The Confluence

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Evaluating Lunch Plan Data in the St. Charles School District (SCSD)

Maddy Alexander

Guillermo Bilbao Olarreaga

Duncan Krige

Alyssa Schreiber

Nick Wintz

See next page for additional authors

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Maddy Alexander, Guillermo Bilbao Olarreaga, Duncan Krige, Alyssa Schreiber, Nick Wintz, and Wojciech Golik

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Maddy Alexander, Guillermo Bilbao Olarreaga, Duncan Krige, Alyssa Schreiber
Advisors: Dr. Nick Wintz and Dr. Wojciech Golik

Abstract

The SCSD is a public school district in St. Charles, with, on average, 4500 students a year. The SCSD is subdivided into an early childhood center, six elementary schools, two intermediate (5-6,7-8) schools, and two high schools. Vocational schools are also within this district but were not included in this report. The SCSD is concerned with the impact of the Covid-19 pandemic on their district's population and on the number of students that needed assistance with lunch. They have asked Lindenwood's 2024-25 PIC Math group to analyze their data from the years 2020-25 and identify any trends. Identifying these trends may help the client understand which areas in the school district are most likely to need financial aid, and which locations were most greatly impacted by the pandemic. So far, the group has analyzed the data to understand the retention rates and distribution of meal statuses and student populations across the 5-year period, as well as using ArcGIS and R programming software to generate various graphs and maps of the SCSD area. We focused our analysis and observations on these key areas employing statistical and data analysis skills to draw our conclusions.

1 Introduction

Preparation for Industrial Careers in Mathematical Sciences (PIC Math) is an applied course to prepare undergraduate students for careers in industry. Students work in teams on a project proposed by a local business, nonprofit, or government agency. This provides students with a professional setting to develop their mathematical and programming skills, interact with a client, manage deadlines, and produce a technical report. This document represents the final result for the spring 2025 cohort.

The SCSD tasked the class with identifying certain trends across 5 years of data. The district wanted to know more about the impact of the pandemic on student population and meal status; i.e., once parents were required to classify their income with the state, did they? (note that during "COVID" years students were all classified as "S", meaning their lunch was " subsidized"). Did the pandemic change their student population to become more reliant or less reliant on state aid? Did the district lose any specific percent of their population during or immediately after the pandemic?

The District also asked if there were any specific findings of the retention rate (of meal statuses and population) between K-4. Further, was this change reflected when transitioning to middle school? In particular, considering the total population and meal status retention during these transition school, were there certain elementary schools that were losing more of a population?

The remainder of this manuscript is as follows. In section 2, we examine the meal status by population within the district and offer some observations. In section 3, we review meal status from year to year since the outbreak of the pandemic. We also break these results down to grade level. In section 4, we investigate how attendance rates are related by meal status and student status. In section 5, we over a year-to-year visualization of meal status in the district using ArcGIS. In section 6, we offer our overall observations of the project and suggestions to our client to help improve their processes.

2 Meal Status by Population & Distribution

Meal status (Free, Reduced, Paid) reflects the socioeconomic makeup of a school district's student population. This section uses faceted charts to show the number of students in each meal status category for each year from 2020-2021 to 2024-2025. By comparing these counts across years, we can identify trends in enrollment, such as the 2024-2025 drop, and explore how economic factors influence student retention.

The distribution of students by meal status (Free, Reduced, Paid) across schools can reveal variations in socioeconomic need within a district and how these patterns shift over time. This section uses faceted line and bar charts to show the number of students in each meal status category for each school, sorted by total enrollment, across the years 20-21 to 24-25. Each chart highlights trends in meal plan distribution, such as the dominance of Paid students and the impact of the 24-25 enrollment drop, providing insights into how economic factors vary by school size and type.

