

Exploring the Effects of Auspice and Program in Toronto Childcare

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Introduction

Rather than hiring babysitters, parents prefer to enroll their children in daycare to improve the child's socialization and cognitive development. However, there are concerns about high fees and limited spaces, especially in Toronto childcare centres. Even if parents can afford childcare through their earnings or subsidies, they might be placed on a waitlist to secure a spot (Perlman et. al., 2023). Waitlists can be very long, such that some parents get in line before their child is born (Perlman et. al., 2023). This high demand leads to the investigation of the capacity in Toronto childcare centres. The *INF2178_A2_data.xlsx* dataset, reported by the City of Toronto Children's Services division, is analyzed to address the following fundamental research questions:

1. Are there significant effects of auspices (commercial, non-profit, and public) on childcare capacity?
2. Do the effects of programs (early years and before- and after-school) on childcare capacity depend on auspices?

Data Features

The dataset listed 1063 licensed childcare centres in Toronto and contains information about their location, operations, and capacity for multiple age groups. Columns were renamed to be more clear. The following features have no missing values and are notable for this research project:

- **Auspice:** The agency that operates childcare services. The three types of agencies are commercial, non-profit, and public. The public centres are operated by the City of Toronto.
- **Infant_Space:** The number of childcare spaces for infants 0-18 months.
- **Toddler_Space:** The number of childcare spaces for toddlers 18-30 months.
- **Preschooler_Space:** The number of childcare spaces for preschoolers 30 months up until they enter grade 1.
- **Kindergarten_Space:** The number of childcare spaces for kindergartens.
- **School_Age_Space:** The number of childcare spaces for grades 1 and up.
- **Total_Spaces:** The total number of childcare spaces from all 5 groups: infant, toddler, preschooler, kindergarten, and school age.

Two new features were created to aid in the analysis of the second research question:

- **Early_Years_Program:** The total number of childcare spaces from three groups: infant, toddler, and preschooler.
- **Before_After_School_Program:** The total number of childcare spaces from two groups: kindergarten and school age.

Exploratory Data Analysis

As visualized in Figure 1, the majority of Toronto childcare centres are non-profit. There are 703 non-public centres, 321 commercial centres, and 39 public centres. According to the boxplot in Figure 2, the median of the childcare centre capacity is between 50 and 60 spaces for each auspice. Non-profit centres have a

larger variability than the other two centres. One of the non-profit centres has a very high capacity, which is over 400 spaces. There are outliers for both non-profit and commercial centres. Similarly, there are outliers in the boxplot shown in Figure 3 for non-profit and commercial centres regardless of the program. For public centres, there are outliers only for the before- and after-school program. The early years program has a larger variability in capacity than the before- and after-school program for commercial and public centres, whereas non-profit centres have it vice-versa.

