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Indicators on Healthcare Equity in Switzerland New Evidence and Challenges

Final report on behalf of the Federal Office of Public Health 2021

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Key concepts (glossary)

Hospital Indicators	Hospital indicators measure hospital admissions, either potentially avoidable or potentially inappropriate, according to specific conditions. They are expressed in admissions per 1000 population and calculated for each region.
Index/Indices	Summary measure created by combining one or more variables that reflect the same effect. Thus, an index can be interpreted as an aggregation of multiple measures into a single indicator.
Gradient	Number of additional hospitalisations per 1000 obtained if we increase the index (for example SDI) by one unit. This corresponds to the slope of a regression line between the hospital indicator and the index. This can be used as a measure of inequality. A flat gradient would imply that an increase in deprivation (for example) would have no effect on the hospital indicator. A positive/negative gradient implies that and increase in deprivation would lead to an increase/decrease of the hospital indicator.
CBAC	Community-Based Ambulatory Care Ambulatory care supplied in the community as opposed to in the hospital. Generally made up of GP practices, pharmacies, and nurse stations.
ACSCs	Ambulatory Care Sensitive Conditions These conditions, based on ICD-10 diagnostic codes, should not generate hospital admissions if treated properly in an ambulatory care setting.
PAH	Potentially Avoidable Hospitalisations Hospitalisations generated by ACSCs and thus considered avoidable if access and quality of CBAC are sufficient.

PAH_S	Hospital indicator of potentially avoidable hospitalisations – simple list
PAH_C	Hospital indicator of potentially avoidable hospitalisations – complex list
PIH	Potentially Inappropriate Hospitalisations This indicator aims at identifying stays that were not justified at the time of admissions, i.e. that could be better treated in an ambulatory setting.
SDI	Socioeconomic Deprivation Index Our main measure of socioeconomic level of a MedStat region created as an index of variables that reflect socioeconomic deprivation in the region.
INC	Income index that reflects the median income in a MedStat region
CLT	Cultural index created as an index of variables that reflect cultural diversity in a MedStat region
MedStat region	Geographical area smaller than a canton. They represent the smallest geographical subdivision that maintains anonymity for each hospitalised individual in Switzerland.

Executive summary

Background

The healthcare system in Switzerland is known for its good performance and the high quality of care delivered [1]. The population benefits from a high density of providers and the country is at the forefront of innovation in many domains [2]. At a broader level, population health outcomes such as life expectancy are among the highest in the world. Switzerland is also one of the countries that spend the highest share of its economy on healthcare (11.9% of GDP in 2018[1]), only second to the United States. What is less known is the strong degree of decentralisation and fragmentation of the system traditionally focused on acute hospital care, with many major policy (planning and financing) decisions made at the canton level [3]. From a financing standpoint, the population contributes directly to a large share of healthcare expenditures via health insurance premiums, cost-sharing and out-of-pocket payments, most of which not related to ability to pay.

Canton disparities in health policy and the strong reliance on households to finance the system might, among other things, generate unwarranted variation in access to adequate care across regions and groups with different socioeconomic status or cultural/migration background. In other words, the good average performance of the Swiss healthcare system might mask important variabilities between population groups and/or regions, some of which being potentially unfair.

In order to know more about the current situation in Switzerland based on existing data, in this report, we investigate whether there is a systematic relationship between socioeconomic and cultural diversity (e.g., migration status, nationality) measured at the regional level, and hospitalisations for chronic and acute conditions that should have been avoided with timely access to adequate community-based ambulatory care (i.e., potentially avoidable hospital admissions).

[1] OECD statistics

Aims

The overarching aim of this report is to **highlight potential healthcare equity issues in access to and quality of community-based primary care in Switzerland**, at the national and cantonal levels. We also focus on the appropriateness of hospital admissions. To do so, we proceed with the following steps:

1. Select a set of relevant indicators

Based on the international scientific literature, we generate a set of indicators using data on admissions collected annually and routinely by all Swiss hospitals. These indicators include hospitalisations for which volumes should be small if adequate access to community-based ambulatory care is provided.

Indicators include **potentially avoidable hospitalisations** (also known as hospital admissions for ambulatory care sensitive conditions - ACSCs) and **potentially inappropriate hospitalisations**.

2. Highlight healthcare equity issues in Switzerland and across Swiss regions

Following an approach developed in the UK [4], **we examine the association between potentially avoidable hospitalisations rates and levels of deprivation of different Swiss geographical areas**. These relationships are investigated using data available at the level of MedStat regions (i.e., 705 regions of between 3,000-10,000 pop.), and clustered within cantons (1-90 MedStat region per canton). **Associations between cultural/immigration factors, in addition to socioeconomic factors are also investigated.**

3. Increase networking with national and international experts

We consult experts from the UK and the USA during the course of our investigations and work closely with the Federal Office of Public Health around potential policy implications and evidence gaps.

Theoretical framework: expected associations

We anticipate **higher deprivation levels to be associated with higher rates of potentially avoidable hospitalisations**. We expect this relationship to be mostly driven by individual-level factors such as low education (i.e., poor health literacy, inability to navigate the system adequately), or financial barriers faced by individuals (i.e., deductibles and co-payments).

- We also anticipate that supply-side factors, such as **community-based provider density** will play a role.
- **We do not expect a strong relationship between potentially inappropriate hospitalisations and socioeconomic factors.** This indicator is designed to reflect admissions that were not justified at the time of presentation which are therefore **most likely driven by supply-side factors such as hospital density.**
- **We do not have clear expectations on the existence and the signs of the associations between cultural diversity (i.e., migration status, nationality, language) and hospital indicators.** On the one hand, migrant populations have been shown to be healthier on average than residents ("healthy migrant effect") [5]. On the other hand, this group may be more likely to have difficulties accessing adequate care due to cultural and language barriers, or limited knowledge of the Swiss healthcare system [6].

Methodology

Hospital indicators

Using patient-level data from all hospital admissions in the country between 2014-2017, we create two main types of indicators at the MedStat level (modified versions of these indicators were used in sensitivity analyses):

1. Our main type of indicator, **potentially avoidable hospitalisations**, focuses on admissions for so-called **ambulatory care sensitive conditions**: asthma, chronic obstructive pulmonary disease, congestive heart failure, hypertension, diabetes, community-acquired pneumonia, and urinary tract infection.

2. A second type of indicator reflects **potentially inappropriate hospitalisations**, i.e., cases in which the admission was likely not justified.

Socioeconomic deprivation and cultural diversity

Socioeconomic Deprivation: we combine several socioeconomic characteristics of the MedStat regions to create an **index of socioeconomic deprivation**. Specifically, we use information on the share of population on social security benefits, with low income, that is unemployed, unskilled, and with low education.

Cultural diversity: similarly, we use cultural/immigration factors of the MedStat regions to create an **index of cultural diversity** combining information on language, religion, origin, and migration status. We also exploit information on the share of the population with different residence permits and use limited patient-level information on region of origin to complement the analyses.

Statistical analysis

1. Geographic variation of hospital indicators

We investigate geographic variation between and within cantons in potentially avoidable hospitalisations and potentially inappropriate hospitalisations. In addition to conventional descriptive statistics, we use spatial analysis techniques to identify clusters with high ("hot spots") and low rates ("cold spots") of potentially avoidable hospitalisations.

2. Gradients between socioeconomic deprivation and hospital indicators

We use multi-level modelling to produce national and cantonal socioeconomic gradients in potentially avoidable hospitalisations and potentially inappropriate hospitalisations. A positive gradient means that hospitalisation rates are higher in more deprived regions compared to less deprived regions. The national gradient is used as a reference to which cantonal gradients are compared. We also produce gradients based on median household income instead of socioeconomic deprivation.

3. Association between cultural diversity and hospital indicators

We assess the association between cultural diversity, potentially avoidable hospitalisations, and potentially inappropriate hospitalisations at the national level and in each canton. We also investigate disparities in potentially avoidable admissions and potentially inappropriate admissions between Swiss and foreign individuals using patient-level data.

4. Potential savings in improving equity

Using various scenarios, we estimate potential gains in terms of avoided hospitalisations and costs in hypothetical cases where the socioeconomic deprivation gradient would be flattened. A conservative scenario assumes that the rate of avoidable admissions in the 20% most deprived regions in the country would reach the country mean. Other scenarios are discussed.

5. Multi-variable modelling

Finally, we estimate a series of multi-level models to assess whether the gradients observed are robust to the inclusion of other factors such as healthcare supply density and cultural diversity. We estimate regression models with the composite indices as explanatory variables, but also "disaggregated" models in which each of the components used to generate the indices are included, allowing us to assess which factors are driving the results.

Results

1. Geographic variation of hospital indicators

Exhibit 1
Spatial variation in Potentially Avoidable Hospitalisations

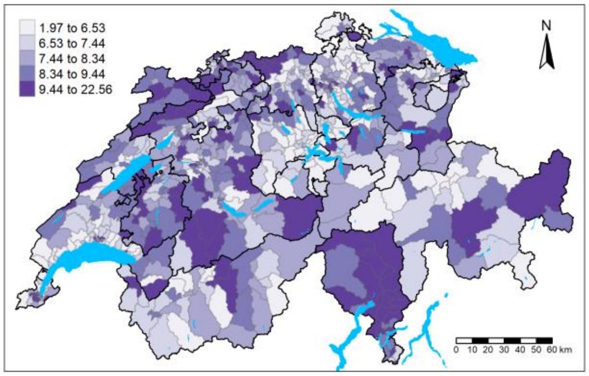
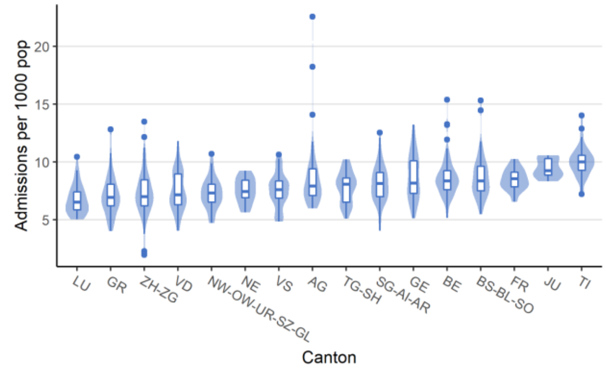


Exhibit 2
Within canton variation in Potentially Avoidable Hospitalisations

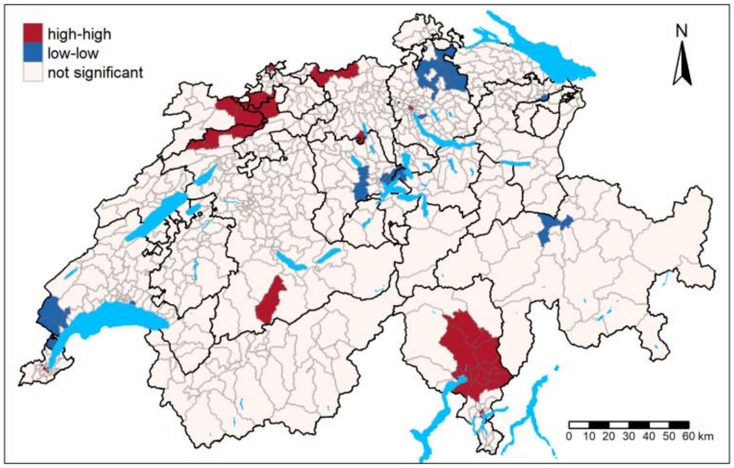


Hospitalisations expressed in rates per 1000 population. Unit of analysis: MedStat regions.

We observe important spatial variation in the rate of potentially avoidable hospitalisations in the country (Exhibit 1), as well as between and within cantons (Exhibit 2). There are large disparities in the average rates of potentially avoidable hospitalisations across cantons, with LU, GR and VD having rates just above 5 per 1'000 pop., whereas JU and TI have rates close to 9 per 1'000 pop.

In terms of within-canton variability, we see cantons (e.g., FR) for which the gap between the region with the lowest admission rate and the region with the highest admission rate (i.e., vertical spread of the distribution) is low. We also observe cantons, for example VD and GE, with a large gap. Similar results are found with potentially inappropriate hospitalisations.

Exhibit 3
Hot and cold spots of potentially avoidable hospitalisations



Taking into account the spatial distribution of the data, we produce maps of "hot" and "cold" spots of admissions. We define hot/cold spots as areas with high/low admission rates that are surrounded by areas with high/low admission rates. The map for potentially avoidable hospitalisations is presented in **Exhibit 3 and shows the presence of clusters.** Hot spots are observed in Ticino and in the North-West of the country, and cold spots in the south part of canton Vaud, in the north of canton Zürich and in central Switzerland.

2. Gradients between socioeconomic deprivation and hospital indicators

Exhibit 4
Socioeconomic gradient in Potentially Avoidable Hospitalisations

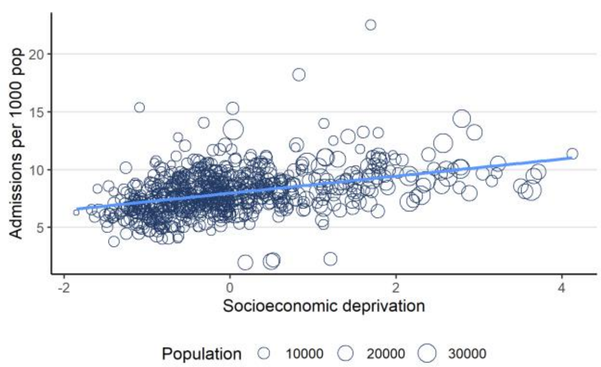
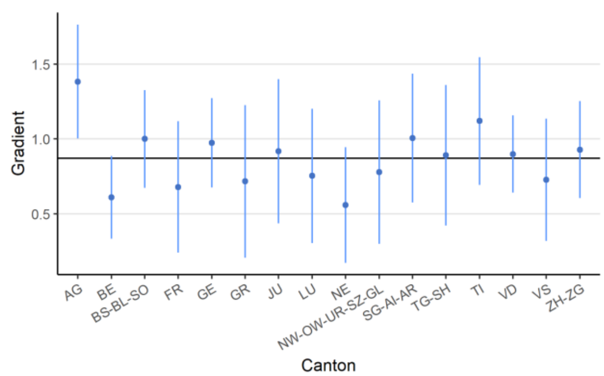


Exhibit 5
Cantonal socioeconomic gradients in Potentially Avoidable Hospitalisations



Hospitalisations expressed in rates per 1000 population. Unit of analysis: MedStat regions.

Next, we study to what extent this variability in potentially avoidable hospitalisation rates is associated with the socioeconomic deprivation index. **We find evidence of a positive and robust association between the socioeconomic deprivation index and potentially avoidable hospitalisation rates.** This is illustrated in **Exhibit 4** that shows this association across all MedStat regions in Switzerland in 2017.

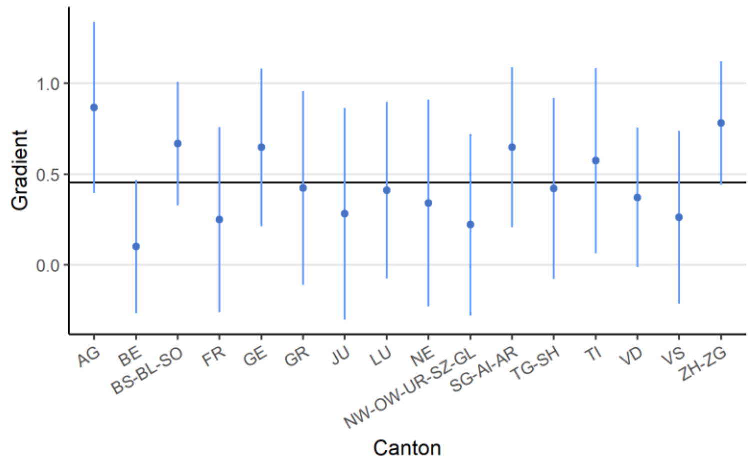
We then compare whether the association between socioeconomic deprivation and potentially avoidable hospitalisations is weaker or stronger at the cantonal level than at the national level. **Exhibit 5 shows the variability in the cantonal socioeconomic gradient in potentially avoidable hospitalisations compared to the national value (horizontal bold line).** Each dot represents the gradient estimated for the corresponding canton. Some cantons tend to have higher gradients such as TI, AG, or BS-BL-SO, while others tend to have lower gradients, e.g. BE, LU and NE. Only AG appears as statistically significant, as evidenced by the wide vertical bars around each cantonal estimate. In multi-variable analyses, we provide some more evidence of statistically stronger (AG, TI), or weaker (NE, BE) gradients than the national gradient.

Finally, we do not find any clear association between the socioeconomic deprivation index and potentially inappropriate hospitalisation rates. This result is expected since the measure of socioeconomic deprivation is more related to healthcare demand side aspects and potentially inappropriate hospitalisations are more likely to be associated with aspects related to traditional supply-side factors such as hospital density.

3. Association between cultural/immigration factors and hospital indicators

When we look at the association between potentially avoidable hospitalisations and an index representing cultural diversity, **we find a positive but relatively weak gradient (i.e., more cultural diversity is associated with more potentially avoidable hospitalisations), and no significant variability between canton gradients and the national one (Exhibit 6).** Similar results are observed for other hospital indicators.

Exhibit 6
Cantonal cultural gradients in Potentially Avoidable Hospitalisations



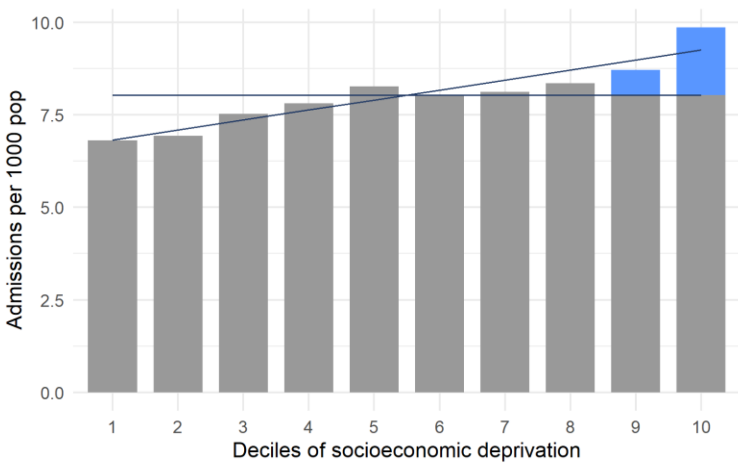
To study this further we compare hospital admission rates using patient-level information on nationality. **We observe higher rates of potentially avoidable hospitalisations among patients with Swiss origin, but this is likely due to the younger age distribution of foreign populations.** Further analyses show differences in rates of potentially avoidable hospitalisations by region of origin and age groups, although sample sizes are too small to draw conclusions and further research on the issue is required.

We then investigate the association between potentially avoidable hospitalisations and the proportion of the population with specific residence permits. In univariate analyses, we show a positive association between the rates of foreign nationals (B, C, F, N permits) and the rate of potentially avoidable admissions. When socioeconomic deprivation and healthcare supply factors are taken into account, most of these associations are no longer observed. However, **high rates of permanently settled foreign nationals (C permit) are positively related to potentially avoidable hospitalisations, while resident foreign nationals (B permit) are negatively related to potentially avoidable hospitalisations**. Finally, interaction analyses revealed that the strength of the association between residence permit and avoidable hospitalizations varies with socioeconomic deprivation for the rate of temporarily admitted refugees and other temporarily admitted persons (F permit) and the rate of short-term residents (L permit). **In socioeconomically deprived regions, the association between the rate of residents with F permit and avoidable hospitalisations is stronger than in affluent regions.**

4. Potential savings in improving equity

Exhibit 7 provides a graphical representation of the potential benefits in terms of reduction in avoidable admissions of bringing the rate of the 20% most deprived regions (i.e., deciles 9 and 10) to the national average. The blue areas illustrate the reduction of potentially avoidable hospitalisations.

Exhibit 7
Illustration of potentially avoidable hospitalisation gains



In total, there were 229,292 potentially avoidable hospitalisations in Switzerland in 2017 (Exhibit 8). This corresponds to an estimated cost of CHF 580 million in inpatient care costs. **The highly conservative scenario presented in Exhibit 7 would lead to a reduction in potentially avoidable hospitalisations of 5,443 hospitalisations in the 20% most deprived regions, corresponding to an estimated CHF 14 million in hospital cost savings.** Note that this does not reflect net savings for the system. Two scenarios that are more ambitious are displayed in Table 1.

Table 1

Potential savings in terms of hospitalisations and costs

	Actual values in Switzerland	Potential savings: conservative scenario (top 20%)	Potential savings: central scenario (top 50%)	Potential savings: Ambitious scenario*
Potentially avoidable hospitalisations	229 292	5 443	13 698	26 190
Cost estimate (million CHF)	580.21	13.77	34.66	66.27

*All regions with a PAH rate that is higher than the national average are brought to the national average

5. Multi-variable modelling

The results discussed so far are based on simple descriptive, bivariate, analyses. We then estimate a series of statistical models that account for the structure of the data (i.e., cantons and MedStat regions) and account for a range of characteristics at the same time. The main findings are the following:

- Results show that the relationship between potentially avoidable hospitalisation rates and the socioeconomic deprivation index is **remarkably robust**. **The coefficients associated with the socioeconomic deprivation index are always positive and significant** and lie between 0.80 and 1.00 approximately.
- Results are less stable for the relationship between potentially avoidable hospitalisation rates and income levels, but there is good evidence of a negative relationship, i.e., **in regions with higher median income, lower rates of potentially avoidable hospitalisations are recorded**.
- **The relationship between the cultural diversity index and potentially avoidable hospitalisations is only positive when socioeconomic deprivation is not accounted for.** In other words, it is likely that a large share of the effect observed for cultural diversity reflects differences in socioeconomic status.

When the indices (socio-economic deprivation and cultural diversity index) are disaggregated, i.e., when we use each variable of the indices separately in the models, we observe the following:

- There is a particularly strong association between **lower education** and **potentially avoidable hospitalisation** rates as well as between **unemployment rate** and **potentially avoidable hospitalisation** rates.
- **There is no robust evidence of independent association between potentially avoidable hospitalisations and variables used to build the cultural diversity index;** most of the cultural variation seems to be captured by the socioeconomic variables.
- **A higher density of primary care providers (i.e., GP practices) is associated with lower rates of potentially avoidable hospitalisations.**
- The models for potentially inappropriate hospitalisations suggest an association with socioeconomic factors. In particular, we find associations between education and potentially inappropriate hospitalisations and between unemployment and potentially inappropriate hospitalisations.
- Language barriers appear to be negatively associated with hospital indicators in several models, but this result requires further investigation.

Discussion

Summary of findings

1. We find robust and stable socioeconomic gradients in potentially avoidable hospitalisations at the national level, both with respect to deprivation and income.

- In other words, the rate of potentially avoidable hospitalisations is higher in more deprived and less affluent regions of the country.
- There is some, albeit weak, variation in gradients between cantons, with a few exhibiting systematically stronger or weaker gradients than the national average.

2. Multivariate analyses show

- particularly strong associations between low education and unemployment, and the rate of potentially avoidable hospitalisations;
- that the density of healthcare providers plays a role in explaining specific hospitalisations rates, specifically:

  (2) better geographical access to community-based ambulatory care (i.e., GP practices) seems to reduce potentially avoidable hospitalisations;

  (3) higher hospital density is associated with higher rates of hospitalisations that are deemed inappropriate.

3. Analyses of cultural diversity as drivers of admissions show mixed results:

- There is an association between some region-level markers of cultural diversity and potentially avoidable hospitalisations.
- The associations are much weaker when socioeconomic status is accounted for, therefore indicating a strong correlation between the two sets of characteristics.
- There is evidence suggesting that the two following effects might be at play in this area:

  (1) A "healthy migrant" effect explained by the fact that a large proportion of foreign nationals living in the country is younger than the average Swiss (i.e., negative association between proportion of foreign nationals and potentially avoidable hospitalisations).

(2) A positive association between potentially avoidable hospitalisations and the proportion of immigrants with specific profiles (i.e., settled foreign nationals, temporarily admitted refugees and other foreigners who live in socially deprived regions) indicating potential access issues specific to these groups. These findings, however, warrant further investigations.

4. **Geographic variation**: all results consistently show **important geographic variation for all indicators**, i.e., potentially avoidable hospitalisations, potentially inappropriate hospitalisations. Irrespective of the correlation between these indicators and socio-economic deprivation or cultural/immigration factors, regions and clusters with relatively high and low rates of admissions should be further studied.
5. **Cost-saving estimations**: the results suggest that potentially avoidable hospitalisations could be reduced by an estimated 5,443 units **if potentially avoidable hospitalisations for the 20% most deprived regions in Switzerland were brought to the national average**. This would correspond to an estimated CHF **14 million saved** in hospital costs. **If the hospitalisation rate of the 50% more deprived regions were brought to the national average, these savings would amount to an estimated CHF 37 million**.

Policy implications

Overall, our main contribution is to shed light on disparities in the Swiss healthcare system when it comes to access to appropriate community-based ambulatory care. The fact that access seems to systematically vary between socioeconomic groups and place of residence raises equity concerns. Indeed, we observe important differences in access between cantons and between regions, with most deprived regions having on average higher rates of potentially avoidable hospitalisations. Such hospital admissions are caused by known health conditions (e.g., diabetes or hypertension) and could be minimized with adequate access to community-based ambulatory care and regular follow up. Based on our main findings, we formulate a series of potential policy implications at two levels: 1) population and patients, and 2) providers and the health system.

1. **On the population and patient side**: addressing broader social determinants of health in specific communities will likely have a strong potential to reduce the observed gap in potentially avoidable hospitalisations between most deprived and least deprived areas. Low levels of **education seem to be a particularly strong driver** of potentially avoidable hospitalisations, as evidenced in other countries and settings, which could reflect **difficulties to identify health needs** (i.e., due to low health literacy for instance), **problems in self-managing**

chronic diseases, or challenges to navigate our complex health system (i.e., due to low navigation health literacy for instance). Efforts targeted at reducing the education gradient in health literacy will likely lead to lower rates of potentially avoidable hospitalisations, in particular for patients suffering from chronic conditions.

In addition, improving the navigation health literacy (i.e., the level of understanding of our health system and how to navigate in the system) of vulnerable groups could lead to improved choices with regards to health insurance and healthcare use. Special attention should be paid to persons with migration background, especially for migrants in precarious working and living conditions (not speaking the local language, low-skilled work, or with an uncertain residency status, and different actions should be undertaken that account for the type of migration (employment or forced migration).

Income also seems to play a major role, which can reflect financial barriers in access to appropriate and timely community-based ambulatory care. The strongly regressive nature of healthcare financing in Switzerland, with per capita premium and high out-of-pocket expenditures, likely explains some of this association.

2. **On the providers and health system side**: we showed that the geographical accessibility/density of community-based ambulatory care providers plays a role in potentially avoidable hospitalisations. We also show that potentially inappropriate hospitalisation rates are partly driven by the density of hospital beds, which would reflect financial incentives at the hospital-level to lower admission thresholds. Overall, our results suggest that inefficiencies in our system might be related to a sub-optimal balance between hospital and community-based ambulatory care accessibility.

Measures for reinforcing health literacy must also be taken by the provider side on the organizational, system and interactional/communicational level. Providing incentives to healthcare professionals, as well as social workers, to improve communication with patients could be a major way to improve health literacy on the provider side The close association between cultural/immigration factors and socioeconomic deprivation makes their relationship with potentially avoidable hospitalisations difficult to disentangle. However, improving intercultural competencies of the healthcare professionals, for community-based ambulatory care as well as in the hospital setting, is likely to lead to benefits.

The financial burden of disease may be unevenly concentrated on the poor. Subsidy programs or cost-sharing exemptions aimed at patients suffering from chronic conditions may reduce the financial burden for this part of the population and improve access to timely care. From a broader perspective, further investments in strengthening access to well-coordinated primary care to all has the potential to improving both efficiency and equity in the system.

Further evidence is needed

While our analyses shed light on equity issues in the Swiss healthcare system, it also leaves important questions unanswered and raises new ones. Despite having access to rich individual-level data on hospital care, we had to rely on a limited set of socio-economic and cultural/immigration indicators at a higher level of aggregation in an ecological approach. We list here several suggestions for future investigations and use of such indicators, with a particular focus on data requirements.

A need for more detailed data for research and monitoring

- A more in-depth understanding of inequities would require additional metrics, if possible measured at the individual level. Feasibility of such approach has been demonstrated by a recent study using patient-level data on both outcomes and socioeconomic factors [7].
- In particular, further research around cultural/migration background is needed to be able to disentangle a “healthy migrant” effect from access issues in specific groups of the migrant population.
- More detailed measures of healthcare supply that goes beyond primary care and specialist provider density would be needed to better describe community-based care in Switzerland, including other health professionals, home care, etc.
- More generally, efforts are required to facilitate the use of nation-wide individual-level data. This could be achieved by developing data linkage (i.e., unique identifier, trust centre) and/or by systematically collecting socio-economic information and information on migration background of patients at the hospital level.
- Also, access to comprehensive outpatient data is lacking, rendering it difficult to measure access to community care and quality of community care directly.

- Preliminary results on all-cause psychiatric admissions show important variation in the country but this was not further explored in this report. Research is needed to develop policy-relevant lists of hospital indicators related to mental health conditions that can shed light on potential unmet needs and access issues in this area.

From descriptive evidence to the understanding of causes

- A natural next step to this national investigation, would be to conduct in-depth, mixed-methods (i.e., quantitative and qualitative) studies in specific regions and cantons to better understand what lies behind strong gradients, weak gradients, or, e.g., hotspots of admissions.
- Additional contextual and policy factors that have not yet been considered could be exploited in comparative analyses (e.g., at the cantonal level), and might shed light on cantonal differences in gradients.
- Accessibility to richer data on both outcomes and determinants will likely be higher in smaller jurisdictions, and qualitative interviews with both providers and policymakers will help overcome the limitations of a purely quantitative approach.

A purpose of this project is also to show feasibility and value of using such indicators to highlight potential issues at the federal or cantonal level in a more routine manner.

- Changes in gradients, or in the rate of avoidable hospitalizations, can help policymakers at various levels target further investigations.
- Rates of potentially avoidable hospitalizations and their distribution in the population (i.e. with respect to socioeconomic status or cultural/migration background) can be used as outcomes to assess the impact of canton-level policies that affect different dimensions of accessibility and coordination between inpatient and outpatient care.

1. General Introduction

1.1 Background

The Swiss healthcare system is widely recognised for its good performance [1, 2]. The country rates highly on several population health outcomes [2], including life expectancy which is one of the highest in the world. The population has access to high-quality providers with an important freedom of choice and the mandatory insurance benefit package is comprehensive. It is also one of the countries that spends the highest share of its Gross Domestic Product (GDP) on healthcare, second only to the United States. The performance of the Swiss healthcare system on health equity is, however, less strong compared to other high-income countries, especially regarding equity in financing [8, 9]. Indeed, households contribute heavily to the financing of the system, mostly through payments that are not income-related, resulting in low-income households spending a disproportionate share of their disposable resources on healthcare [1, 2, 10]. Premiums for mandatory health insurance do not depend on ability to pay, except through state-funded premium subsidies. In addition, out-of-pocket payments in the form of deductibles and cost sharing are high in international comparison [11]. To date, comparative data on Swiss equity performance has mostly focused on equity in financing and limited data exist on equity in healthcare access and outcomes, which is the focus of this report.

Another feature of the Swiss healthcare system is its highly decentralised nature, with many key decisions under the responsibility of the 26 cantons ("states"), giving rise to important geographical disparities in the way healthcare is organised, financed and accessed, and virtually to 26 different healthcare systems [3, 12]. In addition, cultural factors play a large role as the country has several official languages each predominantly spoken in well-defined regions [13]. From an efficiency perspective, such variation might lead to inappropriate or sub-optimal levels of care in some areas or population groups, as evidenced in recent literature focussing on at the (over-) use of potentially low value treatments and its determinants, e.g. in Switzerland [14, 15], or in the United States [16]. From a health equity perspective, these differences might lead to unfair variation in access to appropriate care, which has been less studied in the country. In this report, we are particularly interested in differences in healthcare access and quality between individuals with the same healthcare needs (i.e., "horizontal inequity in healthcare delivery"), and whether such differences are systematically associated with socioeconomic status and cultural diversity (e.g., migration status, nationality), measured at the region of residence level.

One strategy to study inequities in access and quality of care is to analyse indicators measured at the hospital level that reflects issues in other parts of the healthcare system. Such an approach has the advantage of relying on routinely collected administrative hospital data, which follows comparable structure across countries and uses standard international medical coding classifications. A widely used family of indicators are potentially avoidable hospitalisations (PAH), also referred to as hospitalisations for ambulatory care sensitive conditions (ACSCs). These are hospital admissions that could have been avoided with the provision of timely and effective community-based ambulatory care (CBAC), "by preventing the onset of an illness or condition […], or managing a chronic disease or condition" [17]. PAH were shown to be associated with characteristics of the health system and its organisation, such as the density of primary care providers, as well as patient-level or environmental-level factors such as income, education, deprivation, migration status or mental health comorbidities [18-22].

An analytical approach to integrate health equity into mainstream healthcare quality assurance has recently been developed and applied to the English National Health Service [4]. Precisely, the approach uses PAH as a key indicator measuring access to CBAC. The indicator is linked to levels of neighbourhood deprivation, enabling the comparison of inequality within and between larger regional units and allowing the estimation of avoidable hospitalizations attributable to inequality in access to CBAC. A key element of this approach is the comparison of socioeconomic gradients in PAH between various geographic areas and the national gradient. Our project aims to adapt this approach to the Swiss context to provide decision-makers with a general assessment of equity in access to appropriate and timely community-based ambulatory care at the national and regional level, and to test hypotheses regarding potential causes of inequity.

We extend the UK approach in several dimensions. First, we compare different indicators; in particular, we distinguish PAH with potentially inappropriate hospitalisations (PIH) which might reveal equity issues at the CBAC-acute care interface. Then, in addition to socioeconomic status, we study potential association between hospital indicators and "cultural" (migration) factors, which have been found to influence avoidable hospitalisations in other countries and settings [5, 23-25].

With this project, we propose to contribute to a more systematic monitoring of potential health equity issues in the Swiss healthcare system, focussing on the association between regional-level socioeconomic status and cultural factors and equity-relevant hospital indicators measured with routinely collected patient-level hospital data. Our aim is to provide prima facie evidence that healthcare delivery may be unfair, or may be getting more or less unfair, but not to provide a definitive proof as data limitations and potential disagreements about what part of the variation can be considered "unfair" should be kept in mind. The next section develops our conceptual framework and working hypotheses.

1.2 Objectives

The main objective of this report is to shed light on health equity issues using a quantitative, easily replicable, and transparent approach based on routinely collected data. The specific aims of the research are to:

1. Adapt the methodology proposed by Cookson et al. [4] to the Swiss context considering, among other things, the organisational structure of the Swiss healthcare system and the limitations of data availability;
2. Extend the approach by including additional indicators and exploring cultural variables;
3. Produce country-level and canton-level gradients;
4. Estimate explanatory models of the observed variation;
5. Make recommendations for further investigations.

1.3 Conceptual Framework

Our starting point is the concept of potentially avoidable hospitalisations (PAH), also known as hospital admissions for ambulatory care sensitive conditions (ACSCs) that have been widely applied internationally to study access to CBAC [4, 20-22, 26-28]. Several lists of PAH are used, with variations in the inclusion of specific diagnostics and more or less granular exclusion criteria. They all cover similar groups of acute and chronic conditions, such as COPD, hypertension, diabetes, UTI, etc. Starting from a conventional list of PAH [29, 30] we have built a simplified list (PAH_S) in concertation with experts from the team. The list is easy to replicate and focuses on prevalent diagnostics most likely associated with access to CBAC.

While PAH are well established in the scientific literature, they suffer from several limitations, especially given their rather broad definition of admissions mainly based on primary diagnoses. Another shortcoming is that higher rates of PAH might be related to higher access to hospital care rather than a lack of access to CBAC. Some authors proposed a marker of clearly justified stays based on common, well-defined causes of admission (e.g. acute myocardial infarction (AMI), appendicitis, gastrointestinal obstruction, or hip fracture), whose rate is used as a benchmark to evaluate the observed rates of PAH [31, 32]. Despite its relevance, this approach suffers from shortcomings. Medicine has strongly evolved during these last 20 years. For instance, patients with coronary diseases often receive stents, reducing the number of AMI and ambulatory physicians regularly prescribe preventive drugs to prevent osteoporosis and hip fractures. Thus, the proposed marker is less independent of the practice of ambulatory care. With this in mind, we also use an approach proposed by Eggli and colleagues [33] that integrates secondary diagnoses in the detection algorithm of PAH and excludes a range of potentially unjustified stays. This approach is more complex and less straightforward to apply, but probably more accurate in its assessment of the potential "avoidability" of the admissions. This constitutes our second list of PAH (PAH_C).

PAH are potentially avoidable but are appropriate at the time of admission, i.e. they are justified by a clear urgent medical need that require acute treatments. We therefore complement the identification of PAH with an indicator designed to capture potentially inappropriate hospitalisations (PIH) [34].This indicator aims at identifying stays that were not justified at the time of admissions, i.e. that could be better treated in an ambulatory setting. PIH are likely associated with inappropriate referrals or a lack of communication between CBAC and hospital care. This allows us to shift the focus of our analysis from issues in access to CBAC to organisational issues at the hospital level, and coordination between hospital care and CBAC.

We describe all indicators in detail in the methods section. More conventional lists of PAH are used in sensitivity analyses.

Relationship with socioeconomic and immigration factors

Our objective is to study the association of the above-mentioned indicators with socioeconomic determinants measured at the population level, such as lack of education, poverty or deprivation, as well as with immigration factors such as nationality or recent immigration in the country. In Table 1, we propose an overview of our conceptual framework and formulate several hypotheses that will be tested in our empirical approach. Specifically, for each main group of indicators (i.e. PAH, PIH), it presents the expected association with regional-level socioeconomic, immigration and healthcare density measures and formulates possible mechanisms behind the relationship.

We expect a strong association between all socioeconomic measures and potentially avoidable hospitalisations (PAH). These admissions might reflect a lack of early access to CBAC, either because patients were not aware of the necessity to consult (low health literacy, education level) or due to financial barriers [35-42]. In addition, regional differences in PAH rates might reflect differences in the density, i.e. the availability, and quality of CBAC providers. Lack of appropriate access is not only related to geographical distance to CBAC but may also be due to sub-optimal service provision. For instance, lack of insufficient transcultural competencies or lack of interpreting services, may also contribute to access barriers. However, measuring these is beyond the scope of this study.

We expect the relationship between socioeconomic factors and potentially inappropriate hospitalisations (PIH) to be weaker but anticipate some association as lower education or higher levels of deprivation might affect the ability to optimise the patient pathway. The main drivers of such admissions should be hospital density as a high density might create an incentive to fill empty beds and therefore lower admission thresholds.

A proportion of the migrant population tends to be younger and potentially less affected by ACSCs ("healthy migrant effect", see e.g. [5]). On the other hand, recent migration from culturally distant communities poses specific challenges in terms of access to care. This can be driven by language or cultural (i.e. beliefs, attitudes, etc.) barriers or difficulties to understand/navigate the health system. It is important to note that immigration factors are likely strongly correlated with socio-economic factors and that it might be challenging to disentangle their independent effects.

Table 2 Overview of conceptual framework

		Region-level (MedStat)				Canton-level
		SDI	Low income	CBAC density	Cultural	Hospital density
Indicators	PAH	Access to CBAC not optimal	Access to CBAC not optimal	Improved access (e.g. lower waiting times)		Easier access to beds
	PIH			Empty beds to be filled		Empty beds to be filled

SDI is an index of socioeconomic deprivation, PAH stands for potentially avoidable hospitalisations, PIH stands for potentially inappropriate hospitalisations. These indicators are explained in detail in section 2.

Expected associations					
Positive	Slightly positive	Slightly negative	Negative	Unclear	None

2. Data and Methods

2.1 Overview of Empirical Approach

Our analyses are structured around two geographic levels with cantons divided into smaller units, and the general idea is to describe the relationship between socioeconomic and cultural factors and relevant hospital indicators in a given canton of interest by measuring variation observed between smaller geographic units in this canton. As most decisions regarding the organization, planning and financing of healthcare are made at the level of the 26 cantons (median population of 378,902), this is our main "policy-relevant" area of analysis. Then, we require sub-cantonal geographical units to calculate canton-level gradients. The Swiss Statistical Office defines 705 within-canton areas officially called MedStat regions (median population of 10,564) that are built as an aggregation of postal codes. Therefore, our main descriptive results are expressed as cantonal gradients calculated from variation among MedStat regions. In summary, our approach consists in ranking regions according to their level of deprivation for instance and assessing whether hospital indicators are systematically different along this dimension.

As discussed earlier, we focus on PAH_S, PAH_C, and PIH as our main outcomes of interest (see construction below). Regarding socioeconomic status, we construct our own MedStat level measure of socioeconomic deprivation using principal components analysis. We then calculate a national gradient and cantonal gradients, describe how cantonal gradients differ from the national gradient, and document the evolution of these gradients over time. We use a similar approach with cultural factors, i.e., we construct an index reflecting the cultural diversity in each MedStat region (using nationality, immigration and language indicators). We also perform analyses focussing solely on the income distribution as a crude, although easier to interpret, measure of socioeconomic status. We complement these descriptive analyses with maps that illustrate the spatial autocorrelation in the data and that highlight geographical clusters of admissions. Finally, we estimate several multilevel models to predict the factors associated with high rates of potentially avoidable hospitalisations.

2.2 Data

2.2.1 Patient-level hospital data

Administrative, patient-level data on hospital inpatient stays is provided by the Swiss Federal Statistical Office (FSO) ("*Statistique médicale des hôpitaux*") [43]. The dataset documents, for each admission in the country, patient demographic information (including age, sex, nationality, and region of residence), detailed diagnostic and treatment codes (ICD-10 codes, SwissDRG), as well as other characteristics of the hospital stay (e.g., length of stay, discharge information, etc.). It also contains a specific module that adds additional information on psychiatric admissions, such as the type of treatment (e.g., individual therapy, group therapy, couple's therapy), exit decision, stay after release, or type of care after release. The data cover all hospitalisations between 2014 and 2017. We are able track patients with anonymous identifiers, in case of multiple hospitalisations, but only within a single year. It is possible to identify a patient's MedStat region of residence, but the hospital location is only available at the cantonal level.

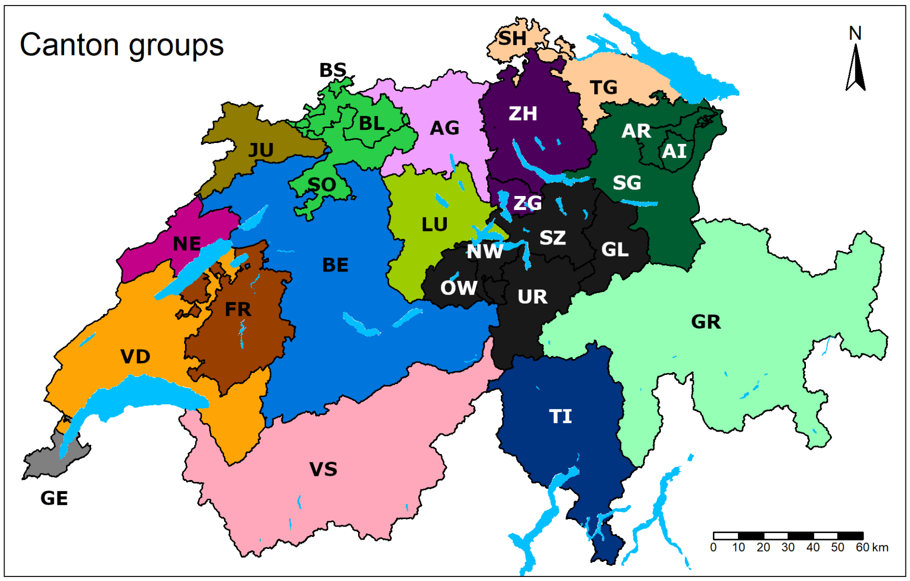
2.2.2 Regional level data

Levels of analysis: MedStat regions and cantons

The basic geographic unit of measurement is the MedStat region (N=705). The mean population is ca. 12,000 and ranges from 1,202 to 39,293. The regions were defined to be homogeneous in terms of demographics and socioeconomic status. In practice, each region is built as an aggregation of postal codes and is located within a single canton, with larger cantons regrouping more regions than smaller ones. They are the smallest geographical subdivision that maintains anonymity for each hospitalised individual in Switzerland.

There are 26 cantons in Switzerland with a mean population of 526,222 that ranges from 73,122 to 1,611,955. The largest cantons include more than 90 regions (i.e., 93 and 99 for Zürich and Bern, respectively), whereas the smallest cantons include less than 10 regions (i.e., 2 and 6 for Appenzell Innerhoden and Glarus, respectively). In order to have enough data points for the descriptive analysis, we regroup small neighbouring cantons, i.e., St. Gallen was merged with Appenzell Innerrhoden and Appenzell Ausserrhoden; Schaffhausen was merged with Thurgau; Zürich was merged with Zug; Basel-Stadt is merged with Basel-Landschaft; and Obwalden, Nidwalden, Schwyz, Uri, and Glarus are merged together. Instead of the usual 26 cantons, we thus end up with 16 larger regions (11 cantons and 5 groups of cantons) that we will still refer to as "cantons" to ease readability. Figure 1 shows a graphical representation of the 16 canton groups. For the multi-variable analysis, we return to the standard definition of canton and keep 26 distinct areas because we use methods that are robust to cantons containing a small number of regions.

Figure 1 Groupings of cantons



Data sources

Socioeconomic and healthcare supply information at the MedStat level is available via MicroGIS [44], an organisation that provides census data on various themes and at different geographical scales. Specifically, they obtain detailed data on various demographic, social and economic indicators from the FSO, that they aggregate and output at a regional level. Canton level variables[2], such as population density, are obtained from the FSO [45].

[2] Several canton-level measures are not updated annually but reflect dimensions with little variability over time.

2.3 Hospital Indicators

All hospital indicators are standardised for sex and age prior to analysis, using an indirect standardisation method. We express all indicators in admission rates per 1'000 population and focus our analysis on two types of indicators that reflect different aspects of quality and access to care, i.e., potentially avoidable hospitalisations (PAH), potentially inappropriate hospitalisations (PIH).

2.3.1 Potentially Avoidable Hospital Admissions (PAH)

We build this indicator around hospitalisations for ambulatory care sensitive conditions (ACSCs). These admissions are related to diseases and conditions that could potentially be avoided if adequate CBAC was available. Thus, they represent a measure of access to CBAC (primary care quality and access). We start from established lists of ICD-10 codes to identify ACSCs [19, 22, 26, 28, 46]. Each list tends to differ slightly in terms of the exact diagnostics included but there is consensus on the most important conditions and diagnostics to include. These lists have been used for a few decades now and were created for a specific purpose in an American context. Therefore, we adapt the lists to build two indicators.

First, we develop a simple list based on the most frequent diagnostics and those that are broadly present in established lists from the literature. This process yields the simplified potentially avoidable hospitalisations outcome that we will refer to as PAH_S. The purpose of this list is to provide a simplification of established lists in terms of the number of diagnostics and restrictions, so that can be easily reproduced. We used a list of ACSCs published by the OECD [30] to select the most important chronic diagnostics. The AHRQ provided confirmation of these diagnostics and expanded our list with candidates for acute conditions [29]. Each condition may have a number of diagnostics to be excluded. To simplify implementation, we only exclude relevant secondary diagnostics instead of any relevant supplementary diagnostics. We provide a list of the conditions and their corresponding ICD-10 codes in Table 3.

