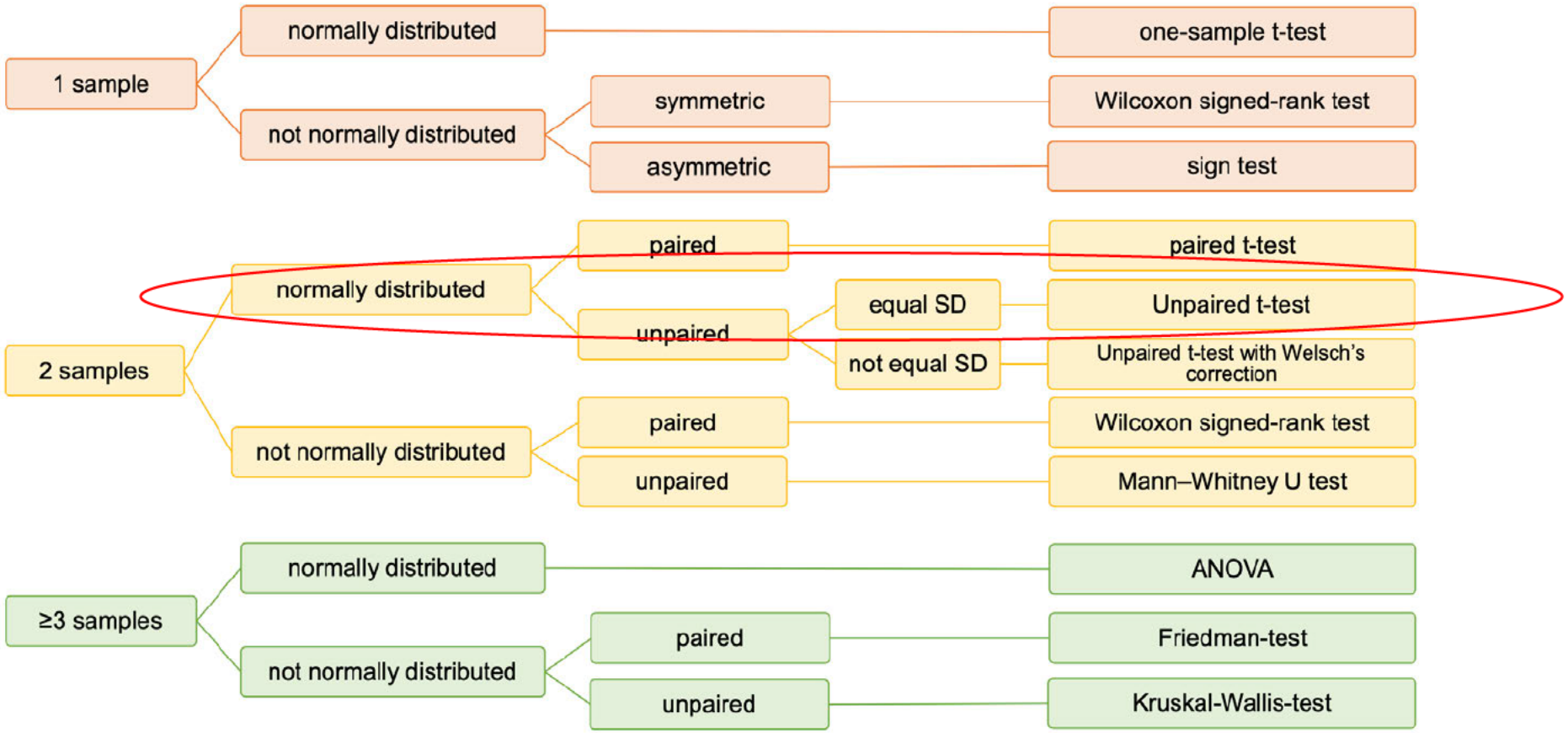
Cantons	German-speaking	Latin-speaking
Standard Deviation	0.249	0.228

Levene's Test:

- H_0 = All input samples are from populations with equal variances
- P = 0.522
- H_0 can not be rejected

We can assume equal variance for our dataset

Part 1: Analysis – Hypothesis testing



Part 1: Analysis – Hypothesis testing

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Question: Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?

Unpaired T-Test

Chosen significance Level = 0.05

- Comparing the German to the Latin speaking cantons
- P-value = 0.018
- We reject the null hypothesis and conclude that there is a statistically significant difference between the two groups.