2.1 Data

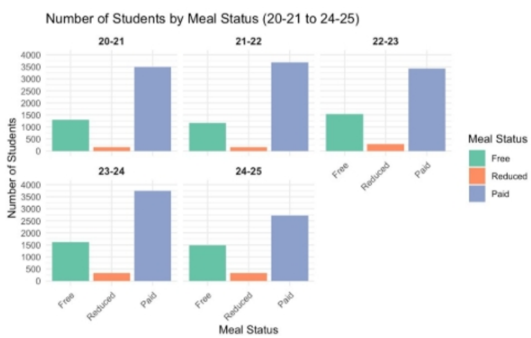

Figure 1: Meal Status vs. Number of Students by Year

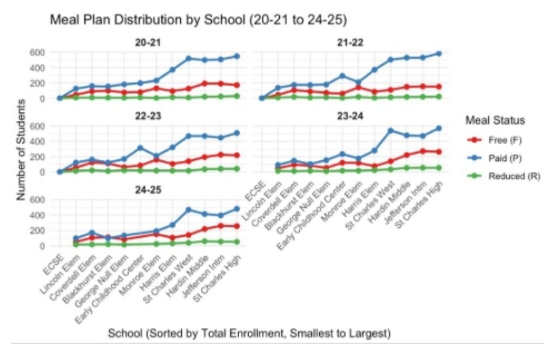

Figure 2: Meal Plan Distribution by Schools

2.2 Observations

2.2.1 Meal Status By Student

Paid Students in the Majority: In each year, the Paid bar is the tallest, reflecting that Paid students (S+P) make up the largest group (e.g., 3499 in 2020-21, 3744 in 2023-24). However, the Paid count drops significantly in 2024-25 to 2724, a decrease of 1020 students (27.24% drop), aligning with the overall 20.3% enrollment drop.

Free Students Increase in Count until 2023-24: The Free bar grows from 1301 in 2020-21 to 1620 in 2023-24, then slightly decreases to 1483 in 2024-25. Despite the count drop, Free students become a larger proportion of the total in 2024-25 (32.70%)

Reduced Students Grow Steadily: The Reduced bar, the shortest in each year, grows steadily from 149 in 2020-21 to 329 in 2023-24, then remains nearly stable at 328 in 2024-25, reflecting increased eligibility over time (from 3.01% to 7.23%).

2.2.2 Meal Status Distribution

Paid Students in the Majority: The Paid line is consistently the highest across all schools and years, reflecting that Paid students are the largest group (e.g., 548 in St Charles High in 2020-21, dropping to 481 in 2024-25). The Paid line shows a significant drop in 2024-25, especially in larger schools (e.g., St Charles High: 570 in 2023-24 to 481 in 2024-25), aligning with the district-wide 20.3% enrollment drop.

Free Students Increase in Count: The Free line generally increases with school size (e.g., in 2020-21, from 0 in The Early Childhood Center to 193 in Hardin Middle) and shows growth over time in most schools (e.g., Blackhurst Elementary: 99 in 2020-21 to 111 in 2024-25), reflecting the district-wide increase in Free percentage (26.29% to 32.70%).

Reduced Students Grow Steadily: The Reduced line remains the lowest but shows a gradual increase over time (e.g., Hardin Middle: 21 in 2020-21 to 59 in 2024-25), consistent with the district-wide growth (3.01% to 7.23%).

2024-25 Enrollment Drop: The 2024-25 subplot shows a noticeable decrease in all bars, especially Paid, due to the 20.3% enrollment drop (from 5693 to 4535 students). Paid students were the most likely to leave (58.41% retention), while Free (65.19%) and Reduced (81.16%) students were more likely to stay. The 2024-25 Distribution subplot shows a dip in all lines, especially Paid, due to the 20.3% enrollment drop.

2.3 Conclusion

The faceted line charts reveal significant variations in socioeconomic composition across schools from 2020-21 to 2024-25, as well as reveals significant shifts in the district's student population across grade levels.. Paid students consistently dominate in all schools, particularly in larger ones like St Charles High and Jefferson Intm., but their numbers drop sharply in 2024-25 due to the district's 20.3% enrollment decline. Free and Reduced student counts grow over time, reflecting increasing economic need, with smaller schools like the Early Childhood Center showing higher proportions of Free students before program cuts in 2024-25. We also see that enrollment grew steadily from 4,949 students in 2020-21 to 5,693 in 2023-24, with relatively stable distributions across grades, though early childhood grades (e.g., PK) saw fluctuations due to program changes. The sharp 20.3% enrollment drop in 2024-25, from 5,693 to 4,535 students, is evident across all grades, with notable declines in early childhood grades and in Grade 12 (from 630 to 353 students), reflecting high school attrition. These trends underscore the impact of economic factors and district-wide changes, such as the discontinuation of early childhood programs, on student enrollment and meal plan participation.

