



# **Path Analysis of Demographic Variables and TCAP Percentile Ranks**

Technical Report

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**May 2020**

## Overview

The Knox County Schools' (KCS) strategic plan continues to focus on reducing gaps in academic outcomes between student subgroups. Longitudinal disparities in educational outcomes have given rise to a number of initiatives in the district and nationwide. Further, literature has documented specific relationships between student outcomes and demographic variables (Page, 1981; Kieffer, 2010; Blair, 2002). The KCS department of Research, Evaluation, and Assessment (REA) conducted the following study to quantify the relationship between student demographic variables and one academic outcome; student percentile ranks from the Tennessee Comprehensive Assessment Program (TCAP). The relationship between demographic variables and TCAP outcomes are estimated using path analysis.

## Methodology

This analysis focuses on the student subgroups defined in the Tennessee Department of Education (TDOE) accountability protocol. TDOE defines subgroups as groups of students who, in aggregate, exhibit significant performance gaps when compared to their peers. These subgroups are as follows:

- BHN (Black/Hispanic/Native American): Students who identify as members of Black/African American, Hispanic, or Native American/American Indian racial/ethnic groups (either completely or in part).
- ED (Economically Disadvantaged): Students who are members of households receiving direct benefits from the government (SNAP, WIC, etc.).
- ELL (English Language Learners): Students for whom English is not their native language and have not yet demonstrated proficiency in the English language.
- SWD (Students with Disabilities): Students who are served by a formal Individual Education Plan (IEP).

It should be noted that all of the demographic variables lack specificity (defined as follows). TDOE chooses to code a student as a member of only one ethnic/racial group based on specific accountability rules. In reality, students may identify with multiple racial/ethnic groups to varying degrees. Students are dichotomously identified as ED (either ED = Yes or ED = No), but economic indicators (such as household income) are more precisely measured on a continuous scale. Additionally, students may live in a household that is eligible for government assistance and opt not to apply for these services. Students in these "opt-out" households are not considered economically disadvantaged in the TDOE accountability framework. An ELL designation indicates that a student is a non-native English speaker that has not passed a national assessment related to English language skills. Students who were formerly identified as ELL may still struggle to read and fully understand the TCAP content because of English language deficits. Finally, students labeled as SWD have a variety of disabilities, each of which may impact state test scores differently. For example, the impact

of an emotional disturbance may have very different consequences compared to a specific learning disability. Therefore, all demographic variables should be considered crude dichotomous indicators of real-world textured spectrums. . The results of this study must be interpreted with this limitation in mind.

The data used in the analysis were generated during the 2017-2018 and 2018-2019 school years (SY1718 and SY1819 respectively) in grades 3 through 12. Path coefficients were generated using valid test results from the SY1718 English/Language Arts (ELA) TCAP (grade 3-8 English/Language Arts, English I, and English II). SY1819 TCAP data from both ELA and Math tests (grade 3-8 math, Algebra I, Algebra II, Geometry, Integrated Math I, and Integrated Math II) were used to validate the model. All TCAP scaled scores were converted to percentile ranks using the conversion tables generated by SAS; the vendor responsible for generating value-added calculations. Student demographic data reflect the information in the KCS student information system at the time of TCAP administration.

**Methodology: Model Specification**

Path Analysis (and Structural Equation Modeling) requires the use of “qualitative causal hypotheses based on theory or the results of empirical studies” (Kline, 2011). The model used in this analysis was derived from peer-reviewed research (Page, 1981; Kieffer, 2010; Blair, 2002) and is contained in Figure 1.

