EXAMINING THE INFLUENCE OF PSYCHOLOGICAL CHARACTERISTICS ON CHILDREN'S ACTIVE COMMUTING TO SCHOOL USING THEORETICAL PERSPECTIVES

A Dissertation

by

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ABSTRACT

Previous research on children's active commuting to school (ACS) focused mainly on physical and social environmental predictors of the behavior, leaving psychological factors under studied. The purpose of this dissertation was to examine psychological characteristics that can influence children's ACS using theoretical perspectives in three separate studies. Beginning with a systematic review of the current literature of ACS, the first manuscript critically evaluated theory utilization and methodological quality of empirical studies on perceived barriers to children's ACS, and provided recommendations for advancing the quality of future ACS studies. The second manuscript presented a quantitative study examining the roles of children's and parents' self-efficacy in children's ACS based on Bandura's self-efficacy theory. In the third manuscript, the efficacy of a modified integrative model (IM) in explaining parents' intention toward ACS and children's subsequent commuting behavior was tested, and multiple key psychological determinants of health behavior, e.g., intention, self-efficacy, health beliefs, were investigated. Structural equation modeling (SEM) was used for secondary data analysis in the second and third manuscripts to test the hypothesized pathways using M*plus* 7.0.

Several key findings emerged from the dissertation. First, many previous studies on perceived barriers to ACS lacked theoretical grounding or used theories superficially. Second, the methodological rigor of ACS studies need to be improved, especially in regard to appropriate statistical analysis techniques, control variable estimation,

multicollinearity testing, and reliability and validity testing. Third, children's self-efficacy is predictive of their ACS and can be increased through improved neighborhood safety and social modeling. Fourth, parents' intention toward ACS has both direct and mediating effects on children's ACS, and self-efficacy represents the most powerful determinants of intention.

This dissertation, as a whole, builds upon current research and knowledge regarding children's ACS and offers insights for more sophisticated ACS studies in the future. The work reported here provides support for the continuing exploration of the roles of psychological factors in children's ACS using theoretical perspectives.

ACKNOWLEDGEMENTS

Now the dissertation is finished. Looking back at the past three years, I would like to thank several people who have contributed in one way or another to my pursuit of a doctoral degree. First, I wish to thank my doctoral advisor, Dr. E. Lisako J. McKyer, for her excellent guidance, caring and support over the years, and for creating a wonderful research environment in the Transdisciplinary Center for Health Equity Research. I would also like to show my appreciation to my co-chair, Dr. Chanam Lee, for her critical monitoring of my dissertation and valuable suggestions. I owe much to my committee members, Drs. Patricia Goodson, Marcia Ory, and Suojing Wang. I am grateful for their time and effort conceptualizing, reading, and revising the dissertation manuscripts. The feedback their provided has contributed significantly to the quality of this dissertation. I am fortunate enough to have the world's best husband and most adorable daughter, and I would like to thank them for standing by my side through the good times, and bad. It is sad that my father passed away on Father's Day, 2013. Wherever you are, dad, please know that you are dearly missed. Lastly, I would like to express my thanks to my mom and sister, who let me know that family will always be there for me, no matter the distance.

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CHAPTER I

INTRODUCTION

Childhood obesity (CHO) has become a global epidemic, with its prevalence increasing in both developed and developing countries (Wang & Lobstein, 2006; Kelishadi, 2007). For example, between 1980 and 2008, the prevalence of CHO has increased from 7% to over 30% in the U.S. (Ogden et al., 2011). Recently, the National Poll on Children's Health (2012) recognized childhood obesity as the leading health concern among parents in the U.S., topping drug abuse and smoking. The increasing trend of CHO has also made it a major public health concern, because CHO has many immediate and long-term adverse consequences, including high blood pressure, type 2 diabetes, and increased cholesterol levels (Reilly, 2003; Dietz, 2004; Reilly & Kelly, 2011).

Recent research has acknowledged the role of active commuting to school (ACS), e.g., walking or biking to/from school, in promoting children's physical activity and its potential for preventing and reducing childhood obesity (Lee, Orenstein & Richardson, 2008; Mendoza et al., 2011). However, the rates of ACS have declined over the past few decades (Van der Ploeg, Merom, Corpuz & Bauman, 2008; McDonald, Brown, Marchetti & Pedroso, 2011). For example, in the U.S., the percentage of children who walked or biked to school declined from 47.7% in 1969 to 12.7% in 2009 (McDonald, Brown, Marchetti & Pedroso, 2011). Similarly, in Australia, the percentage of children aged 5-9 who walked to school decreased from 57.7% in 1971 to 25.5% in

2003 (Van der Ploeg, Merom, Corpuz & Bauman, 2008). Considering the health benefits of ACS, it is important to identify predictors of ACS and develop effective intervention to reverse the declining trend.

Over the past decades, researchers in different disciplines, e.g., public health, urban planning, and transportation, have identified multiple personal, environmental, and social determinants of ACS (Saelens, Sallis, & Frank, 2003; Sirard & Slater, 2008). Based on these empirical findings, various interventions have been developed and conducted. However, most of the interventions have proved insufficient in changing children's commuting behavior to school (Chillón, 2011).

Previous literature on ACS suffered from four notable limitations. First, although many empirical studies have identified various predictors, especially perceived barriers, of ACS, it is not clear how many of these studies are methodologically sound and theoretically grounded. A rigorous assessment of existing literature is important because studies with poor designs, methodological flaws, or theoretical weaknesses could result in biased results and consequently render the subsequent interventions less effective.

Second, little research has been carried out into investigating psychological factors that may influence children's ACS (Sirard & Slater, 2008). Examination of these factors is critical because most interventions that placed emphasis on structural or environmental improvements have proved insufficient in promoting children's ACS (Chillón, 2011) and research has established the predictive power of multiple psychological factors on promoting children's physical activity, including intention, beliefs and self-efficacy (Sallis et al., 2000; Van Der Horst et al.,, 2007).

Third, previous ACS studies focused mainly on parents based on the hypothesis that parents play a greater role than children in choosing the mode of travel to school (Stewart, 2011). However, children can also contribute insightful research data, and their beliefs in their own capabilities (i.e., self-efficacy) should be considered when designing ACS programs. However, few studies have been conducted to examine children's self-efficacy toward ACS.

Fourth, many ACS studies didn't ground their investigations in theoretical foundations. Theories provide a framework for indentifying determinants of a particular health behavior, which represents a critical first step in the development of successful interventions (Fishbein & Cappella, 2006). Without a comprehensive and accurate assessment of the determinants of a health behavior, development of effective interventions to promote the behavior is not likely.

The purpose of this dissertation study is to address the above-mentioned limitations of previous ACS studies by examining the influence of psychological factors on children's ACS using theoretical perspectives. Specifically, I aim to 1) critically assess the current literature of ACS and evaluate theory utilization and methodological quality of empirical studies on perceived barriers to children's ACS, 2) investigate the roles of children's and parents' self-efficacies in children's ACS based on the Self-efficacy Theory, and 3) test a modified integrative model of behavior prediction for explaining parents' intention toward ACS and children's subsequent commuting behavior to school.

This dissertation is organized in a journal article format with five sections. Sections 2 through 4 are independent manuscripts to be submitted for publication in peer-reviewed journals. The following is a brief description of the dissertation contents. Appendices and other supporting documents are included at the end.

