Exploring Toronto's Childcare Centers
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Introduction

Toronto's childcare landscape faces pressing challenges with high fees and limited space availability, impacting many families and the broader socio-economic environment. The provincial government's response, a pledge to create 100,000 new childcare spaces by 2026[1], acknowledges the urgency for actionable insights into the sector's dynamics.

This report aims to dissect and analyze the factors that define the childcare landscape in Toronto as of 2024. We performed a comprehensive quantitative analysis using one-way and two-way ANOVA to dissect the various elements that influence the availability and capacity of childcare spaces. By examining the 'INF2178_A2_data.xlsx' dataset, we aim to answer two key questions:

Research Question 1: How does the operating auspice of a childcare center affect its total capacity?
Research Question 2: What is the impact of Canada-Wide Early Learning and Child Care (CWELCC) program participation on the capacity of childcare centers across different auspices?

Our analysis is designed to inform policy decisions that address the shortage of accessible childcare in Toronto, offering data-driven guidance for future initiatives.

Data Preparation & Exploratory Data Analysis

The dataset represents a snapshot of Toronto's childcare provision, composed of 1063 rows and 17 columns, reflecting both the capacities and operational nuances of childcare centers. It also has subsidy information, indicates if the centre offers subsidized spaces ('subsidy') and if it is part of the Toronto's CWELCC program (cwelcc_flag). We identified the key continuous variable: 'TOTSPACE', which represents the summation of the capacity across different age groups. We also checked **missing value** and found there were only missing values in the building name variable, and as 'building name' is not closely relevant to this study, we chose to proceed without cleaning this null value.

After performed data preparation, we conducted Exploratory Data Analysis using variables of interest.
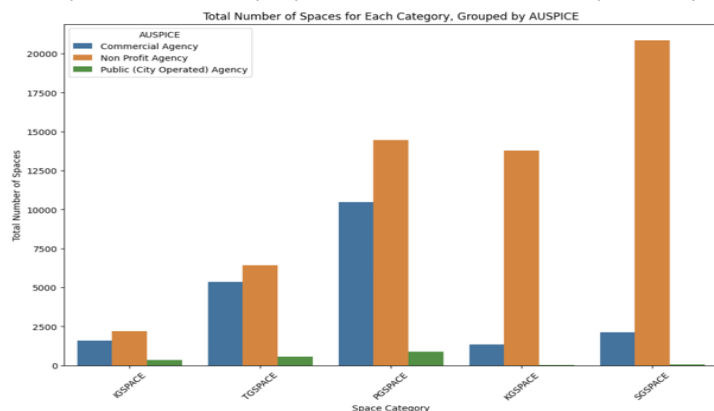

Figure 1 Total Number of Spaces for Each Category, Grouped by AUSPICE

According to the above figure, Non-Profit Agencies have the highest number of spaces in every category. Commercial Agencies come second, with a notable number of spaces, particularly in the Infant (IGSPACE), Toddlers (TGSPACE) and Preschool (PGSPACE) categories. Public Agencies have the fewest spaces, with very low numbers across all categories, indicating a much smaller scale of operation in comparison to the other types of agencies.

Analysis & Critical Reflection

Research Question 1: Does the type of operating auspice (AUSPICE) affect the total capacity (TOTSPACE) of childcare centers in Toronto?
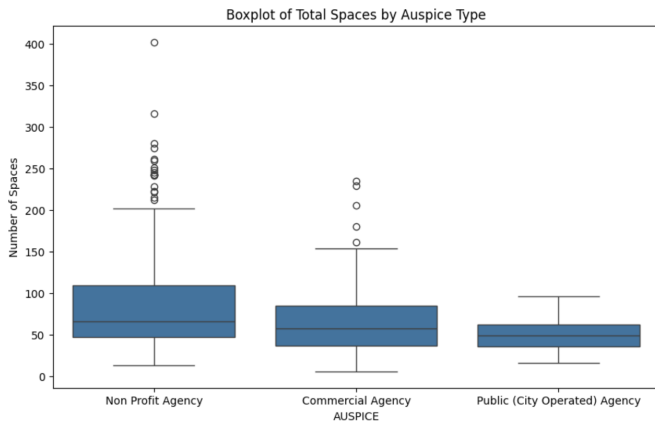