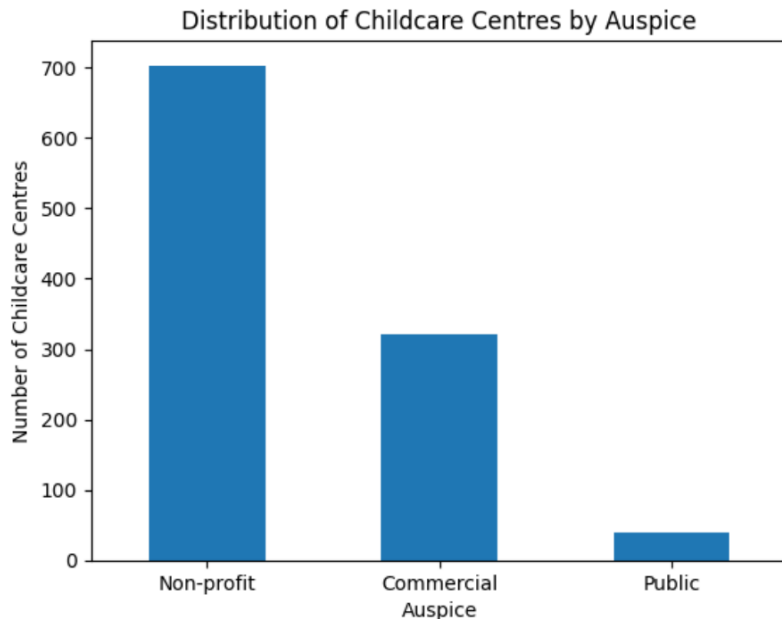


Figure 1. Bar chart of childcare centre capacity in each auspice

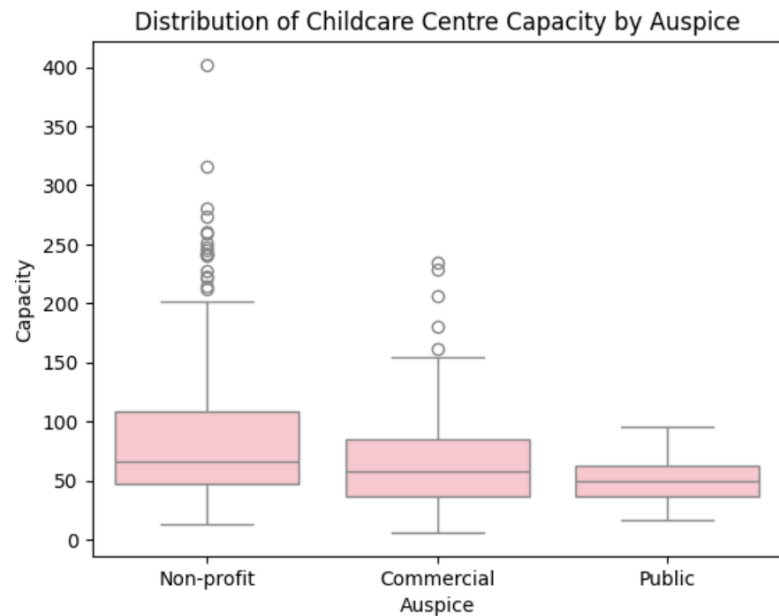


Figure 2. Boxplot of childcare centre capacity in each auspice

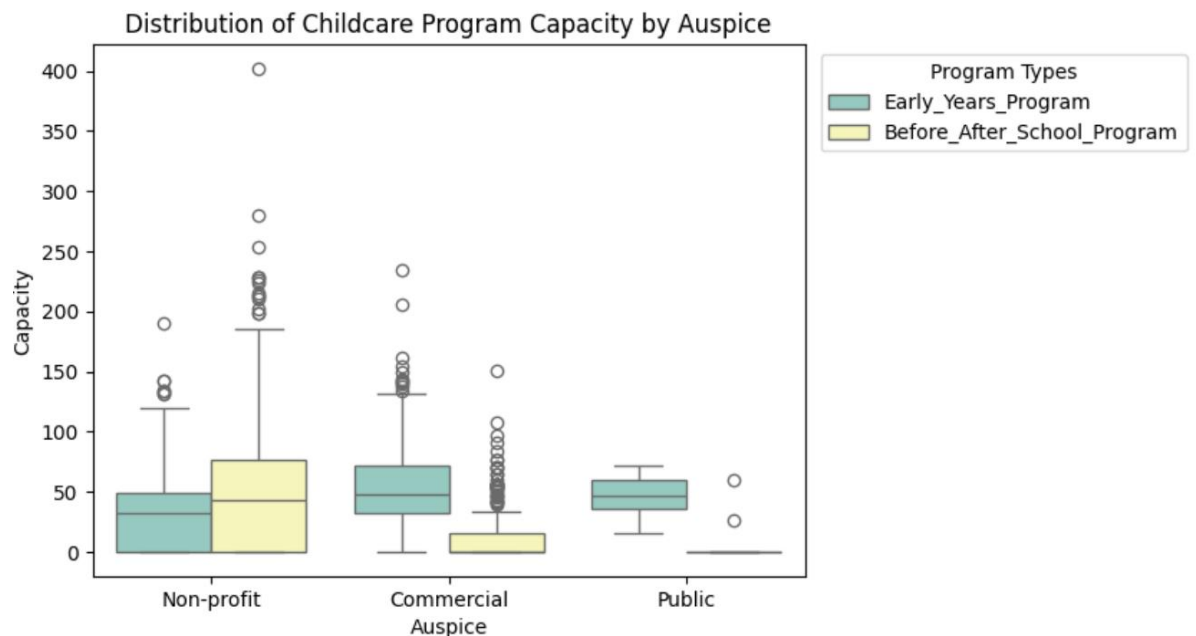


Figure 3. Boxplot of childcare centre capacity by auspice and program

Effects of Auspice on Childcare Capacity

The one-way ANOVA test was performed to determine whether there is a difference in the means of childcare capacity between three auspices. The assumptions of ANOVA are normality and homogeneity of variances. According to Figures 4 and 5, the assumption of normality is violated because the standardized residuals form a quadratic curve in the Q-Q plot and the histogram of residuals is right-skewed. Plus, there is an outlier at the top of the Q-Q plot and on the far right of the histogram. These models' diagnostics can also be supported by the results of the Shapiro-Wilk test shown in Table 1. With p-value < 0.001 , the null hypothesis of data distributed normally is rejected at a significance level of $\alpha = 0.05$. Due to this violation of normality, Levene's test was used to check homoscedasticity (see Table 2). The p-value < 0.001 , thus the null hypothesis of equal variances among different auspices is rejected at a significance level of $\alpha = 0.05$.

