Exploratory and Inferential Analysis of Children's Eye Defects Screening in the Region of Aveiro

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ABSTRACT

Background/Objective: Amblyopia is one of the leading causes of monocular vision loss in children in Portugal, affecting 1 to 4% of children. Diagnosis and treatment of amblyopia at an early stage can prevent visual impairment, and thus the Children's Eye Defects Screening (CEDS) was implemented in primary care health centres nationwide with the aim to identify children with eye changes capable of causing amblyopia. The primary objectives of this study were to compare the proportion of screenings conducted in the different municipalities and the possible interference of the typology of functional units in adherence to screening.

Methods: An exploratory analysis using R Software was performed on the standardised screening data to identify differences between the 11 primary care health centres in the Region of Aveiro. In addition, an inferential analysis was performed using non-parametric tests such as the Kruskal-Wallis test and the Wilcoxon test, both used to verify whether there are significant differences between the analysed groups.

Results: It is possible to observe that the results obtained in 2021 were abnormal because of the COVID-19 pandemic, which lead to an increase in the number of screenings in 2022. The family health units had higher numbers of requests generated, screening attendances, and reports than personalised health care units, especially in 2021 and 2022. Most of the screening results were negative, with approximately 10% of screenings being positive and roughly 1% of scans being inconclusive. There also appears to be a growing trend of positive results in some municipalities, which may result from a higher reach to the target population of this screening.

Conclusions: The purpose of our statistical analysis was to identify differences between the primary health centres in Region of Aveiro. Our results show that might be useful to perform further studies in order to address potential inequities regarding CEDS access.

Introduction

Amblyopia is a recognized public health problem, considered the most frequent cause of monocular vision loss between 20 and 70 years of age. Approximately 1 to 4% of Portuguese children suffer from amblyopia. Early diagnosis of amblyopia is crucial to its prevention and treatment, so that all the losses that result from it can be minimized. [1, 2]

With this in mind, screenings are carried out to reduce the risk of developing blindness and other eye diseases through earlier diagnosis. A screening is a medical procedure or test to people who as yet have no symptoms of a particular disease. In Portugal there are some screenings programs such as the Children's Eye Defects Screening (CEDS), which aims to identify all children with ophthalmological alterations capable of causing amblyopia (lazy eye). [2, 3]

This screening consists of a photo-screening examination of the child's eyes, in a quick, safe and harmless way, and is intended for children aged 2 years old and should be repeated at 4 years old. This exam allows the identification of risk factors for amblyopia at an early stage, since this pathology, when not treated in childhood, can progress to blindness. In addition, it also identifies diseases such as strabismus, myopia, hypermetropy, astigmatism and anisometry. [2, 3, 4]

In Baixo Vouga Group of Health Centres (ACES Baixo Vouga), which is comprised of 11 municipalities: Águeda, Albergaria-a-Velha, Anadia, Aveiro, Estarreja, Ílhavo, Murtosa, Oliveira do Bairro, Ovar, Sever do Vouga and Vagos, the photo-screening examination step is performed by the nursing team of the Public Health Unit. After the examination, the collected information is sent to the Baixo Vouga Hospital Centre - Ophthalmology Department and subsequently analysed by an ophthalmologist who issues the examination result. If the result is normal, the child receives a new invitation to participate in the screening at 4 years of age, if the exam shows any amendment, the child is invited to an ophthalmology consultation

for medical follow-up. Furthermore, if the test result is inconclusive, it is necessary to repeat the examination. [2, 3]

This work aimed to compare the proportion of screenings conducted in the different municipalities and the possible interference of the typology of functional units in adherence to screening. These functional units attend patients to deliver primary health care attention, UCSP is a Personalised Health Care Unit and USF is a Family Health Unit. Regarding the results of the screenings tests, the number of positive results between the primary care health centres was also compared.

Methods

A retrospective observational study was carried out using data collected between 1 January 2019 and 31 December 2022. The databases were provided by ACES Baixo Vouga, and CEDS data resulted from the extraction of records made on the "SiiMaRastreios" platform, covering all users registered in ACES Baixo Vouga.

For the development of this work, 2 different databases were used, both in Excel format. The first database contains all patients enrolled in ACES Baixo Vouga, extracted according to the CEDS target population, by year, gender and age. The second database corresponds to the screening data that was initially composed by 15 variables and 216 observations. Several transformations were carried out, including the grouping and exclusion of variables, as well as the exclusion of some observations containing null or missing values.