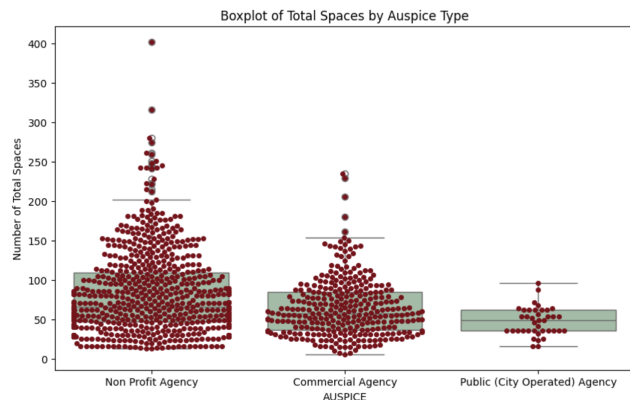*Figure 2 Boxplot of Total Spaces by Auspice Type*

Figure 3 Swarmplot on Boxplot of Total Spaces by Auspice Type

To explore the research question, we made two boxplots. From figure 2, we can see that Non-profit Agency has a higher median of total spaces and the distribution is quite wide, suggesting a large variation in sizes among these centers. Commercial Agency has a lower median compared to Non-Profit Agencies and fewer outliers. Public Agency displays a very tight distribution of total spaces with a low median, and very few outliers.

Figure 3 adds another layer on figure 2, providing a sense of the data density and distribution. Non-Profit Agencies have a dense concentration, particularly in the lower to mid-range, which suggests that many Non-Profit might have a similar capacity around that range. Moreover, there's a noticeable spread of data points well above the upper quartile, indicating a substantial number of Non-Profit centers with capacities exceeding the typical range, at a much larger scale. Commercial Agencies, the cluster of points around the median is less dense and less extreme compared to Non-Profit. This indicates that Commercial childcare tends to have a more uniform capacity with fewer extreme deviations. Public Agencies display the tightest data distribution, suggests that they are the most consistent in capacity, operating on a smaller scale.

One-Way ANOVA Analysis: OLS Model & ANOVA table result
Next, we performed One-Way ANOVA analysis, we created the Ordinary Least Squares(OLS) regression model with 'TOTSPACE' as the response variable and the categorical 'AUSPICE' as the predictor variable.

	sum_sq	df	F	PR(>F)
C(AUSPICE)	9.611211e+04	2.0	21.843051	5.057716e-10
Residual	2.332065e+06	1060.0	NaN	NaN

Figure 4 One-Way ANOVA table result

According to the result, we can see that the **F-Statistic** suggests the ratio of the variance between the group means to the variance within the groups is approximately 21.84 times larger than one would expect to see if the null hypothesis were true. It indicates a significant amount of variance between the groups compared to within them. The **P-value** of 5.057716e-10 is extremely small, much less than any standard alpha level (e.g., 0.05, 0.01); therefore, we reject the null hypothesis, indicating there is strong statistical evidence that the mean total capacity of childcare centers in Toronto varies by the type of operating auspice.

The result has practical implications for policy and management as it might reflect differences in operational scale, funding, and the potential scope of services offered by different types of agencies. Moreover, while we know that there is a difference, we don't know between which groups or the nature of these differences (larger or smaller). To determine this, we would need to conduct a post-hoc analysis to compare the means of each pair of groups.

Post-hoc test : Tukey's HSD test & analysis

	group1	group2	Diff	Lower	Upper	q-value	p-value
0	Non Profit Agency	Commercial Agency	16.806538	3.993722	29.619353	4.356853	0.006071
1	Non Profit Agency	Public (City Operated) Agency	36.177966	8.673910	63.682022	4.369046	0.005901
2	Commercial Agency	Public (City Operated) Agency	19.371429	-10.141900	48.884757	2.180132	0.272554

Figure 5 Tukey's HSD test table result

To pinpoint the differences between each pair of auspice groups, we conducted **Tukey's HSD post-hoc test**. Based on the results from Tukey's HSD test from above table, we found that:

Non-Profit Agency vs. Commercial Agency: **Diff:** Non-Profit Agencies have, on average, 16.807 more total spaces than Commercial Agencies. **p-value:** With a p-value of 0.006071, this difference is statistically significant at the conventional alpha level of 0.05. Indicating that there is a statistically significant difference between the average total capacity of Non-Profit Agencies and Commercial Agencies

Non-Profit Agency vs. Public (City Operated) Agency: **Diff:** Non-Profit Agencies have, on average, 36.178 more total spaces than Public Agencies. **p-value:** The p-value of 0.005901, indicating that the difference in mean total capacity between Non-Profit Agencies and Public Agencies is even more pronounced.