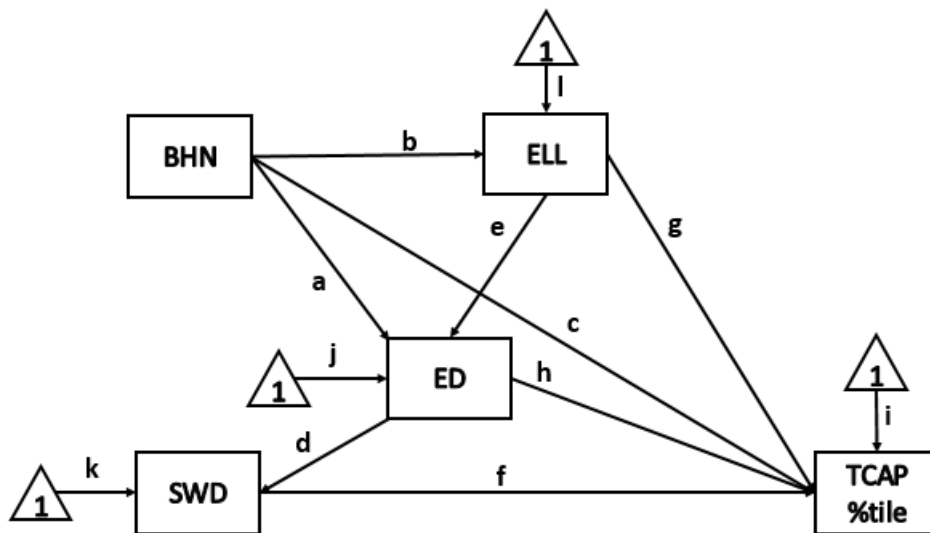


Figure 1: Proposed Path Model: Demographics and TCAP Percentiles

The model assumes that there are causal links between demographic variables and a student’s state percentile on the TCAP and that those links have specific directionality. Previous academic research has assumed a causal link between race/ethnicity and ED status

(Page, 1981), between ELL and ED status (Kieffer, 2010), and between ED status and SWD (Blair, 2002). A causal link between race and ELL is logical based on the TDOE definitions of the subgroups. The model assumes that there is no (direct) causal relationship between SWD and BHN and ELL. Analysis of the variance/covariance matrices (See “Results” section, Tables 1-3) indicate that these assumptions are empirically justifiable.

Path Analysis calculations were completed in R (version 3.6.3) using the lavaan package (version 0.6-5). R was accessed through RStudio (version 1.2.1335). Lavaan parameter estimates were derived using the normal-theory maximum likelihood technique.

### Results: Model Construction

The variance/covariance matrices for the SY1718 ELA, SY1819 ELA, and SY1819 Math data are contained in Tables 1-3 (respectively).

*Table 1: SY1718 ELA TCAP Variance/Covariance Matrix, N=35,616*

	BHN	ED	SWD	ELL	%Tile
BHN	0.190				-0.037
ED	0.060	0.202			-0.045
SWD	0.005	0.015	0.105		-0.036
ELL	0.019	0.007	0.002	0.031	-0.011
%Tile	-0.037	-0.045	-0.036	-0.011	0.087

*Table 2: SY1819 ELA TCAP Variance/Covariance Matrix, N=35,114*

	BHN	ED	SWD	ELL	%Tile
BHN	0.194				-0.039
ED	0.061	0.200			-0.045
SWD	0.006	0.017	0.108		-0.038
ELL	0.020	0.007	0.003	0.033	-0.011
%Tile	-0.039	-0.045	-0.038	-0.011	0.087

*Table 3: SY1819 Math TCAP Variance/Covariance Matrix, N=38,143*

	BHN	ED	SWD	ELL	%Tile
BHN	0.195				-0.039
ED	0.060	0.198			-0.044
SWD	0.006	0.016	0.106		-0.033
ELL	0.022	0.007	0.003	0.035	-0.010
%Tile	-0.039	-0.044	-0.033	-0.010	0.086

The results of the path analysis indicate that the model in Figure 1 provides a good fit to the observed data (Hu, 1999). The Comparative Fit Index (CFI) is well above the cut-off for an acceptable fit (model CFI = 0.998, cuff-off CFI = 0.90) and the Root Mean Square Error of

Approximation (RMSEA) is well below the cut-off for an acceptable fit (model RMSEA = 0.020, cut-off RMSEA = 0.60).

Parameter estimates are contained in Table 4. The z statistics are somewhat uninterpretable due to the large sample size (N>35,000), but are presented for completeness. The intercepts provide the mean value of a variable when all upstream variables equal zero. Path coefficients are partial correlation coefficients for each pair of variables.

Table 4: Parameter Estimates from SY1718 ELA TCAP Path Analysis

Parameter	Path	Estimate	Standard Error	z-value	Standardized Estimate
%tile ~ BHN	c	-0.118	0.003	-36.120	-0.174
%tile ~ ELL	g	-0.218	0.008	-28.297	-0.131
%tile ~ ED	h	-0.155	0.003	-49.871	-0.236
%tile ~ SWD	f	-0.316	0.004	-77.016	-0.347
ED ~ BHN	a	0.312	0.005	58.337	0.303
ED ~ ELL	e	0.041	0.013	3.079	0.016
SWD ~ ED	d	0.074	0.004	19.355	0.102
ELL ~ BHN	b	0.098	0.002	47.005	0.242
%tile Intercept	i	0.655	0.002	385.282	2.218
ED Intercept	j	0.199	0.003	75.797	0.443
SWD Intercept	k	0.098	0.002	48.906	0.304
ELL Intercept	l	0.007	0.001	7.000	0.042
%tile Variance		0.062	0.000	133.447	0.714
ED Variance		0.182	0.001	133.447	0.906
SWD Variance		0.104	0.001	133.447	0.990
ELL Variance		0.030	0.000	133.447	0.942
%tile R-squared		0.286			
ED R-squared		0.094			
SWD R-squared		0.010			
ELL R-squared		0.058			

The data suggests that the direct effect of membership in the BHN subgroup has a small negative effect on TCAP percentile. Membership in the ELL and ED subgroups have small-to-medium negative effects. Membership in the SWD subgroup has a medium negative effect on TCAP ELA percentile.

