The Influencing Factors of Cultural Spaces: A Case Study of the City of Vancouver

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Cultural spaces, including museums, art galleries, theatres, and dining spaces, have been of great interest to researchers. These places are shown to have great benefits on residents' mental health. Past studies, however, have mostly focused on the visitor demographic to such cultural spaces, e.g., household income, age, family with children status, and education level. They did not research the influencing factors on the number of cultural spaces. This paper seeks to remedy that gap. We ask the question: what are the influencing factors of cultural spaces? In addition to the visitor demographic mentioned above, we also include population density. Drawing from the Open Data Portal of the City of Vancouver and the 2021 Census Data from Statistics Canada, we analyze the relationship between the number of cultural spaces and the influencing factors in Vancouver. Controlling for other confounding variables, we found that the income level of residents is negatively and causally associated with the number of cultural spaces in the neighbourhood. Our findings encourage policymakers to look at barrier to access to cultural spaces beyond physical distance. Future research can focus on examining different types of cultural spaces and other cities to see if the results are generalizable. Keywords: Art, Canada, Census Data, Cultural Spaces, Mental Health, Museums, Music, Open Data, Policy Making, Urban Planning, Vancouver, Well-being

Cultural spaces have been of great interest to researchers. While there does not seem to be a widely agreed definition, some census data broadly characterize it to include museums, art galleries, education spaces, music-related venues, food venues including cafes, restaurants, and bars, and general community spaces (City of Vancouver, 2022). Although previous researchers did not target all these spaces included above, they have studied a sub-category of them.

Among these sub-categories, many studies have shown that attending cultural spaces improve mental well-being (H. Lee & Heo, 2021; C.-W. Lee, Lin, & Hung, 2021; Ateca-Amestoy, 2016; Ziogas, Ballas, Koster, & Edzes, 2023; Holt-Lunstad, Smith, & Layton, 2010; Samavati, Desmet, & Ranjbar, 2024; Benita, Bansal, & Tunçer, 2019). Focusing on cultural spaces with regards to art, C.-W. Lee et al. (2021), H. Lee and Heo (2021) and Ateca-Amesto (2016) found that visiting

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the sub-category of art venues (e.g., museums, performing art) improve life satisfaction, happiness, and physical health. Focusing on the sub-category of social spaces, including community spaces, cafes, restaurants, and bars, other scholars found that such public spaces increase social interaction among residents (Benita et al., 2019; Ziogas et al., 2023). Because Holt-Lunstad et al.(2010) has shown that social relationships are associated with decreased mortality, cultural spaces can improve health of residents by increasing social interaction. Based on these findings, it is clear that access to cultural spaces greatly impacts residents' mental well-being, life satisfaction, and physical health.

The health benefits of cultural spaces, however, are not accessed equally by residents of different demographic traits. Dawson (2014) has showcased the systemic mental barrier of low-income residents accessing museums. Concurring with Dawson's conclusion, public survey data in Canada and the US by museum-related organizations have shown four trends: museum attendance increases with income, education level, and family with children status, but is largely unchanged with regards to age (Wilkening, 2023; Hill Strategies Research Inc., 2003).

Among these factors, income level is of particular interest here. Numerous studies have already highlighted the health challenges of low-income individuals around the world, even in countries with universal healthcare such as Nordic European countries and the UK (Aittomäki, Martikainen, Rahkonen, & Lahelma, 2014; Gravelle & Sutton, 2003; Lahelma et al., 2002). Equitable access to cultural spaces, therefore, can potentially mitigate the income disparity in health. However, in reality, low-income individuals already access cultural spaces less in order to reap the health benefits (Wilkening, 2023; Hill Strategies Research Inc., 2003). Although scholars have examined the demographic makeup of attendees of cultural venues, the geographic distribution of cultural spaces has not been studied. This paper seeks to remedy that gap.