Commercial Agency vs. Public (City Operated) Agency: **Diff:** Commercial Agencies have, on average, 19.371 more total spaces than Public Agencies. However, this comparison includes the possibility that Commercial Agencies might have fewer spaces (indicated by the negative lower bound of the confidence interval). **p-value:** With a p-value of 0.2725, which is not statistically significant at the alpha level of 0.05.

ANOVA Assumption Check

Assumption 1: Residuals are standardized and normally distributed.
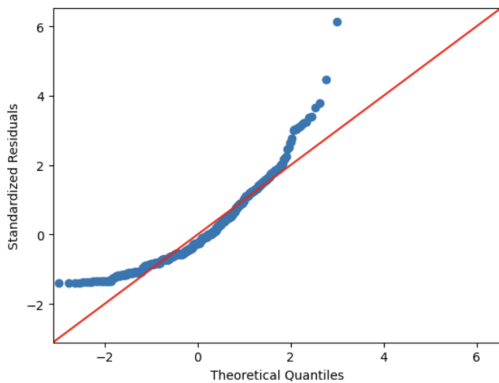
Then, we conducted ANOVA assumption checks to ensure the validity of our findings. **Q-Q plot** is used to visually check the normality of residuals. we see that while the points in the middle portion of the distribution closely follow the red line, the points in the tails deviate significantly from the line. This suggests that the residuals have heavier tails than would be expected in a normal distribution.

Figure 6 Q-Q Plot for Residual Standarlization

Moreover, the **histogram** of residuals provides another perspective. A perfectly normal distribution would have a bell-shaped histogram. Here, the histogram is skewed to the right, indicating that there is a right-skewed distribution of residuals. Such skewness is not in alignment with the assumption of normally distributed errors. The lack of normality, particularly if influenced by outliers or a few centers with exceptionally large or small total spaces, may indicate that mean comparisons using ANOVA do not fully capture the dynamics of childcare capacity across different auspices.
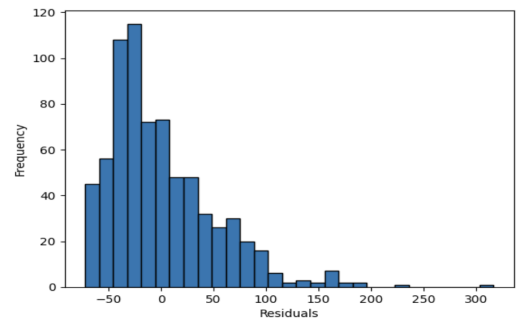

*Figure 7 Histogram of Residual Frequency*

Assumption 2: variances are homogenous - Levene's test

Next, we proceeded to test our second assumption. To this end, we utilized **Levene's test**, which is appropriate when the sample data is not normally distributed and assesses whether different groups have equal variances. The results showed a test statistic (W) of 9.1994 and a p-value of 0.0001. Since the p-value is significantly below the conventional alpha level of 0.05, we can reject the null hypothesis that our group variances are equal. In the context of our analysis, this suggests that there is a statistically significant difference in the variances of total capacities (TOTSPACE) across the different types of childcare center auspices (AUSPICE).

	Parameter	Value
0	Test statistics (W)	9.1994
1	Degrees of freedom (Df)	2.0000
2	p value	0.0001

Figure 8 Levene's test result table

Research Question 2: Is the interaction between operating auspice (AUSPICE) and participation in CWELCC (cwelcc_flag) significant in determining the total capacity (TOTSPACE) of child care centers?
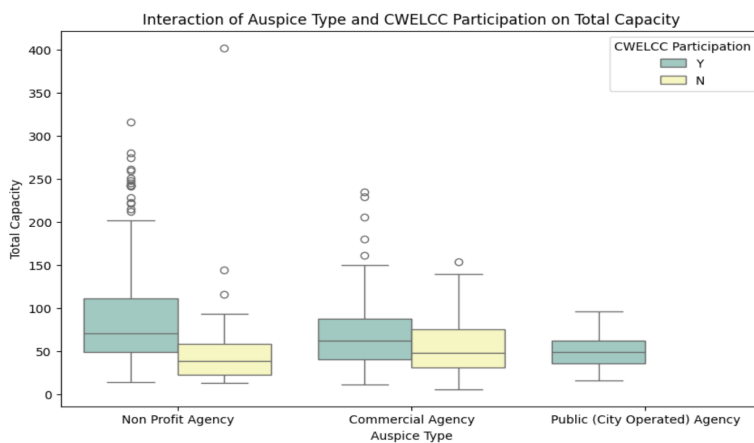
To explore the second research question, we crafted this boxplot.