The variables "Number of Requests Scheduled" and "Number of Invitation Letters" had values equal to the variable "Number of Requests Generated" and all 3 variables were representatives of the number of eligible patients who were called to carry out the screening, so there was only a need to use one of the variables and the remaining 2 were discarded.

Additionally, the observations of the variables "Number of Screening Attendances With Photo Screening Examination Performed" and "Number of Screening Attendances Without Photo Screening Examination Performed" were grouped in the variable "Number of Screening Attendances". The rationale for grouping these variables was that there was no need to distinguish them for our study. Once the transformations were completed, the CEDS database was left with 176 observations and 9 variables (Table 1, Supplementary material).

Regarding outliers, we made the decision not to consider any atypical values found in our data as outliers after the transformations on our databases were done, since all the possibly incorrectly inserted data was removed during the database cleaning. As such, any further removal of data would mean the loss of valid and valuable information.

After preparing the data, a descriptive statistical analysis was performed, shown through a various display of graphical figures to observe multiple outcomes, such as the proportion of screenings conducted in the different municipalities, the adherence to the screening by typology of functional units, the results of the screenings tests, and more specifically, the distribution of the positive results amongst primary care health centres.

Finally, since there was an absence of normal distribution (Shapiro Test with p-value<0.05) a non-parametric Kruskal-Wallis test was performed to compare medians for each variable. Wilcoxon Rank test was used to compare differences between the 2 types of functional units analysed. In addition, a false discovery rate correction for multiple testing was applied to adjust p-values, to correct them for multiple comparisons. For the inferential analyses a significance level of 0.05 was considered.

Results

In Figure 1, it is possible to observe that the variables "Number of Requests Generated" and "Number of Screening Attendances" show an irregular distribution and the variable "Number of Reports" shows an increasing trend (1199 reports in the year 2019, 927 reports in the year 2020, 1479 reports in the year 2021 and 2736 reports in the year 2022). In 2019 and 2020, the "Number of Screening Attendances" was very similar (1914 and 1767, respectively), while in 2022 the number almost doubled compared to the previous years (3638 screening attendances).

In Figure 2, it is possible to observe the differences between municipalities in the proportion of eligible users who attended this screening. The primary care health centres of Vagos and Ílhavo managed to get a greater proportion of their populations to attend the screening compared to the other municipalities. In general, just over 25% of the population eligible for this screening underwent the examination, in the first 2 years (2019 and 2020), with these values almost doubling by the year 2022 to an average of 57% screenings reports.

Figure 3 indicates the sum of the standardised proportions of the variables mentioned in Figure 1, distinguishing between the two types of Functional Units in the database, USF and USCP. Over the years, it is possible to observe a higher "Number of Requests Generated", "Number of Screening Attendances" and
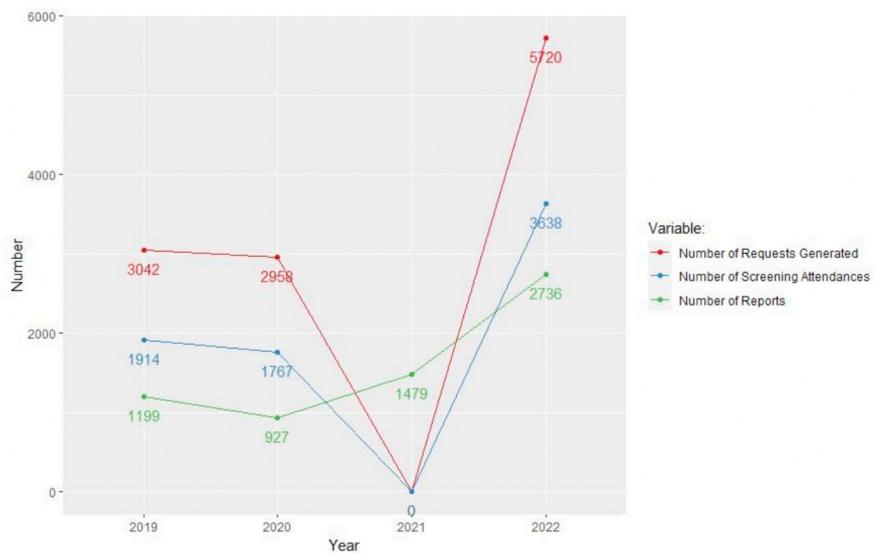
Figure 1 - Connected scatterplot of the relationship between the "Number of Requests Generated", "Number of Screening Attendances" and "Number of Reports" by Year
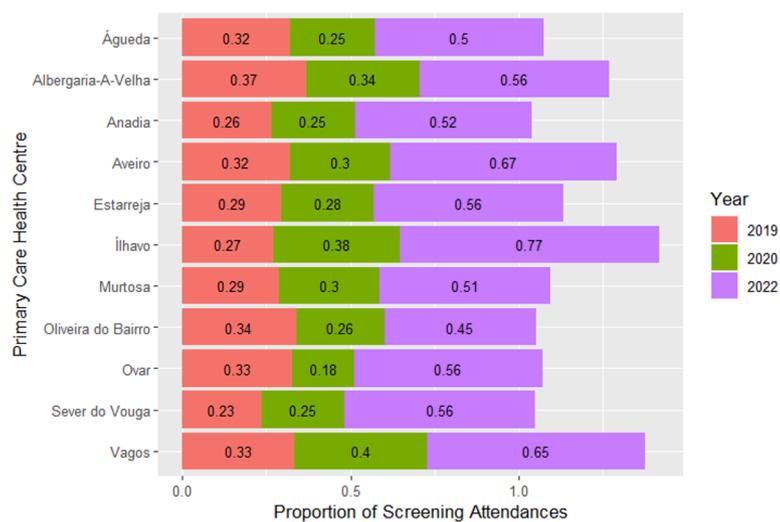
Figure 2 - Stacked bar graph for standardised "Number of Screening Attendances" by Year and by Municipality. The proportion of the screenings was measured in a scale from 0 to 1, where 1 represents, for each year, that all eligible users attended the screening.