- **Chapter 1**: Introduction. Overview of and rationale for the dissertation project.
- **Chapter 2**: Journal article 1. A systematic review of existing empirical, methodological, and theoretical issues in the current literature of ACS, particularly studies regarding perceived barriers to ACS.
- **Chapter 3**: Journal article 2. A quantitative study examining the roles of children's and parents' self-efficacies in children's ACS based on Bandura's self-efficacy theory.
- **Chapter 4**: Journal article 3. A quantitative study testing the efficacy of a modified integrative model in explaining parents' intentions toward ACS and children's subsequent commuting behavior to school.
- **Chapter 5**: Conclusions. Discussion of overall project findings, implications for health education and promotion, and recommendations for future research and practice.

CHAPTER II

PERCEIVED BARRIERS TO CHILDREN'S ACTIVE COMMUTING TO SCHOOL: A SYSTEMATIC REVIEW OF EMPIRICAL, METHODOLOGICAL AND THEORETICAL EVIDENCE

Introduction

Childhood obesity has become a global epidemic, with its increasing prevalence in both developed and developing countries (Wang & Lobstein, 2006; Kelishadi, 2007; Ogden et al., 2010). Active commuting to school (ACS), defined as the use of active means such as walking or biking to and from school, may contribute to increasing children's daily physical activity level and thereby help them maintain a healthy weight (Lee, Orenstein & Richardson, 2008; Mendoza et al., 2010; Mendoza et al., 2011). Despite the significant health implications of ACS, the rates of ACS have declined over the past few decades (McDonald et al, 2009). For example, in the U.S., the percentage of children who walked or biked to school declined from 47.7% in 1969 to 12.7% in 2009 (McDonald et al, 2009). Similarly, in Australia, the percentage of children aged 5-9 who walked to school decreased from 57.7% in 1971 to 25.5% in 2003 (Van der Ploeg et al., 2008).

To reverse the declining trend of ACS, the first crucial step is to identify barriers that prevented children from walking or biking. Research in this area has expanded in the past ten years, and many ACS studies have identified various perceived barriers related to child's ACS (Davison, Werder & Lawson, 2008; Saelens, Sallis & Frank, 2003; Sirard & Slater, 2008). Nevertheless, it is not clear how many of these studies are methodologically sound and theoretically grounded. A rigorous assessment of existing literature is important because studies with poor designs, methodological flaws, or theoretical weaknesses could result in biased results and consequently render the subsequent interventions less effective.

In ACS research, perceived barriers can be defined as a person's estimated level of challenges related to personal, environmental, social, and policy obstacles to ACS (Glasgow & Permanente, 2012). As a social cognitive construct, perceived barriers have been widely used or incorporated in health behavior theories, including the health belief model, social cognitive theory, theory of planned behavior, and social ecological theory (Becker, 1974; Bandura, 1986; McLeroy et al., 1988; Ajzen, 1991). Previous research has suggested that, compared with objective factors, e.g., urban form, individuals' perceptions of the environment around them have a stronger and more direct relationship with children's active commuting behavior (McMillan, 2005). Given the theoretical and empirical importance of perceived barriers in ACS research, it is essential to ensure that this construct is considered properly.

Therefore, the aim of this systematic literature review is to critically assess the current literature on perceived barriers to children's ACS. Specifically, we aim to 1) examine research on perceived barriers to ACS, 2) identify different types and measures of perceived barriers reported by researchers, 3) assess the methodological quality of empirical studies on perceived barriers to ACS, and 4) evaluate the level of theory utilization in the studies, i.e., to what extent theory was used and the construct of perceived barriers was conceptualized and operationalized. Empirical, methodological and theoretical recommendations for future studies will also be provided.

Methods

Search strategy

Following the PRISMA guidelines (Moher et al., 2010), we systematically searched for peer-reviewed articles related to perceived barriers to children's ACS in the following six databases: Academic Search Complete, Eric, Medline, EMBASE, CINAHL Plus with Full Text, and SportDis. We chose these databases because they are comprehensive and include multidisciplinary journals. Different combinations of the following search terms were used: child, school child, adolescent, teen, or youth; elementary school, middle school, junior school, intermediate school, or high school; commute, travel, journey, walk, bike, cycle, bicycle, skateboard, or transport; to school. Specific terms used in the search were obtained from reviews of literature and the librarians' and researchers' expertise, and the search was adapted to match the specific structure of each database. A supplemental search was also conducted by reviewing the reference lists of the identified articles to further identify any relevant articles missed in the key word searches. Internal and external duplicates among the databases were examined and excluded in the process of article retrieval. In this review, *child* refers generically to children, adolescents, and young people aged four to 19, and *active commuting to school (ACS)* is a generic term for both active commuting/transport to *and* from school. The journal selection and search strategy was summarized in Table 1.

Table 1. Database search result

Search	Database	Vendor	Number retrieved	Internal duplicates	External duplicates	New articles added
1	Academic Search	EBSCO	2517	10	0	2507
2	ERIC	PROQUEST	291	2	33	256
3	Medline	Ovid	3181	4	1736	1441
4	Embase	Ovid	130	3	25	102
5	CINAHL	EBSCO	298	3	261	34
6	SportDis	EBSCO	1522	8	1450	64
		Totals	**7939**	**30**	**3505**	**4404**

Search	Expanded search methods	Number retrieved	Duplicates	New articles added
1	Reference lists/ citing articles	3	0	3
2	Hand searching	2	0	2
	Total	**5**	**0**	**5**

Inclusion and exclusion criteria

To be eligible for inclusion in the review, the articles had to a) be published in a peer-reviewed English journal; b) include children and/or related adults (e.g., parent, teacher) as participants; c) be about ACS, including walking, biking, skateboarding, etc.; d) have school as the origin or destination of active commuting; e) present empirical studies; f) use ACS as the outcome variable; and g) investigate perceived barriers to ACS, rather than objective barriers. Further, we focused only on studies that used quantitative measures to examine perceived barriers for the present review to facilitate the process of synthesizing and comparing. A separate systematic review is in progress to analyze the findings of the qualitative studies.

Data extraction

Data from the reviewed articles were abstracted using Garrard's matrix method of literature review in health science (Garrard, 2006). Information extracted from each article included study characteristics (e.g., author information, year of publication, journal information, study area/setting, study design), participant characteristics (e.g., sample size, children's age/grades, school characteristics), research methods (e.g., definition of ACS, independent/dependent variables, data collection/analysis methods), and main findings (e.g., rates of ACS, identified perceived barriers to ACS). To ensure the credibility of data extraction, the first author and another researcher (both with research methods training) drew a sample of 16 articles (41%) and extracted the data independently. The researchers agreed on approximately 90% of the extracted data, indicating good inter-rater reliability.

Methodological quality assessment

The authors tailored a methodological quality scale (MQS) for the current review based on previously established instruments (Law et al, 2003; Vacha-Haase et al., 1999; Harden et al., 2004; Buhi & Goodson, 2007; Zhang & Goodson, 2011; Sofa, 2012; Diep et al., 2013) and the characteristics of the reviewed articles. All studies were assessed on 11 methodological criteria, including study design, sample size, definition of ACS, data analysis methods, inclusion of control variable(s), multicollinearity testing, reliability and validity reporting, participant recruitment, participant characteristics, and school characteristics (Table 2). Possible points ranged from 4 to 24 with a higher score indicating greater methodological rigor. Each study's point was first rated by the first author and then reviewed by another researcher majored in Statistics and trained in research methodology. Disagreements were resolved by discussion until agreement was reached.