3 Meal Status and Population Retention

To better understand the shift between schools and population fluctuations, we analyzed the retention rate of students at schools based on overall enrollment. This meant calculating retention rates by tracking students across years to determine how many remain enrolled in the same dataset (the same school system) from one year to the next, as well as retention over time. After tracking individual students (via Student ID), we could see how their lunch status changed year-to-year and whether they remained in the dataset (indicating retention) or dropped out (indicating attrition). Research indicates that students eligible for free or reduced-price meals often face higher risks of attrition due to socioeconomic challenges, but access to school meals can improve retention by supporting health and academic performance.

3.1 Data

3.1.1 Meal Status Retention

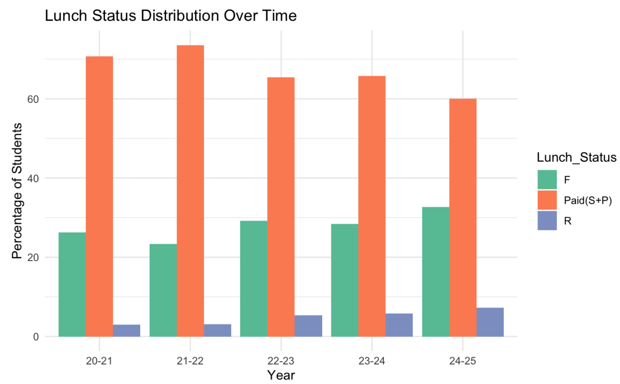

Figure 3: Meal Status Retention Rates by Year

3.1.2 Grade/Population Retention

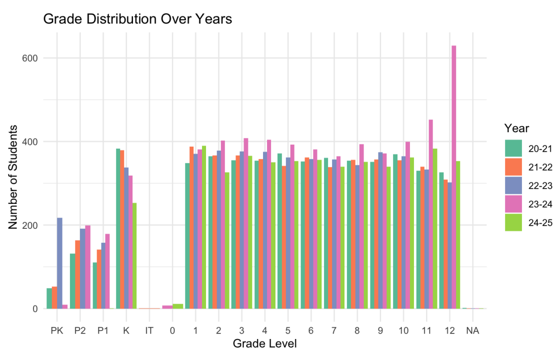

Figure 4: Grade Level Distribution by Year

Year	Total Students
20-21	4912
21-22	4978
22-23	5198
23-24	5693
24-25	4536

Figure 5: Total Population per Year

3.2 Observations

3.2.1 Meal Status Retention

Lunch Status Trends: Free lunch students decreased from 26.29% (1301) in 2020-21 to 23.30% (1169) in 2021-22, then increased to 32.70% (1483) by 2024-25, despite an 8.46% count drop in 24-25. Reduced lunch students grew from 3.01% (149) to 7.23% (328), a 120.13% increase in count, with high stability in 2024-25 (-0.30%). Paid lunch students decreased from 70.70% (3499) to 60.07% (2724), with a 27.24% drop in count in 2024-25, exceeding the overall enrollment drop (20.34%)

Socioeconomic Impact: The 2024-25 enrollment drop (20.34%) disproportionately affected Paid lunch students (58.41% retention), possibly indicating higher-income families leaving the district. Free (65.19%) and Reduced (81.16%) lunch students were more likely to stay, likely due to reliance on school meal programs, though the loss of early education programs (PK/P2) may have impacted younger Free lunch students. The increase in Free (32.70%) and Reduced (7.23%) percentages in 2024-25 suggests the remaining student population has a higher proportion of lower-income families.

3.2.2 Grade Level Retention

Enrollment grew steadily from 4,912 to 5,693 (15.9% increase) over the first four years, peaking in 2023-24. The sharp 20.29% drop in 2024-25 (from 5,693 to 4,536) is significant and could indicate a major event (e.g., students leaving the district, school closures, or data collection issues).

Enrollment Dynamics: Total enrollment grew from 4,912 in 2020-21 to 5,693 in 2023-24 (15.9% increase) but dropped sharply to 4,536 in 2024-25 (20.3% decrease). This decline could reflect student outflows, policy changes, or data issues, requiring further investigation.

