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THE APPLICATION OF HIERARCHICAL LINEAR MODELING FOR BARRIER-FREE SIDEWALK EVALUATION WITH THE BASIS OF DISABILITY ORGANIZATION COGNITIVE

Ching Tsung Hung

Key words: hierarchical linear modeling, barrier-free sidewalk, disability organization.

ABSTRACT

Organizations are hierarchical in nature. Specifically, individuals in the workplace are entrenched in work groups, which are entrenched in departments, which are entrenched in organizations, which are in turn entrenched in the larger environment. Hence, hierarchical linear modeling (HLM) is a statistical technique available to researchers that is ideally suited for the study of such cross-level issues. The purpose of this article is to provide market researchers with an overview and detailed description of HLM as well as a practical illustration of its usage.

The long-term aim of the Americans with Disabilities Act (ADA) is for publicly available services along a public street to be accessible to people with disabilities via a continuous, unobstructed pedestrian circulation network. Many countries believe in the underlying concept of the ADA and have implemented relevant laws. This study assumes that government policies will affect the "barrier-free sidewalk" environment, where government policies are at the organization level and the accessibility of sidewalks is at the individual level. As a result, a related law will not influence the in situ performance of sidewalks, and only the management of sidewalk plans and budgeting will have mediational effects. This means that laws have a long-term effect and the sidewalk accessibility assessment process will be modified. Those interested in the study of teams and cross-level research questions should find HLM advantageous in their research because of its ability to simultaneously investigate relationships within a particular hierarchy level, as well as relationships between or across hierarchical levels.

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I. INTRODUCTION

Sidewalks are part of the infrastructure of a country. For pavements, many studies have functioned as a kind of evaluation method for different purposes. For example, the pavement condition index is used to understand the condition of the pavement surface, and green road rating indicators are used to assess a road's potential for achieving sustainable development (Park et al., 2007; Lee et al., 2009; Juan et al., 2010; Muench et al., 2010). Disability is generally defined as a substantial limitation in daily life activities and is commonly measured in terms of the difficulty of performing basic activities (e.g., eating, bathing, dressing, walking) or more complex instrumental activities (e.g., shopping, managing finances).

The Americans with Disabilities Act of 1990 embodies civil rights legislation that extends to individuals with disabilities (Accommodations, 2005). Its implications are far-reaching: protection is provided in the areas of employment, public accommodation, state and local government services, transportation, and telecommunications. The ADA consists of five titles. Title II ensures that individuals with disabilities are included in public programs and services. Following the ADA concept, the Access Board published the ADA Accessibility Guidelines (ADAAG). The requirements outlined in these Guidelines are applicable to sidewalks, curb ramps, driveway crossings, street crossings, locations where two sidewalks meet, and so forth (O'Leary et al., 1996; Architectural, 1998; Kockelman et al., 2000, 2001).

In Japan, the principal standard for a barrier-free environment was established in 1983 (Tokuda, 2001). At the same time, the Ministry of Construction developed guidelines for laying paving block paths for the visually impaired. In 2000, a new law was introduced, commonly referred to as the "barrier-free law", to facilitate the unhindered movement of the aged and disabled on public transport.

In Taiwan, there are over one million physically and mentally disabled people (4.65% of the total population). The government modified the "Physically and Mentally Disabled Citizens Protection Act" to become the "People with Disabilities Rights Protection Act", which aims to protect the legal rights and interests of people with disabilities and provide them with the equal opportunity to participate fairly in social, political, economic, and cultural activities while increasing the independence and convenience of their lives (Chou and Schalock, 2009). Under this Act, the government has the responsibility to establish a barrier-free environment, and as such, sidewalks, urban roads and buildings should be developed so as to implement a barrier-free environment to promote human rights. A 2011 investigative report of the living conditions and needs of people with disabilities noted that the most common way of moving is walking (36.24%), thus a sidewalk barrier-free environment is very important. Tokuda (2001) investigated the specific barriers encountered and found that they include vehicles parked on sidewalks or textured paving blocks for the visually impaired, bicycles ridden on sidewalks, bicycles left on the sidewalk, uneven sidewalks, obstacles on sidewalks, undulating sidewalks, steep slopes, barging pedestrians, textured paving blocks that have been improperly laid, buttons on traffic lights for persons with disabilities that have been set up in inappropriate locations, etc. As such, the question of how to implement a barrier-free environment for sidewalks is of great importance.