Table 3 PAH$_S$ ACSC list

Chronic conditions (OECD)	ICD-10 diagnostics
Asthma	J450, J451, J458, J459, J46
Chronic obstructive pulmonary disease	J40*, J410, J411, J418, J42, J430, J431, J432, J438, J439, J440, J441, J448, J449, J47 *only if accompanied by J41, J43, J44, J47
Congestive heart failure	I110, I130, I132, I500, I501, I509
Hypertension	I10, I119, I129, I139
Diabetes	E100-E109, E110-E119, E130-E139, E140-E149
Acute conditions (AHRQ)	
Community-acquired Pneumonia	J13, J14, J15211, J15212, J153, J154, J157, J159, J160, J168, J180, J181, J188, J189
Urinary tract infection	N10, N12, N151, N159, N16, N2884, N2885, N2886, N3000, N3001, N3090, N3091, N390

Note: Each category may be accompanied by restrictions on secondary diagnostics. Diagnostics are extracted from the OECD and AHRQ indicators, respectively for chronic and acute conditions. See the source material for detailed exclusions [29, 30]

This PAH$_S$ has the benefit of being simple and easy to reproduce but might lack of sensitivity or specificity. First, some ACSC conditions may be coded as secondary diagnoses (false negatives). Second, hospitalisations may be justified by other conditions or surgical procedures without any link to the ACSC condition (false positives). Thus, high rates of PAH$_S$ might be related to inpatient admissions issues (e.g., low admission thresholds in some hospitals) or to problems in outpatient facilities (e.g., poor quality services or lack of access to installed physicians). To ensure that hospital stays are related to ACSC only, it seems wise to exclude medically unjustified hospitalisations from the list.

To improve the accuracy of the indicator, we therefore apply an algorithm proposed by Eggli et al [33], which is designed to refine the selection of potentially avoidable hospitalisations. Specifically, we extend the identification of ACSCs to secondary diagnoses to improve the sensitivity of their detection. We also adapt the modified list of ACSC (excluding conditions difficult to prevent or manage by primary care) and exclude any unjustified stays from the indicator. We refer to this outcome as the complex potentially avoidable hospitalisations outcome or PAH$_C$.

2.3.2 Potentially Inappropriate Hospital Admissions (PIH)

As mentioned above, the PAH_S indicator may express a tendency of hospitals to admit certain patients too easily (for example if the occupancy rate is too low or for financial reasons), rather than a delayed access to care. We propose to use the indicator of potentially inappropriate hospitalisations (PIH) to better understand if inequity determinants have a direct influence on admission to hospitals or if the mechanism is more related to lack of access to ambulatory care.

Potentially inappropriate hospital admissions (PIH) are hospital stays where the patient was admitted to the hospital but could mostly have been treated as outpatient. For instance, Parkinson's disease, migraine, anaemia, psoriasis, thyroids disorders can usually be treated in ambulatory settings. We compute this indicator using the SQLape® algorithm, i.e. stays with diagnoses usually treated in an ambulatory setting are considered unjustified if they are associated with no other condition (diagnosis and procedures) justifying an inpatient stay [47]. As shown in a forthcoming publication [34], these PIH, or "unjustified stays" correspond to inappropriate hospitalisations from an a posteriori medical point of view; the review of a sample of hospital admissions involving senior clinicians showed that reinforcement of ambulatory settings will probably be necessary to avoid such PIH, often related to social aspects. PIH screened in our study are probably overestimated, because we were not able to exclude admissions after 6 p.m. with a discharge the next day (we did not have access to the hour of admission). The algorithm indeed consider that some time might be required to rule out serious diagnosis (e.g., meningitis in presence of fever).

2.4 Socioeconomic and cultural variables

2.4.1 Socioeconomic status

Socioeconomic status involves multiple dimensions of social disadvantage, and a variety of multidimensional indices has been developed at small area level. The Townsend and Carstairs indices in the UK are historical examples of such measures and have been widely used in previous studies focused on area-level deprivation and hospital indicators [48-50]. Similar indices have been used in many other countries, which vary according to local characteristics, access to data, and research question [51, 52]. For Switzerland, Panczak et al. developed the Swiss SEP, which encompasses four dimensions of socio-economic position: income, education, occupation, and housing conditions [53]. In this study, we create our own socioeconomic deprivation index (SDI) defined at the MedStat region level.

We select 5 MedStat level variables, each representing a specific dimension of socio-economic deprivation. The proportion of people receiving social support represents a general level of deprivation in the region. A variable that gives the probability that a given household earns less than 25,000 CHF per year measures income deprivation. We represent the education dimension with the proportion of adults (>19 years old) who did not complete mandatory schooling. Unemployment is measured with the unemployment rate (as a share of the active population) in the region. Finally, the proportion of active population who are unskilled workers reflects occupational status.

Like the SEP, the SDI uses measures that cover the domains of education, income, and occupation. The SDI then adds the employment and deprivation domains. The SDI thus provides a broad overview of socioeconomic deprivation at a regional level. Overall, we believe that these dimensions of deprivation are directly relevant to policy and, crucially, are available to extract from routinely collected administrative data. We use an approximation of the SEP, with our own variables, as a robustness check for the SDI. Details on the construction and results related to the SEP are available in the appendix.

The index is calculated as a weighted average of the 5 variables. We use a principal components analysis to obtain weights for each variable. Further information about the construction of the index is available in the appendix. We then centre the index around the national mean so that a positive value is associated with a level of deprivation that is higher than the Swiss mean, and a negative value is associated with a level of deprivation that is lower than the Swiss mean. We then explore the income dimension on its own in a separate analysis by using median income in the MedStat region as an indicator. Median income is also centred with the Swiss mean.

2.4.2 Cultural variables

Cultural differences between individuals may lead to differences in health services utilisation. In our context, cultural and socioeconomic variables are highly correlated, yet some aspects of culture are independent from socioeconomic status. A closer look at variations in hospital indicators with respect to culture is therefore interesting. Indeed, individuals from outside of Switzerland may face barriers of access to healthcare related to language or health literacy. Religion may also influence individual relationships with healthcare. For example, religious minorities may experience discrimination or perceived discrimination when accessing the healthcare system [54]. Religious belief may also influence treatment acceptance and decisions to seek healthcare [55-57]. The relationship between health and religion is complex and apparent in all religions. We do not provide a detailed mapping on this relationship; instead, we use religion as an indicator of potential cultural differences between the Swiss population that shares a mostly Christian background, and immigrant population with diverse religious backgrounds.

Cultural index

Our data on cultural aspects is more limited than for socioeconomic status. Interpretation of potential associations with health indicators is also more delicate due to the high collinearity between cultural and socioeconomic variables. We focus on four indicators that reflect cultural diversity from Switzerland. The first indicator is the proportion of Swiss nationality (acquired at birth, or naturalised) in each MedStat region, with respect to the population of the region. The second indicator is the proportion of Christians (Catholic or Protestant) in each MedStat region. The third indicator represents the proportion of individuals who immigrated from abroad in each MedStat region. Specifically, this is the proportion of the region population who came from abroad when they moved into the region. This also includes Swiss immigrants who were living abroad, i.e., return migration. It is likely that this proportion of immigrants shares a high correlation with immigrants who moved from abroad recently. We therefore use this variable as a proxy of recent immigration. The fourth indicator is the proportion of the population of the region that does not speak an official Swiss language (German, French, Italian, Romansch) as their first language. We exploit the correlation between these four indicators to create a single measure of cultural diversity using principal component analysis.

Residence permits

We have access to rates of residence permits in the population at the MedStat level. These data are obtained directly from the FSO and cover settled foreign nationals with and without gainful employment (C, Ci permits), resident foreign nationals (B permit), provisionally admitted foreigners (F permit), short-term residents (L permit), asylum seekers (N permit), and diplomats. We investigate the association between permit rates and hospital indicators with and without controls for socioeconomic status.

Country of origin in patient-level hospital data

Individual-level hospital data include a simple nationality variable that allows us to calculate hospital indicators separately for Swiss and foreign populations, as a complementary, separate, analysis. We obtained a more granular nationality variable and foreigners were further divided into 10 regions of origin: namely Western Europe, Eastern Europe, Northern Europe, Africa, North America, South and Central America, East Asia, South Asia (incl. Middle East), Oceania, and North Asia. Finer stratification was not available due to data protection issues. In our analysis, and due to small numbers of observations, we further regroup America into one single category, and joined East and North Asia, as well as South Asia and Oceania, ending up with seven categories of foreign origin.

We first compare admission rates between the Swiss and foreign population with age-sex standardisation at the MedStat region level. Second, we compare admission rates between the seven origin categories and Swiss nationality with age-sex standardisation at the canton level. The higher level of aggregation for standardisation is due to the limited number of observations at the MedStat level in some subgroups. We find that canton-level standardisation gives results that are more reliable in this instance. Third, we compare admission rates between origin categories and Swiss nationality by age category and without age-sex standardisation.

2.5 Statistical Methods

2.5.1 Descriptive analysis

We first show the distribution of the socioeconomic and hospitalisation indicators, between cantons with boxplots, and across the country with maps. We then estimate ordinary least squares models, with the hospital indicator as dependent variable and the SDI (score centred on the Swiss mean) as our independent variable. The gradient, captured by the coefficient on SDI in the models, therefore reflects the association between deprivation and the rate of potentially avoidable admissions. We also run the models at cantonal level, and over time. Direct comparisons between cantons and with the national gradient is possible as we use an absolute measure of deprivation with the SDI. We present these comparisons in graphical format for selected cantons in 2017, and in a table format for the rest of the results. We complete the analysis with a focus on the income dimension as the sole socioeconomic indicator. To conclude the descriptive part, we present a summary of the robustness checks and our analysis of alternative hospital indicators.

Gradient at the national level

The equation below shows the exact model specification we use to produce the Swiss gradient for a given index and indicator. The model also includes total population in the MedStat region as a weight (not shown here to simplify notation).

$$Indicator_i = \beta_0 + \beta_1 Index_j + \varepsilon$$

$$i = \{PAH_S, PAH_C, PIH\}, \qquad j = \{SDI, INC\}$$

In this simple regression, we have an intercept and a slope. The slope is what we call the Swiss gradient, it shows us by how much the indicator increase (or decreases) if we add 1 unit to the index (either the SDI or the INC)

Comparisons between cantons

We would like to determine a gradient for each canton and assess whether this gradient is statistically different from the national gradient. A simple two-level model, with MedStat regions as the first level and cantons as the second level, is suitable to this task. In this type of model, we can compare the mean slope (gradient) for Switzerland with the individual slope for each canton. We do this by fitting a random slope model. We also add a random intercept in the model to account for variation in canton characteristics. The model is specified as follows:

$$Indicator_{ij} = \beta_0 + \beta_1 Index_{ij} + u_{0j} + u_{1j} * Index_{ij} + \varepsilon_{0ij}$$

Where $\mathrm{Indicator_{ij}}$ represents one of the hospital indicators for region i, in canton j. β_0 is the mean intercept for Switzerland, and β_1 is the mean gradient for Switzerland. The difference in intercept with the mean for each canton is given by u_{0j}, such that $\beta_0 + u_{0j}$ is the intercept for each canton. u_{1j} is the difference in slope with the Swiss mean, for each canton. ε_{0ij} is the residual error term. We are particularly interested in u_{1j}, the difference in slope with the Swiss mean, for each canton. This coefficient is the actual gradient that we want to determine. We can then compare it with the mean gradient for Switzerland estimated by β_1.

Potential avoided costs

Once we have determined the existence of a socioeconomic gradient in potentially avoidable and/or potentially inappropriate hospitalisations, we can calculate the potential gains, in terms of hospitalisations, if we were to reduce potentially avoidable hospitalisations (PAH) or potentially inappropriate hospitalisations (PIH) in the most deprived regions. To investigate this, we separate the 705 MedStat regions into 10 categories, each made up of the same number of regions (deciles), from the least deprived to the most deprived in terms of SDI. The first decile includes the 10% of regions with the lowest SDI (i.e., the least deprived regions), the second decile includes the 10% of regions with the second lowest SDI, and so on until the tenth decile which includes the 10% of regions with the highest SDI (i.e., the most deprived regions). Following that, we create six options to reduce disparities in deprivation between regions and therefore generate potential gains.

I. Work to lower PAH or PIH for the top 10% most deprived regions (decile 10) so that they reach the top 20% most deprived regions (decile 9).
II. Work to lower PAH or PIH for the top 10% most deprived regions (decile 10) so that they reach the Swiss mean of PAH or PIH.
III. Work to lower PAH or PIH for the top 20% most deprived regions (deciles 9 and 10) so that they reach the Swiss mean of PAH or PIH.
IV. Work to lower PAH or PIH for the top 50% most deprived regions (deciles 5 to 10) so that they reach the Swiss mean of PAH or PIH.
V. Work to bring all MedStat regions towards the Swiss mean as an upper bound.
VI. Work to bring all MedStat regions towards the level of the least deprived 10% (decile 1).

Admittedly, some of these options would be quite difficult, or even impossible, to achieve in practice. We rank the options by degree of practicality. For example, option VI is meant as a thought exercise to explore the maximum theoretical gains achievable for the system. Option I would be the most easily achievable, followed by options II and III.

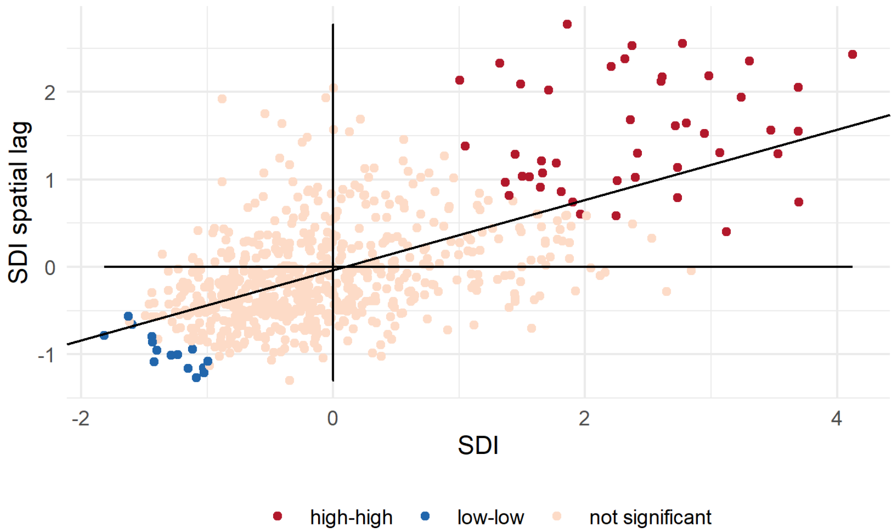
We measure potential gains with three variables and focus on the year 2017 only. First, in terms of PAH or PIH hospitalisations per 1000, the same indicator used throughout the study, which is age and sex standardised. Second, we estimate the total number of hospitalisations (for PAH or PIH) that it would represent in terms of the decile population. We convert hospitalisations per 1000 population into hospitalisations in the deciles considered (divide by 1000 and multiply by population). For example, in option III we would consider the population of the two most deprived deciles. We also extrapolate the total number of hospitalisations it could represent in Switzerland by using the total population of Switzerland for all options. Third, we estimate the average savings in CHF that it would represent, using Swiss DRG cost weights. This is a very rough indicator since the base rate that must be applied to the cost weight, to convert to CHF, varies between providers. Here, we select an average base rate for Switzerland of 9500. We start by computing the total cost of PAH hospitalisations and divide it by the total number of PAH hospitalisations in 2017 so that we have an average cost for a PAH hospitalisation (we follow the same procedure for PIH). We then multiply this average by the total number of hospitalisations gained for each option (second variable above) to get an estimate of financial gains for each option.

Spatial analysis

In the analysis described above, we have ignored the potential spatial correlations between the variables of interest. This section is devoted to the study of these spatial relationships. We start by focusing on the variables of interest from the descriptive analysis, namely potentially avoidable hospitalisations (PAH), potentially inappropriate hospitalisations (PIH), and socioeconomic status (SDI). Spatial relationships are likely to remain similar through time; hence, we produce the results only for the year 2017.

We create a row standardized spatial weights matrix W based on queen contiguity for the variables of interest. Figure 2 illustrates the output of a Moran's plot which provides a graphical representation of the relationship between a region and its neighbours and lets us measure spatial correlation with Moran's I [58, 59]. It shows, for each unit of analysis (i.e., MedStat regions in our case), the standardized outcome of interest on the horizontal axis, and the outcome for neighbouring regions on the vertical axis. The slope of the fit line is Moran's I. Then, we produce maps of local spatial autocorrelation that are intended to isolate clusters of high activity or low activity, so called hot spots and cold spots. In such measures, standard p-value calculations may produce inadequate results because of the multiple comparisons problem. To limit the chance of Type I error, we adjust p-values with the Bonferroni method. Such graphical representation allows identifying clusters of regions with high and low rates of avoidable hospitalisations (in simplified terms, regions with high rates that are surrounded with regions with high rates). Hot and cold spots are also represented in Figure 2.

Figure 2 Illustration of the Moran's plot



Variation through time

There is almost no variation in our variables of interest for the years that we have available (2014 to 2017). Rather than presenting intricate models to investigate changes in time, we show the time trend in simple descriptive plots. Later in the analysis, we focus on the most recent year available and investigate regional variation in the spatial and socioeconomic dimensions.

2.5.2 Multi-variable analysis

We explore the associations found in the descriptive analysis, and test hypotheses formulated in the conceptual framework (see Table 1), using multi-variable models. We are particularly interested in the effect of healthcare supply on the hospital indicators since we did not explore this relationship in the descriptive analysis. We would also like to test the robustness of associations identified in the descriptive analysis. We perform the analysis in cross section only for the year 2017, since the descriptive analysis revealed that relationships are stable over time (see section 3). Estimating models that correct for the hierarchical nature of the data (regions within cantons) and its spatial nature (regions neighbouring each other) is statistically demanding. We therefore estimated both types of models separately. Multilevel models account for the specific hierarchical relationships in the data. Spatial autoregressive models account for the spatial relationships shared between regions. We focused the analysis on models correcting for hierarchical effects and used spatial autoregressive models in conjunction with spatial clustering (section 2.5.1) to check result consistency.

Dependant variables

We focus on three dependant variables, i.e., PAH_S, PAH_C, PIH. All are expressed as hospital admissions per 1000 population. A detailed explanation of the meaning of the indicators can be found in section 2.3.

MedStat-level variables

For socioeconomic deprivation, we use both an aggregated approach using the SDI as the main independent variable in the model (see section 2.4), and a disaggregated approach in which each component of the SDI is introduced in the models. In addition, we include the median income in the region (INC). We model medical density at the MedStat level with two variables that measure the travel time to the closest general practitioner and to the closest specialist, respectively. The distinctions between the categories of healthcare supply are made using the General Classification of Economic Activities (NOGA 2008). We also include variables capturing cultural diversity in the regions, i.e., the CLT (see section 2.4.2). We estimate specifications with the CLT aggregated and separated into individual components in the same approach as with the SDI. As a control, we also add a categorical variable that specifies whether the region has an urban, suburban, or rural topography.[3]

Canton-level variables

We complement our regional density measure using the number of hospital beds per 1000 population. We control for population density (1000 pop. per km^2), a dummy for cantons with a Latin language (French or Italian) as main language (i.e., GE, VD, NE, JU, FR, VS, TI), a variable expressing the proportion of individuals who choose a standard insurance model in the canton, and a variable expressing the proportion of individuals who chose a deductible level of 300CHF in the canton.

It should be kept in mind that canton-level variables do not completely overlap with MedStat level variables. Individuals are free to seek treatment anywhere in Switzerland and, in this study, we do not know in which hospital they are admitted. Overall, we assume that they are more likely to be treated in their own canton and link MedStat regions with their own canton. This assumption may not hold, in particular for MedStat regions close to cantonal borders, specialised treatments that require a university hospital, or language barriers (e.g. German speaking individuals from canton Fribourg would likely seek treatment in neighbouring canton Bern [60]).

[3] Finalised data for the year 2017 were not yet available at the time of extraction. We therefore reused data from 2016 for 2017 as the variation in socioeconomic indicators in the previous years was very small.

Model Specifications

We estimate multilevel regression models with the rate of residence-based admissions (per 1000) as our dependant variable. We estimate specifications with each of the two approaches mentioned above (SDI and disaggregated). We specify to hierarchical levels with level 1 being the MedStat region and level 2 the canton. We return here to the 26 cantons as they actually exist since the hierarchical structure specified here is more robust to small cantons than the methods we used in the descriptive part. The models include a random intercept and a random slope:

$$Indicator_{i,j} = \beta_0 + \beta_1 Index_{i,j} + \boldsymbol{\beta}_2 \boldsymbol{X}_{i,j} + u_{0,j} + u_{1,j} Index_{i,j} + \varepsilon_{0,i,j}$$

Our dependent outcome variable is the hospital indicator for region *i* in canton *j.* Each MedStat region is numbered from $i = 1, \dots, 705$, and cantons go from $j = 1, \dots, 26$. β_0 is the mean intercept, β_1 is the mean slope with respect to the SDI, $\boldsymbol{\beta}_2$ and a vector of slopes related to the other independent variables in matrix $\boldsymbol{X}_{i,j}$. $u_{0,j}$ is the random intercept term and $u_{1,j}$ is the random slope term for the index. $\varepsilon_{0,i,j}$ is the residual error term for region *i* and canton *j*.

To ease interpretation, we normalised[4] all independent variables except for factor variables (region topography and Latin canton dummy variables).

2.5.3 Statistical software

Statistical analyses in this report were conducted with Stata (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC) and R (R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/). We built the hospital indicators and socioeconomic indices with Stata IC version 16. We also merged the datasets with Stata. All descriptive multivariable analyses, including all tables and graphics, were produced with R, using RStudio (RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA http://www.rstudio.com/).

[4] Not to be confused with the concept of standardisation mentioned elsewhere in the report. Normalisation is a statistical transformation that brings the Normal distribution of a variable (with mean μ and standard deviation σ) to the standard Normal distribution (with mean 0 and standard deviation 1). We do this in order to obtain variables that share the same scale and thus can be easily interpreted.
Standardisation, on the other hand, is a transformation used in epidemiology when we want to remove the confounding effect of variables that differ in populations we wish to compare. In this study, we use age-sex standardisation to account for the differences in the age-sex distributions between MedStat regions.

R packages used in the analysis

We used the Tidyverse package[5] to structure and manipulate the data in the descriptive and multi-variable analyses. Most graphical outputs, with the exception of maps, were created with the ggplot2 package (part of the Tidyverse). Correlation plots were created with the corrplot package[6]. Spatial analysis was performed with the following packages: sp[7], rgdal[8], rgeos[9], and spdep[10]. Maps were created with the Thematic maps package (tmap)[11]. We used the lme4[12] and lmerTest[13] packages for multilevel models and the spatialreg[14] package for SAR models. Finally a few packages were used to manage custom fonts, colour palettes, and plot grids.

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5 Wickham et al., (2019). Welcome to the Tidyverse. Journal of Open Source Software, 4(43), 1686, https://doi.org/10.21105/joss.01686

6 Wei T, Simko V (2021). R package "corrplot": Visualization of a Correlation Matrix. (Version 0.88), https://github.com/taiyun/corrplot

7 Pebesma EJ, Bivand RS (2005). "Classes and methods for spatial data in R." R News, 5(2), 9–13. https://CRAN.R-project.org/doc/Rnews/
Bivand RS, Pebesma E, Gomez-Rubio V (2013). Applied spatial data analysis with R, Second edition. Springer, NY. https://asdar-book.org/

8 Roger Bivand, Tim Keitt and Barry Rowlingson (2020). rgdal: Bindings for the 'Geospatial' Data Abstraction Library. R package version 1.5-16. https://CRAN.R-project.org/package=rgdal

9 Roger Bivand and Colin Rundel (2020). rgeos: Interface to Geometry Engine - Open Source ('GEOS'). R package version 0.5-5. https://CRAN.R-project.org/package=rgeos

10 Bivand, Roger S. and Wong, David W. S. (2018) Comparing implementations of global and local indicators of spatial association TEST, 27(3), 716-748. URL https://doi.org/10.1007/s11749-018-0599-x

11 Tennekes M (2018). "tmap: Thematic Maps in R." Journal of Statistical Software, 84(6), 1–39. doi: 10.18637/jss.v084.i06

12 Douglas Bates, Martin Maechler, Ben Bolker, Steve Walker (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48. doi:10.18637/jss.v067.i01.

13 Kuznetsova A, Brockhoff PB, Christensen RHB (2017). "lmerTest Package: Tests in Linear Mixed Effects Models." Journal of Statistical Software_, *82*(13), 1-26. doi: 10.18637/jss.v082.i13 (URL: https://doi.org/10.18637/jss.v082.i13).

14 Roger Bivand, Gianfranco Piras (2015). Comparing Implementations of Estimation Methods for Spatial Econometrics. Journal of Statistical Software, 63(18), 1-36. URL http://www.jstatsoft.org/v63/i18/
Bivand, R. S., Hauke, J., and Kossowski, T. (2013). Computing the Jacobian in Gaussian spatial autoregressive models: An illustrated comparison of available methods. Geographical Analysis, 45(2), 150-179. URL https://doi.org/10.1111/gean.12008
Roger S. Bivand, Edzer Pebesma, Virgilio Gomez-Rubio, 2013. Applied spatial data analysis with R, Second edition. Springer, NY. http://www.asdar-book.org/

3. Results of the Descriptive Analysis

We present results for both the socioeconomic deprivation (SDI) and the income (INC) index in relation to each hospital indicator. We start by showing variation between regions and between cantons in boxplot and map formats, for all indices and indicators.

For each indicator, we show a scatterplot highlighting the national gradient, and a coefficient plot showing slope and intercept coefficients with confidence intervals, for each canton with respect to the Swiss mean. We show separate figures for the SDI and the income index.

We then discuss sensitivity analyses performed with alternative indicators and indices. The spatial analysis subsection presents hot and cold spot clusters for indices and hospital indicators in map format. We present results related to cultural and migration variables, and their associations with hospital indicators. We discuss the potential financial savings of reducing PAH and PIH. Finally, the time variation subsection presents boxplots of the indices and hospital indicators through time.

Figure 3 Correlation between variables of interest for 2017

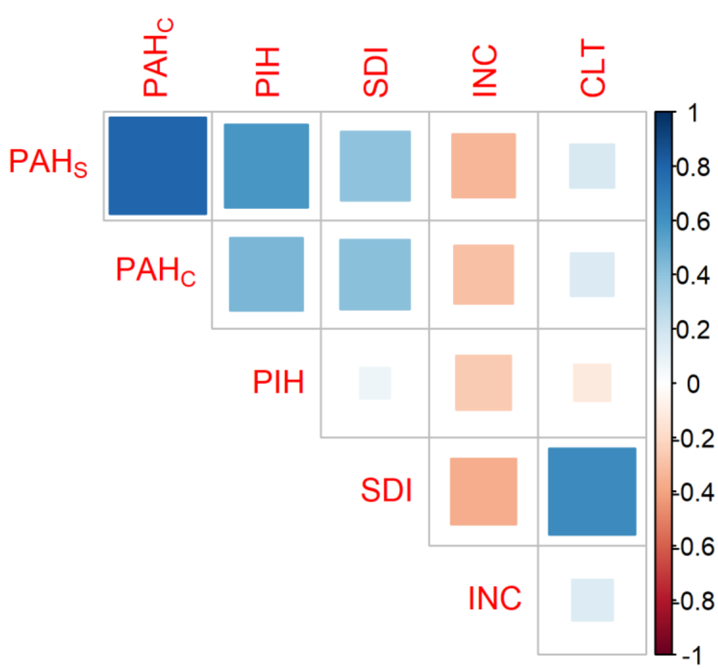


Figure 3 shows a graphical representation of the correlation matrix between our variables of interest (full table available in the appendix). Both PAH_S (potentially avoidable hospitalisations simple list) and PAH_C (potentially avoidable hospitalisations complex list) have a strong positive correlation with each other (0.848). This is expected since they represent different ways of measuring the same effect. PAH_S and PAH_C also share a positive correlation with PIH and PSY, although it is not as strong as with each other. Moving to socioeconomic indicators, SDI is positively correlated with PAH_S and PAH_C, and INC is negatively correlated with the hospital indicators. This hints at a positive gradient between potentially avoidable hospitalisations and socioeconomic status. Interestingly, there is almost no correlation between PIH and SDI, which would indicate that PIH (potentially inappropriate hospitalisations) is not associated with socioeconomic status. Overall, this first correlation table confirms the hypotheses we put forth in our conceptual framework (Table 1).

Table 4 Summary statistics of MedStat regions

MedStat region characteristics for 2017 (N = 705)

Hospital indicators	Mean	Std dev	Median	Min	Max
PAH_S	8.037	1.925	7.928	1.968	22.558
PAH_C	7.709	1.642	7.564	2.187	17.707
PIH	7.926	2.526	7.465	2.330	24.925
Socioeconomic variables					
Population	11942.64	5953.43	10564	1202	39293
SDI	0.000	1.000	-0.208	-1.855	4.123
INC (centred median income)	0.000	1.000	-0.129	-2.772	7.974
Median income (CHF)	33665	7490.8	32700	12900	93400

Table 4 shows some descriptive statistics of our data. There are 705 MedStat regions in Switzerland with a mean population of just below 12,000 and a range of 1202 to 39,293. The SDI ranges from -1.85 to 4.12 deviations from the mean, and INC from -2.77 to 7.97, again as deviation with respect to the mean. Hospital indicators have a mean of 8.04 for PAH_S, 7.71 for PAH_C and 7.93 for PIH, with ranges of 1.97 to 22, 2.19 to 18, and 2.3 to 25, respectively.

PAH_S	Potentially Avoidable Hospitalisations – Simplified list
PAH_C	Potentially Avoidable Hospitalisations – Complex list
PIH	Potentially Inappropriate Hospitalisations
SDI	Socioeconomic Deprivation Index

3.1 Geographical variation of the socioeconomic index (SDI) and income (INC)

Figure 4 shows the distribution of the SDI in our 16 cantons/regions of analysis, where a higher value of the index reflects higher levels of deprivation, and with the MedStat area as the unit of analysis. The lowest mean levels of deprivation are observed in the cantons of GR and ZH-ZG, whereas the cantons of GE and NE exhibit the highest levels of deprivation. Overall, cantons in the French-speaking part of the country show higher mean levels of deprivation. We also observe important within-canton variation, in BS-BL-SO, BE, VD, NE, and GE.

Figure 4 Distribution of SDI for canton groups

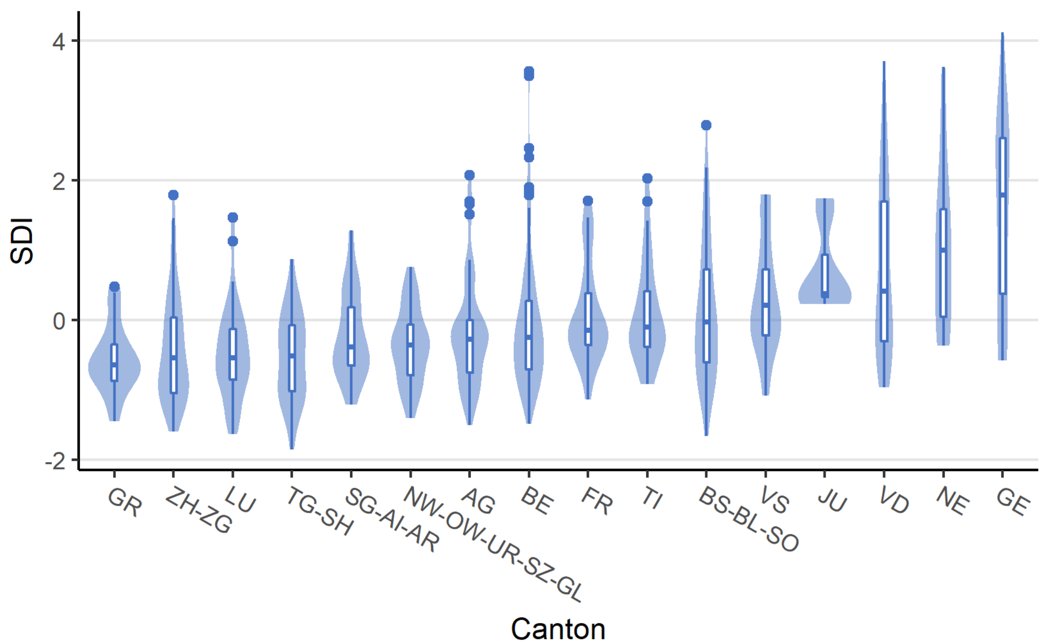
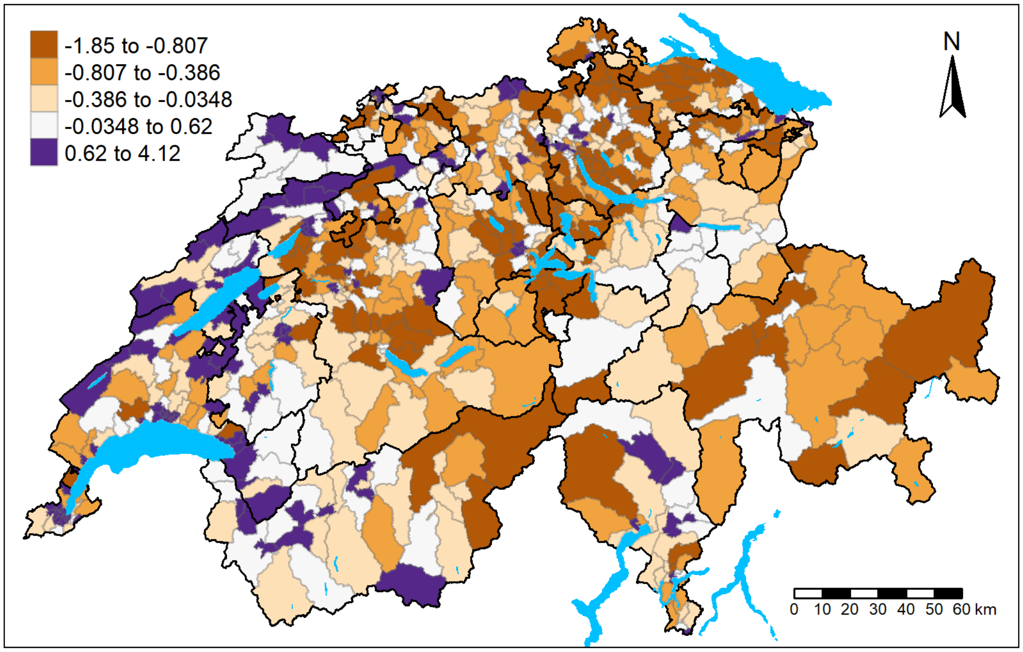


Figure 5 provides a different perspective and describes the spatial distribution of the SDI. It better illustrates the within-canton variation of the SDI. The map also shows higher levels of deprivation for the French speaking cantons located in the western part of the country.

Figure 5　　Spatial distribution of SDI



We then turn to Figure 6 that shows the distribution of INC in the various cantons/regions. Cantons of Vaud, Geneva, and Zug-Zürich have the most income variation. The cantons with the largest INC (at the region level) are Zug-Zürich, Aargau, and Geneva. We observe relatively important income disparities. INC is normalised in the figure. The "poorest" canton has a median income that is 1 standard deviation lower than the mean of the median income in Switzerland. The "richest" canton has an INC value of roughly 0.5 standard deviations higher than the mean. It is worth noting that the regions with high SDI are not necessarily those with low INC. It therefore reinforces the need to look at these two dimensions separately. Figure 7 shows a clear, and expected, spatial concentration if high-income areas around large cities.

Figure 6 Distribution of INC for canton groups

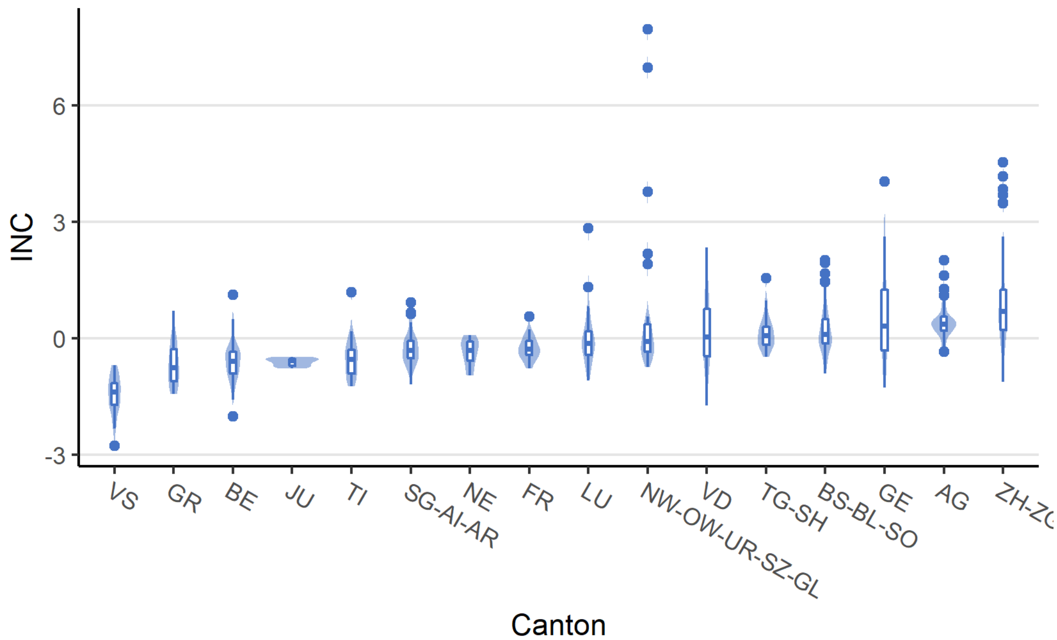
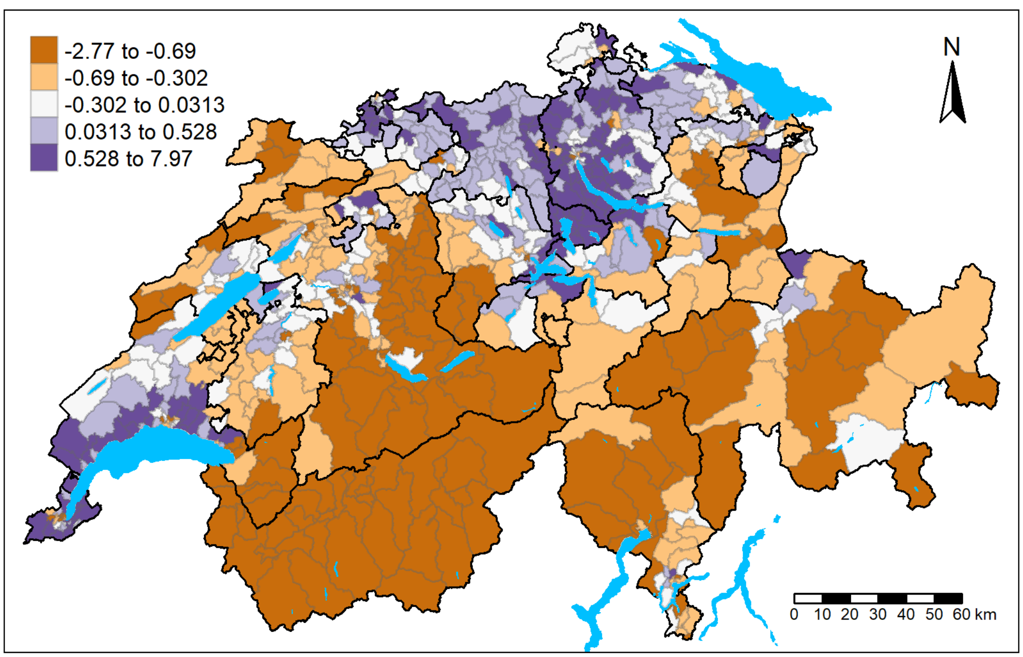


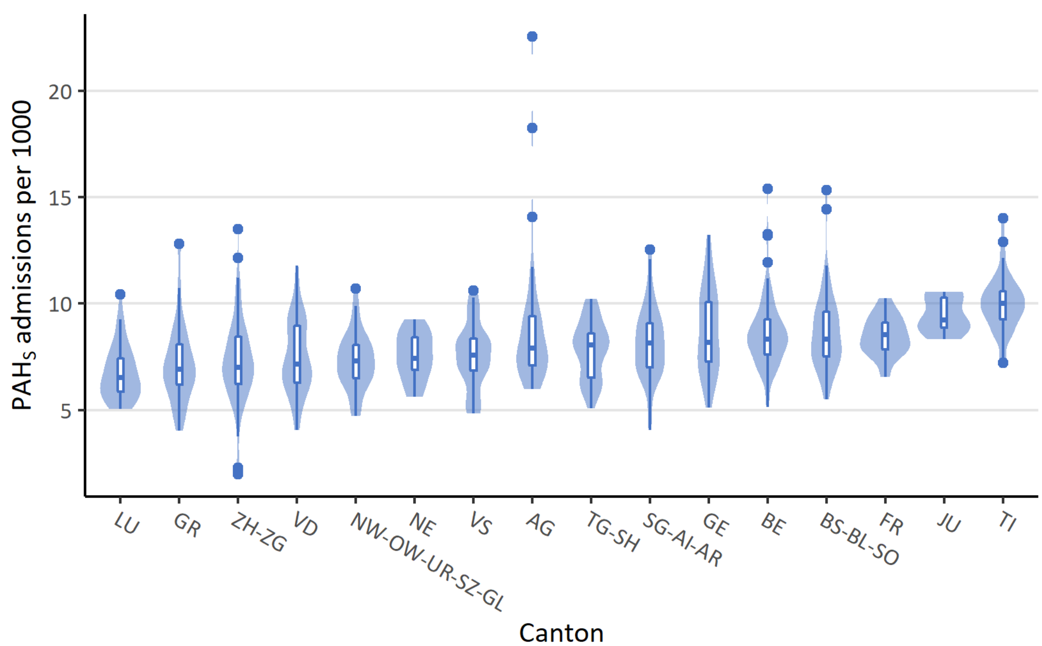
Figure 7 Spatial distribution of INC



3.2 Geographical variation of potentially avoidable admissions (PAH)

We start by presenting the variation of our main indicator of interest (PAH_S) for the whole country and for each canton in Figure 8. Overall, we observe important variation in the country, with hospital admissions for PAH_S ranging from 2 per 1'000 pop. to above 20 per 1'000. We also observe regions with relatively high rates of admissions that cover multiple MedStat regions and cross-cantonal borders (Figure 9). Potential clusters of high admission rates will be explored subsequent spatial analyses. Results for PAH_C (Figure 10) also reveal important between- and within-canton variation in outcomes. For instance, the canton of Lucerne has an average admission rate of 6 per 1'000, with a relatively small intra-canton variation, whereas the canton of Vaud has an average slightly above 8, but with a very wide intra-canton variation. The canton-level average ranges from slightly below 6 to slightly above 10, respectively, in Lucerne and Jura.

Figure 8 Distribution of PAH_S for canton groups



PAH_S	Potentially Avoidable Hospitalisations – Simplified list
PAH_C	Potentially Avoidable Hospitalisations – Complex list
PIH	Potentially Inappropriate Hospitalisations
SDI	Socioeconomic Deprivation Index

Figure 9 Spatial distribution of PAH_S

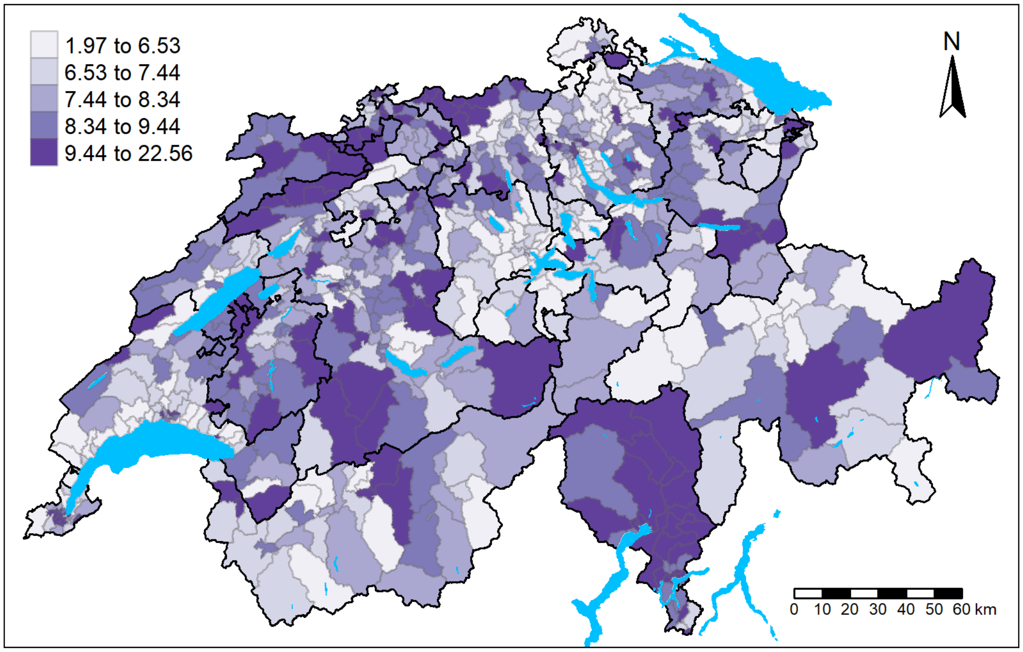


Figure 10 Distribution of PAH_C for canton groups

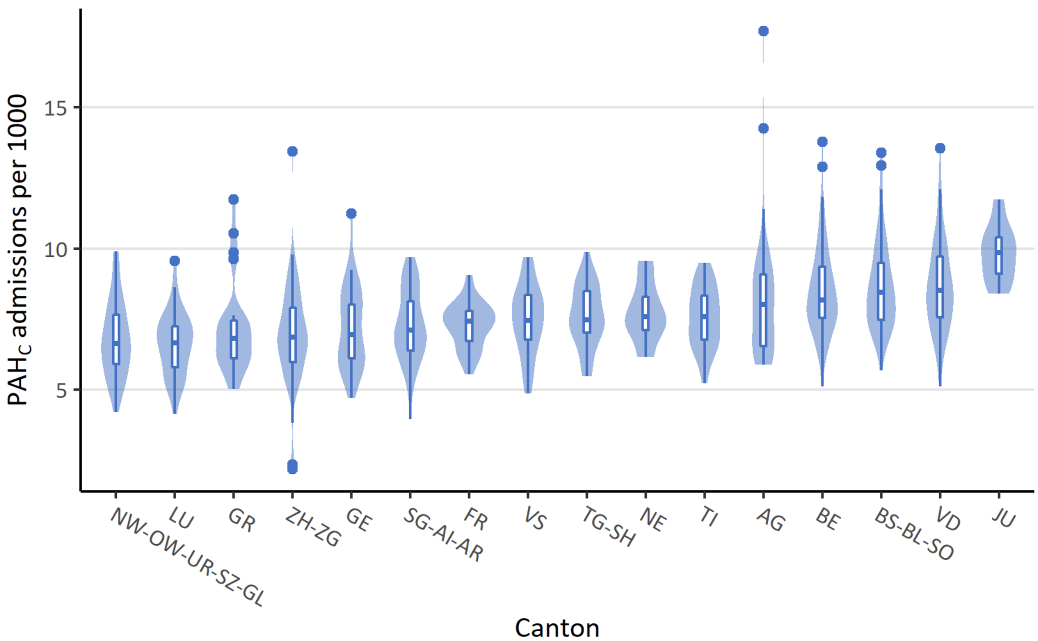
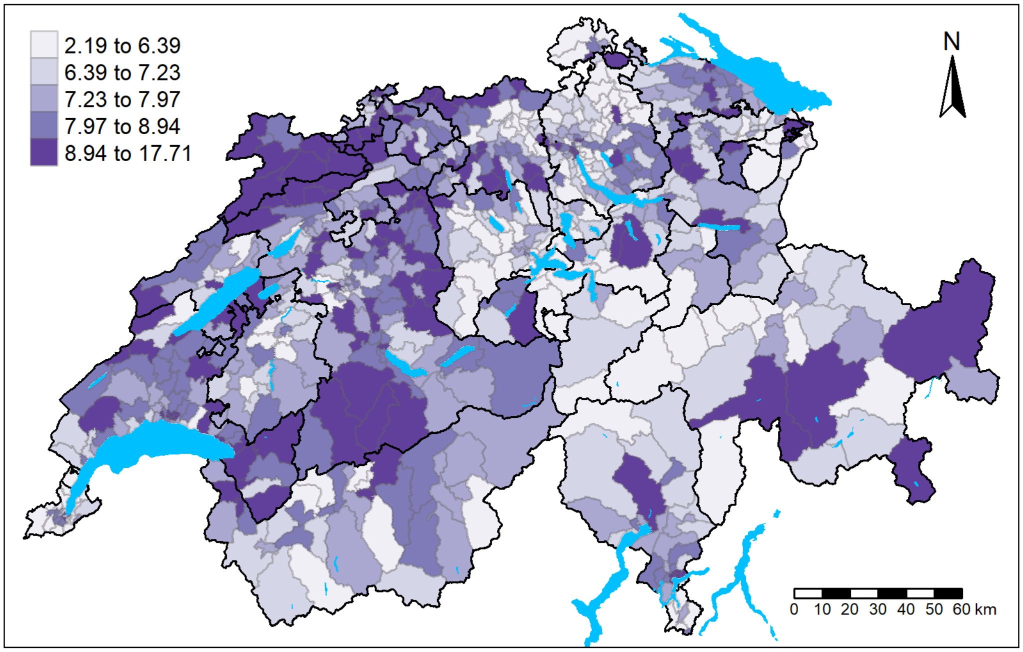


Figure 11 Spatial distribution of PAH_C



3.3 Geographical variation of potentially inappropriate hospital admissions (PIH)

We present the variation of our indicator for PIH across canton groups in Figure 12 and its spatial distribution in Figure 13. Overall, we observe important variation in the country, with hospital admissions for PIH ranging from 1 per 1'000 pop. to almost 25 per 1'000. The variation for this indicator is similar in magnitude to the PAH_S and PAH_C indicators. Figure 13 shows higher rates of admissions in the mountain regions of the Alps and North-Western Switzerland. Potential clusters of high admission rates will be explored subsequent spatial analyses.

