# Autism and ADHD prevalence in Chile through Bayesian prevalence analysis, machine learning and clinical record data linkage

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Declaration: 'This dissertation is submitted for the degree of Master of Philosophy.'

This dissertation is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text.

The dissertation does not exceed the word limit for the respective Degree Committee.

Word count: xxx TODO (including footnotes, but excluding tables, appendices, and bibliography)

**Acknowledgements**

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# Contents

# 1 Abstract

TODO

# 2 Introduction

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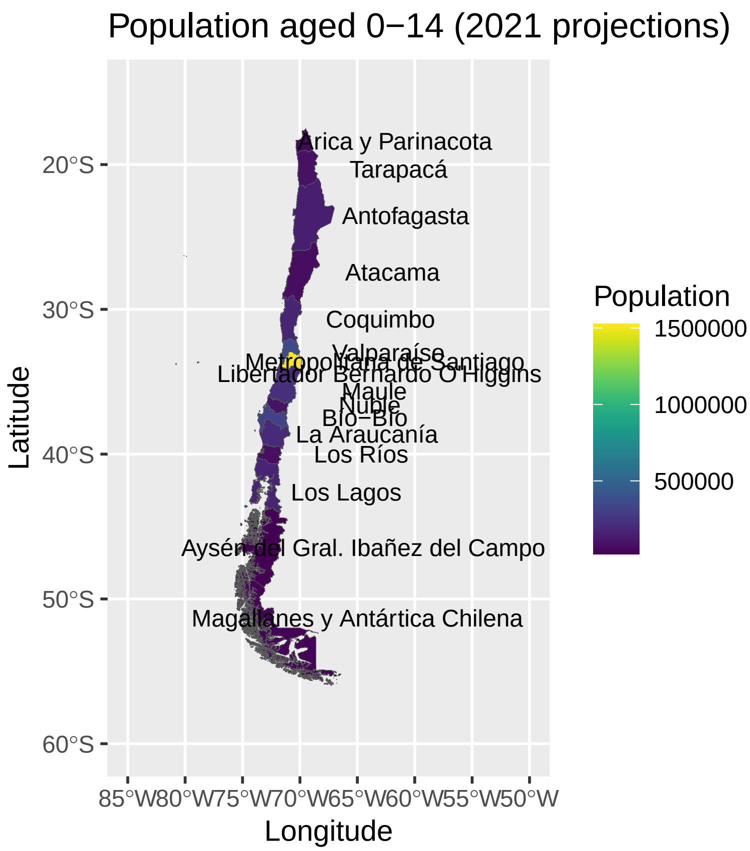



Figure 1: Population of 0-14 year olds in Chile in 2021 by region, from 2017 census projections.

# 3 Methods

## 3.1 Deviation from research protocol

This investigation differs very substantially from the research protocol provided at Appendix X. The protocol intended to investigate autism prevalence in the Cambridgeshire region using clinical data from the Cambridgeshire and Peterborough NHS Foundation Trust and school data from the UK Department for Education's National Pupil Database. Unfortunately this clinical data was found to be of insufficient size and quality to conduct the proposed investigation and while this school data was of high quality, it had been well analysed by Roman-Urestarazu already (8)(10). Therefore school and clinical data from Chile was used instead as they were of high quality and no research on them could be found. The available data from Chile did not have fields on age at autism diagnosis and it was therefore not possible to progress the research protocol's first aim of using machine learning to analyse autism diagnosis age. The protocol's second aim of school autism diagnoses with clinical diagnoses was adapted to be supplementation of the Chilean school

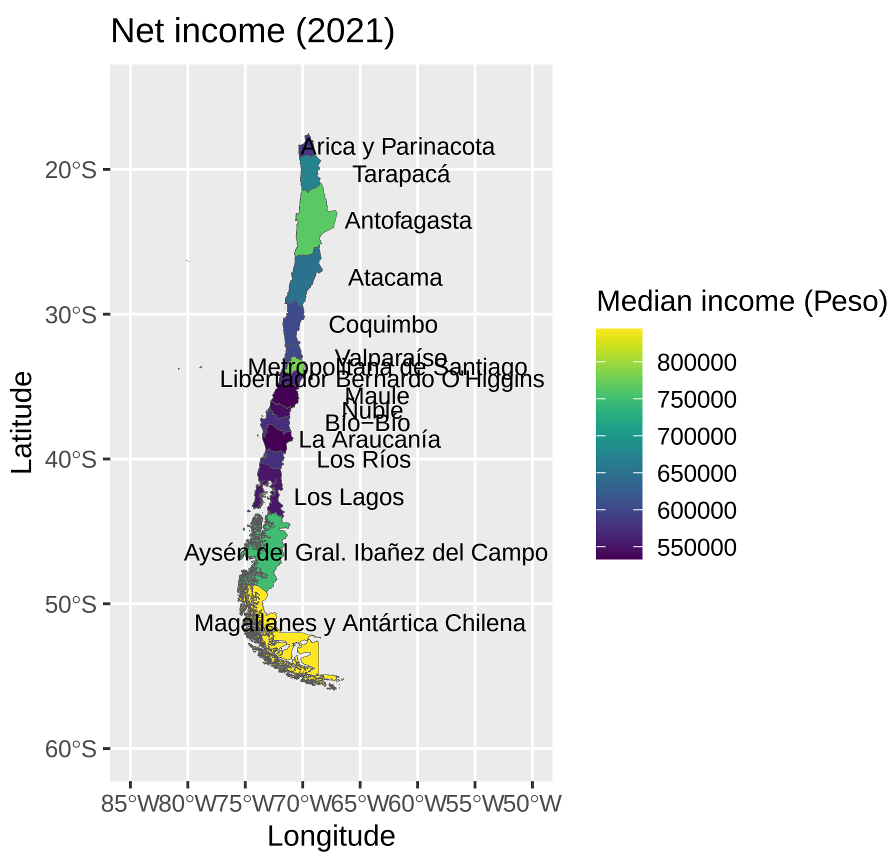



Figure 2: Net income from main job in Chile in 2021 by region, from the INE's Supplementary Income Survey.

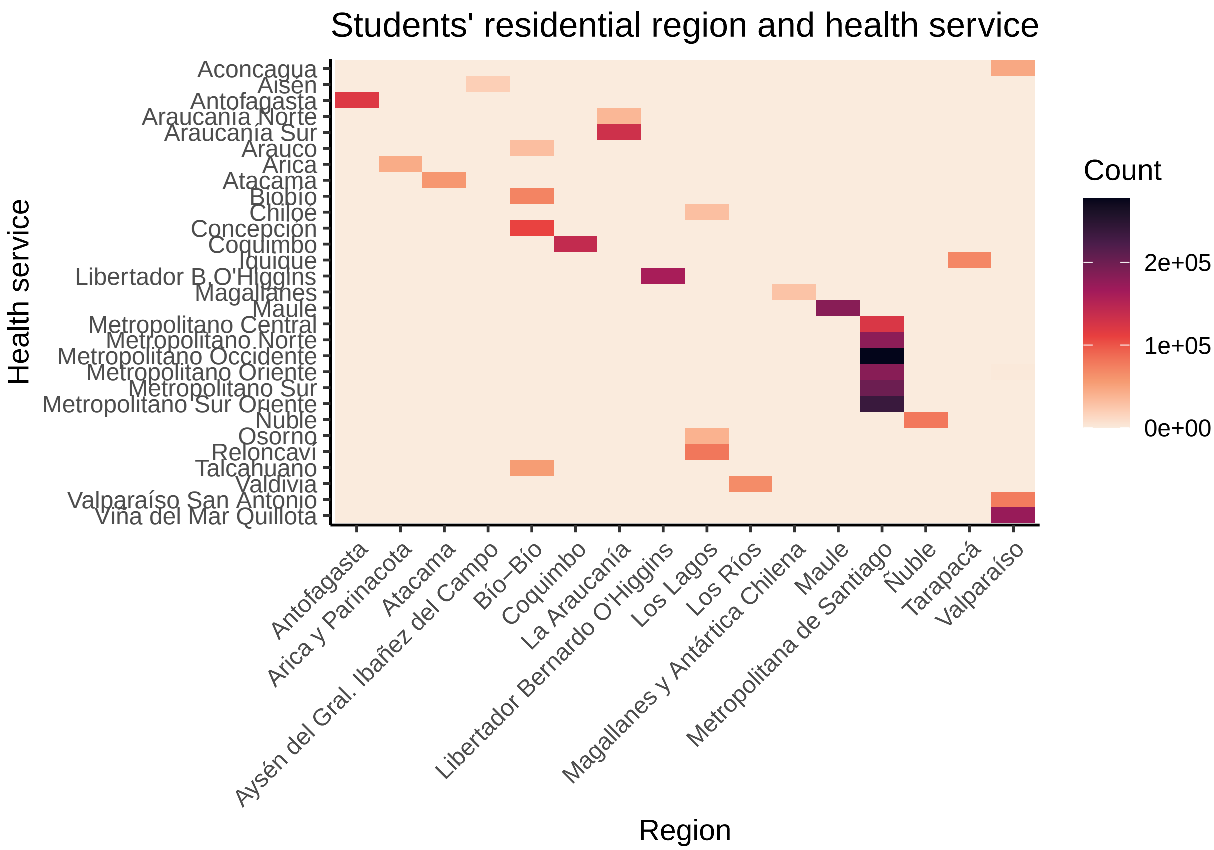



Figure 3: Residential communes aggregated to region level and the health services associated with the aggregated communes, with counts of the number of students resident in the communes in each health service's catchment area.

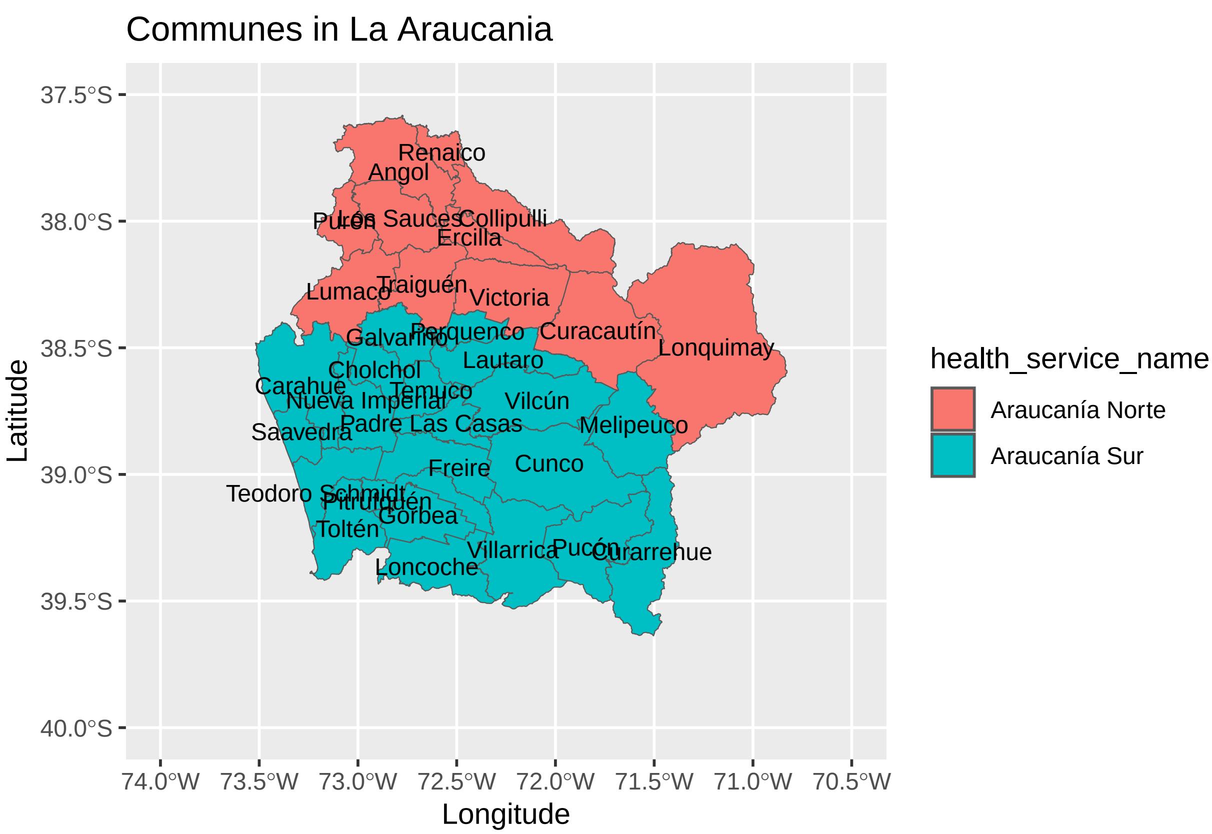



Figure 4: Communes in the Araucanía region, coloured red for the Araucanía Norte (north Araucanía) health services and blue for the Araucanía Sur (south Araucanía) health service.

data diagnoses with clinical diagnoses, see below. Additional aims and analysis that were appropriate to the Chile data were developed and are detailed in Section [Aims] and the rest of this section.

## 3.2 Data management

The statistical software package R has been used to clean, link, analyse and visualise data. R analysis scripts and version control are managed in GitHub and are available at https://github.com/delatee/Autism-diagnosis-age-ML. Raw data and analysis outputs have not been uploaded to GitHub. All data is stored on local devices and will be deleted at conclusion of the project.

## 3.3 Data collection

### 3.3.1 School data

This research uses data from the Chilean Government's Ministerio de Educación (Ministry of Education) that was provided under a freedom of information request and Chile's Law 21545 (28). This dataset contains anonymised records of 3.6 million students in all Chilean schools in 2021. It was collected and curated by the Chilean Unidad de Estadísticas (Statistics Unit), Centro de Estudios (Study Centre) and Ministerio de Educación and is housed in the Sistema de Información General de Estudiantes (General Student Information System, SIGE). It includes data on school type and location, student characteristics, academic performance, special needs and school fee contributions. This dataset will be referred to as the school data, see Supplementary Table **??** for details on its available variables.

The school data shows whether students have accessed the Subvención de Educación Especial Diferencial (Differential Special Education Grant, SEED), which is provided to students with severe physical or mental disabilities, including autism and ADHD, that require education adjustments such as specialist schools or small class sizes (28). The school data includes four groups of students who have autism but are recorded in this dataset as not having autism: students with autism who attend private schools which are not eligible for SEED; students with autism who choose not to apply for SEED; students with autism who apply for SEED but are found to not be sufficiently severely affected to receive SEED; and students with autism who receive SEED but for a different disability as only one can be recorded, perhaps one that more severely affects them. The number of students in each of these groups is unknown and these groups are analogous for students with ADHD. Thus all estimates of autism and ADHD prevalence from this dataset alone are likely to be underestimates.

### 3.3.2 Clinical data

This research also uses data from Chile's Servicio de Salud Araucanía Sur (South Araucanía health service, SSAS), obtained under a freedom of information request. These data are collated from secondary care clinical records, particularly from mental health community care services. They include wage deducted health insurance contributions from Chile's Fondo Nacional de Salud (National Health Fund, FONASA). These data provide the value of health insurance contributions that are based on parents' wages, from which a colleague previously inferred socio-economic status of patients' families. This data collection comprises two datasets which will be referred to as the small clinical data and large clinical data.

The small clinical data was provided by Villarrica Hospital in the Villarrica commune of Chile's Araucanía region. It comprises clinical records for public sector specialist health visits of every patient aged 6-18 with a primary, secondary or tertiary diagnosis of autism or intellectual disability between February 2014 and December 2021 that were registered for that hospital. This is understood to include every such patient resident in the communes of Curarrehue, Loncoche, Pucón and Villarica in the SSAS catchment of Chile's Araucanía region, and include some such patients resident in the communes of Cunco, Freire, Gorbea, Nueva Imperial, Pitrufquén, Temuco, Teodoro Schmidt and Toltén in the SSAS catchment. It also includes some such patients resident in communes in other health service catchments which will not be used.

The large clinical data comprises clinical records for public sector specialist health visits of every patient aged 6-18 with a primary diagnosis of autism between May 2015 and December 2021 for all communes in the

SSAS catchment. It also includes data for patients resident in the communes of Curacautín, Lonquimay and Victoria in the Servicio de Salud Araucanía Norte (North Araucanía health service, SSAN) catchment which will not be used.

The small and large clinical datasets will be collectively referred to as the clinical data and they do not include any records for privately provided healthcare. **??** shows the pre-processing of the clinical data.

#### 3.3.3 Supplementary data

Chile's 2017 census data, held by the Instituto Nacional de Estadisticas (National Statistics Institute, INE) (29), was used to create a standard population of Chile's age and sex distribution from projections of population size by age and sex in 2021. It was also used to obtain projections of population of youth aged 0-14 in 2021 by region.

Data from the INE's Encuesta Suplementaria de Ingresos (Supplementary Income Survey, ESI) of 2021 (30) was used to obtain the nominal median income by region in 2021.

For mapping, shapefiles of administrative areas were obtained from The Humanitarian Data Exchange of the United Nations Office for the Coordination of Humanitarian Affairs (31). Additional region and commune naming information was taken from the R package 'chilemapas'.

### 3.4 Aim 1: Use school data and frequentist method to find a lower bound on autism and ADHD prevalence

#### 3.4.1 School data preparation

The school dataset was restricted to students aged 6-18 as of 30th June 2021 to capture children of school age in Chile. No restriction on sex was necessary as it contained only females and males. Students' commune of residence was mapped to their respective health service catchment areas. Two issues due to boundary changes were corrected. Firstly, the commune now called Tocopilla which falls across the Antofagasta and Tarapacá regions was formerly two communes, Tocopilla in Antofagasta and Pozo Almonte in Tarapacá. The old names have been retained to ensure appropriate region mapping and they are mapped to Antofagasta and Iquique health services respectively. Secondly, the communes recorded as belonging to the former Ñuble sub-region of the Bío-Bío region were mapped to their corresponding communes in the recently formed Ñuble region.

Commune of residence was missing for 4078 students (0.13%) and their school's commune was imputed as most students are likely to go to school near their place of residence.

Students' age as of 30th June 2021 was mapped to age-bands of 6-8, 9-11, 12-14 and 15-18, preserving the divide between primary and secondary school as secondary school starts at age 12 in Chile, and with a larger final band as fewer students are expected to be diagnosed older and the 18 years old group may be small due to students leaving schooling. Students' ethnicity was mapped to being a member of the Mapuche Indigenous group, being a member of another Chilean Indigenous group, or not being a member of an Indigenous group based on their recorded ethnicity which can take at most one value. The 6859 students (0.22%) with ethnicity recorded as 'no registry' were mapped to not being a member of an Indigenous group.

Students' school fee status was mapped to a proxy socio-economic status feature. Students with free schooling were given SES of 1 indicating low status as families with low SES are entitled to schooling rebates. Students paying $1,000-$100,000 monthly were given SES of 2, indicating medium status, and students paying more than $100,000 monthly were given 3 to indicate high status. For school fee status, 49973 students (1.64%) were coded as 'No information' and 29 students (0.00095%) were missing school fee values and these were re-categorised as 'No information' to reflect their unknown school fee status. No other features of interest for this analysis had missingness.

### 3.4.2 Crude prevalence

The crude prevalences of autism and of ADHD were calculated as the count of cases divided by the relevant population size. Grouping features of sex, health service of residential commune, monthly school fee as a proxy for SES, ethnicity and school's rurality were used, and calculations were made for aggregate, by sex, and by sex and age group.

### 3.4.3 Frequentist age and sex adjustment

For each grouping feature, prevalence was standardised by age and sex using direct standardisation. Following the method presented by Fay and Feuer (35), the age- and sex-adjusted prevalence rates for each group were calculated using the 2017 Chile census projections of the distribution of people by age and sex in 2021 as the standard population. Gamma confidence limits were calculated at the 95% level using chi-squared distributions. The adjusted prevalence rates were multiplied by their respective population sizes to give adjusted prevalence counts which were rounded to integers, therefore loosing a small amount of precision.

Ethnicity analysis compared individuals from the Mapuche Indigenous group to those from other Indigenous groups or with no Indigenous group and used data from the Araucanía, Aysén, Biobío, Los Lagos, Los Rios, Magallanes and Región Metropolitana de Santiago regions only as these regions are collectively the five regions with the largest Mapuche populations and the five regions with the highest proportion of Mapuche in their population.

## 3.5 Aim 2: Use clinical data and multiple component analysis to identify autism diagnosis characteristics

### 3.5.1 Clinical data preparation

The small and large clinical datasets were cleaned to ensure internal consistency in feature values and translated into English where appropriate. Patients were categorised as having autism if any of their diagnosis codes were in ICD F84-F89 for any appointment. Patients were categorised as having an intellectual disability if any of their diagnoses codes was in ICD F70-F79 for any appointment. No restriction on sex was necessary as these data contained only females and males. The clinical data includes economic data in the form of patients' family's health insurance contribution level. Values taken are 'FONASA-A' to 'FONASA-D' which are respectively larger contributions to this public health fund and are assumed to map to increasing socio-economic status, and 'Private health insurance' which indicates contributions to a private health insurance provider rather than the public fund and therefore is assumed to map to the highest socio-economic level.

For multiple correspondence analysis, only the small clinical dataset was used as it contained demographic fields not present in the large clinical data. In the small clinical data, patients' age as of 30th June 2021 was mapped to age-bands of 0-2, 3-5, 6-8, 9-11, 12-14 and 15-18 to provide comparability to the school data. The small clinical dataset had many values for ethnicity, disability status and foster care status that were recorded as 'no information'. For disability and foster care status, additional features were created with the 'no information' values imputed as 'no disability' and 'no foster care' respectively, as it is likely that patients who did have a disability or had experienced foster care would have this recorded.

The small clinical data was aggregated to patient level by selecting each patient's most recent commune and rurality, and most common health insurance contribution level, hospital and medical specialty of appointment. For ethnicity, Mapuche was selected if present in any of that patient's appointment records, then Chilean if present, then Foreign if present and else 'No information' was selected. Similarly disability and foster care status were selected as 'Yes' if recorded for any appointment, then 'No' was selected if present, then 'No information' if no status was recorded for any appointment. The data was restricted to patients with a diagnosis of autism.

Only patients with autism and living most recently in a commune in the SSAS catchment area were included.

### 3.5.2 Multiple correspondence analysis

Multiple correspondence analysis (MCA) was conducted using R's FactoMineR package with the number of output dimensions equal to the number of input features. MCA was an appropriate technique to use here because the small clinical dataset contains primarily categorical features which MCA is designed to handle.

Data-led analytics was used to identify features in the small clinical dataset that explained the variance in this patient-level data. Initially, all available features with suspected association with autism were included in MCA, specifically: sex, age group, commune of residence, health insurance contribution level as a proxy for SES, ethnicity, residential rurality, disability status and foster care status. The data grouped well into having information about disability and about foster care and not having information about each, therefore the MCA was rerun with the disability and foster care features exchanged for their respective imputed versions. This identified age, commune and ethnicity as important for explaining the variance, so the MCA was rerun with only these three features.

### 3.5.3 Alternative machine learning approaches

Component factor analysis (CFA) and principle component analysis (PCA) were also considered to analyse the features associated with autism diagnosis in the small clinical data. Both are powerful methods for uncovering the latent structure of data, however CFA typically requires ordered categorical variables and PCA requires continuous variables. As the commune feature, an unordered categorical variable, was thought to be important to the features associated with autism diagnosis and therefore needed to be included in analysis, using CFA or PCA would require one-hot-encoding of commune which would reduce the appropriateness of these tests.

## 3.6 Aim 3a: Link school and clinical records

### 3.6.1 School data preparation

For data linkage, the school data was further restricted to students with autism that were living in communes in the SSAS catchment in 2021 to maximise comparability with the clinical data. A false empty record was added to the school dataset before linkage that allowed the algorithm to correctly match on SES. This false record was only used during linkage, did not match to any patient records and was removed before comparing matched and unmatched records.

### 3.6.2 Clinical data preparation

For data linkage, the small and large clinical datasets were joined to form the clinical dataset. This was restricted to appointments for individuals resident in communes in the SSAS catchment as the data is believed to be complete for this catchment area only. It was also restricted to patients aged 6-18 as of 30th June 2021 to maximise compatibility to the school data. Appointment year was not restricted in order to retain more data and thus maximise linkage opportunities, and only patients of female and male sex were present. Patients with familial socio-economic level of FONASA-A were interpreted to be of low SES status and given proxy status of 1 (equivalent to students with free school fees); patients with FONASA-B, FONASA-C and FONASA-D were interpreted to have moderate SES status and given 2 (equivalent to students paying $1,000-$100,000 monthly for state schooling); and patients with private health insurance were interpreted to have high SES and given 3 (equivalent to students paying more than $100,000 monthly). Students that did not have a clinical autism diagnosis but did have a clinical intellectual disability diagnosis were included to maximise opportunities for matching with the school data, with prioritisation of autism diagnosis over intellectual disability.

The clinical dataset had no missingness in the features of interest for data linkage.

The clinical data was aggregated to one row per patient per commune in the SSAS catchment, to maximise the opportunity for matching patients that had moved within this health service. The majority of patients lived in only one commune in the SSAS catchment during the study period. Aggregation to patient level took the most common SES value. The resulting dataset will be referred to as the patient data.

#### 3.6.3 Selection of features for matching

The features available in both school and patient datasets for matching were sex, date of birth, commune of residence, diagnoses with autism, and the proxies for socio-economic status – monthly school fees in the school data and mode health insurance contributions in the patient data. Although only students with autism diagnoses are included from the school dataset, the clinical dataset comprises primarily patients with a diagnosis of autism, some patients with a diagnosis of intellectual disability and some with both. The diagnosis with autism feature is therefore included in the features to match on to encourage matching of school records to clinical records for patients with an autism diagnosis, but to allow for matching to clinical records for patients with only a diagnosis of intellectual disability when no suitable patient with autism is present.

#### 3.6.4 Manual record linkage

The school and patient data were blocked on sex and date of birth to improve match quality and reduce runtime. As both datasets are from trusted, large-scale data collections, it is reasonable to assume sex and dates of birth are highly accurate in both datasets, and it would not be reasonable to accept any proposed matches that do not agree on either sex or date of birth.

Two versions of manual record linkage were tried. First, the school and patient data were merged with perfect matches required on sex, date of birth, commune of residence and proxies for SES. Second, the school and patient data were merged with perfect matches required only on sex, date of birth and commune of residence, as the proxies for SES are known to be approximate and therefore requiring perfect matches on SES is not reasonable.

#### 3.6.5 Probabilistic record linkage

All possible pairs of blocked matches were generated and agreement weights were calculated for each feature using expectation maximisation, then aggregated into a weight for the pair . Records with missing values were retained as this linkage method is robust to missingness. The similarity comparison method was exact matching for commune of residence, diagnosis with autism and socio-economic status; there was no value in using a string comparison method for commune of residence as all commune names were already standardised and two communes having similarly spelled names does not increase the likelihood of a match between those communes. Linkage was implemented using R's RecordLinkage package. This included consideration of the average frequencies of categories in each feature and estimated errors rates were supplied: the default estimated error rate of 0.01 was supplied for the commune of residence and diagnosis with autism features as they are expected to be fairly accurate features, and an estimated error rate of 0.6 was supplied for the socio-economic status feature as it is a loosely defined proxy. This value was chosen through trial and error to ensure the algorithm prioritised matching on diagnosis of autism above matching on socio-economic status.

Pairs were then selected based on weight to create a 1-1, bipartite, matching between school records and patients. These matches were examined to ensure a patient that lived in multiple communes had matched to only one school record and to assess the plausibility of matches made to patients without autism but with intellectual disability.

#### 3.6.6 Creation of the linked dataset

The patient data was de-duplicated to a single row per patient with the commune of their matched record chosen if they had a multiple. The school data for students aged 6-18 in the SSAS catchment area and the deduplicated patient-level data for patients aged 6-18 in SSAS were combined to form the linked dataset, leaving out the deduplicated patient records that were a match to student records to ensure those individuals were not present twice in the linked data.

It is assumed that the patients that did not match to the school data do exist in the school data but do not have a diagnosis of autism in the school data.

### 3.6.7 Alternative record linkage methods

Record linkage using Bayesian methods in which matched status is modelled, as developed by Sadinle (32) and refined by Stringham (33), was considered for record linkage here. This technique is typically more complex and has longer runtimes than probabilistic matching but can more easily enforce one-to-one matching and is particularly well suited to matching names. As the datasets in this investigation did not include names, there was limited benefit from using Bayesian linkage methods.

Record linkage using machine learning to classify matched and unmatched pairs, as explored by Pita et al, was also considered as it is generally thought to be more accurate than probabilistic matching alone (34). However this was not pursued because the datasets under investigation have very few common features to match on, meaning machine learning algorithms would have few options to trial, and there are no known true matches with which to assess the accuracy of machine learning models.

### 3.6.8 Comparison of matched and unmatched records.

For the school and patient datasets, each record was classified as either matched or unmatched based on whether it appeared in the bipartite matching. The discrete Kolmogorov-Smirnov test was used to compare matched and unmatched records within each dataset for each of the features used for matching, excluding date of birth which has too many categories to have meaningful results and excluding diagnosis of autism which is uniformly true in the school dataset and therefore not informative. Missing values in the socio-economic status feature were omitted before testing.

Permutation tests were then performed for each of the features tested in each dataset by permuting the matched status 2000 times and recomputing the discrete Kolmogorov-Smirnov test for each permutation. The p-values for the Kolmogorov-Smirnov tests on the observed data were then compared to the distributions of p-values for the permuted data to determine the significance of the observed results.

## 3.7 Aim 3b: Accurately estimate autism prevalence and project across health services using Bayesian prevalence prediction

### 3.7.1 Autism prevalence estimation using linked data

The crude and age- and sex-adjusted prevalence of autism in the linked data was calculated as in sections 4.3.2 and 4.3.3 for all the linked data and for females and males separately. The adjusted prevalence delta was calculated as the difference between the adjusted prevalence for SSAS calculated using the linked data and the adjusted prevalence for SSAS from the school data only.

### 3.7.2 Prevalence projection

Prevalence was projected for each of the health services other than SSAS by adding delta to their adjusted prevalence calculated from the school data only. Estimated confidence intervals were calculated for the projections by finding a band around the projection of equal width to the 95% gamma confidence interval for each health service's school data adjusted prevalence.

### 3.7.3 Bayesian prevalence analysis

Bayesian prevalence analysis of autism was conducted for the school data by health service. A random-effects model was constructed with the random effect on health service as follows.

Set

$$y_i = \text{adjusted count of autism cases in health service } i$$

$$n_i = \text{number of students in health service } i$$

$$\theta_i = \text{prevalence of autism in health service } i$$

For each health service $i$, the model formula is

$$y_i|(n_i, \theta_i) \sim \text{Binomial}(n_i, \theta_i)$$

With

$$\theta_i \sim \text{Beta}(a, b)$$

And posterior distribution

$$\theta_i|(y_i, n_i) \sim \text{Beta}(y_i + a, n_i - y_i + b)$$

Fitting a binomial model required integer valued counts of autism cases. As adjusted case counts were used throughout, the adjusted counts had to be rounded to integer values which caused a small amount of precision to be lost. It is anticipated that this may cause the posterior credible intervals to be slightly wider but is not expected to have a large effect on findings.

#### 3.7.4 Prior selection

Four priors for $\theta_i$ were used when fitting the Bayesian prevalence model. First, a conjugate beta prior common to all health services was constructed with the global age- and sex-adjusted prevalence of autism in the school dataset and its standard deviation used respectively as the mean and standard deviation of the prior. This prior was suitable because the global adjusted prevalence in the school data provides a lower bound on the plausible prevalence of autism in Chile. Second, a conjugate beta prior specific to each health service using the health service specific age- and sex-adjusted autism prevalence in the school data as the prior means and their standard deviations as the prior standard deviations. This prior was suitable because it was extending the previous prior to each of the random effect categories. On its own this prior is expected to give uninformative posteriors because it is effectively duplicating the information in the sample data, but it will be used as a more specific lower bound on the plausible prevalence of autism in each health service. Third, a conjugate beta prior specific to each health service with the health service specific adjusted prevalence projected from the linked data as the prior means and prior standard deviations taken from the previous prior. This prior was suitable as captures the extra information provided by the linkage and has narrow standard deviations which will model a theoretical upper bound on the prevalence of autism in each health service. Fourth, a uniform prior specific to each health service with the adjusted autism prevalences from the school data for each health service as its lower bounds and the projected prevalences from the linked data for each health service as its upper bounds. This prior is suitable because it captures the information from both the school and linked datasets, without specifying where within these bounds the true prevalences are likely to be.

#### 3.7.5 Markov chain Monte Carlo sampling

Bayesian prevalence modelling used the JAGS (Just Another Gibbs Sampler) R package which uses Markov chain Monte Carlo (MCMC) sampling to produce posterior density distributions when given the above priors and adjusted prevalence observations. A burn-in period of 2000 samples was used to ensure models converge, then 2000 iterations were used to model the posterior densities . Visual inspection of trace plots showed no evidence of a lack of convergence and rhat values were less than 1.1.

# 4 Results

## 4.1 School data

The school dataset contained records for 3,056,306 Chilean students aged 6-18 in 2021. Of these, 1,487,224 (48.66%) were female and the rest were male. A special needs code was recorded for 339,968 (11.12%) students, indicating they received SEED during that school year. Of these students, 14,549 (4.28%) received SEED for autism and 46,224 (13.6%) received SEED for ADHD. Thus the global crude prevalence of autism in the school data was 0.48% (0.47-0.48%) and the global crude prevalence of ADHD was 1.51% (1.50-1.53%).

The crude prevalence of autism and ADHD vary with age, as shown in Tables 1 and 2, Figures 5 and 6, and Supplementary Figures 49 and 50. Autism prevalence is highest in 6-8 year olds and decreases with age while

Table 1: Count and prevalence of autism cases by age band in Chile school data with normal confidence intervals.

| Age band | Autism cases | Prevalence % (95% CI) |
|---|---|---|
| 6-8 | 5162 | 0.69 (0.67, 0.71) |
| 9-11 | 4212 | 0.55 (0.53, 0.57) |
| 12-14 | 3038 | 0.41 (0.39, 0.42) |
| 15-18 | 2137 | 0.27 (0.26, 0.28) |

Table 2: Count and prevalence of ADHD cases by age band in Chile school data with normal confidence intervals.

| Age band | ADHD cases | Prevalence % (95% CI) |
|---|---|---|
| 6-8 | 5936 | 0.79 (0.77, 0.81) |
| 9-11 | 15549 | 2.03 (1.99, 2.06) |
| 12-14 | 14099 | 1.88 (1.85, 1.91) |
| 15-18 | 10640 | 1.35 (1.32, 1.37) |

ADHD prevalence peaks around age 11 then decreases. Both conditions show a small increase in prevalence for age 18.

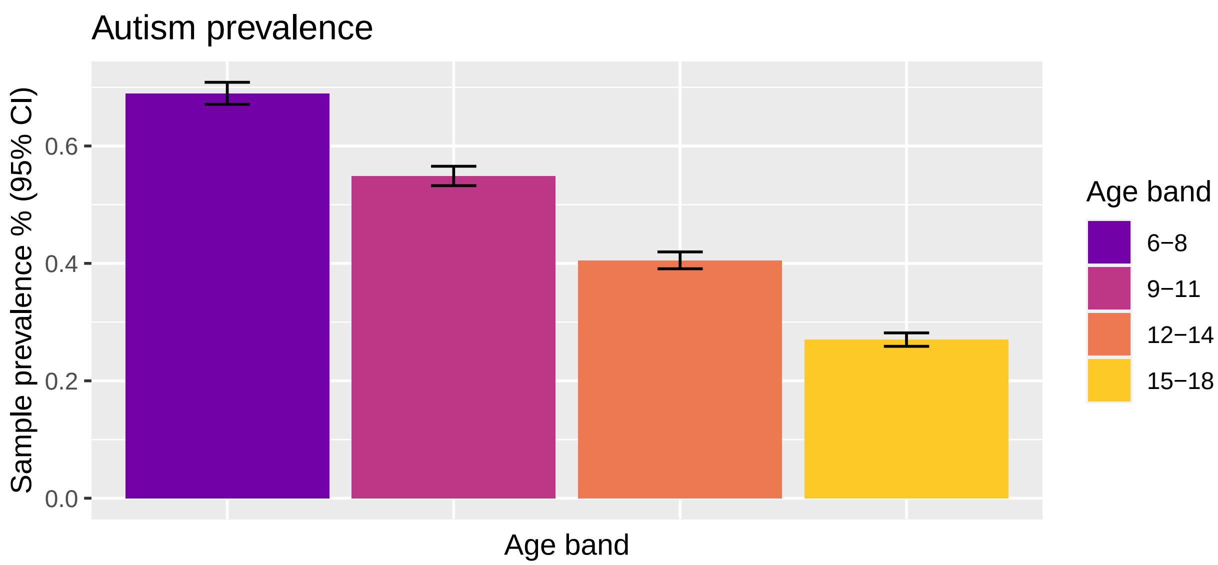



Figure 5: Sample prevalence of autism by age band. Bars show 95% normal confidence intervals.

Autism prevalence is 0.13% (0.13-0.14%) for females and 0.80% (0.79-0.82%) for males, see Table 3 and Figure 7. ADHD prevalence is 1.01% (1.00-1.03%) for females and 1.98% (1.96-2.01%) for males, see Table 4 and Figure 8. Autism and ADHD prevalences are higher in males than females for all ages, see also Supplementary Figures 51 and 52.

Autism varies by health service, as shown in Table 5, Figure 9 and Supplementary Figure 53. Autism prevalence is highest in Ñuble at 1.32% (1.24 - 1.40%) and Antofagasta at 0.84% (0.79- 0.89%), and is lowest in Metropolitano Norte at 0.29% (0.27 - 0.32%) and Araucanía Norte at 0.30% (0.24- 0.36%). Autism peaks in the 6-8 age band across all services except Chiloé and Magallanes where it peaks in the 9-11 band.

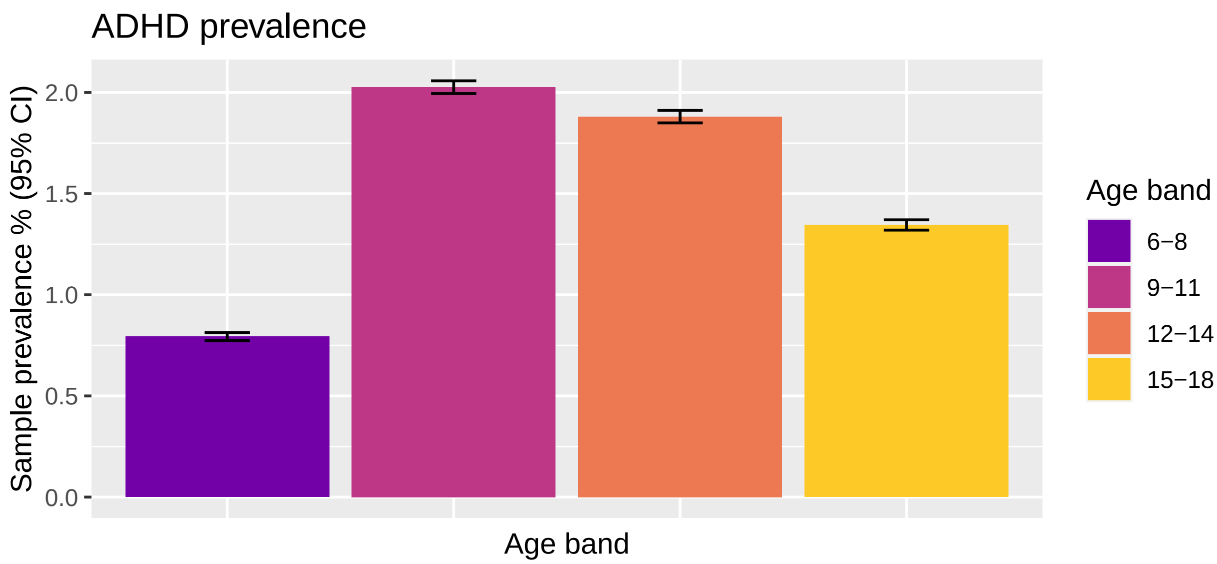



Figure 6: Sample prevalence of ADHD by age band. Bars show 95% normal confidence intervals.

Table 3: Count and prevalence of autism cases by age band in Chile school data for females and males with normal confidence intervals.

| | Female | | Male | |
|---|---|---|---|---|
| Age band | Autism cases | Prevalence % (95% CI) | Autism cases | Prevalence % (95% CI) |
| 6-8 | 774 | 0.21 (0.20, 0.23) | 4388 | 1.15 (1.11, 1.18) |
| 9-11 | 523 | 0.14 (0.13, 0.15) | 3689 | 0.94 (0.91, 0.97) |
| 12-14 | 391 | 0.11 (0.10, 0.12) | 2647 | 0.69 (0.66, 0.72) |
| 15-18 | 290 | 0.08 (0.07, 0.08) | 1847 | 0.45 (0.43, 0.47) |

Table 4: Count and prevalence of ADHD cases by age band in Chile school data for females and males with normal confidence intervals.

| | Female | | Male | |
|---|---|---|---|---|
| Age band | ADHD cases | Prevalence % (95% CI) | ADHD cases | Prevalence % (95% CI) |
| 6-8 | 774 | 0.21 (0.20, 0.23) | 3944 | 1.03 (1.00, 1.06) |
| 9-11 | 523 | 0.14 (0.13, 0.15) | 10322 | 2.62 (2.57, 2.67) |
| 12-14 | 391 | 0.11 (0.10, 0.12) | 9714 | 2.53 (2.48, 2.58) |
| 15-18 | 290 | 0.08 (0.07, 0.08) | 7165 | 1.75 (1.71, 1.79) |

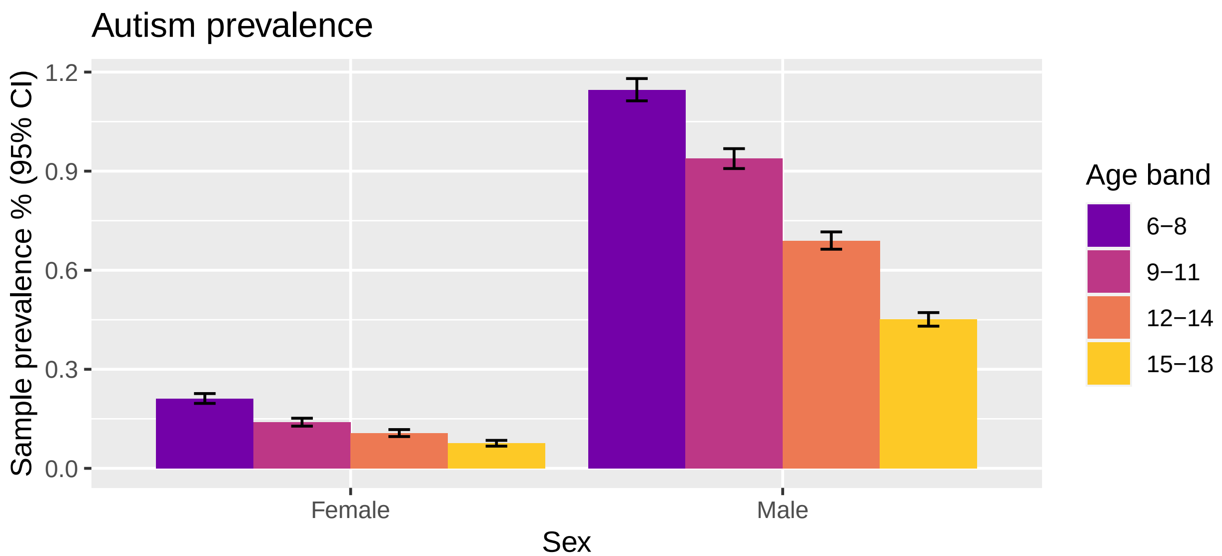



Figure 7: Sample prevalence of autism by age band and sex. Bars show 95% normal confidence intervals.