In this study, we ask the question: what is the association between the number of cultural spaces and income level in an area? Because of the wealth of data in Vancouver, we pick this city as the focus of our case study. By answering this question, we pave the way to understanding how to lower the barrier to cultural spaces for all residents. Our study has major implications for improving the mental well-being, physical health, and life satisfaction of residents in the city of Vancouver.

Our study has shown that contrary to common perception, controlling for other variables, higher income levels potentially cause a lower number of cultural spaces. This means that the low attendance rate of cultural spaces of low-income residents is not because of physical distance. However, psychological barriers should be examined, e.g., people feeling less sense of belonging.

I. Data Description

A. Data sources

In this study, we focus on the city of Vancouver. Therefore, we draw data from the Open Data Portal of the City of Vancouver (City of Vancouver, 2022) and the 2021 Canadian Census of Statistics Canada (Statistics Canada, 2022). The combining of the two data matched by geographic location information was conducted by Dr. Jonathan Graves.

In the resulting combined data set, we have the City of Vancouver divided into 3950 dissemination areas (DA), which are the smallest standard geographic units used by Statistics Canada, including 400-700 people (Statistics Canada, 2021). Such detailed data allows us to conduct a more granular analysis. For each of the 3950 DAs, we have 99 variables, ranging from household income to education. The variables are of variable data types, including numerical and categorical.

B. Variables: Importance and Structure

In this study, we examine the number of cultural spaces, the median household income, the number of individuals aged 65 or above, the number of households with children, the number of individuals with postsecondary education, and the population density of the DA.

Based on previous research, we have identified income as the primary independent variable of interest; we have identified cultural spaces as the dependent variable (Gravelle & Sutton, 2003; Lahelma et al., 2002; Aittomäki et al., 2014; C.-W. Lee et al., 2021; Wilkening, 2023; Hill Strategies Research Inc., 2003). However, other variables could contribute to the number of cultural spaces in an area. Past studies on the demographic of visitors to cultural venues have also showcased the importance of age, family with children status, and education level (Wilkening, 2023; Hill Strategies Research Inc., 2003). Therefore, we have control variables of age, family with children status, education level, and population density.

It is important to note, though, that in some DAs, the population is 0 or significantly low. This edge case is particularly important because some parks in the 2021 Canadian census are listed as a DA with no population, but the park itself might be counted as a cultural space in the City of Vancouver Open Data. These are the edge cases to consider as they do not follow the rule of having 400-700 people in a DA mentioned above (Statistics Canada, 2021). We have identified these edge cases in the table below.

Edge case	Population	Number of DA
1	0	3
2	≤ 100	5
3	≤ 300	25
4	≤ 400	70
5	≤ 500	255
6	All	851

Figure 1. Number of DAs with at least one cultural space controlled by population

Figure 1 shows the number of dissemination areas with at least one cultural space. The data is filtered by population size and having at least one cultural space. Compared to all the DAs having at least one cultural space, there are only 25 DAs under 300 people, 5 DAs under 100 people, and 3 DAs with 0 population. Therefore, although the misleading effect brought by the original data collection method is still present, it is not significant compared to the 851 total cases. We will still include these edge cases in our analysis for completeness.

Another point of consideration is that because of the relatively small size of DAs as the smallest analysis unit, people can still easily travel from within a DA to a cultural space in a neighbouring DA. This is particularly important in the case of Vancouver, where the city is relatively dense and well-connected by public transportation (Chen, 2023). We, therefore, include cultural spaces within 500 metres of the boundary of a DA as part of the cultural spaces in that DA. This data processing was performed by Dr. Jonathan Graves.

A final point of consideration is that the income levels of different DAs cannot readily be differentiated. In the later part of the analysis, we constructed one linear regression for the actual median household income and one for the 1/10000 of the median household income. The 1/10000 of the median household income is used to make the coefficient more interpretable.

C. Summary Statistics

In our study, we are interested in the variables below: the number of cultural spaces, the number of individuals aged 65 or above, the number of households with children, the median household income, the number of individuals with postsecondary education, and the population density of the DA.