Figure 12 Distribution of PIH for canton groups

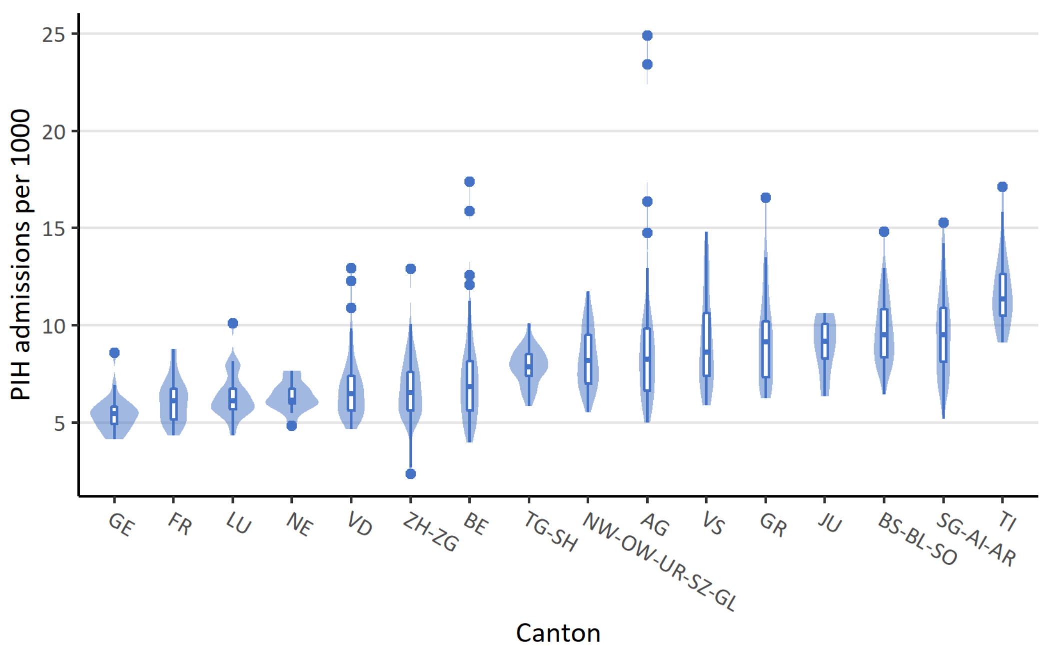
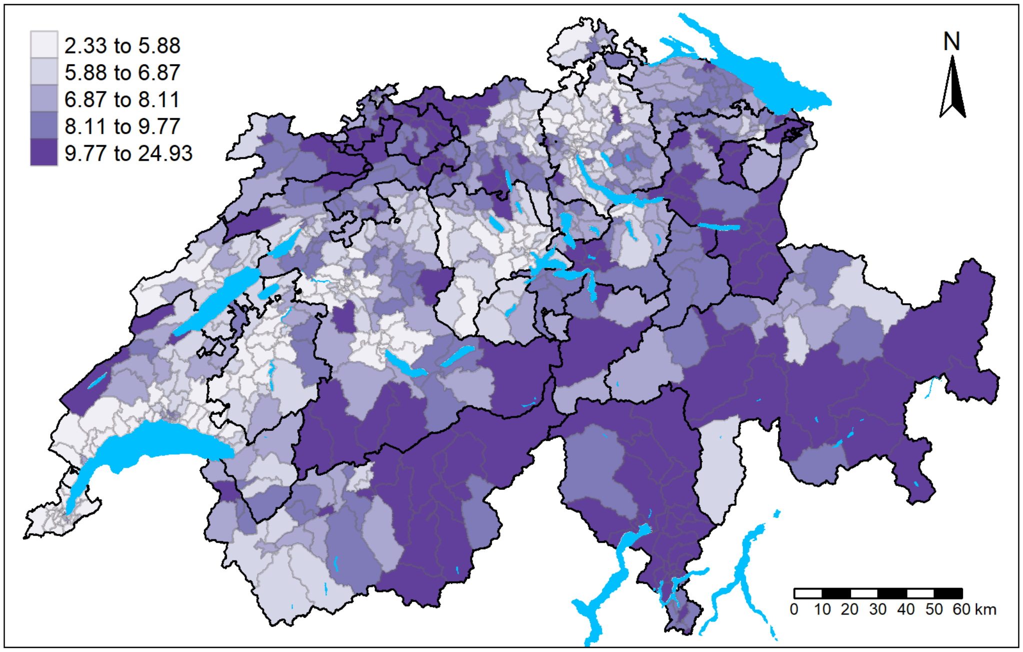


Figure 13 Spatial distribution of PIH



3.4 Socioeconomic gradients of potentially avoidable admissions (PAH)

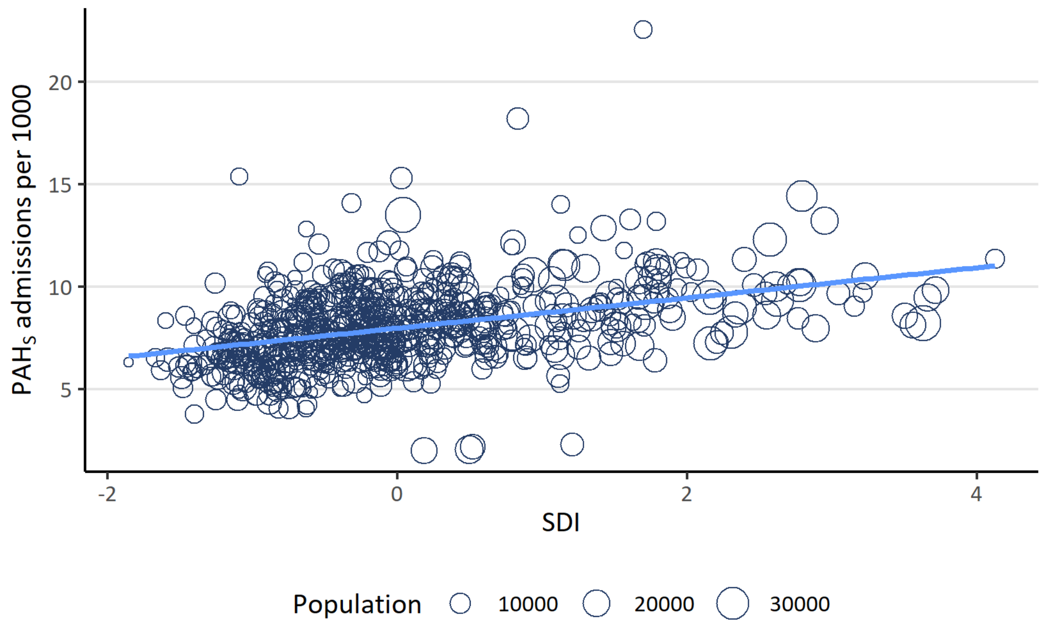
3.4.1 SDI gradient

Figure 14 shows the socioeconomic gradient in admissions calculated at the national level using the PAH_S indicator. We observe a positive relationship between deprivation and the rate of potentially avoidable admissions. These results also show that there are other strong drivers of admissions with regions displaying high or low rates of admissions while having an SDI index close to the average.

Figure 15A shows the gradients in all groups of cantons to illustrate a variety of canton-level gradients and how they compare to the national gradient. The horizontal line represents the national gradient. Each point shows how the canton gradient relates to the national one. Vertical bars are 95% confidence intervals, such that a canton gradient is significantly different from the national gradient if the vertical bar does not intersect the horizontal line. Canton AG for instance, has a gradient that is significantly higher than the national gradient. The other cantons are placed above, or below the national gradient but this variation is not statistically significant. All canton gradients remain positive.

Figure 15B shows canton-level variation of the intercept. This represents the mean level of admissions for a given SDI of 0 (the mean of the SDI). The horizontal line shows the mean intercept for Switzerland, vertical lines are error bars and points are the intercept for each canton group. The intercept varies from around 7 per 1000 for canton Vaud to above 9 per 1000 for canton Ticino. Some cantons, for instance VD, VS, LU, or NE, have a mean level of PAH_S admissions below the national average. Others like TI, BE, AG, or BL-BS-SO, have a mean level of PAH_S admissions above the national average.

Figure 14 PAH$_S$ gradient with SDI for Switzerland



PAH$_S$	Potentially Avoidable Hospitalisations – Simplified list
PAH$_C$	Potentially Avoidable Hospitalisations – Complex list
PIH	Potentially Inappropriate Hospitalisations
SDI	Socioeconomic Deprivation Index

Figure 15 PAH$_S$ gradients with SDI by canton

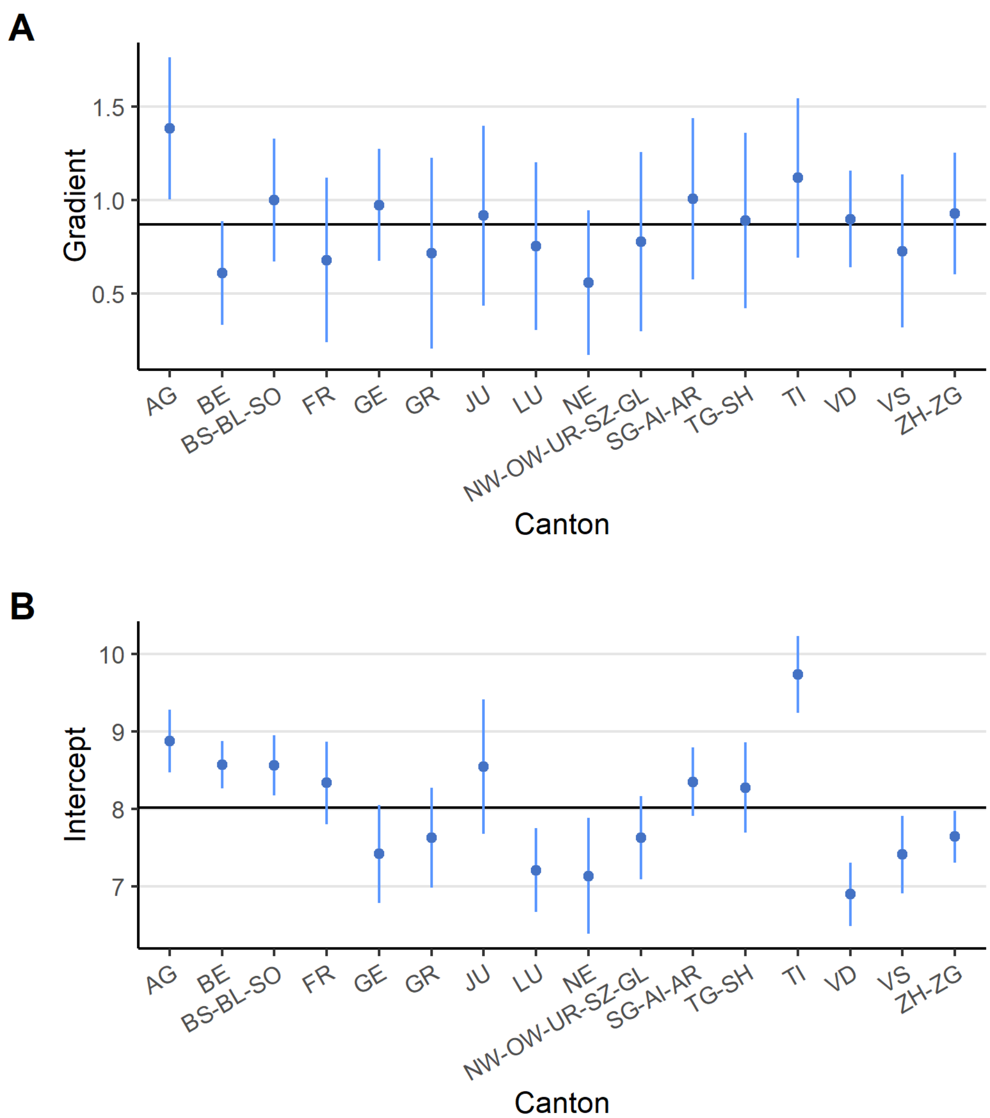


Figure 16 shows the national gradient for PAH_C. We see a positive gradient that is very similar to the one displayed previously for the PAH_S indicator. Once again, this means that regions with a lower SDI are associated with less PAH_C than regions with a higher SDI. Figure 17A compares canton gradients with the national gradient. It shows no statistically significant differences between the cantons and Switzerland as a whole, except for canton AG. Figure 17B shows the mean number of admissions by canton group, for a given SDI. We see significant variation with respect to the national mean for multiple canton groups. Cantons BE, BS-BL-SO, JU, and AG have an intercept that is above the national one. Cantons GE, LU, NW-OW-UR-SZ-GL and ZH-ZG have an intercept below the national average.

Figure 16 PAH_C gradient with SDI for Switzerland

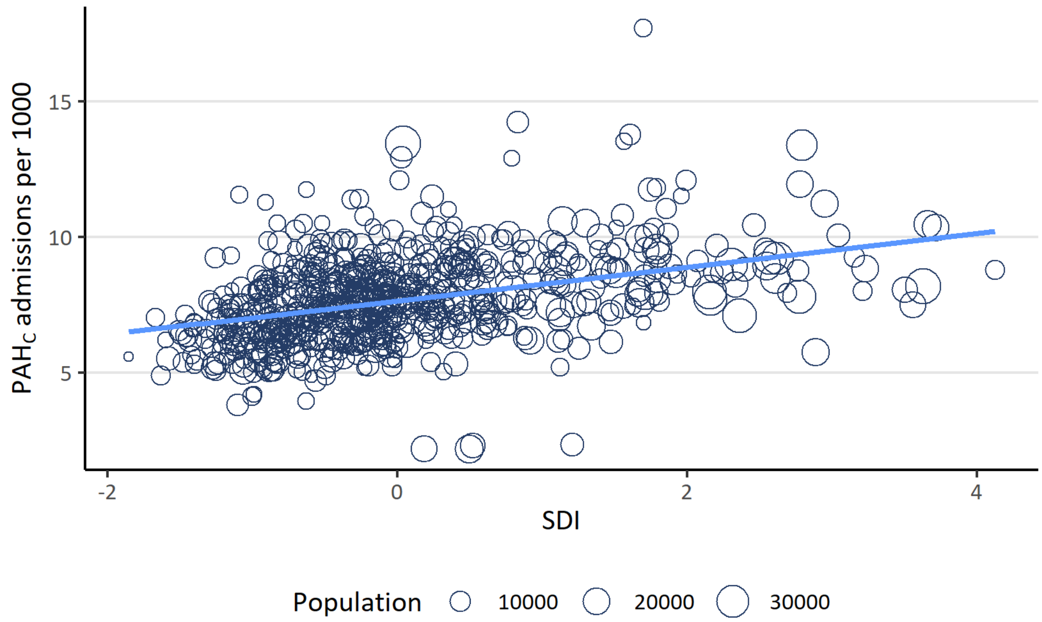
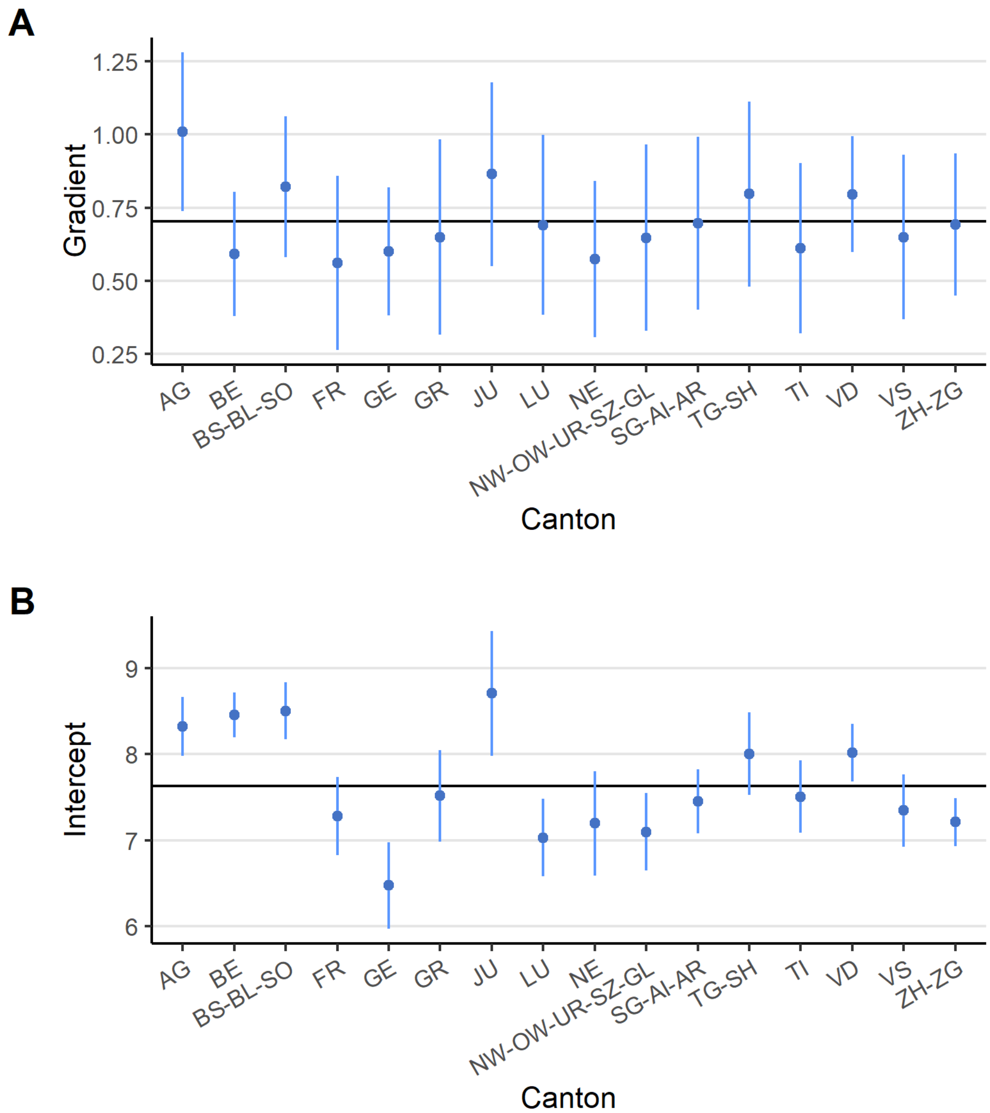


Figure 17 PAH$_C$ gradients with SDI by canton



3.4.2 Income gradient

The principal component analysis identified two important dimensions of socioeconomic status. The first is explained by the SDI and the variables included in it. The second is explained by INC. In this section we investigate this dimension more closely. Figure 18 shows global INC gradients for Switzerland. We see a negative association between PAH_S and INC.

Figure 18 PAH_S gradient with INC for Switzerland

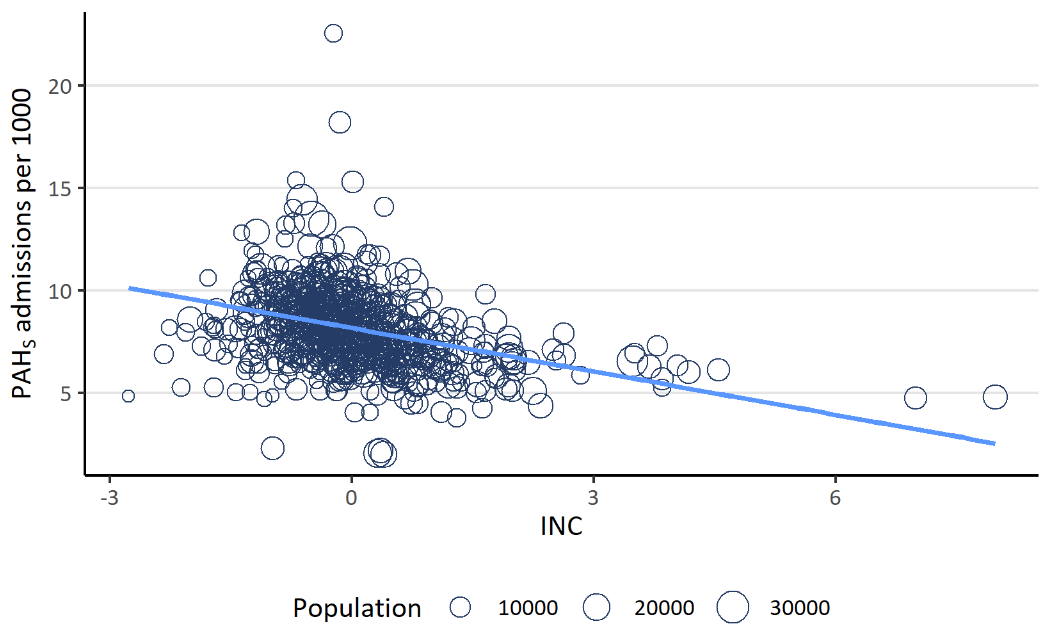


Figure 19A compares canton gradients with the national one. It appears that most cantons, with the potential exceptions of VS, GR, and LU, have negative gradients between PAH_S and INC. Zürich-Zug, Central Switzerland and Valais have flatter gradients (closer to zero) than Switzerland. This means that, in these cantons, the association between INC and PAH_S is not as negative as for Switzerland as a whole. In contrast, cantons Argau and Vaud show a gradient that is steeper than the one for Switzerland.

Figure 19B shows the mean level of PAH_S admissions for a given level of INC, by canton groups. Cantons GR and LU are below the national average. Cantons AG, BS-BL-SO, GE, and TI are above the national average. Overall, we see more variation for intercepts than for gradients. The results for PAH_C, from Figure 20 to Figure 21, are similar with the notable exception of JU that becomes statistically significant with a gradient below the national mean and an intercept above the national mean.

Figure 19 **PAH$_S$ gradients with INC by canton**

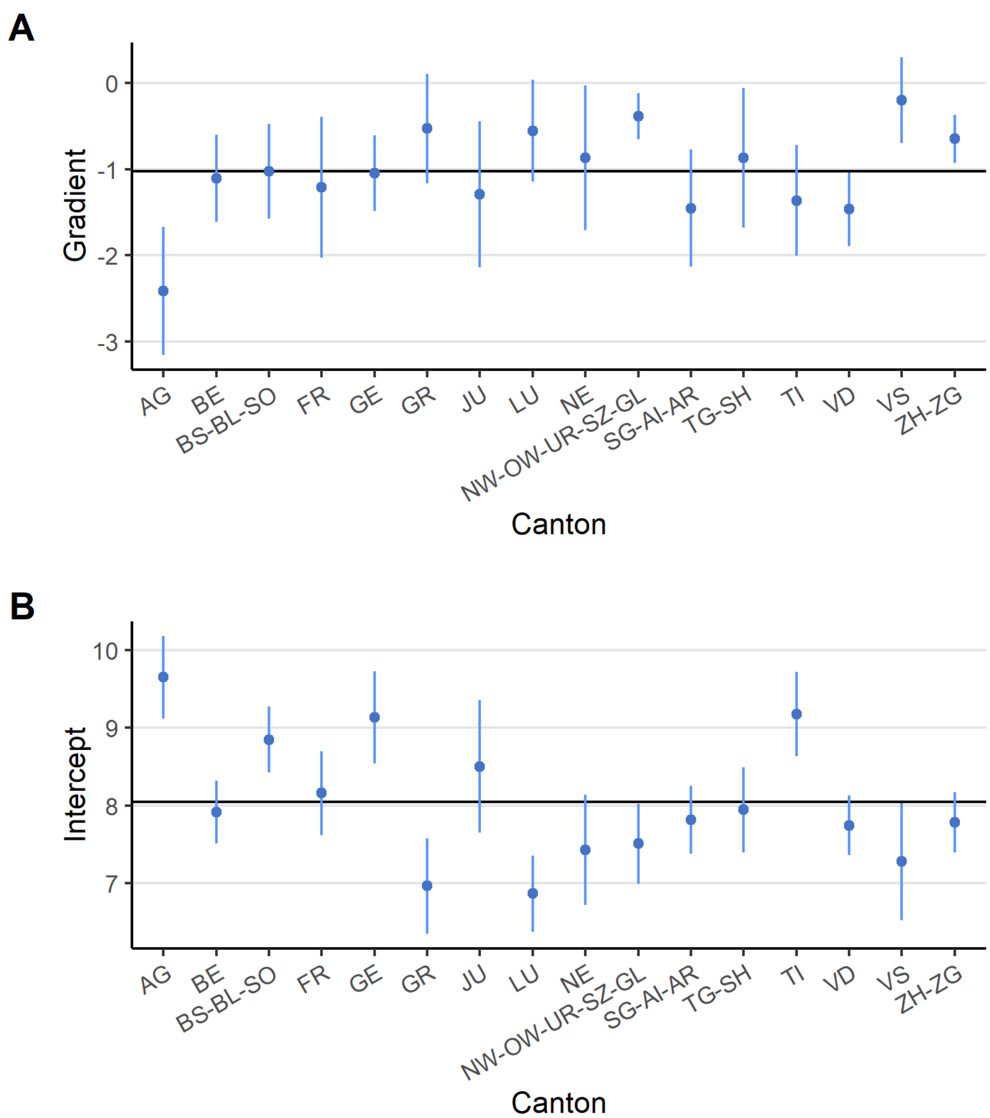


Figure 20 PAH$_C$ gradient with INC for Switzerland

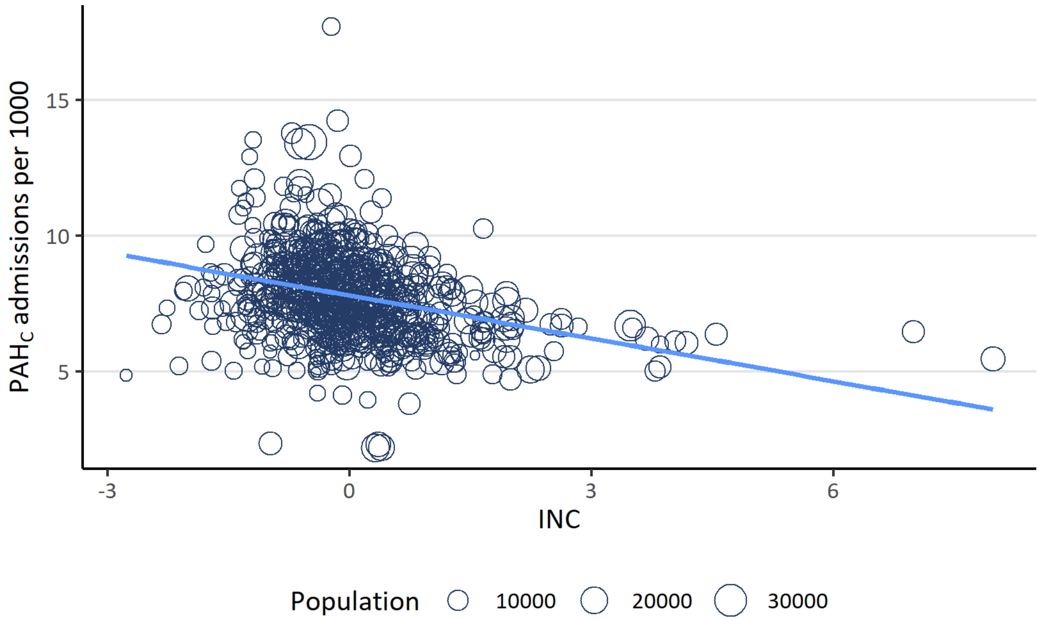
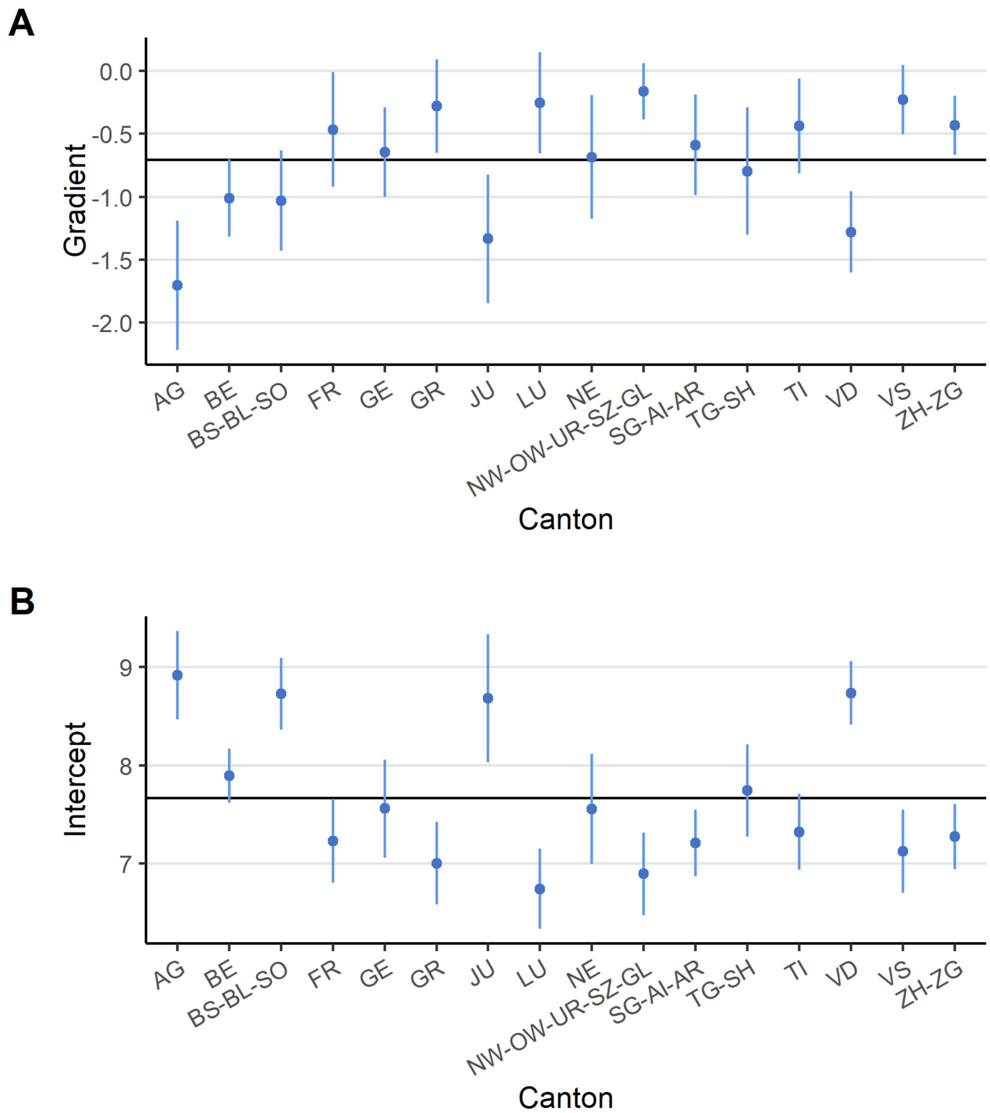


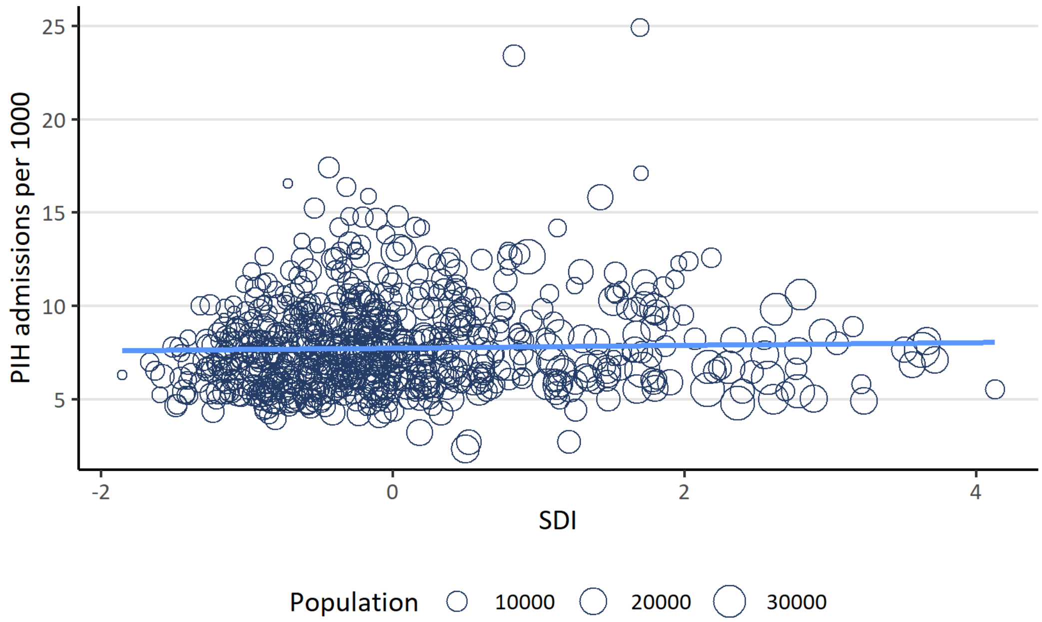
Figure 21 **PAH$_C$ gradients with INC by canton**



3.5 Socioeconomic gradient of potentially inappropriate hospital admissions (PIH)

3.5.1 SDI gradient

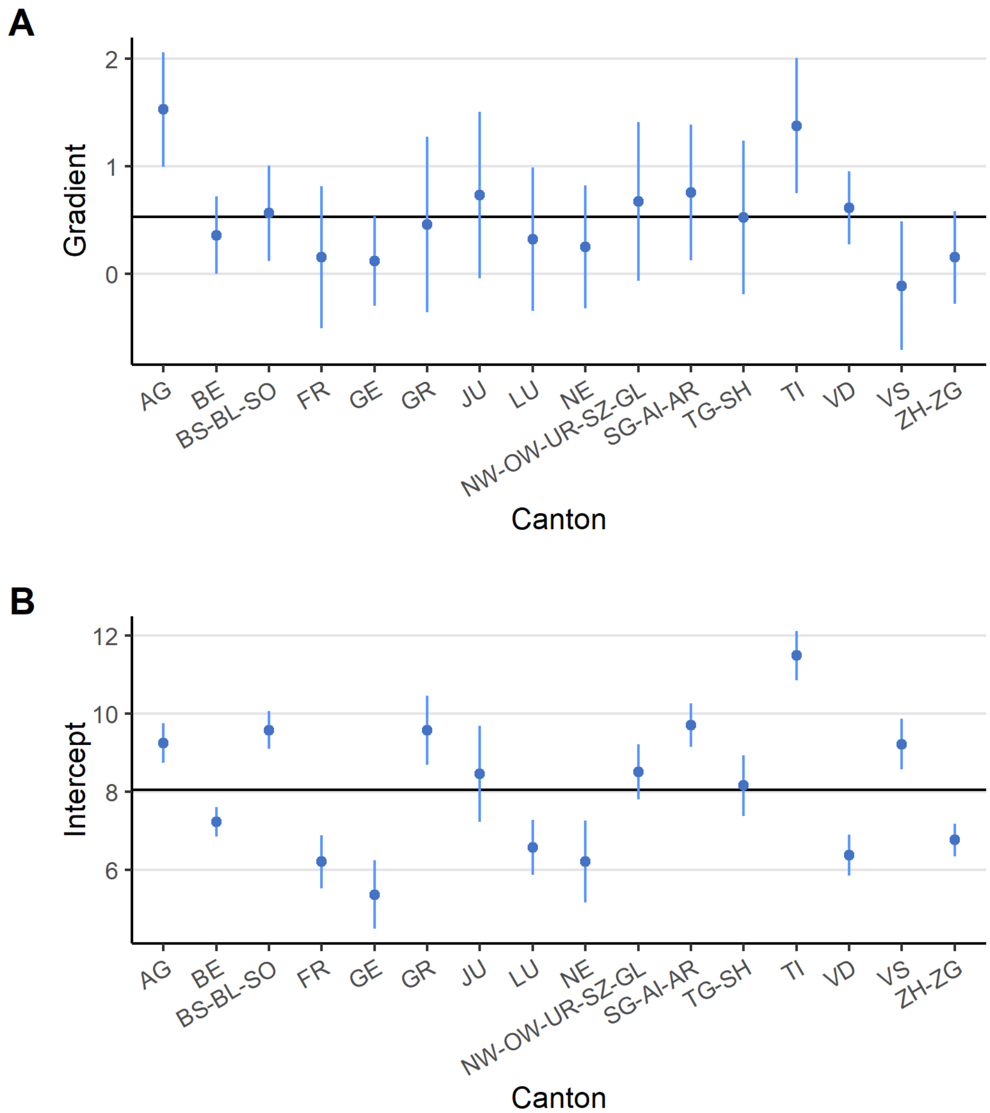
Figure 22 PIH gradient with SDI for Switzerland



In Figure 22, we see an absence of SDI gradient for PIH in Switzerland. In other words, the regression slope is very close to zero. This confirms our assumption from Table 1 and reinforces the results seen in Figure 3.

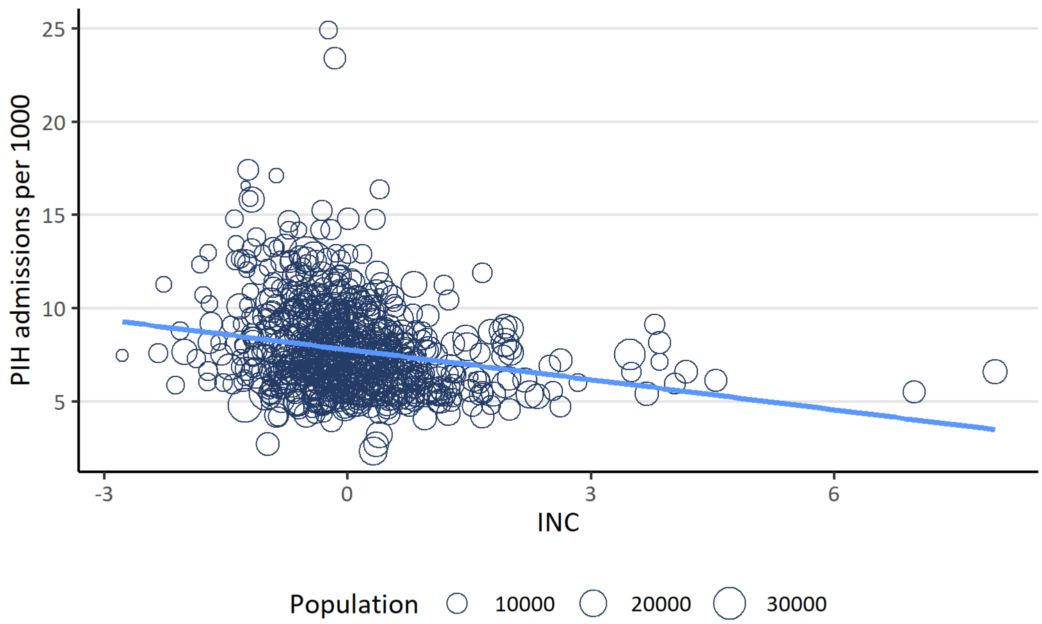
Figure 23 shows results by canton group. For the gradient, a few cantons appear to distance themselves from the overall trend. For instance, AG and TI have a gradient that is statistically significant from the national one, and that is higher than the national gradient. For the intercept, we see a lot of variation between cantons, with most cantons showing statistically significant departures from the national average.

Figure 23 PIH gradients with SDI by canton



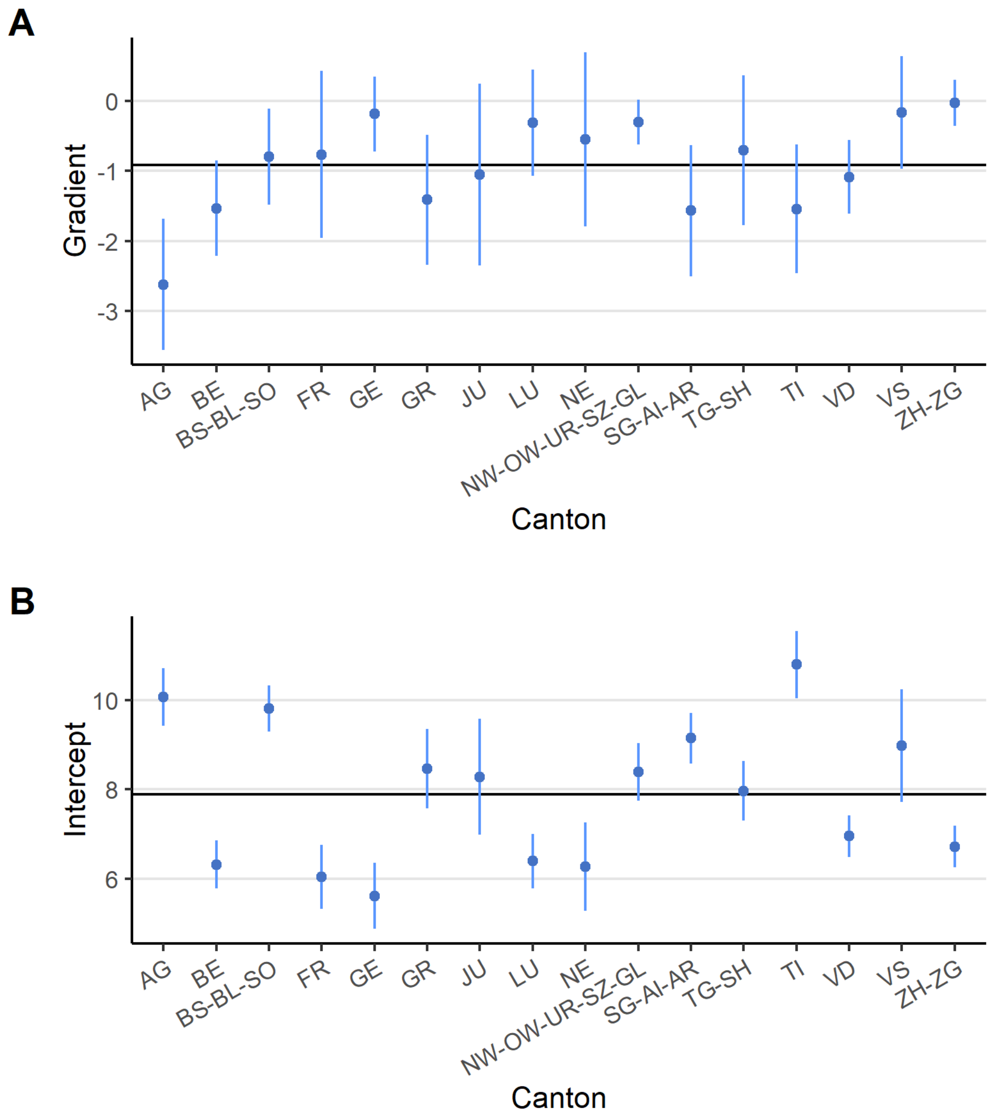
3.5.2 Income gradient

Figure 24 Gradient between PIH and INC for Switzerland



Results for the INC index more closely resemble what we found for the PAH indicators, that is, we see the presence of a negative gradient between PIH and INC at the national level (Figure 24). In Figure 25, we can see results by canton group. Some cantons like, for example GE, ZH-ZG, or NW-OW-UR-SZ-GL have a gradient that is higher than the national one. Since the national gradient is negative, this means that these cantons have a flatter gradient than the Swiss one. Interestingly, no canton has a gradient that is significantly larger than zero. Canton AG has a steeper gradient than the national one. For the intercept, in the bottom part of the figure, we have a great deal of variation between cantons. Most cantons show a statistically significant difference, either above or below, the national average.

Figure 25 PIH gradients with INC by canton



3.6 Sensitivity analysis using alternative indicators

3.6.1 Socioeconomic index

Our main measure of socioeconomic status in a region is the SDI, but other measures exist in the literature. In Switzerland, the Swiss SEP was created as a measure of socioeconomic position at the neighbourhood level. We create an index that is as close to the original SEP as possible with the data available to us. In this section we comment on the results obtained by using the SEP as socioeconomic indicator. Detailed results are available in the appendix.

The SEP varies between regions and canton groups across Switzerland. Within canton variation is similar to that of the SDI, but the median SEP for each canton group is different than the median SDI. Thus, the ranking of canton groups according to the median differs between the SEP and SDI.

The gradient between PAH_S and PAH_C and the SEP is positive and similar to the one for the SDI. We see significant differences in gradient between canton groups for the PAH_S indicator. Cantons AG, BE, BS-BL-SO, and TI show gradients that are significantly above the national mean. Cantons GR, LU, NE, NW-OW-UR-SZ-GL, VD, and VS show gradients that are significantly below the national mean. For PAH_C, the gradient differences between canton groups are also marked. Canton groups AG, BE, BS-BL-SO, JU and VD show gradients that are steeper than the national average. Canton groups FR, GE, LU, NW-OW-UR-SZ-GL, and VS show gradients that are flatter than the national average. These results contrast the ones for the SDI where we found limited deviations from the national gradient that remained statistically significant. Overall, it suggests that our results are not stable to the choice of deprivation measure. When we set the SEP at a given level, we observe a similar pattern between the PAH indicators and the SEP than what we saw for the SDI.

For PIH, we see a small positive gradient with the SEP across Switzerland. Cantons AG, BE, and TI display a steeper gradient than the national one, and canton groups GE VS, and ZH-ZG display a flatter gradient. Overall, the results are comparable to those obtained for the SDI.