Table 2. Criteria for assessing studies' methodological quality

Methodological Criterion	Description	Score
Study design	Experimental study (e.g., randomized control trial)	4
	Case control study	3
	Longitudinal study	2
	Cross-sectional study	1
Sample size	Large (>300)	3
	Medium (>100 and <300)	2
	Small (<100)	1
Definition of ACS	Defined	1
	Not defined	0
Data analysis	More advanced statistics (e.g., mixed models)	4
	Regression/analysis of covariance	3
	Bivariate statistics (e.g., ANOVA, Pearson *r*, *t* test)	2
	Descriptive only (e.g., frequency)	1
Control variable(s)	Included	1
	Not included	0
Multicollinearity testing	Tested	1
	Not tested/not mentioned	0
Data reliability testing	Reported results, based on other & own data (including reported elsewhere)	3
	Reported results, based on own data (including reported elsewhere)	2
	Reported results, based on other data	1
	Not reported	0
Data validity testing	Reported results, based on other & own data	3
	Reported results, based on own data	2
	Reported results, based on other data	1
	Not reported	0
Participant recruitment	Parent and child pair	2
	Parent, child or others (e.g., principals)	1
Participant characteristics	Reported (e.g., child age or grade)	1
	Not reported	0
School characteristics	Reported (e.g., size or composition), multiple locations	2
	Reported, single location	1
	Not reported	0

Theory utilization assessment

A theory utilization quality scale (TQS) was created based on previously developed instruments (Delissaint & McKyer, 2008; Painter et al., 2008) and tailored for the current review. The reviewed articles were evaluated following the criteria described in Table 3. We first assessed whether and to what extent the authors used theories in the articles. For example, studies that proposed a conceptual framework based on previous theories and clearly measured related constructs received the highest score. In contrast, studies that did not clearly identify a theory but inferred, or studies that claimed to use a theoretical framework to guide the overall study design but did not evidence it received a lower score. Based on TQS, we evaluated how the construct of perceived barriers were conceptualized and operationalized in the reviewed articles. According to the criteria described in Table 3, we gave a higher score to studies that provided a clear definition of perceived barriers or described contextually what they meant by perceived barriers in the case of ACS. In contrast, studies that did not define the term clearly received a lower score. Similarly, studies that reported how they operationalized perceived barriers and clearly described the measured items were scored higher, while studies that claimed they measured perceived barriers but did not describe the measured items were scored lower. The possible range of the theory utilization assessment scores was 0 to 7. To examine the reliability of the assessment by the first author, two additional researchers trained in health behavior theories scored a sample of 10 articles (26%) independently.

Table 3. Criteria for assessing studies' theory utilization

Criterion	Description	Examples	Score
Did the authors use theory in their studies?			
Theory utilization	Clear identification/ operationalization of theory/constructs used	A conceptual framework was proposed based on a theory and measured constructs/variables accordingly.	3
	Inferred theory or partial use of theory	A theory was not clearly identified, but three or more theoretical constructs of a theory were measured. A theory was identified but only one or two constructs of the theory were measured.	2
	May be informed by theory/slight evidence of use of theory	The use of a theoretical framework was claimed to guide design, program, or measures, but was not evidenced. A theory was not clearly identified, but one or two theoretical constructs of a theory were measured.	1
	No evidence of using theory		0
What did the authors mean by "perceived barriers" in each article?			
Conceptualization of perceived barriers	Defined or contextually described	A clear definition of "perceived barriers" was provided. What "perceived barriers" mean in the case of active commuting to school was clearly described.	2
	Contextually described, but within a broader category	Participants' perceived environmental characteristics that may influence children's ACS were described, which included both perceived facilitators and barriers.	1
	Not defined/described		0
Did the authors describe/detail how "perceived barriers" were measured?			
Operationalization of perceived barriers	Clearly operationalized /reported	Different items were used to measure "perceived barriers" and the items were clearly described.	2
	Somewhat/slightly operationalized	Different items were claimed to be used to measure "perceived barriers"; however, the items were not described. "Perceived barriers" were claimed to be measured; however, it's not clear what items were used.	1
	Not reported/described		0

Discrepancies found were addressed by re-appraisals and discussions, or judgment by a fourth party, until consensus was reached. This study was considered exempt by the institutional review board at Texas A&M University.

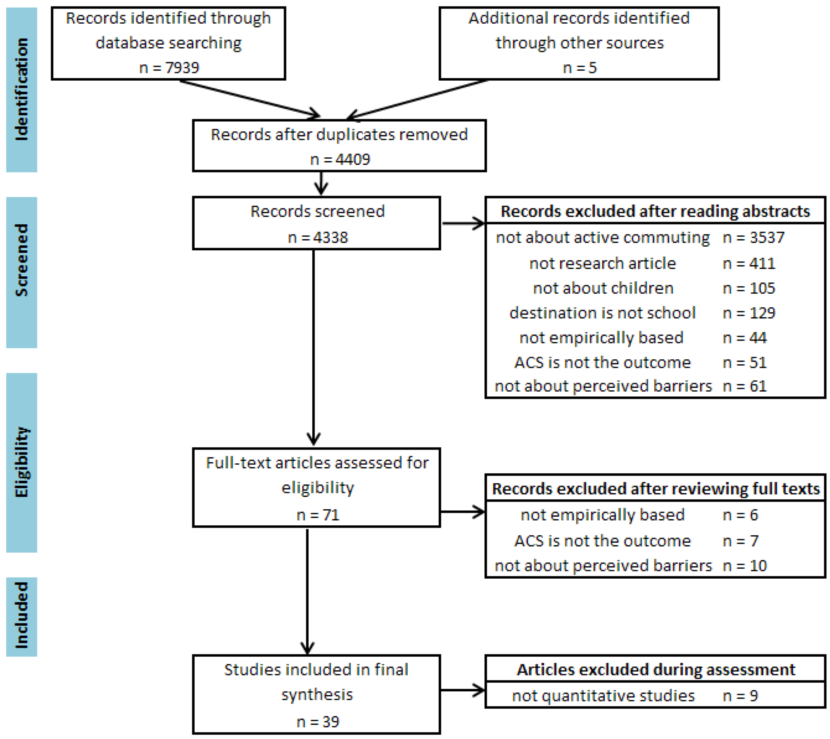
Results

A total of 4,409 unique records were identified from six databases and additional manual searching (Figure 1). More than 4,300 articles were excluded after the abstract review, of which the majority were not about ACS (n = 3,537). After examining the full text of 71 articles, 23 were eliminated because they were not empirically based, did not use ACS as the outcome, or were not about perceived barriers. Nine of the remaining articles were further excluded as they were purely qualitative investigations. The final analysis consisted of 39 articles that met all inclusion criteria.

Characteristics of reviewed studies

Table 4 outlines the select information extracted from the 39 reviewed articles. These articles represented 30 peer-reviewed journals from varying disciplines, including public health (n = 33, 84.6%), transportation (n = 4, 10.3%), and urban planning (n = 2, 5.1%). The majority of the articles (n = 24, 61.5%) were written by researchers from health-related fields, with seven articles (17.9%) representing collaborative work of researchers across disciplines (e.g., public health and urban planning). We did not set a time frame for the systematic reviews; however, all identified articles were published after 2004, with the numbers increasing almost annually.

Figure 1 Search and selection of articles



The studies were undertaken in 10 countries, i.e., the U.S. (n = 20, 29.0%), Australia (n = 10, 23.1%), Belgium (n = 2, 5.1%), Canada (n = 1, 2.6%), Switzerland (n = 1, 2.6%), Cyprus (n = 1, 2.6%), Portugal (n = 1, 2.6%), Ireland (n = 1, 2.6%), England (n = 1, 2.6%), and Brazil (n = 1, 2.6%). Regarding study settings, 15 (38.5%) were conducted in urban areas, 4 (10.3%) included participants from both rural and urban areas, one (2.6%) was undertaken in the rural area, and the remaining studies (n = 19, 48.7%) did not specify study settings or distinguish between urban or rural areas. Sample sizes of the reviewed studies varied from 74 to 12,613, and most studies were exploratory (n = 36, 92.3%) rather than hypothesis-driven (n = 3, 7.7%).