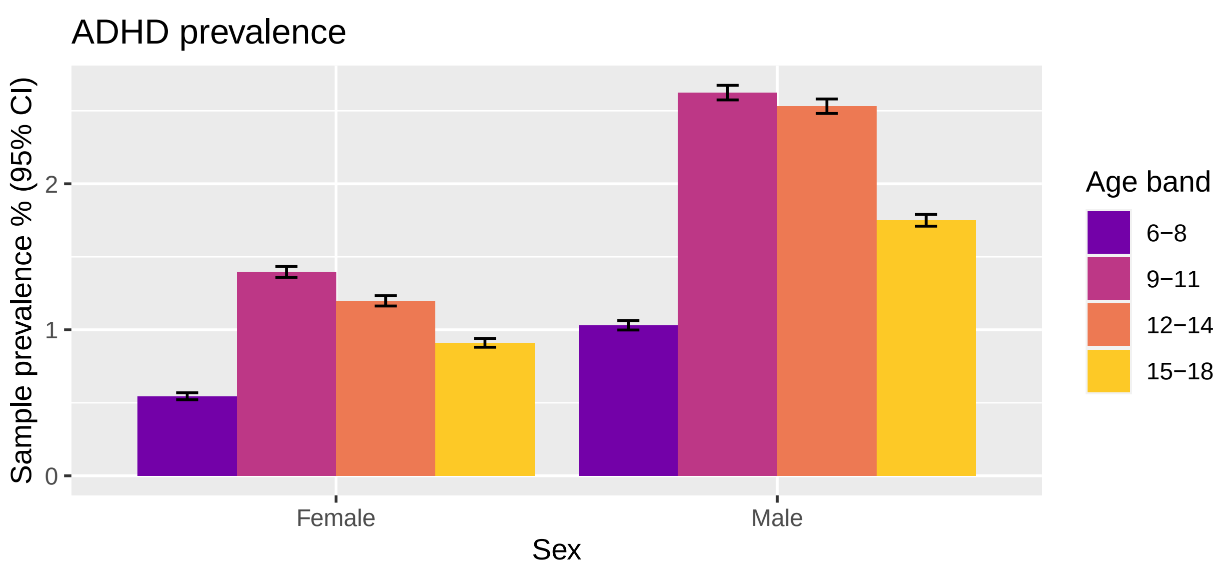



Figure 8: Sample prevalence of ADHD by age band and sex. Bars show 95% normal confidence intervals.

ADHD prevalence also varies across health services, as shown in Table 6, Figure 10 and Supplementary Figure 54. ADHD prevalence is highest in Magallanes at 3.07% (2.87 - 3.27%) and Talcahuano at 3.07% (2.93- 3.22%), and is lowest in Atacama at 0.49% (0.44 - 0.55%) and Antofagasta at 1.00% (0.94- 1.06%).

Table 5: Count and prevalence of autism cases by health service and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| Health service | Age band | Autism cases | Prevalence % (95% CI) | Autism cases | Prevalence % (95% CI) |
| Aconcagua | 6-8 | 14 | 0.25 (0.12, 0.38) | 59 | 0.99 (0.74, 1.24) |
| Aisén | 6-8 | 9 | 0.40 (0.14, 0.66) | 52 | 2.29 (1.67, 2.90) |
| Antofagasta | 6-8 | 54 | 0.39 (0.29, 0.50) | 302 | 2.09 (1.85, 2.32) |
| Araucanía Norte | 6-8 | 3 | 0.07 (0.00, 0.15) | 32 | 0.69 (0.45, 0.93) |
| Araucanía Sur | 6-8 | 26 | 0.17 (0.10, 0.23) | 139 | 0.86 (0.72, 1.00) |
| Arauco | 6-8 | 11 | 0.29 (0.12, 0.46) | 67 | 1.79 (1.36, 2.21) |
| Arica | 6-8 | 18 | 0.34 (0.18, 0.49) | 94 | 1.63 (1.31, 1.96) |
| Atacama | 6-8 | 18 | 0.26 (0.14, 0.39) | 53 | 0.75 (0.55, 0.95) |
| Biobío | 6-8 | 12 | 0.14 (0.06, 0.23) | 92 | 1.06 (0.85, 1.28) |
| Chiloé | 6-8 | 2 | 0.06 (0.00, 0.14) | 38 | 1.07 (0.73, 1.41) |
| Concepción | 6-8 | 44 | 0.34 (0.24, 0.43) | 252 | 1.87 (1.64, 2.10) |
| Coquimbo | 6-8 | 36 | 0.21 (0.14, 0.28) | 207 | 1.14 (0.98, 1.29) |
| Iquique | 6-8 | 15 | 0.18 (0.09, 0.27) | 100 | 1.11 (0.89, 1.33) |
| Libertador B.O'Higgins | 6-8 | 38 | 0.20 (0.14, 0.26) | 215 | 1.08 (0.94, 1.22) |
| Magallanes | 6-8 | 6 | 0.19 (0.04, 0.35) | 42 | 1.30 (0.91, 1.70) |
| Maule | 6-8 | 41 | 0.19 (0.13, 0.24) | 193 | 0.84 (0.72, 0.96) |
| Metropolitano Central | 6-8 | 22 | 0.16 (0.09, 0.22) | 162 | 1.07 (0.91, 1.23) |
| Metropolitano Norte | 6-8 | 26 | 0.12 (0.07, 0.17) | 174 | 0.77 (0.65, 0.88) |
| Metropolitano Occidente | 6-8 | 62 | 0.16 (0.12, 0.20) | 323 | 0.81 (0.72, 0.90) |
| Metropolitano Oriente | 6-8 | 31 | 0.14 (0.09, 0.19) | 155 | 0.69 (0.58, 0.80) |
| Metropolitano Sur | 6-8 | 44 | 0.18 (0.13, 0.24) | 261 | 1.04 (0.91, 1.16) |
| Metropolitano Sur Oriente | 6-8 | 41 | 0.15 (0.10, 0.20) | 277 | 0.95 (0.84, 1.07) |
| Osorno | 6-8 | 9 | 0.20 (0.07, 0.33) | 51 | 1.08 (0.78, 1.37) |
| Reloncaví | 6-8 | 22 | 0.24 (0.14, 0.34) | 96 | 1.02 (0.82, 1.23) |
| Talcahuano | 6-8 | 25 | 0.40 (0.24, 0.55) | 129 | 1.96 (1.63, 2.30) |
| Valdivia | 6-8 | 11 | 0.15 (0.06, 0.23) | 71 | 0.90 (0.69, 1.10) |
| Valparaíso San Antonio | 6-8 | 22 | 0.23 (0.14, 0.33) | 155 | 1.59 (1.34, 1.84) |
| Viña del Mar Quillota | 6-8 | 55 | 0.27 (0.20, 0.34) | 292 | 1.37 (1.21, 1.52) |
| Ñuble | 6-8 | 57 | 0.63 (0.46, 0.79) | 305 | 3.21 (2.85, 3.56) |
| Aconcagua | 9-11 | 3 | 0.05 (0.00, 0.11) | 59 | 0.95 (0.71, 1.20) |
| Aisén | 9-11 | 2 | 0.08 (0.00, 0.20) | 26 | 1.05 (0.65, 1.45) |
| Antofagasta | 9-11 | 45 | 0.30 (0.22, 0.39) | 260 | 1.67 (1.47, 1.87) |
| Araucanía Norte | 9-11 | 4 | 0.09 (0.00, 0.18) | 26 | 0.57 (0.35, 0.79) |
| Araucanía Sur | 9-11 | 16 | 0.10 (0.05, 0.15) | 120 | 0.71 (0.58, 0.83) |
| Arauco | 9-11 | 9 | 0.23 (0.08, 0.38) | 70 | 1.73 (1.33, 2.13) |
| Arica | 9-11 | 11 | 0.20 (0.08, 0.31) | 57 | 0.95 (0.71, 1.20) |
| Atacama | 9-11 | 7 | 0.09 (0.02, 0.16) | 45 | 0.59 (0.42, 0.76) |
| Biobío | 9-11 | 16 | 0.19 (0.09, 0.28) | 68 | 0.76 (0.58, 0.94) |
| Chiloé | 9-11 | 2 | 0.06 (0.00, 0.13) | 49 | 1.27 (0.92, 1.63) |
| Concepción | 9-11 | 30 | 0.22 (0.14, 0.30) | 216 | 1.49 (1.29, 1.69) |
| Coquimbo | 9-11 | 18 | 0.10 (0.05, 0.14) | 145 | 0.78 (0.65, 0.90) |
| Iquique | 9-11 | 16 | 0.19 (0.09, 0.28) | 80 | 0.86 (0.67, 1.04) |
| Libertador B.O'Higgins | 9-11 | 30 | 0.15 (0.10, 0.21) | 193 | 0.92 (0.79, 1.05) |

| | | | | | |
|---|---|---|---|---|---|
| Magallanes | 9-11 | 6 | 0.17 (0.03, 0.31) | 60 | 1.73 (1.30, 2.17) |
| Maule | 9-11 | 16 | 0.07 (0.04, 0.11) | 140 | 0.60 (0.50, 0.70) |
| Metropolitano Central | 9-11 | 17 | 0.11 (0.06, 0.17) | 136 | 0.86 (0.72, 1.00) |
| Metropolitano Norte | 9-11 | 16 | 0.07 (0.04, 0.11) | 147 | 0.62 (0.52, 0.72) |
| Metropolitano Occidente | 9-11 | 28 | 0.09 (0.05, 0.12) | 234 | 0.67 (0.59, 0.76) |
| Metropolitano Oriente | 9-11 | 24 | 0.11 (0.06, 0.15) | 131 | 0.56 (0.46, 0.65) |
| Metropolitano Sur | 9-11 | 38 | 0.15 (0.10, 0.20) | 238 | 0.90 (0.79, 1.01) |
| Metropolitano Sur Oriente | 9-11 | 24 | 0.08 (0.05, 0.12) | 191 | 0.63 (0.54, 0.72) |
| Osorno | 9-11 | 6 | 0.12 (0.02, 0.22) | 54 | 1.05 (0.77, 1.32) |
| Reloncaví | 9-11 | 9 | 0.09 (0.03, 0.15) | 81 | 0.80 (0.62, 0.97) |
| Talcahuano | 9-11 | 25 | 0.38 (0.23, 0.52) | 132 | 1.87 (1.55, 2.18) |
| Valdivia | 9-11 | 4 | 0.05 (0.00, 0.10) | 38 | 0.45 (0.31, 0.59) |
| Valparaíso San Antonio | 9-11 | 15 | 0.16 (0.08, 0.24) | 120 | 1.23 (1.01, 1.45) |
| Viña del Mar Quillota | 9-11 | 47 | 0.22 (0.16, 0.28) | 294 | 1.32 (1.17, 1.48) |
| Ñuble | 9-11 | 39 | 0.41 (0.28, 0.54) | 279 | 2.82 (2.50, 3.15) |
| Aconcagua | 12-14 | 6 | 0.11 (0.02, 0.20) | 38 | 0.67 (0.45, 0.88) |
| Aisén | 12-14 | 6 | 0.24 (0.05, 0.44) | 25 | 0.94 (0.57, 1.31) |
| Antofagasta | 12-14 | 28 | 0.19 (0.12, 0.27) | 170 | 1.09 (0.93, 1.25) |
| Araucanía Norte | 12-14 | 6 | 0.13 (0.03, 0.24) | 21 | 0.44 (0.25, 0.63) |
| Araucanía Sur | 12-14 | 12 | 0.07 (0.03, 0.12) | 94 | 0.57 (0.45, 0.68) |
| Arauco | 12-14 | 5 | 0.14 (0.02, 0.25) | 46 | 1.17 (0.84, 1.51) |
| Arica | 12-14 | 10 | 0.19 (0.07, 0.31) | 44 | 0.80 (0.57, 1.04) |
| Atacama | 12-14 | 3 | 0.04 (0.00, 0.09) | 28 | 0.37 (0.23, 0.51) |
| Biobío | 12-14 | 5 | 0.06 (0.01, 0.11) | 58 | 0.63 (0.47, 0.79) |
| Chiloé | 12-14 | 1 | 0.03 (0.00, 0.08) | 32 | 0.79 (0.52, 1.06) |
| Concepción | 12-14 | 28 | 0.22 (0.14, 0.30) | 155 | 1.14 (0.96, 1.32) |
| Coquimbo | 12-14 | 14 | 0.08 (0.04, 0.13) | 88 | 0.51 (0.40, 0.62) |
| Iquique | 12-14 | 8 | 0.10 (0.03, 0.17) | 52 | 0.58 (0.42, 0.74) |
| Libertador B.O'Higgins | 12-14 | 21 | 0.11 (0.06, 0.15) | 116 | 0.57 (0.47, 0.67) |
| Magallanes | 12-14 | 7 | 0.20 (0.05, 0.35) | 55 | 1.55 (1.15, 1.96) |
| Maule | 12-14 | 16 | 0.07 (0.04, 0.11) | 86 | 0.37 (0.29, 0.45) |
| Metropolitano Central | 12-14 | 5 | 0.03 (0.00, 0.06) | 96 | 0.62 (0.49, 0.74) |
| Metropolitano Norte | 12-14 | 15 | 0.07 (0.03, 0.11) | 78 | 0.35 (0.27, 0.42) |
| Metropolitano Occidente | 12-14 | 25 | 0.08 (0.05, 0.11) | 186 | 0.56 (0.48, 0.64) |
| Metropolitano Oriente | 12-14 | 21 | 0.09 (0.05, 0.14) | 124 | 0.55 (0.45, 0.64) |
| Metropolitano Sur | 12-14 | 18 | 0.07 (0.04, 0.11) | 137 | 0.54 (0.45, 0.63) |
| Metropolitano Sur Oriente | 12-14 | 17 | 0.06 (0.03, 0.09) | 172 | 0.57 (0.49, 0.66) |
| Osorno | 12-14 | 6 | 0.12 (0.02, 0.22) | 27 | 0.53 (0.33, 0.72) |
| Reloncaví | 12-14 | 13 | 0.13 (0.06, 0.21) | 63 | 0.61 (0.46, 0.76) |
| Talcahuano | 12-14 | 11 | 0.17 (0.07, 0.26) | 87 | 1.23 (0.97, 1.49) |
| Valdivia | 12-14 | 3 | 0.04 (0.00, 0.08) | 43 | 0.51 (0.36, 0.66) |
| Valparaíso San Antonio | 12-14 | 16 | 0.18 (0.09, 0.26) | 105 | 1.11 (0.90, 1.32) |
| Viña del Mar Quillota | 12-14 | 31 | 0.15 (0.10, 0.20) | 230 | 1.08 (0.94, 1.22) |
| Ñuble | 12-14 | 34 | 0.35 (0.23, 0.46) | 191 | 1.87 (1.61, 2.13) |
| Aconcagua | 15-18 | 4 | 0.07 (0.00, 0.14) | 22 | 0.36 (0.21, 0.51) |
| Aisén | 15-18 | 5 | 0.19 (0.02, 0.36) | 24 | 0.85 (0.51, 1.19) |
| Antofagasta | 15-18 | 25 | 0.17 (0.10, 0.23) | 120 | 0.76 (0.62, 0.89) |
| Araucanía Norte | 15-18 | 1 | 0.02 (0.00, 0.06) | 17 | 0.34 (0.18, 0.51) |
| Araucanía Sur | 15-18 | 7 | 0.04 (0.01, 0.07) | 74 | 0.42 (0.32, 0.51) |
| Arauco | 15-18 | 0 | 0.00 (0.00, 0.00) | 21 | 0.50 (0.29, 0.71) |
| Arica | 15-18 | 4 | 0.07 (0.00, 0.14) | 35 | 0.61 (0.41, 0.81) |
| Atacama | 15-18 | 3 | 0.04 (0.00, 0.09) | 23 | 0.30 (0.18, 0.42) |
| Biobío | 15-18 | 6 | 0.07 (0.01, 0.12) | 51 | 0.52 (0.38, 0.66) |

| | | | | | |
|---|---|---|---|---|---|
| Chiloé | 15-18 | 1 | 0.02 (0.00, 0.07) | 14 | 0.31 (0.15, 0.47) |
| Concepción | 15-18 | 23 | 0.17 (0.10, 0.24) | 111 | 0.76 (0.62, 0.91) |
| Coquimbo | 15-18 | 10 | 0.06 (0.02, 0.10) | 63 | 0.35 (0.26, 0.43) |
| Iquique | 15-18 | 2 | 0.02 (0.00, 0.06) | 44 | 0.48 (0.34, 0.62) |
| Libertador B.O'Higgins | 15-18 | 16 | 0.08 (0.04, 0.12) | 72 | 0.33 (0.25, 0.40) |
| Magallanes | 15-18 | 14 | 0.38 (0.18, 0.57) | 43 | 1.06 (0.74, 1.37) |
| Maule | 15-18 | 14 | 0.06 (0.03, 0.09) | 51 | 0.21 (0.15, 0.27) |
| Metropolitano Central | 15-18 | 11 | 0.07 (0.03, 0.11) | 67 | 0.40 (0.30, 0.49) |
| Metropolitano Norte | 15-18 | 11 | 0.05 (0.02, 0.08) | 62 | 0.26 (0.19, 0.32) |
| Metropolitano Occidente | 15-18 | 14 | 0.04 (0.02, 0.07) | 122 | 0.35 (0.29, 0.42) |
| Metropolitano Oriente | 15-18 | 9 | 0.04 (0.01, 0.06) | 65 | 0.26 (0.20, 0.32) |
| Metropolitano Sur | 15-18 | 9 | 0.04 (0.01, 0.06) | 86 | 0.33 (0.26, 0.40) |
| Metropolitano Sur Oriente | 15-18 | 15 | 0.05 (0.02, 0.07) | 131 | 0.40 (0.33, 0.47) |
| Osorno | 15-18 | 2 | 0.04 (0.00, 0.09) | 24 | 0.43 (0.26, 0.60) |
| Reloncaví | 15-18 | 2 | 0.02 (0.00, 0.05) | 52 | 0.47 (0.34, 0.59) |
| Talcahuano | 15-18 | 8 | 0.12 (0.04, 0.19) | 42 | 0.56 (0.39, 0.74) |
| Valdivia | 15-18 | 1 | 0.01 (0.00, 0.04) | 35 | 0.39 (0.26, 0.52) |
| Valparaíso San Antonio | 15-18 | 11 | 0.11 (0.05, 0.18) | 91 | 0.87 (0.69, 1.04) |
| Viña del Mar Quillota | 15-18 | 35 | 0.16 (0.11, 0.22) | 172 | 0.73 (0.62, 0.84) |
| Ñuble | 15-18 | 27 | 0.26 (0.16, 0.36) | 113 | 1.02 (0.83, 1.21) |

Table 6: Count and prevalence of ADHD cases by health service and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| Health service | Age band | ADHD cases | Prevalence % (95% CI) | ADHD cases | Prevalence % (95% CI) |
| Aconcagua | 6-8 | 56 | 0.99 (0.74, 1.25) | 71 | 1.19 (0.91, 1.46) |
| Aisén | 6-8 | 12 | 0.54 (0.23, 0.84) | 38 | 1.67 (1.14, 2.20) |
| Antofagasta | 6-8 | 66 | 0.48 (0.36, 0.59) | 106 | 0.73 (0.59, 0.87) |
| Araucanía Norte | 6-8 | 24 | 0.57 (0.34, 0.79) | 52 | 1.13 (0.82, 1.43) |
| Araucanía Sur | 6-8 | 99 | 0.63 (0.51, 0.76) | 206 | 1.27 (1.10, 1.45) |
| Arauco | 6-8 | 20 | 0.53 (0.30, 0.76) | 49 | 1.31 (0.94, 1.67) |
| Arica | 6-8 | 17 | 0.32 (0.17, 0.47) | 46 | 0.80 (0.57, 1.03) |
| Atacama | 6-8 | 7 | 0.10 (0.03, 0.18) | 20 | 0.28 (0.16, 0.41) |
| Biobío | 6-8 | 79 | 0.95 (0.74, 1.16) | 133 | 1.54 (1.28, 1.79) |
| Chiloé | 6-8 | 28 | 0.85 (0.54, 1.16) | 66 | 1.86 (1.42, 2.31) |
| Concepción | 6-8 | 101 | 0.77 (0.62, 0.92) | 162 | 1.20 (1.02, 1.38) |
| Coquimbo | 6-8 | 105 | 0.61 (0.50, 0.73) | 234 | 1.29 (1.12, 1.45) |
| Iquique | 6-8 | 35 | 0.42 (0.28, 0.56) | 96 | 1.07 (0.85, 1.28) |
| Libertador B.O'Higgins | 6-8 | 124 | 0.65 (0.54, 0.77) | 252 | 1.27 (1.11, 1.42) |
| Magallanes | 6-8 | 17 | 0.55 (0.29, 0.81) | 57 | 1.77 (1.31, 2.22) |
| Maule | 6-8 | 69 | 0.31 (0.24, 0.39) | 182 | 0.79 (0.68, 0.91) |
| Metropolitano Central | 6-8 | 87 | 0.62 (0.49, 0.75) | 173 | 1.14 (0.97, 1.31) |
| Metropolitano Norte | 6-8 | 114 | 0.53 (0.43, 0.62) | 218 | 0.96 (0.84, 1.09) |
| Metropolitano Occidente | 6-8 | 167 | 0.43 (0.37, 0.50) | 296 | 0.74 (0.66, 0.82) |
| Metropolitano Oriente | 6-8 | 116 | 0.52 (0.43, 0.62) | 203 | 0.90 (0.78, 1.02) |
| Metropolitano Sur | 6-8 | 131 | 0.55 (0.45, 0.64) | 240 | 0.95 (0.83, 1.07) |
| Metropolitano Sur Oriente | 6-8 | 189 | 0.69 (0.59, 0.79) | 355 | 1.22 (1.10, 1.35) |
| Osorno | 6-8 | 16 | 0.36 (0.18, 0.53) | 32 | 0.68 (0.44, 0.91) |
| Reloncaví | 6-8 | 41 | 0.45 (0.31, 0.59) | 76 | 0.81 (0.63, 0.99) |
| Talcahuano | 6-8 | 62 | 0.99 (0.74, 1.23) | 110 | 1.67 (1.36, 1.98) |

| | | | | | |
|---|---|---|---|---|---|
| Valdivia | 6-8 | 41 | 0.54 (0.38, 0.71) | 102 | 1.29 (1.04, 1.54) |
| Valparaíso San Antonio | 6-8 | 33 | 0.35 (0.23, 0.47) | 88 | 0.90 (0.72, 1.09) |
| Viña del Mar Quillota | 6-8 | 79 | 0.38 (0.30, 0.47) | 171 | 0.80 (0.68, 0.92) |
| Ñuble | 6-8 | 57 | 0.63 (0.46, 0.79) | 110 | 1.16 (0.94, 1.37) |
| Aconcagua | 9-11 | 144 | 2.45 (2.06, 2.85) | 246 | 3.98 (3.49, 4.47) |
| Aisén | 9-11 | 38 | 1.60 (1.10, 2.11) | 94 | 3.79 (3.04, 4.55) |
| Antofagasta | 9-11 | 143 | 0.97 (0.81, 1.12) | 275 | 1.76 (1.56, 1.97) |
| Araucanía Norte | 9-11 | 34 | 0.78 (0.52, 1.04) | 130 | 2.85 (2.37, 3.33) |
| Araucanía Sur | 9-11 | 240 | 1.48 (1.29, 1.66) | 487 | 2.87 (2.62, 3.12) |
| Arauco | 9-11 | 47 | 1.21 (0.86, 1.55) | 107 | 2.64 (2.15, 3.13) |
| Arica | 9-11 | 60 | 1.07 (0.80, 1.34) | 118 | 1.97 (1.62, 2.32) |
| Atacama | 9-11 | 28 | 0.37 (0.24, 0.51) | 62 | 0.81 (0.61, 1.01) |
| Biobío | 9-11 | 175 | 2.03 (1.73, 2.32) | 329 | 3.67 (3.28, 4.06) |
| Chiloé | 9-11 | 83 | 2.31 (1.82, 2.80) | 183 | 4.76 (4.09, 5.43) |
| Concepción | 9-11 | 333 | 2.41 (2.16, 2.67) | 633 | 4.37 (4.03, 4.70) |
| Coquimbo | 9-11 | 321 | 1.76 (1.57, 1.96) | 545 | 2.93 (2.68, 3.17) |
| Iquique | 9-11 | 108 | 1.25 (1.02, 1.48) | 245 | 2.62 (2.30, 2.95) |
| Libertador B.O'Higgins | 9-11 | 318 | 1.60 (1.43, 1.78) | 650 | 3.11 (2.88, 3.35) |
| Magallanes | 9-11 | 83 | 2.39 (1.89, 2.90) | 167 | 4.82 (4.11, 5.54) |
| Maule | 9-11 | 227 | 1.03 (0.90, 1.17) | 567 | 2.43 (2.24, 2.63) |
| Metropolitano Central | 9-11 | 198 | 1.34 (1.15, 1.52) | 430 | 2.72 (2.47, 2.97) |
| Metropolitano Norte | 9-11 | 299 | 1.36 (1.20, 1.51) | 507 | 2.15 (1.96, 2.33) |
| Metropolitano Occidente | 9-11 | 372 | 1.14 (1.02, 1.25) | 713 | 2.05 (1.90, 2.20) |
| Metropolitano Oriente | 9-11 | 238 | 1.06 (0.93, 1.20) | 478 | 2.03 (1.85, 2.21) |
| Metropolitano Sur | 9-11 | 386 | 1.54 (1.39, 1.70) | 656 | 2.48 (2.29, 2.67) |
| Metropolitano Sur Oriente | 9-11 | 446 | 1.56 (1.41, 1.70) | 813 | 2.70 (2.52, 2.88) |
| Osorno | 9-11 | 40 | 0.81 (0.56, 1.06) | 95 | 1.84 (1.48, 2.21) |
| Reloncaví | 9-11 | 80 | 0.83 (0.65, 1.01) | 201 | 1.97 (1.70, 2.24) |
| Talcahuano | 9-11 | 200 | 3.02 (2.60, 3.43) | 316 | 4.47 (3.99, 4.95) |
| Valdivia | 9-11 | 81 | 0.99 (0.77, 1.20) | 179 | 2.12 (1.81, 2.42) |
| Valparaíso San Antonio | 9-11 | 99 | 1.05 (0.84, 1.25) | 200 | 2.05 (1.77, 2.33) |
| Viña del Mar Quillota | 9-11 | 231 | 1.09 (0.95, 1.23) | 531 | 2.39 (2.19, 2.59) |
| Ñuble | 9-11 | 175 | 1.83 (1.57, 2.10) | 365 | 3.70 (3.32, 4.07) |
| Aconcagua | 12-14 | 84 | 1.52 (1.20, 1.84) | 187 | 3.27 (2.81, 3.74) |
| Aisén | 12-14 | 39 | 1.58 (1.09, 2.07) | 112 | 4.22 (3.45, 4.98) |
| Antofagasta | 12-14 | 94 | 0.65 (0.52, 0.78) | 248 | 1.59 (1.40, 1.79) |
| Araucanía Norte | 12-14 | 44 | 0.97 (0.68, 1.25) | 118 | 2.48 (2.04, 2.92) |
| Araucanía Sur | 12-14 | 153 | 0.95 (0.80, 1.10) | 389 | 2.34 (2.11, 2.57) |
| Arauco | 12-14 | 33 | 0.89 (0.59, 1.19) | 118 | 3.01 (2.48, 3.55) |
| Arica | 12-14 | 35 | 0.67 (0.45, 0.89) | 136 | 2.48 (2.07, 2.89) |
| Atacama | 12-14 | 31 | 0.43 (0.28, 0.58) | 59 | 0.78 (0.58, 0.98) |
| Biobío | 12-14 | 140 | 1.61 (1.35, 1.87) | 358 | 3.90 (3.50, 4.30) |
| Chiloé | 12-14 | 95 | 2.49 (1.99, 2.98) | 209 | 5.15 (4.47, 5.83) |
| Concepción | 12-14 | 374 | 2.91 (2.62, 3.20) | 641 | 4.72 (4.36, 5.08) |
| Coquimbo | 12-14 | 286 | 1.71 (1.52, 1.91) | 565 | 3.27 (3.01, 3.54) |
| Iquique | 12-14 | 100 | 1.22 (0.98, 1.46) | 209 | 2.33 (2.02, 2.65) |
| Libertador B.O'Higgins | 12-14 | 263 | 1.35 (1.19, 1.51) | 633 | 3.11 (2.87, 3.35) |
| Magallanes | 12-14 | 81 | 2.35 (1.84, 2.86) | 178 | 5.02 (4.30, 5.74) |
| Maule | 12-14 | 197 | 0.89 (0.77, 1.02) | 544 | 2.36 (2.16, 2.56) |
| Metropolitano Central | 12-14 | 171 | 1.16 (0.99, 1.33) | 400 | 2.57 (2.32, 2.82) |
| Metropolitano Norte | 12-14 | 270 | 1.26 (1.11, 1.41) | 518 | 2.29 (2.10, 2.49) |
| Metropolitano Occidente | 12-14 | 278 | 0.89 (0.78, 0.99) | 597 | 1.80 (1.65, 1.94) |
| Metropolitano Oriente | 12-14 | 212 | 0.96 (0.83, 1.09) | 460 | 2.03 (1.84, 2.21) |

| | | | | | |
|---|---|---|---|---|---|
| Metropolitano Sur | 12-14 | 283 | 1.17 (1.04, 1.31) | 557 | 2.18 (2.00, 2.36) |
| Metropolitano Sur Oriente | 12-14 | 378 | 1.33 (1.19, 1.46) | 687 | 2.29 (2.13, 2.46) |
| Osorno | 12-14 | 30 | 0.60 (0.39, 0.82) | 106 | 2.07 (1.68, 2.46) |
| Reloncaví | 12-14 | 64 | 0.66 (0.50, 0.82) | 156 | 1.52 (1.28, 1.76) |
| Talcahuano | 12-14 | 173 | 2.60 (2.22, 2.98) | 367 | 5.19 (4.67, 5.70) |
| Valdivia | 12-14 | 52 | 0.64 (0.47, 0.81) | 139 | 1.65 (1.38, 1.92) |
| Valparaíso San Antonio | 12-14 | 76 | 0.84 (0.65, 1.03) | 216 | 2.28 (1.98, 2.58) |
| Viña del Mar Quillota | 12-14 | 183 | 0.88 (0.75, 1.01) | 432 | 2.02 (1.83, 2.21) |
| Ñuble | 12-14 | 166 | 1.70 (1.44, 1.95) | 375 | 3.67 (3.31, 4.04) |
| Aconcagua | 15-18 | 58 | 0.99 (0.74, 1.24) | 128 | 2.11 (1.75, 2.47) |
| Aisén | 15-18 | 35 | 1.35 (0.91, 1.80) | 76 | 2.70 (2.10, 3.30) |
| Antofagasta | 15-18 | 72 | 0.48 (0.37, 0.60) | 191 | 1.21 (1.04, 1.38) |
| Araucanía Norte | 15-18 | 34 | 0.74 (0.49, 0.98) | 53 | 1.07 (0.79, 1.36) |
| Araucanía Sur | 15-18 | 98 | 0.58 (0.47, 0.70) | 208 | 1.17 (1.01, 1.33) |
| Arauco | 15-18 | 37 | 0.92 (0.63, 1.22) | 103 | 2.44 (1.98, 2.91) |
| Arica | 15-18 | 30 | 0.55 (0.35, 0.74) | 66 | 1.14 (0.87, 1.42) |
| Atacama | 15-18 | 22 | 0.31 (0.18, 0.43) | 60 | 0.78 (0.58, 0.97) |
| Biobío | 15-18 | 128 | 1.40 (1.16, 1.64) | 278 | 2.83 (2.50, 3.16) |
| Chiloé | 15-18 | 84 | 2.00 (1.58, 2.42) | 167 | 3.67 (3.13, 4.22) |
| Concepción | 15-18 | 373 | 2.74 (2.46, 3.01) | 605 | 4.16 (3.84, 4.49) |
| Coquimbo | 15-18 | 231 | 1.36 (1.19, 1.54) | 508 | 2.79 (2.55, 3.03) |
| Iquique | 15-18 | 72 | 0.85 (0.66, 1.05) | 179 | 1.96 (1.68, 2.25) |
| Libertador B.O'Higgins | 15-18 | 178 | 0.89 (0.76, 1.02) | 366 | 1.67 (1.50, 1.84) |
| Magallanes | 15-18 | 80 | 2.15 (1.69, 2.62) | 198 | 4.87 (4.21, 5.53) |
| Maule | 15-18 | 99 | 0.44 (0.35, 0.52) | 291 | 1.19 (1.05, 1.32) |
| Metropolitano Central | 15-18 | 139 | 0.89 (0.74, 1.03) | 272 | 1.61 (1.42, 1.80) |
| Metropolitano Norte | 15-18 | 256 | 1.15 (1.01, 1.29) | 370 | 1.55 (1.39, 1.70) |
| Metropolitano Occidente | 15-18 | 189 | 0.59 (0.51, 0.67) | 418 | 1.21 (1.09, 1.32) |
| Metropolitano Oriente | 15-18 | 187 | 0.79 (0.67, 0.90) | 342 | 1.36 (1.22, 1.50) |
| Metropolitano Sur | 15-18 | 203 | 0.83 (0.71, 0.94) | 406 | 1.55 (1.40, 1.70) |
| Metropolitano Sur Oriente | 15-18 | 292 | 0.95 (0.84, 1.06) | 538 | 1.65 (1.51, 1.79) |
| Osorno | 15-18 | 31 | 0.59 (0.38, 0.80) | 71 | 1.26 (0.97, 1.55) |
| Reloncaví | 15-18 | 45 | 0.44 (0.31, 0.56) | 152 | 1.36 (1.15, 1.58) |
| Talcahuano | 15-18 | 162 | 2.33 (1.98, 2.69) | 289 | 3.89 (3.45, 4.33) |
| Valdivia | 15-18 | 32 | 0.38 (0.25, 0.51) | 87 | 0.96 (0.76, 1.16) |
| Valparaíso San Antonio | 15-18 | 59 | 0.61 (0.45, 0.76) | 161 | 1.53 (1.30, 1.77) |
| Viña del Mar Quillota | 15-18 | 105 | 0.49 (0.40, 0.58) | 292 | 1.24 (1.10, 1.38) |
| Ñuble | 15-18 | 144 | 1.40 (1.17, 1.63) | 290 | 2.62 (2.33, 2.92) |

For school fees, which are used here as a proxy for SES, autism prevalence is highest among students that receive free or low fee education, though the sample size for students that pay $1,000-$10,000 monthly is very small, see Table 7, Figure 11 and Supplementary Figure 55. ADHD prevalence is more consistent across school fee levels, except for the $1,000-$10,000 band which has low prevalence and very few cases, see Table 8, Figure 12 and Supplementary Figure 56. Prevalence is higher among older students for higher fee bands. For both autism and ADHD, prevalence is very low among students paying more than $100,000 monthly, suggesting students from wealthier families may not be accessing SEED or may not be eligible for it due to attending private schools.

Autism prevalence and distribution by age is very similar between Mapuche and non-Indigenous students in the Araucanía, Aysén, Biobío, Los Lagos, Los Rios, Magallanes and Región Metropolitana de Santiago regions, as shown in Table 9, Figure 13 and Supplementary Figure 57. ADHD prevalence is also consistent across Mapuche and non-Indigenous students, see Table 10, Figure 14 and Supplementary Figure 58. Among students of other Indigenous groups, autism and ADHD prevalence appear to peak in older age groups,

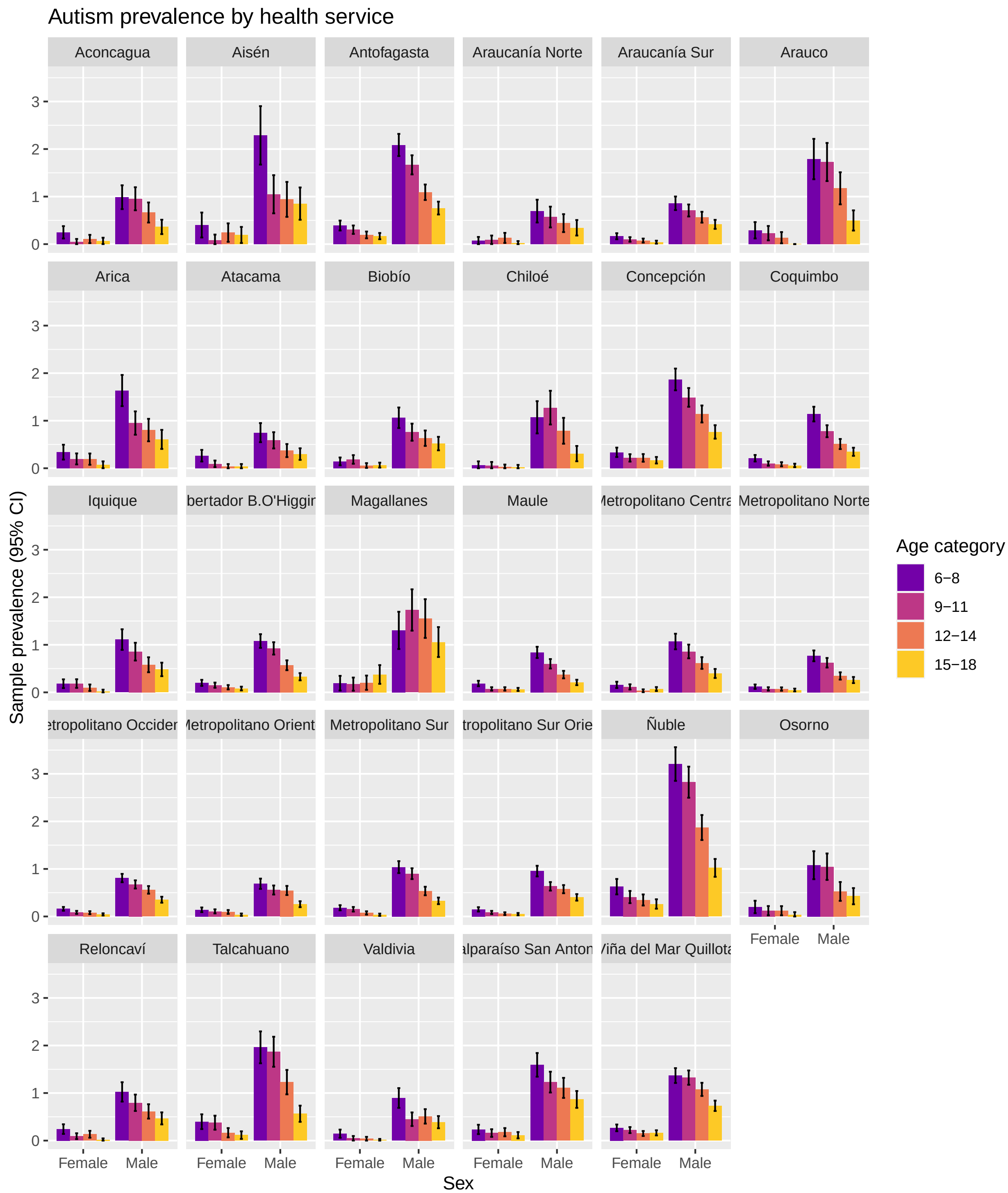



Figure 9: Sample prevalence of autism by health service, age band and sex. Bars show 95% normal confidence intervals.

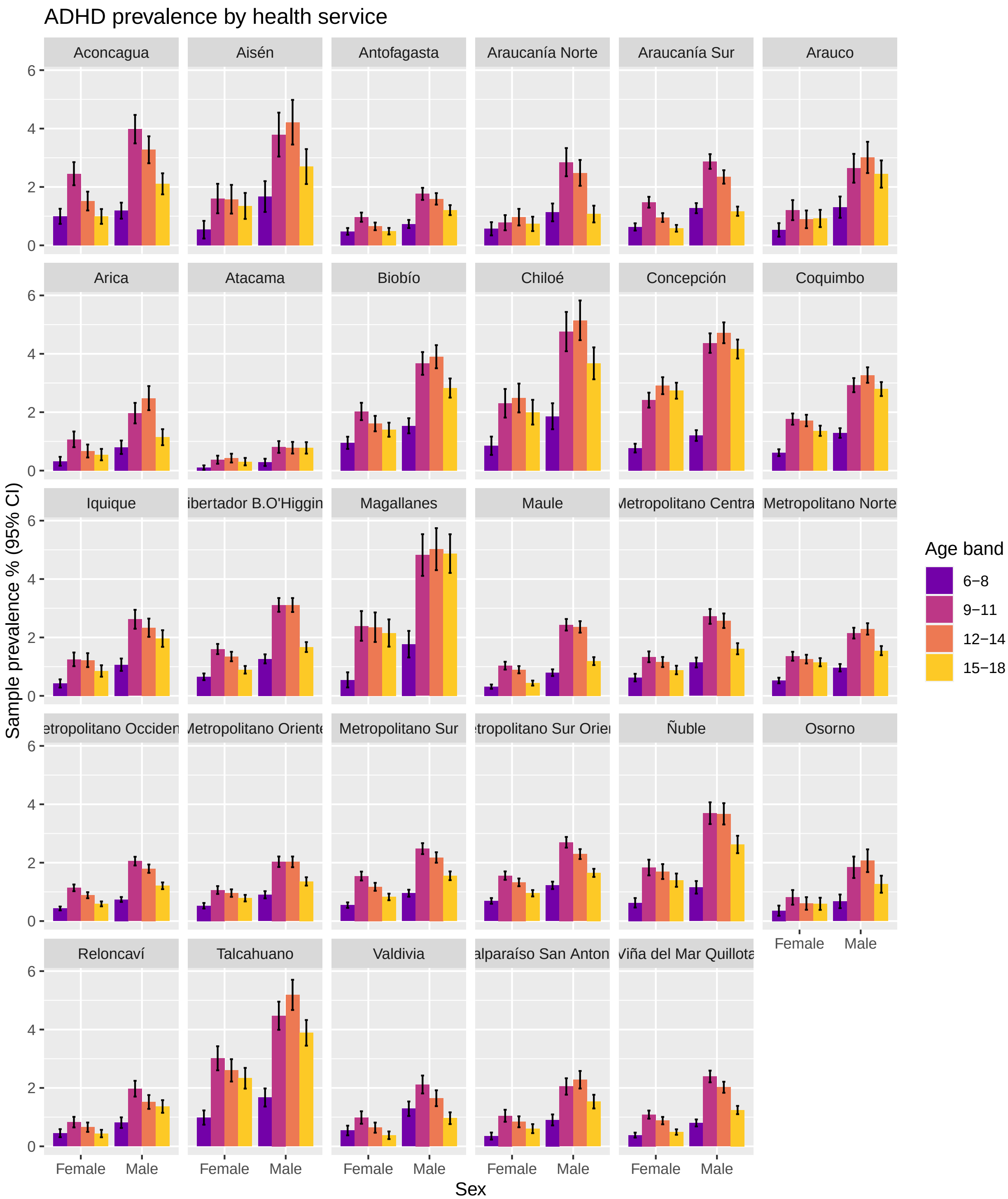



Figure 10: Sample prevalence of ADHD by health service, age band and sex. Bars show 95% normal confidence intervals.