3.6.2 Hospital indicators

Multiple lists of ACSCs that we could use to create an indicator of potentially avoidable hospital admissions are available in the literature. We selected two indicators to analyse in detail. In this section, we present the results obtained with a third PAH indicator derived from an established list in the literature that we refer to as PAH_L. Detailed figures are available in the appendix.

The PAH_L indicator displays a positive gradient with the SDI across Switzerland and is stable through time. When we compare canton groups, we find that AG, BS-BL-SO, and TI have a steeper gradient than the national one, and GE and NE have a flatter gradient than the national one. We see greater gradient variation between canton groups with PAH_L than PAH_S or PAH_C. If we hold the SDI constant, we observe that most canton groups deviate significantly from the national average in terms of PAH_L. This is similar to what we observed for the other PAH indicators. The SEP index provides similar results but with smaller standard errors, which leads to most canton groups deviating significantly from the national gradient.

PAH_S	Potentially Avoidable Hospitalisations – Simplified list
PAH_C	Potentially Avoidable Hospitalisations – Complex list
PAH_L	Potentially Avoidable Hospitalisations – Literature list
PIH	Potentially Inappropriate Hospitalisations
SDI	Socioeconomic Deprivation Index
SEP	Socioeconomic Position Index

3.7 Spatial analysis

This section presents the results from the analysis of the local Moran's I. The following maps highlight clusters of high and low activity that are statistically significant using the Bonferroni method. We create one map for each hospital indicator. High-high (low-low) clusters are composed of a region that has a statistically significant high (low) number of admissions, with respect to the mean, and that is surrounded by other regions with statistically significant high (low) admissions. Those regions appear in red (blue) on the map and they represent the centre of clusters of high (low) activity.

We see large high-high clusters of PAH_S in two areas of Switzerland (Figure 26), one in the south in canton Ticino, and one in the North-West near Basel and canton Jura. Other, smaller, high-high clusters also appear as significant. These areas thus seem to have a higher number of PAH_S admissions per 1000 than elsewhere in the country. The map shows three important low-low clusters. The first is located in canton Vaud, the second in central Switzerland, and the third is located in the northern part of canton Zürich.

Figure 26 Moran clusters for PAH_S

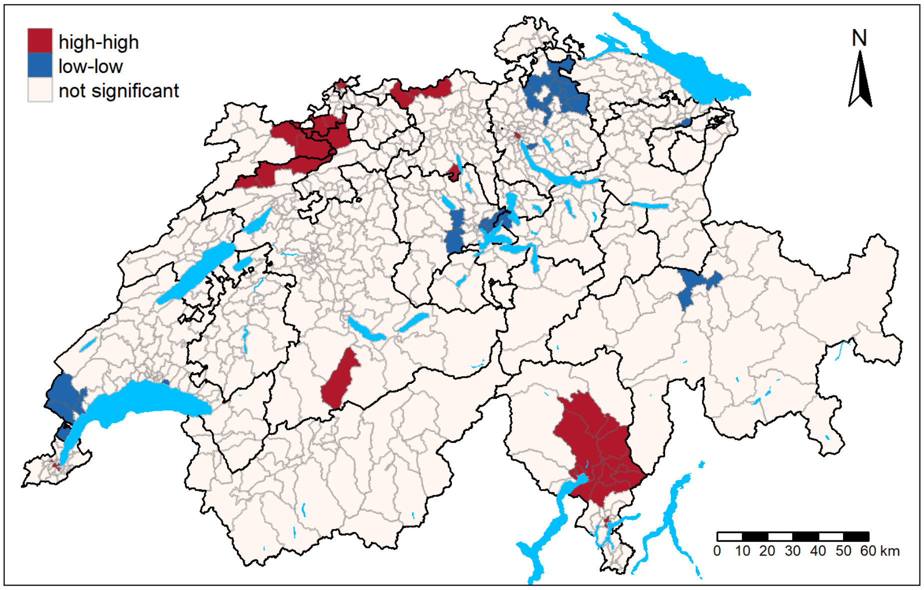
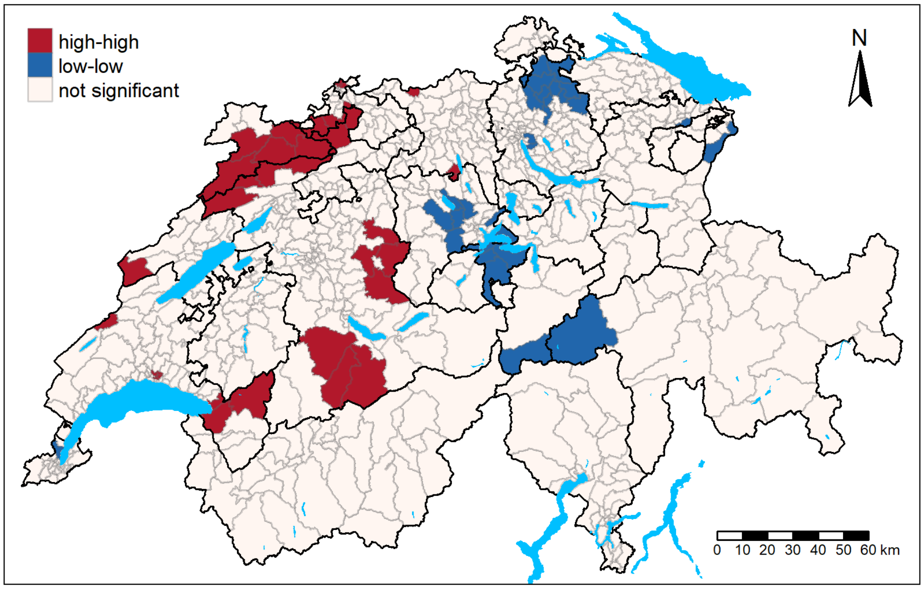


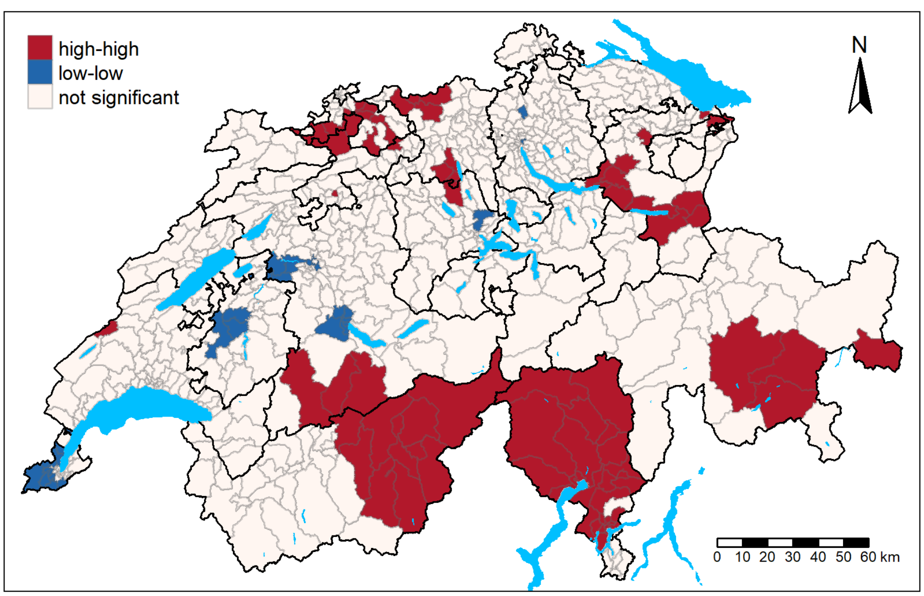
Figure 27 shows the same analysis but this time for the PAH_C indicator. We see high-high clusters in Jura and Basel, and they appear larger than for PAH_S, above. There are no high-high clusters in Ticino anymore. New high-high clusters appear as significant in canton Vaud, and in canton Bern. We still see the three low-low clusters in central Switzerland and to the North of canton Zürich.

Figure 27 Moran clusters for PAH_C



The PIH indicator (Figure 28) shows clusters of high hospital admissions in the South of canton Bern, the North of Switzerland, Oberwallis, Ticino, St-Gallen and Graubünden. Other high-high clusters appear as significant in canton St-Gallen, and in the North of Switzerland. We find low-low clusters in canton Fribourg, and canton Geneva. Additional low activity clusters appear in canton Bern.

Figure 28 Moran clusters for PIH



3.8 Cultural variables

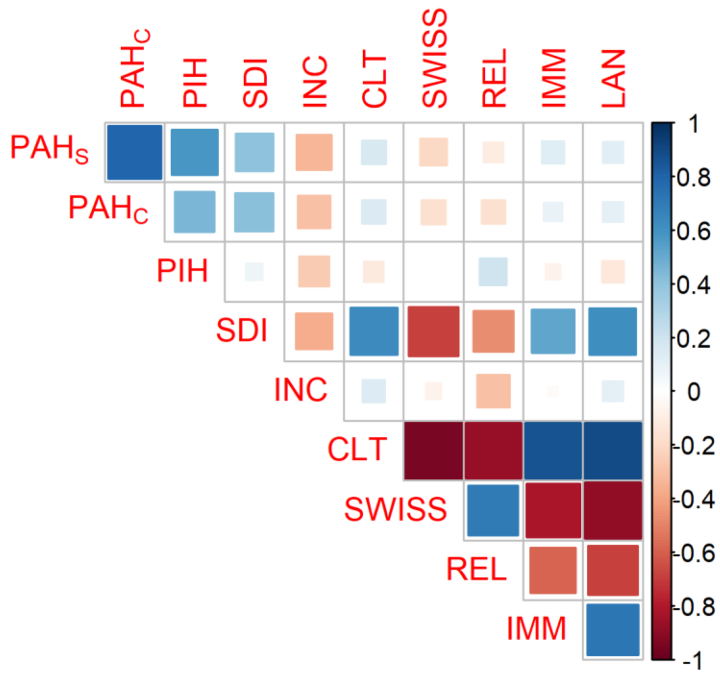
3.8.1 Cultural index (CLT)

Figure 29 shows correlations between our hospital indicators, socioeconomic variables, and cultural variables. SWISS indicates the proportion of the population in the region that is of Swiss origin. REL indicates the proportion of the population in the region that is of catholic or protestant religion. IMM indicates the proportion of the population in the region that immigrated from abroad in the last year. LAN indicates the proportion of the population in the region that has a language other than a national language as their mother tongue. CLT is the cultural index. We will discuss it further below. The correlation plot clearly shows that all cultural variables are strongly correlated with the SDI. IMM and LAN have a positive correlation, SWISS and REL have a negative correlation.

Cultural variables also appear to be only weakly correlated with our hospital indicators, which leads us to believe that gradients and associations between cultural aspects of the population and hospital indicators will be quite flat, or weak.

The last important piece of information that the correlation plot gives us is that all cultural variables share a very strong correlation with each other. This is an ideal situation in with to create a summary measure of cultural aspects in each MedStat region, represented by a cultural index.

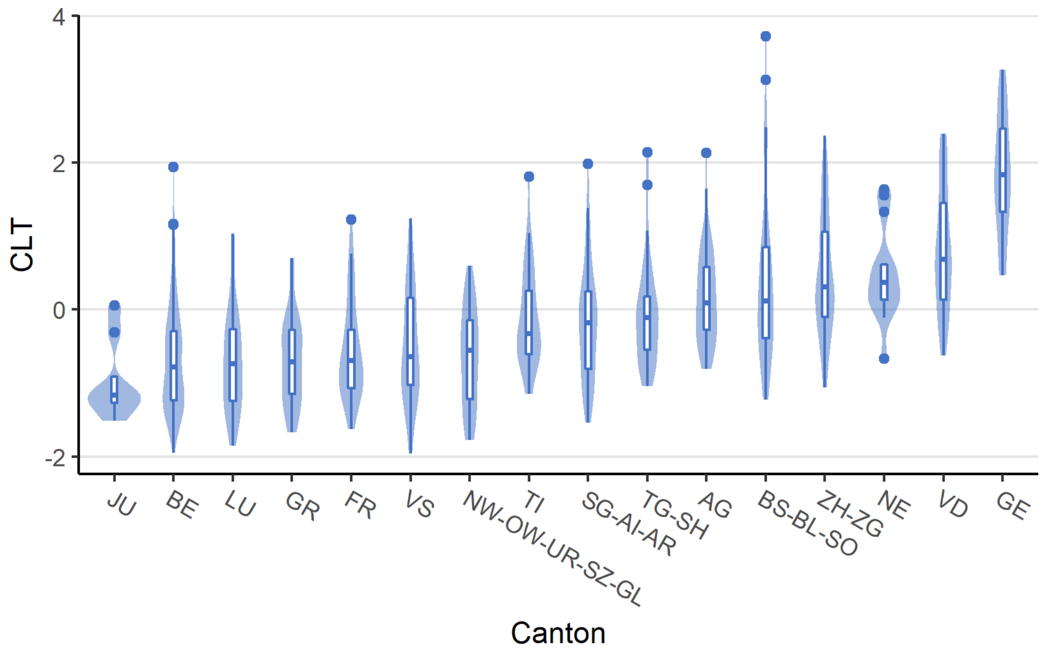
Figure 29 Correlation between variables of interest and cultural variables



We use the same procedure to create the cultural index (CLT) as we have used for the SDI (see 2.4 for details). To build the CLT, we run a PCA (principal component analysis) on the four cultural variables discussed above. We take the opposite sign of REL and SWISS before running the PCA. Specifically, we take the proportion of population in the region with a religion other than catholic or protestant (including individuals with no confession), and the proportion of foreign nationals in the region. We do this so that all four variables have the same scale and meaning, where an increase in the value of the variable leads to an increase in cultural diversity in the region. This simplifies the analysis and interpretation of the CLT.

Figure 30 shows the distribution of the CLT index across canton groups. The index is centred on the national mean so that it is interpreted as a deviation from the mean. About half of the canton groups are below the national mean and half of the canton groups are above the national mean. The cantons below the national mean are quite similar to each other regarding the mean and distribution of the CLT within the canton. Canton groups BS-BL-SO and ZH-ZG have the largest variance. Canton Geneva has the largest proportion of culturally different people in its population.

Figure 30 **Distribution of CLT for canton groups**

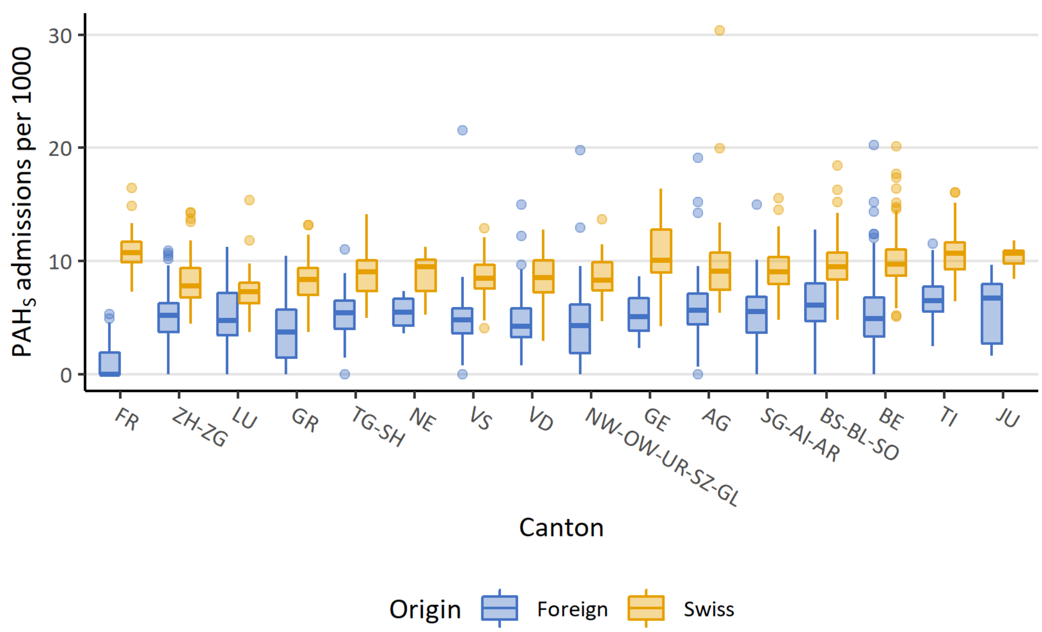


3.8.2 Country of origin

The hospital statistics data contains information about nationality that is available at the individual level. Specifically, we know whether a patient was of Swiss nationality of foreign nationality. We can therefore use this information to investigate whether Swiss patients generate different levels of potentially avoidable hospitalisations than foreign patients.

In Figure 31 we compare age- and sex- standardised rates of PAH_S admissions for Swiss individuals with the rate of PAH_S admissions for foreigners, by canton groups. Overall, we observe a higher rate of PAH_S admissions for Swiss individuals compared to foreigners, supporting the hypothesis that foreigners living in Switzerland are, overall, in better health than Swiss nationals (i.e., "healthy migrant effect").

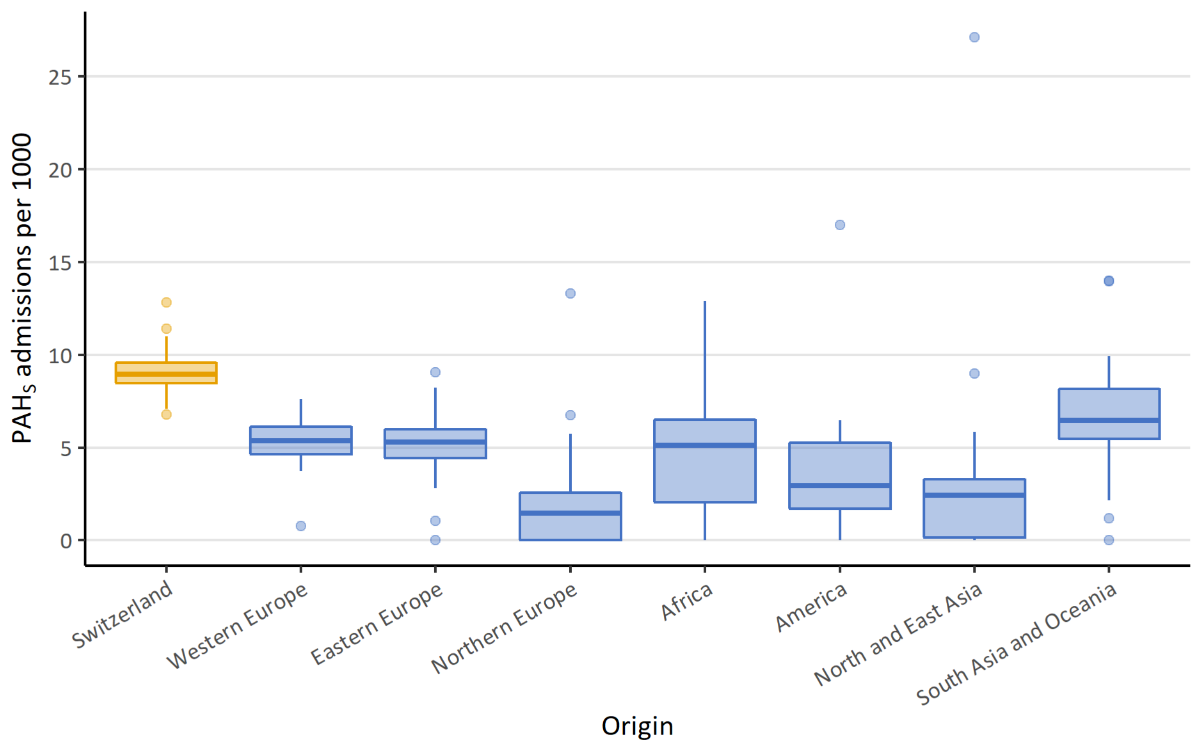
Figure 31 Comparison of PAH_S for canton groups between Swiss nationals and foreigners



However, foreign individuals are an extremely diverse group with some origins likely to be associated with higher risks of PAH_S admissions. We therefore go into more detail about the origin of foreign individuals in the next figure. Origin is defined at the individual level in the hospital statistics, but we are limited in the amount of detail provided because of identity protection concerns. Furthermore, some MedStat areas include very small numbers of individuals from specific origins and age groups such that it is not possible to perform age-sex standardisation at the MedStat region level, as is done in the rest of the report. We therefore perform the standardisation at the canton level instead.

Figure 32 shows the distribution of PAH_S admissions per 1000 by region of origin and standardised at the canton level. Each boxplot is therefore built using 26 data points. Admission rates in Swiss nationals still show the highest median just under 10 PAH_S per 1000. Foreigners from Western and Eastern Europe have comparable distributions of PAH_S with a median of 5 PAH_S per 1000. Other origins show more variability in their distributions, including large outliers. For example, a PAH_S rate of 25 per 1000 for populations of North and East Asia is observed in one canton. Such outliers are likely to be explained by the small population size for specific origins (see Table 5).

Figure 32 Comparison of PAH_S by origin



Overall, these results points to a “healthy migrant effect”. However, these analyses may mask important heterogeneity by age group. As PAH_S admissions are typically linked to health problems that are more prevalent in older populations, very small populations of older age in some groups might lead to artificially lower rates of PAH_S. For instance,

Table 5 shows very small populations from regions outside Europe.

Table 5 **Canton population by origin and age category**

	15 to 39			40 to 59			60 plus		
Origin	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Switzerland	70448	4319	326514	69344	3707	315851	69003	3680	292646
Western Europe	17351	301	92694	16623	406	76424	6852	127	28075
Eastern Europe	7181	184	37777	4260	197	20626	1542	54	8562
Northern Europe	416	1	3492	369	8	2576	124	1	575
Africa	2108	65	8343	941	19	5397	130	1	1105
America	1414	11	7755	1064	8	5950	197	3	1360
North and East Asia	1166	18	6415	572	10	2958	101	3	887
South Asia and Oceania	3435	105	18957	2227	41	12054	580	8	2852

Note: This table shows descriptive statistics for canton populations rather than MedStat region populations.

To investigate this heterogeneity, Figure 33, Figure 34 and Figure 35 show rates of PAH_S admissions by origin and age category. The figures present simplified boxplots with the whiskers and outliers omitted to make the scale more readable. The medians for Switzerland, Western Europe and Eastern Europe are similar within each age. Eastern Europe origin distributions are wider, in particular for women. Populations from Northern Europe are too small to give a definite interpretation, but PAH_S rates seem to be smaller than for Swiss origin. African, American, and North and East Asian origins all display large variabilities that are likely due to the small population size in some cantons. South Asian and Oceanian origins seem to be associated with higher levels of PAH_S than Swiss origin, in particular for ages above 40. Among younger patients, there is also a tendency for African origins to be associated with higher PAH_S, yet the differences do not reach statistical significance due to large variability generated by small sample size.

To sum up, the potential healthy migrant effect observed in Figure 31 and Figure 32 seems to be driven by differences in the age structure of foreign populations. Among older populations, the proportion of Swiss origin is much larger than foreign origin. Since PAH_S are associated with conditions more prevalent in older populations, it is expected that Swiss populations are linked to higher rates of PAH_S. The higher rates of PAH_S observed for populations over 40 years old of South Asian (incl. the Middle East) and Oceanian origins could be linked to problems of access to care for these populations. Yet, we do not have sufficient statistical power to provide a definite answer. Further research is therefore required.

Figure 33 Comparison of PAHs for people aged 15 to 39 by origin

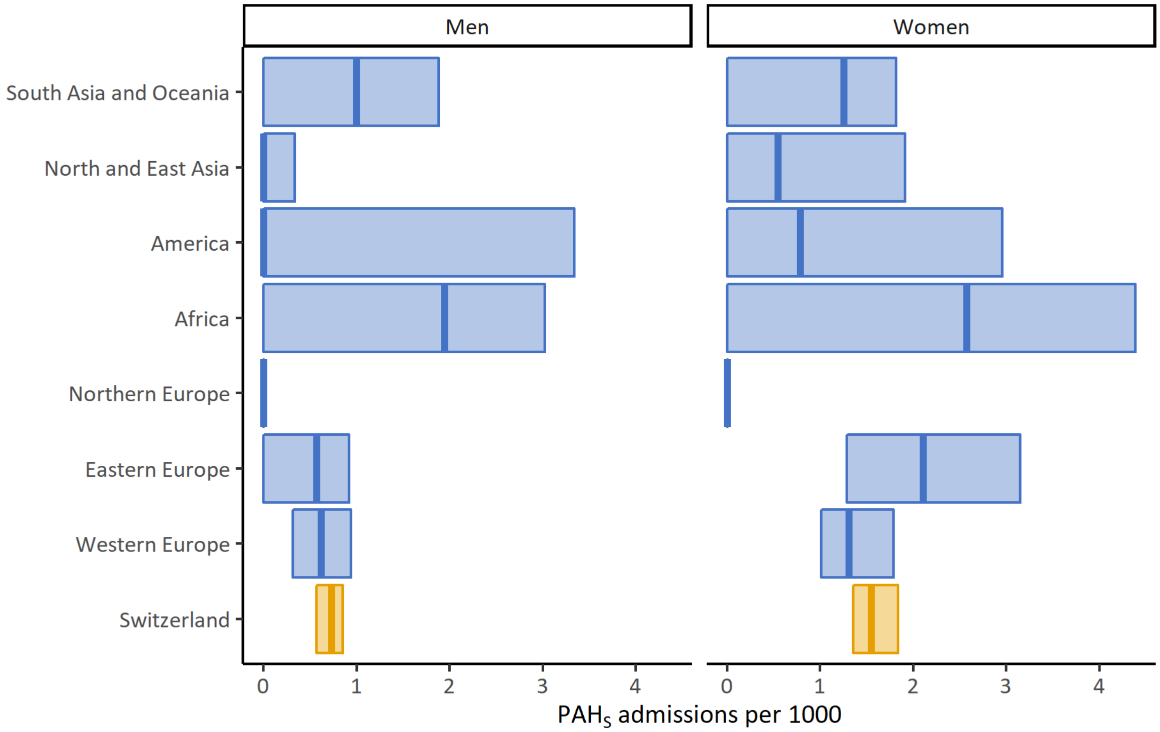


Figure 34 Comparison of PAHs for people aged 40 to 60 by origin

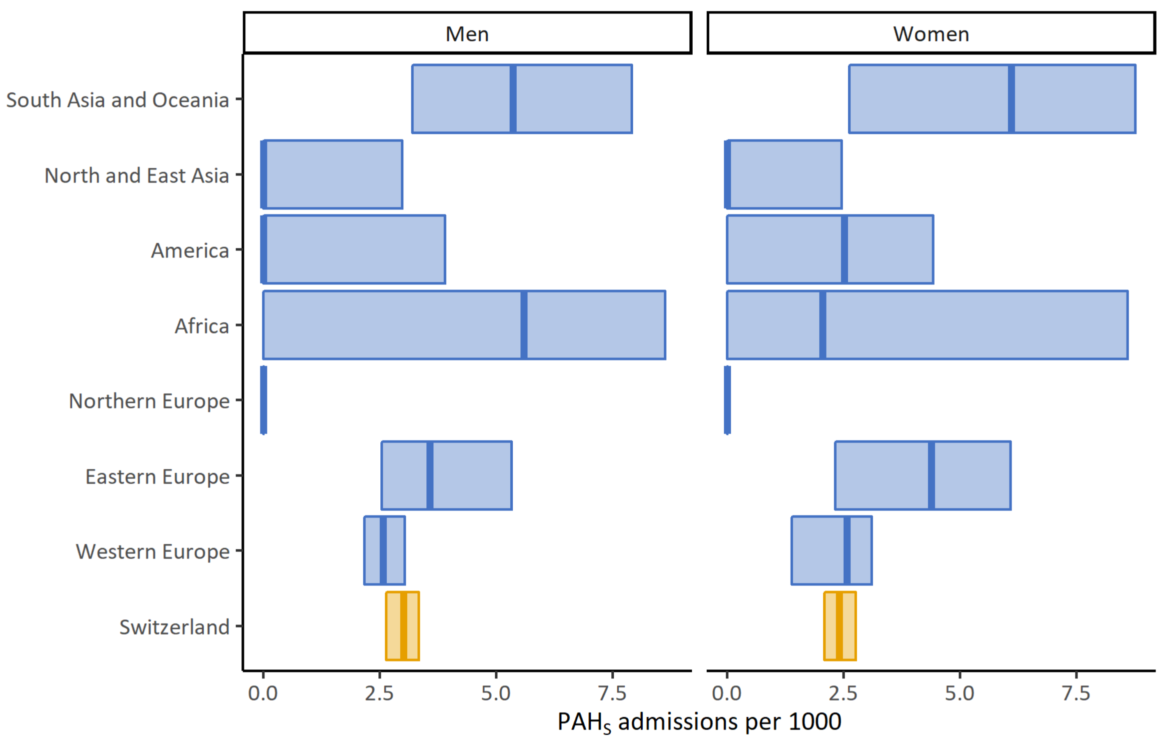
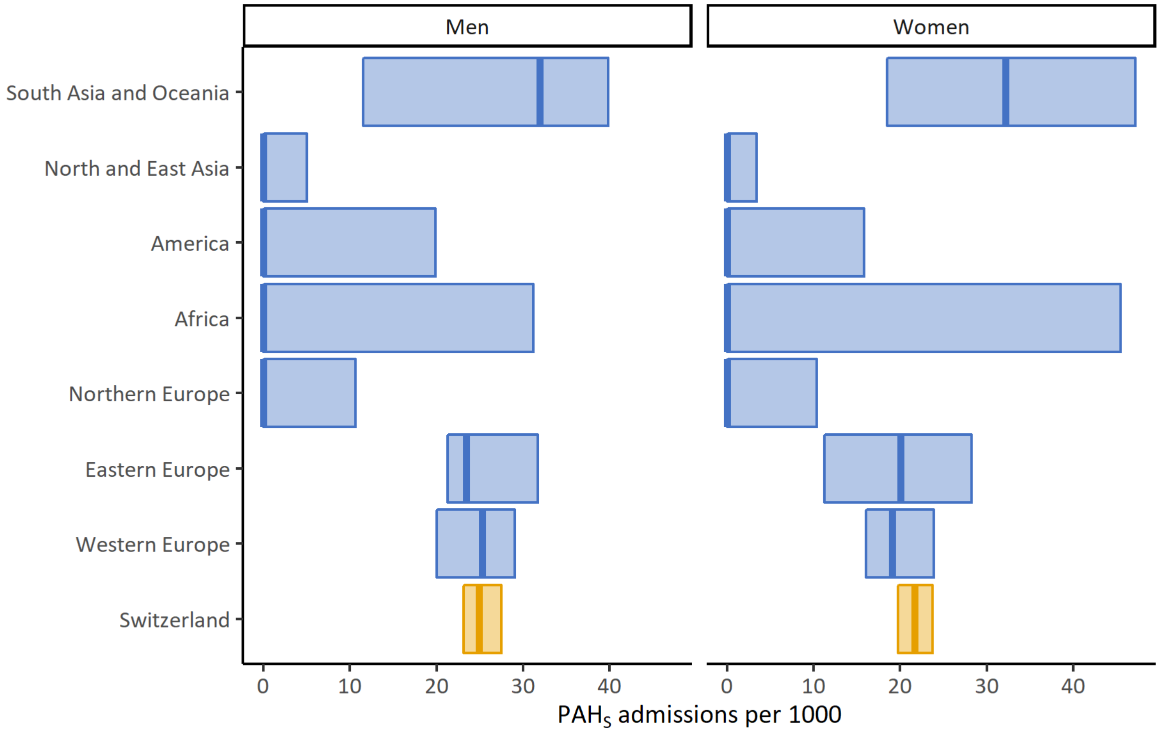


Figure 35 **Comparison of PAH$_S$ for people aged 60 and older by origin**



3.8.3 Residence permits

Another way to assess the influence of cultural diversity on rates of PAH$_S$ is to focus on residence permits. This allows us to compare rate of admission between Swiss individuals, settled foreign individuals, recent immigrants, and immigrants with more uncertain residence status. This section presents the results of the association between PAH$_S$ and the rates of residence permits in MedStat regions. Table 6 shows descriptive statistics about residence permits in Switzerland, at the MedStat region level. There is a mean of 76% of Swiss individuals per region with a range between 45% and 98%. Settled foreign nationals (C permit) are the most represented with a mean of 14% and a range from 1.2% to 43%. Resident foreign nationals (B permit) have a mean of 7% with a range of 1% to 35%. Other permit types have much lower rates in the population with a mean of less than 1% and a maximum of 2% to 5%. Diplomats are mostly concentrated in the canton of Geneva and thus there is little value in performing an analysis of this permit type at a national level. We will therefore leave them out of the following results.

Table 6 **Rates of population holding each permit type**

Permit	Mean	SD	Min	Max	Median	25th percentile	75th percentile
Swiss nationality	0.776	0.102	0.455	0.976	0.789	0.714	0.850
C	0.141	0.066	0.012	0.426	0.138	0.093	0.181
B	0.073	0.042	0.010	0.348	0.064	0.044	0.092
F	0.004	0.004	0.000	0.031	0.004	0.002	0.006
L	0.003	0.004	0.000	0.048	0.002	0.001	0.003
Diplomats	0.003	0.014	0.000	0.156	0.000	0.000	0.000
N	0.002	0.002	0.000	0.023	0.002	0.001	0.003

Given that permit distributions across regions vary widely with permit type, we normalised variables so that they can be compared on a single scale. All variables present in Table 6 were therefore centred to the mean and standardised so that they have a mean of 0 and a standard deviation of 1. The permit rates in the following parts of the analysis are thus interpreted as variation to the mean such that, for instance, a value of 2 corresponds to a region with a rate that is 2 standard deviations higher than the mean.

In the remaining part of the section, we present the overall association between PAH_S and permit rates, the same association controlled for levels of SDI, and we formally test the statistical significance of the association with a regression model.

Figure 36 Association between permit rate and PAH$_S$

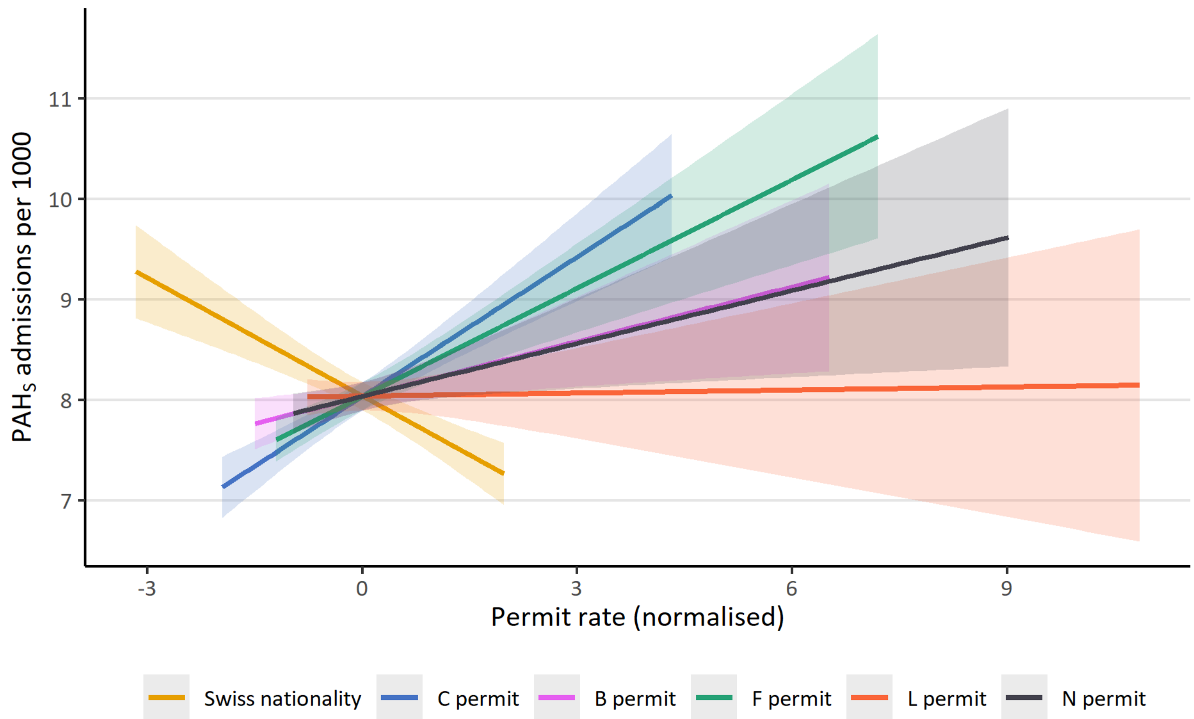


Figure 36 shows the association between PAH$_S$ and normalised permit rates in Switzerland. Each line represents the gradient between a type of permit rate and PAH$_S$ admissions per 1000. The shaded area around the line illustrates the confidence interval around the gradient with a 95% threshold. We observe a negative gradient between rates of Swiss nationality and PAH$_S$, which means that regions with more Swiss individuals than the mean are associated with lower rates of PAH$_S$ admissions. The gradient is positive for C, B, F, and N permits, indicating that regions with high permit rates are associated with high rates of PAH$_S$. The effect appears to be the most pronounced for C and F permits, followed by B and N permits, which have very similar gradients. The gradient for L permits appears to be flat or possibly slightly negative, but a large confidence interval, due to the low variability in L permit rates, makes it difficult to distinguish.

Overall, results suggest that PAH$_S$ admissions are negatively associated with Swiss nationality and positively associated with residence permits held by foreigners. However, we have already pointed out the presence of a strong correlation between nationality and socioeconomic status (see Figure 29). It is therefore necessary to check which variable, between socioeconomic status and nationality, drives the observed association. This is done in Figure 37.

Figure 37 **Association between permit rate and PAH_S by SDI category**

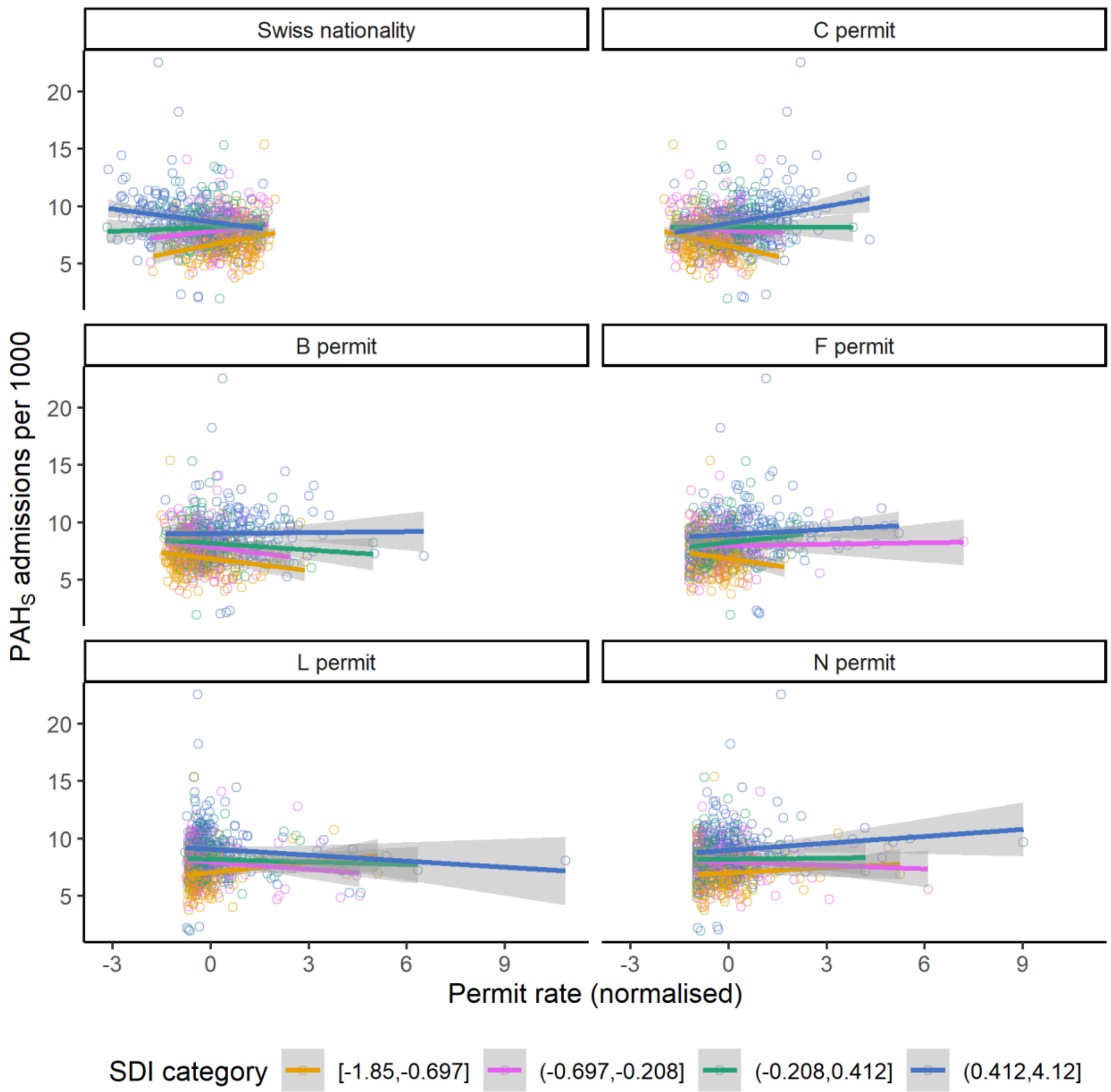


Figure 37 presents the gradient between PAH_S and permit rates separated by SDI category. Each category represents a quartile (25%) of the SDI distribution, i.e., there is the same number of MedStat regions in each SDI category. As a reminder, a high value of SDI corresponds to regions with higher deprivation.

Three messages can be extracted from the figure. First, the mean level of PAH_S increases with increased deprivation. In other words, trend lines for the low SDI category (in yellow) are below the trend lines for the high SDI category (in blue). This holds for all permit types such that more deprived regions are associated with more PAH_S admissions regardless of permit type. The second message is that gradients (i.e., line slopes) vary between SDI categories. For example, it can be seen for C permit rates where the gradient is negative for the low SDI category and becomes positive for the high SDI category. In deprived regions, high rates of C permits are associated with high rates of PAH_S, but the effect is reversed in affluent regions where high rates of C permits are associated with low rates of PAH_S. Similar, but less marked, effects can be seen for the other permit types. The third message is that associations for Swiss nationality appear to be in contrast with associations for permit types, something that we could already see in Figure 36. There is a positive gradient between PAH_S and Swiss nationality if we look at the low SDI category (affluent regions), however the gradient becomes negative if we look at the high SDI category (deprived regions). This relationship is the opposite of what is described above for C permit rates.

So far, we have not tested the statistical significance of the gradients observed between PAH_S and permit rates, nor the differences in gradients between SDI categories. In Table 7, we do these checks and control for important confounding variables such as healthcare supply and region topography. The last two columns of the table show the most complete regression model which includes controls and interactions between permit rates and SDI.

C permit rates emerge as positively associated with PAH_S and B permit rates emerge as negatively associated with PAH_S. Specifically, the 0.26 coefficient for C permit rates is interpreted as a 0.26 increase in PAHS admissions per 1000 for an increase in 1 standard deviation of permit rate. In other words, a region with an increase of C permit rate from 0.141[15] to 0.207[16] (around 5 percentage points) is associated with an increase of 0.26 PAH_S admissions per 1000. The magnitude of the effect if therefore small considering that the mean level of PAH_S for Switzerland is 8.04 (Table 4). Other permit types do not show a statistically significant relationship with PAH_S.

When we direct our attention to the interaction between permit rates and SDI, we note that interactions appear statistically significant for F and L permit rates. This means that there are differences in gradient between affluent and deprived regions, as seen in Figure 37, yet these differences are significant only for F and L permits and remain of small magnitude. More specifically, the rate of temporarily admitted refugees and other persons (F permit) is positively related to PAH_S in socio-economically deprived regions. In socio-economically affluent regions, this effect

[15] Mean rate for C permit in Switzerland. See Table 6
[16] 0.141 + 0.066

is reversed. Control variables for SDI, healthcare density and region topography behave as expected. These results are discussed in detail in section 4 of the report.

To sum up, confounding factors like socioeconomic deprivation and healthcare supply seem to explain most of the observed association between PAH_S and permit rates. C permit rates are positively associated with PAH_S and there is potential evidence of a healthy migrant effect with B permit rates, yet these associations remain small in magnitude. In other words, foreign residents who have not yet permanently settled in Switzerland (B permit) seem to be less prone to PAH_S compared to foreigners who are permanent residents of Switzerland and have generally lived in Switzerland for longer (C permit). This may be linked to the conditions of obtaining a B permit, namely, to be in the possession of an employment contract, or without gainful employment, yet with proof that the applicant is in adequate health, financial situation and with accident insurance.

The association between F and L permit rates and PAH_S appears to vary with socioeconomic deprivation, but the effect is again very small. For socioeconomic deprived regions, the rates of temporarily admitted refugees and other persons (F permit) is more strongly and positively related to PAH_S. This effect may be due to accumulated access barriers in such regions and merits further investigation.

Overall, at a MedStat region level, the relationships between permit rates and PAH_S appear rather modest in size. This points to the need for further testing of the relationships between permit rates, socioeconomic deprivation, and PAH_S, if possible, at a more granular level.

Table 7 **Gradients between PAH_S and permit rates with control for SDI**

	PAH_S		PAH_S		PAH_S	
Predictors	**Estimates**	**p**	**Estimates**	**p**	**Esti-mates**	**p**
(Intercept)	8.28	**<0.001**	8.24	**<0.001**	8.31	**<0.001**
C permit rate (normalised)	0.67	**<0.001**	0.19	0.114	0.26	**0.033**
B permit rate (normalised)	-0.27	**0.006**	-0.33	**0.001**	-0.30	**0.003**
F permit rate (normalised)	0.26	**0.003**	0.09	0.353	0.15	0.13
L permit rate (normalised)	0.02	0.735	0.01	0.901	-0.02	0.775
N permit rate (normalised)	0.06	0.472	-0.01	0.925	-0.02	0.853
SDI			0.87	**<0.001**	0.83	**<0.001**
Typology (ref. rural)						
Suburban	-0.81	**<0.001**	-0.6	**0.003**	-0.62	**0.002**
Urban	-0.08	0.68	-0.02	0.934	-0.14	0.511
Healthcare density						
Distance to closest GP					0.22	**0.019**
Distance to closest specialist					-0.02	0.873
Interaction of SDI with						
C permit rate (normalised)			0	0.992	0	0.973
B permit rate (normalised)			0.07	0.467	0.06	0.482
F permit rate (normalised)			-0.13	**0.04**	-0.15	**0.017**
L permit rate (normalised)			-0.19	**0.023**	-0.17	**0.043**
N permit rate (normalised)			0.03	0.577	0.03	0.541
Observations	705		705		705	
R^2 / R^2 adjusted	0.110 / 0.102		0.206 / 0.191		0.213 / 0.196	

3.9 Potential benefits of reducing equity-related admissions

Potentially avoidable hospitalisations and potentially inappropriate hospitalisations generate avoidable costs for the system because of their preventable nature. By lowering potentially avoidable hospitalisations and potentially inappropriate hospitalisations, potential saving would become apparent in the hospital setting for admission and treatment costs. However, to lower potentially avoidable hospitalisations implies more prevention, treatment, and follow-up in community-based ambulatory care (CBAC), which would increase costs in this setting. We can reasonably expect that the decrease in hospital costs will be larger than the increase in CBAC costs such that we will see an overall decrease in cost for the system.