Early Education Challenges: Pre-K spiked to 217 in 2022-23 (4.175%), then collapsed to 0 by 2024-25, suggesting a discontinued program. P2 followed a similar pattern, disappearing in 2024-25. Kindergarten enrollment declined 33.94% (383 to 253), with its proportion falling from 7.797% to 5.578%, indicating fewer new entrants.

Elementary and Middle Stability: Grades 1-8 show consistent counts (326-408) and percentages (6.4%-8.6%). Grade 1 grew to 390 (8.598%) in 2024-25, becoming the largest grade. The Kindergarten cohort (2020-21) lost 8.62% by Grade 4, suggesting moderate attrition.

High School Volatility: Grade 12 surged to 630 (11.066%) in 2023-24, likely a data error, before dropping to 353 (7.782%) in 2024-25. Grade 11 peaked at 452 in 2023-24 (7.940%), then fell to 383 (8.444%). High school grades grew until 2023-24, then adjusted downward in 2024-25.

3.3 Conclusion

The analysis of grade distribution and meal status retention from 2020-21 to 2024-25 reveals significant shifts in the district's student population across grade levels. Enrollment grew steadily from 4,949 students in 2020-21 to 5,693 in 2023-24, with relatively stable distributions across grades, though early childhood grades (e.g., PK) saw fluctuations due to program changes. The sharp 20.3% enrollment drop in 2024-25, from 5,693 to 4,535 students, is evident across all grades, with notable declines in early childhood grades and in Grade 12 (from 630 to 353 students), reflecting high school attrition. It is clear that while it is common for students to retain the same lunch status, the amount of Free and Reduced students is slowly growing throughout the SCSD, indicating a higher population reliance on State Aid and financial resources.

4 Attendance Rates by Student, School, & Meal Status

Student attendance is a critical factor in academic success, influencing both individual student outcomes and overall school performance. This analysis examines attendance patterns across multiple schools in the St. Charles School District over the academic years 2020-21, 2021-22, 2022-23, and 2024-25, excluding 2023-24 due to incomplete data.

The schools analyzed include all schools along with some unidentified schools labeled "GNULL" and "SUCC." The data reveals variations in attendance by school and grade level, highlighting trends such as the impact of program changes at Early Childhood Center, differences between elementary and high schools, and the presence of students with zero attendance, particularly in 2024-25.

By exploring these patterns, this study aims to identify areas of concern and opportunities for improving student engagement and attendance across the district. The St. Charles School District has been analyzing attendance patterns across its schools from 2020-21 to 2024-25 to identify trends and areas for improvement. Previous analyses revealed that elementary schools generally maintain high attendance rates (above 93%), while middle and high schools show steady improvements (reaching 90-92% in 2024-25), and certain programs like the Early Childhood Center and Juvenile Justice Center face significant challenges (e.g., 80.94%

and 54.15% attendance in 2024-25, respectively).

Using this analysis, the district wants to understand whether socioeconomic factors, as indicated by stu-dents' meal status, can influence attendance rates. Meal status often reflects a student's family income level, which can impact access to resources like transportation, health care, and stable home environments —all of which may affect school attendance. In this analysis, we categorize students into three meal status groups: "Free" (F, indicating eligibility for free meals), "R" (a specific category in the data), and "Paid" (combining S for Subsidized and P for Paid, representing students not on free meals). Additionally, the dataset in-cludes a group of students with an unspecified meal status (Empty), which we will investigate. This analysis aims to explore the correlation between these meal status groups and attendance across the district, using student-level data from 2020-21 to 2024-25.

By examining this relationship, the district can identify whether students from lower-income backgrounds (e.g., those on free meals) face greater attendance challenges and develop targeted interventions to support these students, ultimately enhancing overall academic success.