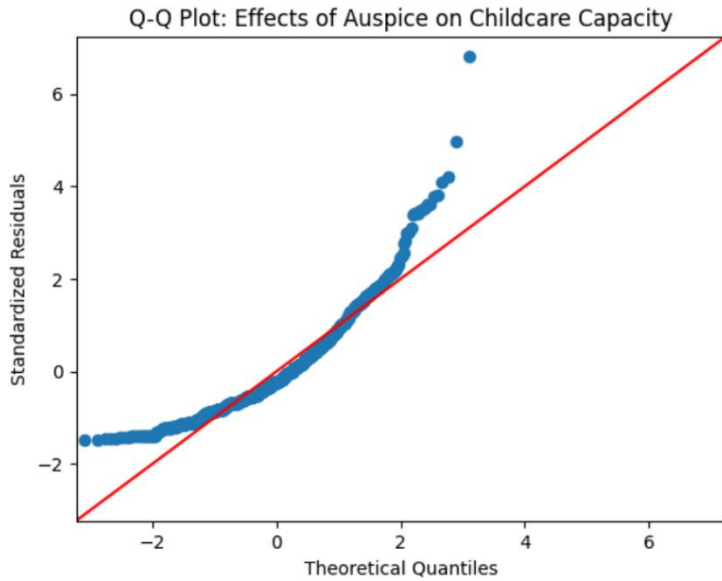


Figure 4. Q-Q-plot of standardized residuals from linear regression, where Total_Spaces is the dependent variable and Auspice is the exploratory variable.

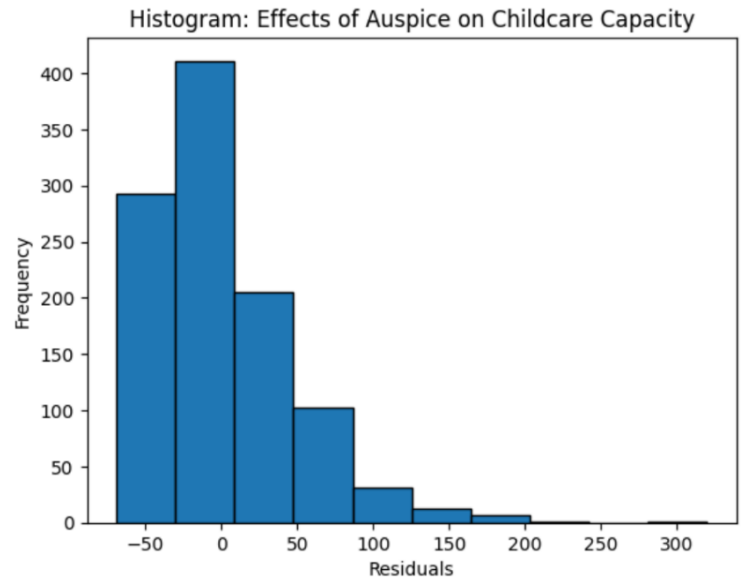


Figure 5. Histogram of residuals from linear regression, where Total_Spaces is the dependent variable and Auspice is the exploratory variable.

Test Statistic	P-value
0.902	$p < 0.001$

Table 1. Shapiro-Wilk test to check normality of residuals for one-way ANOVA.

Test Statistic	df	P-value
17.927	2	$p < 0.001$

Table 2. Levene's test to check whether three auspices have equal variances.