Our data allow us to estimate hospital costs for potentially avoidable and potentially inappropriate hospitalisations by using diagnostic related group codes (see section 2.5.1 for details). We focus on hospital costs because the available data do not allow us to estimate CABC costs. Therefore, we would expect to overestimate the amount of potential savings in the results presented below. We start this section by presenting the overall number of hospital admissions for PAH_S, PAH_C, and PIH, along with the overall cost of these hospitalisations (Table 8). There are slightly more hospitalisations for PAH_S than for PAH_C, however the overall cost is somewhat higher for PAH_C. The average cost of PAH_S is therefore lower than for PAH_C. There are less PIH hospitalisations than PAH hospitalisations. They also have a much lower average cost than PAH hospitalisations.

Table 8 Potentially avoidable or inappropriate hospitalisations in 2017

	PAH_S	PAH_C	PIH
Hospitalisations	229 292	219 585	219 195
Cost estimate (million CHF)	580.21	587.66	314.27
Average cost (CHF)	2530.43	2676.22	1433.75

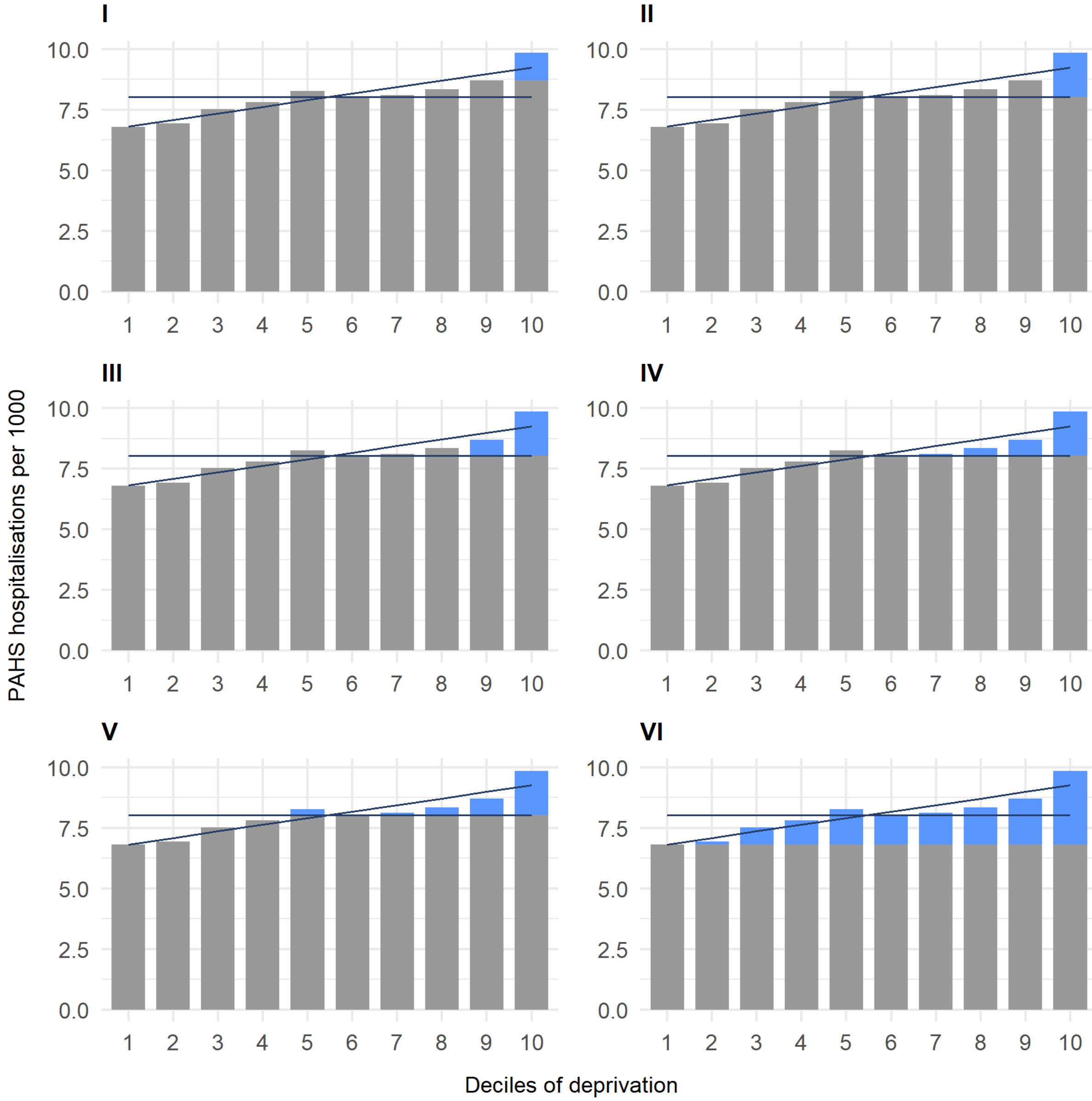
Table 9 shows for each of the six options and for each hospital indicator. Figure 38 illustrates the potential gains in graphical format. The bars represent mean PAH_S admissions for each decile of SDI (e.g., the first decile corresponds to the 10% of MedStat regions that have the lowest SDI). The horizontal line shows the national mean of PAH_S, and the sloped line shows the gradient between PAH_S and SDI. For each option, the blue coloured part shows the potential gain obtained. The logic is the same for PAH_C and PIH; hence, we only provide the results in table format.

Option I, bringing the mean of the most deprived decile to the mean of the second most deprived decile would lower PAH_S admissions by 1 per 1000 population. That would correspond to 1380 hospitalisations and lead to savings of 3.5 million CHF for the deciles considered, or 9685 hospitalisations and 24.5 million CHF if extrapolated to the Swiss population. Option II, bringing the mean of the most deprived decile to the Swiss mean, would increase the gains by 805 hospitalisations in the deciles considered (respectively 5647 for Switzerland) and 2 million CHF (respectively 14 million). Options III, IV and V lower PAH_S admissions by between 2.5 and 3.1 admissions per 1000, which corresponds to between 5443 and 26 190 admissions (20 979 and 26 190 for Switzerland) and a financial gain of between 14 million to 66 million CHF (respectively between 53 million and 66 million for Switzerland). Finally, option VI would lead to large gains in admissions corresponding to more than 89 000 PAH_S admissions and a financial gain of over 200 million CHF, respectively 104 000 admissions and 263 million when extrapolated to Switzerland. This option, however, only represents a thought exercise and we cannot reasonably expect to achieve it in practice. Results for PAH_C show a similar trend, albeit with somewhat smaller gains for each option. Finally, potential gains for PIH are smaller than for PAH because the gradient between PIH and the SDI is smaller also.

Table 9 **Potential gains in hospitalisations**

		Decile Population			Swiss Population	
	PAHs	Hospitalisations avoided per 1000	Hospitalisations avoided	Financial gains (million CHF)	Hospitalisations avoided	Financial gains (million CHF)
I	Top 10% to top 20%	1.15	1 380	*3.49*	9 685	*24.51*
II	Top 10% to Swiss mean	1.82	2 185	*5.53*	15 332	*38.80*
III	Top 20% to Swiss mean	2.49	5 443	*13.77*	20 979	*53.09*
IV	Top 50% to Swiss mean	2.88	13 698	*34.66*	24 255	*61.38*
V	Swiss mean as upper bound	3.11	26 190	*66.27*	26 190	*66.27*
VI	All to bottom 10%	12.34	89 091	*225.44*	103 895	*262.90*
	PAHc					
I	Top 10% to top 20%	1.14	1 364	*3.65*	9 576	*25.63*
II	Top 10% to Swiss mean	1.67	1 999	*5.35*	14 031	*37.55*
III	Top 20% to Swiss mean	2.20	4 796	*12.84*	18 487	*49.47*
IV	Top 50% to Swiss mean	2.71	12 874	*34.45*	22 796	*61.01*
V	Swiss mean as upper bound	2.72	22 864	*61.19*	22 864	*61.19*
VI	All to bottom 10%	11.65	84 110	*225.10*	98 086	*262.50*
	PIH					
I	Top 10% to top 20%	0.28	339	*0.49*	2 380	*3.41*
II	Top 10% to Swiss mean	0.46	550	*0.79*	3 859	*5.53*
III	Top 20% to Swiss mean	0.63	1 385	*1.99*	5 338	*7.65*
IV	Top 50% to Swiss mean	0.89	4 229	*6.06*	7 489	*10.74*
V	Swiss mean as upper bound	1.60	13 487	*19.34*	13 487	*19.34*
VI	All to bottom 10%	9.41	67 927	*97.39*	79 214	*113.57*

**Figure 38	Illustration of potential gains in hospitalisations**



3.10 Time variation

Figure 39 SDI time trend in Switzerland

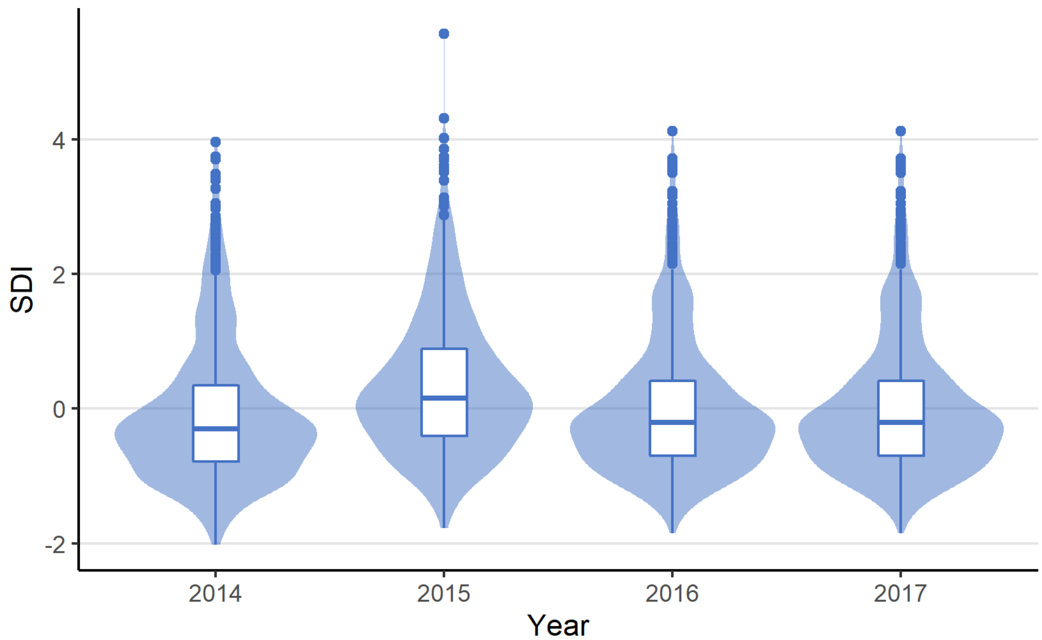


Figure 39 displays the time trend of SDI for Switzerland. There is no evidence of any positive or negative time trend between 2014 and 2017. The distribution looks similar for all years, however, there appears to be a small increase in 2015, although it is not statistically significant. Time trends by canton show a similar pattern in Figure 40. PAH_S shows an even more stable time trend both for Switzerland as a whole for the years investigated (Figure 41), and by canton group (Figure 42). Additional figures for the other hospital indicators are available in the appendix.

Overall, these results lead us to a decision to focus on a detailed investigation for a single year. Evidence suggests that, between 2014 and 2017, associations between socioeconomic status, and hospital indicators are stable over time. We do not have enough data to make assumptions on long-term time trends. This finding is in contrast to international evidence, which suggests that potentially avoidable hospitalisations are sensitive to short-term changes in healthcare delivery (e.g., in the United Kingdom [4]). Further investigations, with data over a longer time period, may be necessary for Switzerland.

Figure 40 SDI time trend by canton groups

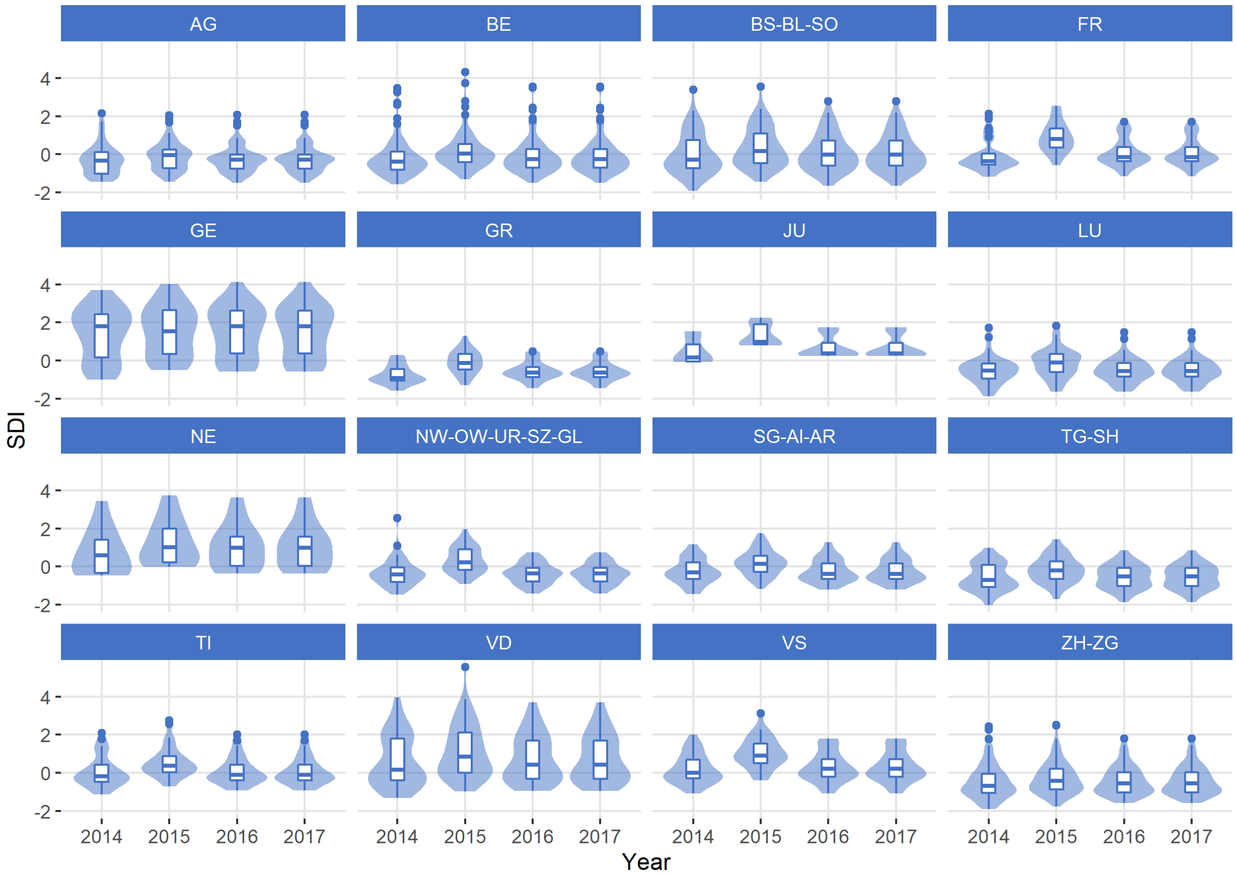


Figure 41 PAH$_S$ time trend in Switzerland

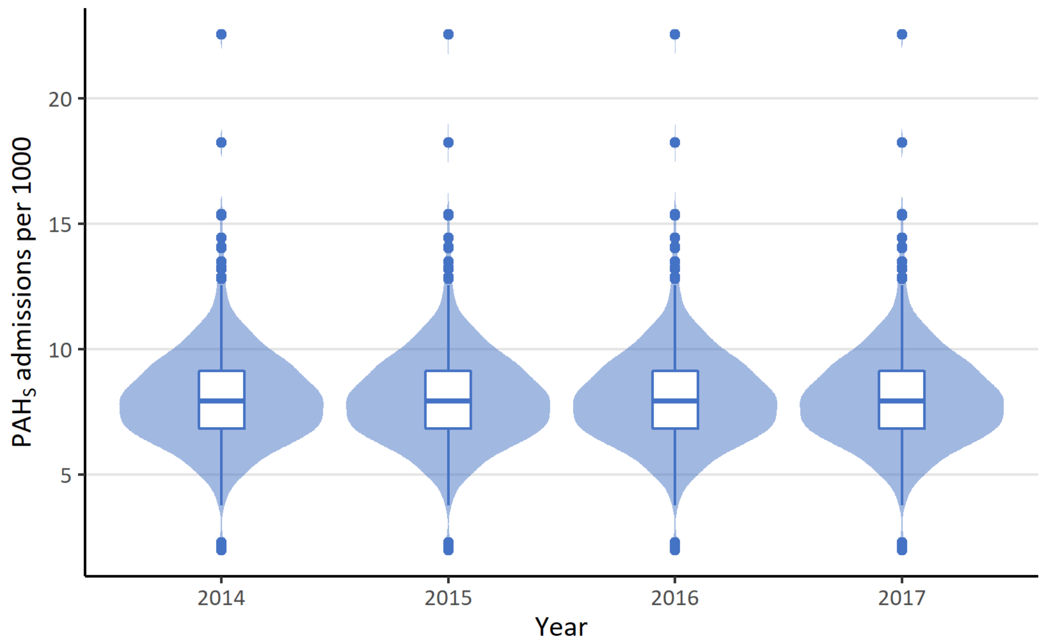
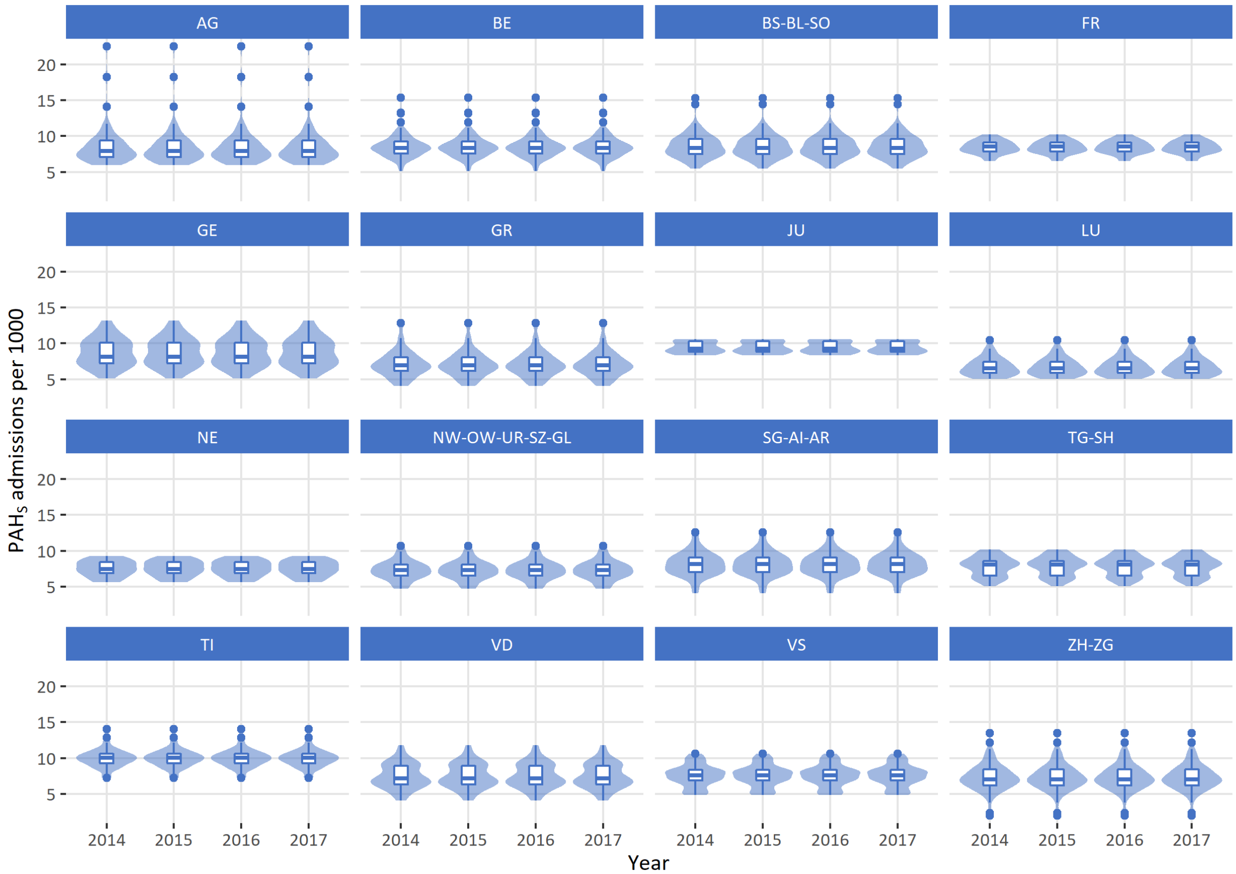


Figure 42 PAH$_S$ time trend by canton groups



4. Results of the Multi-variable Analyses

4.1 Characteristics of the study sample

We use each hospital indicator in turn as our dependent variable. The distribution of these outcomes used are shown in Table 10. The average number of PAH_S admissions is 8.037 per 1000 population at the country level, with a standard deviation of 1.925. For PAH_C, we have a mean of 7.709 admissions per 1000 population and a standard deviation of 1.642. Finally, PIH exhibits a mean of 7.926 admissions per 1000 population and a standard deviation of 2.526.

Descriptive statistics of the explanatory variables measured at the regional and cantonal level are also shown in Table 10. We observe significant variation in the main socioeconomic variables at the regional level. For instance, the proportion of the population receiving social support ("aide sociale") ranges from 0% to 12%. Also, the proportion of the population without any formal qualification ranges from 1.54% to 22.4%. The data also reveals important variation at the MedStat level with respect to the cultural background of the population. For instance, the proportion of the population who does not have an official language as their first language ranges from 0.5% to 25%. Regions and cantons are also quite diverse in terms of access to healthcare providers density (measured as travel time in minutes), especially regarding density of ambulatory physicians.

Table 10 **Sample characteristics**

Panel A – MedStat level (N = 705)					
Outcomes of interest	**Mean**	**Std dev**	**Median**	**Min**	**Max**
PAH_S	8.037	1.925	7.928	1.968	22.558
PAH_C	7.709	1.642	7.564	2.187	17.707
PIH	7.926	2.526	7.465	2.330	24.925
Socioeconomic variables					
SDI	0.000	1.000	-0.208	-1.855	4.123
Proportion with less than mandatory education	0.020	0.008	0.020	0.003	0.050
Proportion of unskilled workers	0.089	0.036	0.085	0.015	0.224
Unemployment rate	0.039	0.021	0.034	0.006	0.136
Proportion receiving social support	0.029	0.021	0.022	0.000	0.119
Proportion with household income < 25K	0.331	0.035	0.329	0.253	0.473
INC	0.000	1.000	-0.129	-2.772	7.974
Healthcare supply					
Travel time to GP (minutes)	4.655	1.979	4.186	1.000	15.392
Travel time to specialist (minutes)	6.464	4.079	5.430	0.000	29.655
Topography					
Urban	0.207	0.406	0.000	0.000	1.000
Suburban	0.241	0.428	0.000	0.000	1.000
Rural	0.552	0.498	1.000	0.000	1.000
Cultural variables					
CLT	0.000	1.000	-0.116	-1.958	3.720
Proportion with a foreign language as first language	0.084	0.045	0.077	0.005	0.250
Proportion of immigrants from abroad	0.134	0.077	0.113	0.026	0.458
Proportion of religion other than catholic or protestant	0.335	0.115	0.332	0.055	0.721
Proportion of foreign nationals	0.224	0.102	0.211	0.024	0.545
Panel B – Canton level (N = 26)					
Socioeconomic variables					
Population density	479.55	709.17	281.14	27.85	5247.85
Dummy for Latin canton	0.301	0.459	0.000	0.000	1.000
Proportion with standard insurance model	0.311	0.064	0.322	0.213	0.466
Proportion with 300 CHF deductible level	0.539	0.036	0.538	0.455	0.623
Healthcare supply					
Hospital beds per 1000 inhabitants	4.428	1.256	4.573	1.411	11.033

4.2 Detailed specifications

4.2.1 Potentially avoidable hospital admissions

Table 11 shows the results of our PAH_S specifications in which the SDI index is included as an independent variable. In the first column, we include the SDI and income index, medical supply variables expressed as travel time to GP and specialists, and regional typography controls as MedStat level variables. Canton level variables include hospital beds per 1000 pop, population density, whether a canton is Latin or Germanic, and the proportion of the canton population who choose a standard health insurance model. We account for a random intercept and a random slope of the SDI. In the second column we replace the SDI by the CLT and include a random slope for the CLT. All other regressors remain unchanged. In the third column we include both the SDI and the CLT. The random slope is set on the SDI.

We only report models that include a random slope, but we conduct a likelihood ratio test to determine whether the random slope improves model fit. Overall, model fit is improved for all models with PAH_S as the dependant variable (Table 11 and Table 12), indicating that allowing the cantonal gradients to differ from the national gradient improves the model. Note however, that slope variance is generally rather modest. Model fit does not improve for models with PAH_C as the dependant variable (Table 13), in particular for the aggregated models (Table 14).

Results in Table 11 show that after controlling for a range of MedStat-level and canton-level variables, the SDI gradient remains statistically significant. One standard deviation increase in the deprivation index leads to a 0.87 increase in PAH_S. We also observe a negative association between INC and PAH_S that becomes stronger when the SDI is not included in the regression. Medstat-level variables of healthcare supply suggest that a lower density of primary care providers (i.e., a longer average distance to providers) is associated with an increase in PAH_S, with coefficients that remain significant for all specifications. When we include both the SDI and CLT in the model, we see that CLT loses statistical significance. The coefficient for SDI does not change once CLT is included in the regression. Finally, suburban regions are associated with significantly less PAH_S admissions than rural regions, whereas urban regions are not significantly different from rural regions. This indicates a U-shaped pattern for urbanisation, with both rural and urban regions showing higher PAH_S, and PAH_S being lowest in suburban regions. With respect to canton level variables, we note a statistically significant negative association between PAH_S and the proportion of individuals that have a CHF 300 deductible level in the canton. This association is not significant in the specification where the SDI is included. Therefore, the proportion of individuals with a CHF 300 deductible likely captures some socioeconomic information that is not related to income.

Looking at random effects, we see that we have reasonable variance for the intercept at 0.50 when the SDI is included and 0.62 when it is not. Slope variance is very small between 0.07 and 0.1 but statistically significant according to the likelihood ratio test (pvalues between 0.013 and 0.025). This suggests that there are differences, albeit small, in the SDI and CLT gradients between cantons. We illustrate this in Figure 43. Graph A shows linear fit lines between PAH_S and the SDI for each canton in grey and for the national mean in blue. We see that most cantons stay close to the national mean both in terms of slope and intercept with three noticeable outliers. Graphs B and C show a representation of gradient and intercept as a caterpillar plot akin to what we presented in the descriptive analysis of section 3. The plots show that TI and AG have gradients and intercepts that are both statistically significant and larger than the national average. LU, VD, and NE have statistically significant intercepts that are lower than the national average.

Table 11 Aggregated multilevel specifications for PAHs

Predictors	PAHs (1) Estimates	PAHs (1) std. Error	PAHs (1) p	PAHs (2) Estimates	PAHs (2) std. Error	PAHs (2) p	PAHs (3) Estimates	PAHs (3) std. Error	PAHs (3) p
(Intercept)	8.35	0.26	**<0.001**	8.38	0.27	**<0.001**	8.36	0.26	**<0.001**
MedStat level									
SDI	0.85	0.12	**<0.001**				0.89	0.13	**<0.001**
INC	-0.40	0.09	**<0.001**	-0.81	0.08	**<0.001**	-0.39	0.09	**<0.001**
CLT				0.54	0.13	**<0.001**	-0.08	0.12	0.505
Distance to closest GP	0.25	0.09	**0.003**	0.20	0.09	**0.025**	0.24	0.09	**0.006**
Distance to closest specialist	-0.10	0.09	0.222	-0.17	0.09	0.053	-0.11	0.09	0.217
Topography (ref. rural)									
Suburban	-0.52	0.18	**0.003**	-0.52	0.18	**0.005**	-0.53	0.18	**0.003**
Urban	-0.08	0.18	0.661	-0.18	0.19	0.330	-0.10	0.18	0.574
Canton level									
Hospital beds	0.07	0.13	0.586	0.06	0.13	0.623	0.08	0.13	0.556
Population density	0.14	0.17	0.402	-0.01	0.21	0.945	0.15	0.17	0.366
Latin canton	-0.43	0.49	0.381	-0.04	0.45	0.929	-0.43	0.49	0.376
Standard insurance model	-0.22	0.20	0.261	-0.22	0.18	0.227	-0.20	0.20	0.294
300 CHF deductible	-0.19	0.22	0.391	-0.46	0.20	**0.025**	-0.19	0.21	0.370
Random Effects									
Random slope on	**SDI**			**CLT**			**SDI**		
Residual variance	2.27			2.46			2.27		
Intercept variance	0.50			0.62			0.50		
Slope variance	0.08			0.11			0.08		
Intercept-slope correlation	0.74			0.98			0.76		
Goodness of fit									
AIC	2659.753			2712.808			2661.324		
Log-Likelihood	-1313.876			-1340.404			-1313.662		
Likelihood ratio test (pvalue)[++]	**0.017**			**0.009**			**0.014**		
Groups	26			26			26		
Observations	705			705			705		

[++] Test of comparison with model that includes no random slope

Figure 43 Graphical representation of the PAH$_S$ aggregated model with SDI

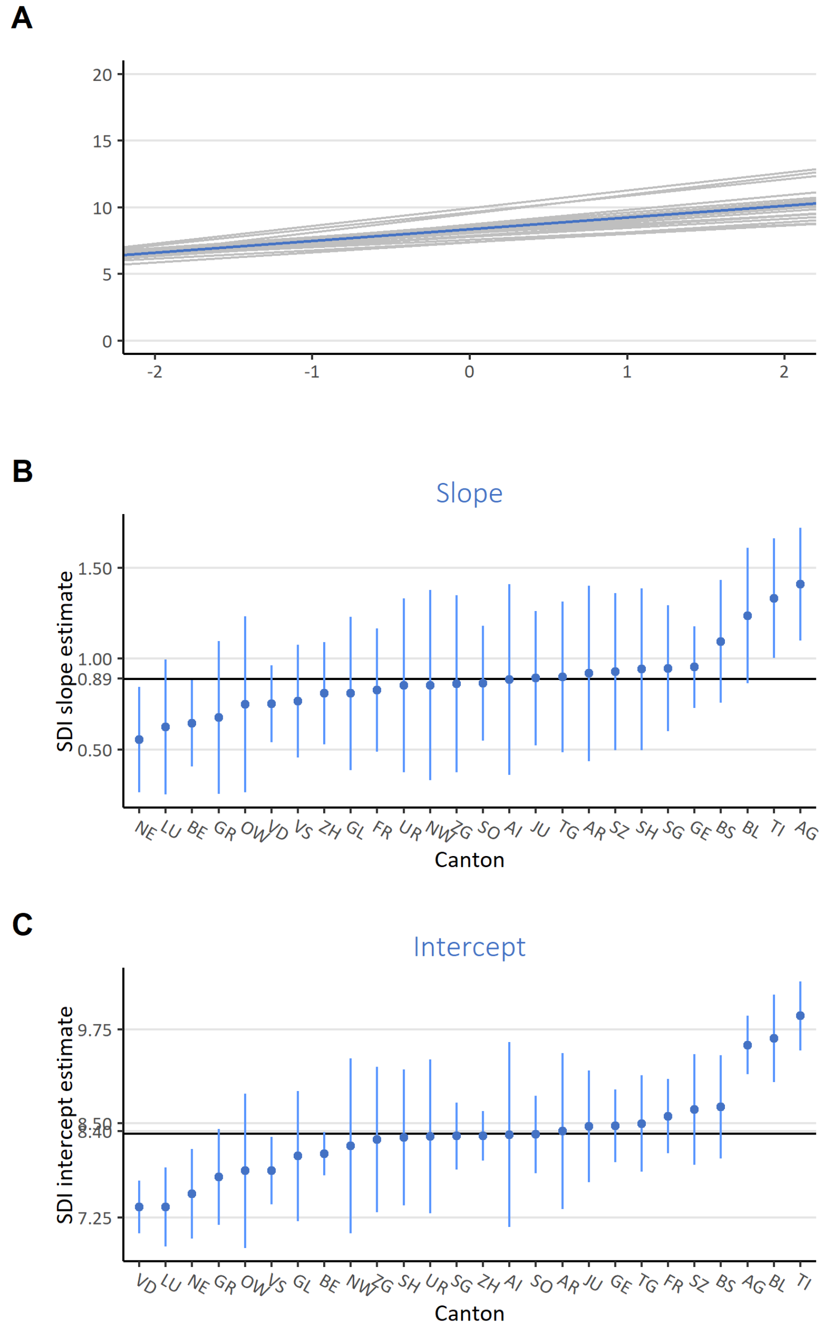


Table 12 shows similar specifications in which the SDI and CLT indicators have been replaced by their individual components, therefore allowing us to better understand what drives the gradients measured above.

Results show that the association is particularly strong for unemployment and education level. The percentage of low skilled workers is also significantly, though less strongly linked to PAH$_S$.

For cultural variables, only language barriers appear as statistically significant in the third specification (where SDI and CLT are both disaggregated). This suggests that regions where the proportion of people who do not speak an official language as their first language increases (i.e., language barrier increases) are associated with a lower PAH_S. It is important to keep in mind however, that the individual components of each index share a strong correlation. This may lead to spurious effects, and caution should be used when interpreting results. Note that the language barrier coefficient is negative. It does not reach statistical significance in the first specification but becomes significant in the third specification, once both the SDI and CLT are disaggregated. This result is likely due to the high level of collinearity among the cultural variables and the socioeconomic variables. Alternate specifications (not shown here) yield no statistical significance when other cultural variables are removed from the regression, and a positive, statistically significant, association between PAH_S and language barrier when both cultural controls and socioeconomic controls are removed form the regression. This last result is in line to what is presented in the previous section and consistent with the correlation matrix in the appendix. In addition to methodological aspects that make the association between PAH_S and language barriers difficult to interpret, other factors may be at play that are discussed in the next section (PAH_C findings).

Table 12 Disaggregated multilevel specifications for PAH_S

	PAH_S (1)			**PAH_S (2)**			**PAH_S (3)**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
(Intercept)	8.42	0.26	**<0.001**	8.37	0.27	**<0.001**	8.42	0.27	**<0.001**
MedStat level									
SDI	0.92	0.15	**<0.001**						
Low education				0.43	0.12	**<0.001**	0.45	0.12	**<0.001**
Unskilled workers				0.16	0.11	0.150	0.25	0.12	**0.046**
Unemployment				0.44	0.15	**0.004**	0.40	0.16	**0.010**
Social benefit				-0.09	0.12	0.465	-0.14	0.12	0.258
Low-income prob.				0.16	0.10	0.105	0.18	0.10	0.080
INC	-0.38	0.09	**<0.001**	-0.41	0.10	**<0.001**	-0.40	0.10	**<0.001**
CLT				-0.08	0.13	0.563			
Language barrier	-0.29	0.17	0.081				-0.35	0.17	**0.039**
Religion	0.04	0.15	0.782				0.20	0.16	0.227
Foreign population rate	0.19	0.21	0.371				0.12	0.22	0.584
Immigrants	-0.03	0.12	0.792				0.01	0.13	0.936
Distance to closest GP	0.24	0.09	**0.006**	0.21	0.09	**0.017**	0.20	0.09	**0.022**
Distance to closest specialist	-0.08	0.09	0.349	-0.14	0.09	0.118	-0.12	0.09	0.160

Predictors	PAHs (1) Estimates	std. Error	p	PAHs (2) Estimates	std. Error	p	PAHs (3) Estimates	std. Error	p
Topography (ref. rural)									
Suburban	-0.54	0.18	**0.002**	-0.49	0.17	**0.005**	-0.49	0.17	**0.005**
Urban	-0.13	0.18	0.475	-0.17	0.18	0.338	-0.22	0.18	0.235
Canton level									
Hospital beds	0.07	0.13	0.611	0.11	0.14	0.434	0.09	0.14	0.496
Population density	0.15	0.17	0.390	0.27	0.17	0.118	0.25	0.17	0.146
Latin canton	-0.53	0.48	0.264	-0.54	0.54	0.312	-0.67	0.53	0.207
Standard insurance model	-0.19	0.19	0.304	-0.22	0.21	0.290	-0.21	0.20	0.293
300 CHF deductible	-0.20	0.21	0.352	-0.25	0.24	0.282	-0.25	0.23	0.282
Random Effects									
Random slope on	**SDI**			**Low education**			**Low education**		
Residual variance	2.27			2.20			2.19		
Intercept variance	0.45			0.44			0.42		
Slope variance	0.08			0.07			0.07		
Intercept-slope correlation	0.74			0.16			0.07		
Goodness of fit									
AIC	2664.462			2652.007			2653.081		
Log-Likelihood	-1312.231			-1305.004			-1302.541		
Likelihood ratio test (pvalue)++	**0.018**			**0.005**			**0.007**		
Groups	26			26			26		
Observations	705			705			705		

++ Test of comparison with model that includes no random slope

Table 13, Figure 44 and Table 14 present the results of the same analysis with PAH_C as the outcome of the regression. SDI has a positive effect on the outcome that is somewhat reinforced when CLT is included. CLT has a statistically significant and positive effect on PAH_C but loses significance once we include the SDI. Travel distance to the nearest GP has a positive effect on PAH_C that remains significant across aggregated specifications. This implies that a lack of access to CBAC (distance to GP increases) is associated with an increase in PAH_C. Suburban regions are associated with significantly less PAH_C with respect to rural regions. The CHF 300 deductible level association appears as statistically significant in all specifications. This indicates that cantons that have a higher proportion of their population with a CHF 300 deductible are associated with lower levels of PAH_C. An explanation could be that individuals who chose a CHF 300 deductible are likely to have greater health needs and generate an important number of doctor visits. Because of the frequent follow-up, health issues would likely be spotted early and therefore less likely to generate potentially avoidable hospitalisations. Another plausible explanation is that individuals with higher deductibles might forgo timely CBAC for financial reasons, with a subsequent impact on PAH. We also see an important negative effect of French/Italian speaking cantons on PAH_C, compared to German speaking cantons (Latin canton variable).

Random effect variance is smaller than for PAH_S with a variance of 0.29 to 0.35 for the intercept and a variance of 0.04 and 0.05 for the slope (gradient). A look at Figure 44 yields similar conclusions, however different cantons show statistical significance with respect to the national average. Cantons BL and AG have a slope that is steeper than that of Switzerland, and canton GE has a flatter slope than Switzerland. Note however, that compared to PAH_S, the random slope model for PAH_C only marginally improves model fit. Thus, the divergences of canton gradients from the national gradient should be interpreted with caution. For the intercept, cantons BL and AG have a higher number of PAH_C admissions per 1000 given a level of SDI of zero, than the national average. Cantons GE, LU, SG, and ZH have an intercept below the national average.

When the specifications are disaggregated, we see a statistically significant association between PAH_C and education, unemployment, and low income. All three variables are associated with increased PAH_C, which is expected. There is also a statistically significant negative association between PAH_C and language barriers, as was the case for PAH_S. However, for PAH_C the association is significant when language barriers are entered alone, and when socioeconomic controls are added (analysis not shown). This makes it unlikely that the observed association is generated by multicollinearity and over-fitting. Therefore, regions with a higher share of the population who do not have an official language as first language seem to be associated with lower PAH_C. The language barrier variable can also be seen as a proxy for first-generation immigrants from countries that do not border Switzerland. It could be that such individuals benefit form a better health state (“healthy migrant” effect), since many of them enter the country at a younger age, with high education and secured employment. The latter does not apply to asylum seekers and refugees, yet this group is likely to be outnumbered by individuals on residence permits (see also findings for permit rates). In either case, more research is required to identify the association between PAH and language barriers.

Table 13 Aggregated multilevel specifications for PAH_C

	PAH_C (1)			PAH_C (2)			PAH_C (3)		
Predictors	*Esti-mates*	*std. Error*	*p*	*Esti-mates*	*std. Error*	*p*	*Esti-mates*	*std. Error*	*p*
(Intercept)	8.09	0.21	**<0.001**	8.10	0.23	**<0.001**	8.11	0.21	**<0.001**
MedStat level									
SDI	0.71	0.09	**<0.001**				0.79	0.11	**<0.001**
INC	-0.25	0.08	**0.001**	-0.57	0.07	**<0.001**	-0.23	0.08	**0.003**
CLT				0.38	0.11	**0.001**	-0.16	0.10	0.111
Distance to closest GP	0.22	0.07	**0.003**	0.15	0.08	0.051	0.19	0.08	**0.011**
Distance to closest specialist	-0.17	0.07	**0.020**	-0.23	0.08	**0.003**	-0.17	0.07	**0.017**
Topography (ref. rural)									
Suburban	-0.39	0.15	**0.011**	-0.40	0.16	**0.011**	-0.40	0.15	**0.008**
Urban	-0.00	0.15	0.997	-0.14	0.16	0.376	-0.05	0.16	0.754
Canton level									
Hospital beds	0.20	0.11	0.061	0.15	0.12	0.232	0.22	0.11	**0.041**
Population density	-0.04	0.14	0.787	-0.08	0.17	0.641	-0.02	0.13	0.897
Latin canton	-0.82	0.38	**0.031**	-0.59	0.43	0.171	-0.83	0.38	**0.028**
Standard insurance model	-0.04	0.15	0.785	-0.00	0.17	0.997	-0.00	0.15	0.974
300 CHF deductible	-0.43	0.17	**0.009**	-0.52	0.20	**0.010**	-0.45	0.16	**0.005**
Random Effects									
Random slope on	**SDI**			**CLT**			**SDI**		
Residual variance	1.68			1.82			1.68		
Intercept variance	0.29			0.35			0.29		
Slope variance	0.04			0.07			0.05		
Intercept-slope correlation	0.86			0.42			0.88		
Goodness of fit									
AIC	2441.078			2504.932			2440.558		
Log-Likelihood	-1204.539			-1236.466			-1203.279		
Likelihood ratio test (pvalue)[++]	0.059			0.179			**0.044**		
Groups	26			26			26		
Observations	705			705			705		

[++] Test of comparison with model that includes no random slope

Figure 44 Graphical representation of the PAH_C model with SDI

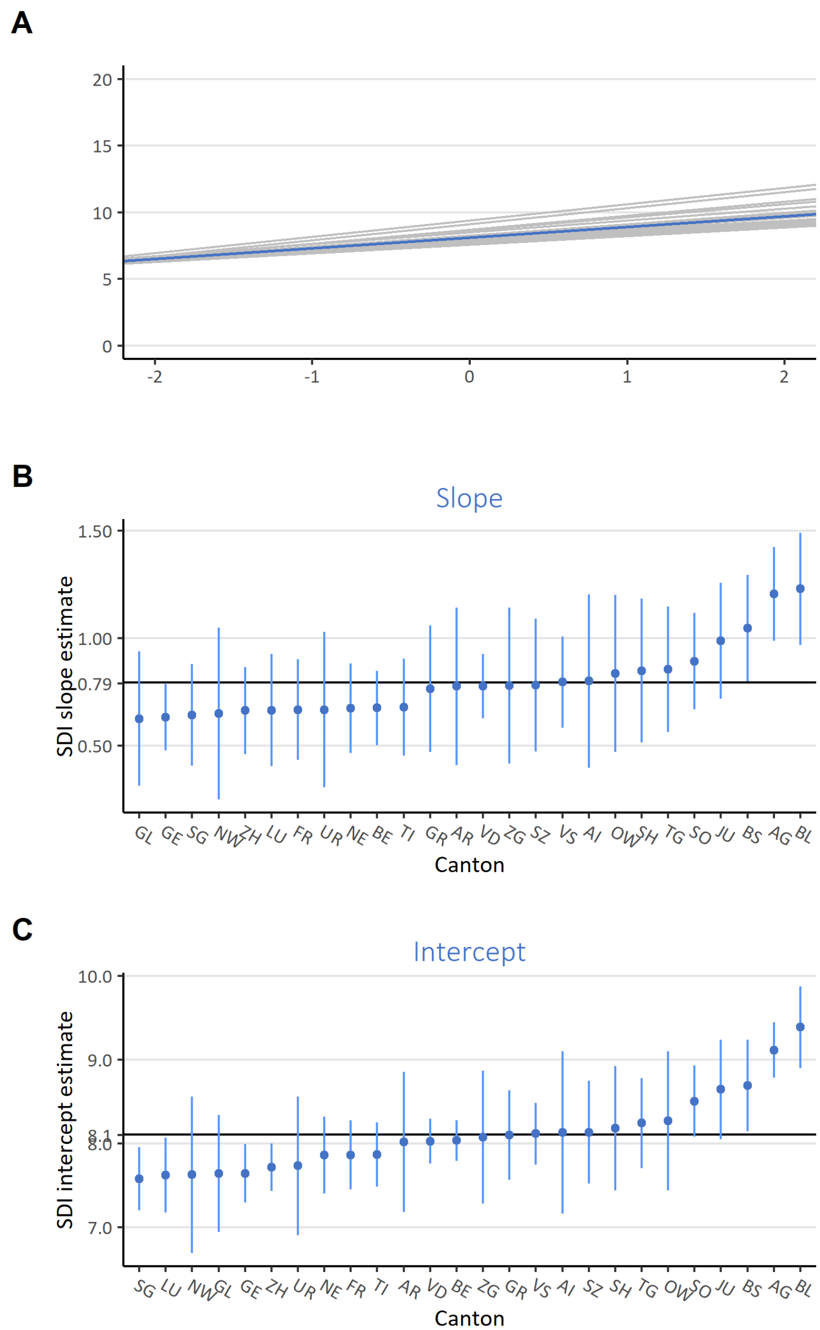


Table 14 Disaggregated multilevel specifications for PAH$_C$

Predictors	PAH$_C$ (1) Estimates	PAH$_C$ (1) std. Error	PAH$_C$ (1) *p*	PAH$_C$ (2) Estimates	PAH$_C$ (2) std. Error	PAH$_C$ (2) *p*	PAH$_C$ (3) Estimates	PAH$_C$ (3) std. Error	PAH$_C$ (3) *p*
(Intercept)	8.18	0.20	**<0.001**	8.16	0.20	**<0.001**	8.23	0.20	**<0.001**
MedStat level									
SDI	0.90	0.13	**<0.001**						
Low education				0.45	0.09	**<0.001**	0.47	0.09	**<0.001**
Unskilled workers				0.06	0.09	0.499	0.16	0.10	0.120
Unemployment				0.36	0.13	**0.004**	0.32	0.13	**0.014**
Social benefit				0.02	0.10	0.813	-0.02	0.10	0.836
Low-income prob.				0.20	0.08	**0.012**	0.24	0.08	**0.005**
INC	-0.21	0.08	**0.010**	-0.22	0.08	**0.007**	-0.20	0.08	**0.014**
CLT				-0.21	0.11	0.058			
Language barrier	-0.34	0.14	**0.017**				-0.36	0.14	**0.013**
Religion	0.15	0.12	0.239				0.19	0.13	0.134
Foreign population rate	0.03	0.18	0.883				0.02	0.18	0.899
Immigrants	-0.00	0.10	0.993				-0.03	0.12	0.764
Distance to closest GP	0.19	0.07	**0.011**	0.15	0.08	**0.044**	0.14	0.08	0.059
Distance to closest specialist	-0.13	0.07	0.069	-0.19	0.07	**0.010**	-0.18	0.07	**0.018**
Topography (ref. rural)									
Suburban	-0.41	0.15	**0.007**	-0.41	0.15	**0.006**	-0.41	0.15	**0.006**
Urban	-0.09	0.16	0.557	-0.14	0.16	0.379	-0.19	0.16	0.217
Canton level									
Hospital beds	0.20	0.10	**0.050**	0.23	0.10	**0.026**	0.22	0.10	**0.023**
Population density	-0.08	0.13	0.525	0.01	0.13	0.930	-0.03	0.12	0.812
Latin canton	-0.93	0.36	**0.010**	-1.01	0.37	**0.007**	-1.14	0.36	**0.001**
Standard insurance model	0.01	0.14	0.921	-0.01	0.14	0.954	-0.01	0.14	0.938
300 CHF deductible	-0.42	0.15	**0.007**	-0.51	0.15	**0.001**	-0.49	0.14	**<0.001**
Random Effects									
Random slope on	**SDI**			**Low education**			**Low education**		
Residual variance	1.66			1.64			1.63		
Intercept variance	0.24			0.23			0.19		
Slope variance	0.07			0.03			0.03		
Intercept-slope correlation	0.80			1.00			1.00		

Goodness of fit			
AIC	2439.588	2426.815	2425.083
Log-Likelihood	-1199.794	-1192.407	-1188.541
Likelihood ratio test (pvalue)++	**0.014**	**0.015**	**0.023**
Groups	26	26	26
Observations	705	705	705

++ Test of comparison with model that includes no random slope

4.2.2 Potentially inappropriate hospital admissions

Table 15 presents the aggregated results of our multilevel specifications for PIH. SDI and INC continue to have important positive, respectively negative effects on the outcome across all specifications. Interestingly, CLT is not statistically significant by itself in column 2 but becomes significant when coupled with SDI in column 3. It is negatively associated with PIH, which means that more cultural diversity is associated to lower PIH. We also see statistically significant effects appearing at the canton level. There is a positive effect of the number of hospital beds on PIH that remains just under the significance level of 5%. Cantons with a higher population density are associated with lower levels of PIH. The proportion of the population with a standard insurance model is associated with an increase in PIH in the second and third specifications.

