INF2178: Experimental Design for Data Science

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# Assignment 2

## Introduction

In Ontario, access to childcare is a huge concern for many families, challenged by the high cost and insufficient availability of spaces. This issue is especially noticeable in Toronto, where a large portion of families finds it difficult to secure affordable childcare options. This assignment investigates this issue through four research questions, each examining childcare provision in Toronto's diverse urban landscape:

(1) Is there a significant difference in space allocation between different types of childcare centers in Toronto?
(2) Does the availability of subsidy impact the total space allocation in childcare centers?
(3) Is there a significant difference in childcare spaces among different wards in Toronto?
(4) Do certain types of childcare centers prefer specific age groups of children?

These questions seek to better understand childcare accessibility in Toronto, aiming to provide a foundation for informed decision-making and policy development aimed at enhancing the quality and availability of childcare services for all families within the city.

## RQ1: Auspice Type and Space Allocation

In the first research question, it was hypothesized that the auspice of a childcare center—Non-Profit, Commercial, or Public—may influence the total number of spaces a childcare center offers. A one-way ANOVA was conducted to compare the mean space allocation across the three auspice categories. As seen in Table 1, the ANOVA results were significant, indicating that the type of auspice does indeed affect space allocation ($F(2, 1060) = 21.84$, $p < 0.001$). Non-Profit agencies were found to offer more spaces on average compared to Commercial and Public agencies. This shows that non-profit agencies are key providers, and this may be due to them benefiting from supportive funding, community backing, or operational mandates, whereas Commercial agencies focus on financial viability and Public agencies face issues with budget constraints and bureaucratic limits, hindering their capacity expansion.

**Table 1.** One-way ANOVA results for Auspice and Space Allocation

| Source | Sum of Squares | df | F | p-value |
|---|---|---|---|---|
| Auspice | 96,112.11 | 2 | 21.84 | < 0.001 |
| Residual | 2,332,065.00 | 1060 | N/A | N/A |

As seen in Table 2, The Tukey post-hoc test shows that Non-Profit agencies offer significantly more spaces compared to Commercial and Public (City Operated) agencies. No significant difference is found between Commercial and Public agencies, which suggests that while Non-Profits stand out in capacity, Commercial and Public agencies may operate with similar constraints or strategies.

**Table 2. Tukey Post-Hoc Test**

| Comparison | Mean Difference | p-value | Lower Bound | Upper Bound | Reject H0 |
|---|---|---|---|---|---|
| Commercial vs Non-Profit | 17.1194 | <0.001 | 9.7037 | 24.5351 | True |
| Commercial vs Public | -17.2152 | 0.0779 | -35.8832 | 1.4528 | False |
| Non-Profit vs Public | -34.3346 | <0.001 | -52.4448 | -16.2244 | True |

As seen in Figure 1, non-profit agencies not only lead in average total spaces but also display a broad range of capacities within their category, as do commercial and public agencies. Strategic planning must, therefore, account for this variability and aim to enhance the capacity where it is most needed. Strategies to improve Commercial and Public agencies could involve easing budget restrictions, fostering community partnerships, and exploring innovative funding models.

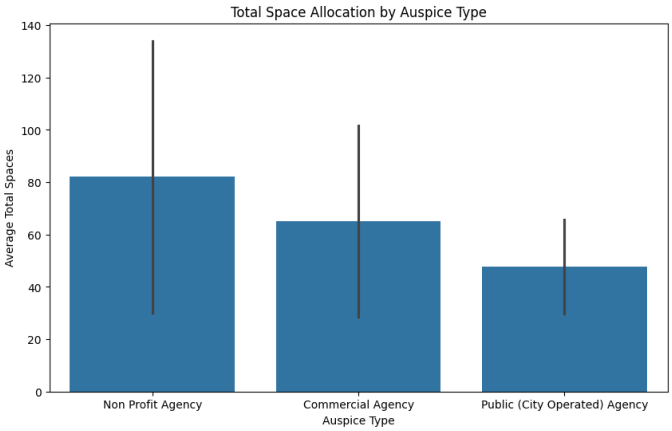


**Figure 1.** Bar chart showing average total spaces provided by each type of childcare center (Non-Profit Agency, Commercial Agency, and Public Agency).