According to the protection law for physically and mentally disabled people, the Taiwanese government is required to provide urban roads and sidewalks so as to create a barrier-free environment. There are 16 categories of officially registered disabilities with different physical and mental conditions focusing on different demands. For example, people with visual impairments stress the importance of consistency in the design because accessible information embedded in the environment is most useful "when used at consistent locations so that the traveler can rely on their existence" and find them reliable (Bentzen, 2007); but wheelchair users need smooth longitudinal slopes. According to the ADAAG, the counter slope to a curb ramp should not exceed 5% (Architectural and Board, 1998). The present study analyzes the relationship between the classified disabilities and the creation of barrier-free sidewalks.

The paper is divided into four main sections. The first section introduces hierarchical linear models and their application. The second section describes the data obtained from sidewalk evaluations. The next section applies HLM to sidewalk data and discusses the influence of disability organizations. Finally, the conclusion is presented.

II. METHOD

1. Hierarchical Linear Modeling

Hierarchical linear modeling (HLM), also known as multilevel linear modeling, mixed effects modeling, and random-effects modeling, is a compelling portrait of experimental data analysis methods. HLM is a multilevel modeling framework for analyzing data that can be collected and ordered hierarchically (Raudenbush, 2004). For data to be used with HLM it must be nested. Such nested data must include at least two nested levels, where entities at a lower level (Level 1) are nested within (i.e., make up) entities at a higher level (Level 2). Real-life examples could include employees nested within workgroups, children nested within schools, or people nested within societies. In all of these cases, entities at Level 1 (employees, children, and people) make up or are nested within entities at Level 2 (workgroups, schools, and societies) (Raudenbush et al., 1995; Juan et al., 2010). Applying traditional statistical analysis to data with a nested structure has several problems, such as aggregation bias, error in the estimated accuracy, and the unit problem (Hofmann, 1997; Lee, 2000).

HLM, however, offers several important advantages over the traditional univariate and multivariate repeated measures analyses. Specifically, it allows for the handling of missing data, non-fixed time intervals (Raudenbush and Bryk, 2002) and unequal error variance of within-subject consecutive measures. Recently, HLM has been used repeatedly to model the randomized trials of interventions (Mittelman et al., 2004; O'Connel et al., 2004). Because HLM does not assume equal error variances across serial observations and considers the influence of random effects such as subject-specific time intervals between measurements, it potentially allows for more accurate regression modeling of the experimental longitudinal data. Furthermore, HLM can simultaneously evaluate multiple evolving response variables (e.g., changes in the volume and cognition), allowing for the investigation of potential correlations between change trajectories (Laird and Ware, 1982; Shah et al., 1997; Thiébaut et al., 2002).

Multilevel models provide a powerful means to model data simultaneously at the levels of the moment and the individual, to estimate variation at each of these levels and to see how known variables predict the variation at these different levels (Snijders and Bosker, 1993; Singer and Willett, 2003; Goldstein, 2004; Hox, 2010). They also offer an improvement over repeated-measures ANOVA models that have been used in the past to model repeated cortisol measures because they do not require that the data be completely balanced (i.e., that each individual has the same number of observations), that the observations be regularly spaced in time or that all the observations be present (Goldstein, 2004).

HLM has been widely used in the literature (Miller and Murdock, 2007). Kirschbaum and others have used latent state-trait models to assess the trait levels of cortisol (Axelson et al., 1999; Handy and Clifton, 2000). Jones and Jørgensen used multilevel models to analyze the predictors of outcome for over 16,000 fatally and seriously injured casualties involved in accidents between 1985 and 1996 in Norway (Jones and Jørgensen, 2003). The analysis presented found a statistically significant residual variation in casualty outcomes between separate accidents and different geographical locations. The benefits of using multilevel models to analyze accident data have been discussed, along with the limitations of traditional regression modeling approaches. Ker and Lee proposed and demonstrated use of the original AASHO road test flexible pavement data with linear mixed-effects (LME) models (Ker and Lee, 2011). The prediction line of the within-group predictions (subject) followed the observed values more closely than that of the population predictions (fixed), indicating that the proposed LME model provides a better explanation of the data.