Source	df	Sum of Squares	Mean Squares	F-value	Prob > F
Auspice	2	9.611×10^4	48056.057	21.843	$p < 0.001$
Residual	1060	2.332×10^6	2200.062		

Table 3. One-way ANOVA summary table

Group 1	Group 2	Mean Difference	Lower CI	Upper CI	P-value
Non-profit	Commercial	17.119	9.704	24.535	$p < 0.001$
Non-profit	Public	34.335	16.224	52.445	$p < 0.001$
Commercial	Public	17.215	-1.453	35.884	0.078

Table 4. Tukey's HSD pairwise comparisons based on one-way ANOVA model (95% confidence interval)

According to the one-way ANOVA summary in Table 3, F-value is 21.843 which leads to a p-value < 0.001 . There is strong evidence that there is at least one auspice that yields a different average childcare capacity than the other auspices. To determine which type of auspice is statistically different from the rest, a post-hoc Tukey's HSD test was performed (see Table 4). There are significant pairwise differences between non-profit and commercial centres with an average difference of 18 childcare spaces (p-value < 0.001), and between non-profit and public centres with an average difference of 35 childcare spaces (p-value < 0.001). For the pair between commercial and public centres, the p-value of 0.078 exceeds the critical threshold of $\alpha = 0.05$, thus the mean difference between these two auspices is not statistically significant.

Effects of Auspice and Program on Childcare Capacity

To analyze the main and interaction effects of two factors: auspice and program, the two-way ANOVA test was utilized to check whether the means of childcare capacity change according to the levels of these categorical variables. Notice that the standardized residuals form a sharp curve in Figure 6 and the histogram of residuals is right-skewed in Figure 7. In addition, the Shapiro-Wilk test shown in Table 5 reveals p-value < 0.001 . As a result, the assumption of normality is violated. In Levene's test shown in Table 6, the p-value < 0.001 , thus the assumption of homoscedasticity is violated as well.

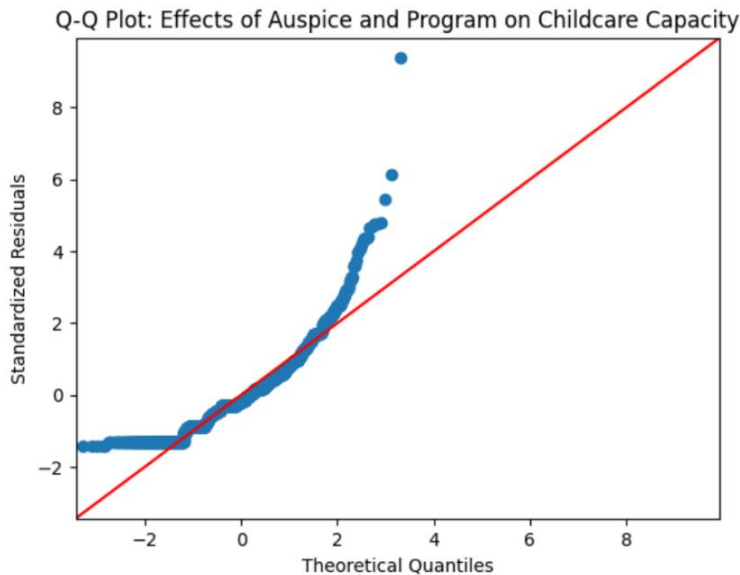


Figure 6. Q-Q-plot of standardized residuals from multi-linear regression, where Total_Space is the dependent variable and Auspice and Program are the exploratory variables.

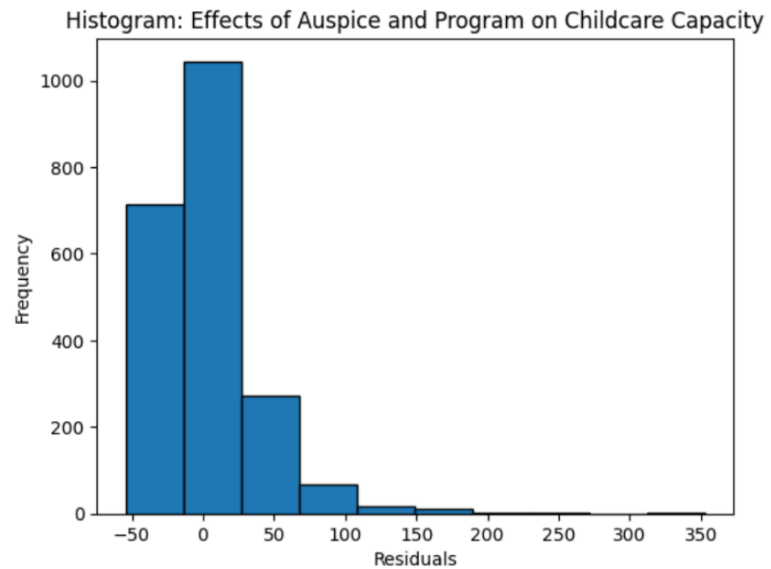


Figure 7. Histogram of residuals from multi-linear regression, where Total_Space is the dependent variable and Auspice and Program are the exploratory variables.