Variable	Mean	Median	Min	Pct. 25	Pct. 75	Max
Culture Spaces	8.866	0	0	0	0	327
Age over 65	129	105	0	75	145	1315
Households with children	73.74	60	0	45	80	1222
Median household income	100413	100000	23200	82000	118000	260000
Postsecondary Education	377.3	305	0	230	420	6710
Population density	6458	4266	0	2678	7198	76474

Figure 2. Summary statistics of the variables

II. Model

A. *Main regression model specification*

We conduct a linear regression model as below:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \epsilon \tag{1}$$

where Y is the number of cultural spaces, X_1 is the number of individuals aged 65 or above, X_2 is the number of households with children, X_3 is the median household income divided by 10000, X_4 is the number of individuals with post-secondary education, X_5 is the population density of the DA, and ϵ is the error term. Each β_k term is the coefficient of the corresponding variable X_k. We will conduct a series of regressions to test the robustness of the results. We then conduct a series of variation regressions to test the robustness of the results.

B. *Alternative model specifications*

To test the specification of the main one (linear regression no.2), we constructed six other regression models. The total seven models are as follows:

1) Cultural spaces ~ Age over 65 + Households with children + Median household income + Postsecondary education + Population density
2) *** Cultural spaces ~ Age over 65 + Households with children + Median household income/10000 + Postsecondary education + Population density (Main model)**
3) Cultural spaces ~ Households with children + Median household income/10000 + Postsecondary education + Population density
4) Cultural spaces ~ Age over 65 + Median household income/10000 + Post-secondary education + Population density
5) Cultural spaces ~ Age over 65 + Households with children + Postsecondary education + Population density

6) Cultural spaces ∼ Age over 65 + Households with children + Median household income/10000 + Population density

7) Cultural spaces ∼ Age over 65 + Households with children + Median household income/10000 + Postsecondary education

C. *Regression results*

	Dependent variable:						
	Total_Culture_Spaces						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age65	-0.045***	-0.045***		-0.045***	-0.041***	0.003	-0.060***
	(0.007)	(0.007)		(0.007)	(0.006)	(0.006)	(0.006)
Kids	-0.258***	-0.258***	-0.257***		-0.270***	-0.046***	-0.301***
	(0.015)	(0.015)	(0.015)		(0.015)	(0.010)	(0.014)
Income	-0.0001***						
	(0.00002)						
IncomeBy10000		-0.562***	-0.190	-1.454***		-0.923***	-1.257***
		(0.211)	(0.205)	(0.213)		(0.220)	(0.201)
Postsecondary_Education	0.059***	0.059***	0.050***	0.016***	0.060***		0.072***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)		(0.003)
Population_Density	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	
Constant	12.045***	12.045***	4.830**	15.391***	6.253***	11.989***	24.143***
	(2.563)	(2.563)	(2.350)	(2.664)	(1.005)	(2.685)	(2.258)
Observations	3,519	3,519	3,519	3,519	3,569	3,519	3,519
R2	0.220	0.220	0.210	0.152	0.211	0.144	0.200
Adjusted R2	0.219	0.219	0.209	0.151	0.210	0.143	0.199
Residual Std. Error	28.807 (df = 3513)	28.807 (df = 3513)	28.994 (df = 3514)	30.028 (df = 3514)	29.379 (df = 3564)	30.178 (df = 3514)	29.176 (df = 3514)
F Statistic	198.155*** (df = 5; 3513)	198.155*** (df = 5; 3513)	232.988*** (df = 4; 3514)	157.762*** (df = 4; 3514)	237.693*** (df = 4; 3564)	147.438*** (df = 4; 3514)	219.113*** (df = 4; 3514)
Note:							*p<0.1; **p<0.05; ***p<0.01

Figure 3. Regression results with standard deviation before the robust standard deviation calculation

D. *Main model intepretation*

The results from the main model (linear regression No.2) are shown below, with the robust standard deviation calculated. The discussion of the robust standard deviation is in the next section.