Table 4. Characteristics of studies on perceived barriers of children's active commuting to school (N = 39)

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Babey (2009), US	*Journal of Public Health Policy*	3,893 parent-child pairs	12-17 years	Individual, family, and environmental characteristics with ACS	(1) Rate of ACS: 49.8% walked, biked or skateboarded to or from school at least once a week, 25% ACS 3 or more days per week. (2) Correlates of ACS: distance, male, Latino, from lower-income families, attending public school, and living in urban areas; parental supervision (-), and parent knowing little or nothing about adolescents' whereabouts after school.
Bringolf-Isler (2007), Switzerland	*Preventive Medicine*	1,345	1st, 4th, 8th graders	Personal and family factors, environmental data (GIS)	(1) Rate of ACS: 77.8% (2) Correlates of ACS: child's age, number of cars in the household, daycare attendance, parental safety concerns, and belonging to French-speaking population.
Carson (2010), Canada	*Revue Canadienne De Sante Publique*	3421 parent-child pairs	5th grade	Socio-demographic characteristics, parental perceptions of neighborhood environment.	(1) Rate of ACS: 39% (2) Predictors of ACS: neighborhood with high perceived sidewalks/parks (+)
Carver (2005), Australia	*American Journal of Health Promotion*	345 parent-child pairs	12-13 years	Socio-demographic characteristics, parental perceptions of neighborhood environment.	(1) Rate of ACS: Walking for boys: 39%; walking for girls: 46%; biking for boys: 10% (17/172); biking for girls: 1% (2/175). (2) Predictors of ACS: For boys: no significant bivariate associations between perceptions of the neighborhood and boys' walking to/from school; For girls: having friends living in the neighborhood (+), lots of other boys/girls to "hang out" with (+) and parents' concerns about busy traffic (-).
D'Haese (2011), Belgium	*International Journal of Behavioral Nutrition and Physical Activity*	696	6th grade	Distance, criterion distance (i.e., cumulative percentages of children commuting to school by bike, on foot, and in a passive way, per covered distance), and environmental perceptions	(1) Rate of ACS: 38.1% by bike, 21.1% walk. (2) Correlates of ACS: Perceived accessibility to walk (+)

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Emond (2011), US	*Journal of Transport Geography*	1,357	10th-12th graders	Socio-demographics and attitudinal factors (individual factors, social-environment factors, and physical-environment factors), distance (home location geo-coded)	(1) Rate of biking: 32.7% to school, 33.4% from school. (2) Correlates of biking: perceived bicycling comfort (+), parental encouragement (+), perceived distance (-), having to cross a freeway (-), confidence in one's bicycling ability (+), being males (+).
Evenson (2006), US	*International Journal of Behavioral Nutrition and Physical Activity*	480	6th and 8th graders	Socio-demographics, perceived safety, aesthetics, and facilities near the home; parental provision of transportation.	(1) The 24 individual items on safety, aesthetics, facilities near the home, and transportation mostly indicated fair to moderate reliability. (2) Predictors of ACS: Perceived neighborhood safety ("walkers and bikers on the streets in my neighborhood can easily be seen by people in their homes") (-); more physical activity facilities (+)
Fries (2012), US	*Advances in Transportati on Studies an international journal*	12,613	Kindergarten through 8th grade	N/A	(1) Rate of ACS: 14.8% (2) Top parental perceived barriers for urban and suburban children: intersection safety and traffic speed/volume. Distance from school affected suburban students more than urban students.
Fulton (2005), US	*Research Quarterly for Exercise and Sport*	1,395 parent-child pairs	4th grad through 12th grade	Demographics, body mass index, behavioral, psychosocial, attitudinal, and environmental characteristics.	(1) Rate of ACS: 14%. (2) Predictors of ACS: having sidewalks (+), boys (+), lower grades (+)
Heelan (2008), US	*Journal of Physical Education, Recreation & Dance*	150	School age	Seven categories of perceived barriers to ACS.	(1) Predictors of ACS: whether or not the child wanted to actively commute, time, busy streets, child maturity, carpool availability, and crosswalks. (2) Perceived barriers of ACS: safety concerns, busy streets, weather, time, convenience

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Hume (2007), Australia	*American Journal of Health Promotion*	280	10 year olds, grade 5	Perceived physical and social environmental characteristics	(1)Frequencies of walking to/from school per week for boys: 2.07, for girls: 1.66. (2) Perceived barriers of ACS for boys: number of accessible destinations in the neighborhood (3) Perceived predictors of ACS for girls: having a neighborhood that was easy to walk/cycle around (+) and perceiving lots of graffiti (+)
Hume (2009), Australia	*American Journal of Preventive Medicine*	309	Children aged 5-6 and children aged 10-12	Demographics, individual-level predictors, social environmental predictors, physical environmental predictors	(1) Rates of ACS: Walking 2.9 mean trips/week, biking 0.4 mean trips/week; ACS 1-5 trips/week: 39.7%; ACS daily 22.3%. (2) ACS significantly increased between 2004 and 2006 among children and adolescents. (3) Predictors of ACS: children of parents who reported that the child had many friends in their areas (+), adolescents whose parents perceived insufficient traffic lights and pedestrian crossings in their neighborhood (-), adolescents of parents who were satisfied with the number of pedestrian crossings (+).
Kerr (2006), US	*Medicine & Science in Sports & Exercise*	259	5-18 years old	Objective measures, including the neighborhood and individual walkability index, and subjective measures, including socio-demographic variables and perception of the local environment (e.g., residential density, street connectivity, and crime safety.).	(1) Rate of ACS: 18.1% walked or biked 5 days a week, and 25.1% actively commuted at least once a week. (2) Correlates of ACS: Parent concerns and neighborhood aesthetics were independently associated with ACS. Perceived access to local stores and biking or walking facilities accounted for some of the effect of walkability on ACS.
Lee (2013), US	*Annals of Behavioral Medicine*	601 parent-child pairs	Hispanic predominant	Environmental perceptions about walkability, safety concerns, and parental attitudes and preferences	(1) Parental attitudes and children's preferences were associated with the odds of walking (2) Safety concerns (traffic danger, stranger danger, and getting lost) were higher among drivers, but only significant in bivariate analyses.

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Loucaides (2010), Cyprus	*Central European Journal of Public Health*	1966	Grades 1-12	Personal, social and environmental characteristics	(1) Rates of ACS: 19.4%. (2) Predictors of ACS: having enough time in the morning to walk to school (+) and parents feeling that it was safe for children to walk to school (+), and long distance from home to school (-).
McMillan (2007), US	*Transportation on Research Part A*	1128	Grades 3-5	Urban form demographics, caregivers' beliefs, perceptions and attitudes about travel by different modes, household demographics	Correlates of ACS: urban form, perceived neighborhood safety, perceived traffic safety, household transportation options, caregiver attitudes, social/cultural norms, and socio-demographics.
Mendoza (2010), US	*Journal of Applied Research on Children: Informing Policy for Children at Risk*	149	Grade 4, Latino subsample	Socio-demographics, child self-efficacy, parent self-efficacy, parent outcome expectations, perceived neighborhood safety, observed pedestrian safety behaviors	(1) Rate of ACS: 43%. (2) Predictors of ACS: parent self-efficacy for the full sample, parent outcome expectations for Latino children (3) ACS was positively associated with daily moderate-to-vigorous physical activity.
Mendoza (2011), US	*Pediatrics*	149	Grade 4	Socio-demographics, child self-efficacy, parent self-efficacy, parent outcome expectations, perceived neighborhood safety, observed pedestrian safety behaviors	(1)Acculturation and parent outcome expectations were significantly and positively associated with the change in percent active commuting. (2) Positive associations between active commuting and physical activity.
Merom (2006), Australia	*Health& Place*	812	5-12 years	Socio-demographics, parents' perceptions about safe environment, child's enjoyment of walking, and perceived health benefits of ACS, child's level of	(1) Rate of frequent ACS: 37%; Rates of regular ACS: 22% (2) Predictors of ACS: distance (-), child's age (+), parental perceptions of road safety (-), and attending public school (+).