Figure 3 - Bar charts for the standardised proportions of the variables "Number of Requests Generated", "Number of Screening Attendances" and "Number of Reports" between the two types of Functional Units.

"Number of Reports" in the USFs compared to the USCPs, especially in the most recent years, 2021 and 2022, where the difference is even more noticeable. The variables "Number of Requests Generated" and "Number of Screening Attendances" registered null values in the year 2021. The variable "Number of Reports" showed a more remarkable increase in both types of functional units in 2022, however in the USFs the first increase took place in 2021.

Throughout the 4 years, from 2019 to 2022, the results of 6341 screenings were analysed, and the vast majority of results were negative (5645 tests), with around 10% (625 tests) of screenings being positive for some type of visual impairment and only around 1% (71 tests) of scans being inconclusive (Figure 1, Supplementary material).

In Figure 4, it is possible to observe the distribution of the proportion of positive reports in the screening in each of the municipalities of Baixo Vouga compared to the eligible population. It also shows some atypical values, especially in 2022, where the primary care health centres of Ílhavo, Aveiro and Vagos registered considerably higher proportions of positive reports than in previous years. In 2019, the municipality of Aveiro, in 2020, Águeda, Murtosa, Oliveira do Bairro and Ovar, and in 2021, Anadia, recorded no positive results.
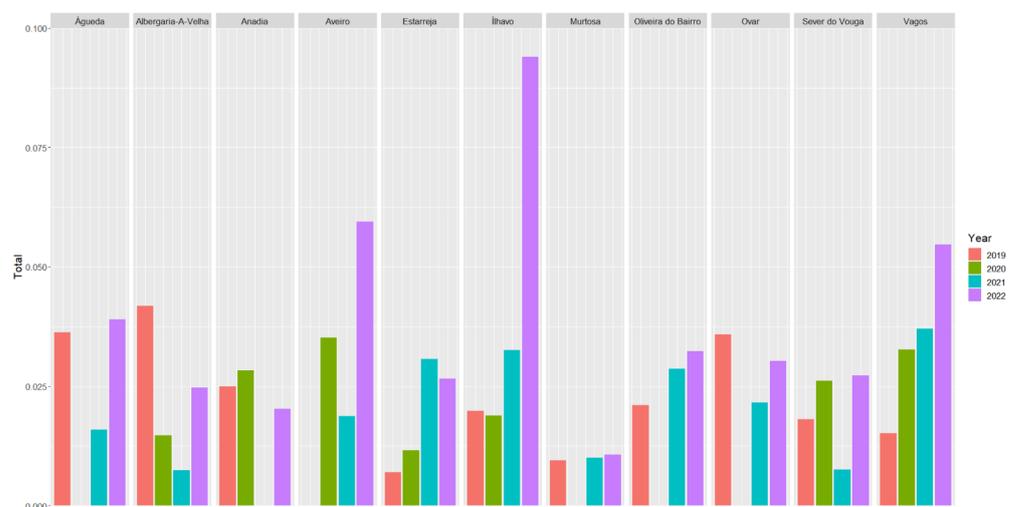
Figure 4 - Bar chart with the distribution of the standardised proportion of positive reports of the screening by Year and by Municipality.