Random effect variance is stronger for PIH than for PAH, hinting at more nuanced differences between cantons. We see in Figure 45A that there is a large fan effect around the national average when looking at the linear fit between SDI and PIH. Cantons TI and AG have a gradient that is steeper than the national one. Cantons. ZH, VS, and GE have a flatter gradient than the national one. In terms of intercept, cantons SO, SG, BL, and TI are above the national average, and cantons ZH, GE, LU, FR, VD, BE, and NE are below the national average.

When we disaggregate the SDI and CLT (Table 16), we see that low education, unemployment, and the probability of low income are positively associated with an increase in PIH. Once we disaggregated the CLT, language barrier and religion are negatively associated with PIH. This suggests that regions where the proportion of people who speak an official language as their first language increases (i.e., language barrier decreases) are associated with a larger PIH. As for PAH_S, this is likely related to the high level of collinearity between cultural variables and may not represent the association between language barriers and PIH. At the canton level, coefficients lose statistical significance once the SDI is disaggregated.

Table 15 Aggregated multilevel specifications for PIH

	PIH (1)			PIH (2)			PIH (3)		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
(Intercept)	8.79	0.41	**<0.001**	8.91	0.42	**<0.001**	8.85	0.40	**<0.001**
MedStat level									
SDI	0.63	0.17	**<0.001**				0.93	0.19	**<0.001**
INC	-0.33	0.11	**0.003**	-0.62	0.10	**<0.001**	-0.26	0.11	**0.022**
CLT				0.13	0.17	0.434	-0.58	0.15	**<0.001**
Distance to closest GP	0.26	0.11	**0.015**	0.14	0.11	0.199	0.15	0.11	0.157
Distance to closest specialist	-0.05	0.11	0.631	-0.13	0.11	0.248	-0.06	0.10	0.596
Topography (ref. rural)									
Suburban	-0.48	0.22	**0.028**	-0.50	0.23	**0.028**	-0.54	0.22	**0.012**
Urban	-0.07	0.22	0.761	-0.30	0.23	0.193	-0.24	0.22	0.280
Canton level									
Hospital beds	0.36	0.21	0.088	0.44	0.21	**0.036**	0.40	0.20	**0.046**
Population density	-0.60	0.27	**0.024**	-0.82	0.32	**0.011**	-0.53	0.26	**0.040**
Latin canton	-1.21	0.78	0.121	-1.06	0.75	0.158	-1.13	0.74	0.127
Standard insurance model	0.55	0.32	0.081	0.67	0.30	**0.028**	0.72	0.30	**0.018**
300 CHF deductible	0.21	0.35	0.544	0.06	0.34	0.860	0.17	0.32	0.605
Random Effects									
Random slope on	**SDI**			**CLT**			**SDI**		
Residual variance	3.45			3.64			3.39		
Intercept variance	1.81			1.91			1.78		
Slope variance	0.27			0.21			0.30		
Intercept-slope correlation	0.80			0.91			0.86		
Goodness of fit									
AIC	2975.861			3007.744			2963.671		
Log-Likelihood	-1471.930			-1487.872			-1464.836		
Likelihood ratio test (pvalue)++	**<0.001**			**0.002**			**<0.001**		
Groups	26			26			26		
Observations	705			705			705		

++ Test of comparison with model that includes no random slope

Figure 45 Graphical representation of the PIH model with SDI

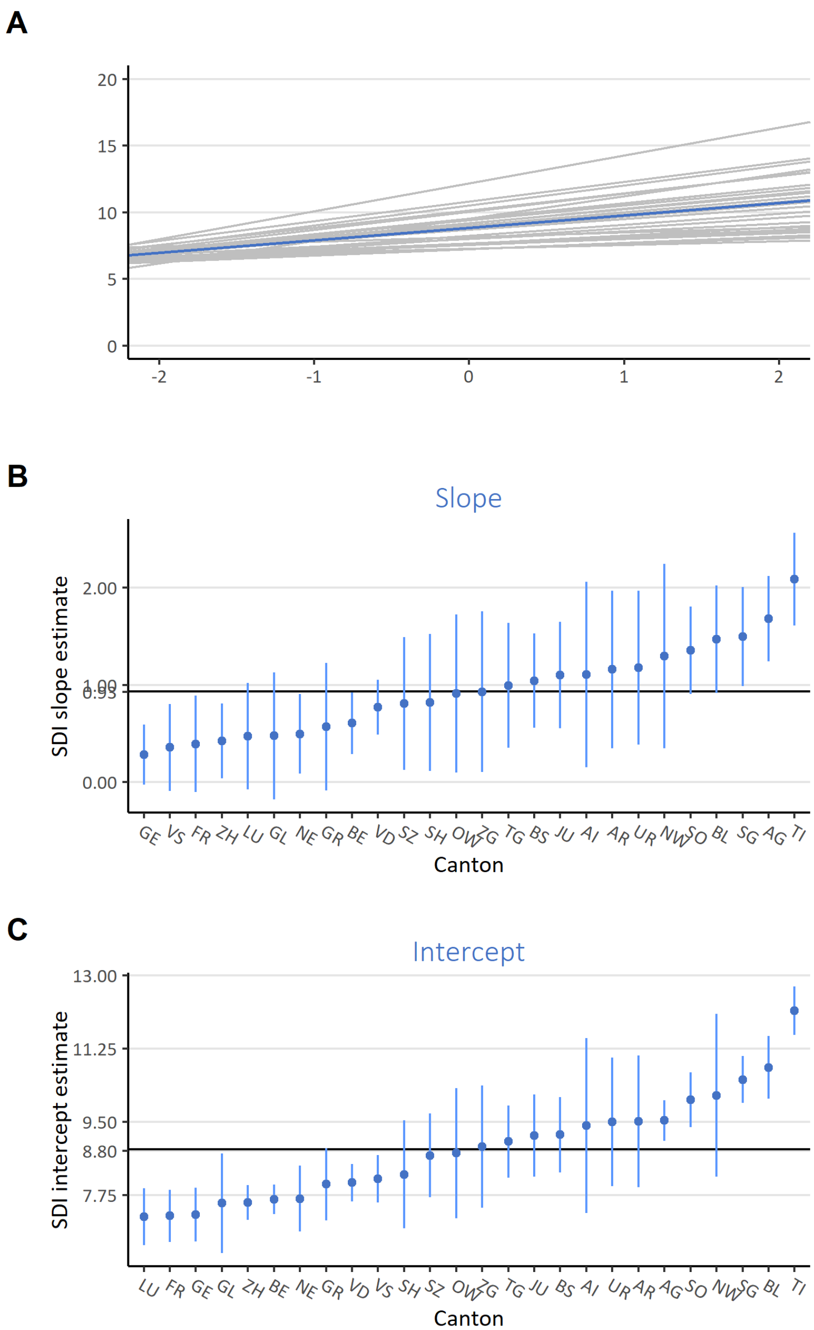


Table 16 **Disaggregated multilevel specifications for PIH**

Predictors	*Estimates*	PIH (1) *std. Error*	*p*	*Estimates*	PIH (2) *std. Error*	*p*	*Estimates*	PIH (3) *std. Error*	*p*
(Intercept)	8.81	0.39	**<0.001**	8.69	0.47	**<0.001**	8.74	0.45	**<0.001**
MedStat level									
SDI	0.93	0.19	**<0.001**						
Low education				0.74	0.15	**<0.001**	0.78	0.15	**<0.001**
Unskilled workers				0.25	0.13	0.060	0.32	0.15	**0.033**
Unemployment				-0.38	0.19	**0.042**	-0.44	0.19	**0.020**
Social benefit				-0.06	0.14	0.686	-0.06	0.15	0.681
Low-income prob.				0.37	0.12	**0.002**	0.33	0.13	**0.008**
INC	-0.21	0.12	0.065	-0.12	0.12	0.330	-0.06	0.12	0.600
CLT				-0.45	0.16	**0.006**			
Language barrier	-0.37	0.21	0.081				-0.70	0.21	**0.001**
Religion	-0.84	0.19	**<0.001**				-0.40	0.21	0.054
Foreign population rate	0.33	0.27	0.222				0.41	0.26	0.119
Immigrants	-0.03	0.15	0.851				0.07	0.16	0.651
Distance to closest GP	0.14	0.11	0.179	0.06	0.11	0.586	0.06	0.11	0.585
Distance to closest specialist	-0.10	0.11	0.351	-0.21	0.10	**0.046**	-0.21	0.10	**0.042**
Topography (ref. rural)									
Suburban	-0.54	0.22	**0.012**	-0.45	0.21	**0.032**	-0.43	0.21	**0.040**
Urban	-0.25	0.22	0.268	-0.35	0.22	0.111	-0.39	0.22	0.072
Canton level									
Hospital beds	0.38	0.19	**0.046**	0.47	0.25	0.057	0.46	0.24	0.054
Population density	-0.35	0.25	0.166	-0.32	0.30	0.288	-0.25	0.29	0.397
Latin canton	-1.21	0.69	0.078	-0.88	0.95	0.353	-1.13	0.90	0.212
Standard insurance model	0.84	0.28	**0.003**	0.36	0.38	0.346	0.40	0.36	0.262
300 CHF deductible	-0.01	0.29	0.975	-0.02	0.43	0.963	-0.15	0.41	0.723
Random Effects									
Random slope on		**SDI**			**Low education**			**Low education**	
Residual variance		3.34			3.12			3.08	
Intercept variance		1.77			2.15			1.87	
Slope variance		0.27			0.16			0.14	
Intercept-slope correlation		0.96			0.62			0.63	

Goodness of fit			
AIC	2955.967	2924.912	2917.490
Log-Likelihood	-1457.984	-1441.456	-1434.745
Likelihood ratio test (pvalue)++	**<0.001**	**<0.001**	**<0.001**
Groups	26	26	26
Observations	705	705	705

++ Test of comparison with model that includes no random slope

4.2.3 Models correcting for spatial autocorrelation

The descriptive analysis of the spatial distribution of admissions (section 3.1.4) reveals clusters of high and low rates of admissions in the country. The models shown in the following tables present models that specifically account for this potential spatial autocorrelation. SDI, INC and CLT still show important associations with the outcome variables for all hospital indicators. We also see important effects that are statistically significant for most canton level variables across specifications. These results are to be interpreted with caution because the current specifications do not account for repeated observations at the canton level, therefore statistical significance calculations for canton level variables are inaccurate.

Table 17 Aggregated SAR specifications for PAH_S

	PAHs (1)			PAHs (2)			PAHs (3)		
Predictors	*Esti-mates*	*std. Er-ror*	*p*	*Esti-mates*	*std. Er-ror*	*p*	*Esti-mates*	*std. Er-ror*	*p*
(Intercept)	6.00	0.41	**0.000**	5.89	0.42	**0.000**	6.05	0.41	**0.000**
MedStat level									
SDI	0.82	0.10	**0.000**				0.88	0.13	**0.000**
INC	-0.24	0.11	**0.023**	-0.69	0.08	**0.000**	-0.23	0.12	**0.047**
CLT				0.42	0.10	**0.000**	-0.06	0.12	0.640
Distance to closest GP	0.22	0.09	**0.014**	0.18	0.10	0.054	0.21	0.09	**0.022**
Distance to closest specialist	-0.13	0.09	0.157	-0.22	0.09	**0.018**	-0.13	0.09	0.161
Topography (ref. rural)									
Suburban	-0.43	0.18	**0.019**	-0.46	0.19	**0.015**	-0.44	0.18	**0.017**
Urban	-0.05	0.19	0.771	-0.18	0.20	0.351	-0.06	0.19	0.733
Interactions									
SDI * INC	0.12	0.08	0.130				0.12	0.09	0.174
SDI * CLT							-0.05	0.06	0.406
CLT * INC				0.02	0.08	0.822	-0.01	0.09	0.888
Canton level									
Hospital beds	0.07	0.08	0.401	-0.05	0.08	0.579	0.07	0.08	0.389
Population density	0.16	0.10	0.112	0.22	0.10	**0.029**	0.18	0.10	0.072
Latin canton	-0.31	0.23	0.182	0.02	0.24	0.930	-0.32	0.23	0.170
Standard insurance model	-0.17	0.10	**0.079**	-0.21	0.10	**0.044**	-0.16	0.10	0.112
300 CHF deductible	0.05	0.09	0.571	0.01	0.09	0.876	0.04	0.09	0.622
Observations		705			705			705	

Table 18 Aggregated SAR specifications for PAH_C

	PAH_C (1)			PAH_C (2)			PAH_C (3)		
Predictors	*Esti-mates*	*std. Error*	*p*	*Esti-mates*	*std. Error*	*p*	*Esti-mates*	*std. Error*	*p*
(Intercept)	5.98	0.39	**0.000**	5.84	0.40	**0.000**	6.06	0.39	**0.000**
MedStat level									
SDI	0.79	0.08	**0.000**				0.92	0.11	**0.000**
INC	-0.13	0.09	0.150	-0.58	0.07	**0.000**	-0.13	0.10	0.168
CLT				0.34	0.09	**0.000**	-0.16	0.10	0.105
Distance to closest GP	0.26	0.07	**0.000**	0.19	0.08	**0.017**	0.22	0.08	**0.004**
Distance to closest specialist	-0.18	0.07	**0.014**	-0.28	0.08	**0.000**	-0.19	0.07	**0.011**
Topology (ref. rural)									
Suburban	-0.36	0.15	**0.018**	-0.40	0.16	**0.013**	-0.38	0.15	**0.013**
Urban	0.05	0.16	0.732	-0.10	0.17	0.531	0.02	0.16	0.889
Interactions									
SDI * INC	0.11	0.07	0.096				0.08	0.07	0.262
SDI * CLT							-0.07	0.05	0.152
CLT * INC				0.08	0.07	0.223	0.06	0.07	0.414
Canton level									
Hospital beds	0.22	0.07	**0.001**	0.11	0.07	0.130	0.23	0.07	**0.001**
Population density	-0.11	0.08	0.172	-0.03	0.09	0.696	-0.06	0.08	0.468
Latin canton	-1.01	0.19	**0.000**	-0.69	0.20	**0.001**	-1.06	0.19	**0.000**
Standard insurance model	0.06	0.08	0.481	0.04	0.09	0.656	0.09	0.08	0.281
300 CHF deductible	-0.30	0.08	**0.000**	-0.35	0.08	**0.000**	-0.32	0.08	**0.000**
Observations	705			705			705		

Table 19 Aggregated SAR specifications for PIH

	PIH (1)			PIH (2)			PIH (3)		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
(Intercept)	4.06	0.38	**0.000**	4.19	0.39	**0.000**	4.23	0.38	**0.000**
MedStat level									
SDI	0.49	0.13	**0.000**				0.79	0.16	**0.000**
INC	-0.15	0.13	0.260	-0.44	0.09	**0.000**	-0.11	0.15	0.445
CLT				0.03	0.13	0.796	-0.37	0.15	**0.012**
Distance to closest GP	0.20	0.11	0.081	0.10	0.12	0.417	0.12	0.12	0.289
Distance to closest specialist	-0.08	0.11	0.464	-0.17	0.11	0.144	-0.09	0.11	0.429
Topography (ref. rural)									
Suburban	-0.18	0.23	0.437	-0.21	0.24	0.362	-0.20	0.23	0.376
Urban	-0.04	0.24	0.866	-0.23	0.24	0.335	-0.12	0.24	0.614
Interactions									
SDI * INC	0.03	0.10	0.788				0.00	0.11	0.965
SDI * CLT							-0.14	0.08	0.068
CLT * INC				0.06	0.10	0.538	0.03	0.11	0.780
Canton level									
Hospital beds	0.42	0.10	**0.000**	0.37	0.10	**0.000**	0.45	0.10	**0.000**
Population density	-0.62	0.12	**0.000**	-0.54	0.13	**0.000**	-0.52	0.13	**0.000**
Latin canton	-0.45	0.29	0.122	-0.24	0.29	0.405	-0.54	0.29	0.062
Standard insurance model	0.24	0.12	**0.049**	0.28	0.13	**0.026**	0.32	0.13	**0.011**
300 CHF deductible	0.42	0.12	**0.000**	0.36	0.12	**0.003**	0.37	0.12	**0.001**
Observations	705			705			705		

5. Discussion

When monitoring the performance of healthcare systems, experts and policymakers typically rely on indicators that reflect average outcomes in the population or in specific patient groups. These assessments often overlook how outcomes are distributed in the population according to socioeconomic status or cultural background for instance. In other words, average outcomes might mask important heterogeneity that can reflect equity issues in access to appropriate care. In this project we sought to investigate whether, in Switzerland, hospital admissions that indicate sub-optimal access to community-based ambulatory care (CBAC), i.e., potentially avoidable admissions (PAH), where observed more frequently in regions that are more deprived, or culturally diverse. We applied and extended a method developed by Cookson and colleagues that studied gradients in admissions for ambulatory care sensitive conditions (ACSCs) in the English NHS.

We find robust and stable socioeconomic gradients in potentially avoidable hospitalisations at the national level, both with respect to deprivation and income. In other words, the rate of potentially avoidable hospitalisations is higher in more deprived and less affluent regions of the country. We also find that there is some, albeit weak, variation in gradients between cantons, with a few exhibiting systematically stronger or weaker gradients than the national average. In multivariate analyses, we show particularly strong associations between low education and unemployment, and the rate of potentially avoidable hospitalisations. We also show that the density of healthcare providers plays a role in explaining specific hospitalisations rates. Specifically, better geographical access to community-based ambulatory care (i.e., GP practices) seems to reduce potentially avoidable hospitalisations, whereas higher hospital density is associated with higher rates of hospitalisations that are deemed inappropriate.

The analyses of cultural diversity as drivers of admissions showed mixed results. While we find association between some region-level markers of cultural diversity and potentially avoidable hospitalisations, the associations are much weaker when socioeconomic status is accounted for, therefore indicating a strong correlation between the two sets of characteristics. We find, however, evidence suggesting that two mechanisms might be at play in this area:

I. A “healthy migrant” effect explained by the fact that a large proportion of foreign nationals living in the country is younger than the average Swiss (i.e., negative association between proportion of foreign nationals and potentially avoidable hospitalisations).

II. A positive association between potentially avoidable hospitalisations and the proportion of immigrants with specific profiles (i.e., settled foreign nationals, temporarily admitted refugees and other foreigners who live in socially deprived regions). This could indicate potential access issues specific to these groups. The findings however warrant further investigations.

Our results also consistently show important geographic variation in all indicators, i.e., potentially avoidable hospitalisations, potentially inappropriate hospitalisations. Irrespective of the correlation between these indicators and deprivation or cultural factors, regions and clusters with relatively high and low rates of admissions should be further studied.

Finally, our results suggest that potentially avoidable hospitalisations could be reduced by an estimated 5,443 units if potentially avoidable hospitalisations for the 20% most deprived regions in Switzerland were brought to the national average. This would correspond to an estimated CHF 14 million saved in hospital costs. If the hospitalisation rate of the 50% more deprived regions were brought to the national average, these savings would amount to an estimated CHF 37 million.

Strengths and limitations

Our study has several strengths. First, our approach is grounded on an established methodology developed and applied to the English NHS that we adapt to the Swiss context. Then, we propose to use a range of indicators, each offering different insights in potential issues in the Swiss healthcare system. Our methodology is transparent and therefore easily replicable and adaptable at the national or cantonal level for monitoring purposes for instance. Previous studies have documented socioeconomic gradients in health outcomes or in access to care in Switzerland and related mechanisms (see e.g. Avendano et al. 2006 [61] about ischaemic heart disease mortality, Franzen et al. 2014 on the association between health literacy and costs [62], or de Mestral et al. 2016 on barriers to healthy eating [63]), as well as variation in rates of avoidable hospitalisations in the general population [64] and in nursing home residents [65]. However, our study is one of the first to provide comprehensive, national evidence on a socioeconomic and cultural gradient in healthcare access with a methodology that allows comparisons across cantons. One distinctive advantage of this work is that it indeed compares canton equity performance, potentially providing more actionable intelligence for canton level healthcare policymakers. Our results are in line with a recent study using patient-level data by Bayer-Oglesby et al. (2020) [7] that shows that in Switzerland certain social groups have an increased risk of being admitted to hospital due to chronic conditions. Those affected are persons with a low education level, limited social resources and a lack of labour market integration.

Our main limitation, however, is that our analysis is based on aggregated data on deprivation and cultural diversity and that the associations observed do not necessarily reflect a causal relationship between deprivation and poor access to CBAC. For instance, we are limited in our ability to measure population health status (i.e., morbidity) at the MedStat level. Also, we have used only limited measures of healthcare supply, and these could be enriched with information on, for instance, density of social care providers, in particular home care and nursing homes. Our cultural diversity and migration measures, while useful to get initial insights in potential issues, are limited. Even in our analyses using finer patient-level nationality data, we were rapidly constrained by sample size to make credible statistical comparisons between groups. Finally, by construction, our indicators are limited to the hospital setting and we are therefore constrained by the information included in this type of administrative data.

Policy implications

Overall, our main contribution is to shed light on disparities in the Swiss healthcare system when it comes to access to appropriate community-based ambulatory care. The fact that access seems to systematically vary between socioeconomic groups and place of residence raises equity concerns. Indeed, we observe important differences in access between cantons and between regions, with most deprived regions having on average higher rates of potentially avoidable hospitalisations. Such hospital admissions are caused by known health conditions (e.g., diabetes or hypertension) and could be minimized with adequate access to community-based ambulatory care and regular follow up. Based on our main findings, we formulate a series of potential policy implications at two levels: 1) population and patients, and 2) providers and the health system.

On the population and patient side, addressing broader social determinants of health in specific communities will likely have a strong potential to reduce the observed gap in potentially avoidable hospitalisations between most deprived and least deprived areas. Low levels of **education seem to be a particularly strong driver** of potentially avoidable hospitalisations, as evidenced in other countries and settings, which could reflect **difficulties to identify health needs** (i.e., low health literacy), **problems in self-managing chronic diseases**, or **challenges to navigate our complex health system** (i.e., low navigation literacy for instance). Efforts targeted at reducing the education gradient in health literacy will likely lead to lower rates of potentially avoidable hospitalisations, in particular for patients suffering from chronic conditions.

In addition, improving the navigation health literacy (i.e., the level of understanding of our health system and how to navigate in the system) of vulnerable groups could lead to improved choices with regards to health insurance and healthcare use. Special attention should be paid to persons with migration background, especially migrants living in precarious working and living conditions (not speaking the local language, low-skilled work, or with an uncertain residency status) and different actions should be undertaken taking into account the type of migration (employment or forced migration).

Income also seems to play a major role, which can reflect financial barriers in access to appropriate and timely community-based ambulatory care. The strongly regressive nature of healthcare financing in Switzerland, with per capita premium and high out-of-pocket expenditures in international comparison, likely explains some of this association.

On the providers and health system side, we showed that the geographical accessibility/density of community-based ambulatory care providers plays a role in potentially avoidable hospitalisations. We also show that potentially inappropriate hospitalisation rates are partly driven by the density of hospital beds, which would reflect financial incentives at the hospital-level to lower admission thresholds. Overall, our results suggest that inefficiencies in our system might be related to a sub-optimal balance between hospital and community-based ambulatory care accessibility.

Measures to improve health literacy also need to be taken on the provider side. Providing incentives to healthcare professionals and social workers to improve communication with patients could be a major way to improve health literacy. The close association between cultural factors and socioeconomic deprivation makes their relationship with potentially avoidable hospitalisations difficult to disentangle. However, improving cultural competencies of the healthcare professionals, for community-based ambulatory care as well as in the hospital setting, would likely lead to benefits.

The financial burden of disease may be unevenly concentrated on the poor. Subsidy programs or cost-sharing exemptions aimed at patients suffering from chronic conditions may reduce the financial burden for this part of the population and improve access to timely care. From a broader perspective, further investments in strengthening access to well-coordinated primary care to all has the potential to improving both efficiency and equity in the system.

Next steps

While our analyses shed light on equity issues in the Swiss healthcare system, it also leaves important questions unanswered and raises new ones. In particular, despite having access to rich individual-level data on hospital care, we had to rely on a limited set of socio-economic and cultural indicators at a higher level of aggregation in an ecological approach. A more in-depth understanding of inequities would require additional metrics, if possible measured at the individual level. In particular, further research around cultural background is needed to be able to disentangle a "healthy migrant" effect from access issues in specific groups of the migrant population. Also, more detailed measures of healthcare supply that goes beyond primary care and specialist provider density would be needed to better describe community-based care in Switzerland, including other health professionals, home care, etc. Research is needed to develop policy-relevant lists of hospital indicators related to mental health conditions that can shed light on potential unmet needs and access issues in this area. Overall, more granular data on both indicators and socioeconomic and cultural determinants would help better understand what causes the gradients observed in this report.

All hospital indicators considered in this report are related to somatic health conditions. It would also be interesting to focus on mental health indicators. Those conditions are more specific to individual patients and must be treated on a case-by-case basis. Therefore, despite rare attempts [66], no consensus yet exists on what can be considered as avoidable with better access to CBAC. Patients who suffer from mental health disorders have specific needs that are more difficult to identify than somatic health needs, thus leading to unmet needs in this population and potential equity issues. At the system level, we often observe an underinvestment in mental healthcare with respect to the burden of disease that it represents [67]. Supply side factors such as the availability of psychiatrists and specialised mental health institutions also play an important role in this context. During the course of this study, we conducted some preliminary analyses on mental health indicators. We selected all-cause psychiatric admissions as hospital indicator and applied the same methodology as for potentially avoidable and potentially inappropriate hospitalisations. The results are available in the appendix.

A purpose of this project is also to show feasibility and value of using such indicators to highlight potential issues at the federal or cantonal level in a routine manner. Changes in gradients, or in the rate of avoidable hospitalizations, can help policymakers at various levels target further investigations. Also, rates of potentially avoidable hospitalizations and their distribution in the population can be used as outcomes to assess the impact of canton-level policies that affect different dimensions of accessibility. However, efforts are required to facilitate the use of nation-wide individual-level data. This could be achieved by developing data linkage (i.e., unique identifier, trust centre) and/or by systematically collecting socio-economic information and information on migration background of patients at the hospital level. Also, access to comprehensive outpatient data is lacking, rendering it difficult to measure access to community care and quality of community care directly.

A natural next step to this national investigation, would be to conduct in-depth, mixed-methods (i.e., quantitative and qualitative) studies in specific regions and cantons to better understand what lies behind strong gradients, weak gradients, or, e.g., hotspots of admissions. Accessibility to richer data on both outcomes and determinants will likely be higher in smaller jurisdictions, and qualitative interviews with both providers and policymakers will help overcome the limitations of a purely quantitative approach.

6. References

1. de Pietro, C., et al., *The performance of the Swiss health system: good results but high costs: Wilm Quentin.* European Journal of Public Health, 2015. **25**(suppl_3).
2. OECD, *Health at a Glance 2019*. 2019.
3. Wyss, K. and N. Lorenz, *Decentralization and central and regional coordination of health services: the case of Switzerland.* Int J Health Plann Manage, 2000. **15**(2): p. 103-14.
4. Cookson, R., et al., *Health equity monitoring for healthcare quality assurance.* Social Science & Medicine, 2018. **198**: p. 148-156.
5. Laberge, M. and M. Leclerc, *Immigration factors and potentially avoidable hospitalizations in Canada.* SSM Popul Health, 2019. **7**: p. 100336.
6. Tzogiou, C., S. Boes, and B. Brunner, *What explains the inequalities in health care utilization between immigrants and non-migrants in Switzerland?* BMC Public Health, 2021. **21**(1): p. 530.
7. Bayer-Oglesby, L., N. Bachmann, and A. Zumbrunn, *Social situation and hospitalisation due to chronic conditions (Obsan Report 11/2020)*. 2021.
8. Doty, M.M., et al., *Income-Related Inequality In Affordability And Access To Primary Care In Eleven High-Income Countries.* Health Affairs, 2021. **40**(1): p. 113-120.
9. Papanicolas, I., L.R. Woskie, and A.K. Jha, *Health Care Spending in the United States and Other High-Income Countries.* Jama, 2018. **319**(10): p. 1024-1039.
10. *Health policy in Switzerland*, in *OECD Health Policy Overview*. 2017, OECD.
11. Wagstaff, A., P. Eozenou, and M. Smitz, *Out-of-Pocket Expenditures on Health: A Global Stocktake.* The World Bank Research Observer, 2020. **35**(2): p. 123-157.
12. Crivelli, L. and P. Salari, *The inequity of the Swiss Health Care system financing from a federal state perspective.* Int J Equity Health, 2014. **13**: p. 17.
13. FDFA. *Discover Switzerland: Language facts and figures*. [cited 2020 25 August]; Available from: https://www.eda.admin.ch/aboutswitzerland/en/home/gesellschaft/sprachen/die-sprachen---fakten-und-zahlen.html#:~:text=Switzerland%20has%20four%20language%20regions,while%20French%20speakers%20are%20increasing.
14. Wei, W., et al., *Variation of preoperative chest radiography utilization in Switzerland and its influencing factors: a multilevel study with claims data.* Scientific Reports, 2018. **8**(1): p. 17475.
15. Wei, W., et al., *Degree of regional variation and effects of health insurance-related factors on the utilization of 24 diverse healthcare services - a cross-sectional study.* BMC Health Services Research, 2020. **20**(1): p. 1091.
16. Gruber, J., et al., *The effect of increased cost-sharing on low-value service use.* Health Econ, 2020.
17. Billings, J., et al., *Impact Of Socioeconomic Status On Hospital Use In New York City.* Health Affairs, 1993. **12**(1): p. 162-173.
18. Bergamo, C., E. Juarez-Colunga, and R. Capp, *Association of mental health disorders and Medicaid with ED admissions for ambulatory care-sensitive condition conditions.* Am J Emerg Med, 2016. **34**(5): p. 820-4.
19. Berlin, C., et al., *Avoidable hospitalizations in Switzerland: a small area analysis on regional variation, density of physicians, hospital supply and rurality.* Bmc Health Services Research, 2014. **14**.

20. Mercier, G., V. Georgescu, and J. Bousquet, *Geographic Variation In Potentially Avoidable Hospitalizations In France.* Health Affairs, 2015. **34**(5): p. 836-843.
21. Renner, A.T., *Inefficiencies in a healthcare system with a regulatory split of power: a spatial panel data analysis of avoidable hospitalisations in Austria.* Eur J Health Econ, 2020. **21**(1): p. 85-104.
22. Weeks, W.B., B. Ventelou, and A. Paraponaris, *Rates of admission for ambulatory care sensitive conditions in France in 2009-2010: trends, geographic variation, costs, and an international comparison.* European Journal of Health Economics, 2016. **17**(4): p. 453-470.
23. Dalla Zuanna, T., et al., *Avoidable hospitalisation for diabetes mellitus among immigrants and natives: Results from the Italian Network for Longitudinal Metropolitan Studies.* Nutr Metab Cardiovasc Dis, 2020. **30**(9): p. 1535-1543.
24. Dalla Zuanna, T., et al., *Avoidable hospitalization among migrants and ethnic minority groups: a systematic review.* European Journal of Public Health, 2017. **27**(5): p. 861-868.
25. Nishino, Y., S. Gilmour, and K. Shibuya, *Inequality in diabetes-related hospital admissions in England by socioeconomic deprivation and ethnicity: facility-based cross-sectional analysis.* PLoS One, 2015. **10**(2): p. e0116689.
26. Fleetcroft, R., et al., *Does practice analysis agree with the ambulatory care sensitive conditions' list of avoidable unplanned admissions?: a cross-sectional study in the East of England.* Bmj Open, 2018. **8**(4).
27. Laberge, M., et al., *Hospitalizations for ambulatory care sensitive conditions across primary care models in Ontario, Canada.* Soc Sci Med, 2017. **181**: p. 24-33.
28. Weissman, J.S., C. Gatsonis, and A.M. Epstein, *Rates of Avoidable Hospitalization by Insurance Status in Massachusetts and Maryland.* JAMA, 1992. **268**(17): p. 2388-2394.
29. AHRQ. 2020 [cited 2020 20 August]; Available from: https://www.qualityindicators.ahrq.gov/modules/pqi_resources.aspx.
30. OECD, *Health Care Quality and Outcomes (HCQO)2018-19 Indicator definitions*. 2018.
31. Billings, J., G.M. Anderson, and L.S. Newman, *Recent findings on preventable hospitalizations.* Health Aff (Millwood), 1996. **15**(3): p. 239-49.
32. Gusmano, M.K., V.G. Rodwin, and D. Weisz, *A new way to compare health systems: avoidable hospital conditions in Manhattan and Paris.* Health Aff (Millwood), 2006. **25**(2): p. 510-20.
33. Eggli, Y., et al., *Comparing potentially avoidable hospitalization rates related to ambulatory care sensitive conditions in Switzerland: the need to refine the definition of health conditions and to adjust for population health status.* Bmc Health Services Research, 2014. **14**.
34. Eggli, Y., et al., *Measuring unnecessary hospitalizations in Switzerland.* submitted, 2020.
35. Agabiti, N., et al., *Income level and chronic ambulatory care sensitive conditions in adults: a multicity population-based study in Italy.* BMC Public Health, 2009. **9**: p. 457.
36. Blustein, J., K. Hanson, and S. Shea, *Preventable hospitalizations and socioeconomic status.* Health Aff (Millwood), 1998. **17**(2): p. 177-89.
37. Laditka, J.N., S.B. Laditka, and M.P. Mastanduno, *Hospital utilization for ambulatory care sensitive conditions: health outcome disparities associated with race and ethnicity.* Soc Sci Med, 2003. **57**(8): p. 1429-41.
38. Levin, K.A. and E.M. Crighton, *The Reshaping Care for Older People programme and changes in unscheduled hospital care: Analysis of routinely collected hospital data.* Maturitas, 2017. **103**: p. 23-31.
39. McCormick, B., P.S. Hill, and S. Redding, *Comparative morbidities and the share of emergencies in hospital admissions in deprived areas: a method and evidence from English administrative data.* BMJ Open, 2018. **8**(8): p. e022573.

40. Pappas, G., et al., *Potentially avoidable hospitalizations: inequalities in rates between US socioeconomic groups.* Am J Public Health, 1997. **87**(5): p. 811-6.
41. Balakrishnan, M.P., et al., *The Association of Health Literacy With Preventable Emergency Department Visits: A Cross-sectional Study.* Academic Emergency Medicine, 2017. **24**(9): p. 1042-1050.
42. Mitchell, S.E., et al., *Health literacy and 30-day postdischarge hospital utilization.* J Health Commun, 2012. **17 Suppl 3**: p. 325-38.
43. FSO. *MedStat Regions*. 2020 [cited 2020 19 March]; Available from: https://www.bfs.admin.ch/bfs/fr/home/statistiques/sante/nomenclatures/medsreg.html.
44. MicroGIS. *Swiss Facts*. 2020 [cited 2020 19 March]; Available from: http://www.microgis.ch/donnees/donnees-statistiques.
45. FSO. *Choix d'indicateurs en comparaison régionale, 2019 (cantons)*. 2020 [cited 2020 28 August]; Available from: https://www.bfs.admin.ch/bfs/en/home/statistics/regional-statistics/regional-portraits-key-figures/cantons.assetdetail.7786545.html.
46. Purdy, S., et al., *Ambulatory care sensitive conditions: terminology and disease coding need to be more specific to aid policy makers and clinicians.* Public Health, 2009. **123**(2): p. 169-73.
47. *SQLape - unjustified stays*. [cited 2020 28 August]; Available from: https://www.sqlape.com/unjustified-stays/.
48. Thorne, K., et al., *The impact of social deprivation on mortality following hip fracture in England and Wales: a record linkage study.* Osteoporos Int, 2016. **27**(9): p. 2727-2737.
49. Lazzarino, A.I., et al., *Inequalities in stroke patients' management in English public hospitals: a survey on 200,000 patients.* PLoS One, 2011. **6**(3): p. e17219.
50. Fairley, L., R. Dundas, and A.H. Leyland, *The influence of both individual and area based socioeconomic status on temporal trends in Caesarean sections in Scotland 1980-2000.* BMC Public Health, 2011. **11**: p. 330.
51. Omer, W. and T. Al-Hadithi, *Developing a socioeconomic index for health research in Iraq.* Eastern Mediterranean Health Journal, 2017. **23**(10): p. 670-677.
52. Saif-Ur-Rahman, K.M., et al., *Use of indices to measure socio-economic status (SES) in South-Asian urban health studies: a scoping review.* Systematic Reviews, 2018. **7**(1): p. 196.
53. Panczak, R., et al., *A Swiss neighbourhood index of socioeconomic position: development and association with mortality.* Journal of Epidemiology and Community Health, 2012. **66**(12): p. 1129-1136.
54. Kang, C., L. Tomkow, and R. Farrington, *Access to primary health care for asylum seekers and refugees: a qualitative study of service user experiences in the UK.* British Journal of General Practice, 2019. **69**(685): p. e537.
55. Popper-Giveon, A. and Y. Keshet, *Non-Vaccination Stage Model (NVST): The decision-making process among Israeli ultra-orthodox Jewish parents.* Health, 2021: p. 1363459320988884.
56. Pratt, R., et al., *"We are Muslims and these diseases don't happen to us": A qualitative study of the views of young Somali men and women concerning HPV immunization.* Vaccine, 2019. **37**(15): p. 2043-2050.
57. Rodnay, M., et al., *Bridging the gap: challenging attitudes towards smoking in pregnancy among healthcare professionals.* 2018. **16**(1).
58. Anselin, L., *Local Indicators of Spatial Association—LISA.* Geographical Analysis, 1995. **27**(2): p. 93-115.
59. Anselin, L. and F. European Science. *The Moran Scatterplot as an ESDA Tool to Assess Local Instability in Spatial Association*. in *Meeting, Spatial analytical perspectives on GIS*. 1996. London: Taylor & Francis;.

60. FSO. *Ausserkantonale Hospitalisierungen: Saldo der interkantonalen Patientenströme*. 2018 [cited 2021 July 29]; Available from: https://www.bfs.admin.ch/bfs/en/home/statistics/catalogues-databases/maps.assetdetail.4946174.html.
61. Avendano, M., et al., *Socioeconomic status and ischaemic heart disease mortality in 10 western European populations during the 1990s.* 2006. **92**(4): p. 461-467.
62. Franzen, J., et al., *The relationship between functional health literacy and the use of the health system by diabetics in Switzerland.* European Journal of Public Health, 2013. **24**(6): p. 997-1003.
63. de Mestral, C., S. Stringhini, and P. Marques-Vidal, *Barriers to healthy eating in Switzerland: A nationwide study.* Clinical Nutrition, 2016. **35**(6): p. 1490-1498.
64. Berlin, C., et al., *Avoidable hospitalizations in Switzerland: a small area analysis on regional variation, density of physicians, hospital supply and rurality.* BMC Health Services Research, 2014. **14**(1): p. 289.
65. Muench, U., et al., *Preventable hospitalizations from ambulatory care sensitive conditions in nursing homes: evidence from Switzerland.* International Journal of Public Health, 2019. **64**(9): p. 1273-1281.
66. Lavoie, J.G., et al., *Hospitalization for mental health related ambulatory care sensitive conditions: what are the trends for First Nations in British Columbia?* Int J Equity Health, 2018. **17**(1): p. 156.
67. Ngui, E.M., et al., *Mental disorders, health inequalities and ethics: A global perspective.* Int Rev Psychiatry, 2010. **22**(3): p. 235-44.
68. Leung, K.S., J. Parks, and J. Topolski, *Preventable hospitalizations among adult Medicaid beneficiaries with concurrent substance use disorders.* Prev Med Rep, 2015. **2**: p. 379-84.
69. Yoon, J., et al., *Reducing costs of acute care for ambulatory care-sensitive medical conditions: the central roles of comorbid mental illness.* Med Care, 2012. **50**(8): p. 705-13.
70. White, J., et al., *Hospital admissions for severe mental illness in England: Changes in equity of utilisation at the small area level between 2006 and 2010.* Social Science & Medicine, 2014. **120**: p. 243-251.
71. Kim, D., *Financial hardship and social assistance as determinants of mental health and food and housing insecurity during the COVID-19 pandemic in the United States.* SSM - Population Health, 2021: p. 100862.
72. Meyer, O.L., L. Castro-Schilo, and S. Aguilar-Gaxiola, *Determinants of Mental Health and Self-Rated Health: A Model of Socioeconomic Status, Neighborhood Safety, and Physical Activity.* American Journal of Public Health, 2014. **104**(9): p. 1734-1741.
73. Mossakowski, K.N., *Dissecting the Influence of Race, Ethnicity, and Socioeconomic Status on Mental Health in Young Adulthood.* Research on Aging, 2008. **30**(6): p. 649-671.
74. Domènech-Abella, J., et al., *The association between socioeconomic status and depression among older adults in Finland, Poland and Spain: A comparative cross-sectional study of distinct measures and pathways.* Journal of Affective Disorders, 2018. **241**: p. 311-318.
75. Lorant, V., et al., *Socioeconomic Inequalities in Depression: A Meta-Analysis.* American Journal of Epidemiology, 2003. **157**(2): p. 98-112.
76. Georgiadou, E., E. Morawa, and Y. Erim, *High Manifestations of Mental Distress in Arabic Asylum Seekers Accommodated in Collective Centers for Refugees in Germany.* Int J Environ Res Public Health, 2017. **14**(6).
77. Hameed, S., A. Sadiq, and A.U. Din, *The Increased Vulnerability of Refugee Population to Mental Health Disorders.* Kansas journal of medicine, 2018. **11**(1): p. 1-12.

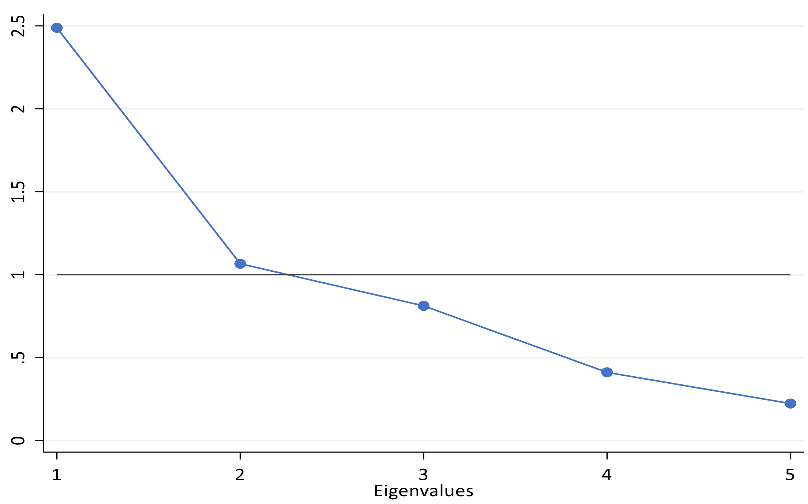
7. Appendix

7.1 Index creation, technical details

Socioeconomic deprivation index (SDI)

To build the SDI, we ran a principal component analysis (PCA), corrected for population weights, on the selected socio-economic deprivation variables. Prior to the PCA analysis, the 5 variables were centred at the mean and divided by the standard error. The figure below shows a scree plot of the PCA. The graph pictures the eigenvalues of each component in descending order on the horizontal axis, with the vertical axis showing the value of eigenvalues. A rule of thumb with PCA analysis is that to best explain the data, one should select all components with an eigenvalue greater or equal to 1. Following this rule, the analysis suggests that we should use 2 components to represent our SDI. A change of slope in the curve is also apparent after the second eigenvalue.

Scree plot of the PCA analysis



The table below shows loadings for the first two components. Together, these two components explain 71% of the variation. The first component gives important loadings to all variables except for the income proxy (0.07). The second component has a very high loading for the income proxy (0.84).

Component loadings

	Socioeconomic Variables (x_i)	Component 1 (w_i)	Component 2
1	Social support	0.4964	0.2291
2	Income < 25,000	0.0726	0.8405
3	Unskilled work	0.5315	-0.2188
4	Unemployment	0.5284	0.2065
5	Less than mandatory schooling	0.4320	-0.3880

The SDI for region m is then calculated with the following formula, where w_i identify the loadings of the first component and $x_{m,i}$ identify the socio-economic variables for each region:

$$SDI_m = \frac{1}{\sum_{i=1}^{5} w_i} * \sum_{i=1}^{5} w_i * x_{m,i}$$

This corresponds to a weighted average of the socio-economic variables, using the loadings of the first component as weights (a sensitivity analysis excluding income from the SDI yielded remarkably similar results).

Since the second component appears mainly driven by the income variable, we do not compute a weighted average for it but rather reflect it by using median income.

Socioeconomic position index (SEP)

The SEP includes four variables each representing a dimension of socioeconomic status. The four variables are reduced to a single index measure by using principal components analysis (see details above). The original SEP is created at the neighbourhood level and includes median rent per square metre, the proportion households headed by a person with primary education or less, the proportion of households headed by a person in manual or unskilled occupation, and the mean number of persons per room [53].

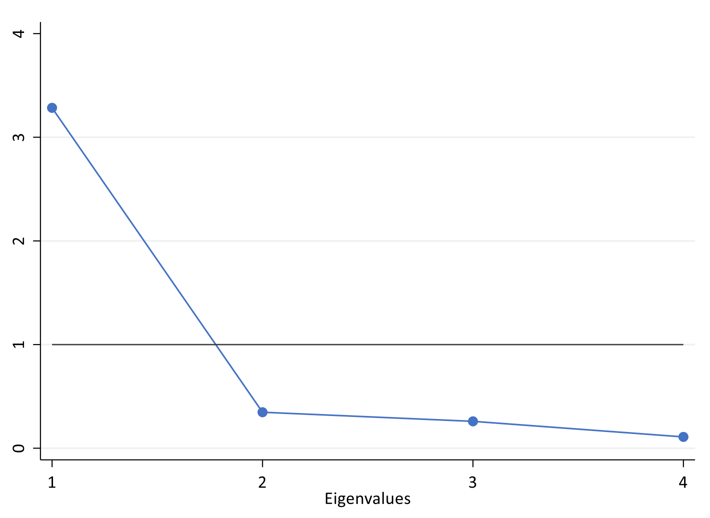
Our data did not allow us to recreate the SEP with the original four variables. Instead, we selected the corresponding components at the MedStat level. We used median rent per square meter in the region, the proportion of adults who have not completed mandatory schooling, the proportion of individuals working in an unskilled occupation, and a gross measure of the mean number of persons per square meter in the region.