4.1 Data

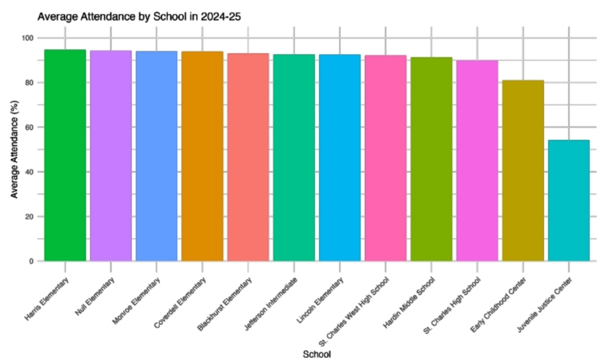

Figure 6: Average Attendance by School

4.2 Observations

4.2.1 Analysis of Average Attendance

Averages Across the District: The analysis of attendance in the St. Charles School District from 2020-21 to 2024-25 shows strengths and challenges. Elementary schools like Harris, Blackhurst, and Coverdell maintain high attendance above 93%, reflecting strong engagement. Middle and high schools, including Hardin Middle, Jefferson Intermediate, St. Charles High, and St. Charles West High, improve over time, reaching 90-92% in 2024-25, but lag behind elementary schools. The Early Childhood Center struggles, dropping to 80.94% in 2024-25 due to 38 zero-attendance students, likely from program changes. The Juvenile Justice Center also faces issues, with 54.15% attendance in 2024-25, needing targeted interventions.

4.2.2 Comparing Attendance Rates to Meal Status

Empty: The 977 students with an unspecified meal status have the lowest average attendance at 81.82%, with a high standard deviation (SD) of 23.22, indicating significant variability. This group likely includes students who were not assigned a meal status due to data entry issues, transfers, or other administrative reasons. Their low attendance suggests they may face unique challenges, possibly related to incomplete enrollment or socioeconomic factors not captured by meal status.

Free: Students with "Free" meal status (likely from lower-income families) have an average attendance of 89.64%, with an SD of 11.02. This is higher than the unnamed category but lower than "Paid" and

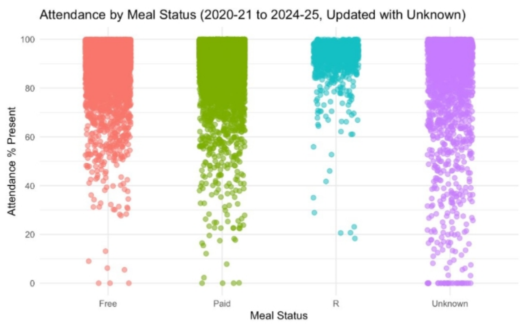

Figure 7: Average Attendance vs. Meal Status by Year

Meal Status	Avg. Attendance	SD Attendance	Total Students
Empty	81.8248311156602	23.2238066625328	977
Free	89.644789191261	11.0166716467604	5218
Paid	92.742006244496	8.82660570686855	12491
Reduced	92.0998074745187	8.96271363355862	883

Figure 8: Average Attendance vs. Meal Status by Year TABLE

"Reduced," suggesting that socioeconomic barriers may impact their attendance.

Paid: The "Paid" group (combining S and P) has the highest average attendance at 92.74%, with an SD of 8.83, indicating more consistent attendance. This group, representing students not on free meals, likely benefits from greater access to resources.

Reduced: The "Reduced" category has an average attendance of 92.10%, very close to "Paid", with an SD of 8.96. This group is smaller (883 students) and may represent a specific subset of students (e.g., a special program or data entry variation).

4.3 Conclusion

The analysis of student attendance in the St. Charles School District from 2020-21 to 2024-25, with meal statuses grouped into "Free," "Reduced," and "Paid" (combining S and P), highlights a clear correlation between socioeconomic factors and attendance rates.

The "Paid" group, representing students not on free meals, achieves the highest attendance, averaging 92.74% with an SD of 8.83, and improves from 91.57% in 2020-21 to 94.41% in 2024-25. The "R" category follows closely with an average of 92.10% (SD 8.96), rising from 90.22% to 93.30% over the same period. Students with "Free" meal status, likely from lower-income families, have a lower average attendance of 89.64% (SD 11.02), improving from 88.61% to 90.77%. The "Unknown" meal status group (2044 students) has the lowest average attendance at 81.9% (SD 22.94), increasing from 74.13% in 2020-21 to 82.87% in 2024-25, but remaining significantly below the other groups. The differences across all meal status groups are statistically significant (ANOVA F-value 544.5, p-value ¡ 0.001), confirming that meal status impacts attendance.