- $\hat{\beta}_0 = 8.866$ with robust standard deviation of 3.987910237
- $\hat{\beta}_1 = -0.045$ with robust standard deviation of 0.009772574
- $\hat{\beta}_2 = -0.258$ with robust standard deviation of 0.035829408
- $\hat{\beta}_3 = -0.562$ (the coefficient for median household income/10000) with a robust standard deviation of 0.297930753
- $\hat{\beta}_4 = 0.059$ with robust standard deviation of 0.009409840
- $\hat{\beta}_5 = 0.001$ with robust standard deviation of 0.000171494

There are 3519 observations in the regression. The R^2 value is 0.220, and the adjusted R^2 value is 0.219. The F-statistic is 198.155 with a p-value of < 0.01. The p-values of the coefficients are all below 0.01, showing that they are all statistically significant. Notably, with regard to the research question, the β value is -0.562. This means that for every 10000 Canadian dollar increase in the median household income in a dissemination area, it can be predicted that there will be 0.562 of cultural space. We then conclude that a higher income level in a DA is associated with fewer cultural spaces in the DA.

III. Discussion

A. *Motivation for specification check*

In this paper, we aim to examine the relationship between the number of cultural spaces and various socioeconomic factors in the City of Vancouver. However, multiple variables could potentially confound the results (Gravelle & Sutton, 2003; Lahelma et al., 2002; Aittomäki et al., 2014; C.-W. Lee et al., 2021; Wilkening, 2023; Hill Strategies Research Inc., 2003). After controlling for those variables in our main regression model, studies have shown the correlation between education level and income (Statistics Canada, 2017). Therefore, income level and education level can also be collinear with each other, necessitating a check for multicollinearity. In addition, the presence of heteroskedasticity in the model can affect the robustness of the results. Therefore, we conduct a series of specification checks to ensure the validity of our main model.

B. *Check for Multicollinearity*

We perform a Variance Inflation Factor (VIF) test to check for multicollinearity. The results are shown below.

Model	Age 65	Children	Income/IncomeBy10000	Postsecondary	Density
lm1	1.691275	3.503274	1.399074 (Income)	4.297891	1.515622
lm2	1.691275	3.503274	1.399074 (IncomeBy10000)	4.297891	1.515622
lm3	-	3.503263	1.306054 (IncomeBy10000)	3.645414	1.427994
lm4	1.691270	-	1.317001 (IncomeBy10000)	1.710312	1.370834
lm5	1.582091	3.324460	-	4.296366	1.333594
lm6	1.434517	1.394101	1.387154 (IncomeBy10000)	-	1.232847
lm7	1.593492	3.168604	1.233137 (IncomeBy10000)	3.496018	-

Figure 4. Variance Inflation Factor (VIF) values for different models.

In the results, we can see that the VIF values are all below 5, indicating that there is little multicollinearity in the models. However, we observe that the VIF for the number of households with children is above 3 in all models except for lm6 without controlling for postsecondary education individuals. The VIF for postsecondary education individuals is above 3 in all models except for lm4 without controlling for the number of households with children. This indicates that there might be collinearity between the number of households with children and postsecondary education individuals.

Despite the VIF analysis, we did not remove the two variables from the model because of two reasons. First, the VIF values are insignificant to cause multicollinearity. Second, regression models with either one of the two variables removed perform significantly worse than the main model in terms of R^2. Comparing models (2) and (4), the model with the household with kids variable removed has an R^2 value of 0.152, much lower than the 0.222 R^2 value of the model (2). Similarly, the model (6) with the postsecondary education individuals variable removed has an R^2 value of 0.218, much lower than the 0.144 R^2 value of the model (2) compared with 0.218. This shows that both variables are important in explaining the number of cultural spaces in a DA. Removing either of them significantly reduces the explanatory power of the model.