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
				independence, parents' modes of transport to work	
Miller (2013), US	*American Journal of Health Behavior*	74 parent-child pairs	Grades 1-6	Age, designated time periods, gender, parent vs. child, normal weight vs. overweight	(1) Children were most active after and least active before and during school. (2) Weight was not related to activity. (3) Boys were more confident than girls, whereas parents felt more confident than children did about active transport.
Mota (2007), Portugal	*Annals of Human Biology*	705	Grades 7-12	Socio-economic position, environmental assessment, including connectivity of the street network, infrastructure for walking and cycling, neighborhood safety, and social environment.	(1) Rate of ACS: 52.6%. (2) Predictors of ACS: occupational status of mother (-) and father (-), father's educational level (-), street connectivity (+), father's occupation (+), perceived presence of four-way intersections (+).
Nelson (2010), Ireland	*Journal of Physical Activity and Health*	2159	15 to 17 years	Socio-demographics, perceived physical environmental characteristics	(1) Rates of ACS: 61.3% walked and 8.7% cycled (2) Correlates of ACS in the final model for boys: perceived land-use-mix diversity (+), perceived presence of public parks (+); for girls: traffic safety (-), visibility (+), the presence of cycle tracks (+), and the ease of walking/cycling to transit (+).
Panter (2010), England	*Journal of Epidemiology and Community Health*	2012	9-10 years	Socio-demographics, attitudes, perceptions, and social support.	(1) Rates of ACS: 54%; 40% walking and 9% biking. (2) Correlates of ACS: boy (+) for biking, girl (+) for walking, distance less than 1km (+), mothers ACS (+), parental attitude (+), parental safety concerns (-), the presence of social support from parents and friends, (+), parental perceived neighborhood walkability (+).
Price (2011), US	*Journal of School Health*	314	N/A	respondents type, school type, respondents' perceptions of ACS factors	(1) Top 3 factors of ACS: distance to school (-), traffic speeds (-), and traffic volume (-). (2) Several participants expressed concerns about liability issues related to students' ACS. (3) Some reported that schools are not responsible for students' safety once students leave school grounds.

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Ridgewell (2009), Australia	*Urban Policy and Research*	248 students, 128 parents	8-11 years	N/A	(1) Rates of ACS: 21.0% walking to school, 25.3% walking from school; 4.7% biking to school, 4.3% biking from school.
Rodriguez (2009), US	*Journal of School Health*	1,897	Grades 3-5	Socio-demographics, environmental factors, access factors, attitude factors	(1) Rates of ACS: 11.1% walked, 1.4% biked. (2) Predictors of ACS: age (+), perceptions that walking saves time (+), distance (-), car ownership (-), access to a school bus.
Rojas-Guyler (2007), US	*Californian Journal of Health Promotion*	71	N/A	Principals' beliefs conducive to children and health.	(1) Rate of ACS: Mean percentage of ACS was 11.77%. (2) The no. of students using ACS did not significantly differ between schools with a restrictive policy and schools with no restrictive poll.icy. Principals at schools with higher ACS rates were significantly more likely to report that students should consider ACS if residing within one mile, had significantly more enabling environments, and had significantly less restrictive environments.
Rossen (2011), US	*Journal of Physical Activity and Health*	365	Grades 3-5	Street block-residence characteristics, individual-level characteristics, perceived safe neighborhood etc.,	(1) Rate of ACS: 56% walked. (2) Predictors of ACS: distance to school (-) and level of incivilities (+). (3) High levels of neighborhood incivilities were associated with lower levels of perceived safety.
Salmon (2007), Australia	*American Journal of Health Promotion*	720	4-13 years	Socio-demographics	(1) Rate of ACS: 41% (2) Predictors of ACS: individual ("child prefer to be driven" (-), "no time in the mornings" (-); social ("worry child will take risks" (-), "no other children to walk with" (-), "no adults to walk with" (-), and environmental barriers ("too far to walk" (-), "no direct route" (-). Positive association: "concern child may be injured in a road accident" and ACS (+).
Schlossberg (2006),	*Journal of the American Planning*	292	Grades 6-8	Distance from school on the street network, five measures of perceived urban form:	(1) Rates of ACS: 15% to school, 25% from school. (2) Predictors of ACS: distance (-), intersection density (-), dead ends (-). (3) Reported perceived

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
US	*Association*			intersection density, dead-end density, route directness, major roads, and railroads, and measures of perceived convenience (e.g., desire to drop a child off on the way to work, backpack is too heavy)	barriers by frequency: ease of dropping child off on the way to work, the heaviness of the child's backpack, bad weather, dangerous traffic conditions, high-speed vehicles, lack of complete sidewalks.
Silva (2011), Brazil	*Journal of Physical Activity and Health*	1672	11 to 17 years	Socio-demographics, type of school attended, time spent, and perceived barriers.	(1) Rate of ACS: 62.7%. (2) Predictors of frequent use of ACS: long distance (-), and traffic (-). (3) Predictors of modes of transport: long distance (-), crime (-), and traffic (-).
Timperio (2006), Australia	*American Journal of Preventive Medicine*	912 (235 families of children aged 5 to 6; 677 families of children aged 10 to 12)	Two groups: 5 to 6 years; 12 to 19 years	Personal factors, family factors, SES, parent-perceived social/physical neighborhood, child-perceived social/physical neighborhood, objective measures of route to school	(1) Rates of ACS: 47.8% walked for children aged 5-6, 60.4% walked for those aged 10-12; 6.6% biked for children aged 5-6 and 6.3% for those aged 10-12; Either walked or biked: 48.9% for children aged 5-6 and 62.0% for those aged 10-12. (2) No gender difference among younger children; boys cycled more than girls in older children. (3) Correlates of ACS: parental perception of few other children around and no lights or crossings, and objectively assessed busy road barrier en route to school. For younger group, objectively assessed variables (-); older group: good connectivity (-). For both group, route 800 meters (+).
Trapp (2011), Australia	*International Journal of Behavioral Nutrition and Physical Activity*	1197 parent-child pairs	Grades 5-7	Individual, social, perceived environmental, objective environmental factors.	(1) Rates of ACS: 31.2% for boys, and 14.6% for girls. (2) Predictors of ACS: school neighborhood design (in boys), parental confidence in their child's cycling ability, parental perceived convenience of driving, parental perceptions regarding neighborhood safety issues (i.e., whether the neighborhood is safe enough and the need to cross busy roads) and child's preference to cycle (for both boys and girls)
Van Dyck	*International*	1,281	17.1±0.5 years	Socio-demographics, physical	(1) Rates of ACS: 6.6% walked, 51.8% cycled. (2)