The results of the inferential analysis shows that there are no significant results to report when we compare the differences found between the primary care health centres (Table 2, Supplementary material). However, by comparing along the 4 years, the variables "Number of Requests Generated", "Number of Screening Attendances", "Number of Reports" and the "Number of Negative Reports" were statistically significant for a p-value < 0.05 (Table 3, Supplementary material). Finally, the results of the analysis of the USFs compared to the USCPs showed that there are no statistical differences between the two types of functional units (Table 4, Supplementary material).

Discussion

The null values of the variables "Number of Requests Generated" and "Number of Screening Attendances" shown in Figure 1 are due to the fact that in 2021 the execution of this screening was halted due to the COVID-19 pandemic. Except for this anomalous year, it is possible to verify an ordinal relationship between the variables, with the annual values of "Number of Requests Generated" being higher than "Number of Screening Attendances" and these higher than "Number of Reports", as expected. In 2021, no requisitions were generated by the primary care health centres and, consequently, no attendances at screenings. Nevertheless, there was the option of having the screening done independently without a requisition, hence there are records of the screening results, which is explained by the variable "Number of Reports".

Figure 2 shows that the vast majority of the population eligible for this screening did not attend the examination, which may be indicative of a widespread difficulty for the different primary care health centres in the municipalities of Baixo Vouga in promoting this screening. Taking into account the information displayed in the figure, an increasing trend in the number of screening attendances is to be expected over the next few years, considering the evolution between 2019 and 2022.

In Figure 3, we can see that the variables "Number of Requests Generated", and "Number of Screening Attendances" registered null values in 2021, which resulted from the COVID-19 pandemic. Their values,

however, almost doubled in the aftermath of the pandemic when compared to pre-pandemic values, which could be due to a duplication of requests generated (and as a result, also a duplication of screening attendances) to compensate for the lack of requests in the previous year. In addition, there is a higher attendance of users from USF, when compared to those from UCSP, which can also reflect a better functioning of this type of functional unit.

It is possible to observe, in figure 4, that all municipalities show distinct trends regarding positive results of this screening, for example, Vagos and Oliveira do Bairro show a visible increasing trend. In the municipalities of Ílhavo, Aveiro and Vagos, the peak of positive results was verified in 2022, while in the municipalities of Albergaria-a-Velha and Ovar, this peak was verified in 2019 and values have been lowered ever since.

Regarding the inferential analyses, there were no statistically significant differences found in the variables analysed between the primary care health centres, which indicates that there is a good distribution of the screenings in the Baixo Vouga region (Table 2, Supplementary material). The statistical differences found between the years proves that there is at least one year where the proportions of the variables are considerably different from the other years, which had already been verified in the exploratory analysis (Table 3, Supplementary material). The results that compare the USFs to the USCPs shows that the difference visualized in the exploratory analysis for the year 2022 between the functional units is not statistically significant (Table 4, Supplementary material).

The purpose of statistical analyses like this one is to identify differences between the primary health centres in Region of Aveiro and to give information to the competent authorities to potentially address the problems identified. Based on the analysis of the screening, several differences between primary care health centres in its execution were identified, such as those mentioned previously.

Is important to note some limitations and publication bias found throughout the development of this work, most notably errors found in the original databases, namely the large amount of missing values or not allocated to any primary care health centre, which may be due to linkage errors between different health databases. Another limitation of this study is the limited geographical area on which we analysed upon, as CEDS is a nationwide screening and such small sample doesn't allow for extrapolations of the functioning of Health Centres in other regions of Portugal and is not representative of the country's population.

Some causes of bias identified were the exclusion bias of patients that were already medically followed in public or private sector, which have to be manually excluded from CEDS eligibility population due to lack of interoperability of the different electronic platforms. SARS-CoV-2 pandemic also caused a major disruption of most health services, which originated highly abnormal values, especially in the year of 2021.

The results presented show that it might be useful to perform further studies in order to address potential inequities regarding CEDS access. Additional research will be necessary to evaluate the CEDS efficacy nationwide, and to infer if the different structure of functioning of primary care health centres has an effect on the attendance to screening by patients.

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