2. HLM Model

HLM can be understood by thinking of the analysis as being conducted in two steps. In the first step, analyses are conducted separately for every expert group (or some other unit) in the system using individual-level data. For example, sidewalk evaluation scores (the outcome measure of interest) could be regressed on a set of individual-level predictor variables, such as accessibility, safety and convenience. In this case, the regression model for each expert group l would be expressed as follows:

$$(road\_socre)_{ij} = \beta_0 + \beta_1(Accessiblity)_{ij} + \beta_2(Safety)_{ij} + \beta_3(Convenience)_{ij} + \varepsilon_{ij} \quad (1)$$

where $(road\_score)_{ij}$, $(Accessiblity)_{ij}$, $(Safety)_{ij}$ and $(Convenience)_{ij}$ are the scores on these variables for the i^{th} road in the j^{th} group. The analysis yields j separate sets of the regression parameters β_0, β_1, β_2, and β_3, one set for each expert group. The model can be constructed such that β_0 indicates the level of performance for each group after adjustment for accessibility, safety, and convenience, and β_1, β_2, and β_3 indicate the extent of inequalities between students with differing accessibility, safety, and convenience.

In the second step, the regression parameters from the first step of the analyses (i.e., levels of performance and extent of inequalities) become the outcome variables of interest. These are regressed on the group-level data describing the feeling from the barriers-free policy. For example, one could specify a regression of the adjusted levels of performance on the average score of a related law and a measure of managing sidewalks:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(Accessible_{group}) + \gamma_{02}(Safety_{group}) + \gamma_{03}(Convenience_{group}) + U_{01} \quad (2)$$

The analyses at this level yield estimates of the magnitude of the impact of the policy variable. In this example, the estimate of the parameter γ_{01} indicates the expected gain (or loss) in accessible scores for an average reduction in the groups of one site. The estimate for γ_{02} indicates the average effect on the safety of the groups. The estimate for γ_{03} indicates the average effect on the convenience of the groups. The statistical and computing techniques on which HLM is based incorporate into a single model the regression analyses specified in both steps. The model estimates the parameters of this model using iterative procedures (Raudenbush and Bryk, 1986; Goldstein, 2011).

Thus, the basic idea underlying HLM is that there are separate analyses for each unit in a hierarchical structure. The simple two-level model described here can be applied to address a range of questions that policy makers might pose. There are more complex hierarchical linear models; indeed, the statistical analyses specified at each level are not limited to linear regressions, and the models can include three- or even four-level models (Guo and Hussey, 1999).

A key statistic when considering the relative proportion of within- and between-individual variation is the expected correlation among measurements from the same individual. This statistic is often referred to as the intra-class (or intra-unit, intra-individual) correlation coefficient (ICC). Because the ICC assesses the degree of correlation within individuals, it can inversely indicate the degree of difference between individuals. For any sample, the ICC is easily calculated with estimates from the multilevel models of both the between-individual variance and the within-individual variance. Specifically:

$$\mathrm{ICC} = \frac{\tau^2}{\tau^2 + \sigma^2} \quad (3)$$

where τ^2 is a commonly used symbol for the between-individual variance and σ^2 for the within-individual variance (Singer, 1998; Snijder and Bosker, 2011). If the ICC is 0.30 for the site performance measurements taken of a set of individuals groups, we would expect the correlation between any pair of measurements of the same individual to be approximately 0.30.

This ICC statistic has several other useful interpretations. For example, it indicates the proportion of the total variance ($\tau^2 + \sigma^2$) attributable to between individual differences (τ^2). A final interpretation of the ICC is as the reliability statistic in classical measurement theory (Snijders and Bosker, 2011).

The ICC ranges from 0 to 1.0 and describes the proportion of the total variance that depends upon group membership. This is different from commonly reported estimates of inter- and intra-assay reliability typically using coefficients of variation (CV), which measure the reliability of momentary cortisol measurements. Rather, the ICC indicates the degree to which momentary cortisol measurements are stable within individuals at different times. Thus, it generally indicates lower reliability than that described by intra- and inter-assay reliability statistics. In addition because the coefficients of variation measure random variation, high CVs indicate low reliability whereas high ICCs, which measure 'true' variation, indicate high reliability.