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
(2010), Belgium	*Journal of Behavioral Nutrition and Physical Activity*			environmental perceptions, psychosocial factors	Predictors of ACS: gender, smoking status, higher walkability of the neighborhood (+) and more social modeling (+).
Yeung (2008), Australia	*Transportation Research Part A*	318	8 vs. 10 years	Anthropometric characteristics (self-reported), distance (self-reported), and perceived barriers, including safety issues and physical infrastructure.	(1) Rate of ACS: 1/3. (2) Predictors of ACS: commuting distance
Zhou (2010), US	*Journal of Transportation on Safety & Security*	347 students, 2551 parents	75% elementary (K-5th grade)	Demographics, and subjective variables (e.g., school attitudes, enjoyment, and health)	(1) Rates of ACS: 8.9% (child reported), 9.5% (parent reported) (2). Students living in different distance intervals are subject to different barriers (3) Security and safety remain the primary factors of concern for parents to allow their children to ACS, esp. for those living at short walkable distances (4) School, parents' and students' attitudes, grade levels, allowable grade level all had significant impact on the students' walking/biking rates.
Zhu (2008), US	*Child Health and Human Development*	1281	Grades 1-5	Personal factors, social factors, and parents' perception of the physical environment	(1) Walking was a typical mode for 28% and 34% of trips to and from school, respectively, and mostly accompanied by an adult. (2) Correlates of ACS: parental education level(-), car ownership(-), child and parental personal barriers(-), and school bus availability(-), and positive peer influences(+); environmental factors, including proximity to school(+), safety concerns(-) and the presence of highway or freeway en route(-).

Table 4. Continued

Lead author, year, country	Journal	Sample size	Children's grades/ ages	Independent variables/Program	Select Findings
Zhu (2009), US	*Journal of Public Health Policy*	2695	Grades 1-5	Personal, social, and physical environmental factors.	(1) Walking was a typical mode for 27.8% and 31.5% for the trips to and from school, respectively. (2) Correlates of ACS: Personal and social factors, including parental education (-), car ownership(-), personal barriers(-), and school bus availability(-), parental and child positive attitude and regular walking behavior(+), and supportive peer influences(+); Environmental factors, including distance(-), safety concerns(-), presence of highways/freeways(-), convenience stores(-), office buildings(-), and bus stops en route(-).
Ziviani (2004), Australia	*Occupational Therapy International*	164	Grades 1-7	Socio-demographics, psychosocial factors, perceived environmental factors, children's level and enjoyment of physical activity, and perceived importance of physical activity	(1) Mean number of days walking to school in a week was 1.00 ± 1.62. (2) Predictors of ACS: perceived importance of physical activity, parents' individual history of transport to school, distance, concern about traffic, and concerns about personal safety.

Note: ACS = Active Commuting to School; (+) means positive correlation with outcome measures; (-) means negative correlation with outcome measures.

Active commuting to school

The definitions of ACS were not consistent across the studies. For example, most studies defined ACS as walking or biking to school *usually* (n = 32, 82.1%), while some defined it as walking or biking to school at least once a week (n = 3, 7.7%). Other definitions of ACS included walking or biking to school *ever*, walking or biking to school the longest portion of the journey to school, and walking or biking to school five days a week. Similarly, the dependent variable, i.e., ACS, was measured differently across the studies. Most studies used a dichotomized dependent variable as ACS versus not (n = 24, 61.5%), or the frequency of ACS as a continuous variable (n = 10, 25.6%). Eight studies (20.5%) did not report the rates of ACS. For studies that measured walking, biking, and other modes of transports, such as skateboarding, together as the usual mode to/from school (n = 19, 48.7%), the rates of ACS ranged between 11.8% (Rojas-Guyler et al., 2007) and 77.8% (Bringolf-Isler et al., 2007). For studies that considered/reported walking or biking separately as the usual mode to/from school (n = 12, 30.8%), the rates of walking were from 6.6% (Van Dyck et al., 2010) to 61.3% (Nelson & Woods, 2010) and the rates of biking were between 1% (Carver et al., 2005) and 51.8% (Van Dyck et al., 2010).

Perceived barriers to ACS

Fourteen studies (35.9%) did not find any statistically significant (significant for short hereafter) perceived barriers to child's ACS in their analyses. For the other 25 studies, we further excluded four studies (10.3%) that reported perceived barriers based on descriptive or bivariate statistics (Ridgewell, Spe & Buchanan, 2009; Zhou et al., 2010; Price et al., 2011; Fries, Sykut & Zhou, 2012), one study (2.6%) that measured a single item (i.e., perceived safety) (Miller, Redmond & Vaux-Bjerke, 2013), and one study (2.6%) that used a summary index (i.e., 11 items for parental concerns with the mean calculated) (Kerr et al., 2006).

Among the remaining 19 studies (48.7%) that reported significant results, four studies included personal barriers, including parents' lack of time, ease of dropping child off the way to work, child's heavy backpack, child's preference to be driven to school, and walking as requiring too much planning ahead; 18 studies reported physical environmental barriers, among which traffic safety and distance were most commonly cited; and 11 studies identified different types of perceived social environmental barriers to ACS, which were centered on neighborhood safety (Table 5).

Eleven of the 19 studies that identified significant predictors of ACS used/included children's surveys, and, unanimously, traffic safety was regarded as a barrier to ACS among children. Compared with children, parents were more concerned about neighborhood safety, e.g., crime, strangers, and stray dogs.

Table 5. Summary of statistically significant perceived barriers identified in reviewed studies (n = 19) *

Personal barriers (n = 4)**	Physical environment barriers (n = 18)	Social environment barriers (n = 11)
No time (Salmon et al., 2007; Zhu & Lee, 2009)	Traffic safety (e.g., speed, volume) (Carver et al., 2005; Evenson et al., 2006; McMillan, 2007; Nelson & Woods, 2010; Panter et al., 2010; Schlossberg et al., 2006; Silva et al., 2011; Ziviani, Scott, & Wadley, 2004)	Neighborhood safety (McMillan, 2007; Trapp et al., 2011; Lee et al., 2013)
Ease of dropping child off the way to work (Schlossberg et al., 2006; Lee et al., 2013)	Distance (Emond & Handy, 2012; Loucaides, 2010; Salmon et al., 2007; Silva et al., 2011; Ziviani, Scott, & Wadley, 2004)	Stranger danger (Heelam et al., 2008; Zhu, Arch & Lee, 2008)
Heaviness of the child's backpack (Schlossberg et al., 2006; Zhu, Arch & Lee, 2008)	Freeway/highway (Emond & Handy, 2012; Zhu, Arch & Lee, 2008; Lee et al., 2013)	Crime/danger (Silva et al., 2011)
Child's preference of being driven to school (Salmon et al., 2007)	Road safety (Bringolf-Isler, 2008; Merom et al., 2006)	Graffiti (Hume, Salmon, Kylie, 2007)
Walking as requiring too much planning ahead (Lee et al., 2013)	Bad weather (Schlossberg et al., 2006; Zhu, Arch & Lee, 2008)	Worry child will take risk (Salmon et al., 2007)
	Busy street (Heelam et al., 2008)	No other child to walk with (Salmon et al., 2007)
	No direct route (Salmon et al., 2007)	No adults to walk with (Salmon et al., 2007)
	Lack of sidewalks (Schlossberg et al., 2006)	Few children around (Timperio et al, 2006)
	No/insufficient lights or crossings (Hume et al., 2009; Timperio et al., 2006)	Getting lost (Zhu, Arch & Lee, 2008)
		Stray dogs (Zhu, Arch & Lee, 2008)
		Exhaust fume (Zhu, Arch & Lee, 2008)
		Personal safety (Ziviani, Scott, & Wadley, 2004)
		Concern about something happening to child on the way (Panter et al., 2010)

Note: * $p < .05$. **Number of studies that identified the categories of perceived barriers.