- Comparing university hospitals to non-university hospitals
- P-value = 0.014
- We reject the null hypothesis and conclude that there is a statistically significant difference between the two groups.

Part 1: Conclusion

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- Research Question: *Is there a statistically significant difference in inpatient cesarean section rates between the Latin-speaking cantons (GE, VD, NE, JU, FR, VS, TI) and the German-speaking cantons in Switzerland?*

Test	Mann-Whitney U	Unpaired T-Test
P-value	0.0056	0.018

- Answer: Yes!

Part 1: Conclusion

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Suisse Modifié le 12 avril 2023 à 15:19

Plus de naissances par césarienne en Suisse alémanique qu'en Romandie

Source: RTS, l'Observatoire de la santé (Obsan)

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Part 2: Analysis – Data Preparation

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Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?

1. We have already checked previously that the log of the C-section rate follows a normal distribution
2. 1 or 0 for hospitals that do or do not perform kidney transplants
3. In order to be able to better compare hospitals of very different size, we normalized our variables to the number of beds:

```
df['doc_bed'] = df['Doctor']/df['Beds']
df['nurse_bed'] = df['Nurse']/df['Beds']
df['staff_bed'] = df['Total_staff']/df['Beds']
df['operat_bed'] = df['Operation_rooms']/df['Beds']
df['deliv_bed'] = df['Delivery_rooms']/df['Beds']
```

Part 2: Analysis – Regression

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Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?

- Results of the Ordinary Least Square Regression:

Variable	P-Value
Intercept	0.008
Year [2015 - 2021]	0.002
Region (German/Latin)	0.000
University Hospital (y/n)	0.007
Total Staff / Bed	0.016
Operating Theaters / Bed	0.000
Delivery Rooms /Bed	0.000
Private Division (y/n)	0.000
Performs Kidney Transplantation (y/n)	0.021
Doctors / Bed	0.111
Nurses / Bed	0.382

R^2

- The proportion of variance in the dependent variable explained by the independent variable
- higher R^2 = better fit
- R^2 = 0.478

Part 2: Analysis – Regression

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Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?

- Result OLS-Regression using only the significant variables

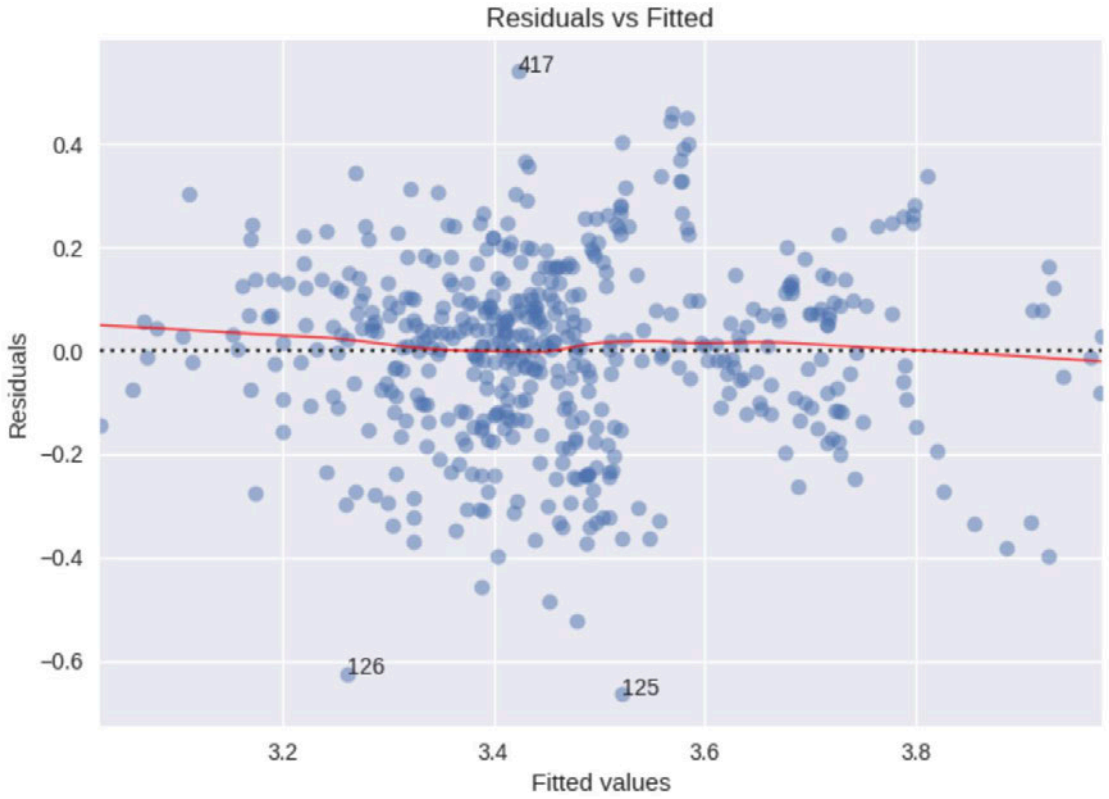
Variable	P-Value	Coefficient	95% CI
Intercept	0.011	-21.8825	[-38.761, -5.004)
Year [2015 - 2021]	0.004	0.0124	[0.004, 0.021]
Region (German/Latin)	0.000	-0.1346	[-0.173, -0.096]
University Hospital (y/n)	0.000	0.3141	[0.233, 0.395]
Total Staff / Bed	0.000	-0.0513	[-0.065, -0.037]
Operating Theaters / Bed	0.000	3.0191	[1.690, 4.348]
Delivery Rooms /Bed	0.000	-4.0009	[-5.337, -2.665]
Private Division (y/n)	0.000	0.4927	[0.396, 0.589]
Kidney Transplantation (y/n)	0.037	0.1360	[0.008, 0.264)