C. Check for Heteroskedasticity

Model	BP	df	p-Value
lm1	274.25	5	$< 2.2e-16$
lm2	313.72	5	$< 2.2e-16$
lm3	274.25	5	$< 2.2e-16$
lm4	265.30	4	$< 2.2e-16$
lm5	190.08	4	$< 2.2e-16$
lm6	228.39	4	$< 2.2e-16$
lm7	157.39	4	$< 2.2e-16$

Figure 5. Breusch-Pagan test results for different models.

As the p-values are all below 0.05, we reject the null hypothesis that there is no heteroskedasticity in the models. Consequently, we use the robust standard errors in the regression results calculated using the HC1 setting in R.

Therefore, the robust standard errors are shown below:

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      (Intercept)                Age65                 Kids               Income Postsecondary_Education      Population_Density
     3.987910e+00         9.772574e-03         3.582941e-02         2.979308e-05         9.409840e-03         1.714940e-04
      (Intercept)                Age65                 Kids          IncomeBy10000 Postsecondary_Education      Population_Density
      3.987910237          0.009772574          0.035829408          0.297930753          0.009409840          0.000171494
      (Intercept)                  Kids          IncomeBy10000 Postsecondary_Education      Population_Density
     3.8040070306         0.0361271347         0.2947304333         0.0079826671         0.0001602629
      (Intercept)                Age65          IncomeBy10000 Postsecondary_Education      Population_Density
     4.2325732960         0.0100952747         0.3160109781         0.0042839442         0.0001641557
      (Intercept)                Age65                 Kids Postsecondary_Education      Population_Density
     1.5315637116         0.0096972037         0.0361250271         0.0094086142         0.0001629634
 (Intercept)              Age65               Kids      IncomeBy10000 Population_Density
4.2114690668       0.0067320230       0.0109374892       0.3031669640       0.0001610751
      (Intercept)                Age65                 Kids          IncomeBy10000 Postsecondary_Education
      3.891089096          0.009035531          0.036089833          0.306867592          0.009451768
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FIGURE 6. ROBUST STANDARD ERROR RESULTS

D. Interpretation of Results

We suggest that higher income levels cause fewer cultural spaces after examining the selection bias in the data. Income levels are negatively associated with cultural spaces. However, this variable can be confounded with postsecondary education individuals. Postsecondary education individuals are more likely to have higher income (Statistics Canada, 2017). However, this does not affect our findings. This is because the number of postsecondary education individuals is positively associated with the number of cultural spaces, which is the reverse for income level. Therefore, our model shows that income level has an even stronger negative association with the number of cultural spaces. We can, therefore, tentatively conclude that higher income levels cause fewer cultural spaces in a DA as part of the causal analysis.

E. Limitations

First, the study only includes the City of Vancouver. Different cities may exhibit different patterns. Future studies are recommended to examine other cities. Second, this paper shows that the physical distance between residents and cultural spaces is not the most determinative factor of attendance. The psychological aspect, hinted by Dawson (2014), should be further examined. Third, the definition of cultural space can be overly broad. It might be of interest to examine art venues, music venues, performance venues, and social venues separately.

IV. Conclusion

In this study, we examined the relationship between various socioeconomic factors and the number of cultural spaces in a designated area (DA). Our analysis included tests for multicollinearity and heteroskedasticity to ensure the robustness of our models. Our findings suggest that higher income levels are negatively associated with the number of cultural spaces in a DA. This relationship persists even after accounting for the potential confounding effect of postsecondary education

individuals, who are positively associated with cultural spaces. Therefore, even if postsecondary education might be correlated with higher income, our study indicates that income level has a potentially causal negative impact on the availability of cultural spaces. This finding encourages policymakers to consider the psychological barriers to cultural spaces, not just the physical distance barrier, as studied in this paper. Future research can focus on conducting a more granular analysis of different types of cultural spaces and examining other cities to see if the results are generalizable.

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