According to the plot, we can observe that **Non-Profit Agencies** show a wide range of total capacities, both for centers that participate in CWELCC and those that do not, with participating centers generally exhibiting a higher median total capacity. **Commercial Agencies** display a narrower interquartile range in total capacity. Also, the number of CWELCC-participating centers appears to be higher

Figure 9 Boxplot of Auspice type and CWELCC on Capacity

than non-participating centers within the Commercial category. **Public Agencies** have a lower total capacity among three with 100% CWELCC participation rate. Also, the interquartile range for CWELCC-participating Public Agencies is quite compact, indicating a more uniform capacity among these centers. From these observations, it seems that while CWELCC participation may influence capacity to some extent in Non-Profit Agencies, the effect is less pronounced in Commercial and Public Agencies.

Two-Way ANOVA Analysis: OLS Model & ANOVA table result

To determine if these visual differences are statistically significant, we conducted the two-way ANOVA analysis.

	df	sum_sq	mean_sq	F	PR(>F)
C(AUSPICE)	2.0	1.083348e+05	54167.406210	25.188746	6.095400e-07
C(cwelcc_flag)	1.0	3.768832e+04	37688.323276	17.525698	3.070092e-05
C(AUSPICE):C(cwelcc_flag)	2.0	2.949561e+04	14747.806131	6.857975	1.098398e-03
Residual	1058.0	2.275187e+06	2150.460631	NaN	NaN

Figure 10 Two-Way ANOVA table result

According to the table above, we can see that for **Auspice**, with an F-statistic of approx. 25.19 and a very small p-value (6.0954e-07). This indicates that different auspice types are associated with significant differences in total capacity. There was also a significant main effect of **CWELCC participation** on total capacity, shown by an F-statistic of approx. 17.53 and the small p-value, suggesting that whether a center participates in the CWELCC program has a significant impact on its capacity. Lastly, **Interaction Effect** between operating auspice and CWELCC participation, with an F-statistic

of approx. 6.86 and a very small p-value. This signifies that the influence of CWELCC participation on total capacity varies depending on the type of auspice.

Then, we created the **interaction plot** for total capacity by auspice type and CWELCC participation to see how these two factors work together to influence the capacity of childcare centers. For **Non-Profit Agencies**, the mean total capacity increases significantly when participating in the CWELCC program. The steep upward line indicates that CWELCC participation is associated with a substantial boost in capacity. This suggests that the CWELCC program may be particularly effective for these agencies, possibly
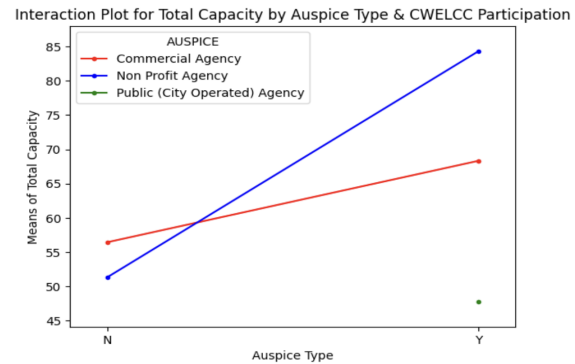

Figure 11 Interaction Plot for Capacity by Auspice Type & CWELCC

due to funding or policies that specifically enhance the services Non-Profit organizations can offer.
For Commercial Agencies: There's a moderate positive trend, although it is less pronounced than for Non-Profit Agencies. This implies that while CWELCC participation does have a positive association with capacity for Commercial Agencies, the effect is not as strong. This could reflect different operational models in the commercial sector that do not leverage CWELCC participation to the same extent as Non-Profit Agencies. Lastly, The single green point on the **'Public Agency'** line at CWELCC participation 'Yes' suggests the need for further investigation to understand why Public Agencies with CWELCC participation have such low capacity compare to others.