III. DATA DESCRIPTION

1. Components of the Sidewalk Evaluation

According to the law, the Ministry of the Interior is required to promote a barrier-free environment. It presides over urban roads and monitors the performance of local governments in their implementation of policies. To provide a safe and comfortable barrier-free sidewalk, it established a "sidewalk accessibility assessment process for urban roads" to evaluate local government performance in the provision of barrier-free sidewalks in 2008. The assessment process is divided into two parts: (1) policy support and (2) site performance, which are described in detail below:

A. Policy Support

To understand how well the local government carries out its responsibilities with regard to the law and construction, their respective implementation percentages need to be considered. Based on the physically and mentally disabled Rights Protection Law, the central government needs to develop management laws and rules for a barrier-free environment, and the local government needs to establish related laws (e.g., disability facilities, motorcycle parking on sidewalks, overall improvement and construction plans). It should also be noted that because sidewalks are ancillary facilities next to buildings or roads, surveying the sidewalk's location and quantity is very important.

B. In situ performance

Axelson et al. developed an assessment process to evaluate sidewalk accessibility (Axelson et al., 1999). It was a means of collecting objective information about the sidewalk features such as the grade and cross slope that impact pedestrian access. The data found that the ADA had taken forward strides in improvements in access across all aspects for people with disabilities. The Texas Department of Transportation also developed a formulation for measuring the accessibility of a sidewalk. The impedance factor was divided into four attributes that a traveler may take into consideration when evaluating travel choices. The first attribute describes safety-related qualities affecting impedance. Personal safety is most closely related to walk and transit modes. The second attribute is convenience that related directly to the conceptual definition of accessibility. It is a measure of ease to pursue an activity. Comfort and aesthetics are two areas that may enhance from the characteristics of the other categorics. The World Bank attempted to devise a type of reliability index to rank cities across the world based on the safety, security, and convenience of their pedestrian environments. It defined safety and security by the number of pedestrians that fell victim to crime along the walking path. Convenience was defined by the number of paths that were blocked with temporary or permanent obstructions.

In accordance with lectures (Axelson et al., 1999; Kocklman et al., 2001), sidewalk in situ performance in Taiwan is made up of three components. The first of the components is accessibility, which refers to the availability of disability facilities or non-blocked sidewalks. The second component is safety, which refers to pedestrian protection and the maintenance of sidewalks. The third component is convenience, which refers to tree shadows and the cleanliness of walking paths.

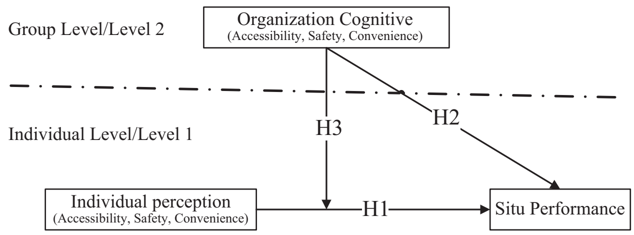

Fig. 1. Conceptual framework.

2. Differences in Social Welfare Groups

Clarke et al. have used data from the Chicago Community Adult Health Study (2001-2003) to confirm the effect of the built environment characteristics on mobility disabilities (Clarke et al., 2011). The authors found using multinomial logistic regression that adults with only a mild physical impairment, or none at all, were not affected by the outdoor environment. Hwang collected 600 samples, which included the visually impaired, orientation Training Groups, an architectural design group and competent authorities, and found that different groups demanded different barrier-free environments. These different demands should be considered when attempting to create a barrier-free environment (Hwang, 2010).

IV. RESULTS

The two-level hierarchical linear model as described previously was estimated using HLM 6.08 software. Level 1 was a measurement model of the variation within each sidewalk responding to items and captured item inconsistency, which is the variation around the individual's "true score" or true perception of the sidewalk; Level 2 of the model captured the variation among the respondents within the group around the group's 'true score' or, in other words, individual variations in perceptions of the group (see Fig. 1).