The direct and total effects of the demographic variables are contained in Table 5. The largest difference between direct effects and total effects occurs within the BHN subgroup. The direct effect of membership in the BHN subgroup, when holding all other variables constant, is a decrease of 11.8 percentage points in a student’s TCAP percentile. The total effect of

membership in the BHN subgroup, which considers the mediating effect of membership in other subgroups, is a decrease of 19.6 TCAP percentage points.

*Table 5: Direct and Total Effects of Subgroup Membership on TCAP ELA Percentile*

Subgroup	Direct Effect Paths	Direct Effect	Indirect Effect Paths	Total Effect
BHN	c	-0.118	bg+ah+beh+adf+bedf	-0.196
ELL	g	-0.218	eh+edf	-0.225
ED	h	-0.155	df	-0.178
SWD	f	-0.316	-	-0.316

**Results: Model Validation**

The path model generated from the SY1718 ELA data was successfully validated against both the SY1819 ELA data and the SY1819 Math data. The fit statistics indicate that the SY1819 ELA data is well-described by the model, with a CFI of 0.995 and a RMSEA of 0.014. The SY1819 Math data is also well-described by the model, with a CFI of 0.998 and a RMSEA of 0.024.

## Conclusions & Considerations

The results of the analysis suggest that the path model presented in Figure 2 can be used to describe a causal relationships between demographic variables and TCAP results (NOTE: Path coefficients are unstandardized in Figure 2 and intercept terms have been removed for clarity). The model was successfully validated within subjects and between subjects.

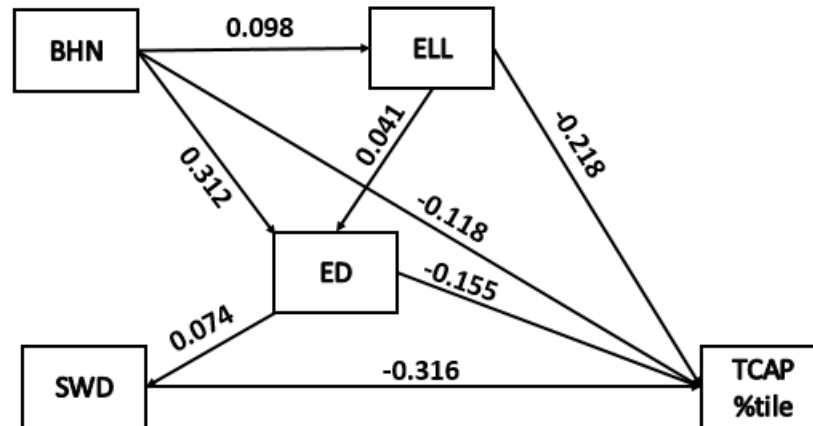


Figure 2: Final Path Model

The model suggests that, in isolation, membership in the BHN subgroup reduces the average TCAP percentile of a student by approximately 12 percentage points. Membership in the ED, ELL, and SWD subgroups reduce the average TCAP percentile by approximately 16, 22, and 32 percentage points respectively (when controlling for all other variables).

The model suggests that there are indirect effects (i.e. effects that impact the outcome through other demographic variables) that considerably impact the BHN subgroup. The total effect of membership in the BHN subgroup is significantly mediated through other demographic variables (with 62% of the indirect effect stemming from ED mediation). The total effect of membership in the BHN, ED, ELL, and SWD subgroups reduce the average TCAP percentile by approximately 20, 23, 18, and 32 percentage points respectively.

These findings may better inform KCS gap-reducing strategies. The model suggests that any strategy aimed at decreasing gaps associated with student race/ethnicities can only be limited in success if they do not also address the mechanisms leading to economic disparities. Attenuation of the direct effect of BHN on state test outcomes on the basis of race/ethnicity alone will likely only address approximately half of the underlying cause of the TCAP gap. The findings of this study may also provide a mechanism to monitor the effectiveness of strategies designed to reduce gaps in TCAP performance. Monitoring how path coefficients change in time can inform the district about the efficacy of these strategies.

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