Table 7: Count and prevalence of Autism cases by school fee and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| School fee | Age band | Autism cases | Prevalence % (95% CI) | Autism cases | Prevalence % (95% CI) |
| Free | 6-8 | 655 | 0.25 (0.23, 0.27) | 3799 | 1.37 (1.33, 1.42) |
| $1,000-$10,000 | 6-8 | 0 | 0.00 (0.00, 0.00) | 2 | 1.17 (0.00, 2.78) |
| $10,001-$25,000 | 6-8 | 5 | 0.11 (0.01, 0.20) | 20 | 0.44 (0.25, 0.64) |
| $25,001-$50,000 | 6-8 | 37 | 0.14 (0.10, 0.19) | 168 | 0.70 (0.59, 0.80) |
| $50,001-$100,000 | 6-8 | 53 | 0.17 (0.13, 0.22) | 296 | 0.94 (0.83, 1.04) |
| $100,001+ | 6-8 | 8 | 0.02 (0.01, 0.04) | 30 | 0.08 (0.05, 0.11) |
| No information | 6-8 | 16 | 0.23 (0.12, 0.35) | 73 | 0.92 (0.71, 1.13) |
| Free | 9-11 | 434 | 0.16 (0.15, 0.18) | 3147 | 1.10 (1.06, 1.14) |
| $1,000-$10,000 | 9-11 | 0 | 0.00 (0.00, 0.00) | 2 | 1.59 (0.00, 3.77) |
| $10,001-$25,000 | 9-11 | 1 | 0.02 (0.00, 0.06) | 23 | 0.52 (0.31, 0.73) |
| $25,001-$50,000 | 9-11 | 26 | 0.10 (0.06, 0.14) | 152 | 0.61 (0.52, 0.71) |
| $50,001-$100,000 | 9-11 | 45 | 0.14 (0.10, 0.18) | 255 | 0.77 (0.67, 0.86) |
| $100,001+ | 9-11 | 6 | 0.02 (0.00, 0.03) | 35 | 0.09 (0.06, 0.12) |
| No information | 9-11 | 11 | 0.19 (0.08, 0.30) | 75 | 1.11 (0.86, 1.36) |
| Free | 12-14 | 332 | 0.13 (0.11, 0.14) | 2246 | 0.81 (0.77, 0.84) |
| $1,000-$10,000 | 12-14 | 0 | 0.00 (0.00, 0.00) | 4 | 3.67 (0.14, 7.20) |
| $10,001-$25,000 | 12-14 | 2 | 0.04 (0.00, 0.10) | 9 | 0.21 (0.07, 0.34) |
| $25,001-$50,000 | 12-14 | 21 | 0.08 (0.04, 0.11) | 126 | 0.53 (0.44, 0.63) |
| $50,001-$100,000 | 12-14 | 25 | 0.08 (0.05, 0.11) | 195 | 0.56 (0.48, 0.64) |
| $100,001+ | 12-14 | 4 | 0.01 (0.00, 0.02) | 31 | 0.09 (0.06, 0.12) |
| No information | 12-14 | 7 | 0.14 (0.04, 0.25) | 36 | 0.60 (0.41, 0.80) |
| Free | 15-18 | 236 | 0.09 (0.08, 0.10) | 1547 | 0.53 (0.50, 0.55) |
| $1,000-$10,000 | 15-18 | 0 | 0.00 (0.00, 0.00) | 0 | 0.00 (0.00, 0.00) |
| $10,001-$25,000 | 15-18 | 3 | 0.06 (0.00, 0.13) | 10 | 0.23 (0.09, 0.37) |
| $25,001-$50,000 | 15-18 | 16 | 0.05 (0.03, 0.08) | 82 | 0.31 (0.24, 0.38) |
| $50,001-$100,000 | 15-18 | 29 | 0.08 (0.05, 0.11) | 153 | 0.40 (0.33, 0.46) |
| $100,001+ | 15-18 | 2 | 0.01 (0.00, 0.01) | 25 | 0.06 (0.04, 0.09) |
| No information | 15-18 | 4 | 0.08 (0.00, 0.16) | 30 | 0.44 (0.29, 0.60) |

Table 8: Count and prevalence of ADHD cases by school fee and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| School fee | Age band | ADHD cases | Prevalence % (95% CI) | ADHD cases | Prevalence % (95% CI) |
| Free | 6-8 | 1543 | 0.59 (0.56, 0.62) | 3117 | 1.13 (1.09, 1.17) |
| $1,000-$10,000 | 6-8 | 0 | 0.00 (0.00, 0.00) | 1 | 0.58 (0.00, 1.73) |
| $10,001-$25,000 | 6-8 | 32 | 0.70 (0.46, 0.94) | 32 | 0.71 (0.46, 0.95) |
| $25,001-$50,000 | 6-8 | 167 | 0.65 (0.55, 0.75) | 267 | 1.11 (0.97, 1.24) |
| $50,001-$100,000 | 6-8 | 200 | 0.65 (0.56, 0.74) | 437 | 1.38 (1.26, 1.51) |
| $100,001+ | 6-8 | 20 | 0.05 (0.03, 0.07) | 32 | 0.08 (0.06, 0.11) |
| No information | 6-8 | 30 | 0.44 (0.28, 0.59) | 58 | 0.73 (0.54, 0.92) |
| Free | 9-11 | 4061 | 1.52 (1.47, 1.57) | 8323 | 2.91 (2.85, 2.97) |
| $1,000-$10,000 | 9-11 | 0 | 0.00 (0.00, 0.00) | 0 | 0.00 (0.00, 0.00) |
| $10,001-$25,000 | 9-11 | 47 | 1.01 (0.72, 1.29) | 102 | 2.29 (1.85, 2.73) |
| $25,001-$50,000 | 9-11 | 417 | 1.58 (1.43, 1.73) | 616 | 2.49 (2.29, 2.68) |
| $50,001-$100,000 | 9-11 | 567 | 1.76 (1.62, 1.91) | 1024 | 3.08 (2.89, 3.26) |
| $100,001+ | 9-11 | 62 | 0.17 (0.12, 0.21) | 112 | 0.30 (0.24, 0.35) |
| No information | 9-11 | 73 | 1.26 (0.97, 1.54) | 145 | 2.15 (1.80, 2.50) |
| Free | 12-14 | 3342 | 1.28 (1.24, 1.33) | 7634 | 2.74 (2.68, 2.80) |
| $1,000-$10,000 | 12-14 | 0 | 0.00 (0.00, 0.00) | 0 | 0.00 (0.00, 0.00) |
| $10,001-$25,000 | 12-14 | 48 | 1.02 (0.74, 1.31) | 79 | 1.80 (1.41, 2.20) |
| $25,001-$50,000 | 12-14 | 364 | 1.36 (1.22, 1.50) | 638 | 2.70 (2.49, 2.90) |
| $50,001-$100,000 | 12-14 | 509 | 1.55 (1.42, 1.68) | 1083 | 3.12 (2.94, 3.30) |
| $100,001+ | 12-14 | 72 | 0.20 (0.15, 0.24) | 147 | 0.41 (0.34, 0.47) |
| No information | 12-14 | 50 | 1.03 (0.74, 1.31) | 133 | 2.23 (1.85, 2.60) |
| Free | 15-18 | 2579 | 0.97 (0.93, 1.00) | 5529 | 1.88 (1.83, 1.93) |
| $1,000-$10,000 | 15-18 | 0 | 0.00 (0.00, 0.00) | 1 | 0.39 (0.00, 1.14) |
| $10,001-$25,000 | 15-18 | 21 | 0.43 (0.25, 0.62) | 25 | 0.57 (0.35, 0.80) |
| $25,001-$50,000 | 15-18 | 343 | 1.17 (1.04, 1.29) | 482 | 1.84 (1.67, 2.00) |
| $50,001-$100,000 | 15-18 | 416 | 1.12 (1.01, 1.22) | 898 | 2.33 (2.18, 2.48) |
| $100,001+ | 15-18 | 79 | 0.21 (0.16, 0.26) | 151 | 0.39 (0.33, 0.45) |
| No information | 15-18 | 37 | 0.73 (0.50, 0.97) | 79 | 1.17 (0.91, 1.43) |

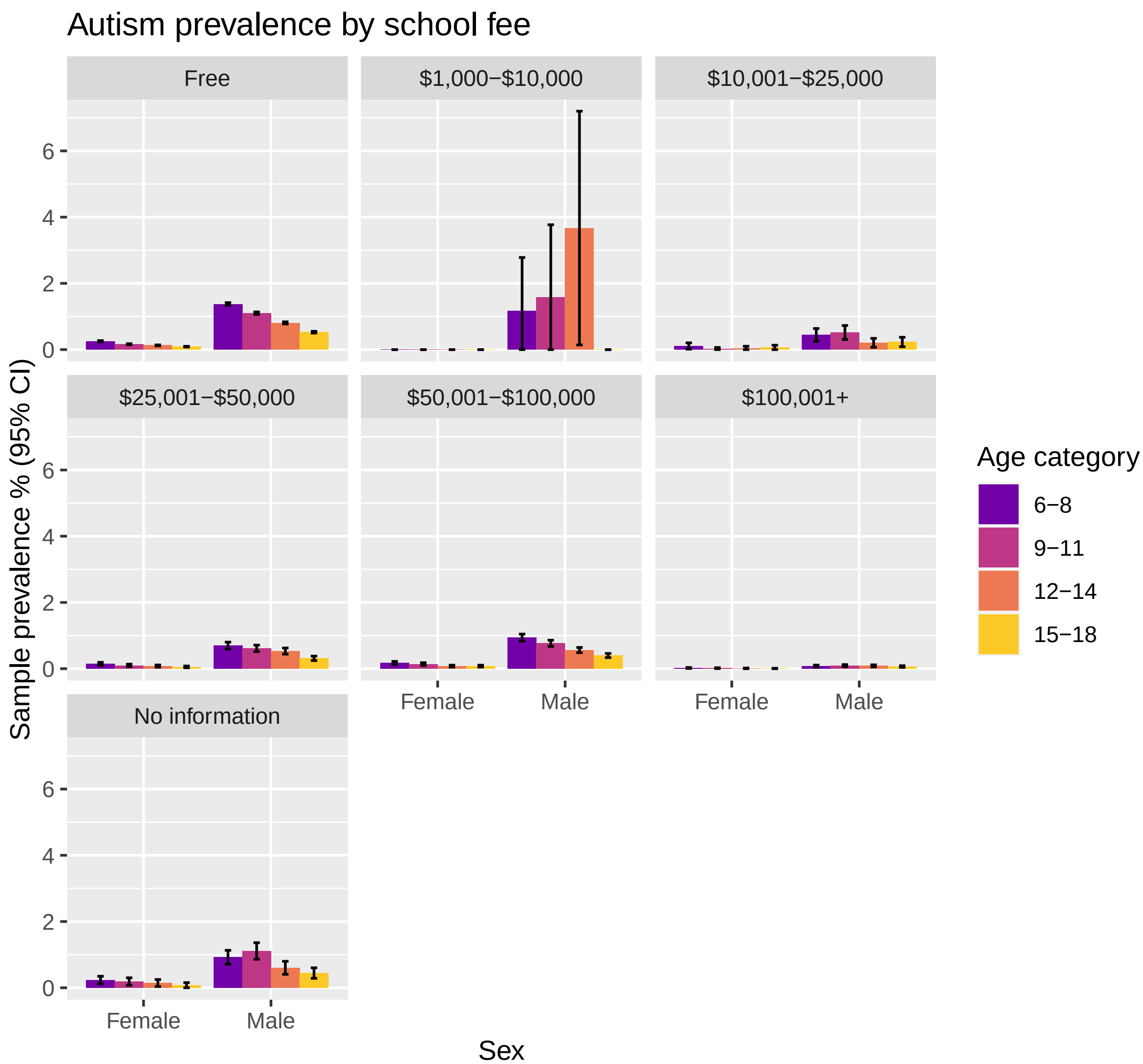



Figure 11: Sample prevalence of autism by student's monthly school fee (Peso), age band and sex. Bars show 95% normal confidence intervals.

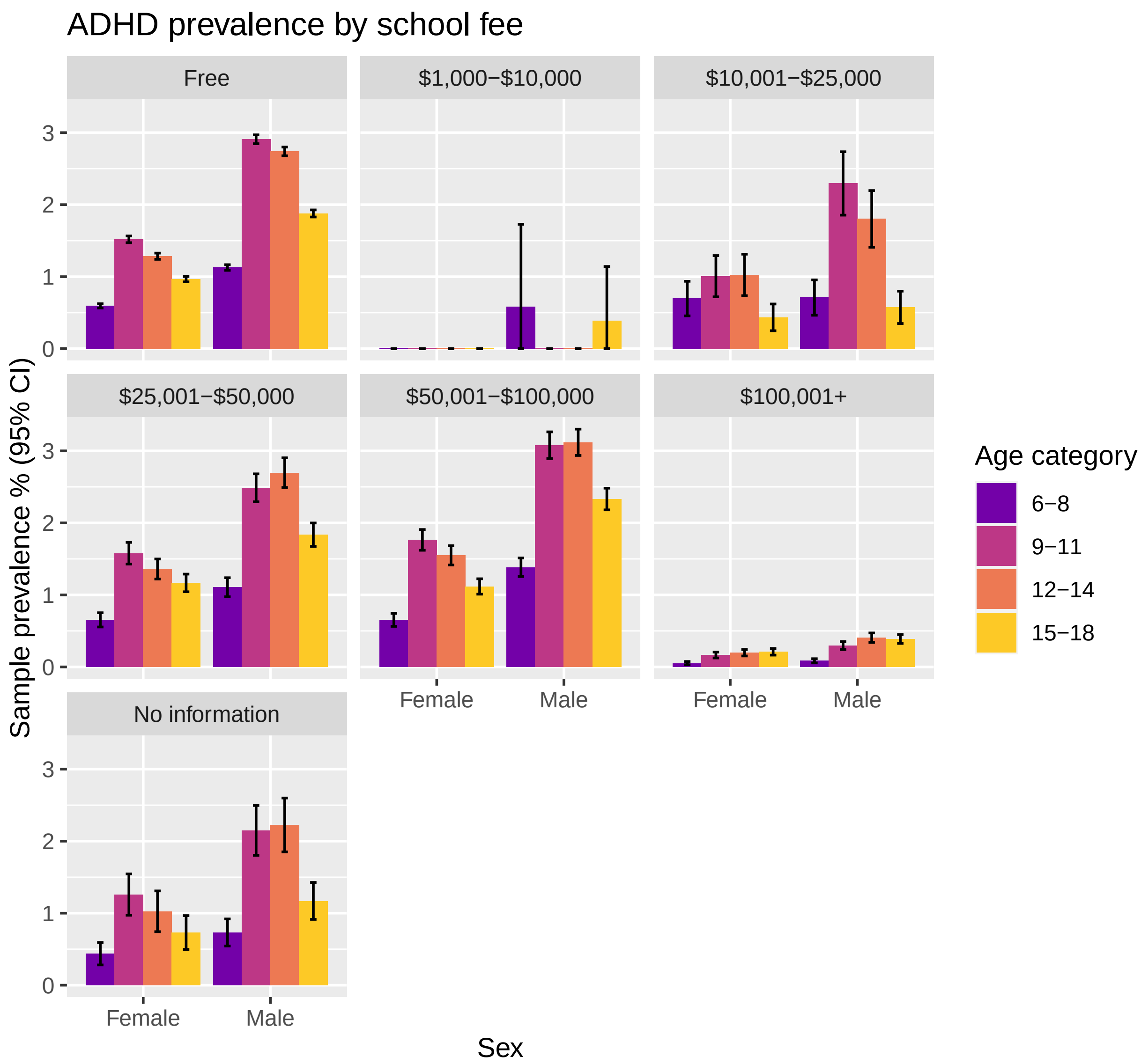



Figure 12: Sample prevalence of ADHD by student's monthly school fee (Peso), age band and sex. Bars show 95% normal confidence intervals.

Table 9: Count and prevalence of Autism cases by ethnicity and age band in Chile school data for females and males with normal confidence intervals. Regions with high Mapuche populations only.

| | | Female | | Male | |
|---|---|---|---|---|---|
| Ethnicity | Age band | Autism cases | Prevalence % (95% CI) | Autism cases | Prevalence % (95% CI) |
| Mapuche | 6-8 | 29 | 0.15 (0.10, 0.20) | 186 | 0.93 (0.80, 1.07) |
| Other Indigenous group | 6-8 | 0 | 0.00 (0.00, 0.00) | 6 | 0.77 (0.16, 1.39) |
| No Indigenous group | 6-8 | 377 | 0.18 (0.16, 0.20) | 2220 | 1.02 (0.98, 1.06) |
| Mapuche | 9-11 | 11 | 0.05 (0.02, 0.09) | 155 | 0.72 (0.61, 0.84) |
| Other Indigenous group | 9-11 | 1 | 0.17 (0.00, 0.50) | 8 | 1.36 (0.42, 2.30) |
| No Indigenous group | 9-11 | 264 | 0.13 (0.11, 0.14) | 1852 | 0.84 (0.80, 0.87) |
| Mapuche | 12-14 | 12 | 0.06 (0.03, 0.09) | 110 | 0.52 (0.42, 0.62) |
| Other Indigenous group | 12-14 | 0 | 0.00 (0.00, 0.00) | 2 | 0.34 (0.00, 0.81) |
| No Indigenous group | 12-14 | 192 | 0.09 (0.08, 0.11) | 1385 | 0.64 (0.61, 0.67) |
| Mapuche | 15-18 | 3 | 0.02 (0.00, 0.03) | 71 | 0.35 (0.27, 0.43) |
| Other Indigenous group | 15-18 | 0 | 0.00 (0.00, 0.00) | 1 | 0.19 (0.00, 0.56) |
| No Indigenous group | 15-18 | 136 | 0.06 (0.05, 0.07) | 969 | 0.41 (0.39, 0.44) |

Table 10: Count and prevalence of ADHD cases by ethnicity and age band in Chile school data for females and males with normal confidence intervals. Regions with high Mapuche populations only.

| | | Female | | Male | |
|---|---|---|---|---|---|
| Ethnicity | Age band | ADHD cases | Prevalence % (95% CI) | ADHD cases | Prevalence % (95% CI) |
| Mapuche | 6-8 | 113 | 0.58 (0.48, 0.69) | 218 | 1.09 (0.95, 1.24) |
| Other Indigenous group | 6-8 | 3 | 0.39 (0.00, 0.84) | 7 | 0.90 (0.24, 1.57) |
| No Indigenous group | 6-8 | 1227 | 0.59 (0.56, 0.62) | 2342 | 1.07 (1.03, 1.12) |
| Mapuche | 9-11 | 253 | 1.24 (1.08, 1.39) | 557 | 2.59 (2.38, 2.81) |
| Other Indigenous group | 9-11 | 7 | 1.19 (0.31, 2.06) | 11 | 1.87 (0.78, 2.97) |
| No Indigenous group | 9-11 | 3113 | 1.48 (1.43, 1.53) | 5950 | 2.68 (2.62, 2.75) |
| Mapuche | 12-14 | 206 | 1.00 (0.87, 1.14) | 479 | 2.26 (2.06, 2.46) |
| Other Indigenous group | 12-14 | 4 | 0.72 (0.02, 1.42) | 15 | 2.54 (1.27, 3.81) |
| No Indigenous group | 12-14 | 2660 | 1.29 (1.24, 1.34) | 5614 | 2.59 (2.52, 2.66) |
| Mapuche | 15-18 | 131 | 0.70 (0.58, 0.81) | 278 | 1.38 (1.22, 1.54) |
| Other Indigenous group | 15-18 | 6 | 1.14 (0.23, 2.05) | 2 | 0.38 (0.00, 0.90) |
| No Indigenous group | 15-18 | 2268 | 1.03 (0.99, 1.08) | 4353 | 1.86 (1.80, 1.91) |

however this result is based on very few cases.

Autism and ADHD are slightly more prevalent for students at rural schools and both follow the same age patterns observed earlier. See Tables 11 and 12, Figures 15 and 16 and Supplementary Figures 59 and 60.

## 4.2 Frequentist prevalence estimation

After using frequentist methods to adjust for the age and sex distribution of the child population of Chile in 2021, the adjusted prevalence of autism was 0.46% (0.46-0.47%) and the adjusted prevalence of ADHD was 1.50% (1.48-1.51%). Among females, the adjusted prevalence of autism was 0.13% (0.13-0.14%) and among males it was 0.79% (0.77-0.80%). Among females, the adjusted prevalence of ADHD was 1.01% (1.00-1.03%) and among males it was 1.97% (1.94-1.99%). As we know the prevalences of autism and ADHD in this data are likely to be underestimates, the age- and sex-adjusted prevalences can be considered a lower bound on the true prevalence of autism and of ADHD in Chile.

Considering school data by health service, shown in Table 13, the adjusted prevalence of autism is much higher in Ñuble at 1.29% (1.21 - 1.37%) than other health services and is low in rural areas such as Araucanía.

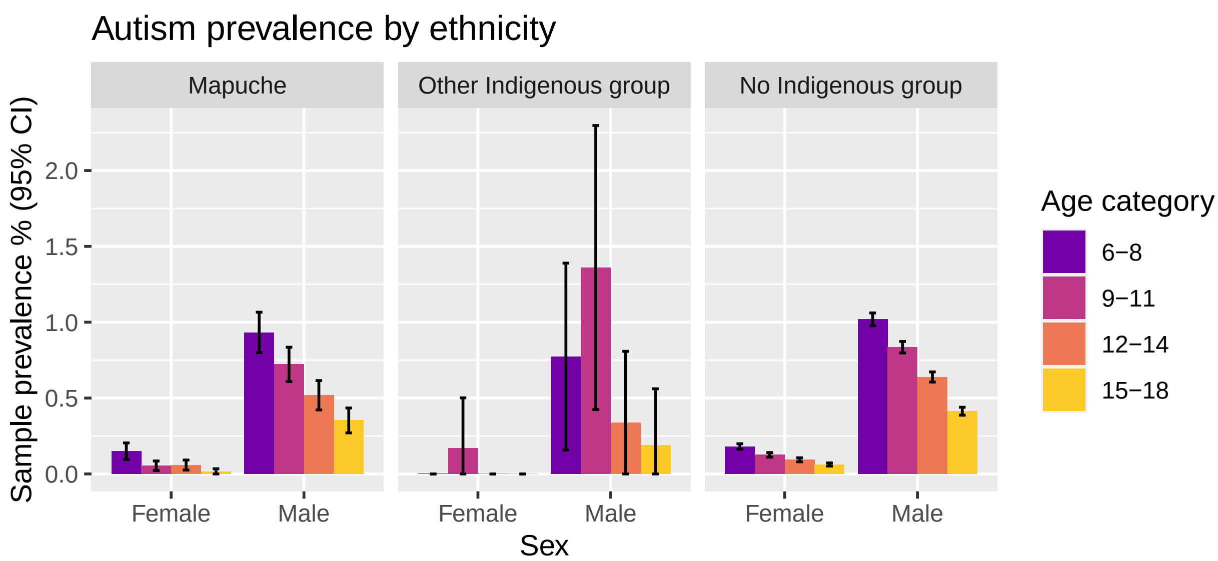



Figure 13: Sample prevalence of autism by ethnicity, age band and sex. Bars show 95% normal confidence intervals. Regions with high Mapuche populations only.

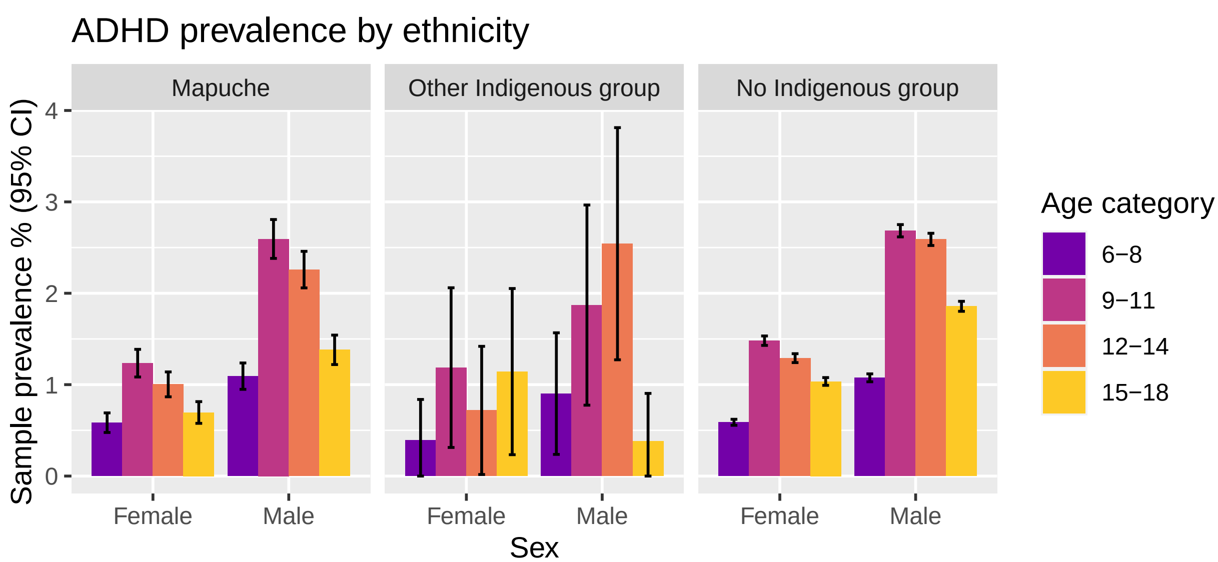



Figure 14: Sample prevalence of ADHD by ethnicity, age band and sex. Bars show 95% normal confidence intervals. Regions with high Mapuche populations only.

Table 11: Count and prevalence of Autism cases by school's rurality and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| School rurality | Age band | Autism cases | Prevalence % (95% CI) | Autism cases | Prevalence % (95% CI) |
| Rural | 6-8 | 93 | 0.26 (0.21, 0.31) | 519 | 1.33 (1.22, 1.45) |
| Urban | 6-8 | 681 | 0.21 (0.19, 0.22) | 3869 | 1.13 (1.09, 1.16) |
| Rural | 9-11 | 61 | 0.16 (0.12, 0.20) | 472 | 1.14 (1.03, 1.24) |
| Urban | 9-11 | 462 | 0.14 (0.12, 0.15) | 3217 | 0.91 (0.88, 0.95) |
| Rural | 12-14 | 44 | 0.16 (0.12, 0.21) | 291 | 0.93 (0.82, 1.03) |
| Urban | 12-14 | 347 | 0.10 (0.09, 0.11) | 2356 | 0.67 (0.64, 0.70) |
| Rural | 15-18 | 9 | 0.08 (0.03, 0.13) | 92 | 0.61 (0.49, 0.73) |
| Urban | 15-18 | 281 | 0.08 (0.07, 0.08) | 1755 | 0.45 (0.42, 0.47) |

Table 12: Count and prevalence of ADHD cases by school's rurality and age band in Chile school data for females and males with normal confidence intervals.

| | | Female | | Male | |
|---|---|---|---|---|---|
| School rurality | Age band | ADHD cases | Prevalence % (95% CI) | ADHD cases | Prevalence % (95% CI) |
| Rural | 6-8 | 221 | 0.62 (0.53, 0.70) | 503 | 1.29 (1.18, 1.40) |
| Urban | 6-8 | 1771 | 0.54 (0.51, 0.56) | 3441 | 1.00 (0.97, 1.03) |
| Rural | 9-11 | 532 | 1.41 (1.29, 1.53) | 1304 | 3.14 (2.97, 3.31) |
| Urban | 9-11 | 4695 | 1.40 (1.36, 1.44) | 9018 | 2.56 (2.51, 2.62) |
| Rural | 12-14 | 323 | 1.21 (1.08, 1.34) | 946 | 3.02 (2.83, 3.21) |
| Urban | 12-14 | 4062 | 1.20 (1.16, 1.23) | 8768 | 2.49 (2.44, 2.54) |
| Rural | 15-18 | 112 | 0.97 (0.79, 1.15) | 287 | 1.90 (1.68, 2.12) |
| Urban | 15-18 | 3363 | 0.91 (0.88, 0.94) | 6878 | 1.74 (1.70, 1.79) |

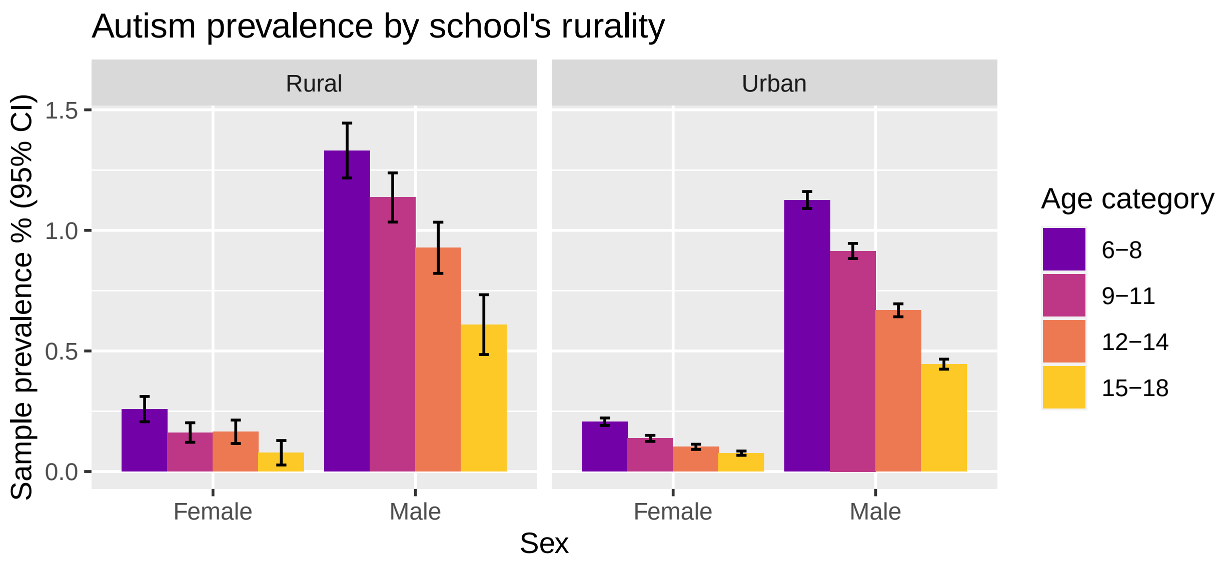



Figure 15: Sample prevalence of autism by school's rurality, age band and sex. Bars show 95% normal confidence intervals.

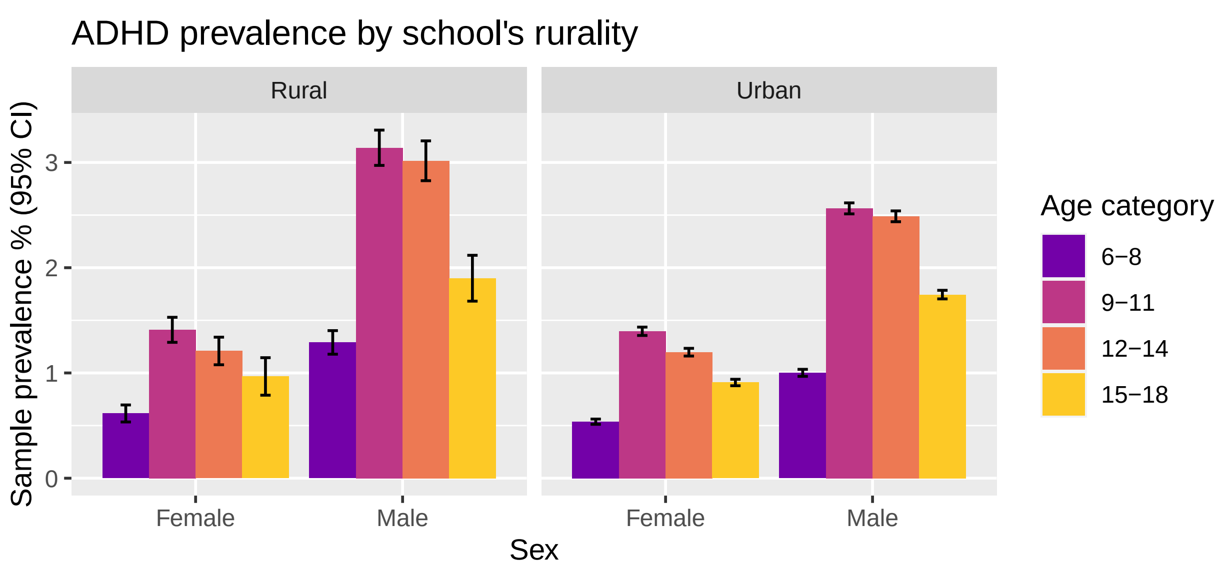



Figure 16: Sample prevalence of ADHD by school's rurality, age band and sex. Bars show 95% normal confidence intervals.

It is also low in the Metropolitano health services which serve Santiago, Chile's largest city. Adjusted ADHD prevalence, shown in Table 14, is medial for Metropolitano health services and very low for Atacama, a fairly urbanised region, at 0.49% (0.43 - 0.56%).

Table 13: Crude and age- and sex-adjusted autism prevalence by health service in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| Health service | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Aconcagua | 0.44 (0.38, 0.50) | 0.43 (0.37, 0.50) |
| Aisén | 0.75 (0.63, 0.87) | 0.75 (0.63, 0.90) |
| Antofagasta | 0.84 (0.79, 0.89) | 0.83 (0.77, 0.88) |
| Araucanía Norte | 0.30 (0.24, 0.36) | 0.30 (0.24, 0.38) |
| Araucanía Sur | 0.37 (0.34, 0.40) | 0.37 (0.34, 0.41) |
| Arauco | 0.73 (0.64, 0.83) | 0.72 (0.62, 0.82) |
| Arica | 0.61 (0.54, 0.68) | 0.61 (0.54, 0.70) |
| Atacama | 0.31 (0.26, 0.35) | 0.31 (0.27, 0.37) |
| Biobío | 0.43 (0.38, 0.48) | 0.42 (0.37, 0.47) |
| Chiloé | 0.45 (0.38, 0.52) | 0.43 (0.36, 0.52) |
| Concepción | 0.78 (0.73, 0.84) | 0.77 (0.72, 0.83) |
| Coquimbo | 0.41 (0.38, 0.45) | 0.40 (0.36, 0.43) |
| Libertador B.O'Higgins | 0.43 (0.40, 0.47) | 0.42 (0.39, 0.46) |
| Maule | 0.31 (0.28, 0.33) | 0.30 (0.28, 0.33) |
| Reloncaví | 0.42 (0.38, 0.47) | 0.42 (0.37, 0.47) |
| Iquique | 0.45 (0.40, 0.50) | 0.43 (0.38, 0.49) |
| Magallanes | 0.83 (0.72, 0.94) | 0.83 (0.72, 0.96) |
| Metropolitano Central | 0.42 (0.38, 0.46) | 0.42 (0.38, 0.46) |
| Metropolitano Norte | 0.29 (0.27, 0.32) | 0.29 (0.26, 0.31) |
| Metropolitano Occidente | 0.36 (0.34, 0.38) | 0.34 (0.32, 0.36) |
| Metropolitano Oriente | 0.30 (0.28, 0.33) | 0.30 (0.27, 0.33) |
| Metropolitano Sur | 0.41 (0.39, 0.44) | 0.40 (0.37, 0.43) |
| Metropolitano Sur Oriente | 0.37 (0.34, 0.39) | 0.36 (0.34, 0.39) |
| Osorno | 0.44 (0.38, 0.51) | 0.43 (0.37, 0.51) |
| Talcahuano | 0.84 (0.76, 0.92) | 0.81 (0.74, 0.90) |
| Valdivia | 0.31 (0.27, 0.35) | 0.30 (0.26, 0.35) |
| Valparaíso San Antonio | 0.69 (0.64, 0.75) | 0.68 (0.62, 0.75) |
| Viña del Mar Quillota | 0.67 (0.63, 0.71) | 0.66 (0.62, 0.70) |
| Ñuble | 1.32 (1.24, 1.40) | 1.29 (1.21, 1.37) |

Table 14: Crude and age- and sex-adjusted ADHD prevalence by health service in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| Health service | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Aconcagua | 2.08 (1.95, 2.21) | 2.04 (1.91, 2.19) |
| Aisén | 2.23 (2.03, 2.44) | 2.17 (1.97, 2.40) |
| Antofagasta | 1.00 (0.94, 1.06) | 0.98 (0.93, 1.04) |
| Araucanía Norte | 1.33 (1.22, 1.45) | 1.29 (1.18, 1.43) |
| Araucanía Sur | 1.42 (1.36, 1.49) | 1.38 (1.32, 1.45) |
| Arauco | 1.64 (1.50, 1.78) | 1.64 (1.50, 1.81) |

| Health service | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Arica | 1.14 (1.04, 1.24) | 1.12 (1.02, 1.24) |
| Atacama | 0.49 (0.44, 0.55) | 0.49 (0.43, 0.56) |
| Biobío | 2.27 (2.16, 2.38) | 2.26 (2.15, 2.38) |
| Chiloé | 2.96 (2.77, 3.15) | 2.87 (2.68, 3.07) |
| Concepción | 2.94 (2.84, 3.04) | 3.00 (2.89, 3.11) |
| Coquimbo | 1.98 (1.91, 2.05) | 2.00 (1.92, 2.08) |
| Libertador B.O'Higgins | 1.73 (1.66, 1.79) | 1.69 (1.63, 1.76) |
| Maule | 1.19 (1.14, 1.24) | 1.15 (1.11, 1.21) |
| Reloncaví | 1.02 (0.95, 1.09) | 0.99 (0.92, 1.07) |
| Iquique | 1.49 (1.40, 1.58) | 1.50 (1.40, 1.60) |
| Magallanes | 3.07 (2.87, 3.27) | 3.06 (2.85, 3.29) |
| Metropolitano Central | 1.53 (1.46, 1.59) | 1.49 (1.43, 1.57) |
| Metropolitano Norte | 1.42 (1.36, 1.47) | 1.42 (1.36, 1.48) |
| Metropolitano Occidente | 1.09 (1.05, 1.13) | 1.12 (1.08, 1.17) |
| Metropolitano Oriente | 1.21 (1.16, 1.26) | 1.20 (1.15, 1.25) |
| Metropolitano Sur | 1.42 (1.37, 1.48) | 1.41 (1.35, 1.46) |
| Metropolitano Sur Oriente | 1.56 (1.51, 1.61) | 1.53 (1.48, 1.58) |
| Osorno | 1.05 (0.95, 1.14) | 1.02 (0.92, 1.13) |
| Talcahuano | 3.07 (2.93, 3.22) | 3.02 (2.87, 3.18) |
| Valdivia | 1.08 (1.00, 1.16) | 1.06 (0.98, 1.15) |
| Valparaíso San Antonio | 1.21 (1.13, 1.29) | 1.21 (1.13, 1.29) |
| Viña del Mar Quillota | 1.17 (1.12, 1.22) | 1.15 (1.10, 1.20) |
| Ñuble | 2.12 (2.02, 2.22) | 2.11 (2.00, 2.22) |

For both autism and ADHD, adjusted prevalences by school fees, ethnicity and school's rurality show similar patterns to crude prevalences, except for students at rural schools which have notably lower adjusted prevalence for both conditions. See tables 15 - 20. These results indicate that for autism and ADHD there are differences in prevalence across location and demographic features.

Table 15: Crude and age- and sex-adjusted autism prevalence by monthly school fee (Peso) in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| School fee | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Free | 0.57 (0.56, 0.58) | 0.55 (0.54, 0.56) |
| $1,000-$10,000 | 0.71 (0.22, 1.21) | 0.69 (0.29, 3.25) |
| $10,001-$25,000 | 0.20 (0.15, 0.25) | 0.20 (0.16, 0.27) |
| $25,001-$50,000 | 0.30 (0.28, 0.33) | 0.32 (0.29, 0.34) |
| $50,001-$100,000 | 0.39 (0.36, 0.41) | 0.40 (0.37, 0.43) |
| $100,001+ | 0.05 (0.04, 0.05) | 0.05 (0.04, 0.06) |
| No information | 0.50 (0.44, 0.57) | 0.46 (0.40, 0.52) |

Table 16: Crude and age- and sex-adjusted ADHD prevalence by monthly school fee (Peso) in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| School fee | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Free | 1.65 (1.63, 1.67) | 1.62 (1.60, 1.64) |
| $1,000-$10,000 | 0.18 (0.00, 0.43) | 0.11 (0.01, 2.74) |
| $10,001-$25,000 | 1.06 (0.95, 1.16) | 1.05 (0.94, 1.17) |
| $25,001-$50,000 | 1.59 (1.54, 1.65) | 1.65 (1.59, 1.72) |
| $50,001-$100,000 | 1.90 (1.84, 1.95) | 1.90 (1.84, 1.96) |
| $100,001+ | 0.22 (0.21, 0.24) | 0.23 (0.21, 0.25) |
| No information | 1.21 (1.11, 1.31) | 1.22 (1.13, 1.33) |

Table 17: Crude and age- and sex-adjusted autism prevalence by ethnicity in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| Ethnicity | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Mapuche | 0.36 (0.33, 0.39) | 0.34 (0.31, 0.37) |
| Other Indigenous group | 0.37 (0.20, 0.54) | 0.38 (0.21, 0.75) |
| No Indigenous group | 0.43 (0.42, 0.44) | 0.42 (0.41, 0.43) |

Table 18: Crude and age- and sex-adjusted ADHD prevalence by ethnicity in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| Ethnicity | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Mapuche | 1.38 (1.32, 1.44) | 1.33 (1.28, 1.39) |
| Other Indigenous group | 1.12 (0.82, 1.41) | 1.10 (0.83, 1.55) |
| No Indigenous group | 1.59 (1.57, 1.61) | 1.58 (1.56, 1.60) |

Table 19: Crude and age- and sex-adjusted autism prevalence by school's rurality in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| School rurality | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Rural | 0.66 (0.63, 0.69) | 0.57 (0.54, 0.61) |
| Urban | 0.46 (0.45, 0.47) | 0.46 (0.45, 0.46) |

Table 20: Crude and age- and sex-adjusted ADHD prevalence by school's rurality in Chile school data. Crude prevalence has 95% normal confidence intervals and adjusted prevalence has 95% gamma confidence intervals.

| School rurality | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| Rural | 1.77 (1.72, 1.82) | 1.67 (1.61, 1.74) |
| Urban | 1.49 (1.48, 1.50) | 1.48 (1.47, 1.50) |

## 4.3 Clinical data

The small clinical dataset has data on 2,263 appointments for 405 unique patients aged 1-18 in 2021, of which 247 patients have autism and have lived in a commune in the SSAS catchment area during the period the data covers. Among the patients with autism that live in SSAS, 55 (22.27%) are female, 4 (1.62%) are Mapuche, 221 (89.47%) live in an urban area, 12 (4.86%) have a disability and 2 (0.81%) have experienced foster care. 17 (6.88%) have an intellectual disability as well as autism.