Three group constructs were included in the model: accessibility (four items), safety (four items), and convenience (two items). Additionally, organizational cognitive (two items: disability and expert) was established on Level 2 to discuss organizational cognitive influence. Consequently, the Level 1 file contained 1521 observations (227 sidewalks), and Level 2 had 12 cases (organizational cognitive). Dummy coding was used to label each item to show which construct it belonged to. The analysis was multivariate, and all environment constructs were the outcome variables. All scale measures were on a 100 point rating scale anchored from "poor" to "excellent". They were treated as intervals, which is common in the literature. Assuming reasonably normal distributions, the HLM analyses should not be affected (Raudenbush and Bryk, 2002). Specifically, they assessed the following hypotheses:

Hypothesis 1: Individual effort is positively related to sidewalk performance.

Hypothesis 2: Cognitive of the disability organization is positively related to sidewalk performance above and beyond individual effort.

Hypothesis 3: Cognitive of the disability organization moderates the effort and sidewalk performance relationship.

1. Testing Random Effects

Certain prerequisites must be satisfied to conduct cross-level analyses. First, there must be systematic within- and between-group variances in the dependent variable. This condition is necessary because the dependent variable (sidewalk performance) is hypothesized to be significantly related to both an individual level variable (individual effort) and group level variable (team cohesiveness). This is assessed in HLM using a one-way analysis of variance.

Unless there is significant between-group variance in the dependent variable, team cohesiveness would not explain a significant amount of such variance. A null model with no independent variables at Level 1 or Level 2 estimates the following equations:

$$\text{Level-1: } (road\_score)_{ij} = \beta_{0j} + r_{ij} \tag{4}$$

$$\text{Level-2: } \beta_{0j} = \gamma_{00} + \mu_{0j} \tag{5}$$

where

road_score = performance of the sidewalk
β_{0j} = mean performance of the sidewalk for group j
γ_{00} = grand mean performance of the sidewalk
$r_{ij} = \sigma^2$ = within-group variance in the performance of the sidewalk
$\mu_{0j} = \tau_{00}$ = between-group variance in the performance of the sidewalk

The Level 1 equation does not include an independent variable; therefore, the regression equation includes only an intercept estimate. The Level 2 model regresses each group's mean dependent variable onto a constant. In other words, β_{0j} is regressed onto a unit vector, which results in a γ_{00} parameter equal to the grand mean of the dependent variable (i.e., the mean of the group means, β_{0j}).

The one-way ANOVA provides information regarding the amount of variance in the dependent variable that is within and between groups. Since there is no significance test for within group variance, the HLM program produces a chi-square statistic to test the significance of the between-group variance. A significant chi-square for the dependent variable shows that the between-group variance is significantly different from zero, indicating that the intercept term varies across groups.

In addition, using the information estimated in the null model, an intra-class correlation coefficient (ICC) that represents the percent of the total variance in the dependent variable that is between groups can be computed (Raudenbush and Bryk, 1986). The ICC indicates the amount of variance that could potentially be explained by the Level 2 predictor, team cohesiveness. The following equation is used: $\text{ICC} = \frac{\tau^2}{\tau^2 + \sigma^2}$, resulting in ICC = 0.23.

2. Random Coefficient Regression Model

Next, researchers can assess whether there is a significant between-group variance in the intercepts and slopes using a random-coefficient regression model. To find support for Hypothesis 2, there must be significant variance in the intercepts across groups, and for Hypothesis 3 to be supported, there must be significant variance in the slopes across groups. This model tests the significance of Hypothesis 1. The random-coefficient regression model estimates the following equations:

$$\text{Level-1: } (road\_score)_{ij} = \beta_{0j} + \beta_{1j}(Accessibility)_{ij} + \beta_{2j}(Safety)_{ij} + \beta_{3j}(Convenience)_{ij} + r_{ij} \tag{6}$$