Test Statistic	P-value
0.892	$p < 0.001$

Table 5. Shapiro-Wilk test to check normality of residuals for two-way ANOVA.

Test Statistic	df	P-value
81.474	5	$p < 0.001$

Table 6. Levene's test to check whether each program in each auspice have equal variances.

Source	df	Sum of Squares	Mean Squares	F-value	Prob > F
Auspice	2	4.806×10^4	24028.029	17.024	$p < 0.001$
Program	1	7.822×10^3	7822.241	5.542	0.02
Auspice x Program	2	4.255×10^5	212747.740	150.732	$p < 0.001$
Residual	2120	2.992×10^6	1411.433		

Table 7. Two-way ANOVA summary table

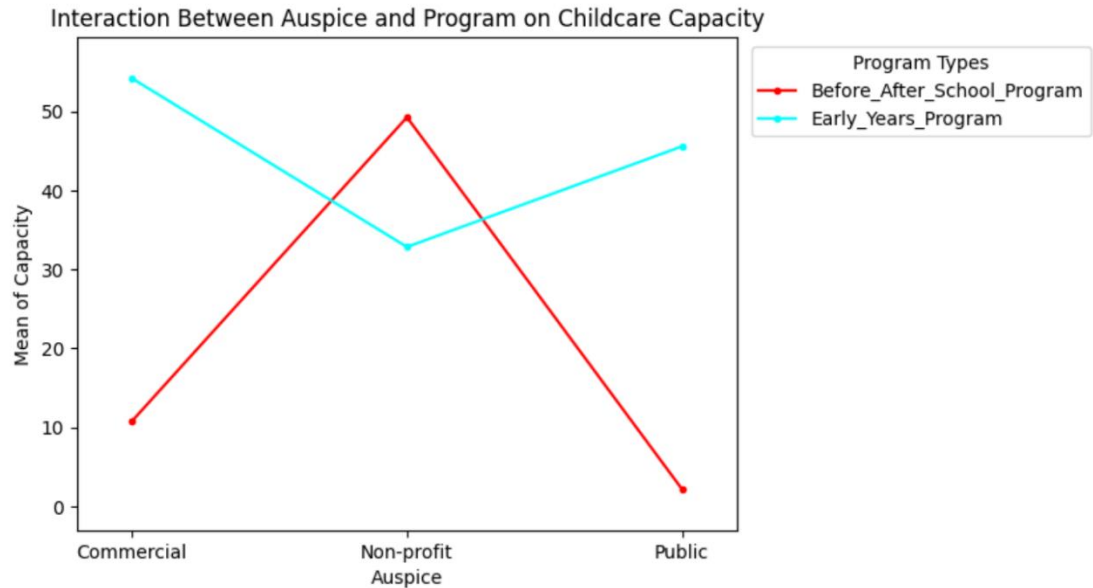


Figure 8. Interaction plot between auspice and program on childcare capacity

The two-way ANOVA summary table in Table 7 conveys a significant effect on childcare capacity by auspice ($F(2) = 17.024$, $p\text{-value} < 0.001$), program ($F(1) = 5.542$, $p\text{-value} = 0.02$), and the interaction between auspice and program ($F(2) = 150.732$, $p\text{-value} < 0.001$). This significant interaction implies that the average capacity differs between the early years program and before- and after-school program for at least one auspice. As illustrated in Figure 8, the effect of auspice interacts with the effect of program because the two lines (which represent different programs) are not parallel in the interaction plot. The early years program has the highest capacity in commercial centres. The before- and after-school program has a much greater capacity in non-profit centres. These observations of significant differences are supported by the following post-hoc Tukey's HSD test (see the green highlighted pairs in Table 10).