## 4.4 Multiple Correspondence Analysis

Multiple correspondence analysis was first conducted with all features thought to be associated with autism diagnosis with no imputation. Figure 17 shows approximately 14.6% of the variance in this data can be captured by the first two dimensions of MCA. Disability and foster care status are well separated by the first dimension but Figures 26 and27 show that this separation is primarily driven by whether information is available for these features. Ethnicity, age band and commune of residence are well separately by the second dimension of MCA, as shown in Figure 17, and are somewhat separated by the first dimension. Figures 18 and 19 further shows the importance of categories within the foster care, disabilities, ethnicity, age band and commune features for explaining the variance in this data. In particular, categories that explain more of the variance include not having disability or foster care status, or not having information on these, age 0-2 and 3-5, being foreign or Chilean, living in Toltén and having private health insurance. Examining the clustering of individual patients by the first two dimensions of MCA, Figure 20 demonstrates that patients in age bands 0-2 and 3-5 cluster well and those in older age bands do not. There is some clustering by ethnicity in Figure 21 but it is obscured by the separation of points into the two larger clustered defined by having or not having information on disability and foster care status. Figure 22 shows clear separation of Toltén and Nueva Imperial communes, however it is important to know here that these and several other communes are represented by only one patient, see Table 21. There is decent clustering of patients in Temuco and Pitrufquén communes. Figure 23 shows possible separation for patients with private health insurance and Figures 24 and 25 show little clustering by sex or rurality of residence.

Exchanging disability and foster care status for their imputed versions leads to the MCA capturing approximately 14.1% of the variance in that data with its first two dimensions, as shown in Figure 28. Disability and foster care status are no longer well separated by the first dimension and Figures 37 and 38 show that the patients who have experienced foster care do cluster well but the patients with a disability do not. In Figure 28, age band and ethnicity are now well separated by both dimensions and commune mostly by the second. With the reduced importance of disability and foster care, age bands 0-2 and 3-5, foreign, no information and Chilean ethnicity and Toltén and Nueva Imperial communes contribute most to the first two dimensions, see Figures 29 and 30. Again patients with age bands 0-2 and 3-5 cluster well and older age bands do not, as shown in Figure 31. Figure 32 shows much clearer clustering of ethnicity than before. For communes with more than one patient resident, clustering is less clear than before with only Pitrufquén well separated by these dimensions, see Figure 33. In Figures 34, 35 and 36, clustering by feature is weak.

MCA on the small clinical data using only age band, ethnicity and commune results in the first two dimensions capturing 17.8% of the variance in that data, see Figure 39, and these features are fairly well represented by the first two dimensions. Again age bands 0-2 and 3-5, foreign, no information and Chilean ethnicity and Toltén and Nueva Imperial communes contribute most to the first two dimensions, see Figures 40 and 41. By

Table 21: Count and percentage of features' values in the small clinical dataset.

| Feature | Available values | Count (%) |
|---|---|---|
| Sex | Female | 55 (22.27%) |
| Sex | Male | 192 (77.73%) |
| Age band | Age 0-2 | 13 (5.26%) |
| Age band | Age 3-5 | 55 (22.27%) |
| Age band | Age 6-8 | 37 (14.98%) |
| Age band | Age 9-11 | 56 (22.67%) |
| Age band | Age 12-14 | 45 (18.22%) |
| Age band | Age 15-18 | 41 (16.60%) |
| Private health level | FONASA - A | 99 (40.08%) |
| Private health level | FONASA - B | 67 (27.13%) |
| Private health level | FONASA - C | 35 (14.17%) |
| Private health level | FONASA - D | 38 (15.38%) |
| Private health level | Private Health Insurance | 8 (3.24%) |
| Commune | Curarrehue | 6 (2.43%) |
| Commune | Freire | 2 (0.81%) |
| Commune | Gorbea | 1 (0.40%) |
| Commune | Loncoche | 39 (15.79%) |
| Commune | Nueva Imperial | 1 (0.40%) |
| Commune | Pitrufquén | 2 (0.81%) |
| Commune | Pucón | 50 (20.24%) |
| Commune | Temuco | 7 (2.83%) |
| Commune | Teodoro Schmidt | 1 (0.40%) |
| Commune | Toltén | 1 (0.40%) |
| Commune | Villarrica | 137 (55.47%) |
| Rurality | Rural | 26 (10.53%) |
| Rurality | Urban | 221 (89.47%) |
| Ethnicity | Mapuche | 4 (1.62%) |
| Ethnicity | Chilean | 131 (53.04%) |
| Ethnicity | Foreign | 32 (12.96%) |
| Ethnicity | No ethnicity information | 80 (32.39%) |
| Disability | Yes disability | 12 (4.86%) |
| Disability | No disability | 78 (31.58%) |
| Disability | No disability information | 157 (63.56%) |
| Foster care | Yes foster care | 2 (0.81%) |
| Foster care | No foster care | 88 (35.63%) |
| Foster care | No foster care information | 157 (63.56%) |
| Intellectual disability | Yes intellectual disability | 17 (6.88%) |
| Intellectual disability | No intellectual disability | 230 (93.12%) |

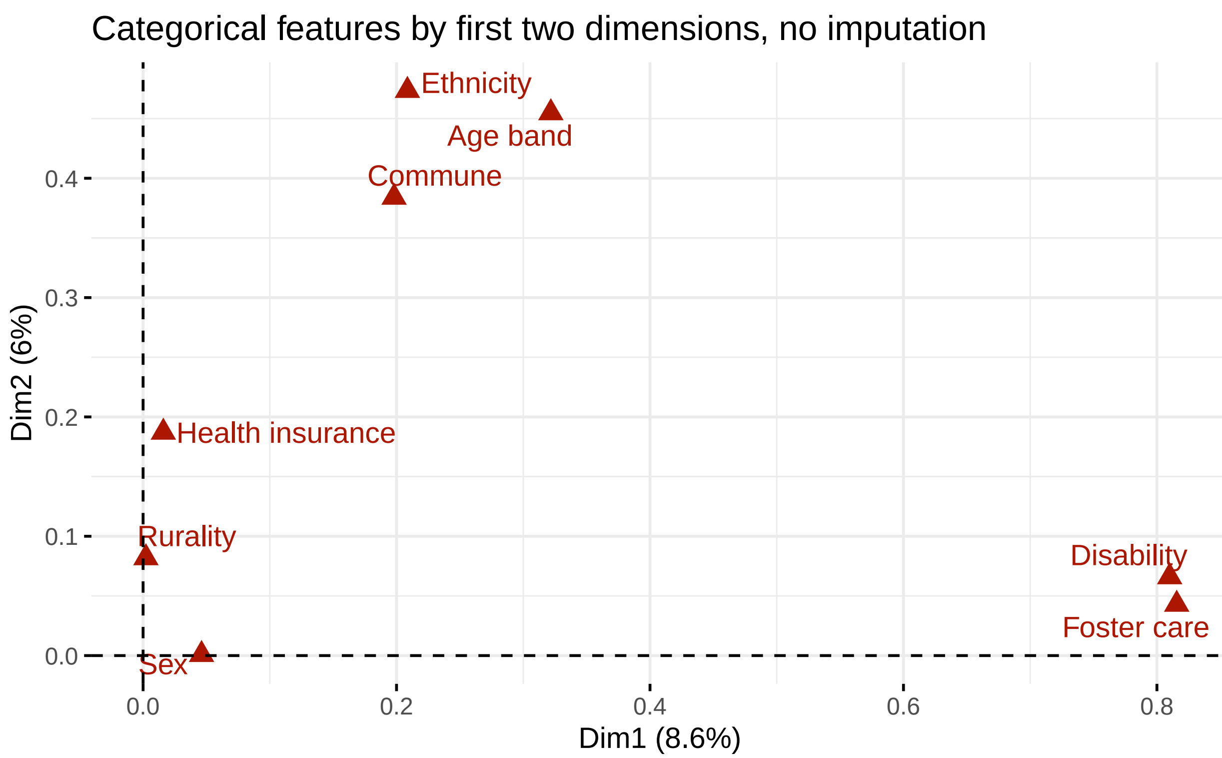



Figure 17: Categorical features by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation.

patient, age bands 0-2 and 3-5 still cluster well (Figure 42), ethnicity clusters are very distinct (Figure 43), and communes show more structure than previously (Figure 44).

## 4.5 Linkage of school and patient records

In the school records, 132,242 students live in SSAS health service catchment, of which 488 (0.37%) have autism.

Aggregating the combined clinical data to patient-level data for linkage resulted in the patient dataset with 1,528 records for 1,514 unique patients as 12 patients lived in 2 communes and 1 lived in 3 during the period covered by the data.

### 4.5.1 Manual record linkage

Using perfect match on sex, date of birth, commune of residence and the proxies for SES, 79 matches can be found between the school and patient records. Of these, 77 unique school records can be perfectly matched to clinical records, and all perfect matches were for unique patients. When mismatch on SES proxy is allowed, 197 matches can be manually found between the school and patient records. Of these, 188 unique school records can be perfectly matched to clinical records and 193 patients can be perfectly matched to school records.

### 4.5.2 Probabilistic record linkage

Blocking on sex and date of birth, resulted in 301 blocked pairs. Probabilistic matching on sex, date of birth, commune of residence and the proxies for SES with selection of possible matches to create a bijective set of matches resulted in 236 matches of unique school and patient records. This corresponds to 48.26% of the

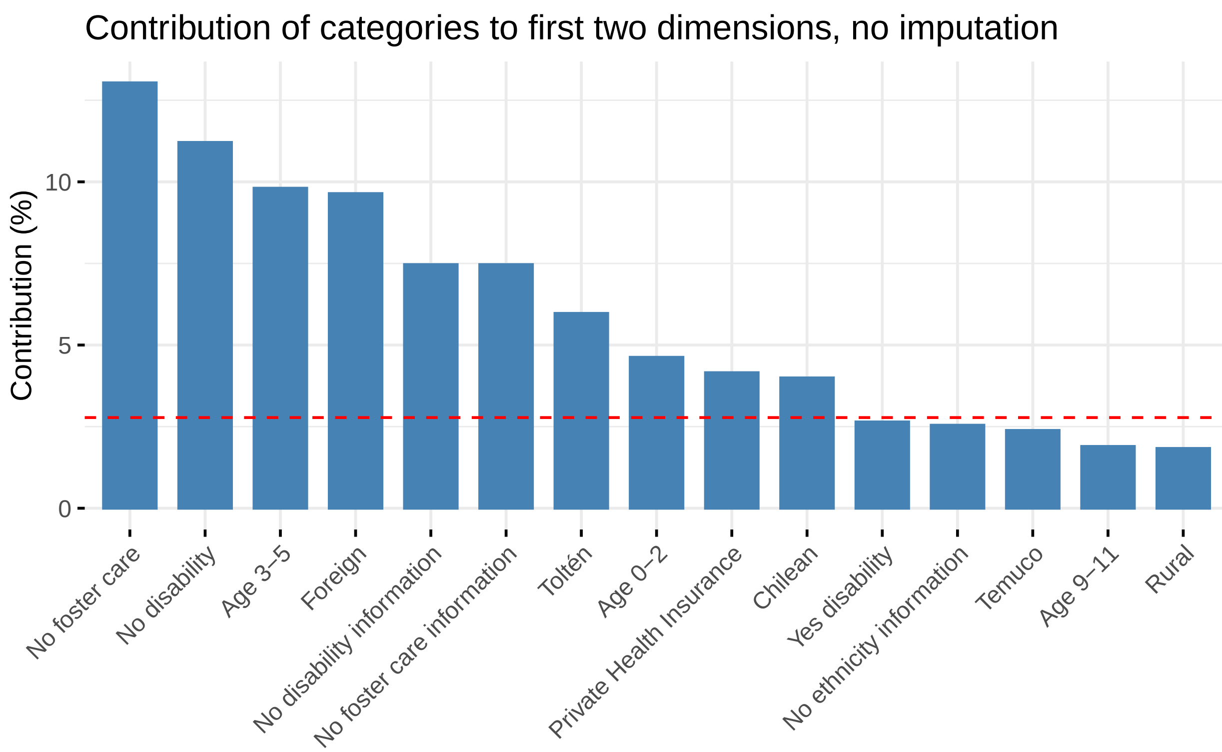



Figure 18: Contribution of the top 15 categories to the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation. The red line shows the expected average if contributions were uniform.

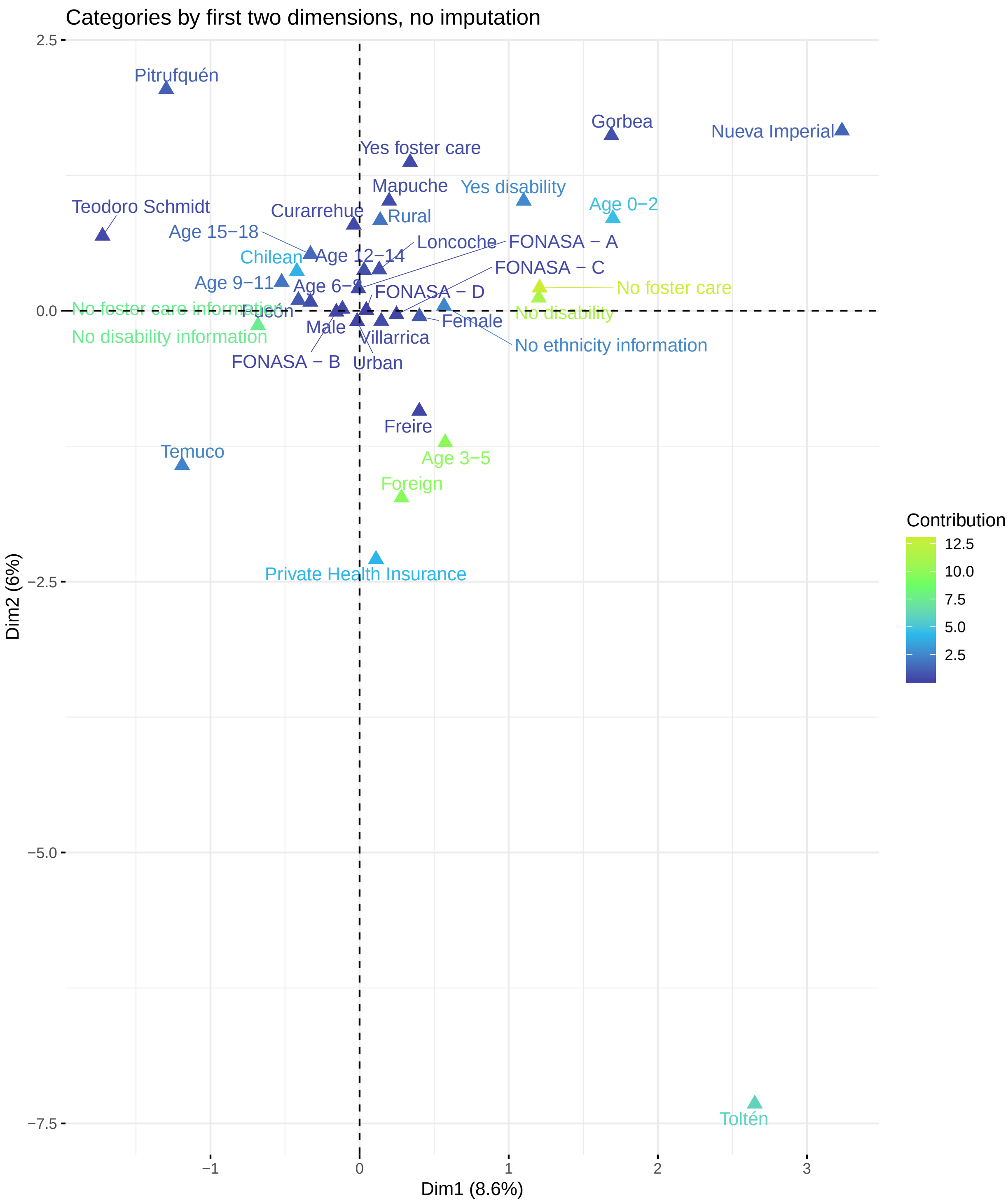



Figure 19: Available categories by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation. Brigther, more yellow colours indicate larger contribution to the first two dimensions.

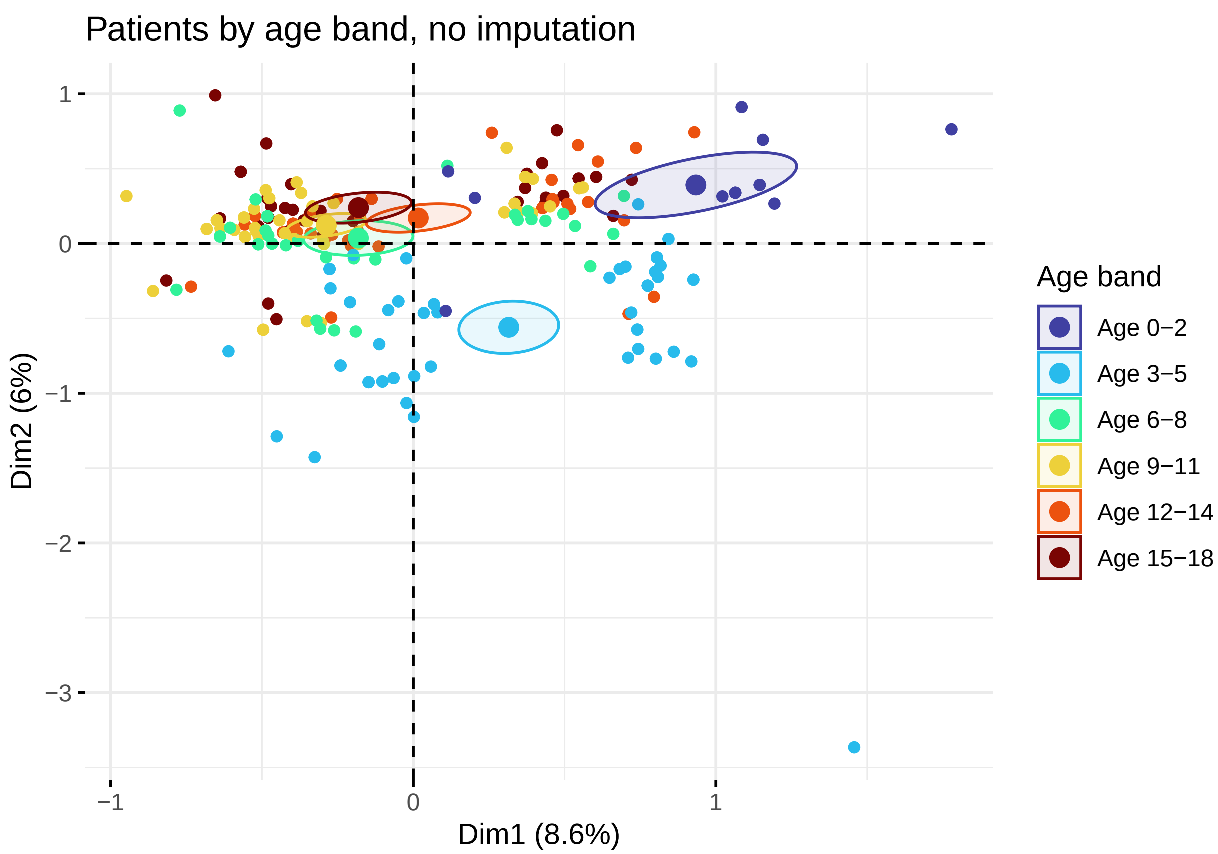



Figure 20: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by age band.

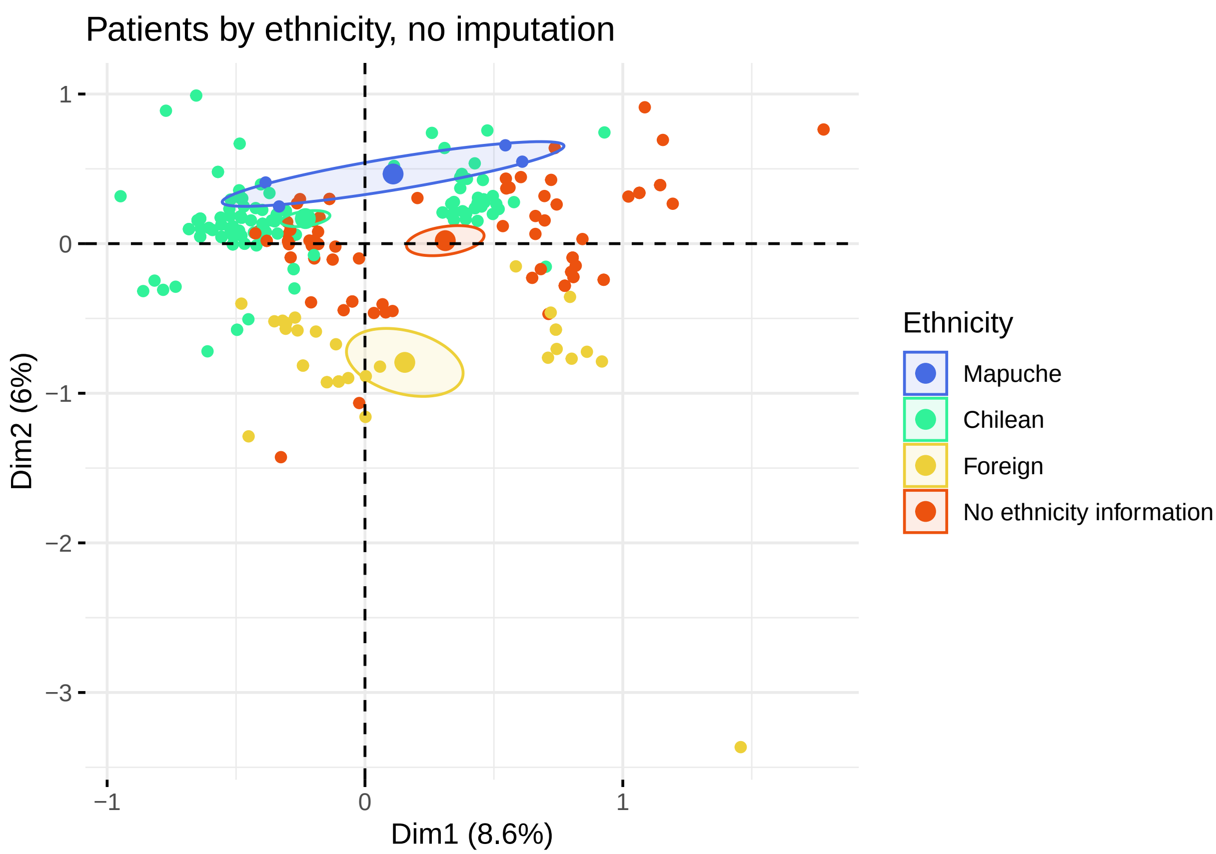



Figure 21: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by ethnicity.

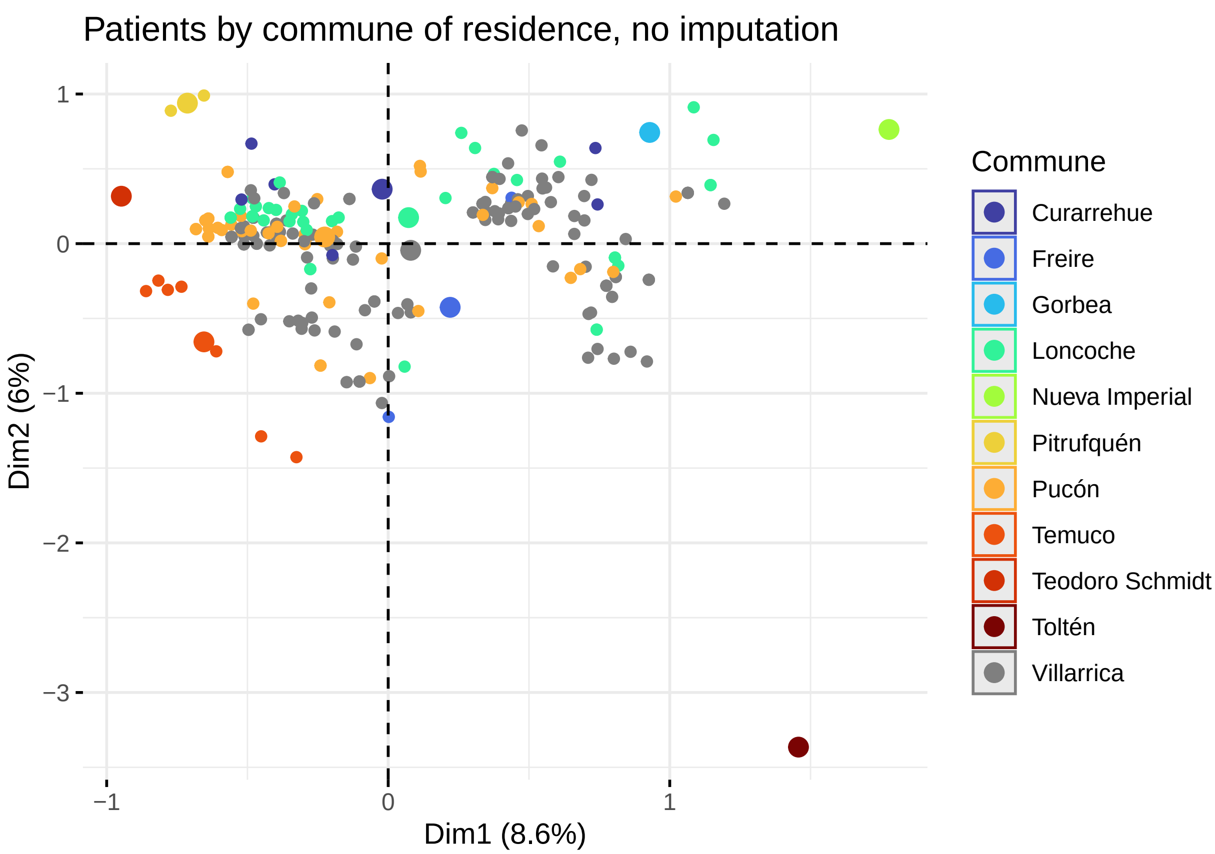



Figure 22: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by commune of residence.

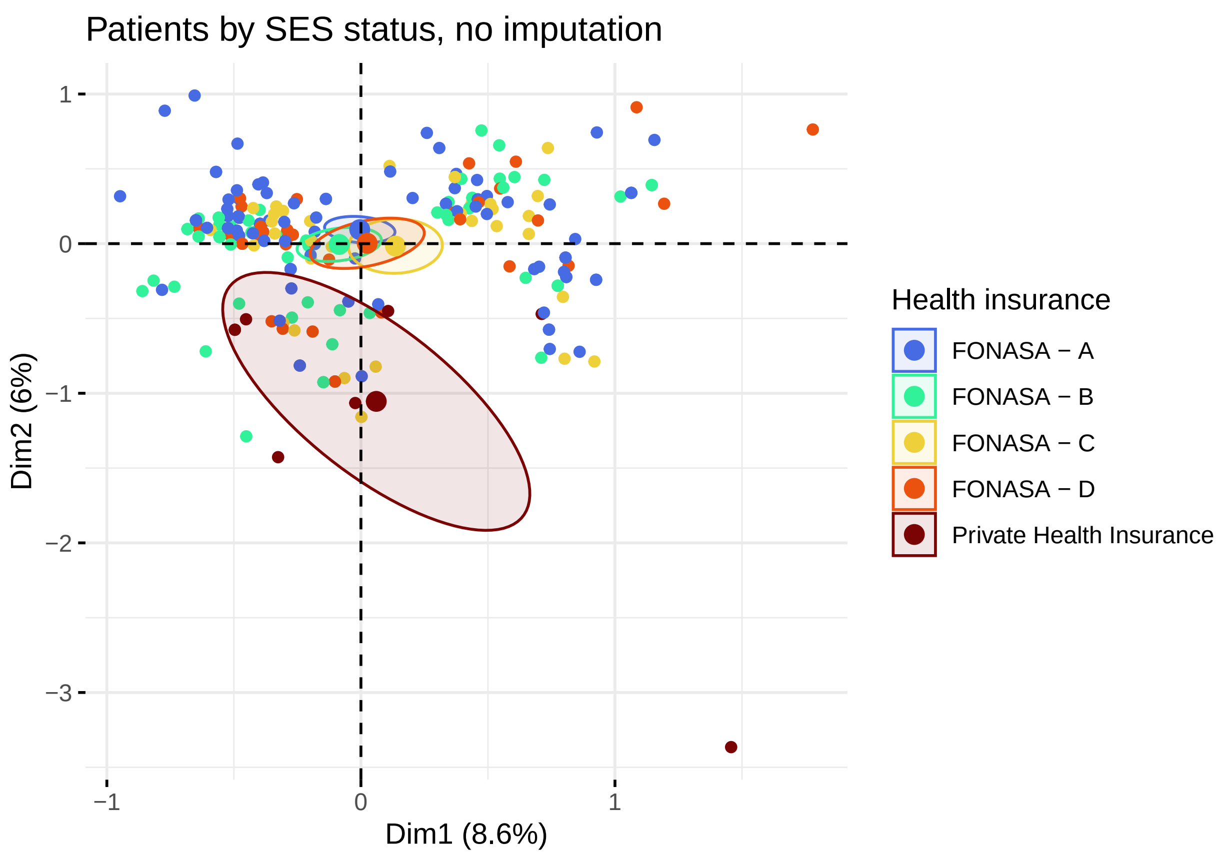



Figure 23: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by health insurance level.

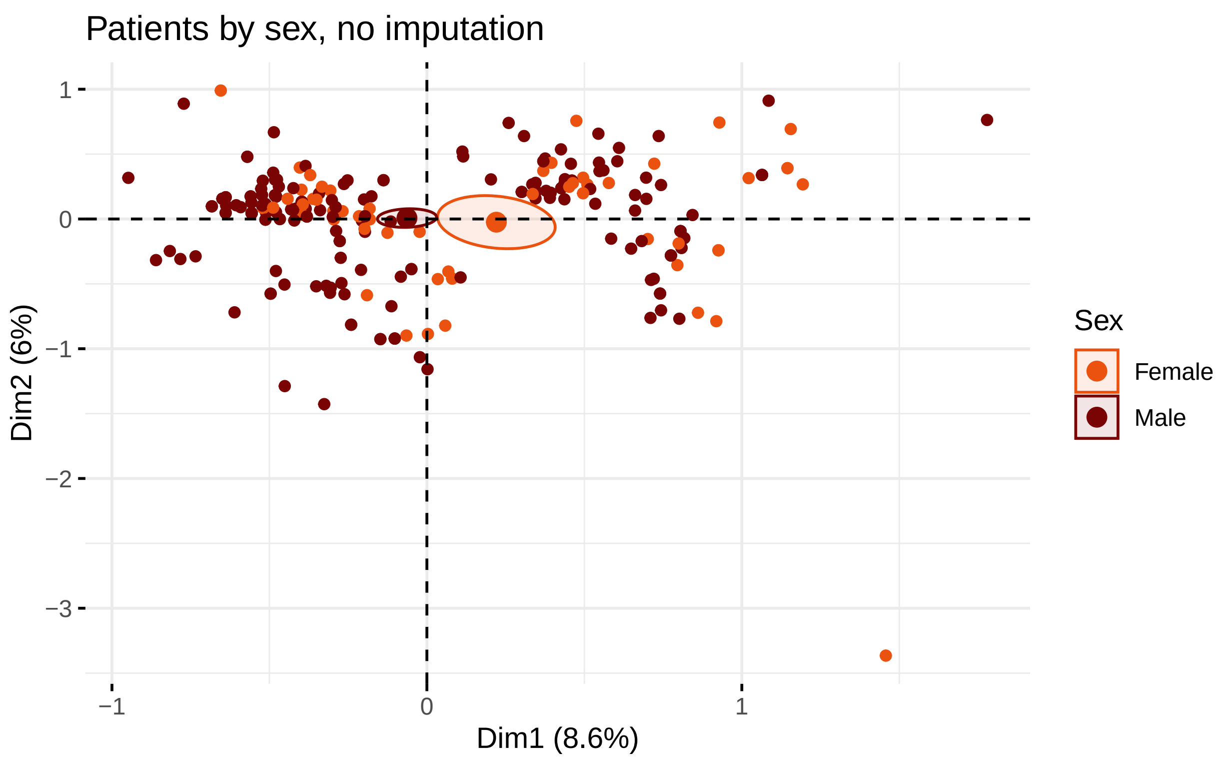



Figure 24: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by sex.

school records having a match in the patient records, 15.45% of the patient records having a match in the school records and 15.59% of the unique patients having a match in the school records. For each patient that had lived more than one commune and therefore appeared more than once in the patient data, only one match to a school record was made, meaning the linked data was bijective for school records and unique patients. 3 matches were made between a school record and a patient that did not have autism, rather had intellectual disability. For each of these, only one patient had sex and date of birth that perfectly matched the sex and date of birth in the school records, therefore no match to a patient with autism was available and thus these matches to patients with diagnosis of intellectual disability only were retained.

Analysis of differences between matched and unmatched records in the school data and in the patient data by sex, commune and proxy for SES are provided in the Supplementary Figures. Kolmogorov-Smirnov permutation tests found no difference in frequency of sexes between matched and unmatched school records, see Figure 61. They did find a difference in the frequency of sexes between matched and unmatched patient records, see Figure 62. This difference is likely due to the sex ratios differing across the datasets: the school data is 12.47% female, the patient data is 21.34% female and the matches are 13.14% females. Kolmogovo-Smirnov permutation testing found matched and unmatched records differed by commune for both the school data, see Figure 63, and patient data, see Figure 63. This appears to be driven by the matchability of students and patients living in Temuco, the most prevalent commune. Differences were also found by proxy SES for both school and patient data, see Figure 65 and Figure 66 respectively, likely reflecting different frequencies in these values across datasets. Kolmogorov-Smirnov permutation testing was not conducted for date of birth as this feature contains too many categories for results to be meaningful.

#### 4.5.3 Linked dataset

The linked dataset contains 133,520 records, comprising 132,242 school records and 1,278 patient records.

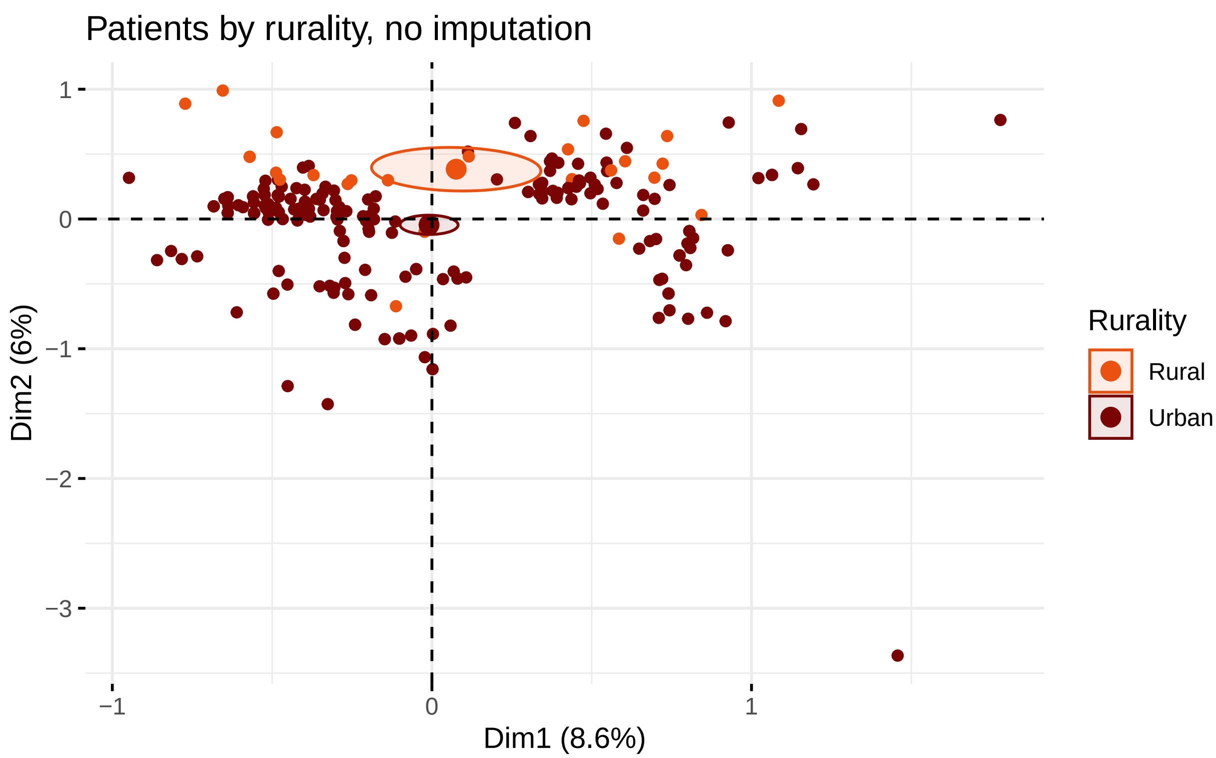



Figure 25: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by rurality of residence.

### 4.6 Updated autism prevalence estimates and delta

Table 22: Age- and sex-adjusted autism prevalence from linked data in SSAS by age band with 95% gamma confidence intervals.

| Age band | Crude prevalence (95% CI) | Adjusted prevalence (95% CI) |
|---|---|---|
| 6-8 | 1.52 (1.39, 1.66) | 1.52 (1.39, 1.66) |
| 9-11 | 1.32 (1.20, 1.45) | 1.31 (1.19, 1.44) |
| 12-14 | 1.07 (0.96, 1.18) | 1.07 (0.96, 1.19) |
| 15-18 | 0.96 (0.85, 1.06) | 0.97 (0.86, 1.10) |

Using the linked dataset, the crude prevalence of autism in SSAS is 1.21% (1.15-1.27%) and the age- and sex-adjusted prevalence of autism is 1.20% (1.14-1.27%). For females, crude prevalence is 0.47% (0.42-0.52%) and the adjusted prevalence is 0.46% (0.41-0.53%). For males, crude prevalence is 1.92% (1.82-2.02%) and the adjusted prevalence is 1.92% (1.81-2.03%). Autism prevalence is highest among individuals aged 6-8 with crude prevalence of 1.52% (1.39-1.66%) and age- and sex- adjusted prevalence of 1.52% (1.39-1.66%) and decreases with age, see Table 22,

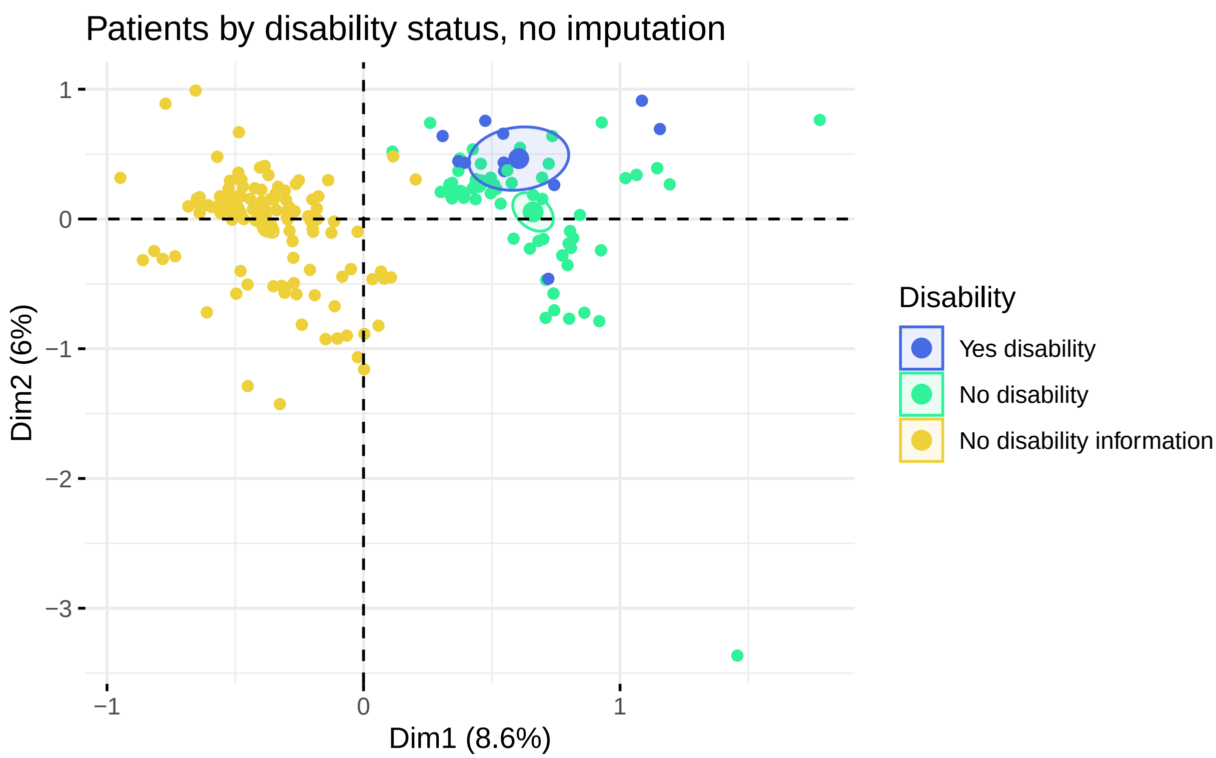



Figure 26: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by disability status.