**RQ2: Subsidy Availability and Space Allocation**

For the second research question, it was hypothesized that centers offering subsidies might have greater capacity, reflecting government strategies to make childcare more accessible. A one-way ANOVA was performed to test for differences in the mean number of spaces between subsidized and non-subsidized centers. According to Table 2, the results were statistically significant ($F(1, 1061) = 75.23$, $p < 0.001$), demonstrating that subsidy availability is a factor in determining space allocation. Childcare centers that offer subsidies tend to provide more spaces, which suggests that subsidies play a crucial role in enabling these centers to expand their capacity.

**Table 3.** One-way ANOVA results for Subsidy Availability and Space Allocation

| **Source** | **Sum of Squares** | **df** | **F** | **p-value** |
|---|---|---|---|---|
| Subsidy Availability | 160,765.4 | 1 | 75.23 | < 0.001 |
| Residual | 2,267,412 | 1061 | N/A | N/A |

As seen in Table 4, the Tukey test shows that childcare centers with subsidies offer substantially more spaces than those without. This significant mean difference reflects the strong influence of subsidies in expanding childcare center capacity.

**Table 4. Tukey Post-Hoc Test**

| **Subsidy Presence** | **Mean Difference** | **p-value** | **Lower Bound** | **Upper Bound** | **Reject H0** |
|---|---|---|---|---|---|
| Yes vs No | 26.2658 | <0.001 | 20.3236 | 32.208 | True |

Figure 2 shows this relationship, showing a higher mean total space in centers with subsidy availability ('Y') compared to those without ('N'), highlighted by the variance depicted through the error bars. These findings emphasize the pivotal role of subsidies in supporting larger childcare centers, which are crucial for meeting the demand for childcare spaces, particularly in lower-income areas or regions with higher demand. From a strategic perspective, policies might prioritize the continuation and growth of subsidy programs, ensuring that they align with the expansion goals of centers, especially in communities with higher needs. Additionally, encouraging non-subsidized centers to participate in subsidy programs could be another avenue to explore, potentially increasing their capacity to serve more families.

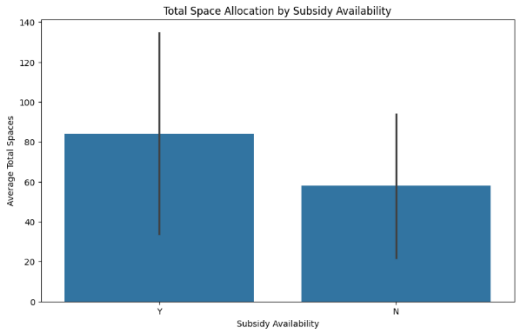


**Figure 2**. Barplot shows the average total spaces in child care centers that have subsidy availability ('Y') compared to those that do not ('N').

**RQ3: Geographic Distribution of Childcare Spaces**

For the third research question, it was hypothesized that ward-based disparities could point to inequities in the accessibility of childcare services across the city. A one-way ANOVA was carried out to determine if there were significant differences in the total number of spaces offered by childcare centers in each ward. As presented in Table 3, the ANOVA results approached significance ($F(24, 1038) = 1.446798$, $p = 0.07592$), suggesting that there may be differences in the distribution of spaces among wards.

**Table 3.** One-way ANOVA results for Ward-based Space Distribution

| **Source** | **Sum of Squares** | **df** | **F** | **p-value** |
|---|---|---|---|---|
| Ward | 78,598.06 | 24 | 1.446798 | 0.07592 |
| Residual | 2,349,579 | 1038 | N/A | N/A |

Figure 3 shows variability in the average number of childcare spaces across the wards of Toronto, with error bars illustrating the spread within each ward. Despite some wards showing higher averages, the lack of statistical significance from the ANOVA suggests these differences may not reflect consistent trends across the city. This suggests that space allocation might be influenced by an array of factors beyond geographic location, such as population density and socio-economic status. From a strategic perspective, policymakers are encouraged to look beyond the data to understand the nuanced needs of each ward. Future strategies could include detailed studies to unravel the underpinnings of the current distribution pattern and identify wards with pressing needs for additional childcare spaces.

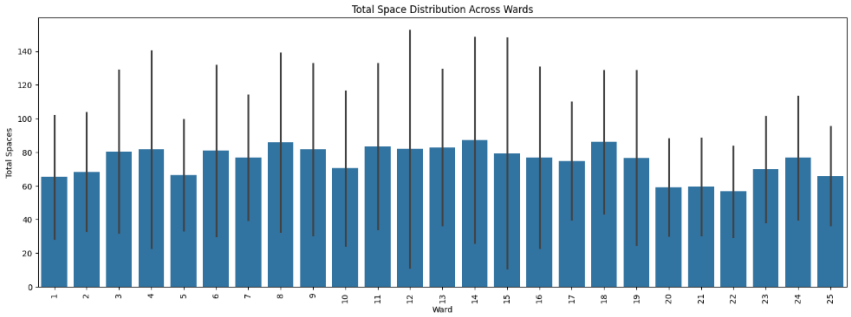


**Figure 3.** Barchart showing average total childcare spaces available across different wards in Toronto. Error bars indicate variability in each ward.