R^2

- higher R^2 = better fit
- R^2 = 0.471

Part 2: Analysis – Regression Evaluation

Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?



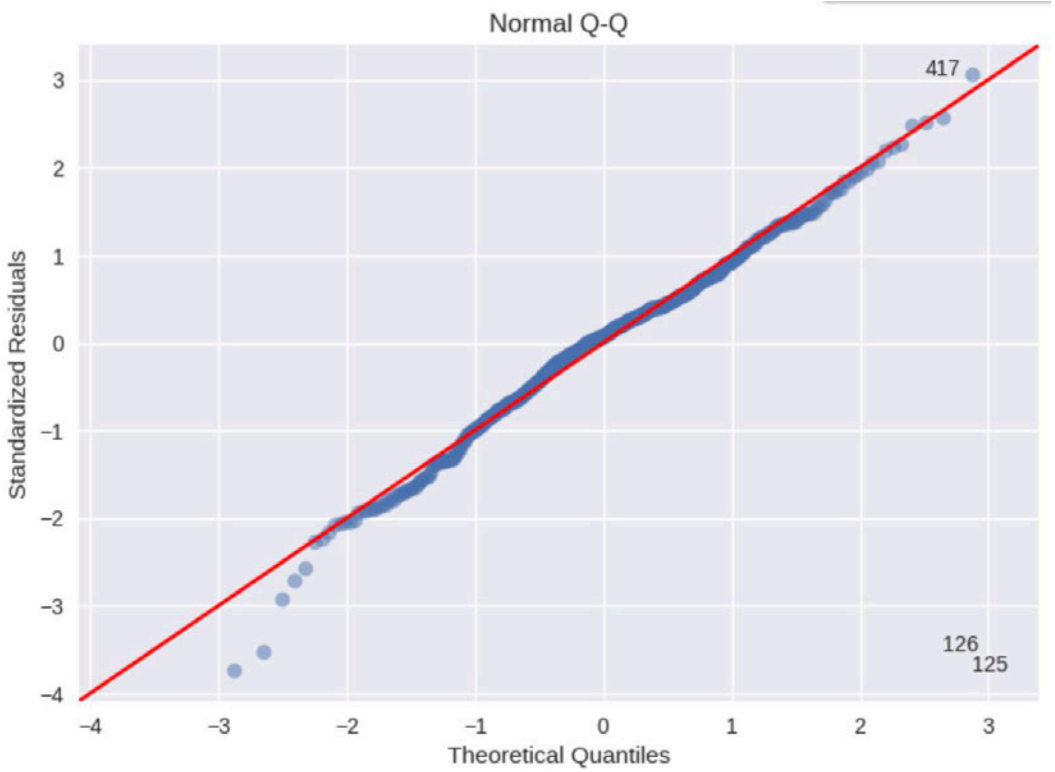
- Residuals seem to be randomly distributed around 0
- Residuals do not show a clear pattern