Table 23: Projected age- and sex-adjusted autism prevalence by health service in Chile school data and linked school and patient data. Projections for the linked adjusted prevalence for health services other than Araucanía Sur were calculated by adding delta to each health service's adjusted prevalence from the school data. Adjusted prevalence from the school data has 95% gamma confidence intervals and projected adjusted prevalence from the linked data has confidence intervals equal in width to the school data adjusted prevalence intervals for each health service other than Araucanía Sur which has the 95% gamma confidence intervals found earlier.

| Health service | School data (95% CI) | Projected linked data (Equivalent CI) |
|---|---|---|
| Aconcagua | 0.43 (0.37, 0.50) | 1.26 (1.19, 1.32) |
| Aisén | 0.75 (0.63, 0.90) | 1.58 (1.45, 1.71) |
| Antofagasta | 0.83 (0.77, 0.88) | 1.66 (1.60, 1.71) |
| Araucanía Norte | 0.30 (0.24, 0.38) | 1.13 (1.07, 1.20) |
| Araucanía Sur | 0.37 (0.34, 0.41) | 1.20 (1.14, 1.27) |
| Arauco | 0.72 (0.62, 0.82) | 1.55 (1.45, 1.65) |
| Arica | 0.61 (0.54, 0.70) | 1.45 (1.36, 1.53) |
| Atacama | 0.31 (0.27, 0.37) | 1.14 (1.09, 1.19) |
| Biobío | 0.42 (0.37, 0.47) | 1.25 (1.20, 1.30) |
| Chiloé | 0.43 (0.36, 0.52) | 1.26 (1.19, 1.34) |
| Concepción | 0.77 (0.72, 0.83) | 1.60 (1.55, 1.66) |
| Coquimbo | 0.40 (0.36, 0.43) | 1.23 (1.19, 1.26) |
| Libertador B.O'Higgins | 0.42 (0.39, 0.46) | 1.26 (1.22, 1.29) |

| Health service | School data (95% CI) | Projected linked data (Equivalent CI) |
|---|---|---|
| Maule | 0.30 (0.28, 0.33) | 1.13 (1.11, 1.16) |
| Reloncaví | 0.42 (0.37, 0.47) | 1.25 (1.20, 1.30) |
| Iquique | 0.43 (0.38, 0.49) | 1.26 (1.21, 1.31) |
| Magallanes | 0.83 (0.72, 0.96) | 1.66 (1.55, 1.78) |
| Metropolitano Central | 0.42 (0.38, 0.46) | 1.25 (1.21, 1.29) |
| Metropolitano Norte | 0.29 (0.26, 0.31) | 1.12 (1.09, 1.14) |
| Metropolitano Occidente | 0.34 (0.32, 0.36) | 1.17 (1.15, 1.19) |
| Metropolitano Oriente | 0.30 (0.27, 0.33) | 1.13 (1.10, 1.16) |
| Metropolitano Sur | 0.40 (0.37, 0.43) | 1.23 (1.20, 1.26) |
| Metropolitano Sur Oriente | 0.36 (0.34, 0.39) | 1.20 (1.17, 1.22) |
| Osorno | 0.43 (0.37, 0.51) | 1.26 (1.20, 1.33) |
| Talcahuano | 0.81 (0.74, 0.90) | 1.65 (1.57, 1.72) |
| Valdivia | 0.30 (0.26, 0.35) | 1.13 (1.09, 1.18) |
| Valparaíso San Antonio | 0.68 (0.62, 0.75) | 1.52 (1.45, 1.58) |
| Viña del Mar Quillota | 0.66 (0.62, 0.70) | 1.49 (1.45, 1.53) |
| Ñuble | 1.29 (1.21, 1.37) | 2.12 (2.04, 2.20) |

This gives an adjusted prevalence delta for SSAS of 0.83%. Table 23 shows the projection of adjusted prevalence from the linked data for SSAS onto the other health services. The patterns of prevalence across health services are retained and Ñuble has the highest projected adjusted prevalence at 2.12% (2.04, 2.20%).

### 4.7 Bayesian prevalence projection

Bayesian prevalence projections by health service with common global autism prevalence prior is shown in Figure 45. The differences in adjusted sample prevalence across health services are evident in the red bands and the posterior predictive distributions have been pulled towards the common prior. For regions like Ñuble which have adjusted sample prevalence in the school data higher than the global adjusted prevalence, these posterior densities are not plausible.

Figure 46 shows Bayesian prevalence projections by health service with health service specific priors and as expected, the posteriors 95% credible intervals are coincident with the adjusted sample prevalence 95% confidence intervals. The posterior prevalence peaks can be considered lower bounds for the true autism prevalence in each health service.

With projected prevalence priors, the Bayesian prevalence projections shown in Figure 47 are pulled upward toward their priors by approximately delta. For regions with high sample prevalence such as Ñuble, this addition of delta results in a posterior prevalence projects up to 1.5 percentage points higher than the global adjusted prevalence for the school data. The posterior prevalence peaks can be considered plausible upper bounds for the prevalence of recorded cases of autism in each health service.

In Figure 48, the posterior distributions are reflective of their uniform priors with posterior credible intervals slightly within the prior bounds (Table 23). These predictive densities show a considerable departure from the adjusted sample prevalence from the school data and provide a window within which the true prevalence of recorded autism in each health service would plausibly fall.

## 5 Discussion

### 5.1 Findings

#### 5.1.1 Aim 1: school data frequentist prevalence

- Crude prevalence peaks match known disease diagnosis patterns (young for autism and early teen for ADHD). Uptick for age 18 likely due to people with autism or ADHD taking slightly longer to complete

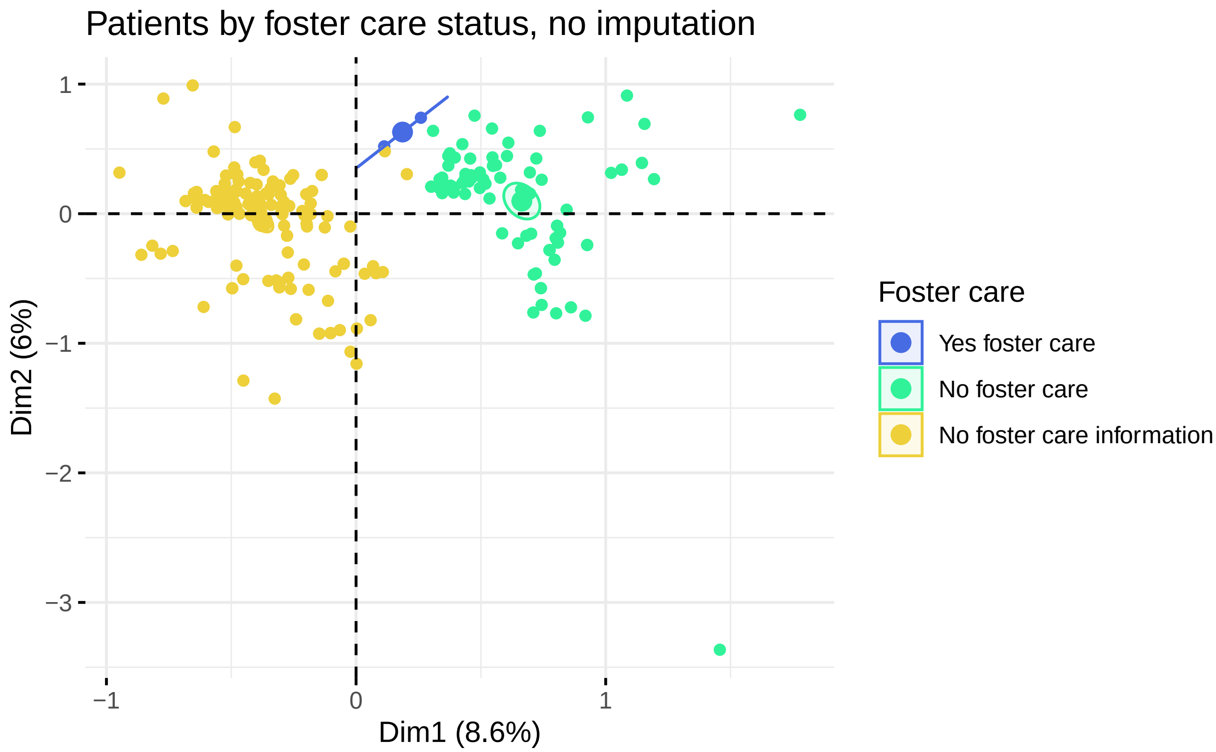



Figure 27: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features without imputation, coloured by foster care status.

schooling or being slightly older for their year group, therefore appear to have higher prevalence in 18yo group. Age patters are preserved across demographic features (check if true when all are done). Observed prevalences are different across the many features known to be associated with autism diagnosis which suggests Chile is comparable to other countries with more closely studied autism diagnosis patterns.

- Known differences in autism and ADHD prevalence across sexes is preserved after adjusting for age and sex structure. "Prevalence is higher among older students for higher fee bands." What is a plausible explanation for this??

#### 5.1.2 Aim 2: clinical data MCA

- Found features associated with autism – age, ethnicity, commune from MCA. Showed missingness in data matters.

#### 5.1.3 Aim 3a: linkage

- Better to do probabilistic matching than manual perfect match merging because you get more matches and get the likelihood of them being matches.
- There are differences in the matched and unmatched school and patient records which suggests there may be other factors at play.
- The lower percentage of females in the school dataset than the patient dataset suggests females may be under represented in school autism cases.

#### 5.1.4 Aim 3b: Bayesian

- Found lower and upper-ish bounds on diagnosed autism prevalence in Chile's health services.

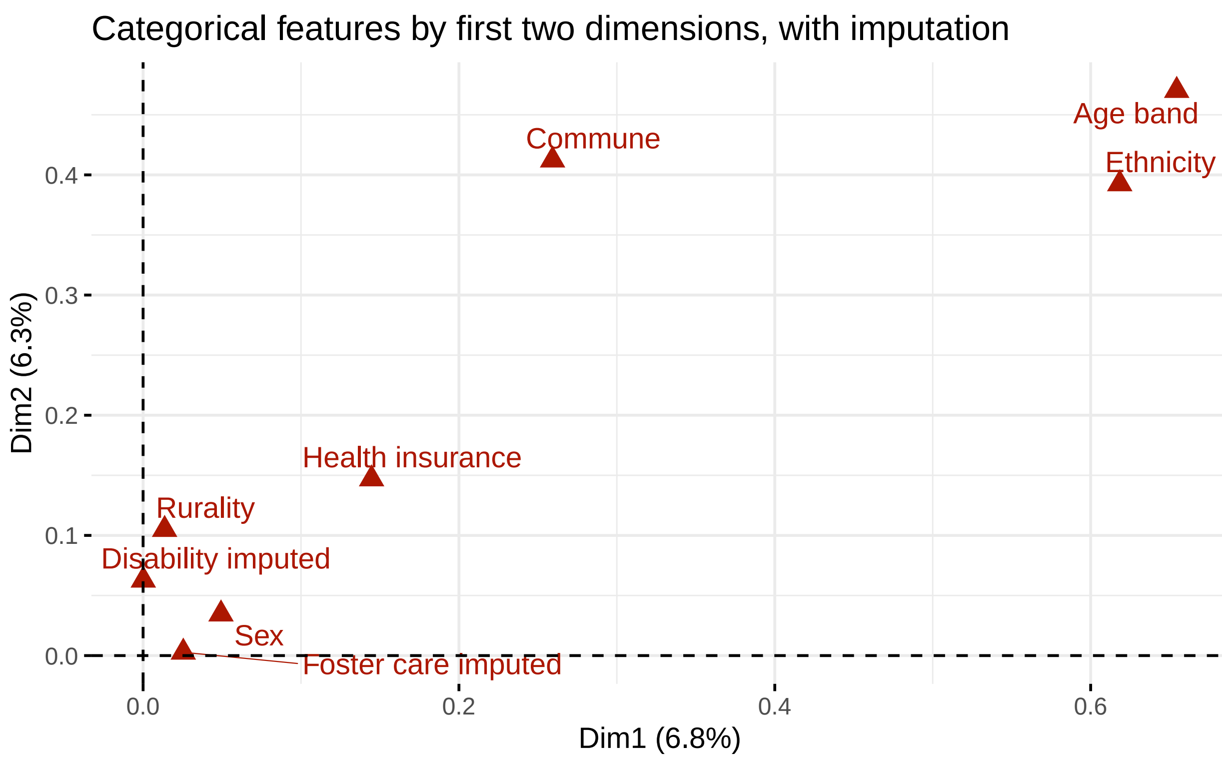



Figure 28: Categorical features by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation.

- Used same delta for all regions which might not be appropriate. There is a phenotypic upper bound to autism prevalence to might not be possible for Nuble upper bound to be as high as it is.

## 5.2 Limitations

- Single special needs code per student
- Inconsistent data selection across the two clinical datasets re number of diagnosis codes and inclusion of intellectual disability. Needed better diagnosis codes for clinical data. More clinical data.
- SES status coding is very imprecise though tried to account for that by declaring high error in weight allocation during matching.
- Disability and foster care are unbalanced and imputation adds bias.
- Double-dipping on prior selection
- Consider other limitations in the opioid paper https://pubmed.ncbi.nlm.nih.gov/37292044/

## 5.3 Extensions

While this investigation has progressed the understanding of autism and ADHD prevalence in Chile, it has also uncovered new avenues for exploration. If clinical data on ADHD diagnoses were available for a region of Chile, the MCA analysis, data linkage and Bayesian projection conducted here for autism could be extended to ADHD. If clinical data on autism for other health service regions were available, the delta calculation could be validated and thus more accurate autism prevalence estimates could be found.

This investigation used MCA to assess the contribution of feature categories among patients with autism in SSAS which required casting the age feature to categorical age bands. However age is a continuous variable

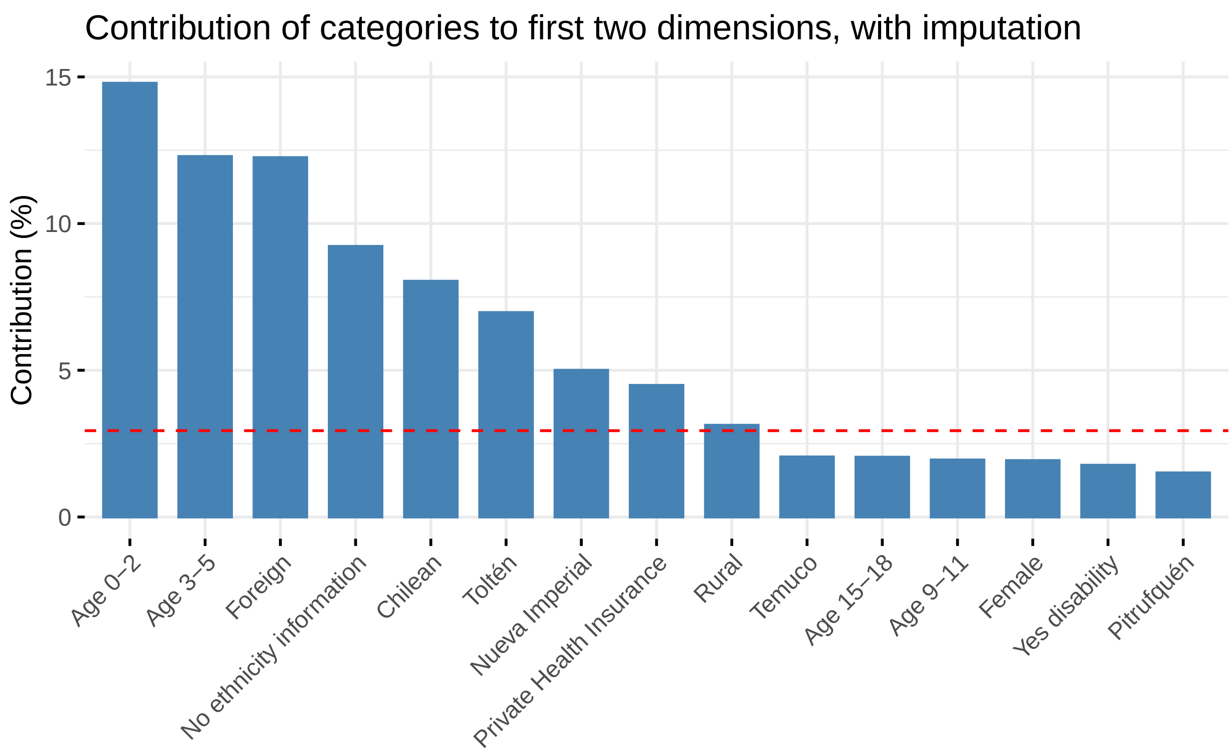



Figure 29: Contribution of the top 15 categories to the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation. The red line shows the expected average if contributions were uniform.

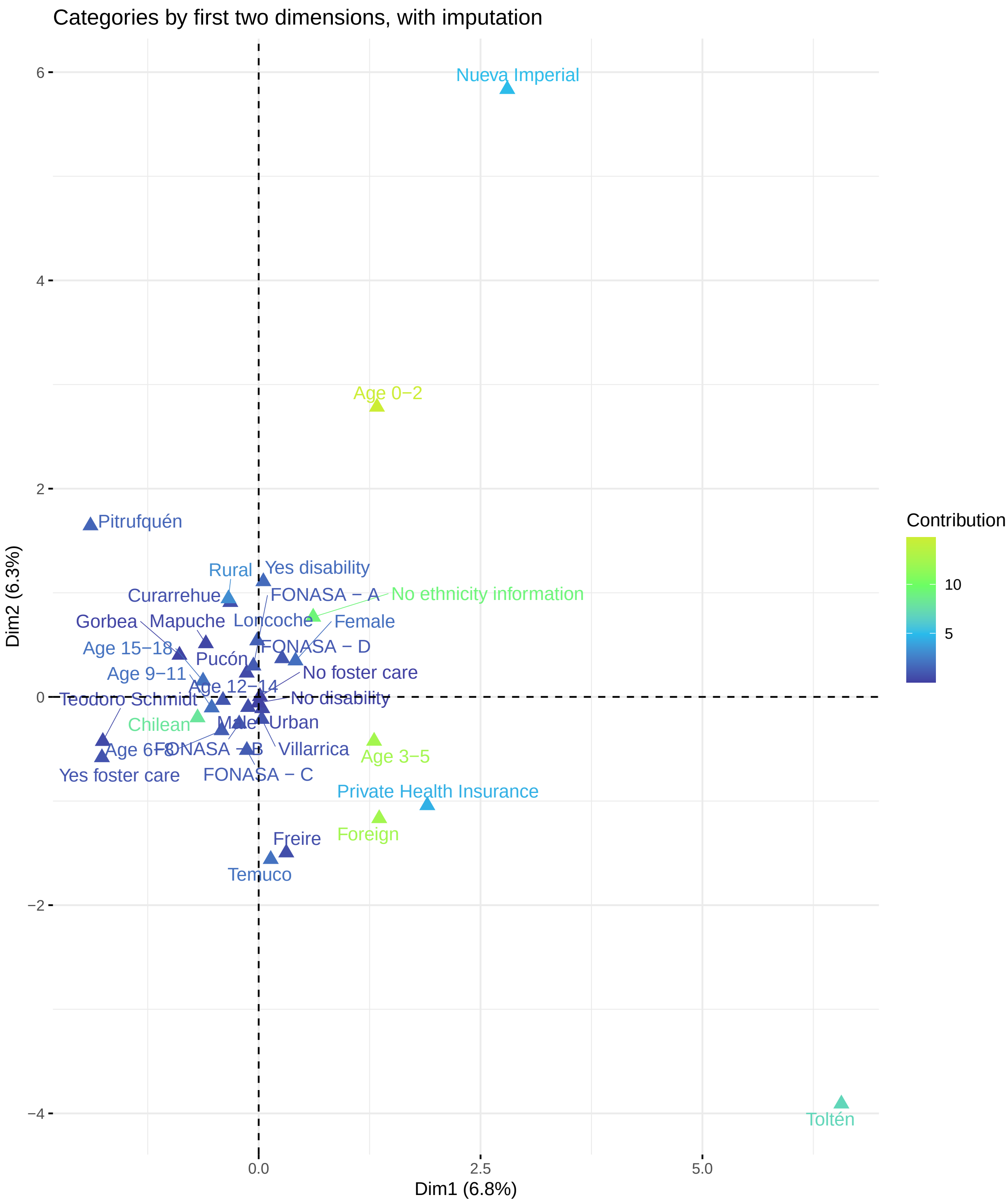



Figure 30: Available categories by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation. Brigther, more yellow colours indicate larger contribution to the first two dimensions.

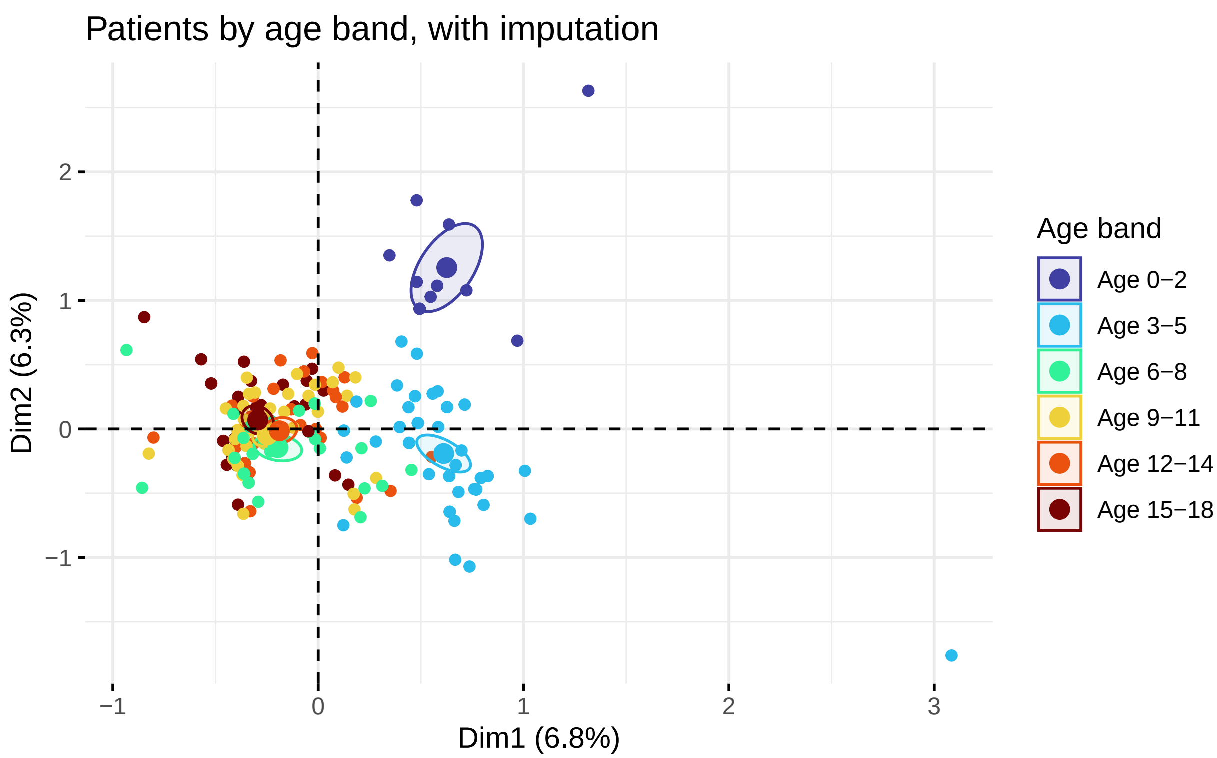



Figure 31: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by age band.

and the information contained in it would be better captured using a continuous variable analysis technique such as principle component analysis. The commune feature would need to be excluded because it cannot be meaningfully encoded as a continuous or ordered categorical variable. The remaining features could be one-hot encoded to pseudo-continuous variables before performing PCA. This would allow the contribution of patient age to be better characterised but one-hot encoding would somewhat reduce the power of inferences about the other features used.

During data linkage, this investigation assumed that unmatched patients in the clinical data existed in the school data but did not have an autism diagnosis in the school data. It would be valuable to test this assumption by attempting to link the patient data for SSAS to all school records for SSAS, including those students that do not have an autism diagnosis. This would allow the number of patients that do not exist in the school data to be estimated which would provide a more accurate sample size for use as the denominator in prevalence calculation.

This investigation assumed the adjusted prevalence delta found for SSAS was directly applicable to other regions which may not be the case. Further analysis of the Bayesian prevalence projection could use health service specific deltas that are inversely proportional to the sample prevalence observed for each health service. This would decrease the delta for services with high observed prevalence and thus lessen the increase in the updated prevalence estimate, and would increase the updated prevalence estimate for health services with low observed prevalence. This would provide more biologically plausible prevalence estimates, however subsequent Bayesian analysis would be using information from the school data twice – as the sample data and to inform the health service specific prior through use of observed prevalence to scale delta.

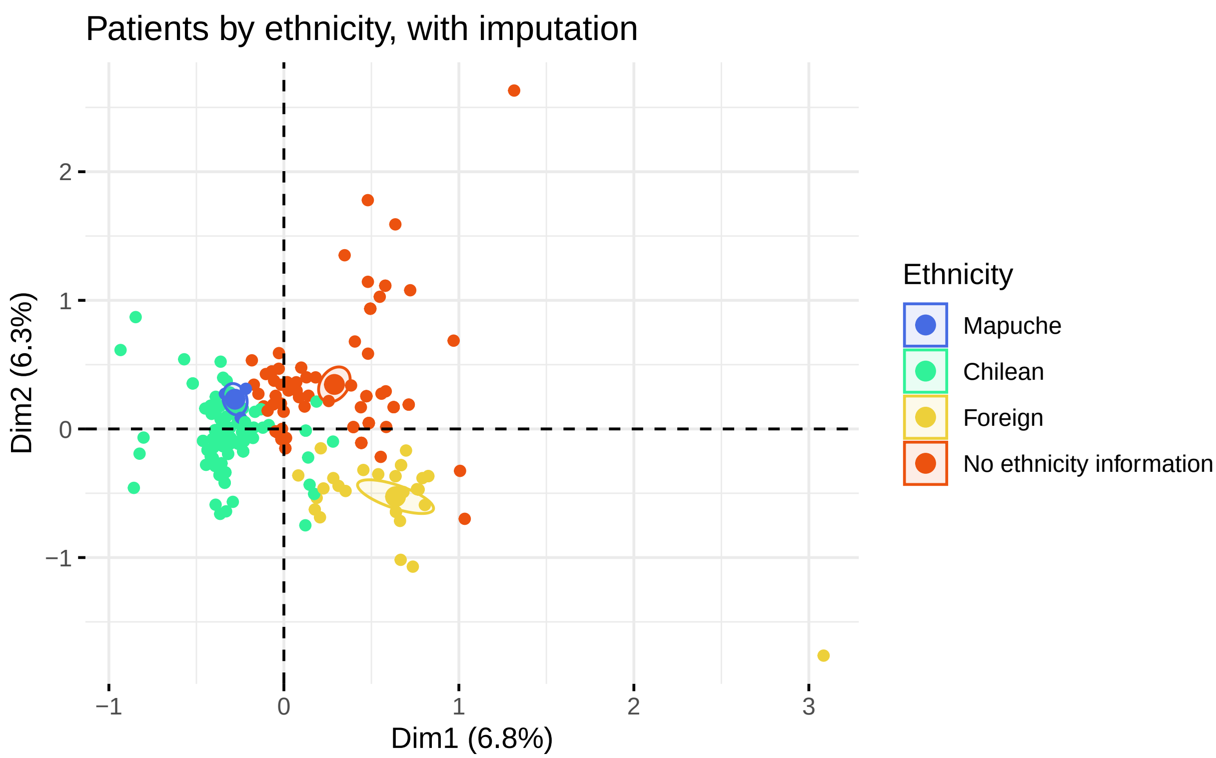



Figure 32: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by ethnicity.

# 6 Conclusions

This investigation has furthered the understanding of autism and ADHD prevalence in Chile. It has found a lower bound on the prevalence of autism to be 0.46% (0.13% in females and 0.79% in males) and a lower bound on the prevalence of ADHD to be 1.5% (1.01% in females and 1.97% in males). Prevalence of autism and ADHD differs across age, socio-economic status, ethnicity and rurality of students' schools. In Servicio de Salud Araucanía Sur, age, ethnicity and commune of residence were found to be important components for explaining the variance in data on patients with autism. School data and patient data on individuals with autism in Servicio de Salud Araucanía Sur were successfully linked and used to calculate that a more accurate estimate of the prevalence of autism in this region is 1.21% (0.47% for females and 1.92% for males). Bayesian prevalence projection extended this findings across health services and demonstrated that prevalence of recorded autism cases in Chile could up to 2.12%.

# 7 Supplementary materials

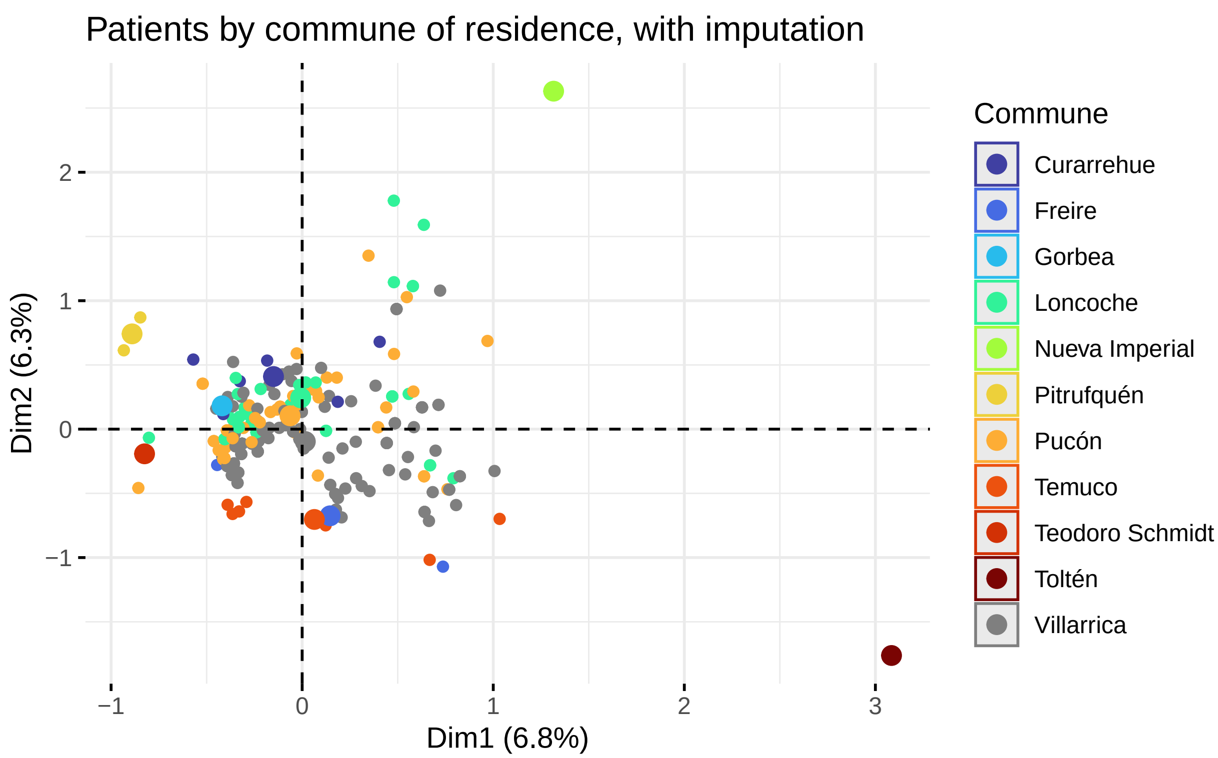



Figure 33: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by commune of residence.

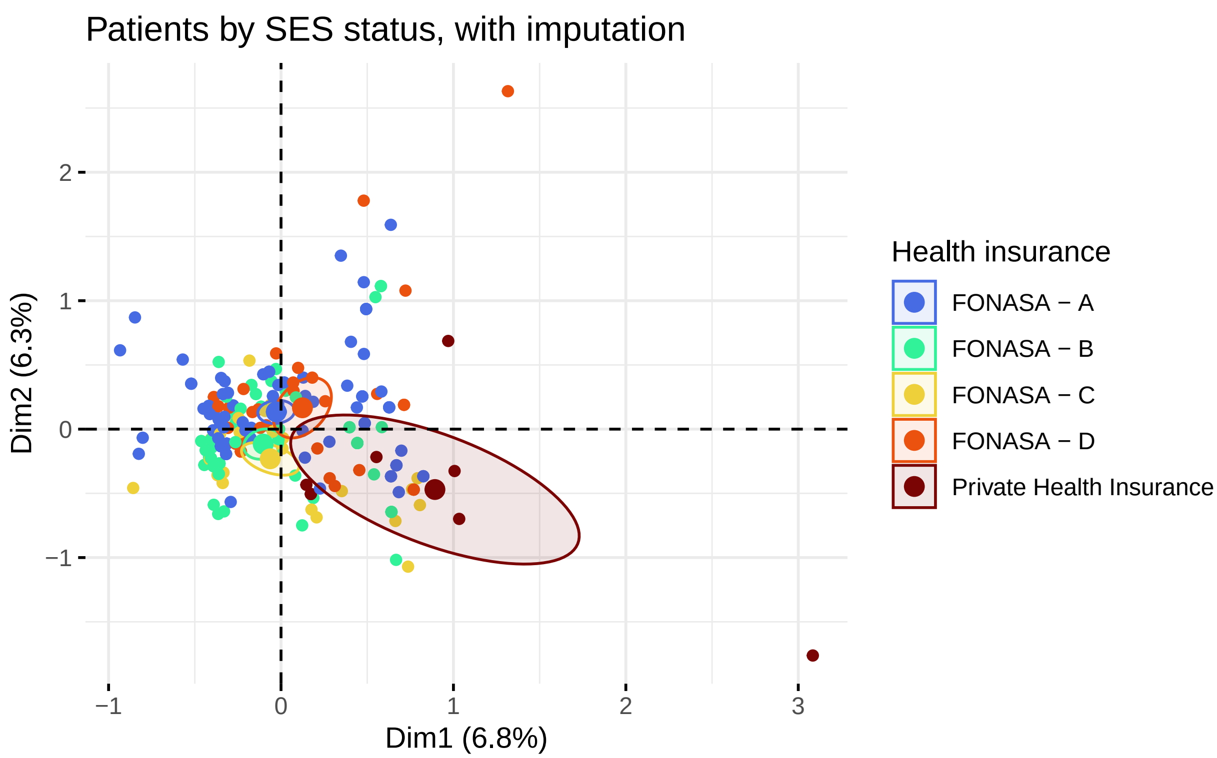



Figure 34: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by health insurance level.

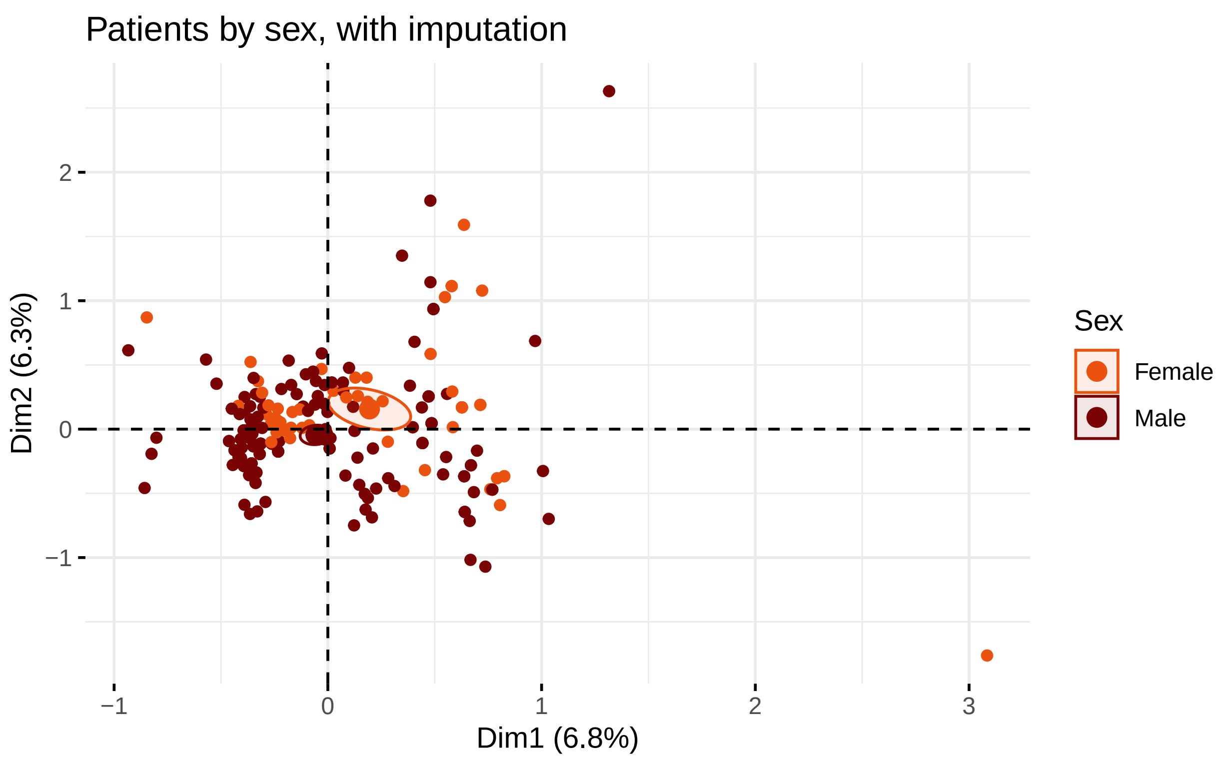



Figure 35: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by sex.

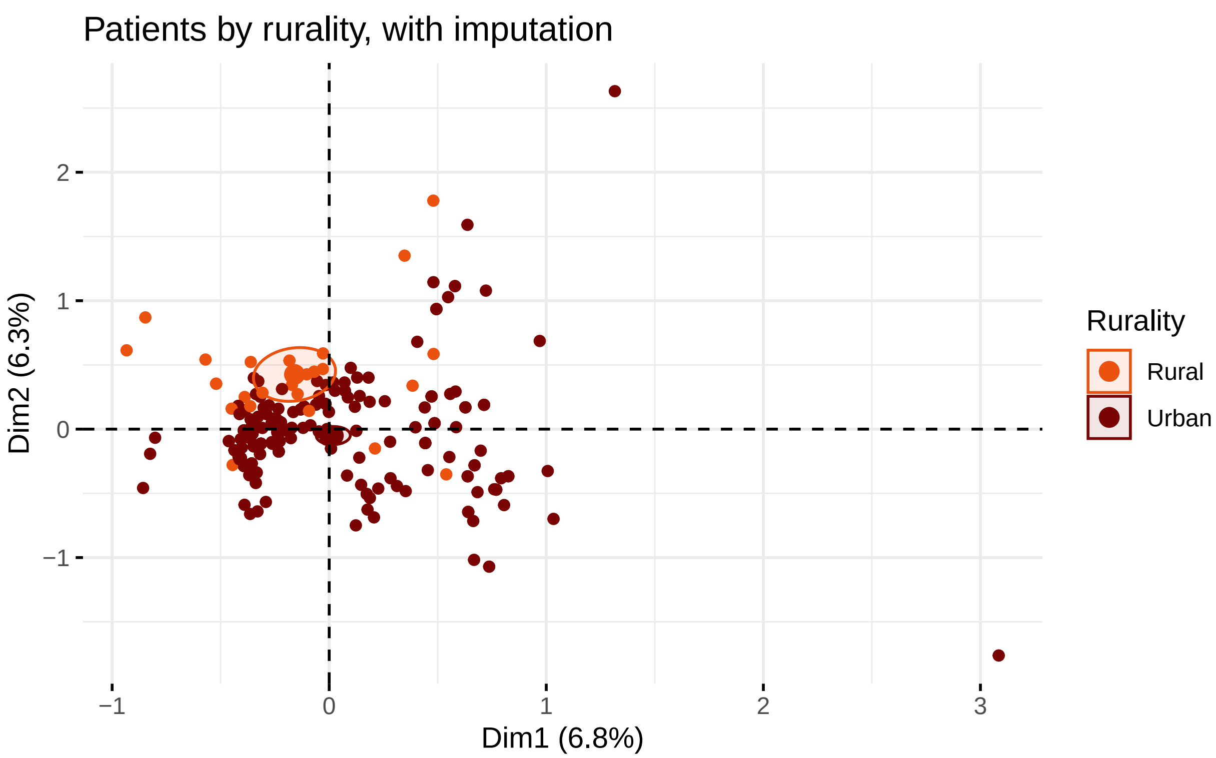



Figure 36: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by rurality of residence.

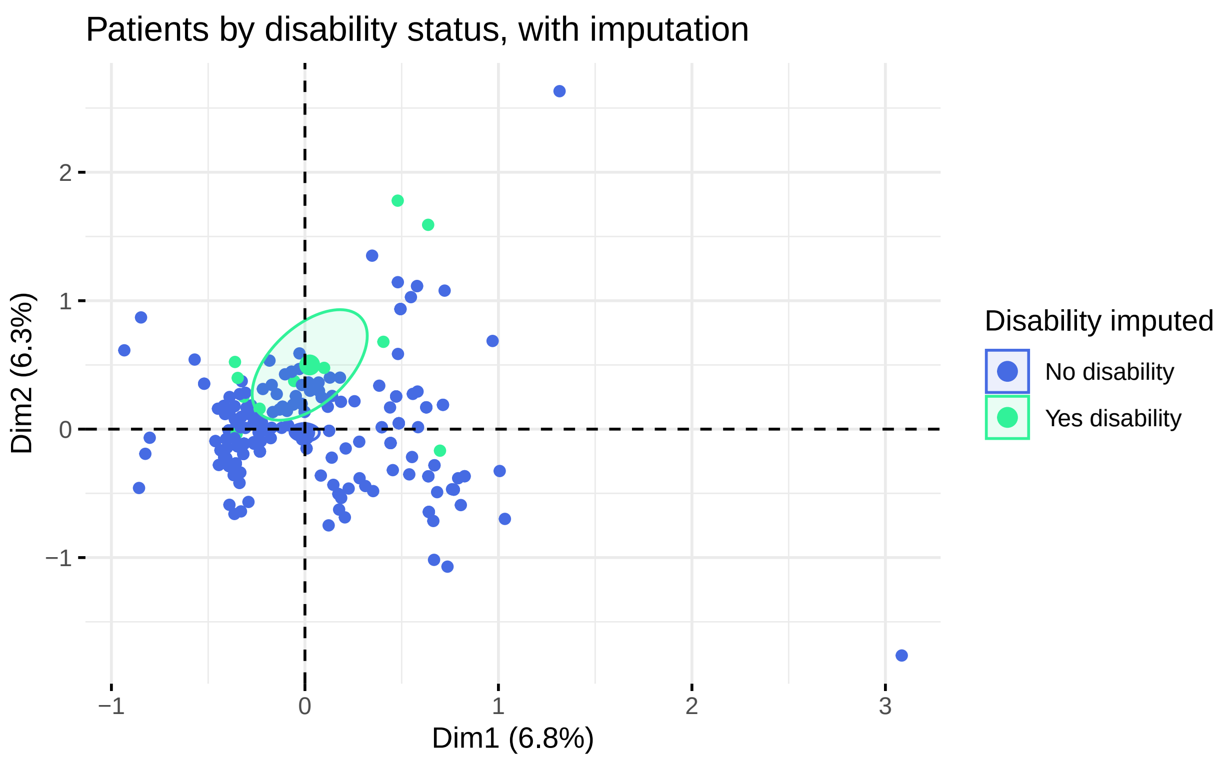



Figure 37: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by disability status.