$$\text{Level-2: } \beta_{0j} = \gamma_{00} + \mu_{0j} \tag{7}$$

$$\beta_{1j} = \gamma_{10} + \mu_{1j} \tag{8}$$

$$\beta_{2j} = \gamma_{20} + \mu_{2j} \tag{9}$$

$$\beta_{3j} = \gamma_{30} + \mu_{3j} \tag{10}$$

where

road_socre = performance of the sidewalk
Accessibility = accessibility of the sidewalk
Safety = safety of the sidewalk
Convenience = convenience of the sidewalk
β_{0j} = mean performance of the sidewalk for group j
β_{1j} = grand mean accessibility effort for group j
β_{2j} = grand mean safety effort for group j
β_{3j} = grand mean convenience effort for group j
γ_{00} = mean of the intercepts across groups
γ_{10} = mean of the slopes across groups
γ_{20} = mean of the slopes across groups
γ_{30} = mean of the slopes across groups
$r_{ij} = \sigma^2$ = Level 1 residual variance
$\mu_{0j} = \tau_{00}$ = variance in the intercepts
$\mu_{1j} = \tau_{11}$ = variance in the slopes
$\mu_{2j} = \tau_{22}$ = variance in the slopes
$\mu_{3j} = \tau_{33}$ = variance in the slopes

The Level 2 regression equation is equal to an intercept term and a residual because there are no Level 2 predictors of β_{0j}, β_{1j}, β_{2j}, or β_{3j}. The γ_{00} to γ_{30} parameters denote the Level 1 coefficients averaged across groups (i.e., they are the pooled β_{0j} and β_{1j} parameters). Because β_{1j} to β_{3j} are regressed onto constants, the variance of the Level 2 residual terms (i.e., μ_{0j}

to μ_{3j}) represents the between-group variance in the Level-1 parameters.

A t-test was used to test the significance of γ_{10} to γ_{10}.This provides evidence of whether the pooled Level-1 slopes between the independent variable and the dependent variable differ from zero.

Thus, this test assesses whether, on average, the relationship between the independent variable (individual effort) and the dependent variable (sidewalk performance) is significant or whether Hypothesis 1 is supported. Hypothesis 1 was supported by the data ($t = 3.687, p \leq 0.01$).

To test the cross level hypotheses, the HLM procedure states that there must be significant variance across groups in the Level-1 intercepts (β_{0j}). The intercept terms represent the between-group variance in the dependent variable after controlling for the independent variable. Chi-square tests for the estimates of the intercept (τ_{00}) and slopes (τ_{11}, τ_{22}, τ_{33}) are performed to confirm that the variance in the intercepts and slopes for the dependent variable across groups is significant. If there is not significant between group variance, then a group effect would not exist. The simulated data indicated that there was significant between group variance ($\chi^2 = 75.34, p < .001$).

With information provided from the null and random-coefficients regression models, researchers can calculate R^2 for the relationship between individual effort and the performance of a sidewalk. This R^2 is the percentage of the individual variance in sidewalk performance that is explained by individual effort. R^2 is calculated using the following equation:

$$R^2 = \frac{S^2_{null} - S^2_{random\_regression}}{S^2_{null}} = \frac{11780.2 - 4285.8}{11780.2} = 0.634$$

3. Intercepts-as-Outcomes Model

After establishing that there is significant variance across groups in the Level-1 intercepts, then the cross level hypothesis (Hypothesis 2) can be directly tested. It was tested using the following equations:

$$\text{Level-1}: (road\_score)_{ij} = \beta_{0j} + \beta_{1j}(Accessibility)_{ij} + \beta_{2j}(Safety)_{ij} + \beta_{3j}(Convenience)_{ij} + r_{ij} \quad (11)$$

$$\text{Level-2}: \beta_{0j} = \gamma_{00} + \gamma_{01}(Accessibility)_{group} + \gamma_{02}(Safety)_{group} + \gamma_{03}(Convenience)_{group} + \mu_{0j} \quad (12)$$

$$\beta_{1j} = \gamma_{10} + \mu_{1j} \quad (13)$$

$$\beta_{2j} = \gamma_{20} + \mu_{2j} \quad (14)$$

$$\beta_{3j} = \gamma_{30} + \mu_{3j} \quad (15)$$

where

$(Accessibility)_{group}$ = accessibility of the sidewalk by groups

$(Safety)_{group}$ = safety of the sidewalk by groups

$(Convenience)_{group}$ = convenience of the sidewalk by groups

γ_{01} = Level 2 slope of the accessibility

γ_{02} = Level 2 slope of the safety

γ_{03} = Level 2 slope of the convenience

A t-test was performed to test the significance of γ_{0j}. The results show whether the group level variable (team cohesiveness) has a significant effect on the dependent variable (sidewalk performance). The results from the data support Hypothesis 2 ($t = 2.423, p < 0 .01$).