The "Unknown" group's low attendance and high variability suggest data quality issues or unique challenges (e.g., transfers, special programs like the Juvenile Justice Center, which had 54.15% attendance in 2024-25), warranting further investigation. For the "Free" group, socioeconomic barriers such as transportation difficulties or family responsibilities may contribute to their lower attendance, with a consistent gap of about 3-4 percentage points compared to "Paid" students.

The district should prioritize targeted interventions, such as enhanced transportation support, family outreach, and breakfast programs, to support "Free" students. Additionally, resolving the "Unknown" meal status data through improved record-keeping or separate analysis can ensure a more accurate understanding of attendance patterns, ultimately helping the district close the attendance gap and promote equitable academic success for all students

5 Exploring Meal Status Distribution with ArcGIS

The SCSD also tasked the group with determining if location within the district had any correlation to meal status. Using ArcGIS, the group was able to geocode the provided addresses of every student in the district from the years 2020-25.

By observing heat maps of every student within the district, the group was able to determine if there was a correlation between location in the district & meal status, i.e., do students that live in one part of the school district require free lunch more often than students than live in other parts of the district?

By determining this correlation, it allows for the SCSD to determine if certain areas need more financial assistance and how they can stage interventions to encourage these kids from these certain areas to attend school more often, as described in the previous section, but it also allows for them to see which areas were more greatly impacted by the COVID-19 pandemic.

5.1 Data

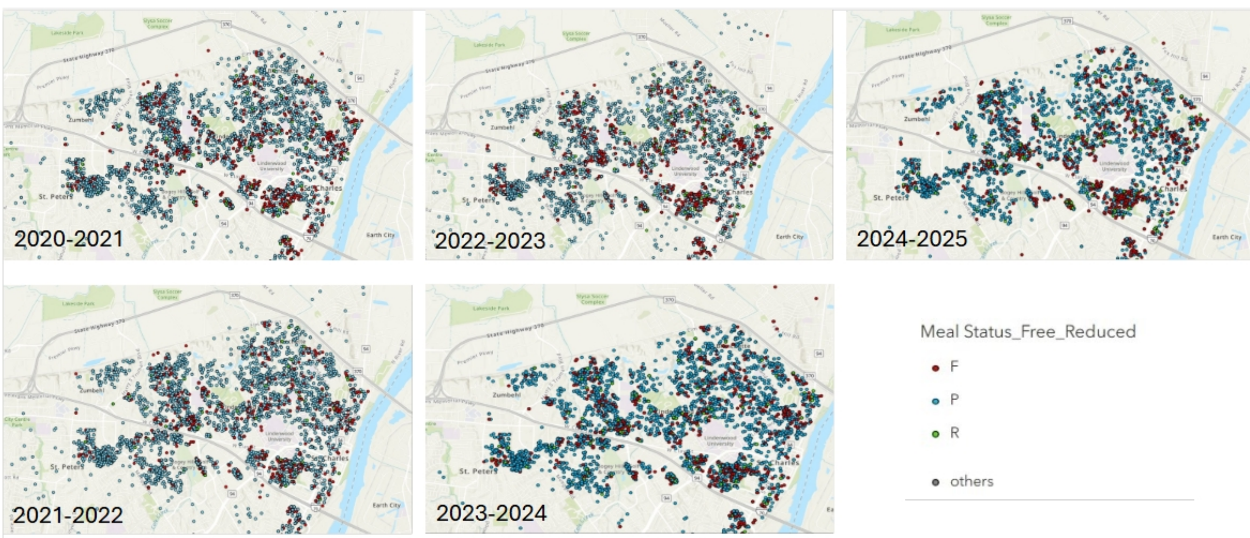

Figure 9: Mapping using ArcGIS

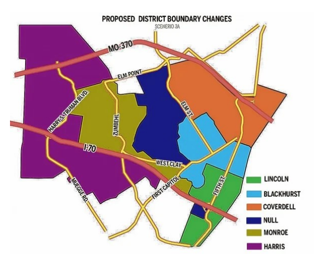

Figure 10: SCSD District Lines

5.2 Observations

In 2021-22, large clusters of Free meal recipients appeared in the central and southern parts of St. Charles, mainly within the lines of Blackhurst Elementary, Lincoln Elementary, and Monroe Elementary, indicating these may be lower-income neighborhoods. These areas showed signs of economic strain following the Pandemic. By 2023-2025, there is a noticeable increase in Paid (P/S) meal statuses, indicating partial economic recovery. However, many red clusters remain, especially in the same high-need zones, revealing persistent inequality. Throughout all the years, the regions with the highest concentrations of free and reduced meals remained largely consistent, suggesting structural issues in food access and income disparities. The use of graduated symbol sizes in each map effectively shows where the highest densities of affected students are located, helping stakeholders target interventions.