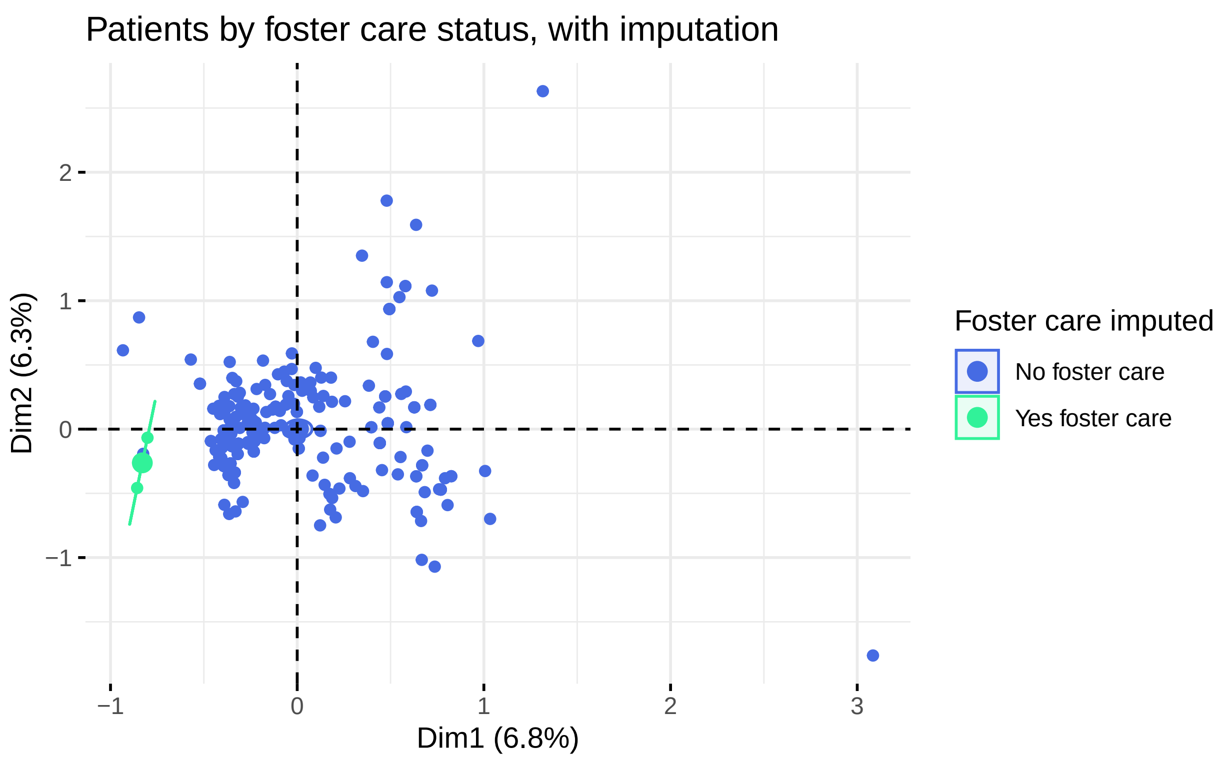



Figure 38: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using all features with imputation, coloured by foster care status.

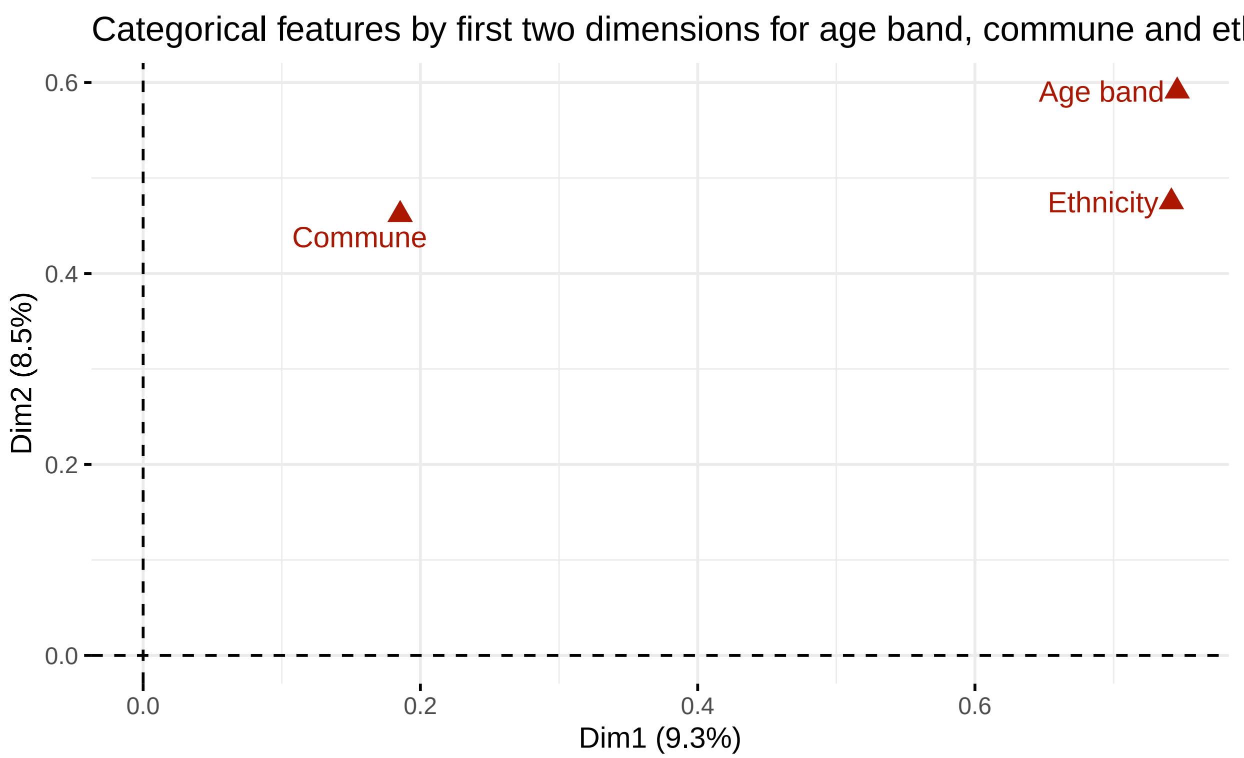



Figure 39: Categorical features by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using patients' age band, commune of residence and ethnicity.

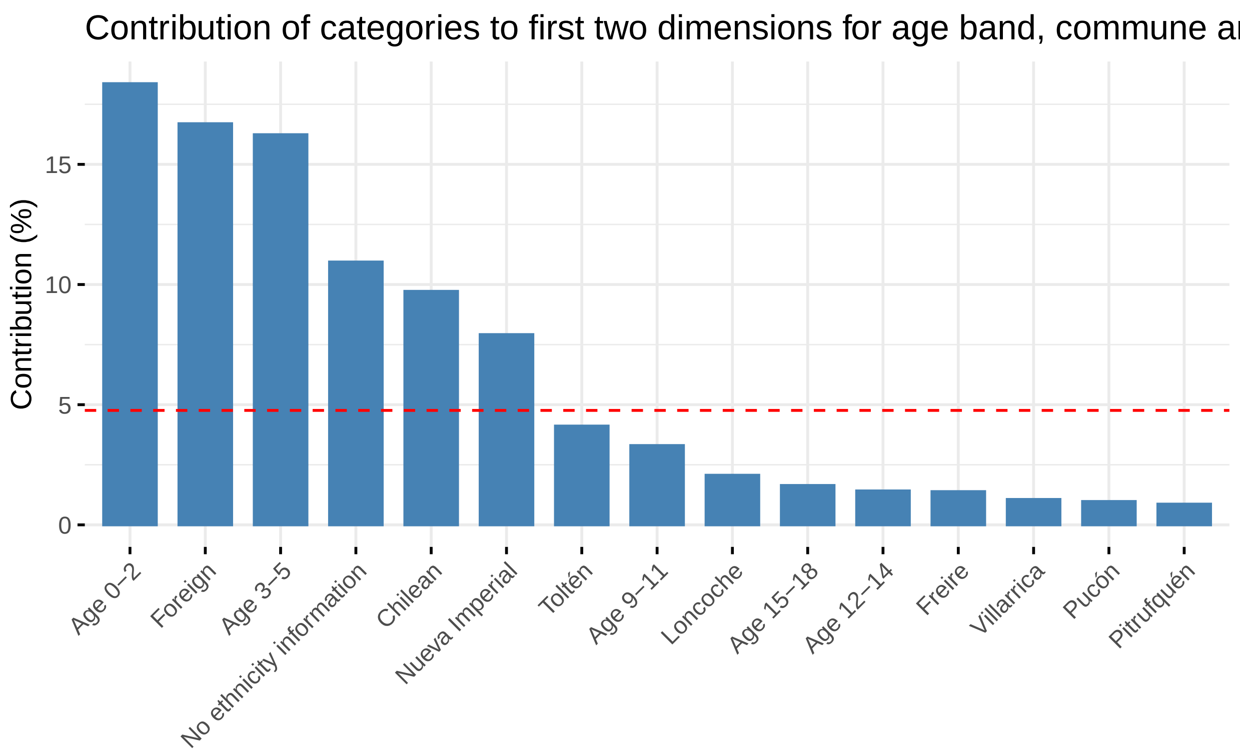



Figure 40: Contribution of the top 15 categories to the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using patients' age band, commune and ethnicity. The red line shows the expected average if contributions were uniform.

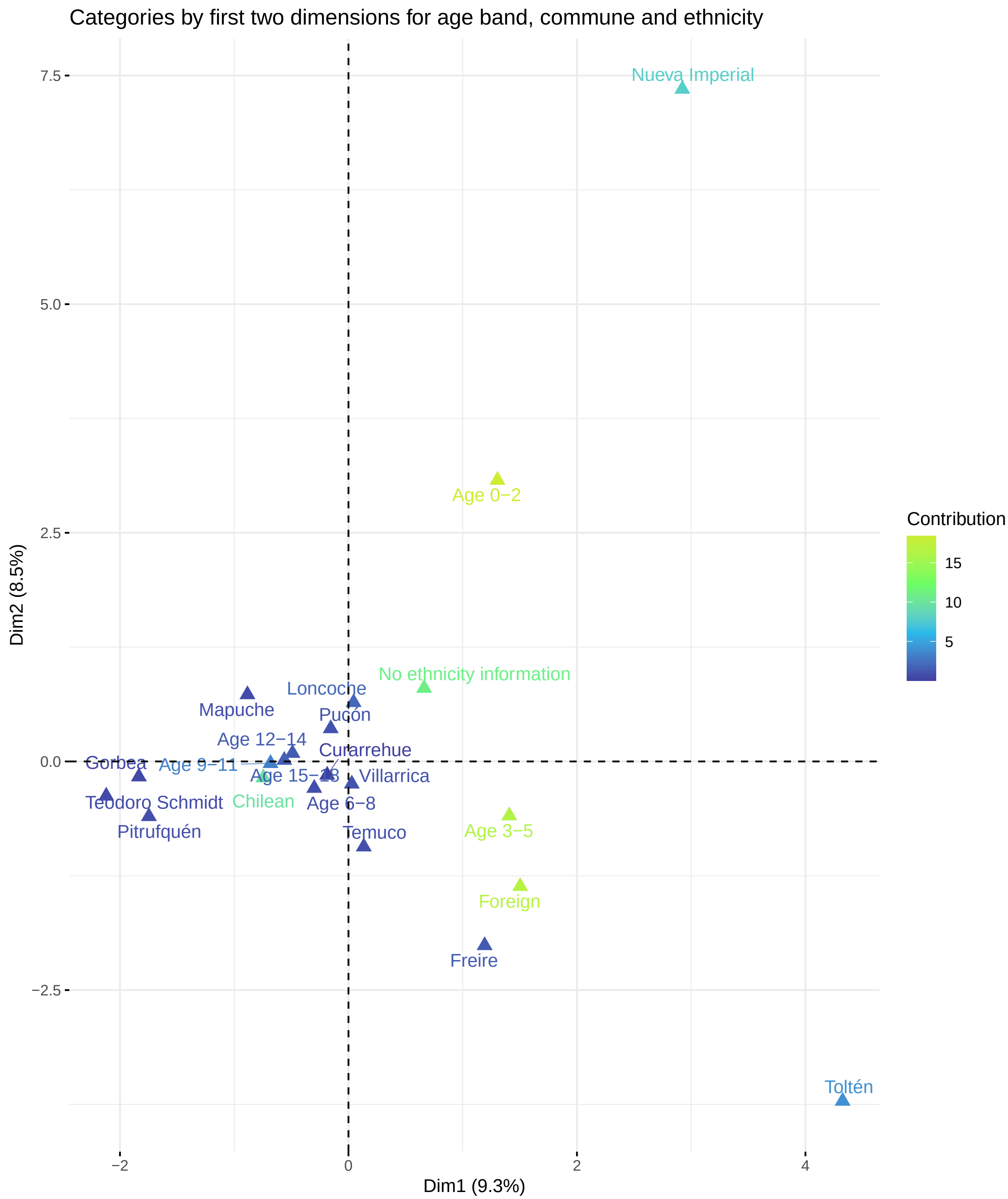



Figure 41: Available categories by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using patients' age band, commune and ethnicity. Brigther, more yellow colours indicate larger contribution to the first two dimensions.

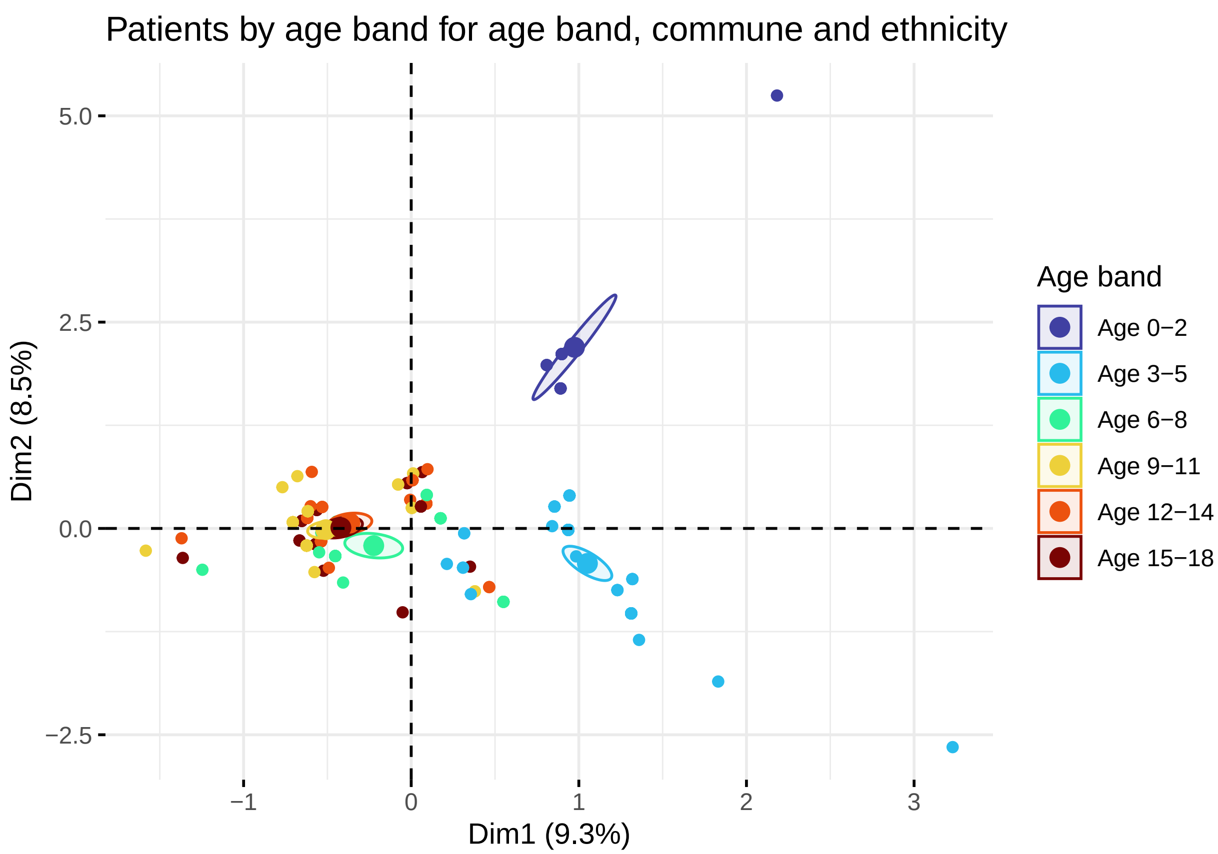



Figure 42: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using patients' age band, commune and ethnicity, coloured by age band.

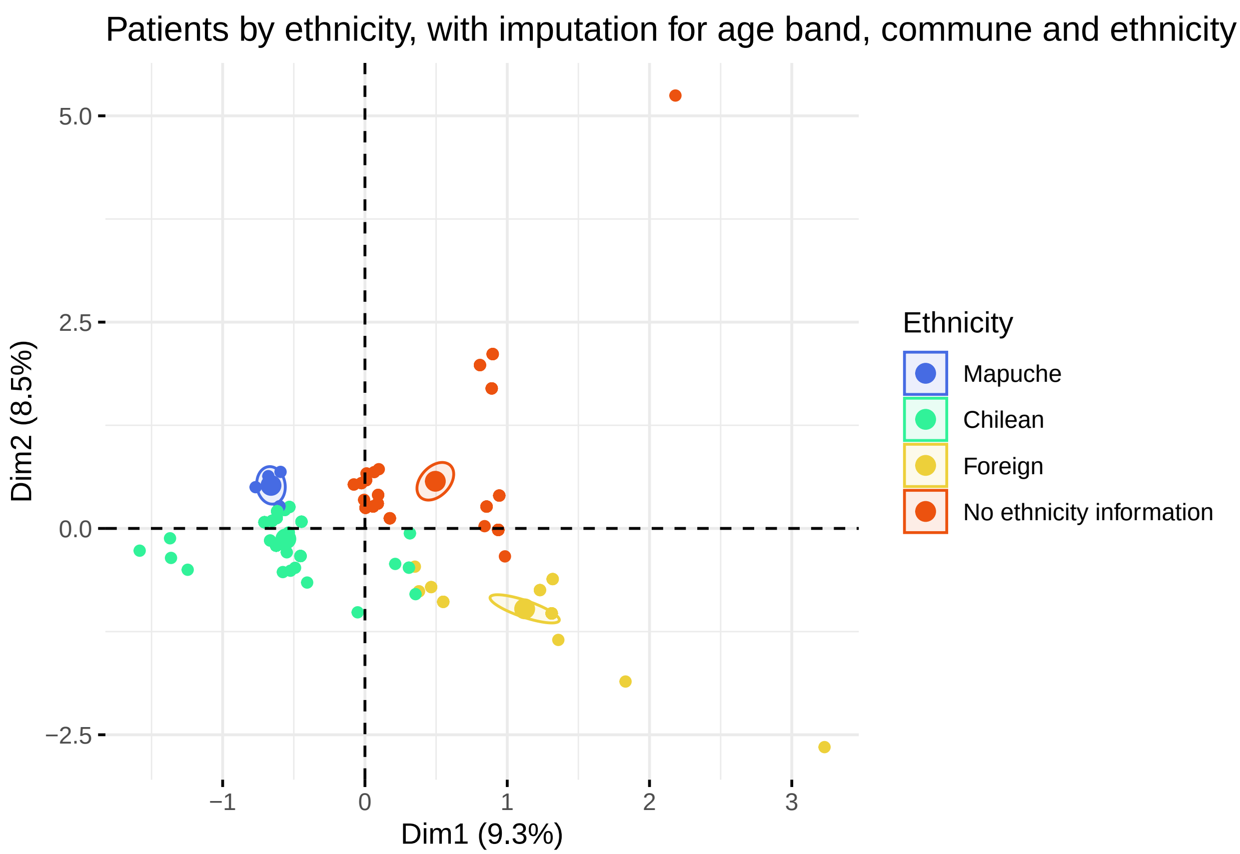



Figure 43: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using age band, commune and ethnicity, coloured by ethnicity.

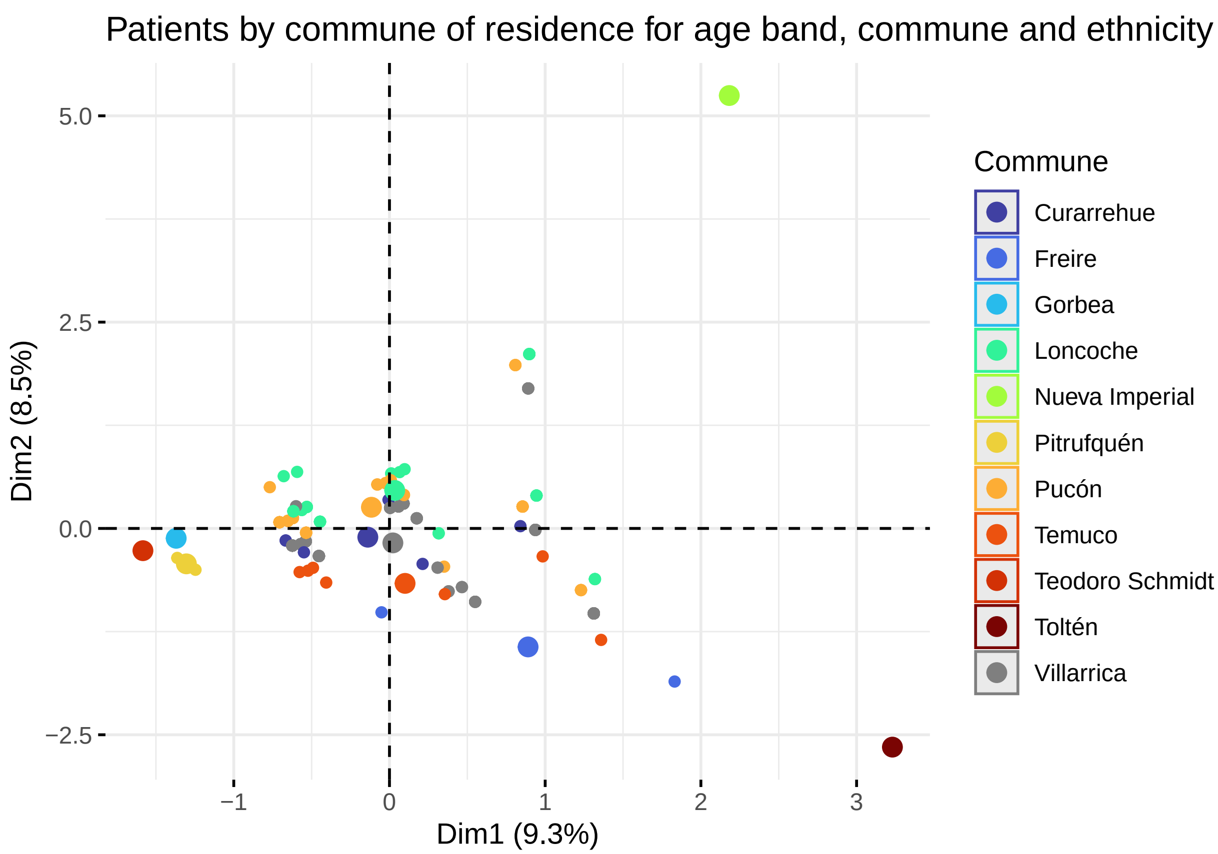



Figure 44: Patients by the first two dimensions of multiple correspondence analysis on autism patients in the small clinical data using age band, commune and ethnicity, coloured by commune of residence.

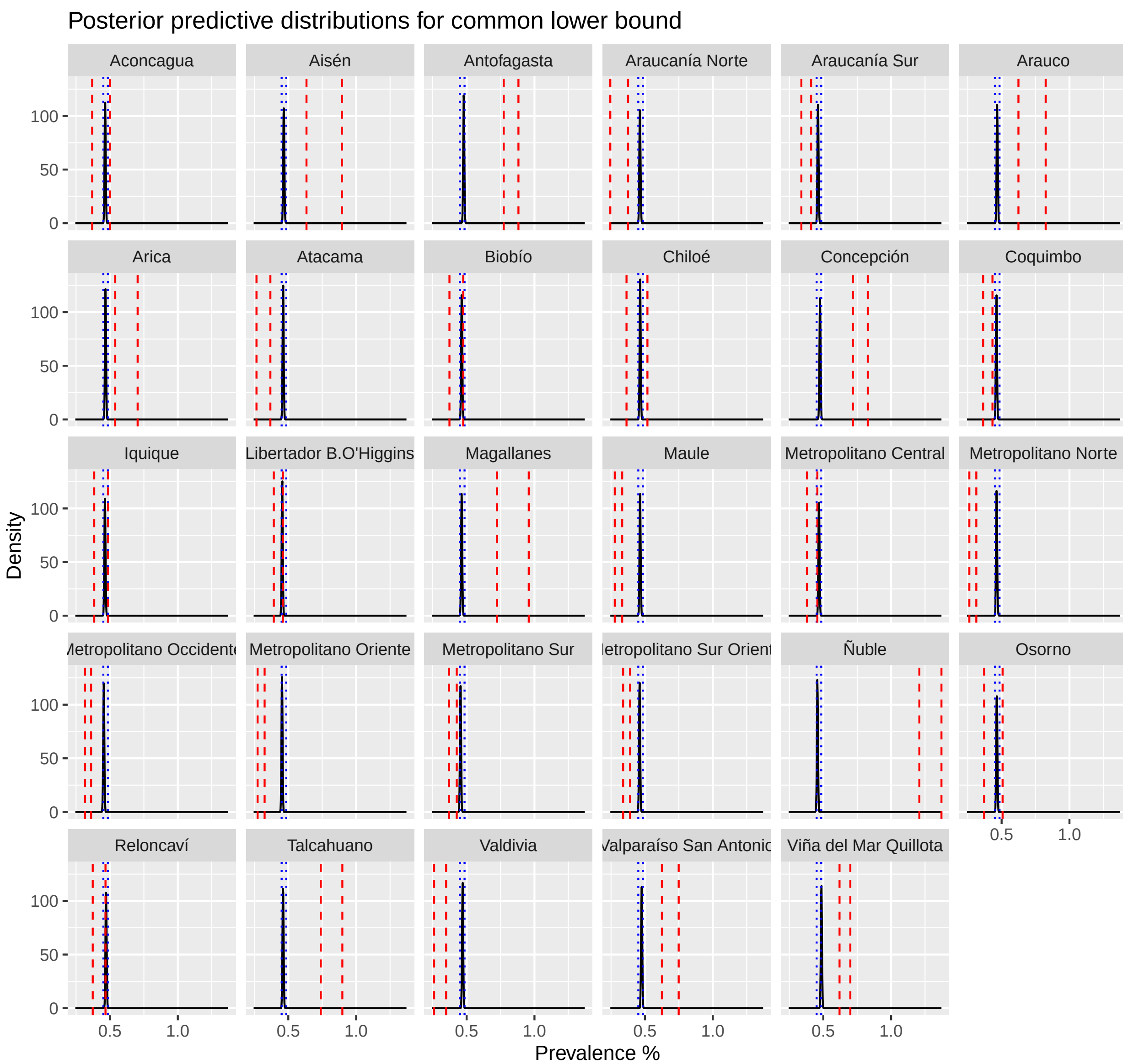



Figure 45: Posterior predictive distributions for autism prevalence using adjusted case counts from the school data with a random effect on student's health service. Beta conjugate prior of age- and sex-adjusted global autism prevalence from school data. Red dashed lines show the adjusted sample prevalence 95% gamma confidence intervals and blue dotted lines show the posterior 95% credible interval.

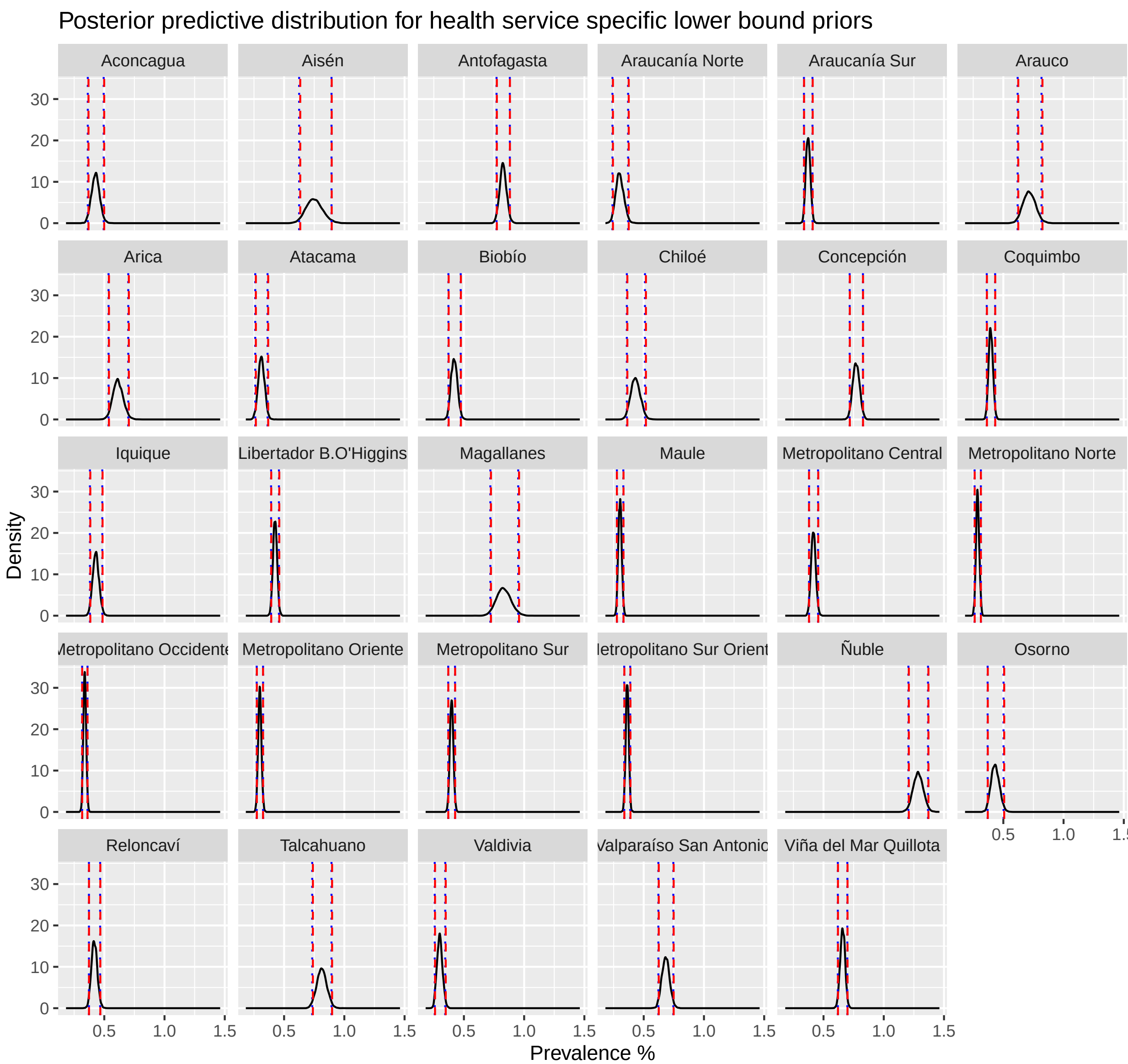



Figure 46: Posterior predictive distributions for autism prevalence using adjusted case counts from the school data with a random effect on student's health service. Beta conjugate prior of health service specific age- and sex-adjusted autism prevalence from school data. Red dashed lines show the adjusted sample prevalence 95% gamma confidence intervals and blue dotted lines show the posterior 95% credible interval.

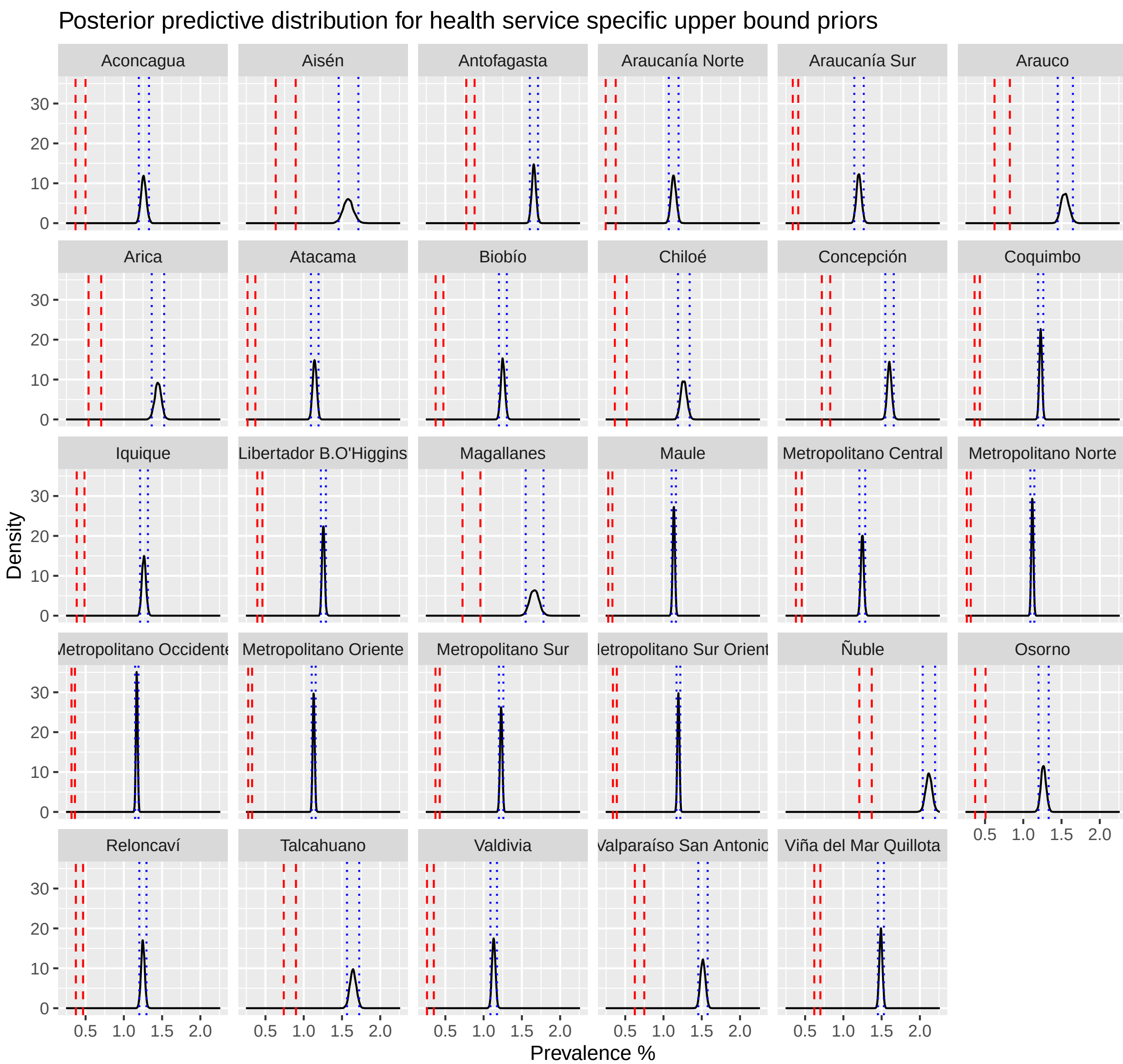



Figure 47: Posterior predictive distributions for autism prevalence using adjusted case counts from the school data with a random effect on student's health service. Beta conjugate prior of health service specific age- and sex-adjusted projected autism prevalence from linked data. Red dashed lines show the adjusted sample prevalence 95% gamma confidence intervals and blue dotted lines show the posterior 95% credible interval.

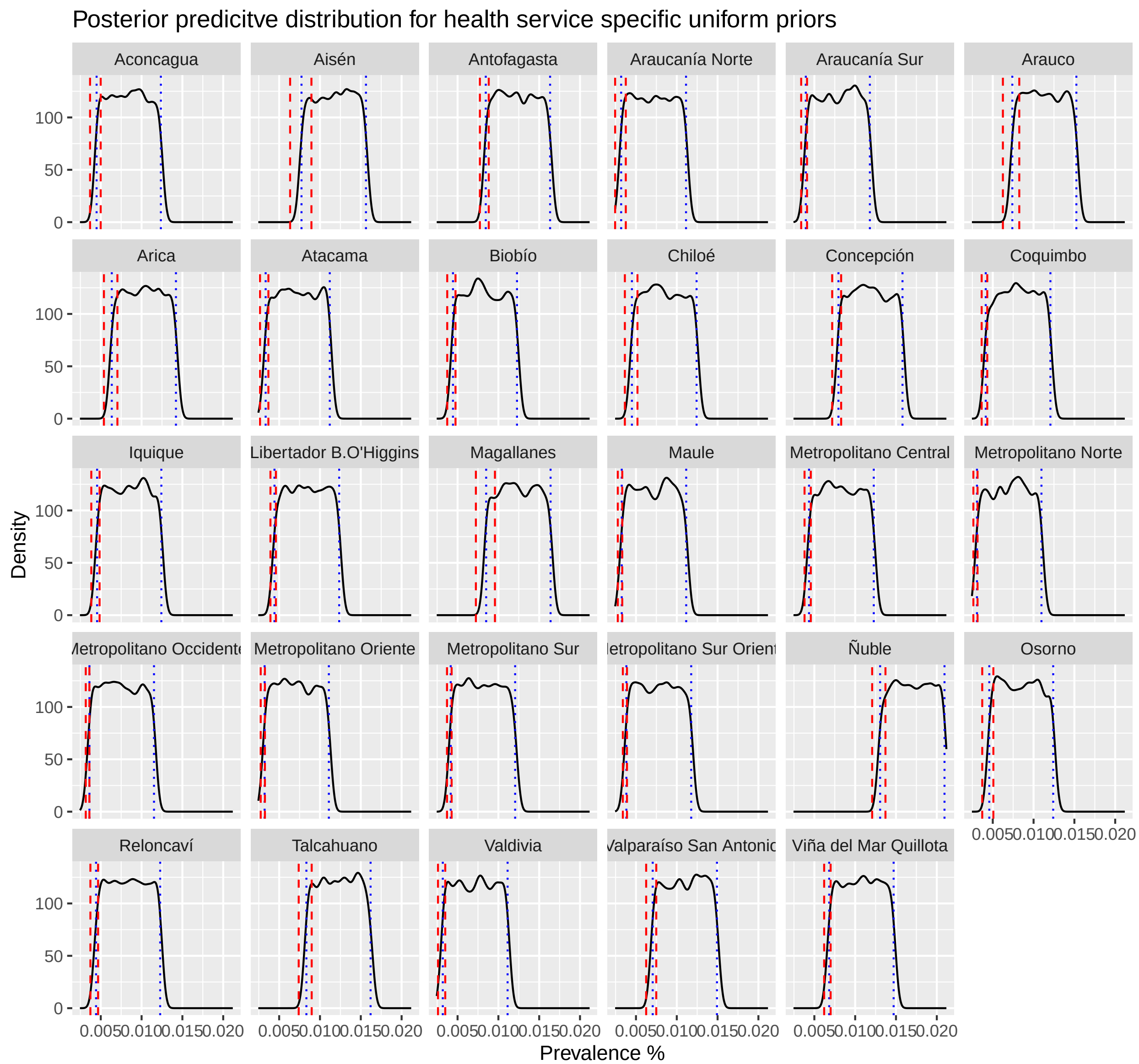



Figure 48: Posterior predictive distributions for autism prevalence using adjusted case counts from the school data with a random effect on student's health service. Uniform prior bounded by health service specific age- and sex-adjusted autism prevalence from school data, and health service specific age- and sex-adjusted projected autism prevalence from linked data. Red dashed lines show the adjusted sample prevalence 95% gamma confidence intervals and blue dotted lines show the posterior 95% credible interval.

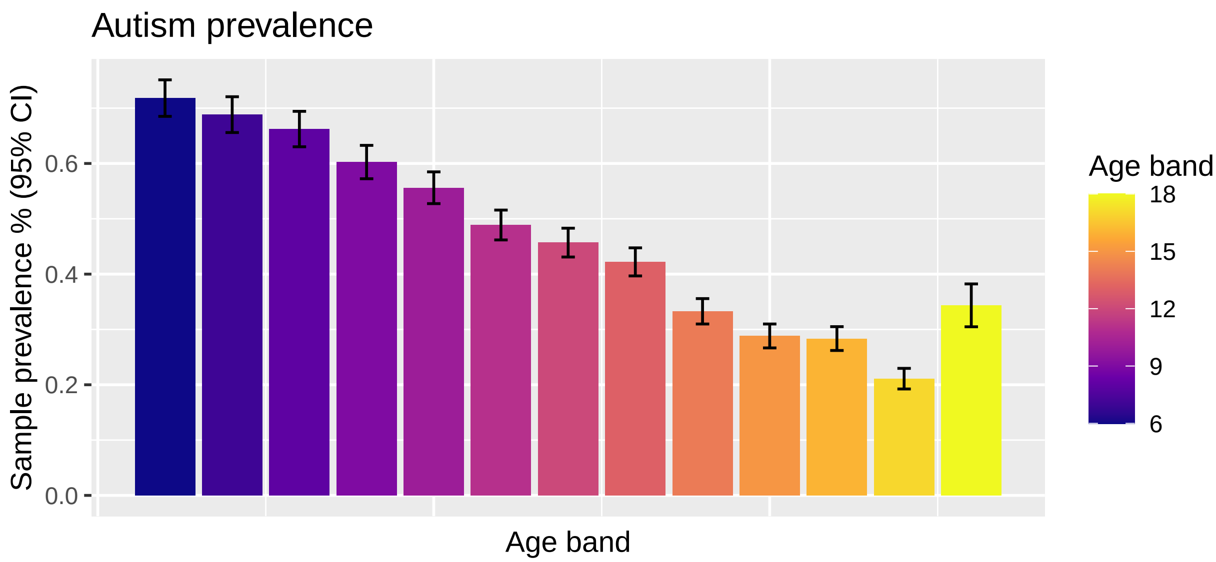



Figure 49: Sample prevalence of autism by age band. Bars show 95% normal confidence intervals.