Methodological quality of reviewed articles

The methodological quality of reviewed studies varied, with the MQS scores ranging between 7 and 20 (Mean = 12.95, SD = 2.95) (Table 6). Most studies employed a cross-sectional study design and used a survey instrument to collect the data (n = 36, 92.3%). For the data analysis, 26 (66.7%) utilized regression or analysis of covariance; seven employed more advanced statistics (17.9%), e.g., mixed models; and six used bivariate or descriptive statistics (15.4%). Over half of the studies (n = 22, 56.4%) included control variables in the data analysis, and the most commonly included control variables were distance, participants' sociodemographics such as race/ethnicity, gender, and educational level, and school site. Moreover, 27 (69.4%) articles tested multicollinearity among the variables, and around 30% did not mention any testing performed for the multicollenarity issue.

Many studies (n = 15, 38.5%) did not report the method or result of the data reliability assessment. Nine studies (23.1%) reported data reliability based on another study's data and their own data, including those reported elsewhere. Nine studies (23.1%) reported the reliability based solely on their own data, and another 6 articles reported (15.4%) the metrics based on other studies' data. Among the studies that reported reliability results, eight (20.5%) conducted both internal consistency test and test-retest reliability test; seven (17.9%) performed internal consistency tests only; and six (15.4%) conducted test-retest reliability test only.

Likewise, most of the studies did not report the data validity testing (n = 29, 74.4%). Only four articles (10.3%) reported validity testing based on their own data and six articles (15.4%) reported results from other studies. Among the studies that reported validity, four (10.3%) tested face validity, and four (10.3%) tested construct validity.

Regarding participants recruitment, 12 (30.8%) studies recruited parent/child pairs, and 27 (69.2%) recruited only children, parents, or other stakeholders. Two studies (5.1%) did not report any participant characteristics, and 11 studies (28.2%) did not present any information about the school characteristics. Among the studies that reported school characteristics, 26 had the participating schools at different locations, and two studies focused on a single school.

Theory utilization of reviewed articles

The theory utilization scores of the reviewed studies ranged from 1 to 7 (Mean = 3.62, SD = 1.74). As shown in Table 7, 17 (43.6%) of the reviewed studies did not propose or test any theoretical model or show any evidence of theoretical uses. Sixteen studies (41.0%) clearly identified a theoretical model and measured part or all of the relevant constructs; four studies (10.3%) either inferred a theory or presented partial use of a theory; and two studies (5.1%) only showed some but often weak evidence of theory uses.

Among the 16 studies that clearly identified a theoretical framework, 14 used the Social Ecological Model; one used the Theory of Reasoned Action; and one developed a modified theoretical model based on Social Ecological Theory and Social Cognitive Theory (McMillan, 2007).

Table 6. Distribution of methodological quality characteristics across reviewed studies

Methodological Criterion	Description	Score	*n* of studies	Percentage (%)
Study design	Experimental study (e.g., Randomized control trial)	4	1	2.6
Study design	Case control study	3	1	2.6
Study design	Longitudinal study	2	1	2.6
Study design	Cross-sectional study	1	36	92.3
Sample size	Large (>300)	3	29	74.4
Sample size	Medium (>100 and <300)	2	8	20.5
Sample size	Small (<100)	1	2	2.6
Definition of ACS	Defined	1	38	97.4
Definition of ACS	Not defined	0	1	2.6
Data analysis	More advanced statistics (e.g., mixed models)	4	7	17.9
Data analysis	Regression/analysis of covariance	3	26	66.7
Data analysis	Bivariate statistics (e.g., ANOVA, Pearson *r*, *t* test)	2	3	7.7
Data analysis	Descriptive only (e.g., frequency)	1	3	7.7
Control variable(s)	Included	1	22	56.4
Control variable(s)	Not included	0	17	43.6
Multicollinearity testing	Tested	1	27	69.2
Multicollinearity testing	Not tested/not mentioned	0	12	30.8
Data reliability testing	Reported results, based on other & own data (including reported elsewhere)	3	9	23.1
Data reliability testing	Reported results, based on own data (including reported elsewhere)	2	9	23.1
Data reliability testing	Reported results, based on other data	1	6	15.4
Data reliability testing	Not reported	0	15	38.5
Data validity testing	Reported metrics, based on other & own data	3	0	0.0
Data validity testing	Reported metrics, based on own data	2	4	10.3
Data validity testing	Reported, based on other data	1	6	15.4
Data validity testing	Not reported	0	29	74.4
Participant recruitment	Parent and child pair	2	12	30.8
Participant recruitment	Parent, child or others (e.g., principals)	1	27	69.2
Participant characteristics	Reported (e.g., child age or grade)	1	37	94.9
Participant characteristics	Not reported	0	2	5.1
School characteristics	Reported (e.g., size or composition), multiple locations	2	26	66.7
School characteristics	Reported, single location	1	2	5.1
School characteristics	Not reported	0	11	28.2

As to the conceptualization of perceived barriers, the majority of the studies (n = 26, 66.7%) did not provide a definition of perceived barriers. Only one study (2.6%) provided a clear definition of perceived barriers and 12 studies (30.8%) described perceived barriers but within a broader category, e.g., perceived environmental characteristics which included both perceived facilitators and barriers. In contrast, most studies clearly described how they operationalized perceived barriers (n = 32, 82.1%); five studies (12.8%) slightly operationalized the construct, e.g., not indicating what items were used to measure perceived barriers; and two studies (5.1%) did not include any description on the operatioanlization method (Table 7).

Table 7. Distribution of theory utilization characteristics across reviewed studies

Criterion	Description	Score	*n* of studies	Percentage (%)
Theory utilization	Clear identification/operationalization of theory/constructs used	3	16	41.0
	Inferred theory or partial use of theory	2	4	10.3
	May be informed by theory/slight evidence of use of theory	1	2	5.1
	No evidence of using theory	0	17	43.6
Conceptualization of perceived barriers	Defined or contextually described	2	1	2.6
	Contextually described, but within a broader category	1	12	30.8
	Not defined/described	0	26	66.7
Operationalization of perceived barriers	Clearly operationalized	2	32	82.1
	Somewhat/slightly operationalized	1	5	12.8
	Not reported or described	0	2	5.1

Discussion

The aim of this systematic literature review was to summarize and critically assess the current literature on perceived barriers to children's ACS. To our knowledge, this is the first systematic review evaluating theory utilization and methodological quality of empirical studies on perceptions of children's ACS. A detailed appraisal of the literature suggests several empirical, methodological, and theoretical issues.

Empirical issues

The results of our analysis revealed a need for more ACS studies globally. Most of the studies identified were conducted in the U.S. or Australia. There is a need for more studies to better understand the roles of perceived barriers to ACS in other areas, e.g., Asia. Although international literature showed higher rates of ACS in several Asian countries, e.g., the Philippines and China, shifts to more passive commuting modes were anticipated in these countries with continued modernization and increasing car ownership (Tudor-Locke et al., 2007; Garrard, 2009). Given that childhood obesity has become a global epidemic, promotion efforts for ACS should begin immediately in Asian countries. Individuals' health behavior can be influenced by characteristics of the geographical area where they live (Sutton, 2004), thus there might be wide variations in perceived barriers to ACS across countries. With limited studies conducted in areas other than the U.S. and Australia, such comparisons are not meaningful, if not impossible. Future studies using well-established instruments tailored for specific populations are needed in regions other than those reported in this review.

This review also highlights a shortage of ACS studies regarding perceived barriers in rural settings. Among the 39 studies identified, only five studies clearly stated the inclusion of rural locations. The roles of environmental or social characteristics on ACS may vary across different community settings. However, few comparative studies examine such potential variations. Given that rural residents are less likely to meet physical activity recommendations compared with urban or suburban residents (Parks, Housemann & Brownson, 2003), more work is needed on ACS that specifically focuses on rural-urban variations.