- However we might have unequal variances (=heteroscedasticy) as the spread of our residuals narrows and widens as the fitted values change → We check this later

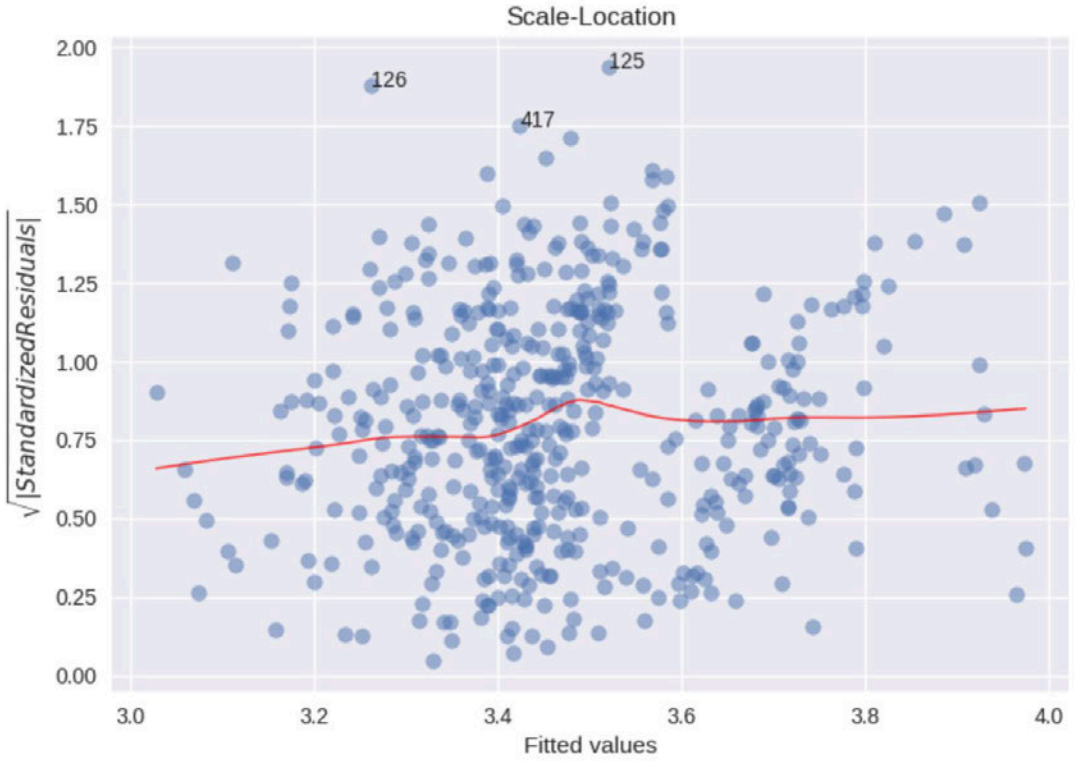
Part 2: Analysis – Regression Evaluation

Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?