At the regional level, the variables do not capture the same effects compared to the neighbourhood level. In particular, we were not able to estimate the number of persons per room adequately at the regional level. Selecting the education level and occupation of the head of the household at the neighbourhood level does not provide the same information as simply taking education and occupation rates at the regional level. Therefore, our version of the SEP is not an exact reproduction of the original SEP index and may not measure socioeconomic position as intended by the authors of the Swiss SEP, at the MedStat region level.

Cultural index (CLT)

The figure below shows the scree plot of the PCA analysis on the cultural variables. As a rule of thumb, it is customary to include all components that have an eigen value larger than 1 into the summary measure. It is clear from the figure that only one component will suffice to provide an appropriate summary measure of the four variables. The CLT index itself is a weighted average of the four cultural variables. The table below shows the individual weights that we use for each cultural variable in the creation of the index.

Scree plot of the PCA analysis for cultural variables



Component loadings for the cultural variables

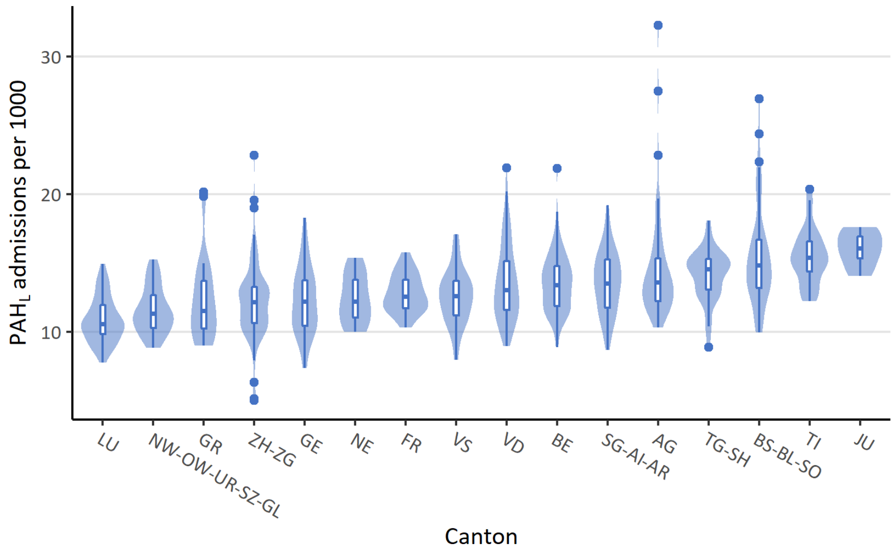
	Cultural Variables	Component 1
1	Language barrier	0.5128
2	Religion other than catholic or protestant	0.4731
3	Foreign origin	0.5215
4	Rate of immigrants from abroad	0.4912

7.2 Correlation matrix of the variables of interest

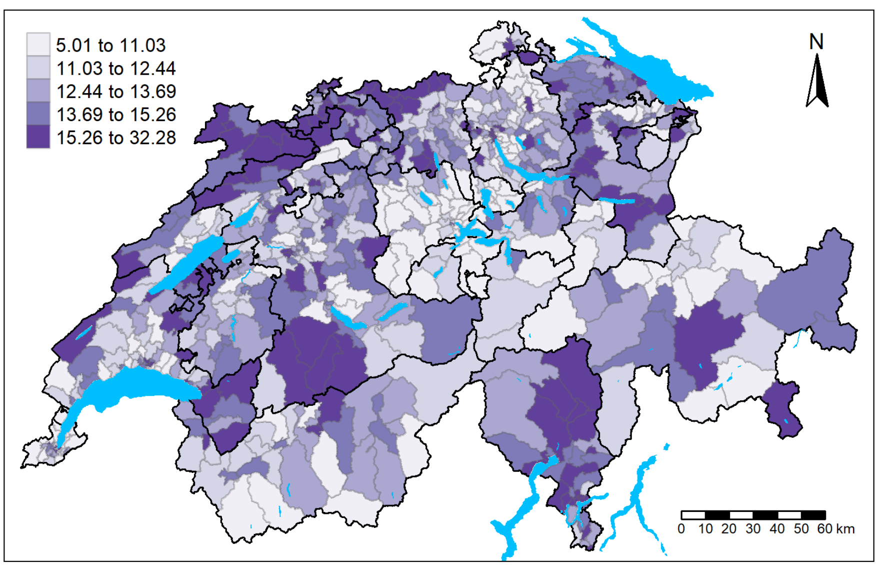
	PAH_S	PAH_C	PIH	PAH_L	CLT	IMM	SWISS	REL	LAN	SDI	INC	SEP
PAH_S	1	0.792	0.587	0.857	0.163	0.136	-0.204	-0.106	0.120	0.406	-0.339	0.361
PAH_C	0.792	1	0.451	0.823	0.158	0.096	-0.165	-0.162	0.114	0.417	-0.291	0.367
PIH	0.587	0.451	1	0.624	-0.113	-0.063	0.009	0.204	-0.130	0.079	-0.253	0.141
PAH_L	0.857	0.823	0.624	1	0.239	0.201	-0.254	-0.206	0.157	0.384	-0.275	0.284
CLT	0.163	0.158	-0.113	0.239	1	0.863	-0.946	-0.862	0.896	0.637	0.142	0.351
IMM	0.136	0.096	-0.063	0.201	0.863	1	-0.811	-0.589	0.728	0.526	-0.026	0.258
SWISS	-0.204	-0.165	0.009	-0.254	-0.946	-0.811	1	0.701	-0.882	-0.686	-0.067	-0.456
REL	-0.106	-0.162	0.204	-0.206	-0.862	-0.589	0.701	1	-0.685	-0.466	-0.298	-0.151
LAN	0.120	0.114	-0.130	0.157	0.896	0.728	-0.882	-0.685	1	0.614	0.114	0.461
SDI	0.406	0.417	0.079	0.384	0.637	0.526	-0.686	-0.466	0.614	1	-0.366	0.840
INC	-0.339	-0.291	-0.253	-0.275	0.142	-0.026	-0.067	-0.298	0.114	-0.366	1	-0.481
SEP	0.361	0.367	0.141	0.284	0.351	0.258	-0.456	-0.151	0.461	0.840	-0.481	1

7.3 Variation and socioeconomic gradient of PAH_L

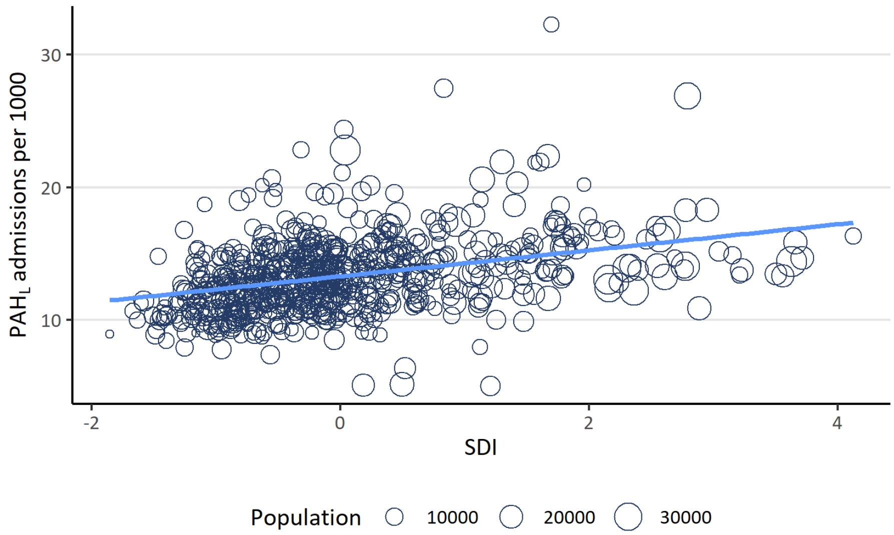
Distribution of PAH_L for canton groups



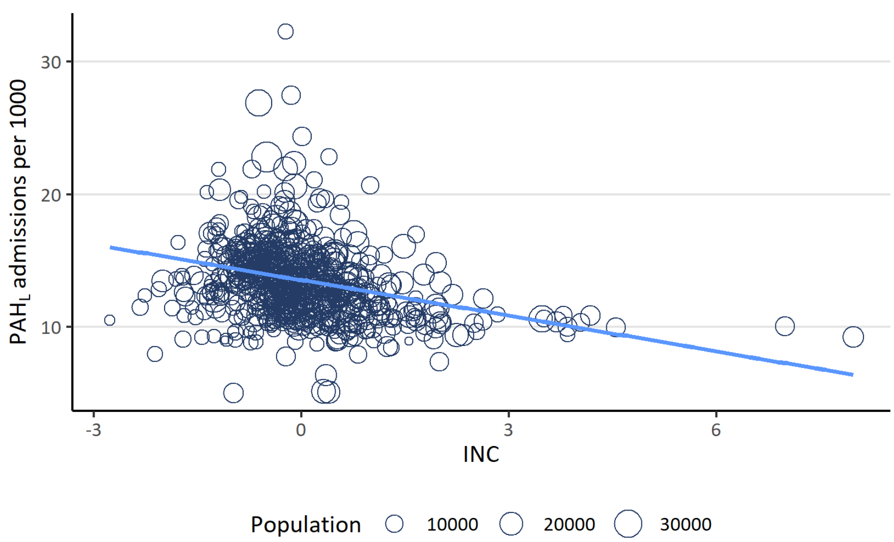
Spatial distribution of PAH_L



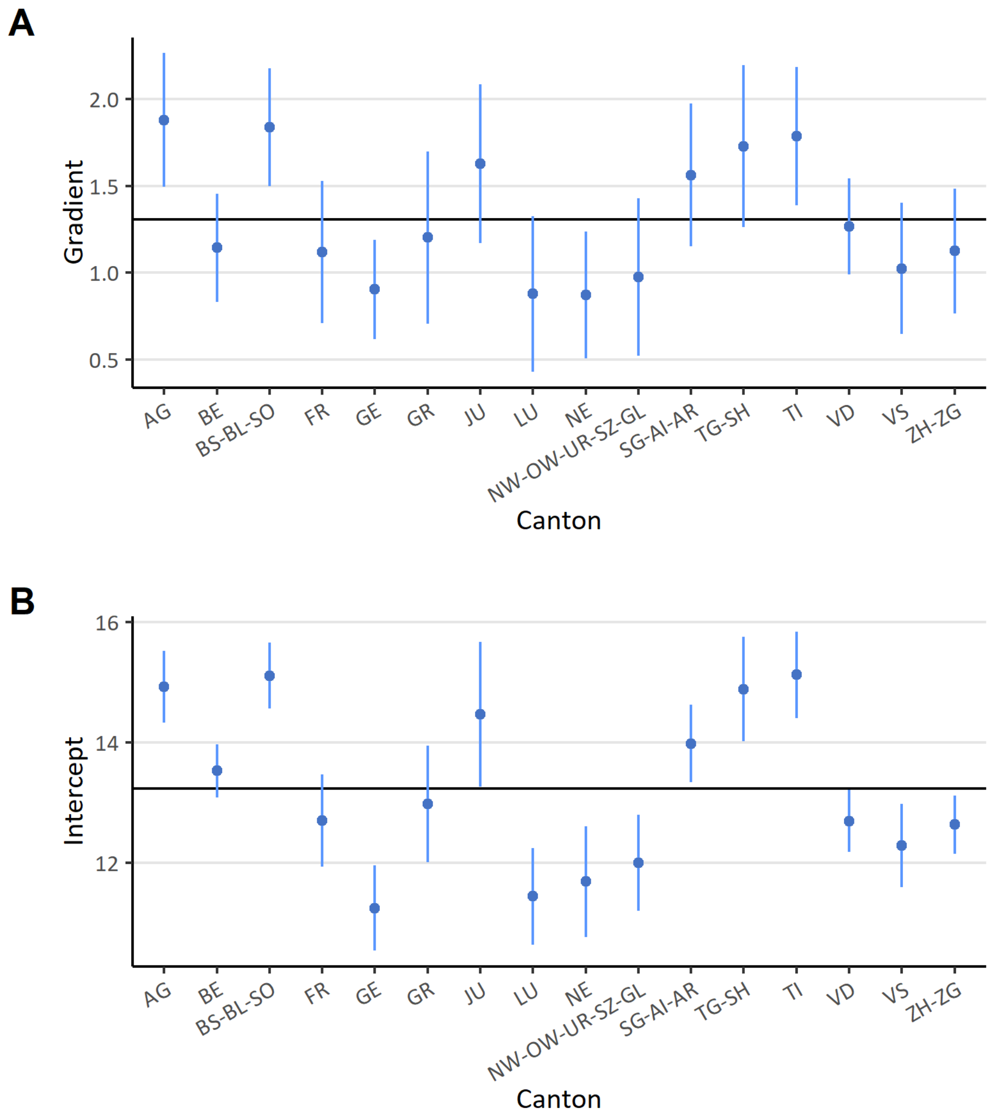
PAH_L gradient with SDI for Switzerland



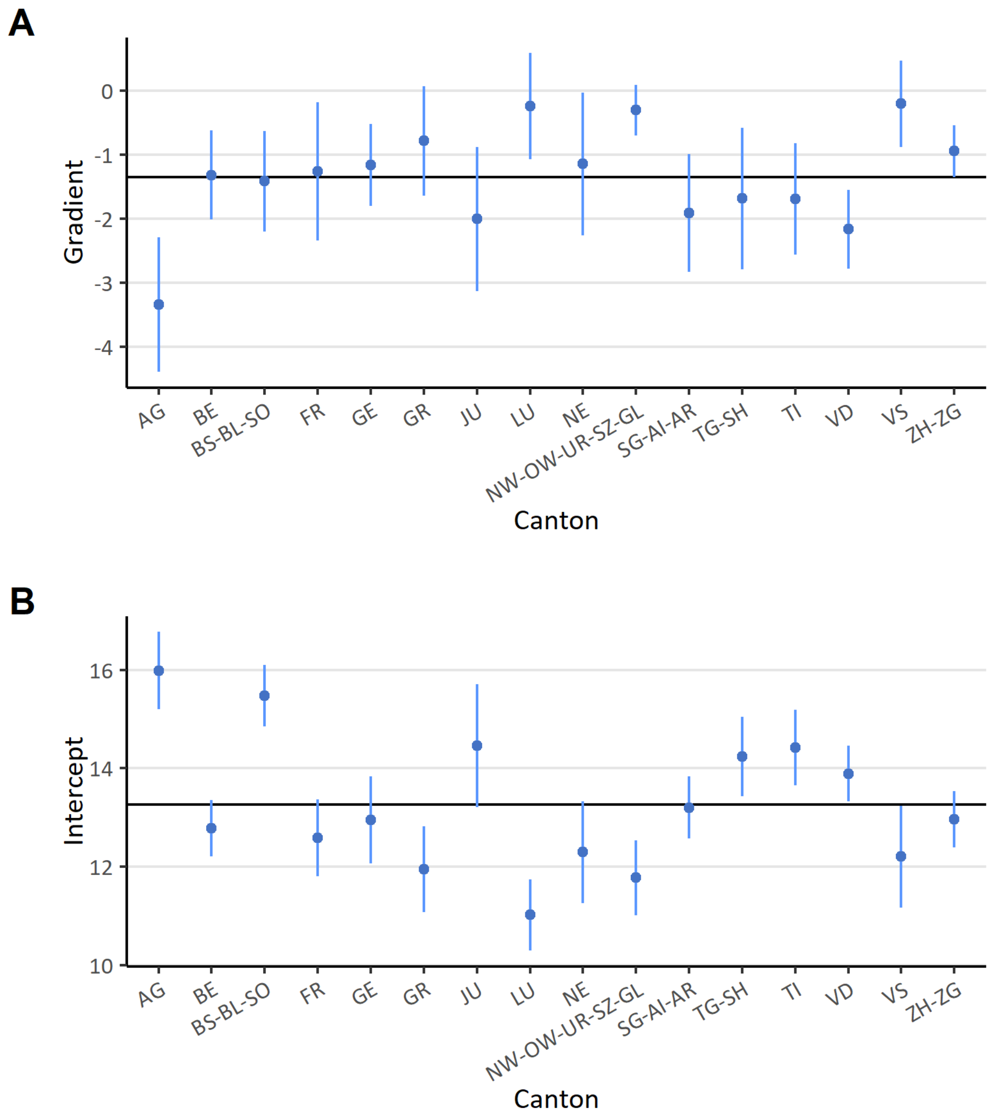
Gradient between PAH_L and INC for Switzerland