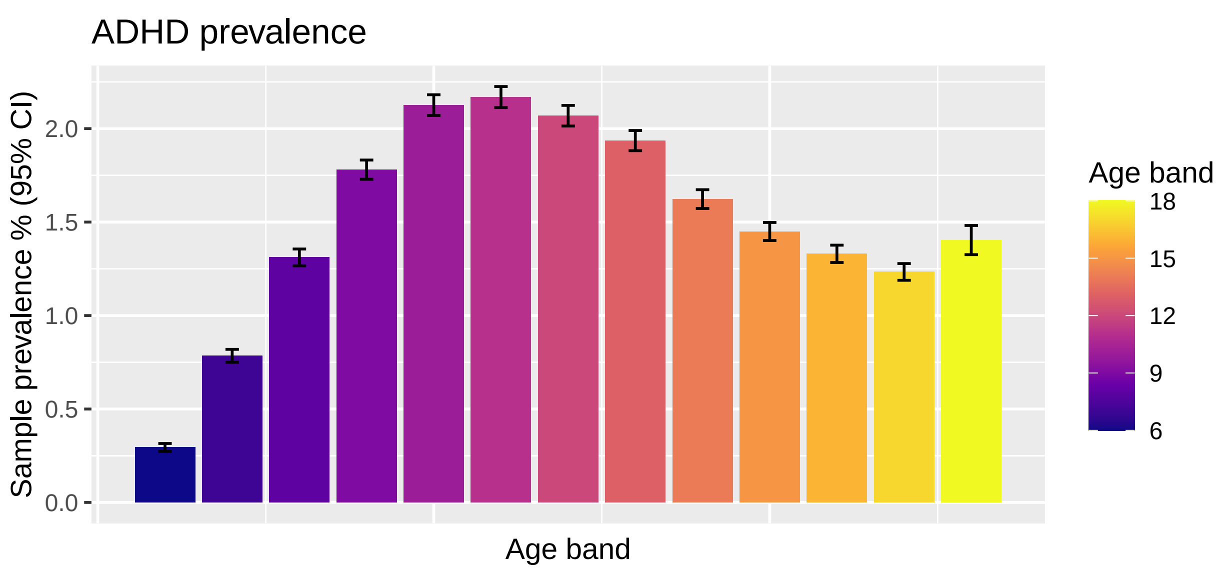



Figure 50: Sample prevalence of ADHD by age band. Bars show 95% normal confidence intervals.

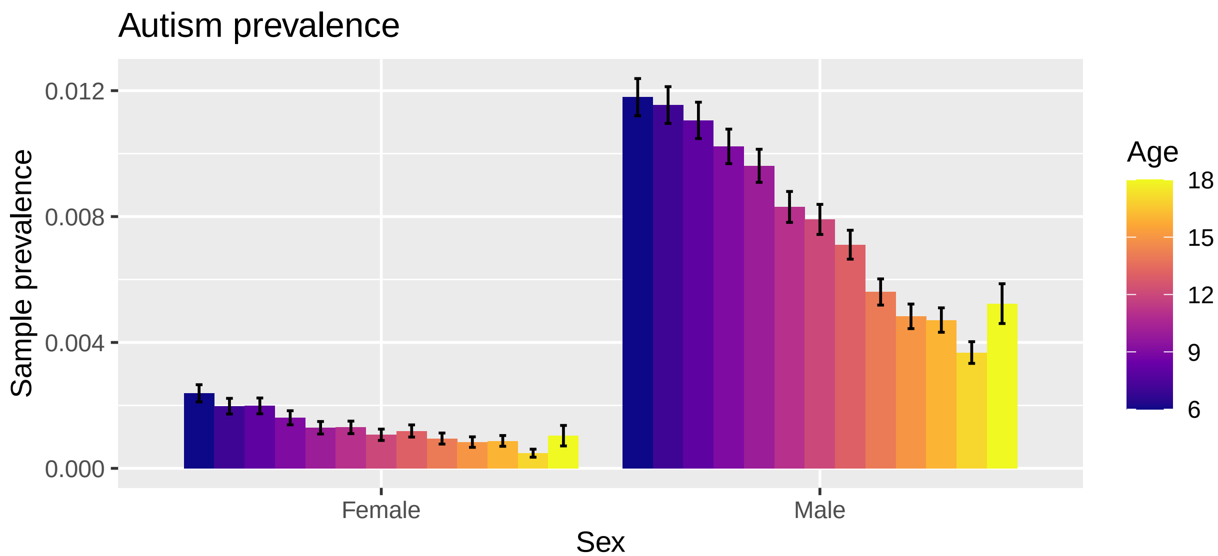



Figure 51: Sample prevalence of autism by age and sex. Bars show 95% normal confidence intervals.

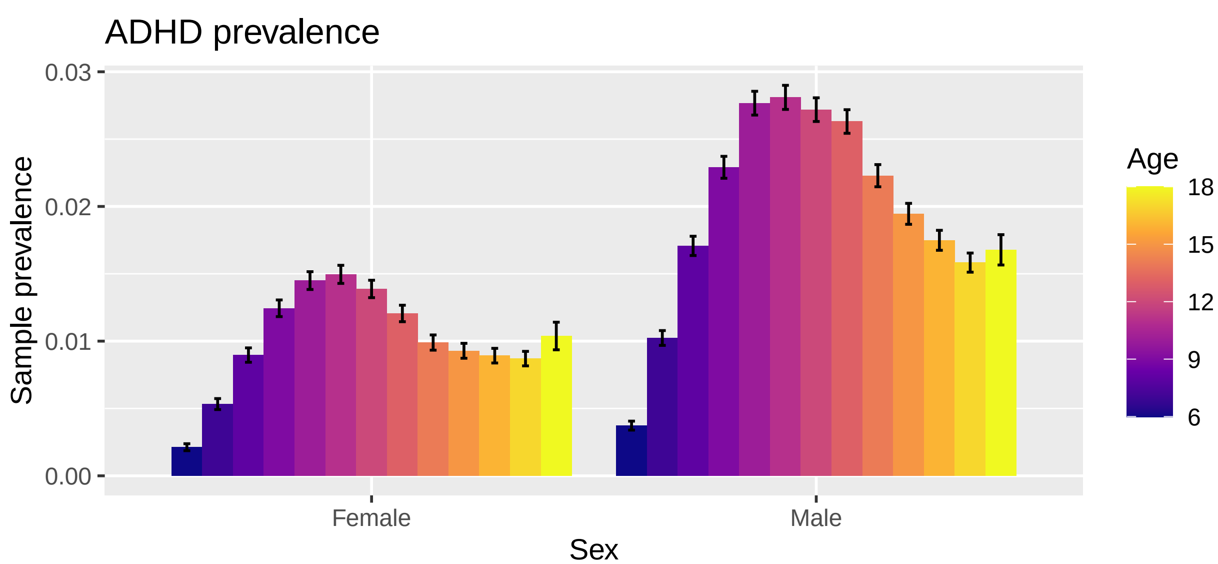



Figure 52: Sample prevalence of ADHD by age and sex. Bars show 95% normal confidence intervals.

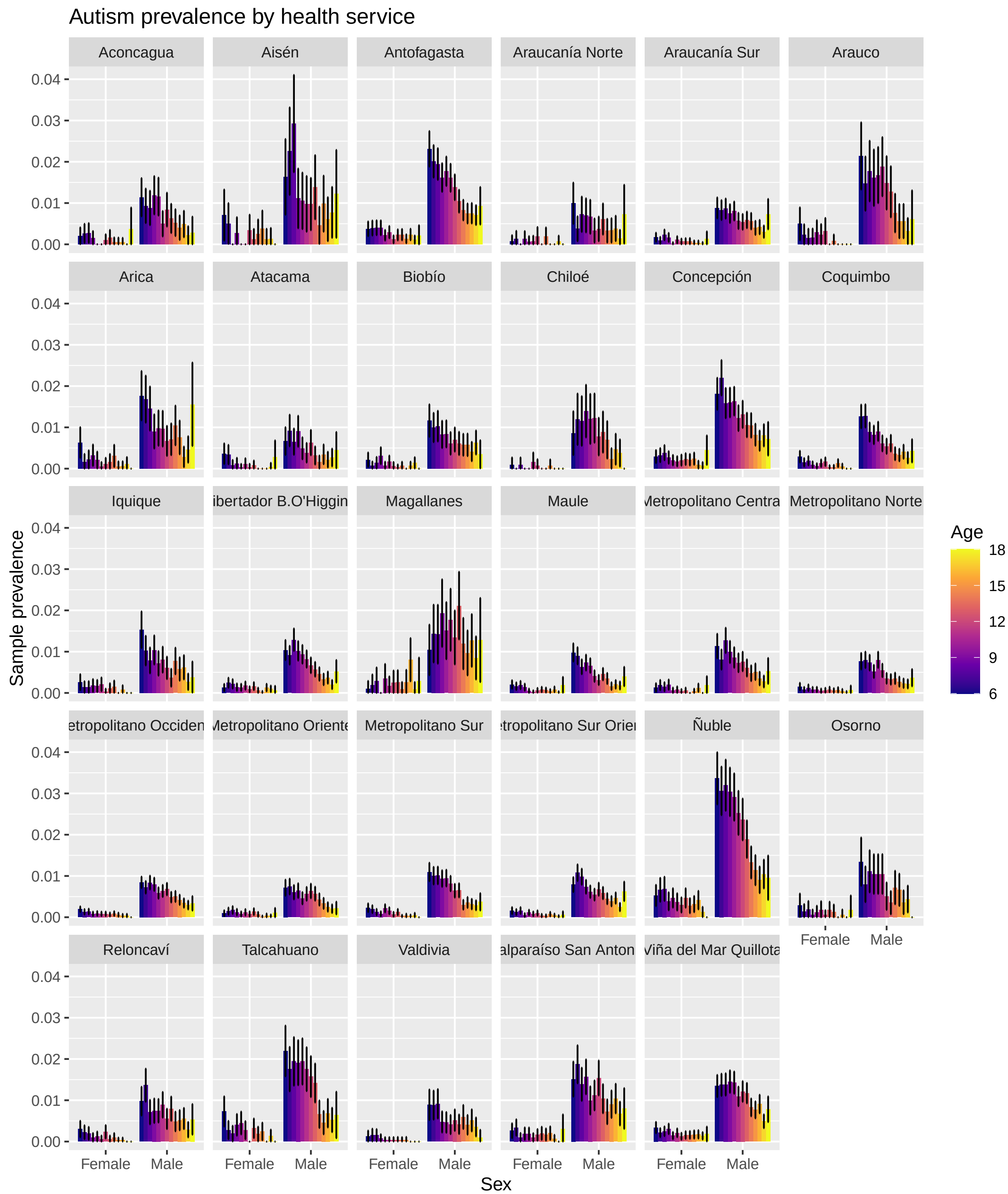



Figure 53: Sample prevalence of autism by health service, age and sex. Bars show 95% normal confidence intervals.

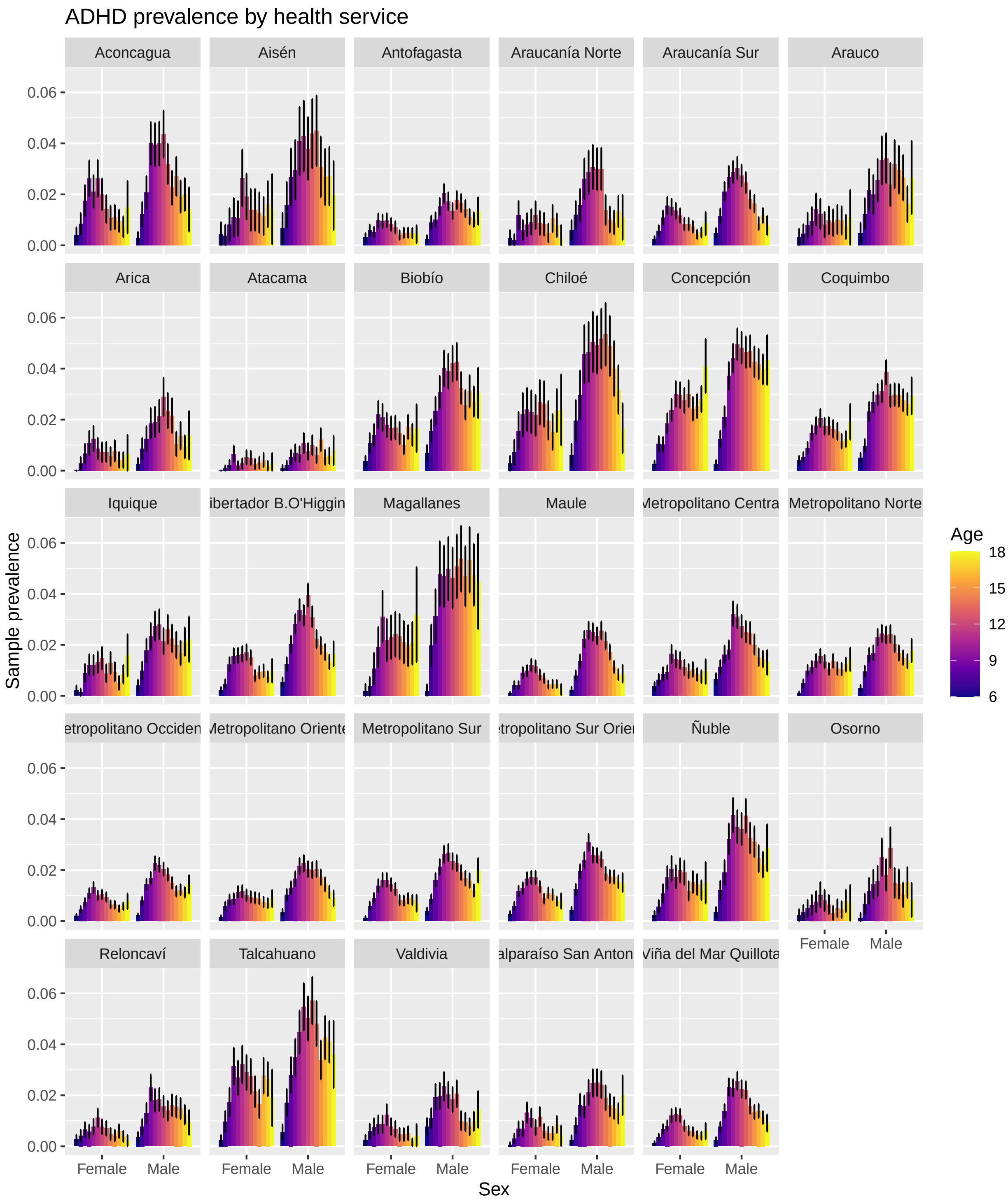



Figure 54: Sample prevalence of ADHD by health service, age and sex. Bars show 95% normal confidence intervals.

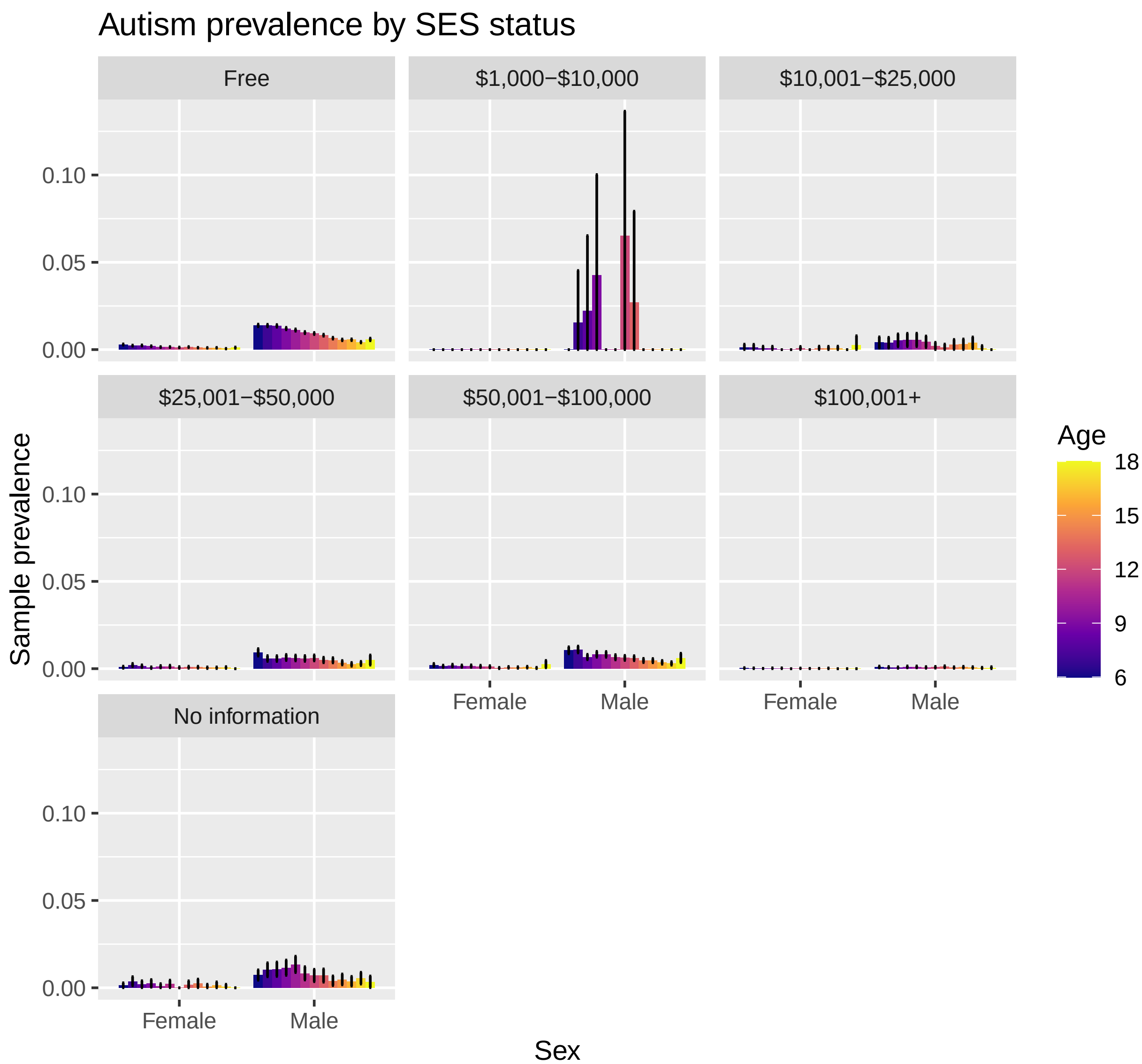



Figure 55: Sample prevalence of autism by socio-economic (SES) status of student's family, age and sex. Bars show 95% normal confidence intervals.

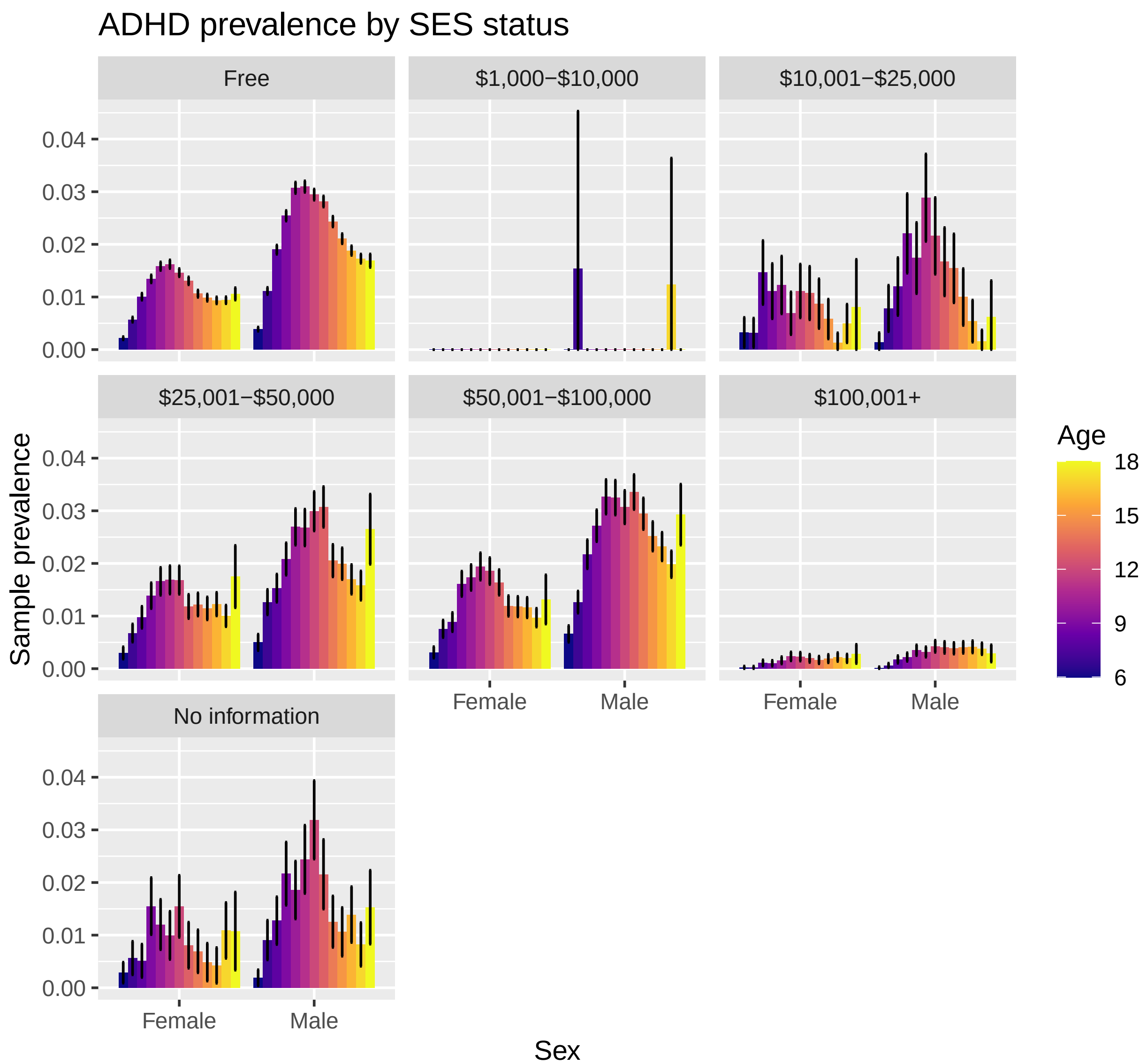



Figure 56: Sample prevalence of ADHD by socio-economic (SES) status of student's family, age and sex. Bars show 95% normal confidence intervals.

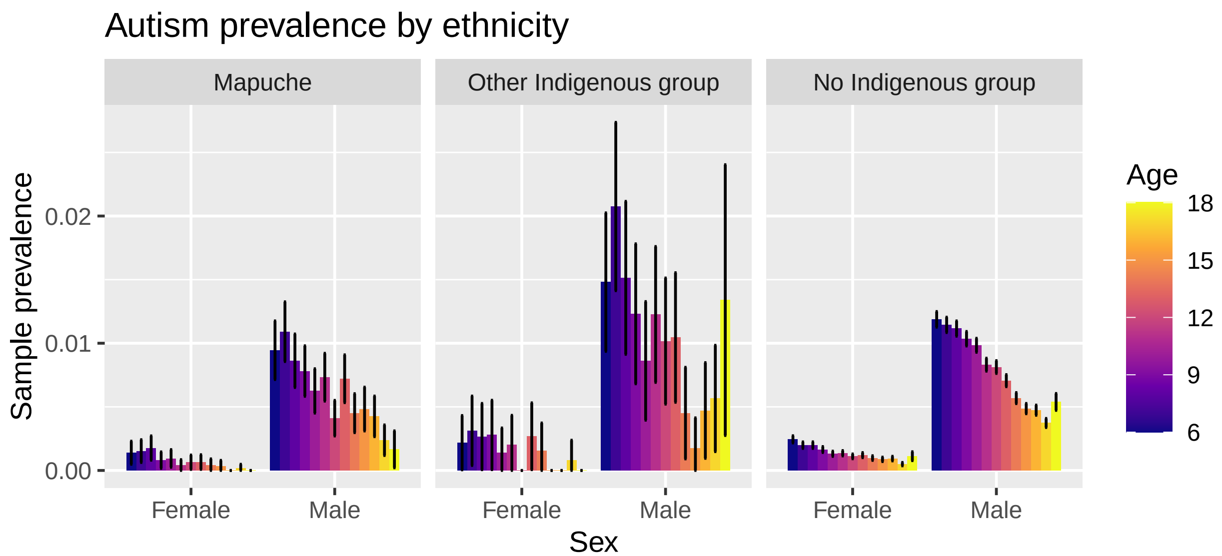



Figure 57: Sample prevalence of autism by ethnicity, age and sex. Bars show 95% normal confidence intervals.

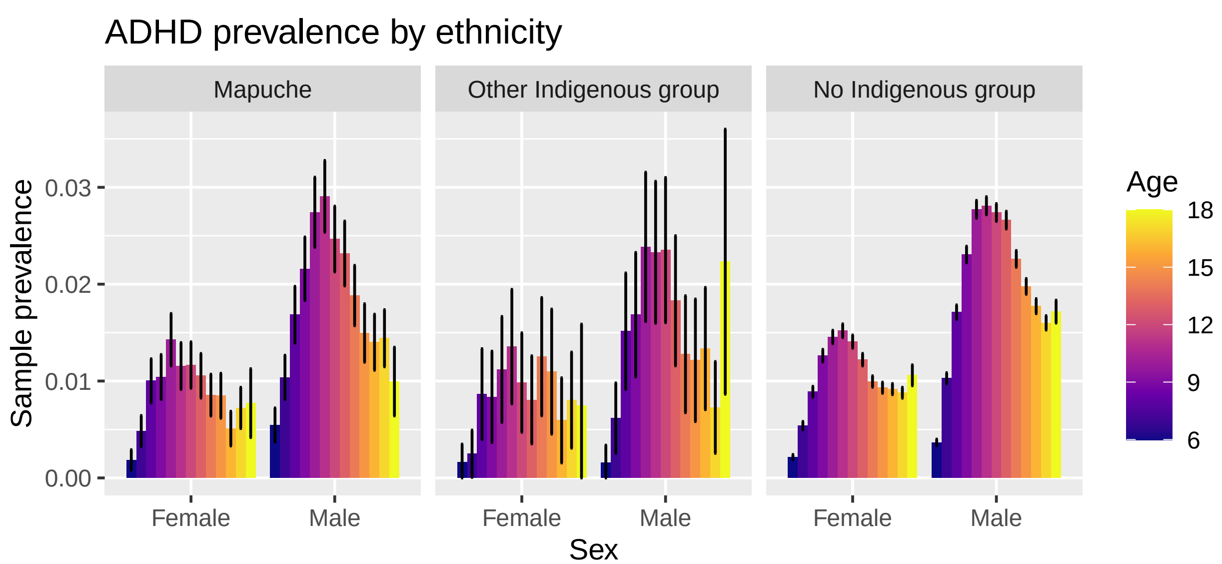



Figure 58: Sample prevalence of ADHD by ethnicity, age and sex. Bars show 95% normal confidence intervals.

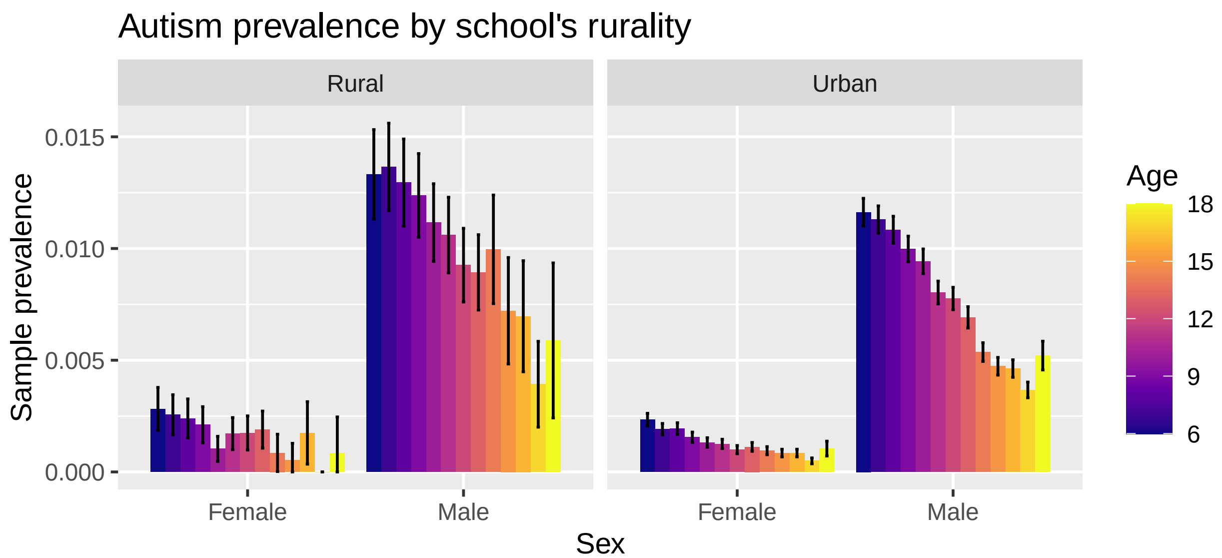



Figure 59: Sample prevalence of autism by school's rurality, age and sex. Bars show 95% normal confidence intervals.

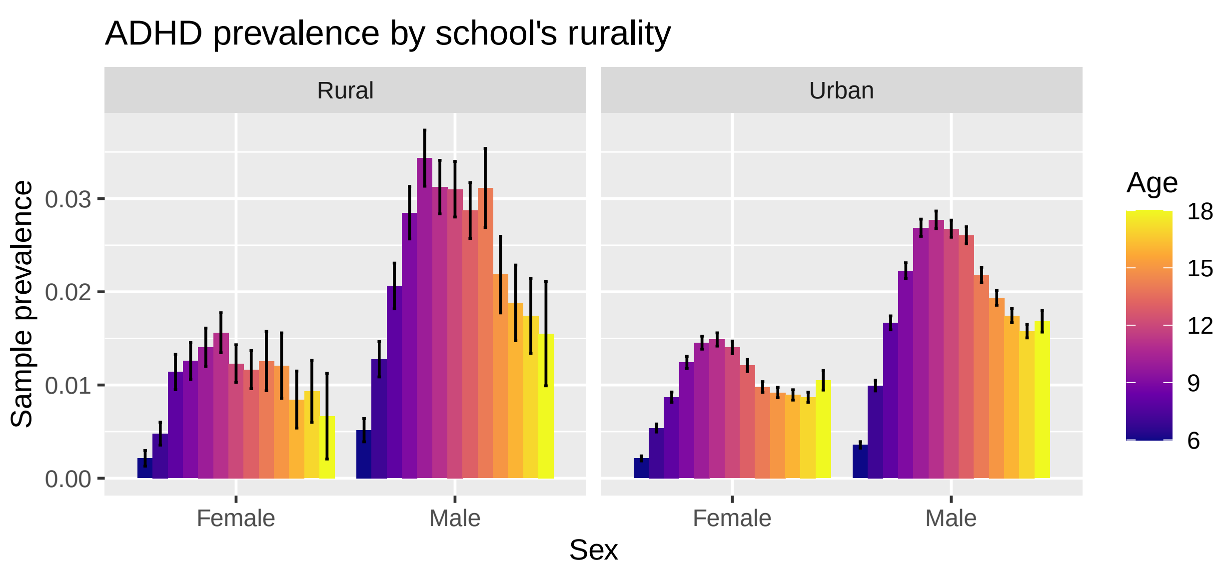



Figure 60: Sample prevalence of ADHD by school's rurality, age and sex. Bars show 95% normal confidence intervals.

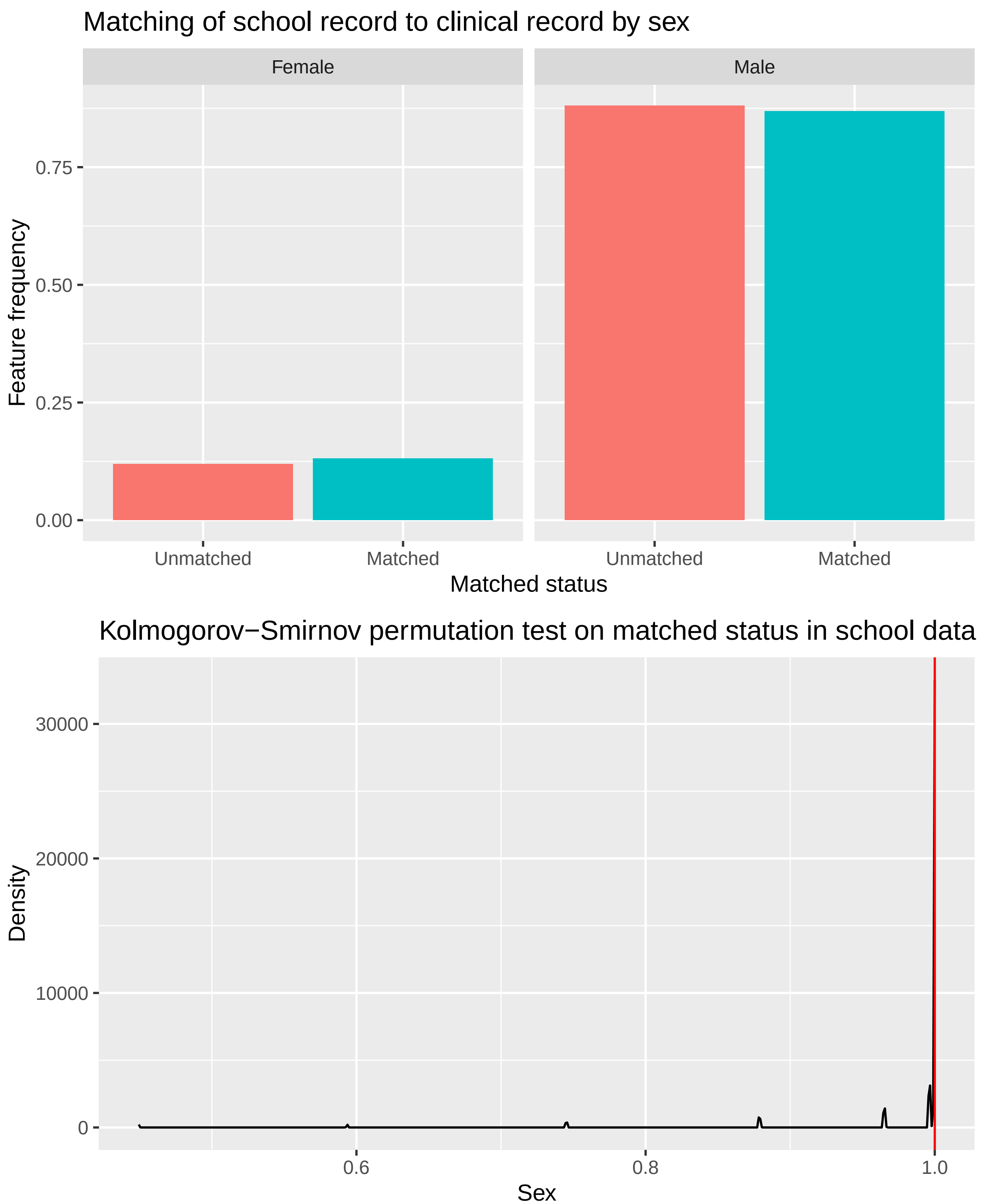



Figure 61: a) Difference in frequency of sexes among school records that matched to patient records and school records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for school records by sex with observed p-value shown in red.

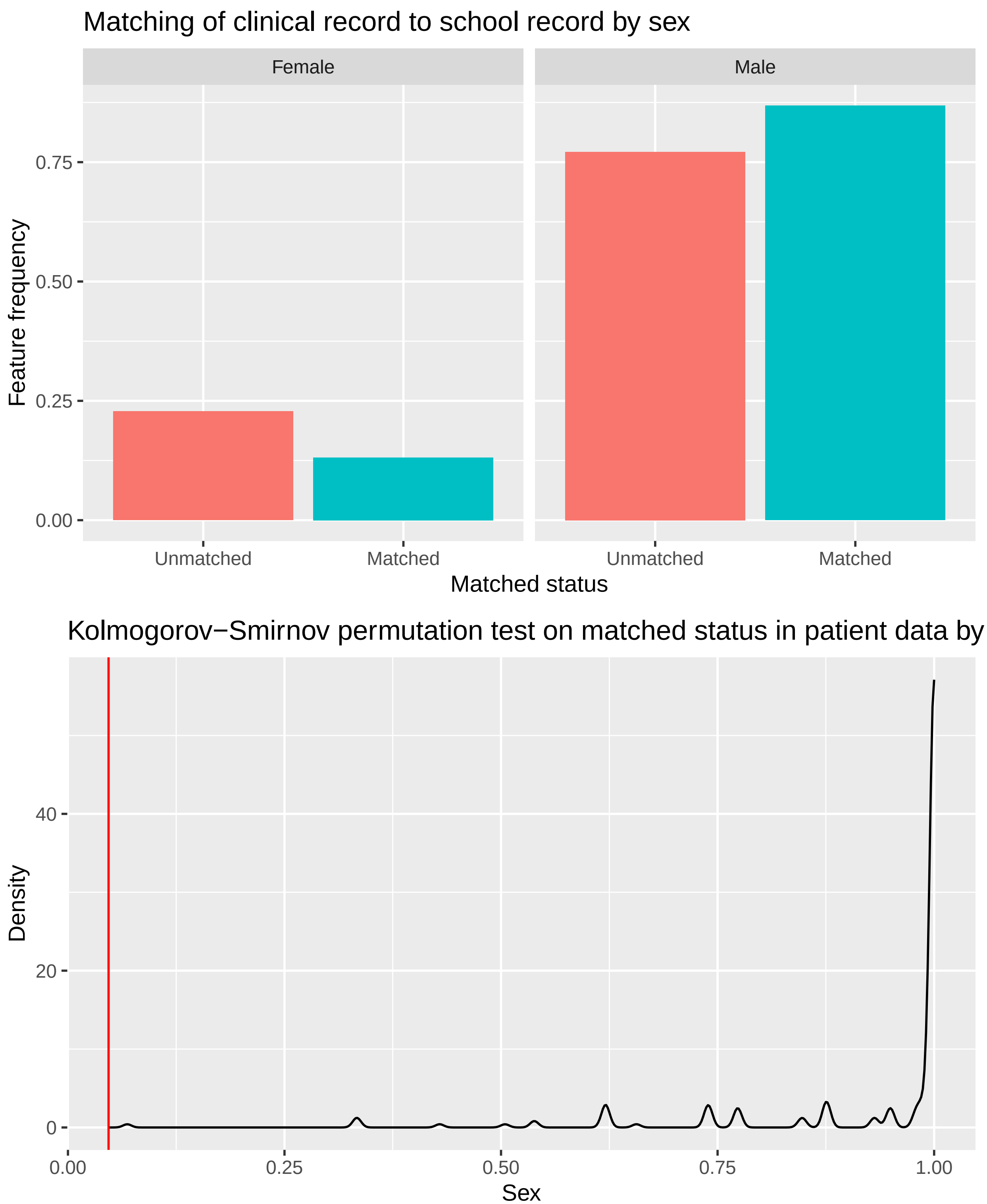
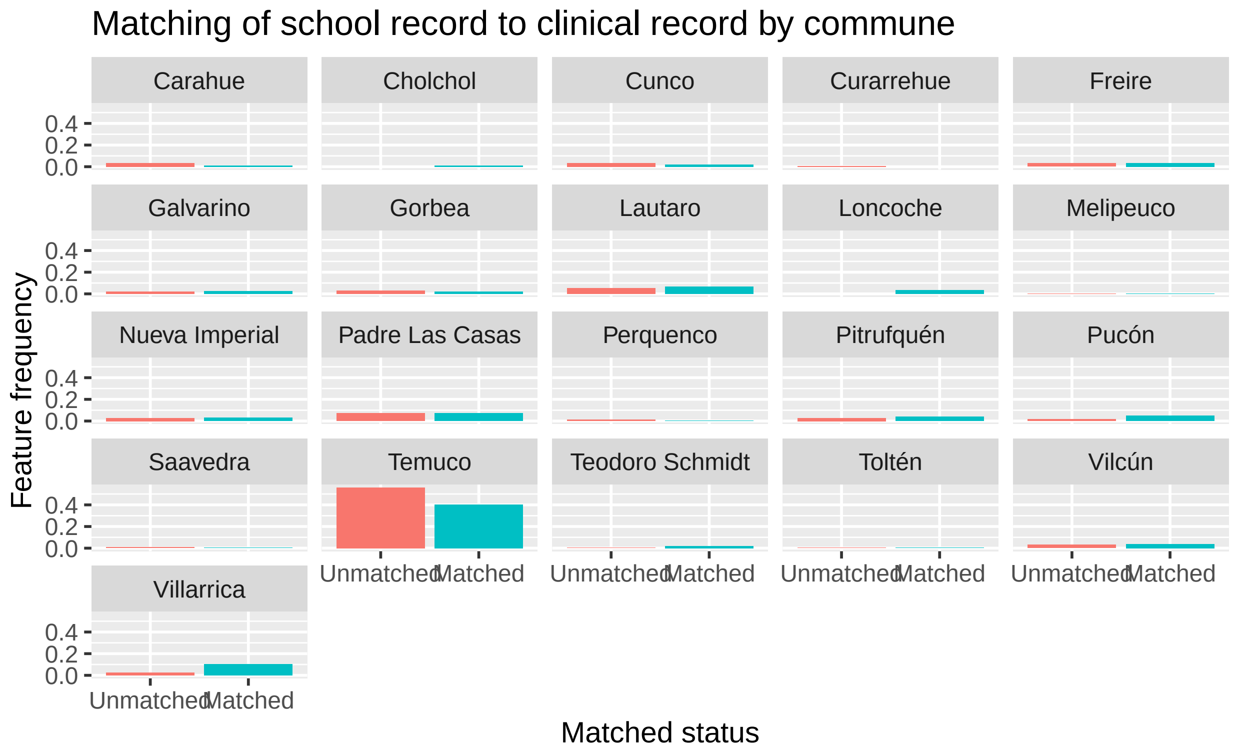



Figure 62: a) Difference in frequency of sexes among patient records that matched to school records and patient records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for patient records by sex with observed p-value shown in red.



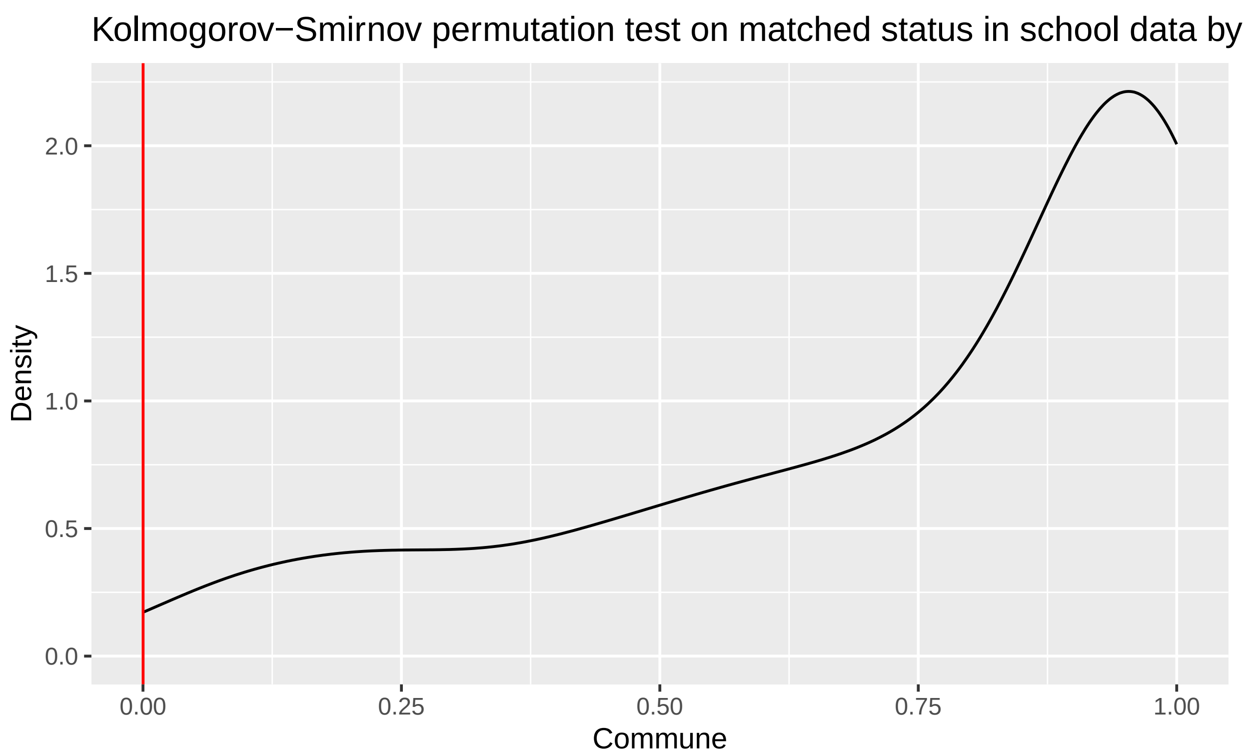




Figure 63: a) Difference in frequency of communes of residence among school records that matched to patient records and school records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for school records by commune of residence with observed p-value shown in red.