Assessing Normality

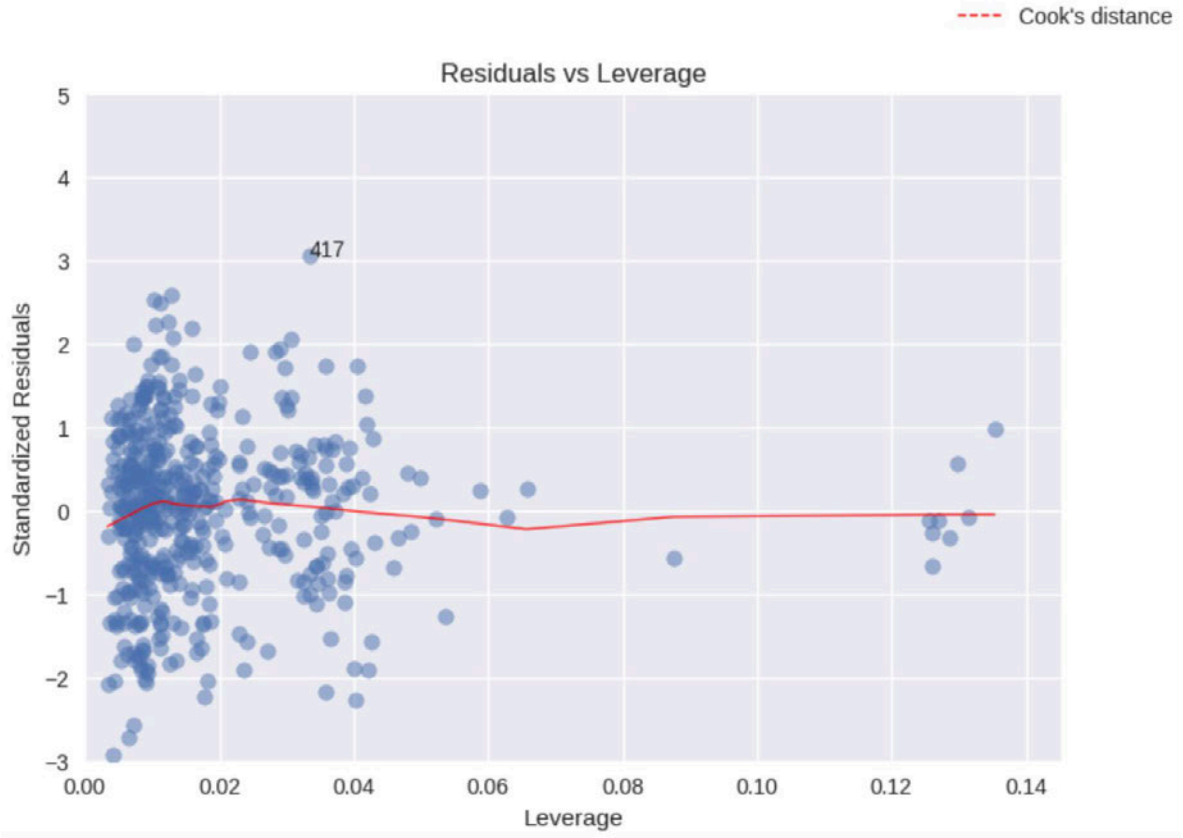


Assessing Homoscedasticity



Part 2: Analysis – Regression Evaluation

Question: What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?



Looking for Influential Points

- Influential Points:
  - are outliers (have large standardized residuals)
  - have high leverage (points that have the potential to strongly influence the regression coefficients)

Part 2: Conclusion

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- Research Question: *What is the relationship between hospital attributes, including infrastructure and personnel, and the rate of C-section procedures?*

Variable	P-Value	Coefficient	95% CI
Intercept	0.011	-21.8825	[-38.761, -5.004)
Year [2015 - 2021]	0.004	0.0124	[0.004, 0.021]
Region (German/Latin)	0.000	-0.1346	[-0.173, -0.096]
University Hospital (y/n)	0.000	0.3141	[0.233, 0.395]
Total Staff / Bed	0.000	-0.0513	[-0.065, -0.037]
Operating Theaters / Bed	0.000	3.0191	[1.690, 4.348]
Delivery Rooms /Bed	0.000	-4.0009	[-5.337, -2.665]
Private Division (y/n)	0.000	0.4927	[0.396, 0.589]
Kidney Transplantation (y/n)	0.037	0.1360	[0.008, 0.264)

Strongest Relationships:

- Delivery Rooms/Bed (inverse relationship)
- Operating Theaters/Bed

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Discussion

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- Where we justified in eliminating Hospitals that hadn‘t performed any C-Sections in a specific year?

hospital	canton	delivery	year
Geburtshus Storchenäscht AG	AG	152	2015
Swiss Medical Network Hospitals SA Clinique Gé...	FR	1	2015
Geburtshus Storchenäscht AG	AG	148	2016
Pôle santé du Pays-d'Enhaut	VD	1	2016
Geburtshus Storchenäscht AG	AG	138	2017
Geburtshus Storchenäscht AG	AG	157	2018
Nouvelle Clinique Vert-Pré	GE	1	2018
Geburtshus Storchenäscht AG	AG	129	2019
Center da Sanadad Savognin SA	GR	1	2019
Clinique la Colline	GE	1	2019
Spital Zofingen AG	AG	1	2020
Asana Spital Menziken AG	AG	1	2021

Discussion

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- Were we justified in removing the 98 lines without bed?
  - Alternative options: Replacing the missing values be the means of the last years?
  - Checking manually if the data is available elsewhere?

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Thank you for your attention!