Multiple pairwise comparisons were computed to find which auspice and program are statistically different from each other. Similarly to the results of Tukey's HSD test for one-way ANOVA, there are significant differences for the same pairs: between non-profit and commercial centres and between non-profit and public centres with $p\text{-value} < 0.001$ (see Table 8). For the main effect program shown in Table 9, there is a significant pairwise difference between the early years program and before- and after-school program with an average difference of 4 childcare spaces with a $p\text{-value}$ of 0.019, which is less than the critical threshold of $\alpha = 0.05$. Lastly, the post-hoc test suggests that all interaction combinations are statistically different ($p\text{-value} < 0.001$), except for five pairs highlighted in orange in Table 10. There is not enough evidence that the capacity of early years program in public centres is statistically different from the capacity of the same program in commercial centres ($p\text{-value} = 0.728$), and from any program in non-profit centres ($p\text{-value} = 0.31$ and $p\text{-value} = 0.90$ for early years and before- and after-school programs respectively). The before- and after-school programs in commercial and public centres are not statistically different ($p\text{-value} = 0.729$). In addition, the before- and after-school program in non-profit centres is not statistically different from the early years program in commercial centres ($p\text{-value} = 0.376$).

Group 1	Group 2	Mean Difference	Lower CI	Upper CI	P-value
Non-profit	Commercial	8.560	4.363	12.757	$p < 0.001$
Non-profit	Public	17.167	6.917	27.417	$p < 0.001$
Commercial	Public	8.608	-1.958	19.173	0.136

Table 8. Tukey's HSD pairwise comparisons for main effect auspice from two-way ANOVA (95% confidence interval)

Group 1	Group 2	Mean Difference	Lower CI	Upper CI	P-value
Early years	Before- and after-school	3.836	0.641	7.032	0.019

Table 9. Tukey's HSD pairwise comparisons for main effect program from two-way ANOVA (95% confidence interval)

Group 1	Group 2	Mean Difference	Lower CI	Upper CI	P-value
(non-profit, early years)	(non-profit, before- and after-school)	16.411	10.696	22.127	$p < 0.001$
(non-profit, early years)	(commercial, early years)	21.334	14.116	28.553	$p < 0.001$
(non-profit, early years)	(commercial, before- and after-school)	22.043	14.824	29.261	$p < 0.001$
(non-profit, early years)	(public, early years)	12.718	-4.911	30.346	0.310
(non-profit, early years)	(public, before- and after-school)	30.641	13.013	48.270	$p < 0.001$
(non-profit, before- and after-school)	(commercial, early years)	4.923	-2.295	12.142	0.376
(non-profit, before- and after-school)	(commercial, before- and after-school)	38.454	31.235	45.672	$p < 0.001$
(non-profit, before- and after-school)	(public, early years)	3.693	-13.935	21.322	0.900
(non-profit, before- and after-school)	(public, before- and after-school)	47.052	29.424	64.681	$p < 0.001$
(commercial, early years)	(commercial, before- and after-school)	43.377	34.919	51.835	$p < 0.001$
(commercial, early years)	(public, early years)	8.617	-9.555	26.788	0.728
(commercial, early years)	(public, before- and after-school)	51.976	33.804	70.147	$p < 0.001$
(commercial, before- and after-school)	(public, early years)	34.760	16.589	52.932	$p < 0.001$
(commercial, before- and after-school)	(public, before- and after-school)	8.599	-9.573	26.770	0.729
(public, early years)	(public, before- and after-school)	43.359	19.093	67.625	$p < 0.001$

Table 10. Tukey's HSD pairwise comparisons for interaction effect from two-way ANOVA (95% confidence interval)

Limitations

The assumptions of normality and homoscedasticity were violated in both one-way and two-way ANOVAs. Thus, we are less confident in the validity of the results. The presence of outliers and vastly unequal sample sizes among groups may be the reasons behind these two violations. We can consider performing data transformation to reduce the skewness. Alternatively, we can conduct the Kruskal-Wallis test because the median is more resistant to outliers.

Conclusion

Based on the results of the one-way ANOVA, there is a significant effect of auspices on childcare capacity, particularly non-profit centres which are statistically different from commercial and public centres. The two-way ANOVA revealed that the effects of programs on childcare capacity depend on auspices. Parents might have a higher chance of securing a spot for their children in commercial centres for the early years program and in non-profit centres for the before- and after-school program. For future work, we can incorporate a third factor, the participation in the Canada-wide Early Learning and Child Care (CWELCC) system, to investigate whether this has a significant effect on childcare capacity.

References

Children's Services (2024, February). *Licensed Child Care Centre*. [Dataset]. Retrieved from <https://open.toronto.ca/dataset/licensed-child-care-centres/>

Perlman, M., Varmuza, P., and Burns, S. (2023, September 15). Ontario needs to remove barriers to child-care subsidies for low-income families. *TVO Today*. Retrieved from <https://www.tvo.org/article/ontario-needs-to-remove-barriers-to-child-care-subsidies-for-low-income-families>