PAH_L gradients with SDI by canton

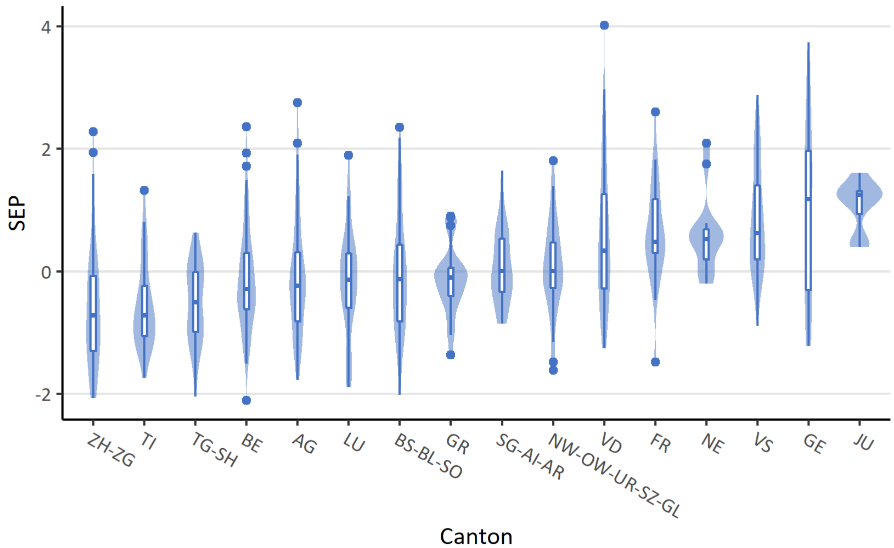


PAH$_L$ gradients with INC by canton

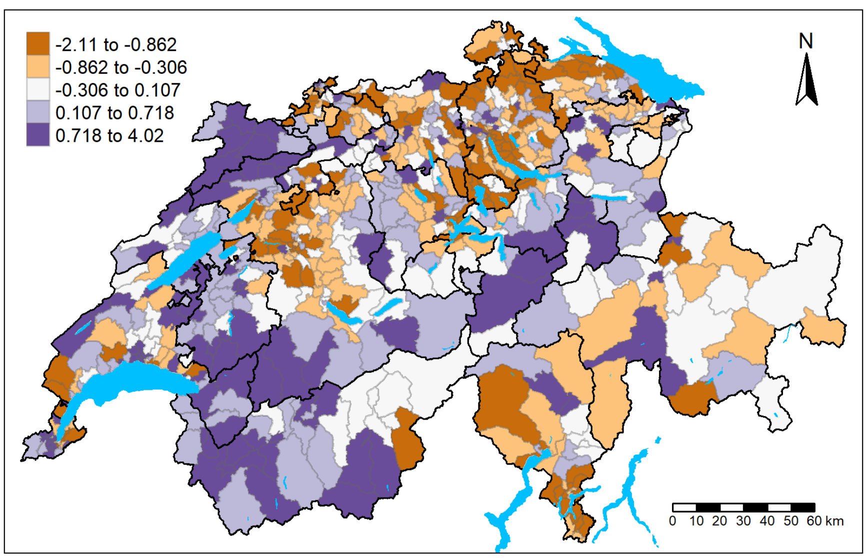


7.4 Detailed results for the Swiss SEP

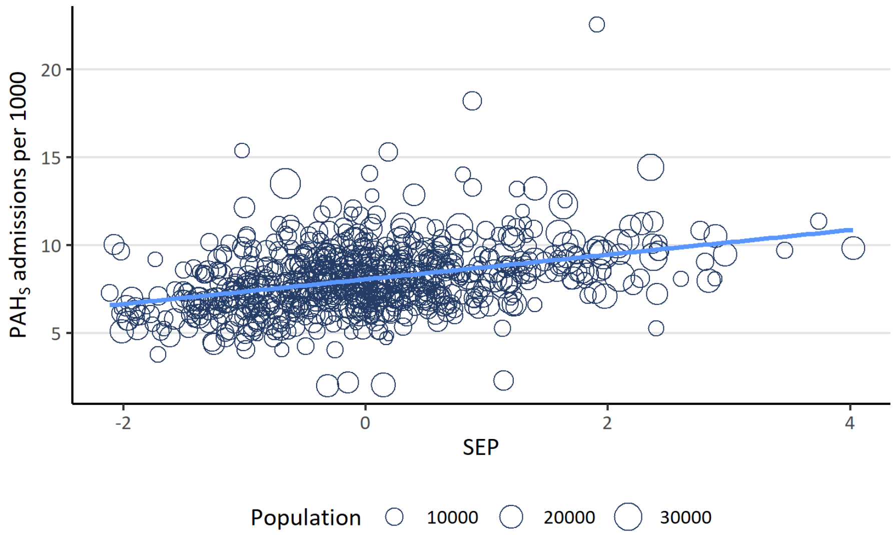
Distribution of SEP for canton groups



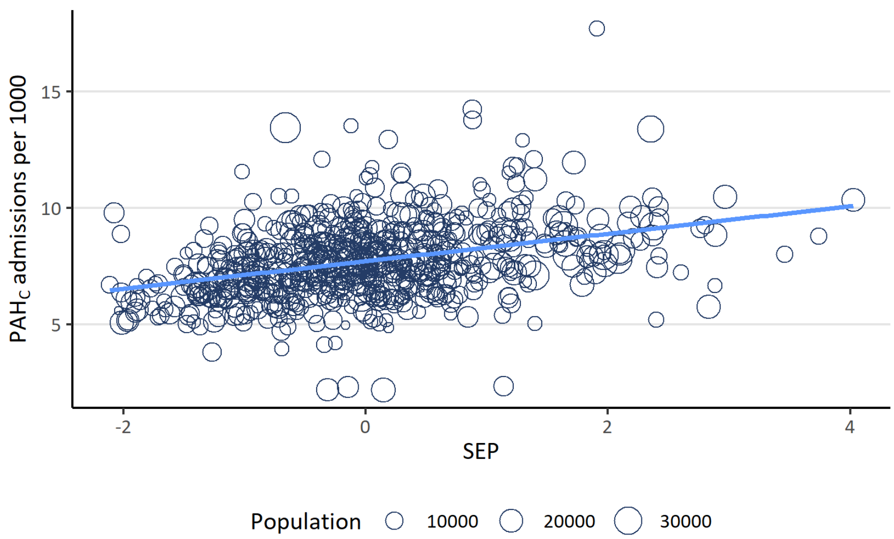
Spatial distribution of SEP



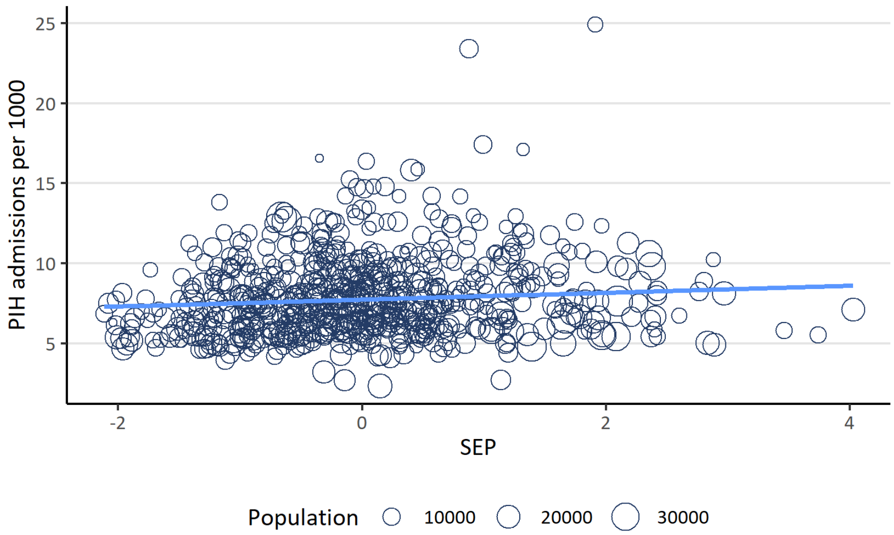
PAH_S gradient with SEP for Switzerland



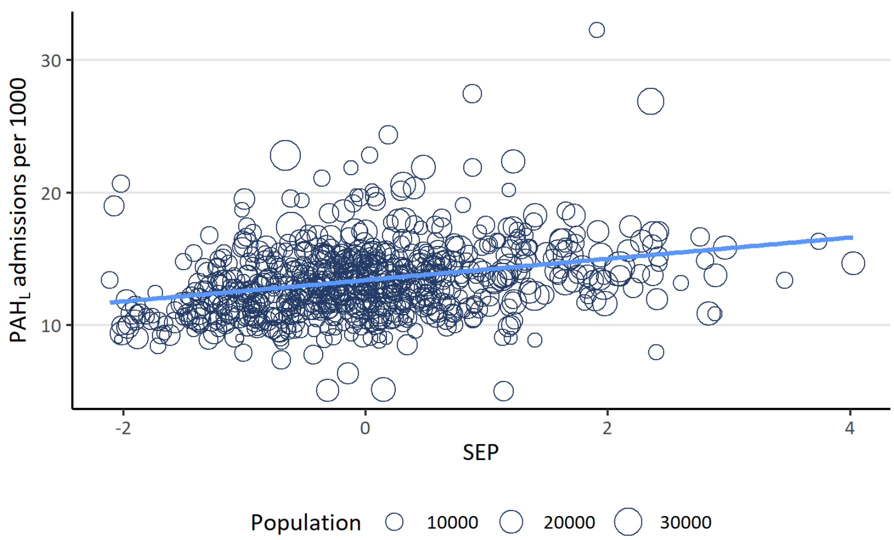
PAH_C gradient with SEP for Switzerland



PIH gradient with SEP for Switzerland

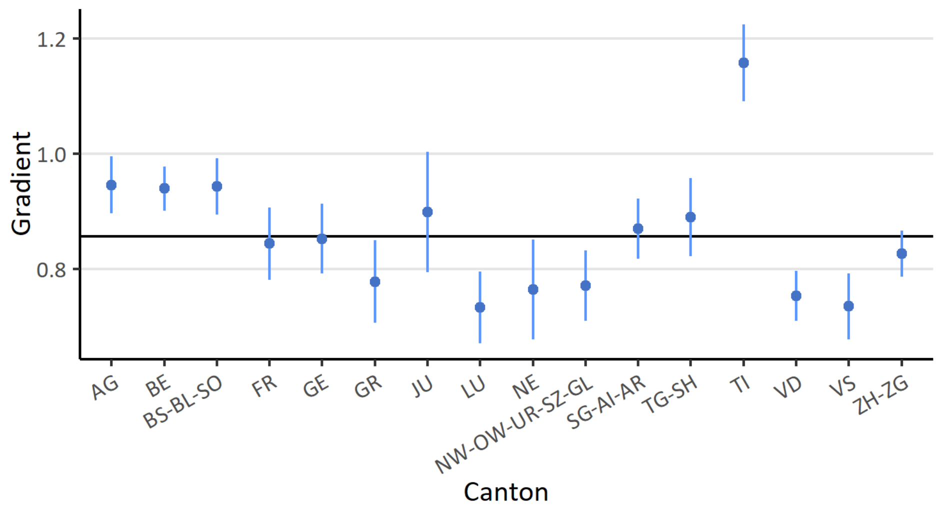


PAH$_L$ gradient with SEP for Switzerland

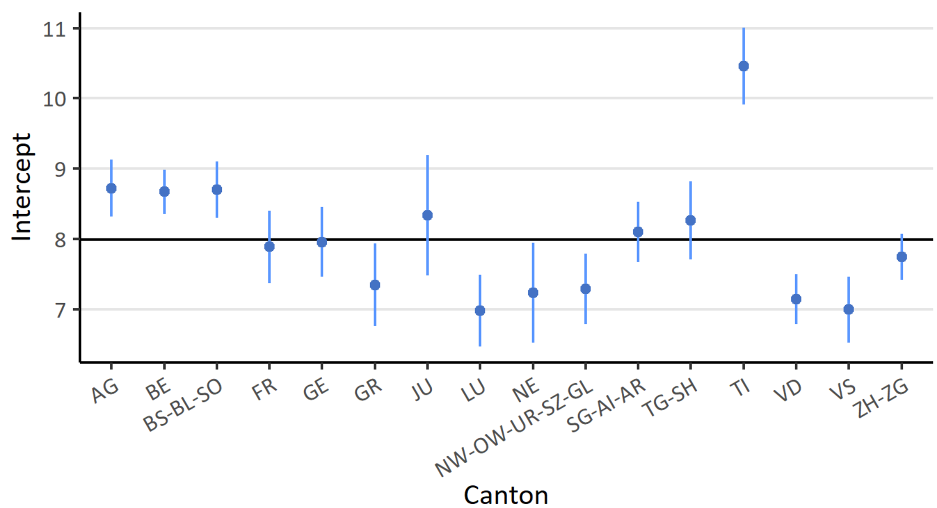


PAHs gradients with SEP by canton

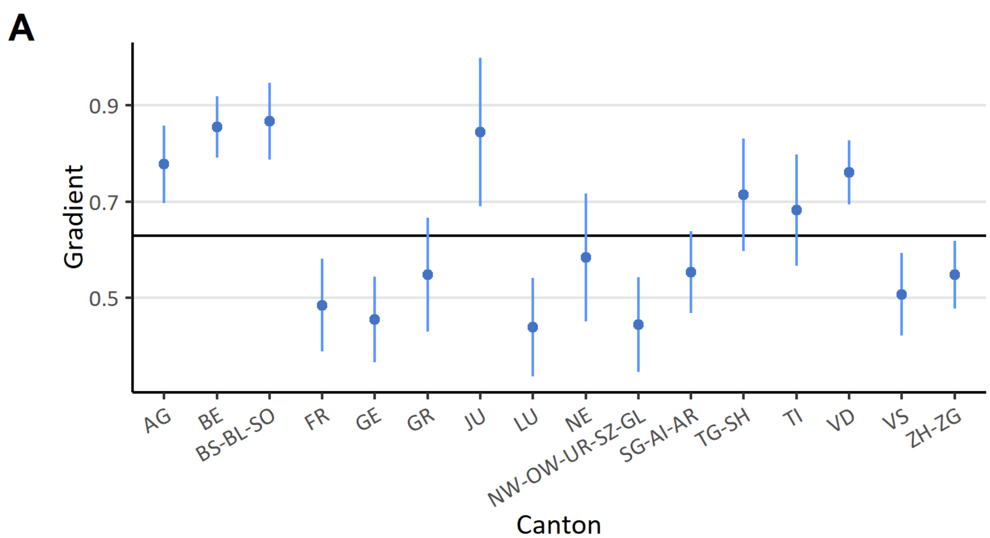
A

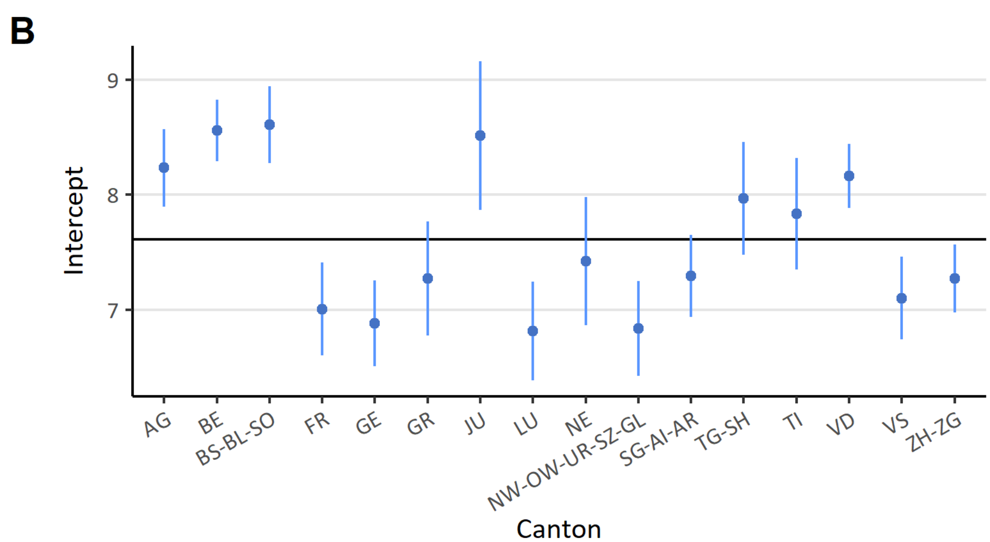


B

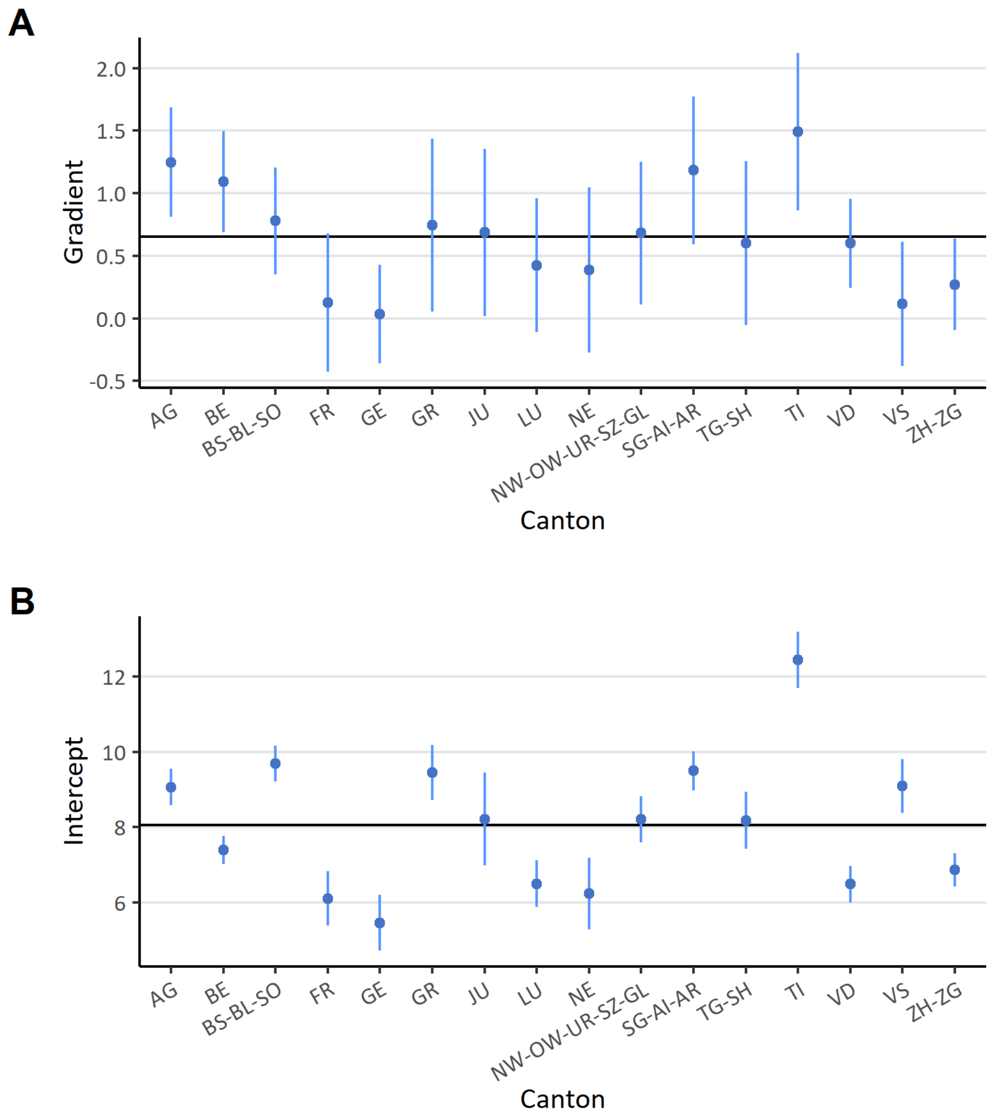


PAH$_C$ gradients with SEP by canton

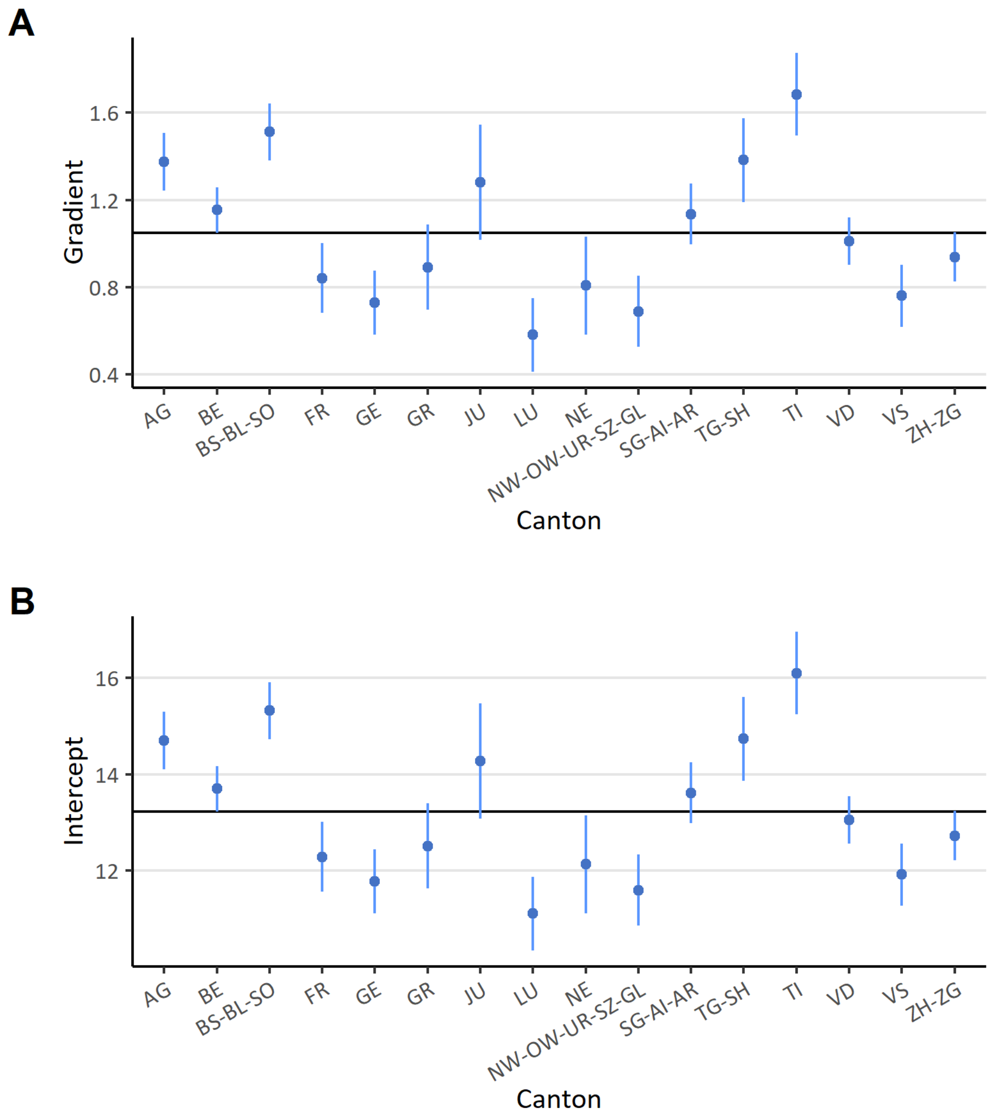




PIH gradients with SEP by canton

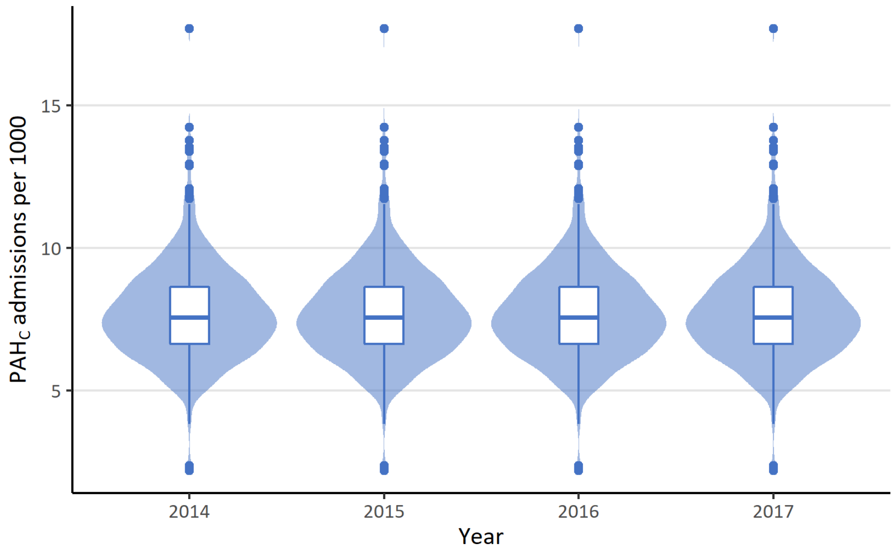


PAH_L gradients with SEP by canton

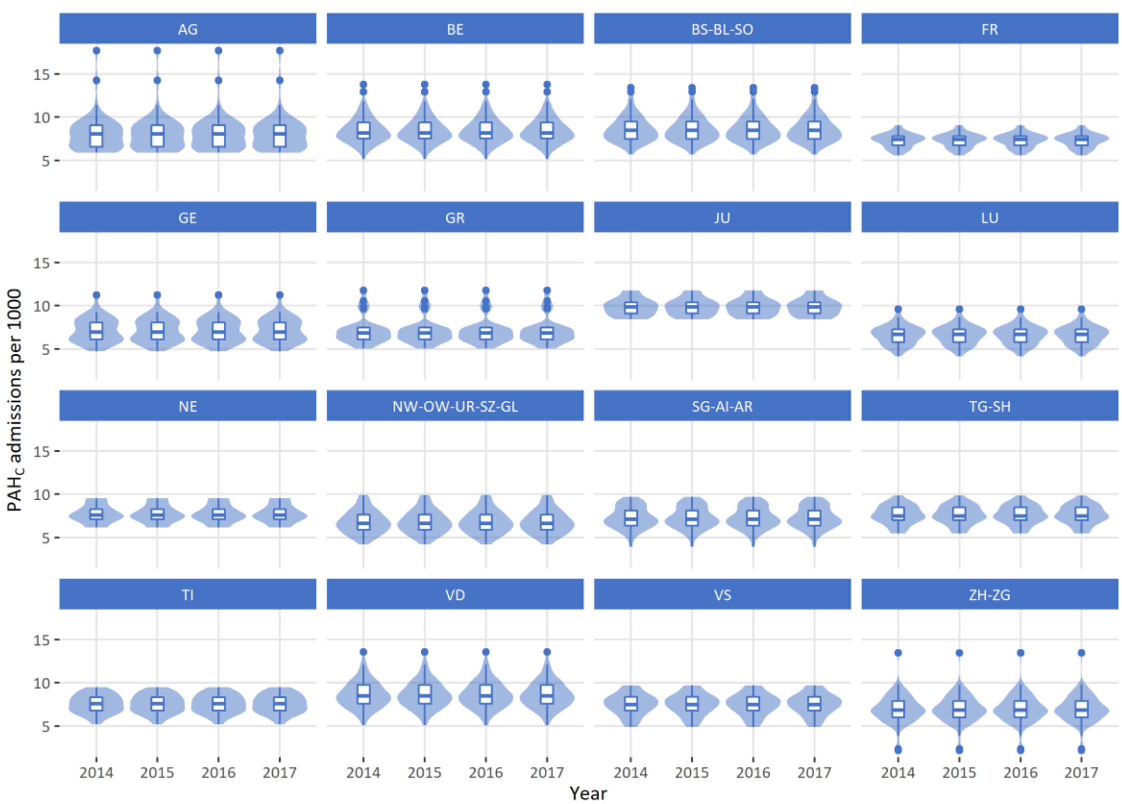


7.5 Time variation of additional indicators

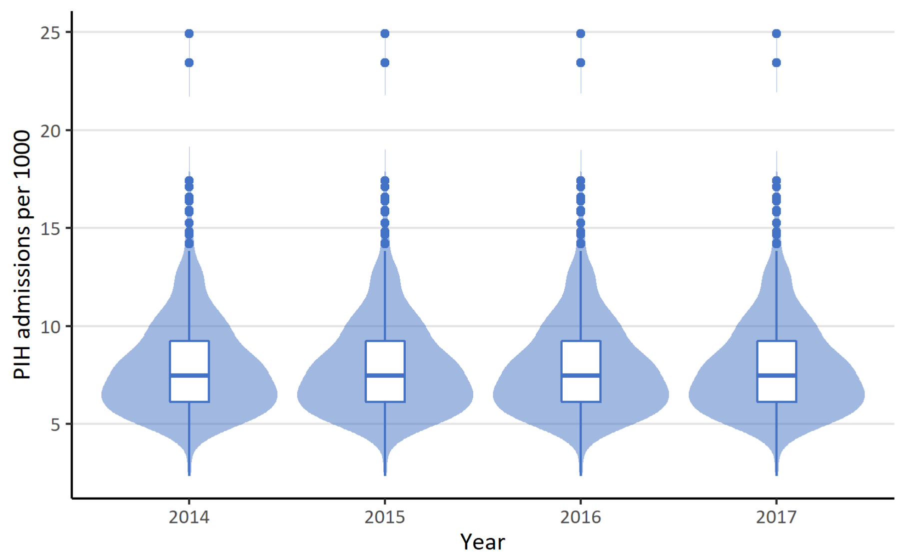
PAH$_C$ time trend in Switzerland



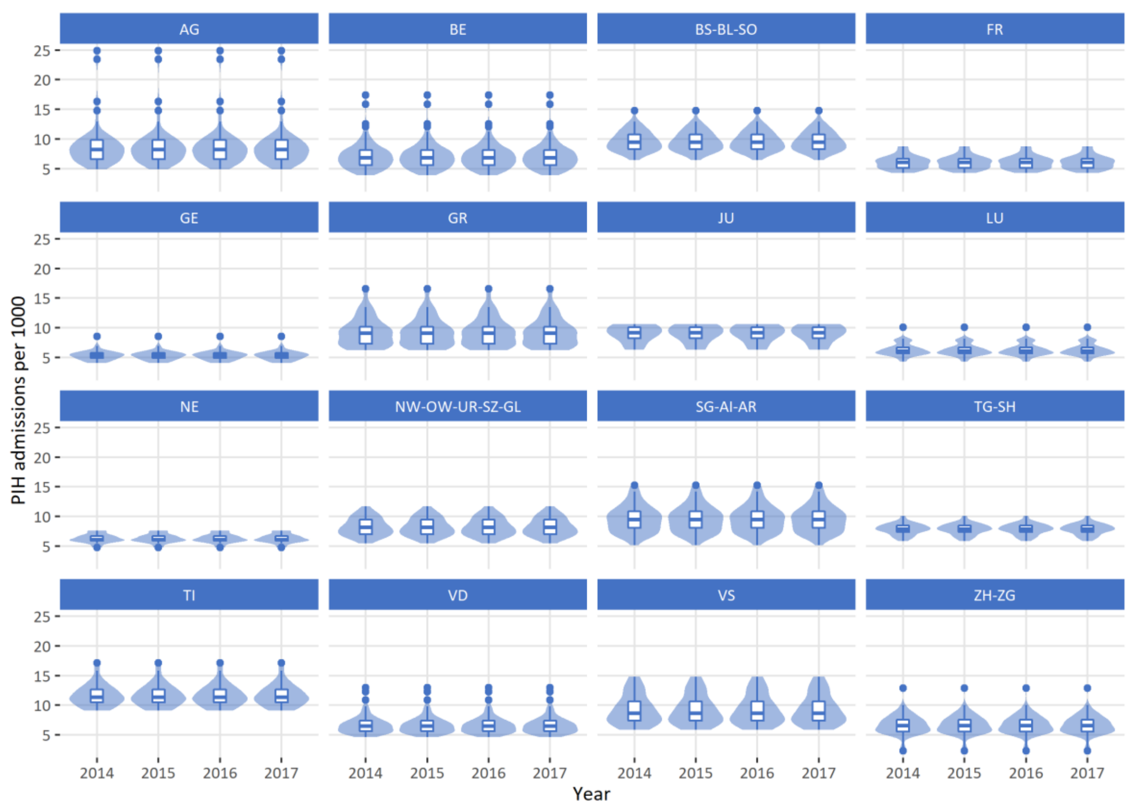
PAH$_C$ time trend by canton groups



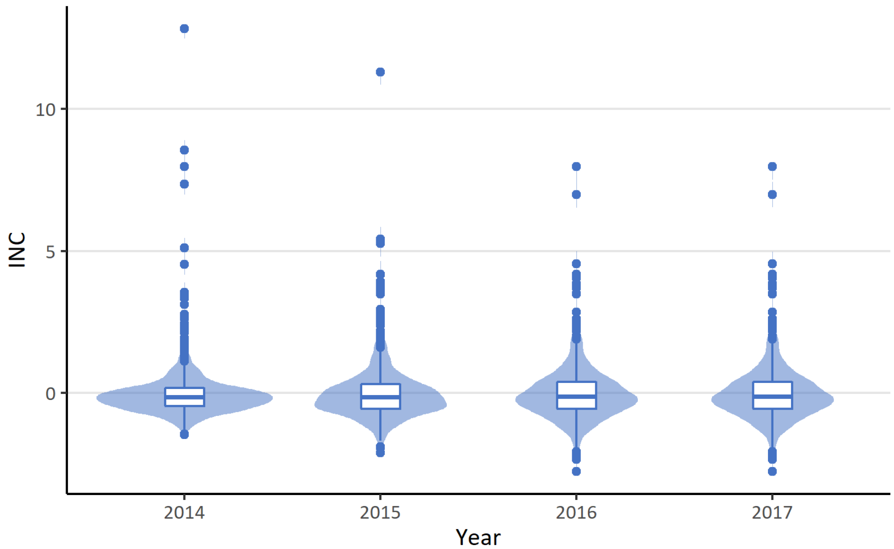
PIH time trend in Switzerland



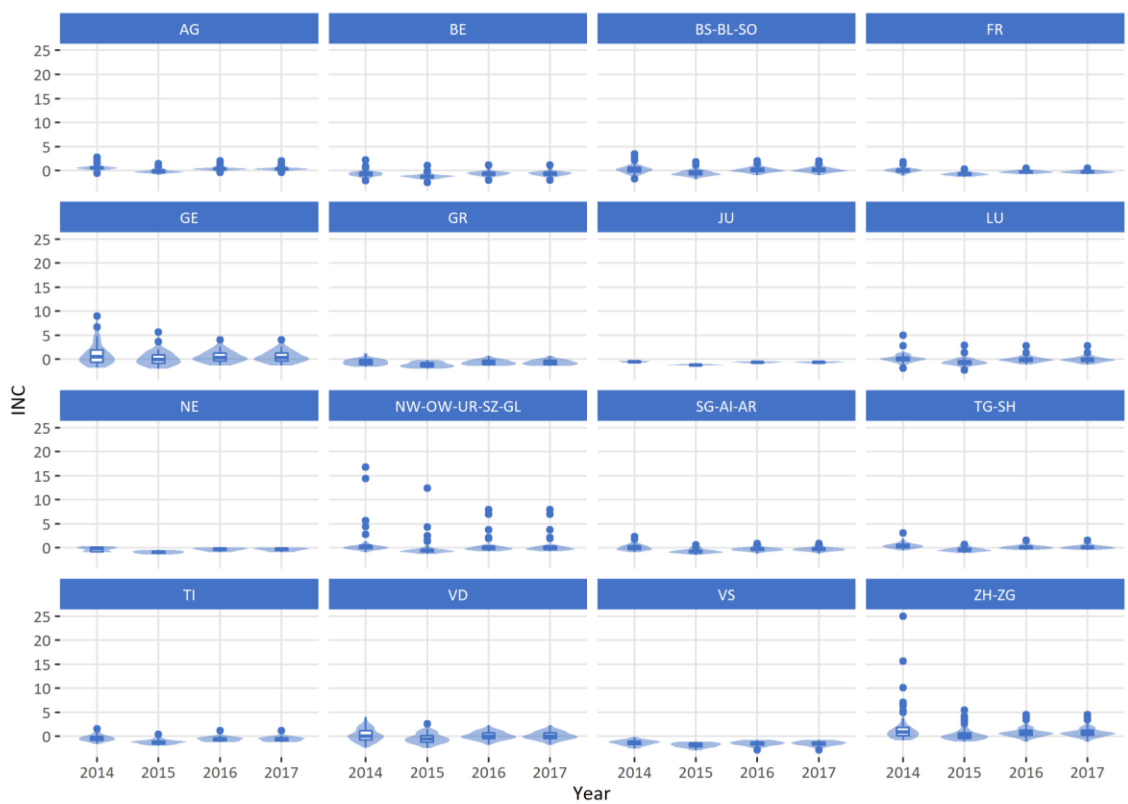
PIH time trend by canton groups



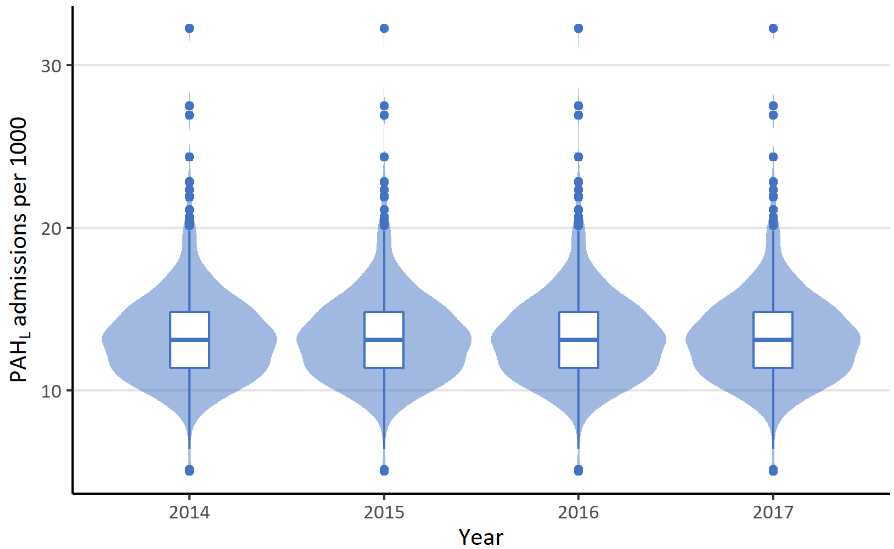
INC time trend in Switzerland



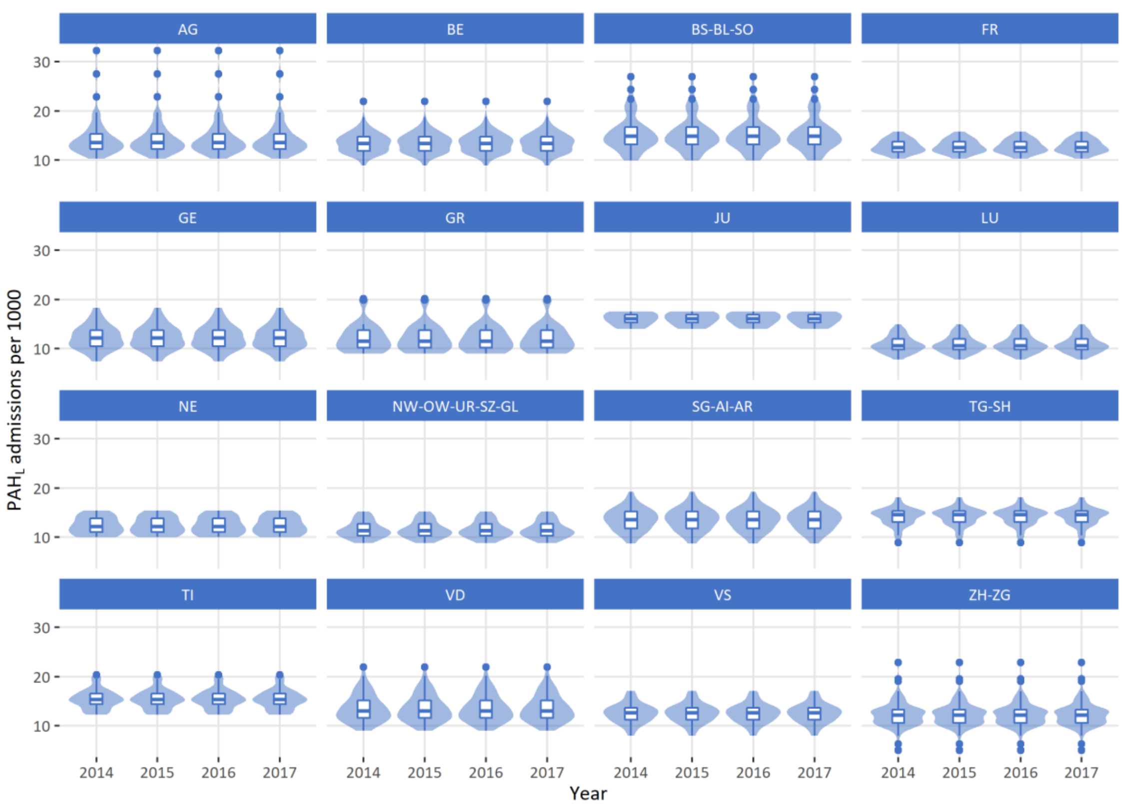
INC time trend by canton groups



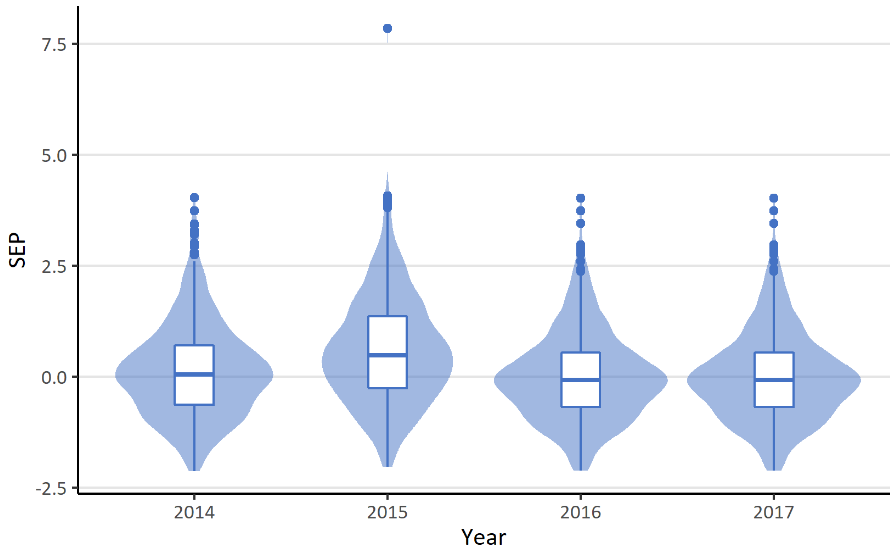
PAH_L time trend in Switzerland



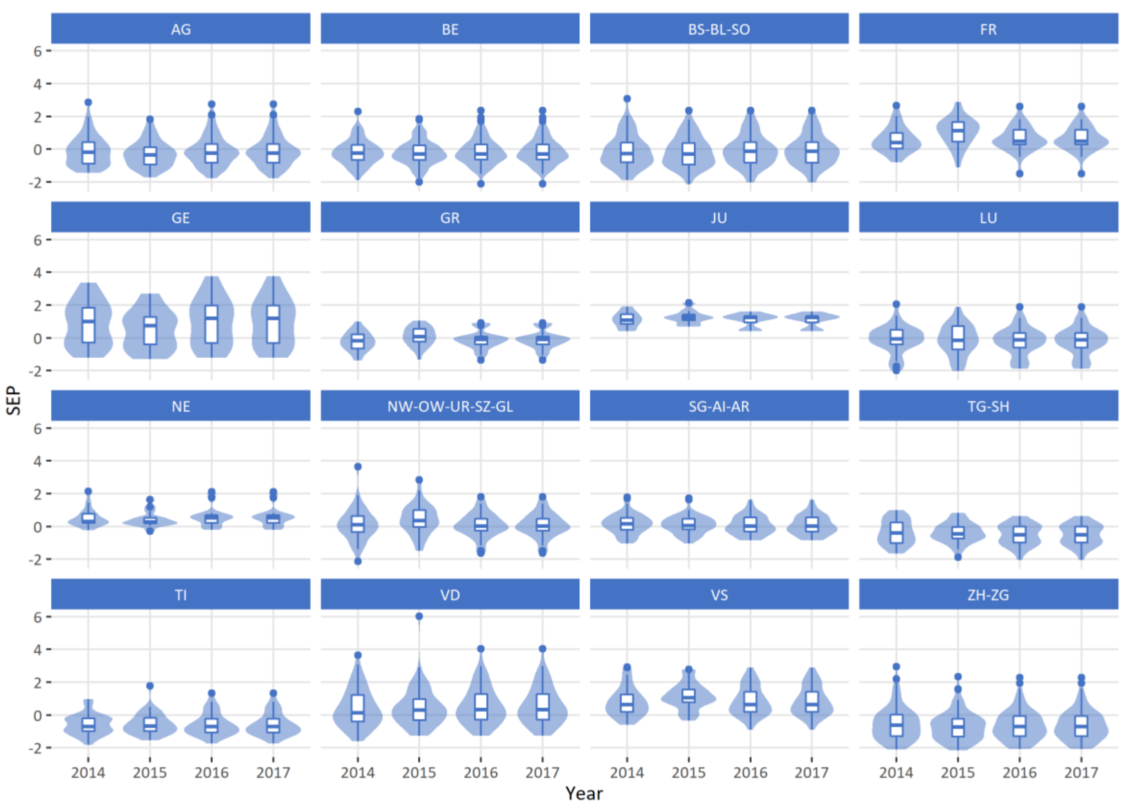
PAH_L time trend by canton groups



SEP time trend in Switzerland

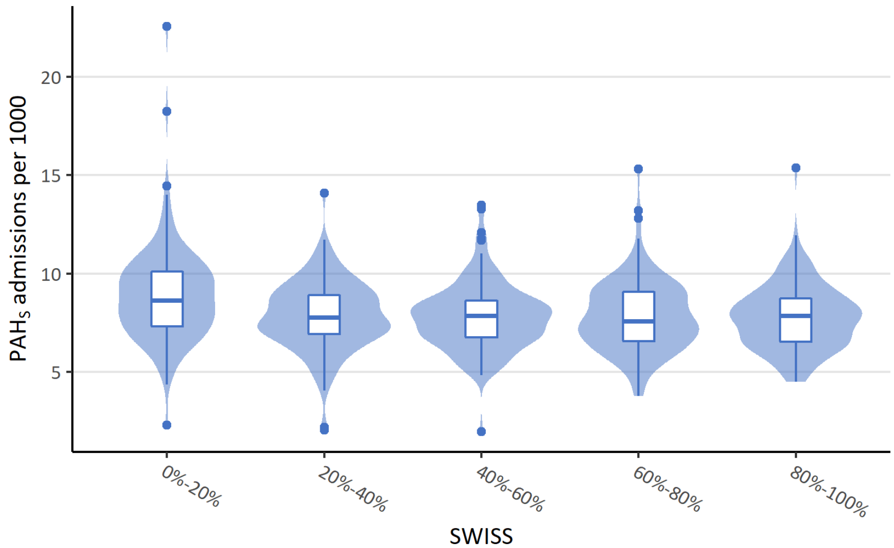


SEP time trend by canton groups

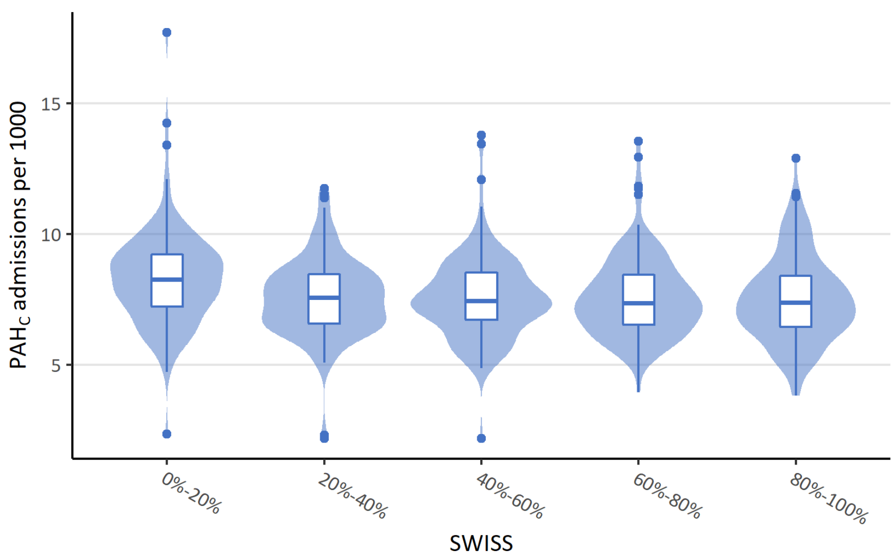


7.6 Detailed results for cultural variables

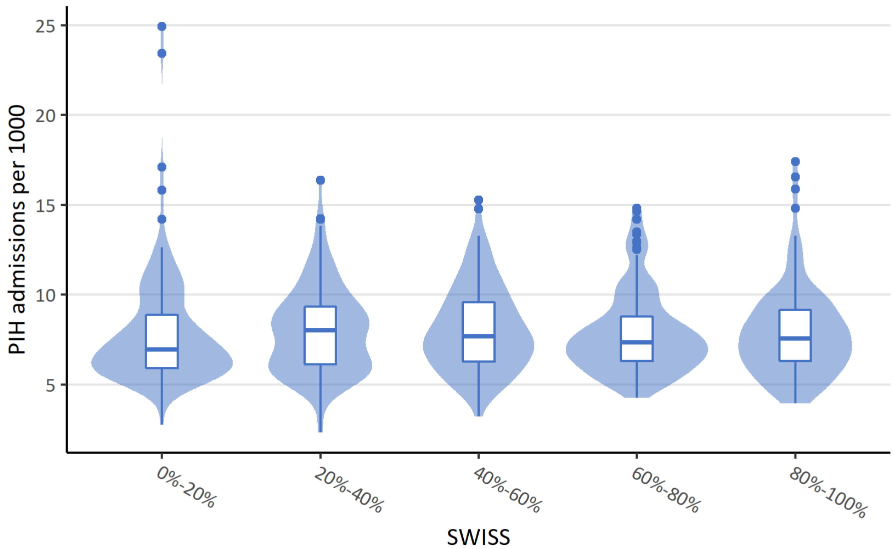
Distribution of PAH_S by quantiles of Swiss origin



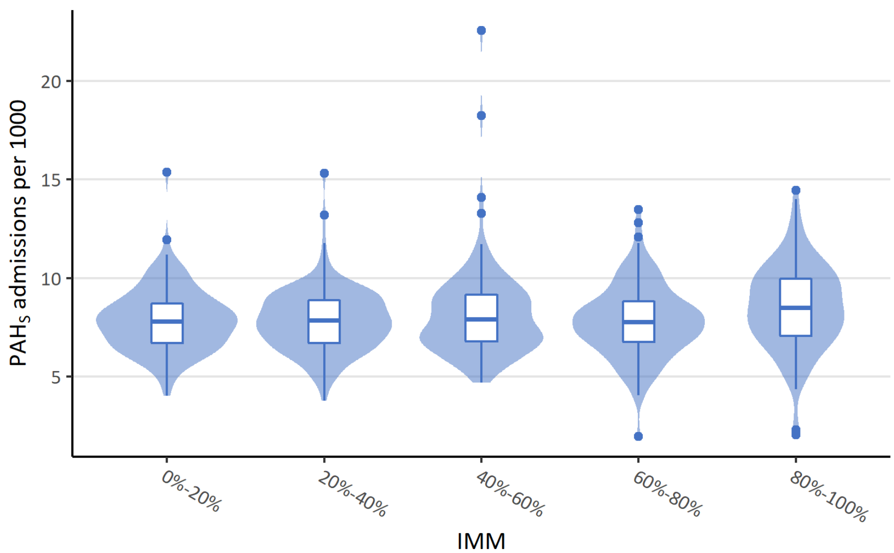
Distribution of PAH_C by quantiles of Swiss origin



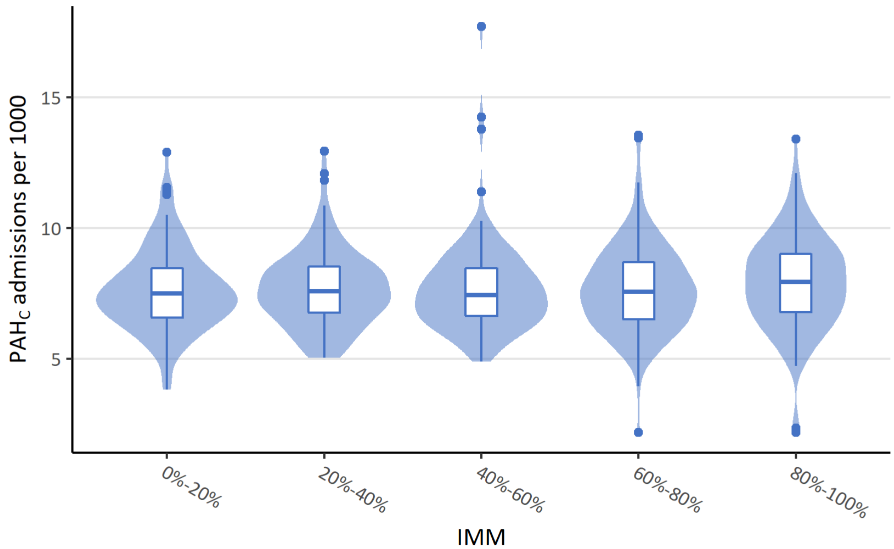
Distribution of PIH by quantiles of Swiss origin



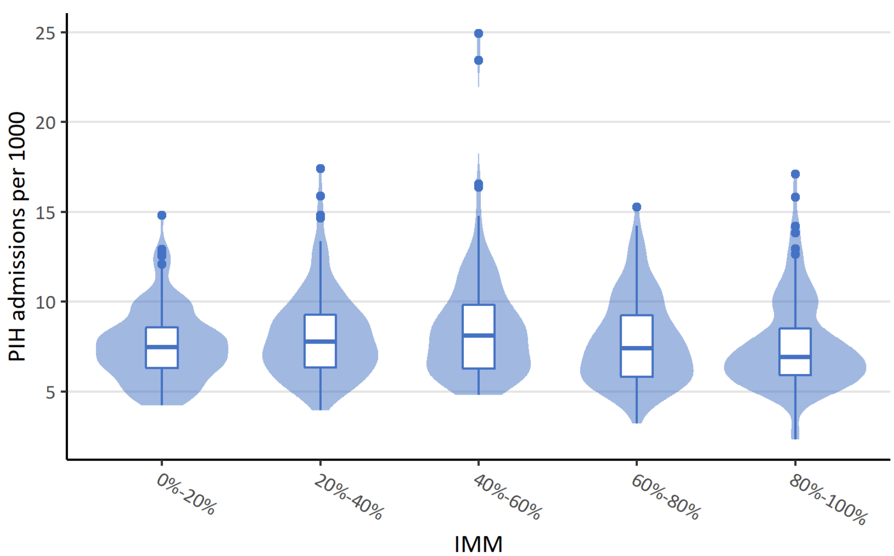
Distribution of PAH_S by quantiles of the rate of immigrants



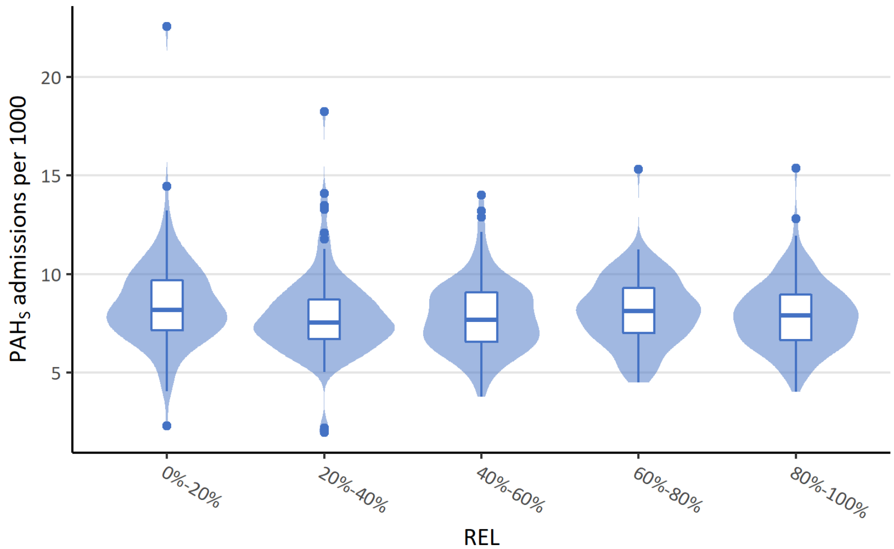
Distribution of PAH_C by quantiles of the rate of immigrants



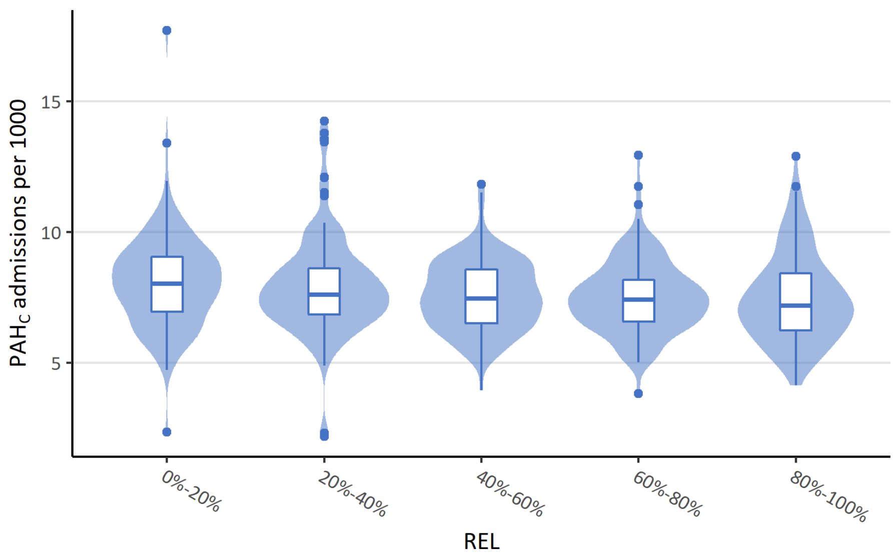
Distribution of PIH by quantiles of the rate of immigrants



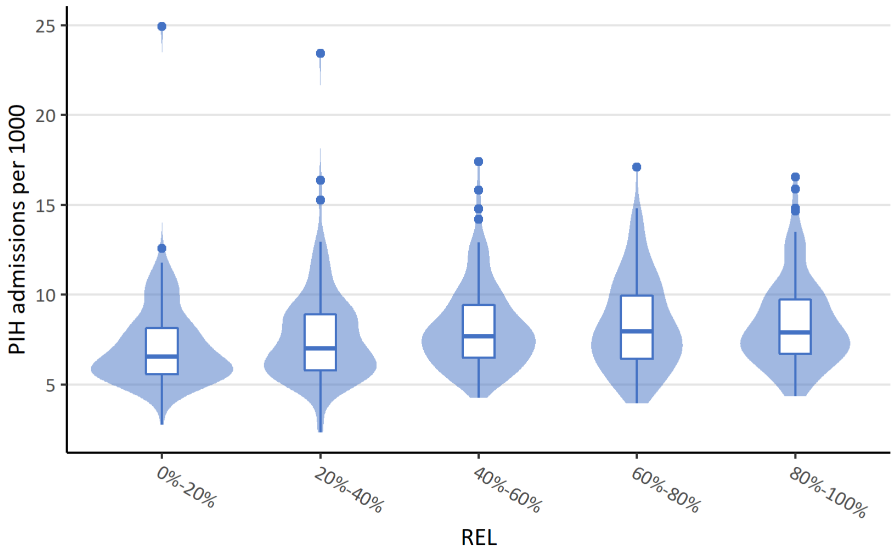
Distribution of PAH_S by quantiles of religion



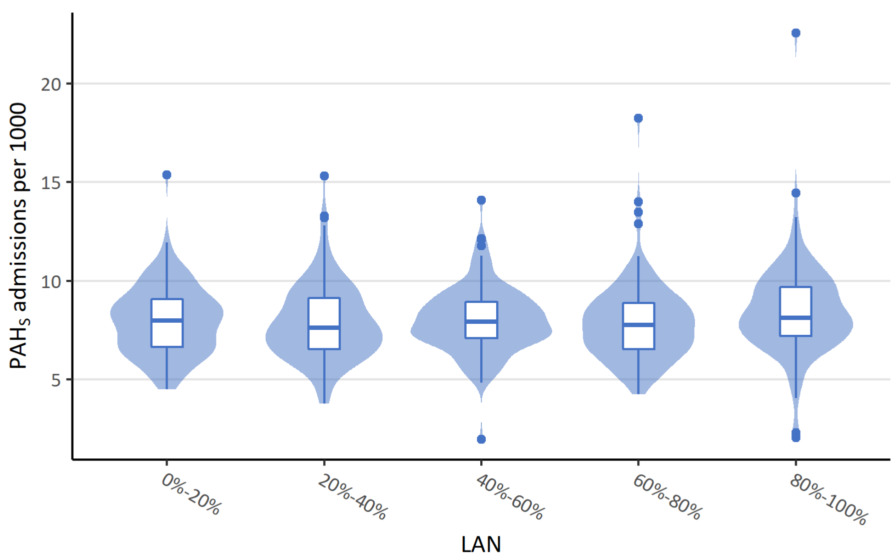
Distribution of PAH_C by quantiles of religion



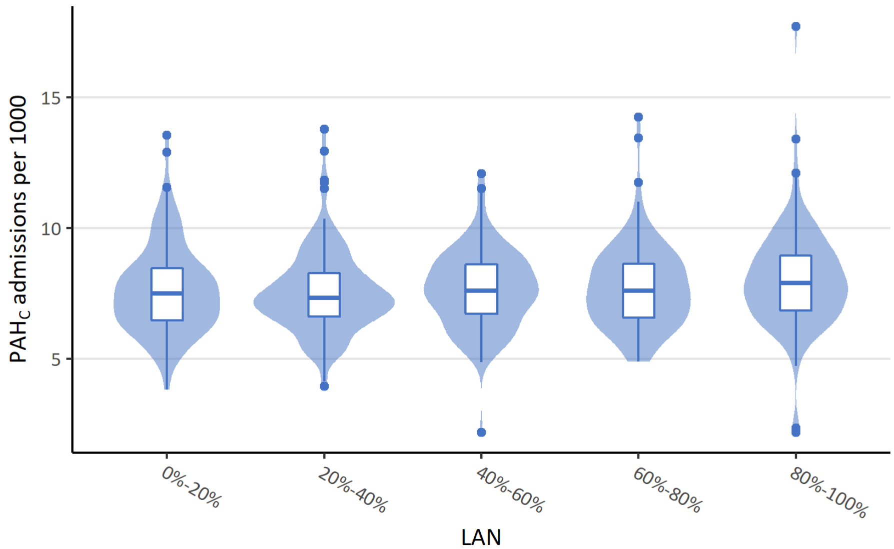
Distribution of PIH by quantiles of religion



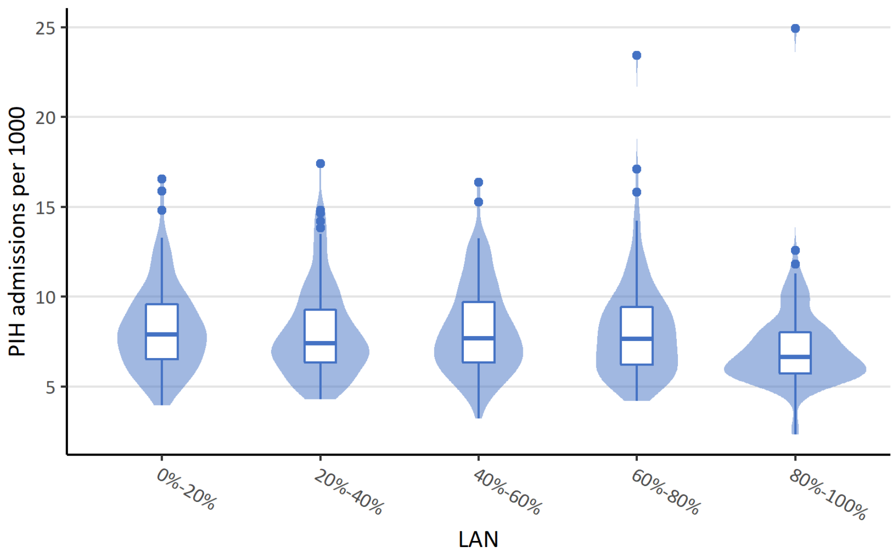
Distribution of PAH_S by quantiles of language barrier



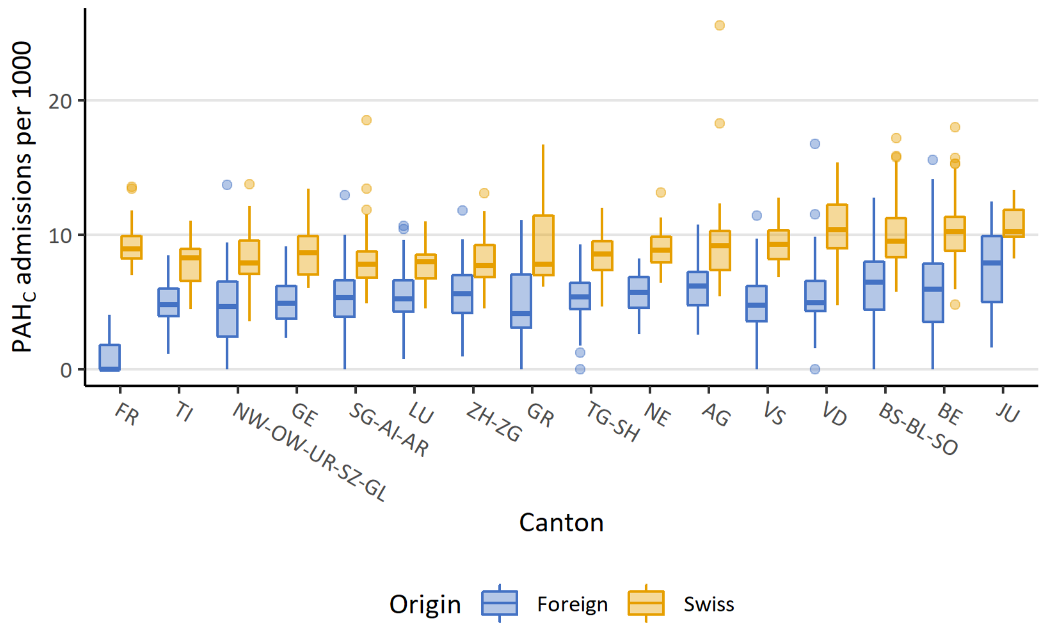
Distribution of PAH_C by quantiles of language barrier



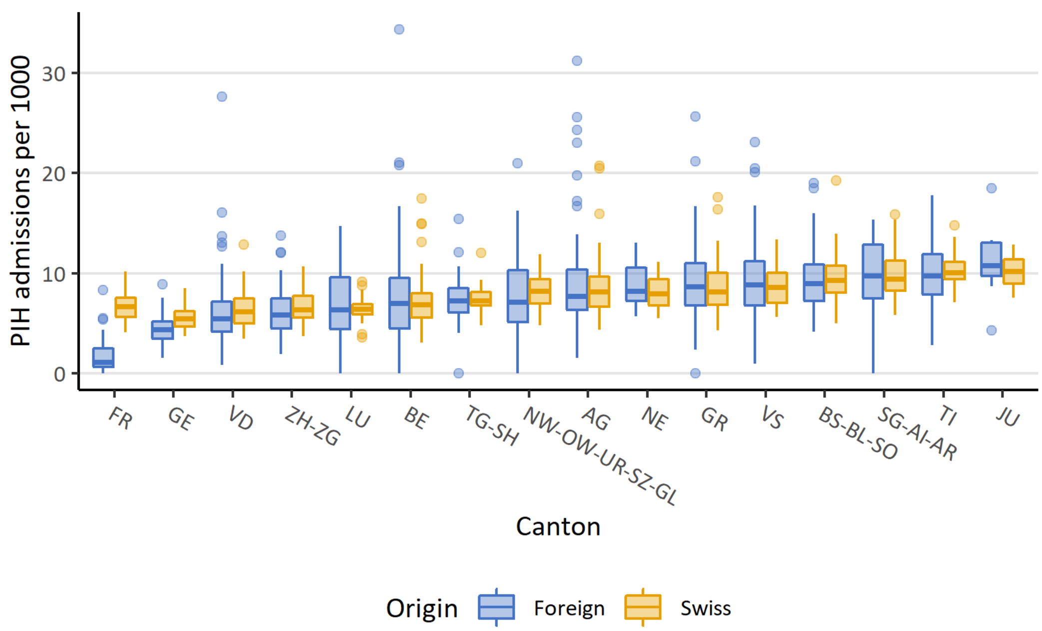
Distribution of PIH by quantiles of language barrier



Comparison of PAH_C for canton groups between Swiss nationals and foreigners



Comparison of PIH for canton groups between Swiss nationals and foreigners



7.7 Psychiatric hospital admissions

In this section, we move from somatic admissions and create an indicator of psychiatric hospital admissions that is separate from potentially avoidable and potentially inappropriate hospitalisations. Mental health is typically studied as a comorbidity or aggravating factor in the context of traditional ACSCs [18, 68, 69]. We identified a single study that attempted to create a psychiatric-specific indicator reflecting “potentially preventable” psychiatric admissions [66]. They proposed a list of mental health related ACSCs, which include schizophrenic disorders, paranoid conditions, and major depressions. One reason for the lack of established list of avoidable psychiatric admissions is that for some conditions, acute episodes requiring an emergency hospitalisation may happen even if ambulatory treatment is accessed and followed properly. One could focus on emergency hospitalisations only, or on admissions for severe mental illness [70]. However, in Switzerland, there is some variation between cantons and hospitals as to how to define emergency hospitalisations in a psychiatric setting. All cause emergency psychiatric admissions are therefore an unreliable indicator if we wish to compare performance between cantons. As a first step in the investigation, we therefore focus on all-causes psychiatric hospital admission (PSY).

We expect psychiatric hospital admissions to show a positive association with socioeconomic deprivation and low income. Indeed, Low socioeconomic status has been shown to be associated with poor mental health [71-73]. In particular, evidence shows that low income and low education increase the likelihood of depression [74, 75]. Mental health disorders tend to be more prevalent in deprived and vulnerable populations such as refugees and asylum seekers [76, 77].

Methods

We follow the methodology used in the analysis of potentially avoidable hospitalisations and potentially inappropriate hospitalisations. Detailed descriptions of data and methods can be found in section 2: Data and Methods.

Results

The table below shows the correlation between PSY, PAH, PIH, and socioeconomic indicators. PSY is negatively correlated with the proportion of Swiss individuals in the region (SWISS) and median income (INC). The correlation between PSY and other hospital indicators is positive and below 0.5.

	PAH_S	PAH_C	PIH	PAH_L	CLT	IMM	SWISS	REL	LAN	SDI	INC	SEP
PSY	0.246	0.331	0.124	0.464	0.324	0.260	-0.255	-0.346	0.287	0.234	-0.107	0.037

We now turn to hospital admissions for all-cause psychiatric conditions. Figure P1 shows the distribution of the PSY indicator in MedStat regions across canton groups. Admissions per 1000 pop appear stable across canton groups. However, we see very large outliers that go above 30 admissions per 1000 pop for cantons ZH-ZG, and BS-BL-SO, compared to a national mean of less than 10 admissions per 1000 pop. In P1 we see clusters of high admission rates in the North of the country and canton Bern.

P1: Distribution of psychiatric hospitalisations in Switzerland

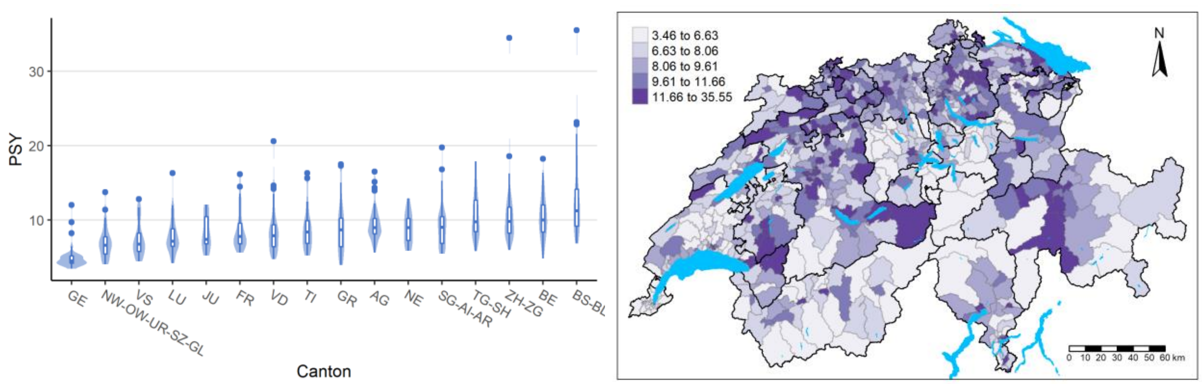
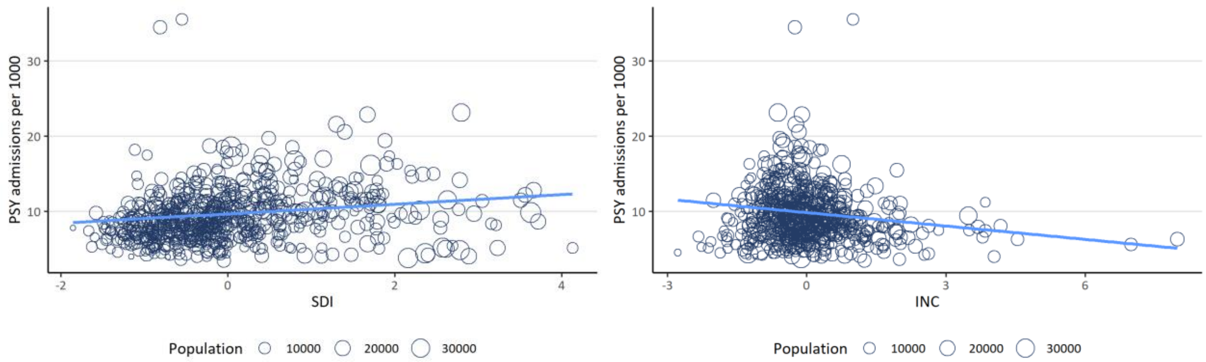
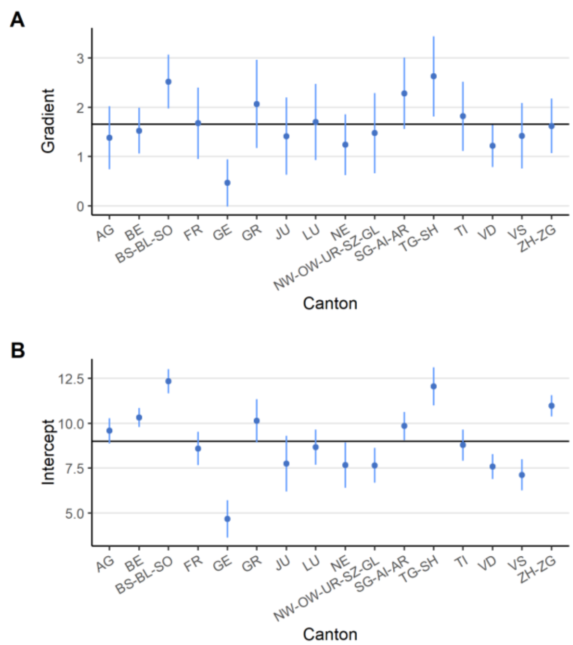


Figure P3A shows the gradient between PSY and the SDI for canton groups. Recall that the horizontal line corresponds to the national gradient. A point with a vertical line as error bar represents each canton group. Canton groups GE and VD have a gradient for PSY admissions that is flatter than the national gradient. This indicates that, for the cantons mentioned above, there is less difference in PSY admissions between the least deprived regions and most deprived regions, than for Switzerland as a whole. Canton groups BS-BL-SO and TG-SH show a gradient that is steeper than the national one, thus indicating the opposite effect. Figure P3B shows large variation between the mean level of PSY admissions, holding SDI constant at zero. Most canton groups exhibit a statistically significant difference, either above or below, the national mean.

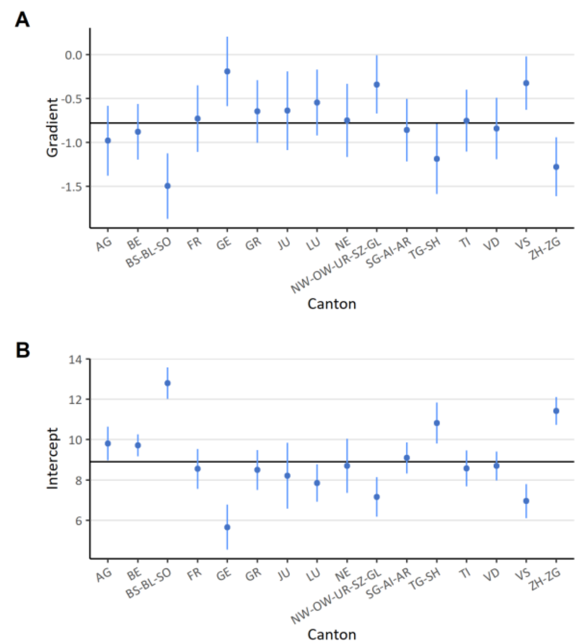
P2: PSY gradient with SDI and INC for Switzerland



P3: Gradient between PSY and SDI



P4: Gradient between PSY and INC



It is important to note however, that this indicator of psychiatric admissions does not include aspects of preventability or appropriateness. The regional differences we see in the level of admissions between canton groups may very well be entirely justified and necessary given the local needs of the population. This is true also for the variability found in the social gradient - a strong gradient may point to an appropriate response to a higher need of hospitalisation for patients in more deprived regions. Finally, given that the provision of mental healthcare in Switzerland is complex, with a large amount of services being delivered in outpatient and intermediate settings, more research is needed that complements findings on hospital indicators.