5.3 Conclusion

The analysis of the ArcGIS maps reveals significant challenge areas in the district. Across all 5 years, Blackhurst Elementary, Lincoln Elementary, and Monroe Elementary all had the largest clusters of free and reduced lunch status students. By understanding where these high-need areas are, the SCSD can focus on staging certain interventions within these elementary schools in order to ensure that these children receive the same quality education and are encouraged to attend school. The SCSD can also focus on these high-need areas in an effort to understand where these income disparities are stemming from, and maybe even provide financial aid to certain struggling areas.

6 Conclusion

6.1 What Can the SCSD do?

After the analysis of the provided data, our team recommends that the SCSD:

- Investigates the 24-25 enrollment drop and the 23-24 Grade 12 spike for data accuracy.
- Monitor Kindergarten declines to address potential long-term enrollment challenges.
- Validate cohort data to confirm retention rates and identify transfer patterns.
- Investigate the 24-25 enrollment drop, focusing on why Paid lunch students left at a higher rate (e.g., economic migration, dissatisfaction with school changes).
- Enhance meal program support to retain Free and Reduced lunch students, especially in early grades, to encourage continued enrollment in the district.
- Monitor the socioeconomic shift toward a higher proportion of Free and Reduced lunch students, ensuring resources are allocated to support lower-income families.

By considering these recommendations, the SCSD may be able to understand on an even deeper level the retention rates of their students, and also understand who, where, and why certain areas of their district are leaning more towards Free and Reduced meal plans.

6.2 Data Entry Problems

Our team was tasked with cleaning and analyzing 10,000+ lines of data. In doing so, we discovered multiple discrepancies. The SCSD, between 2023 and 2024, changed their student records-keeping systems. With this change, some data was lost in translation or completely changed. This led to some issues in our analysis as certain grade levels needed to be changed, some students' information was lost, and some programs (vocational) were completely ignored. We also ran into a few communications issues with the district, which led to some of our questions going unanswered, and therefore we decided to alter our methods as best as possible in order to provide proper analysis for the SCSD.

6.3 Conclusion

The analysis of student attendance in the St. Charles School District highlights a clear correlation between socioeconomic factors, attendance rates, and population retention. We recommend the district should consider providing resources such as meal-support for "Free" students, targeted programs for low-attendance schools, and focus on utilizing better data systems to ensure equity and accuracy post-COVID-19

After speaking with Mr. Jeremy Shields, our client from the SCSD, we also discovered that IT employees in the SCSD have also been investigating the discrepancies in enrollment numbers after 2023. The shift from the "Tyler SIS" system to "Power Schools" has created a substantial challenge for the SCSD- the Power Schools program is new to the Midwest Region of the United States, so while the State is learning how to use this new system, so are all of the schools. This has led to a loss in certain data sets (i.e., race, age) in the collection of student data, but has also led to multiple miscommunications among the data. Mr. Shields informed us that after the switch, there is the possibility many students were counted multiple times throughout the data sets under different program names, which ultimately contributed to the large enrollment "drop" observed in 2024-25. Mr. Shields informed our group that the SCSD did not see a 20% enrollment drop in their students, so he intends on working with his team over at the SCSD to investigate the data discrepancies we found while working on this report.

Mr. Shields also was interested to hear that a lot of their student population is now beginning to rely on financial aid, i.e., students with free and reduced lunch. Although pre-COVID, a majority of their retained populations were "Paid" students, post-COVID, a majority of their population were "Free" students, indicating a substantial shift in the makeup of their student population.

Acknowledgments

Special thanks to Dr. Ana Londoño for her mentoring and assistance in creating the GIS plots found in this document. The group also thanks the SCSD for their data set and insights used in this project. In addition, we would like to personally thank the referees for their contributions in improving the quality of this manuscript.