**RQ4: Age Group Preferences by Auspice Type**

For the fourth research question, we hypothesized that childcare centers' preferences for certain age groups could be influenced by their auspice type. A two-way ANOVA was used to evaluate the interaction between auspice type and the capacity for different age groups, ranging from infants to school-aged children. As shown in Table 4, the two-way ANOVA showed statistically significant effects for both the type of childcare center (auspice) ($p < 0.001$) and the age group ($p < 0.001$), with a significant interaction between the two factors ($p < 0.001$). This suggests that childcare centers' preferences and capacities for specific age groups are dependent on the auspice type.

**Table 4.** Two-way ANOVA results for Age Group Preferences by Auspice Type

| **Source** | **Sum of Squares** | **df** | **F** | **p-value** |
|---|---|---|---|---|
| Auspice | 1.922242e+04 | 2 | 29.104369 | 2.685589e-13 |
| Age Group | 2.821233e+05 | 4 | 213.579208 | 3.726614e-170 |
| Auspice:Age Group | 2.206458e+05 | 8 | 83.519093 | 9.972931e-131 |
| Residual | 1.750233e+06 | 5300 | N/A | N/A |

In the post-hoc comparisons (table too large to add), Commercial Agencies are found to focus on preschool-aged children whereas-Profit Agencies cater broadly but show a marked preference for school-age and preschool groups. In addition, Public Agencies, despite showing varied allocations, have a notable drop in kindergarten space offerings.

Figure 4 shows the variability in the allocation of spaces across different age groups within each childcare center auspice. The interaction plot reveals that while Non-Profit Agencies tend to provide more spaces for preschoolers, Commercial Agencies offer fewer spaces for infants and kindergarteners, and

Public Agencies show a consistent distribution of spaces across most age groups, with a notable exception for kindergarten. This suggests that each auspice type has its unique strategic focus and capacity when it comes to serving different age groups. From a strategic perspective, understanding these preferences is essential for planning and resource allocation. Stakeholders could use these insights to identify gaps in childcare provision and direct resources where they are most needed. For example, support could be increased for Commercial Agencies to expand infant care spaces or for Public Agencies to enhance their kindergarten programs.

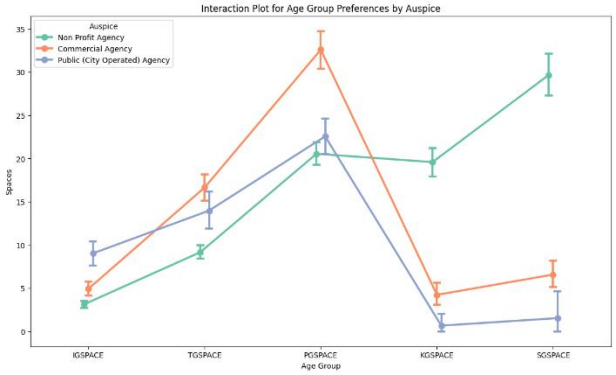


**Figure 4.** Interaction plot showing number of age group preferences by auspices.

**Conclusion:**

In conclusion, the analysis of Toronto's childcare system has revealed key insights. Non-Profit agencies are providing a significantly larger number of spaces, suggesting their pivotal role in the sector. The critical impact of subsidies in enabling centers to expand capacity has been clearly demonstrated. While the ward-based distribution of spaces did not show statistically significant disparities, a closer inspection might uncover more subtle trends. And finally, our exploration of age group preferences by auspice type has highlighted the tailored approaches centers adopt in servicing different age groups. Further analysis could look into the factors influencing these trends, such as the specific nature of funding models, community needs, and the operational mandates of childcare centers. A more granular look at demographic and socioeconomic variables within wards could also shed light on the nuanced needs of Toronto's families. Additionally, longitudinal studies assessing the impact of policy changes on space allocation would offer valuable feedback on the efficacy of current strategies and guide future endeavors. Such comprehensive analyses will continue to inform and optimize the provisioning of childcare services, ensuring that the needs of all families are met effectively.