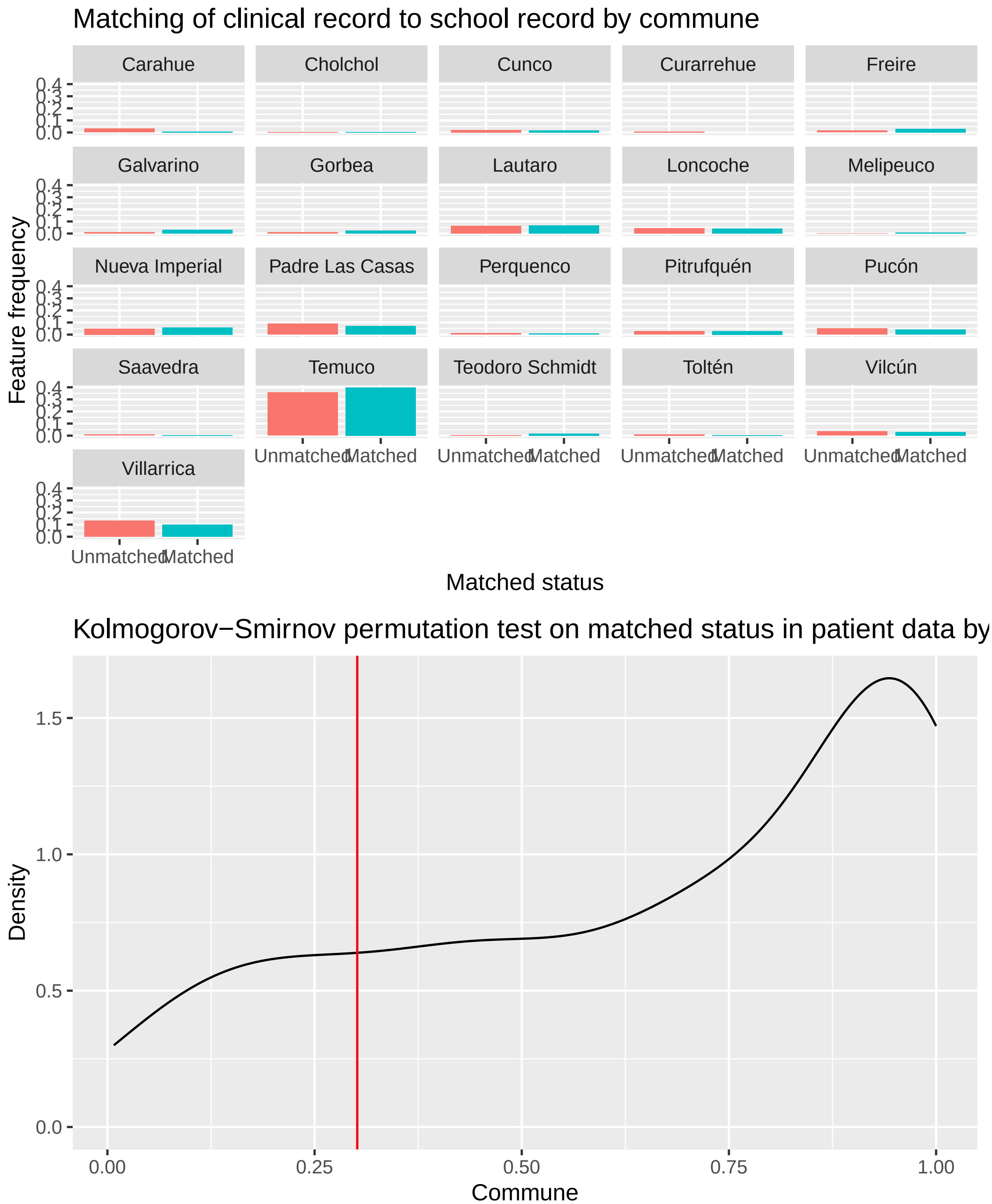



Figure 64: a) Difference in frequency of commune of residence among patient records that matched to school records and patient records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for patient records by commune of residence with observed p-value shown in red.

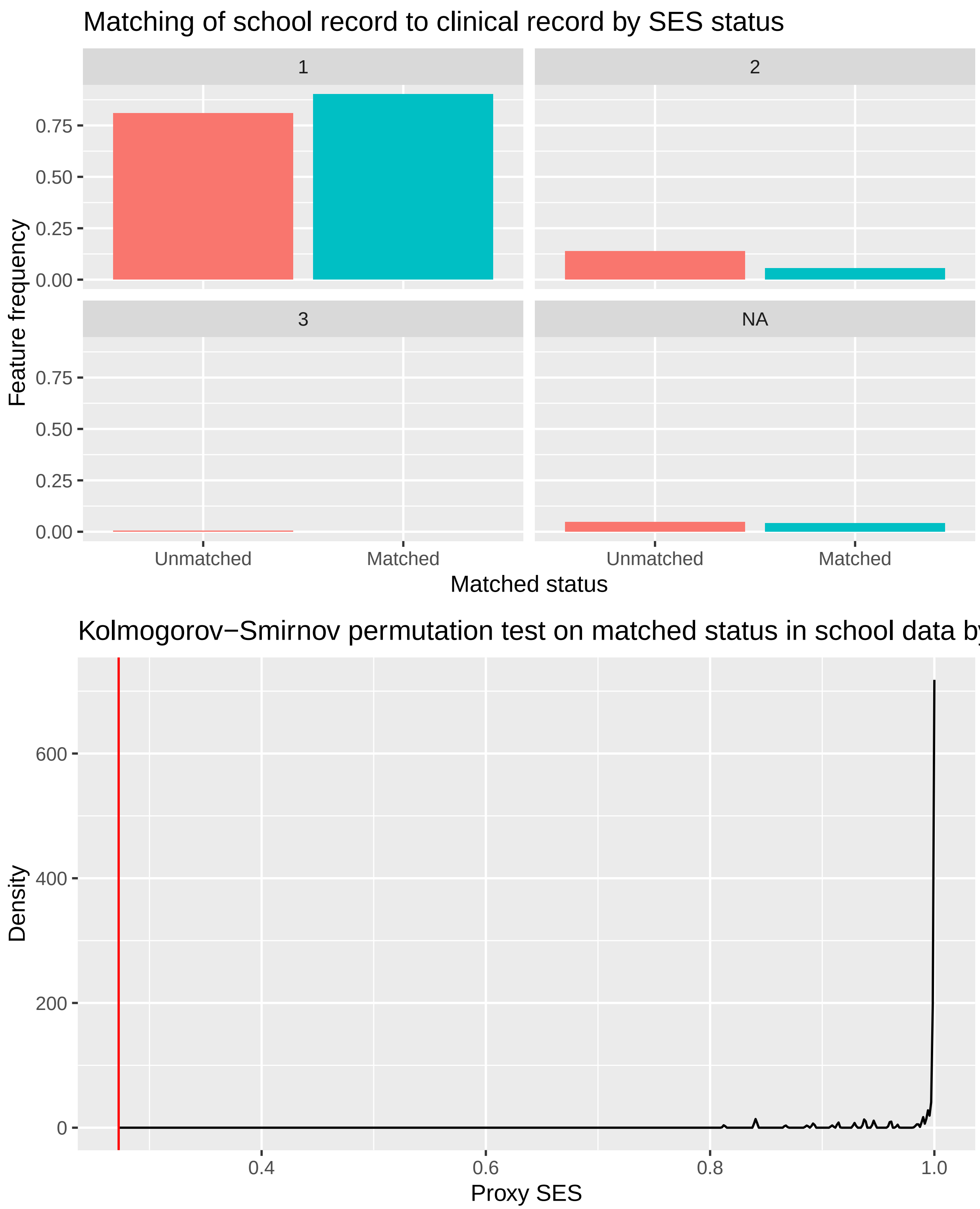



Figure 65: a) Difference in frequency of proxy SES among school records that matched to patient records and school records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for school records by proxy SES with observed p-value shown in red.

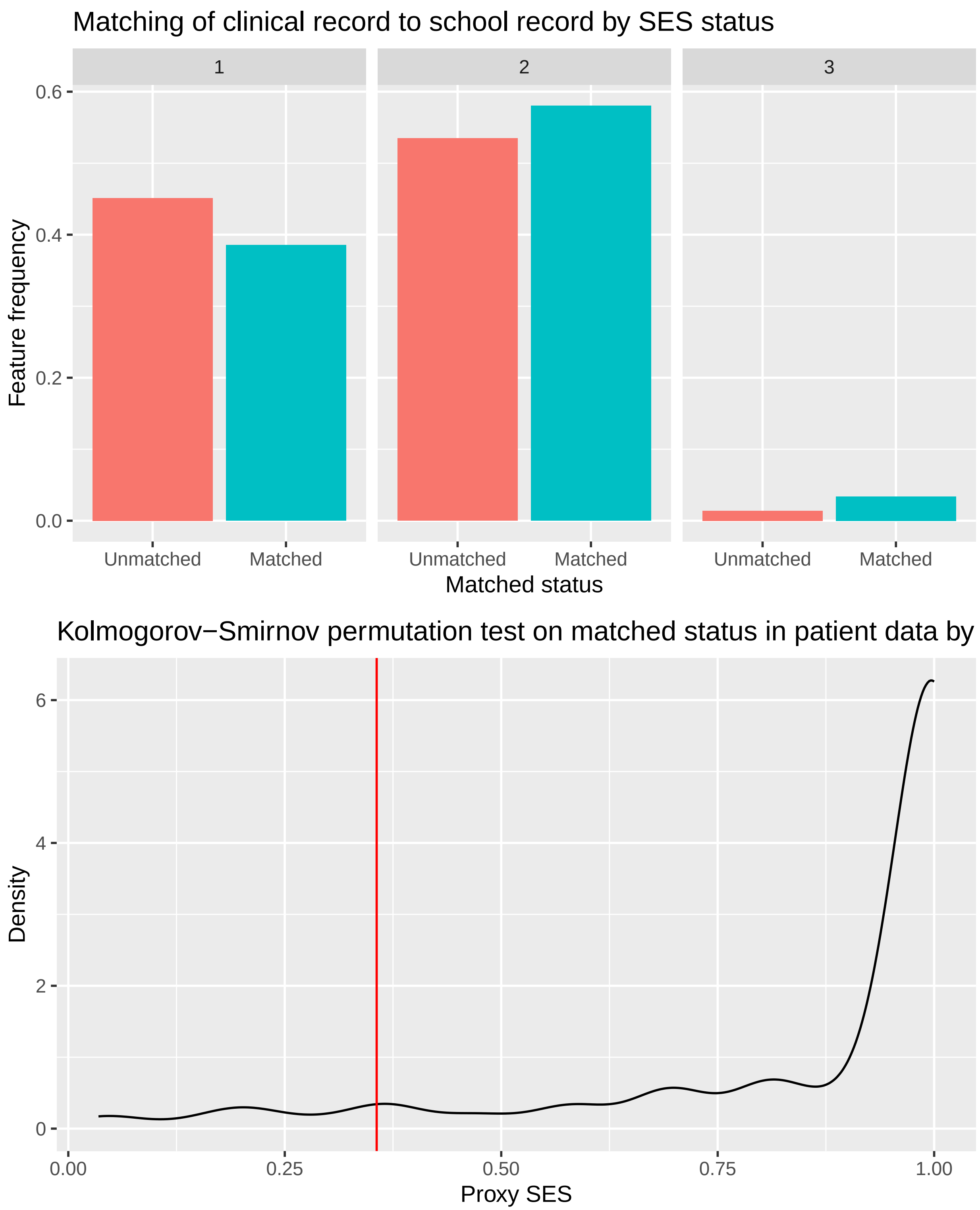



Figure 66: a) Difference in frequency of proxy SES among patient records that matched to school records and patient records that did not match. b) Density of Kolmogorov-Smirnov p-values for 2000 permutations of matched status for patient records by proxy SES with observed p-value shown in red.

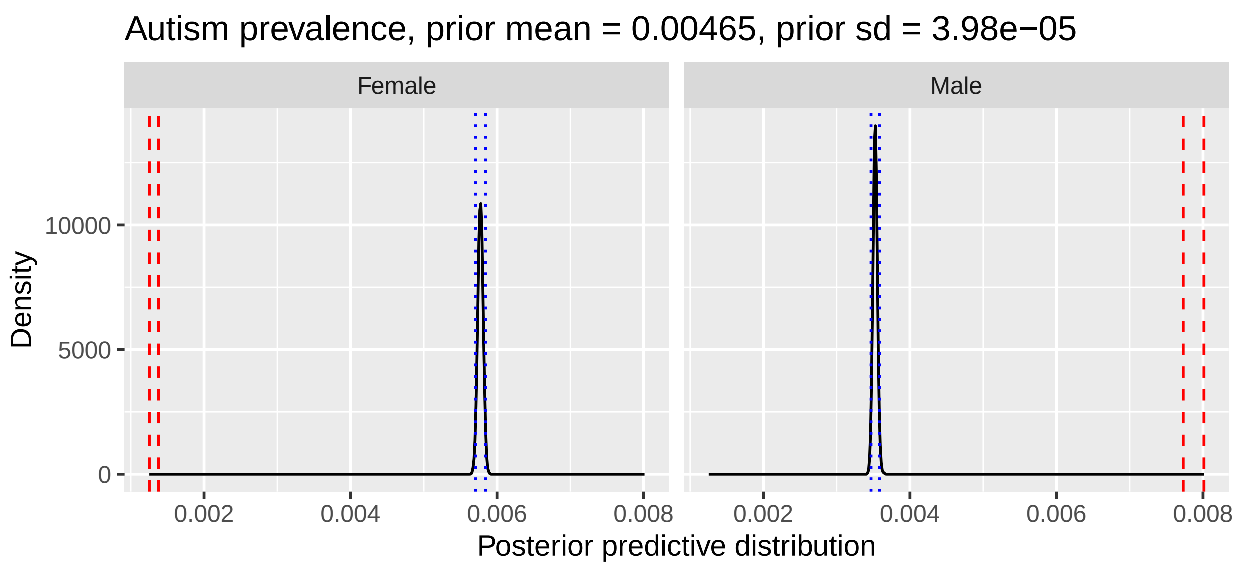



Figure 67: Posterior predictive distribution for autism with a random effect on sex, and with age- and sex-adjusted global prevalence prior.

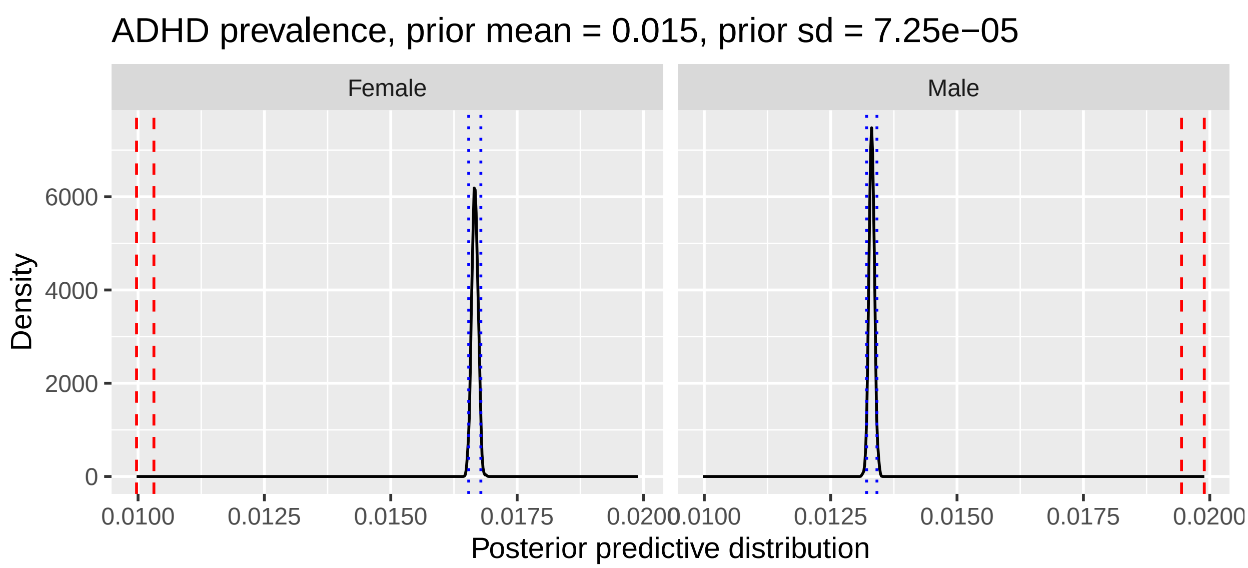



Figure 68: Posterior predictive distribution for ADHD with a random effect on sex, and with age- and sex-adjusted global prevalence prior.

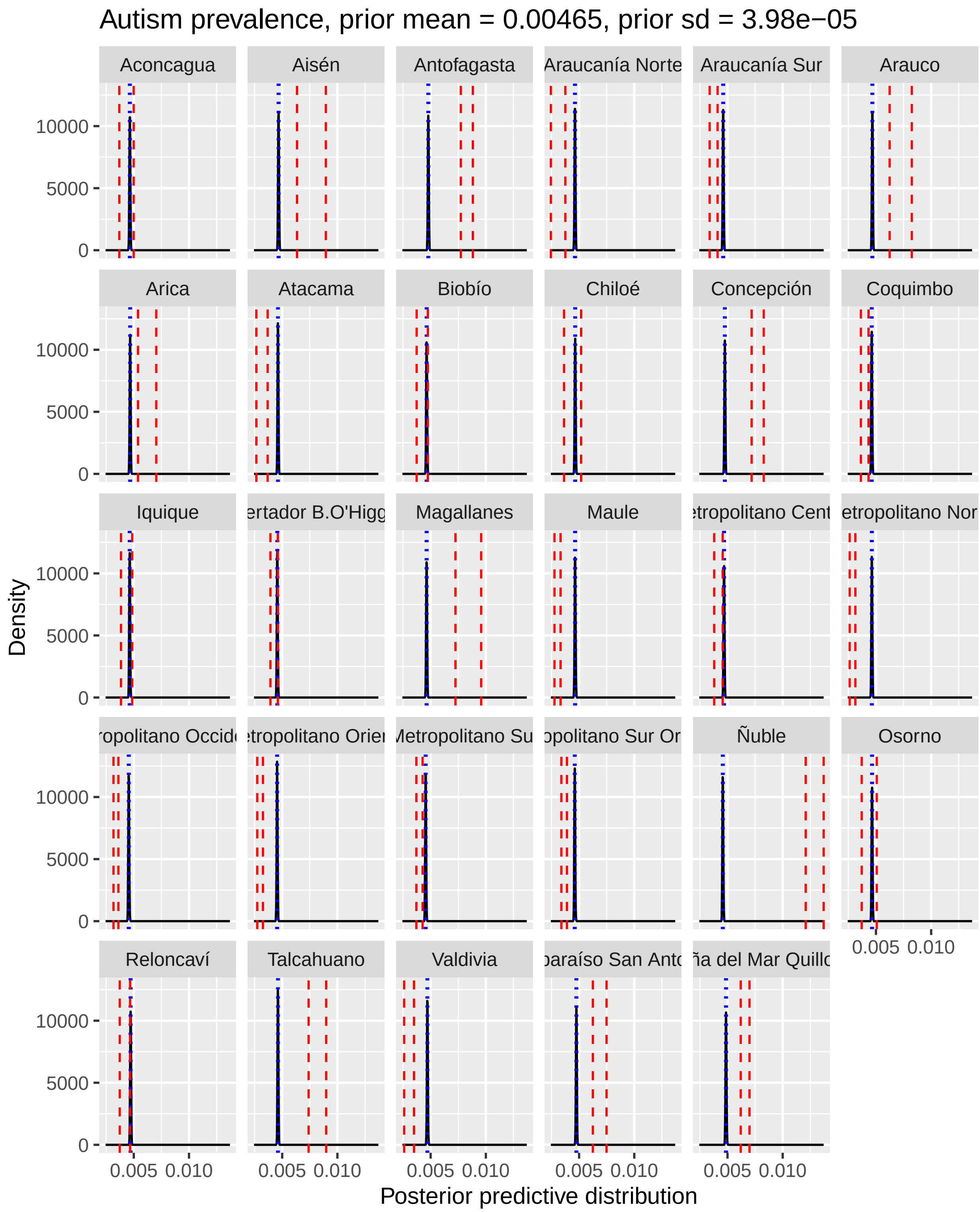



Figure 69: Posterior predictive distribution for autism with a random effect on student's health service, and with age- and sex-adjusted global prevalence prior.

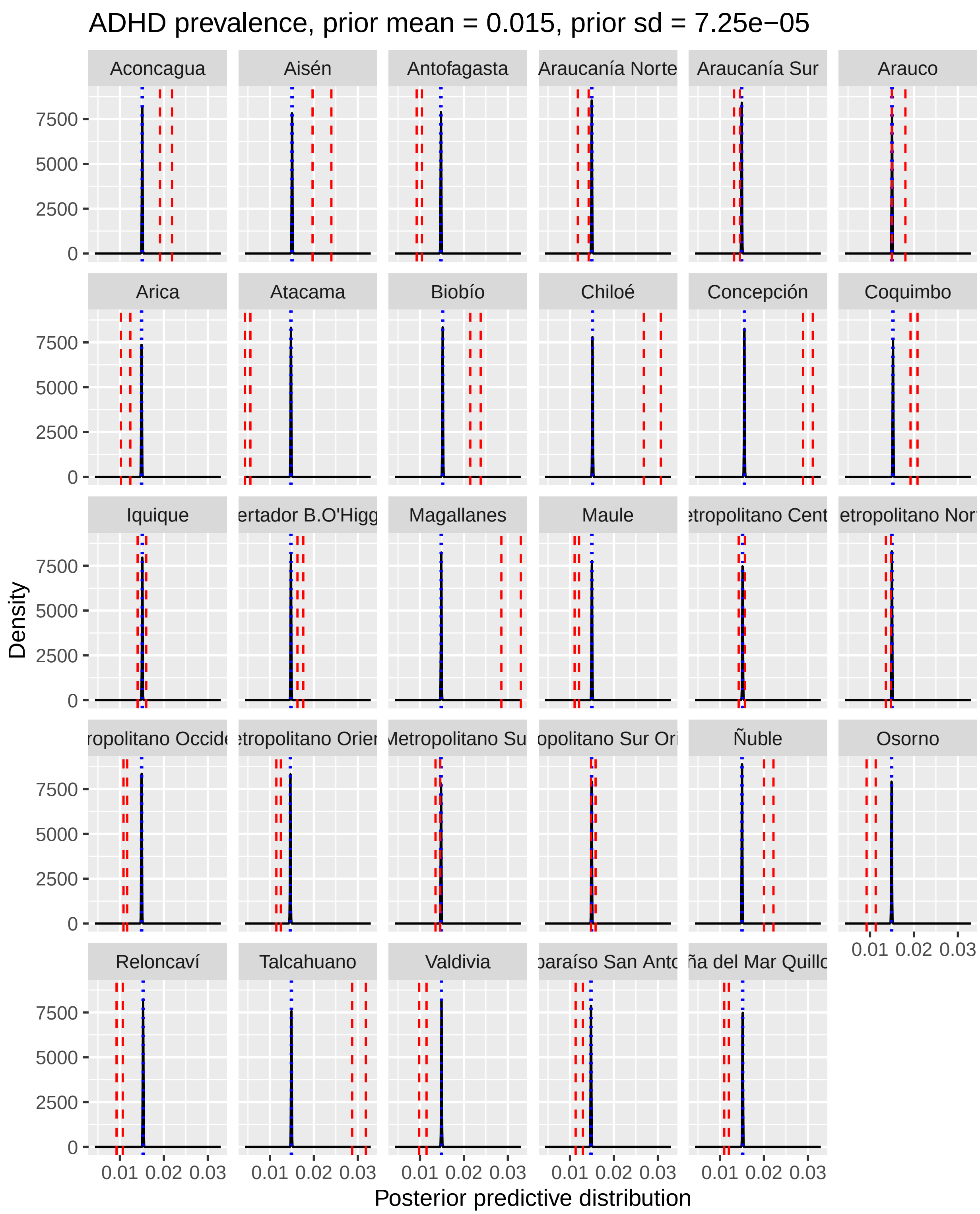



Figure 70: Posterior predictive distribution for ADHD with a random effect on health service, and with age- and sex-adjusted global prevalence prior.

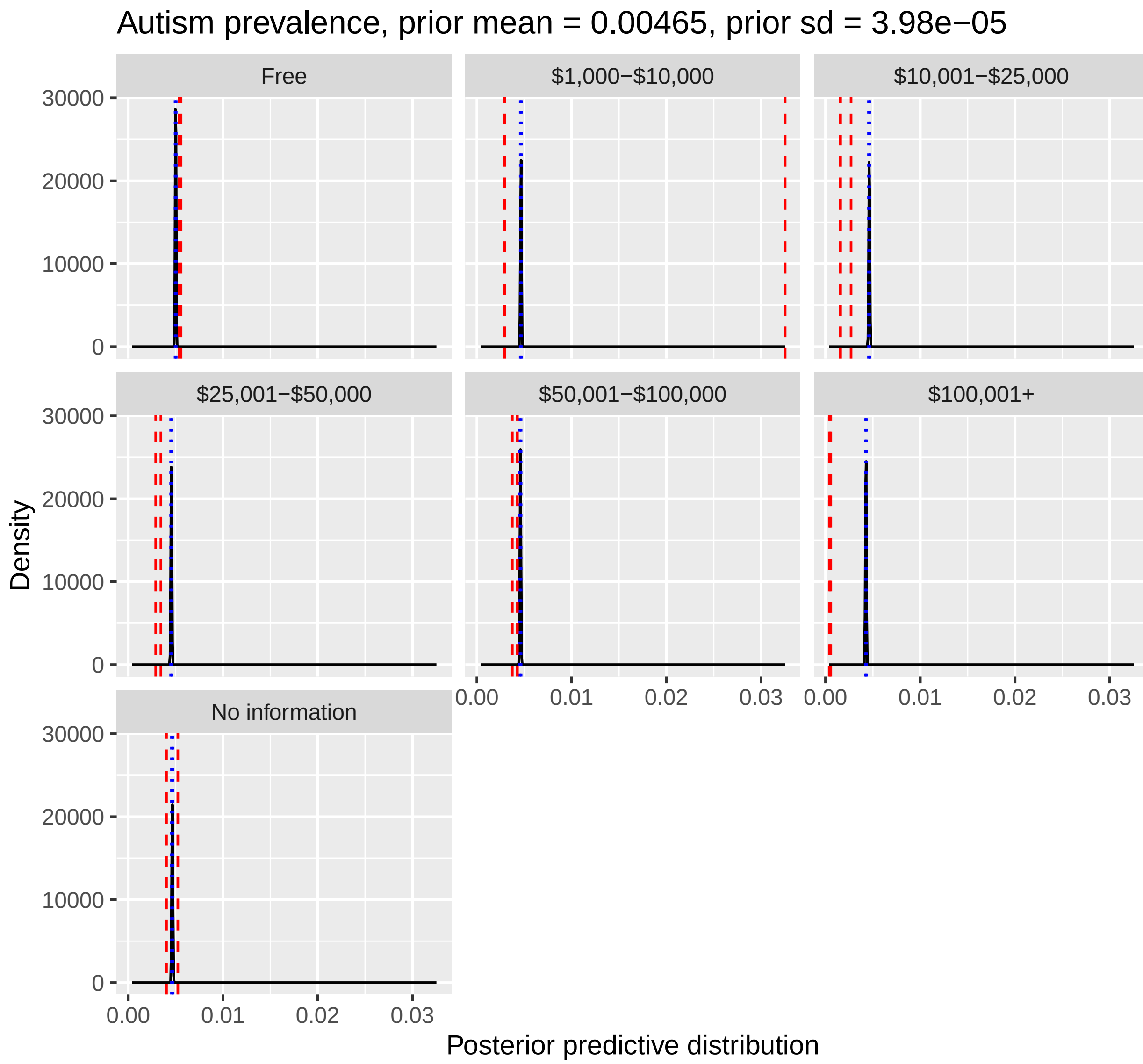



Figure 71: Posterior predictive distribution for autism with a random effect on socio-economic status of student's family, and with age- and sex-adjusted global prevalence prior.

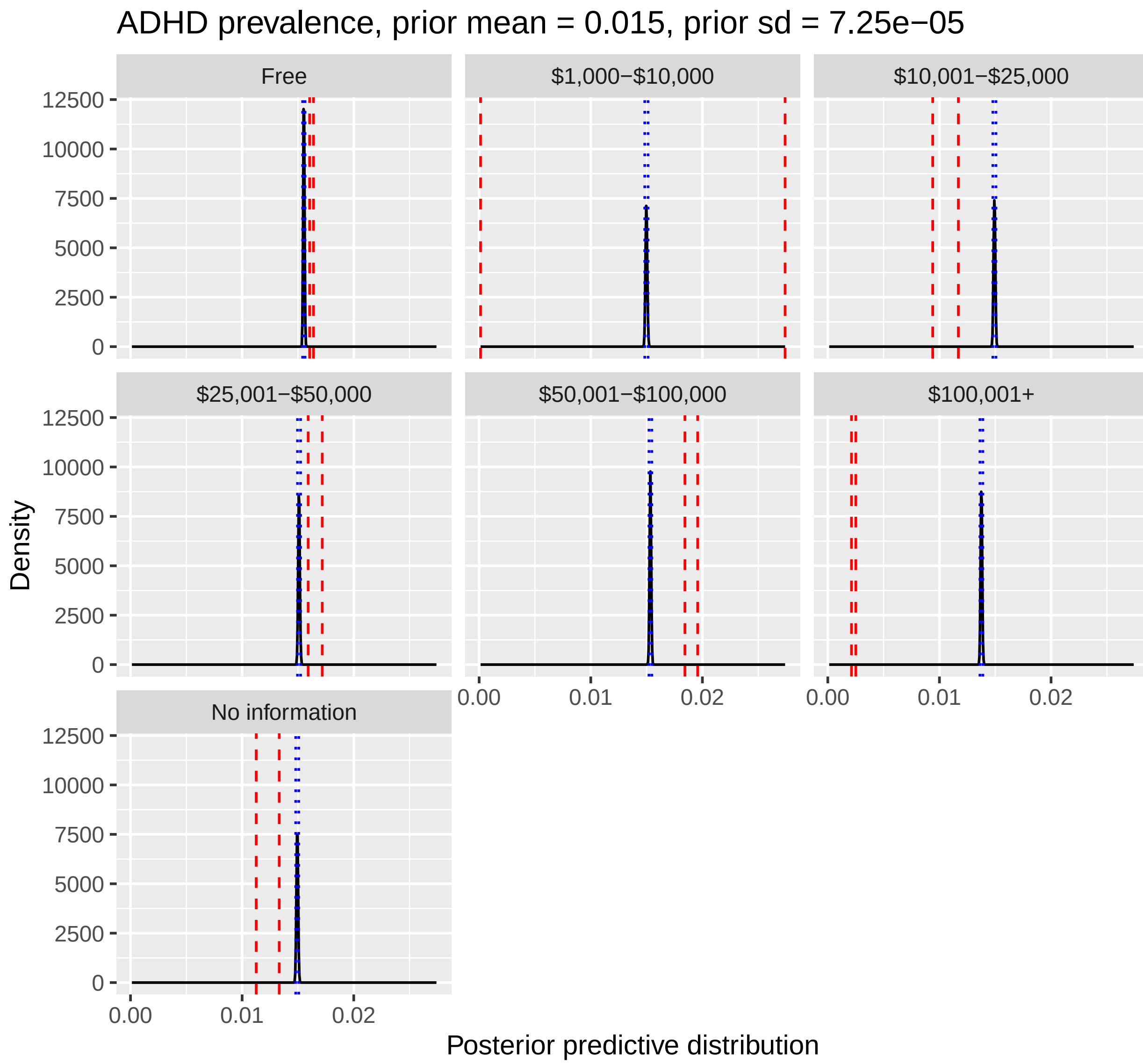



Figure 72: Posterior predictive distribution for ADHD with a random effect on socio-economic status of student's family, and with age- and sex-adjusted global prevalence prior.

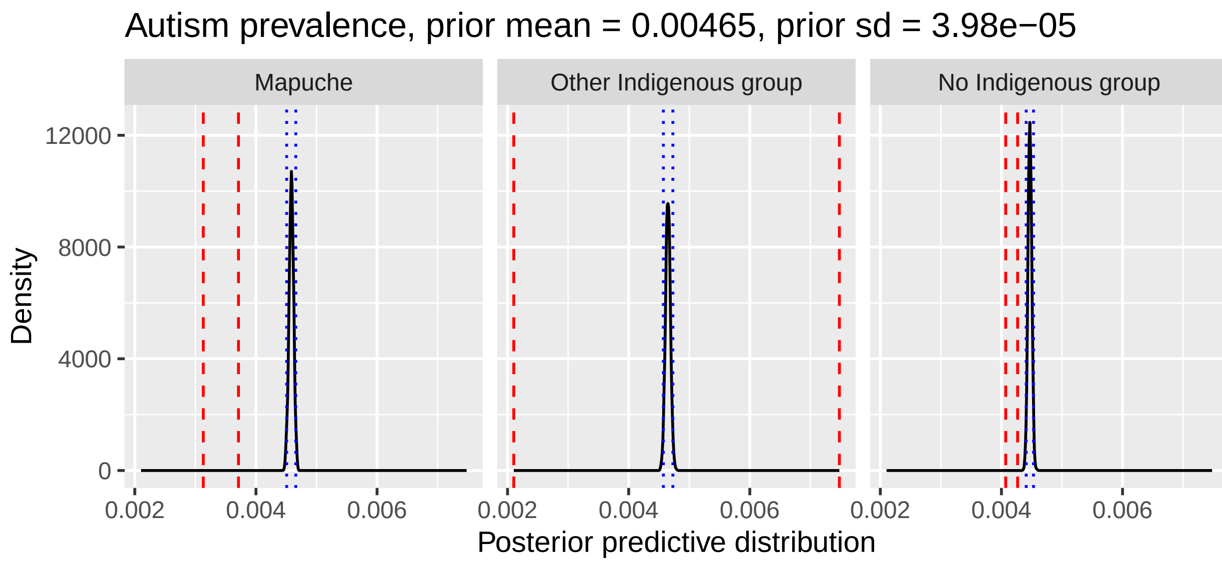



Figure 73: Posterior predictive distribution for autism with a random effect on ethnicity, and with age- and sex-adjusted global prevalence prior.

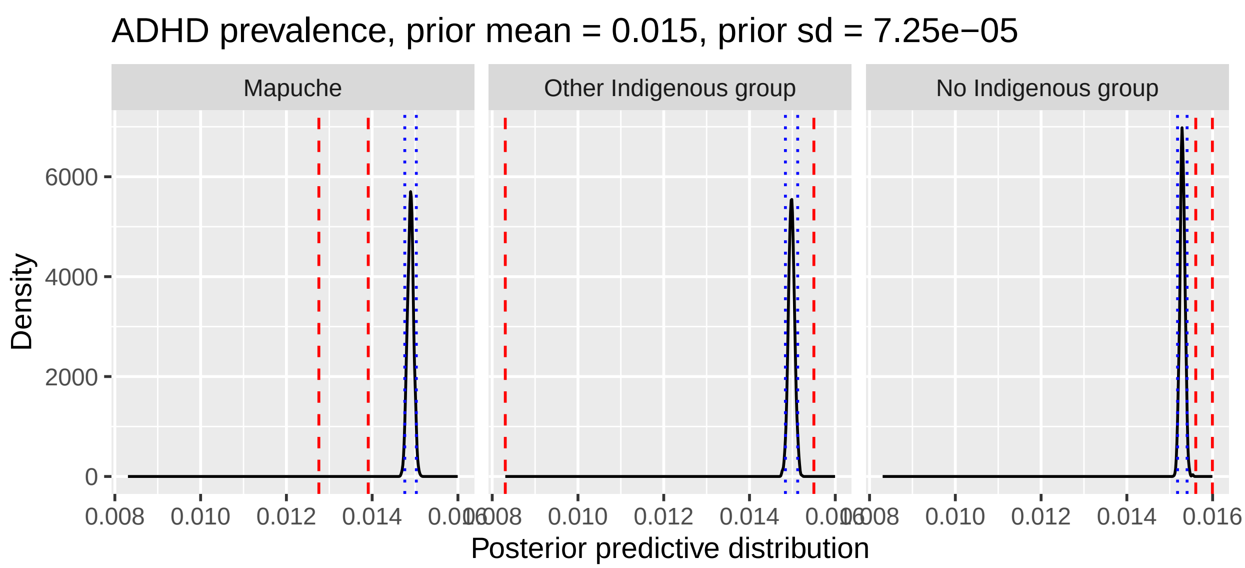



Figure 74: Posterior predictive distribution for ADHD with a random effect on ethnicity, and with age- and sex-adjusted global prevalence prior.

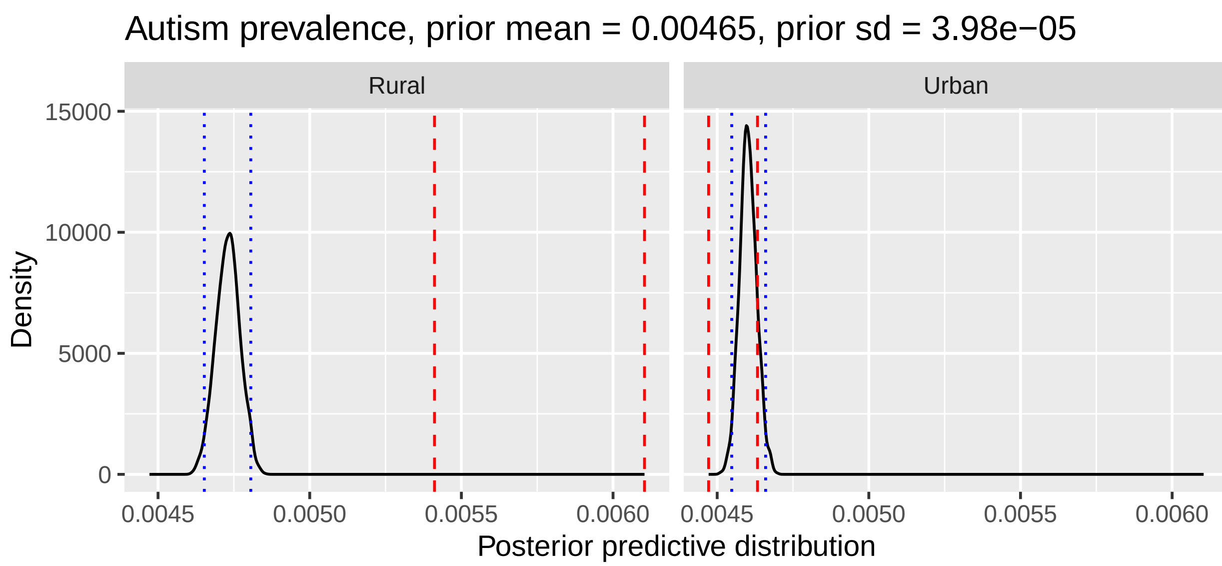



Figure 75: Posterior predictive distribution for autism with a random effect on school's rurality, and with age- and sex-adjusted global prevalence prior.

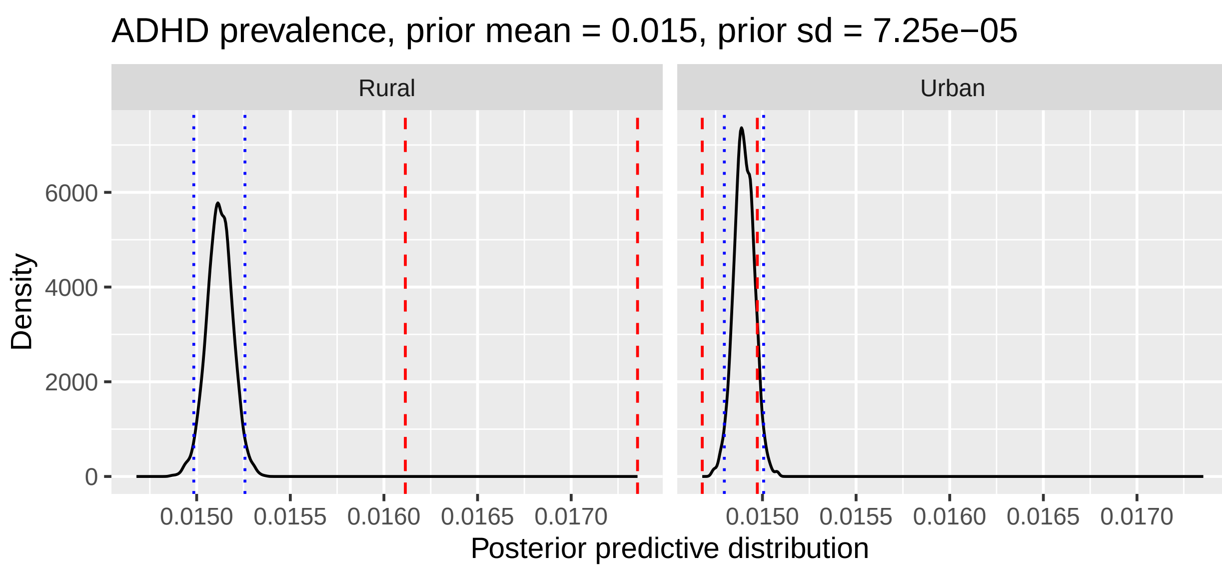



Figure 76: Posterior predictive distribution for ADHD with a random effect on school's rurality, and with age- and sex-adjusted global prevalence prior.