Using information from the HLM intercepts-as-outcomes analyses, an overall R^2 for the respective Level 2 equations can be computed. Given the R^2 value, one can determine what the independent variables' variance is between groups and, subsequently, how much of the total variance can be attributed to team cohesiveness. The R^2 equation is:

$$R^2 = \frac{\tau_{00\,(random\_regression)} - \tau_{00\,(intercepts\text{-}as\text{-}outcome)}}{\tau_{00\,(random\_regression)}}$$

$$= \frac{4285.8 - 3728.6}{4258.8} = 0.13$$

The intercepts-as-outcomes model also produces a chi-square test that indicates whether, after including team cohesiveness, there still remains significant variance in the intercept term across groups that could be explained by additional group level variables. A significant condition must exist to test for a moderator. The data indicated that a moderator could be tested for ($t = 70.68, p < .01$).

4. Slopes-as-Outcomes Model

Finally, after establishing that significant group variance in the slopes was present in the random coefficient regression model, the researcher can then examine whether the variance in the slope across groups is significantly related to the group level independent variable (team cohesiveness). This is a direct test for the cross-level moderator (Hypothesis 3). The slopes-as-outcomes model is employed for this step as follows:

$$\text{Level-1}: (road\_score)_{ij} = \beta_{0j} + \beta_{1j}(Accessibility)_{ij} + \beta_{2j}(Safety)_{ij} + \beta_{3j}(Convenience)_{ij} + r_{ij} \quad (16)$$

$$\text{Level-2}: \beta_{0j} = \gamma_{00} + \gamma_{01}(Accessibility)_{group} + \gamma_{02}(Safety)_{group} + \gamma_{03}(Convenience)_{group} + \mu_{0j} \quad (17)$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}(Accessibility)_{group} + \gamma_{12}(Safety)_{group} + \gamma_{13}(Convenience)_{group} + \mu_{1j} \quad (18)$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(Accessibility)_{group} + \gamma_{22}(Safety)_{group} + \gamma_{23}(Convenience)_{group} + \mu_{2j} \quad (19)$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}(Accessibility)_{group} + \gamma_{32}(Safety)_{group} + \gamma_{33}(Convenience)_{group} + \mu_{3j} \quad (20)$$

where
γ_{11} = Level 2 slope of the accessibility
γ_{12} = Level 2 slope of the safety
γ_{13} = Level 2 slope of the convenience
γ_{21} = Level 2 slope of the accessibility
γ_{22} = Level 2 slope of the safety
γ_{23} = Level 2 slope of the convenience
γ_{31} = Level 2 slope of the accessibility
γ_{32} = Level 2 slope of the safety
γ_{33} = Level 2 slope of the convenience

The t-test associated with γ_{11} tests Hypothesis 3. Hypothesis 3 is supported by the simulated data (t = 2.118, p < 0.01). The information provided in the HLM output for the intercepts-as-outcomes and slopes-as-outcomes models can be used to calculate R^2 for the moderator and team cohesiveness. The R^2 value indicates the percentage of variance in the relationship between the individual effort and sidewalk performance that is accounted for by team cohesiveness. The R^2 equation is:

$$R^2 = \frac{\tau_{11\,(intercepts\text{-}as\text{-}outcome)} - \tau_{00\,(slope\text{-}as\text{-}outcome)}}{\tau_{00\,(intercepts\text{-}as\text{-}outcome)}}$$

$$= \frac{3728.6 - 2945.6}{3728.6} = 0.21$$

V. CONCLUSION

Multilevel approaches provide the flexibility to model variation in the sidewalk performance at multiple levels under a variety of study designs. By partitioning the variation, multilevel models can examine the degree to which fixed effects, such as accessibility, safety, and convenience, explain variance in each of these different levels, which is a significant improvement over crude assessments of the total explained variance. In preserving information about the precision of person-level estimates, they also permit the detection of associations that might be missed by simply analyzing crude aggregates. In null model, the Cognitive of the disability organization has significant effect in sidewalk performance because ICC is greater than 0.138. Accessibility, safety and convenience has directly effect to situ-performance in random coefficient regression model. The influence of slope of accessibility, safety and convenience is non-significant.

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