Post-hoc test: Tukey's HSD test & analysis
Then, to further dissect the interaction effects highlighted by our two-way ANOVA, we employed Tukey's HSD post-hoc test to investigate pairwise comparisons among the various combinations of AUSPICE types and CWELCC participation.

	group1	group2	Diff	Lower	Upper	q–value	p–value
0	(Non Profit Agency, Y)	(Non Profit Agency, N)	32.990302	12.999232	52.981373	6.662830	0.001
1	(Non Profit Agency, Y)	(Commercial Agency, Y)	15.993434	5.864514	26.122354	6.375101	0.001
2	(Non Profit Agency, Y)	(Commercial Agency, N)	27.876118	12.994318	42.757918	7.562847	0.001
3	(Non Profit Agency, Y)	(Public (City Operated) Agency, Y)	36.540220	14.719584	58.360857	6.761020	0.001
4	(Non Profit Agency, Y)	(Public (City Operated) Agency, N)	0.000000	-inf	inf	0.000000	0.900

Figure 12 Tukey's HSD test result table between AUSPICE types and CWELCC participation

From the table, for **Non-Profit Agencies**, with a p-value of 0.001, there's a significant difference in total capacity between those participating in CWELCC (Y) and those not (N), with the former having an average of approximately 32.99 more spaces. **For Non-Profit vs. Commercial Agencies (both Y)**, p-value of 0.001 here also indicates a statistically significant difference between them. Non-Profit Agencies have an average of 15.99 more spaces than Commercial Agencies, suggesting that the CWELCC program might be particularly effective in Non-Profit settings. **For Non-Profit(Y) vs. Commercial Agencies(N),** the difference is even more pronounced, with Non-Profit Agencies having about 27.88 more spaces on average. Lastly, for **Non-Profit(Y) vs. Public Agencies(Y),** with a p-value of 0.001 and highest difference of about 36.54 more spaces on average. Suggesting that Public Agencies may be not utilizing the CWELCC program to the same extent to increase their capacity.

	group1	group2	Diff	Lower	Upper	q-value	p-value
0	Y	N	24.101945	15.772582	32.431309	8.029722	0.001

Figure 12 Tukey's HSD test result table of CWELCC participation

Furthermore, we also conduct another Tukey's HSD test on **CWELCC (Y/N),** two groups to gain insights on the **overall effect of CWELCC Participation**. With the 0.001 p-value, child care centers participating in the CWELCC program, regardless of AUSPICE type, have an average of 24.10 more spaces than those not participating.

Conclusions

In conclusion, our investigation into Toronto's childcare landscape has yielded significant findings that answer our research questions and offer implications for policy and practice. Through comprehensive analysis, we found that

1. **Research Question 1 Conclusion**: The operating auspice does indeed have a significant effect on the total capacity of childcare centers. Non-Profit agencies are shown to offer a larger number of spaces, suggesting their critical role in the childcare ecosystem of Toronto.
2. **Research Question 2 Conclusion**: The interaction between operating auspice and CWELCC participation is significant across different auspices, particularly for Non-Profit agencies, which show a substantial increase in capacity with CWELCC involvement. This interaction effect is less pronounced in Commercial agencies and in Public agencies.

The **Tukey's HSD post-hoc tests** corroborated these insights, revealing statistically significant differences between Non-Profit agencies participating in CWELCC and all other groups, underscoring the unique benefit that CWELCC participation confers upon Non-Profit setups. However, this post-hoc analysis also illuminated that Commercial agencies maintain more consistent capacity, regardless of CWELCC participation, and Public agencies show no significant difference in capacity based on their participation status.

Critical to our statistical validation, the **ANOVA assumption checks** underscored certain caveats. The residuals exhibited a right skew, suggesting that there are childcare centers with capacities substantially higher than predicted by our model. This skew challenges the assumption of normally distributed errors, hinting at complexities within the data that simple ANOVA may not fully capture. Moreover, Levene's test indicated heterogeneity of variances, suggesting that the childcare centers' capacities are not uniformly distributed across the groups. These findings warrant a degree of caution in interpreting the ANOVA results and suggest a potential exploration of alternative statistical models or transformations for more robust insights.

These findings, especially the substantial boost in capacity that Non-Profit agencies experience through CWELCC, have important policy implications. They suggest a pathway for targeted governmental support and a call for refined strategies that take into account the diverse operational contexts of childcare centers. For policymakers, this study provides a data-driven foundation to forge initiatives aimed at amplifying childcare space availability in a city where families continue to grapple with access and affordability.