Third, more prospective and intervention studies with perceived barriers as predictors of ACS changes are needed. The majority of the reviewed studies were cross-sectional, which cannot infer cause-and-effect relationships. To influence policy changes and large-scale environmental interventions, evidence from intervention studies is crucial (Sallis & Owen, 1999). Further, prospective studies conducted at a minimum of 3 time points are recommended, because studies with two observation points are limited in drawing firm conclusions on the direction of the relationships among study variables (Owen et al., 2004). It is possible that participants' perceptions of the environment might be influenced by the increased level of ACS at the second point, e.g., after an intervention was conducted (Humpel et al., 2004).

In regard to perceived barriers identified by previous studies, our findings underscored the lack of inquiries into participants' perceptions on policy/regulatory barriers. Most research on participants' perceived barriers to ACS used a couple of established instruments that focused on factors at the personal, physical and social environment levels, thus leaving policy as an under-researched area. Policy issues can influence individuals' decision-making regarding ACS. For example, different countries or districts may have different school siting or school choice policies, which can influence their commuting distance and availability of viable travel modes (Eyler et al., 2008; Alport et al., 2008). Individual schools may also have opposing school bus policies that discourage ACS, e.g., grade/age minimums for ACS or policies requiring parents to designate their child as a walker or a rider (Ahlport et al., 2008; Dellinger & Staunton, 2002). Identification of participants' perceived policy barriers could inform possible policy changes in support of ACS, while neglect of these potential barriers may result in less effective interventions.

Methodological issues

Assessment of the methodological quality of the reviewed articles raised several methodological and analytical concerns. One of the major limitations was the lack of consistent definition for ACS. Great variation was observed in the proposed definitions and measurement of ACS. Although many studies defined ACS as walking or biking to school *usually*, researchers did not clarify what "usually" means, e.g., whether it's over 3 days a week or 4 days a week. Some studies defined ACS as walking or biking at least *once* a week. Moreover, when used as the dependent variable, ACS was measured categorically in some studies but continuously in others, e.g., as frequency of ACS or percentage of ACS children, which compromised the generalizability of identified perceived correlates. Although there's no "golden rule" for defining ACS, researchers should at least provide a valid rationale for the use of specific definitions and measurements of ACS. For example, health researchers may be more interested in the relationship between ACS and health outcome, and therefore prefer more detailed or rigorous measurements such as frequency and duration of ACS which are more relevant for long-term health benefits (Saelens, Sallis & Frank, 2003).

Second, multiple studies applied only univariate or bivariate statistical techniques and failed to justify their applications. When these techniques are used to analyze the association between multiple determinants and an outcome variable, biased or misleading results may be produced. To correctly assess the complicated relationships among the variables, we need more sophisticated methods which allow for modeling multiple variables and diverse pathways among them. Further, given that most ACS data are school-based or district-based, we recommend that researchers resort to multilevel or hierarchical techniques that can effectively separate individual-level effects from cluster-level effects (Desai & Begg, 2008). Advanced statistical techniques may not be necessary for all research questions, but researchers need to provide valid rationale for using simpler methods in multivariate cases. Otherwise, results should be interpreted with caution.

Also, most studies that conducted correlation tests did not include control variables in their analysis. Leaving out important control variables can cause model specification bias and render the interpretation of results suspicious (Barreto & Howland, 2006). Lack of a theoretical basis may account for the lack of control variable(s) in data analysis, as the selection of control variables is mainly theory-driven. Although control variables can also be chosen based on the statistical tests, we recommend ACS researchers to utilize theory to more effectively conceptualize the multi-level constructs related to behavioral outcomes. For those who included control variables, socioeconomic factors and distance were the most common variables. Researchers may also be interested in how the association between perceived barriers and ACS is modified by objective environmental characteristics such as neighborhood walkability and land use. To achieve this goal, collaborations among scholars from various disciplines such as public health, urban planning, and transportation are encouraged.

Another concern was the lack of reporting multicollinearity diagnostics in the articles. In the presence of multicollinearity, regression estimates are unstable. Multicollinearity can misleadingly inflate the standard errors of coefficients and make some variables statistically insignificant when they should be significant otherwise (O'brien, 2007). Moreover, when multicollinearity exists, the simultaneous analysis of interrelated constructs may yield spurious or confounded results whereby it is impossible to distinguish the individual effects. To minimize the risk of multicollinearity, researchers should avoid including predictors that are conceptually identical, regardless of the sample size. Other alternatives dealing with multicollinearity include ridge regression, combining of independent variables into a single index, or conducting factor analysis (O'brien, 2007; Farrar & Glauber, 1967). It is also possible that some researchers tested multicollinearity but didn't report the diagnostics in their papers. To confirm the audience of the studies' methodological rigor, we suggest that researchers report multicollinearity testing in their papers.

The quality of the reviewed studies/articles was further compromised by the authors' neglect of reliability and validity testing. Most of the studies either did not mention data reliability/validity or reported the test result based on previous studies' data. Reliability and validity testing is critical because measurement errors can directly affect the results and their interpretation (Vacha-Haase et al., 1999). Researchers can either evaluate the score reliability and validity using their own samples or rely on published sources (Kline, 2011). However, reliability and validity evidence from established instruments is applicable only if researchers use the same instrument in the same form and the instrument has been validated in a population similar to their samples (Kimberlin & Winterstein, 2008). Published reliability/validity coefficients may not be generalizable to a particular sample under consideration (Kline, 2011). Despite the importance of reporting reliability and validity testing, many journals do not include specific requirements for empirical studies to report psychometric properties of the instrument being used and scores being analyzed. To facilitate the publication of high quality research, we recommend that journals refine their editorial guidelines and require authors to report reliability and validity coefficients for the data being analyzed. Researchers' awareness regarding the roles of reliability and validity also need to be increased to ensure the correct interpretation of their results.

Theoretical issues

The level of theory utilization among the reviewed studies was not lower than expected. Over half of the studies were not theoretically driven or used theories superficially. Theories provide a framework for identifying determinants of particular health behaviors, which constitutes a critical initial step in the development of successful interventions (Fishbein & Cappella, 2006). The lack of theoretical basis might account for the overarching number of exploratory studies among the reviewed articles, which typically assume only their direct effects on ACS without considering interaction among predictor variables. The lack of theory use posed an added concern regarding "kitchen sink" regressions in which any variables available were included. When selecting a variable, its theoretical relevance should be as important as, if not more important than, its statistical significance. The relatively low level of theory utilization suggests that health behavior studies need to advance further in sophistication of study designs (Painter et al., 2008). To overcome this shortcoming, researchers need to raise their awareness of using theories, not only in funding application but also for manuscript development. Journals may also need to expand the word limits they placed on manuscript submissions to ensure researchers have enough space to elaborate on theory utilization (Delissaint & McKyer, 2008; Painter et al., 2008).

Our findings also highlighted the common use of the social ecological models (SEM). All except two of the reviewed studies that identified a theoretical framework used SEM. Our result was in line with findings from previous reviews of physical activity research that SEM has been the most commonly adopted theoretical framework (Humpel, Owen & Leslie, 2002; Nelson et al., 2008). SEM provides a comprehensive framework for understanding the multi-level determinants of health behaviors (McLeroy et al., 1988; Stokols, 1996). Recently, researchers have used SEM to support a new emphasis on environmental causes of behaviors (Fishbein & Cappella, 2002; Nelson et al., 2008). While the consistent use of the SEM facilitated the process of synthesizing and comparing findings, the SEM lacks sufficient specificity regarding specific characteristics at all levels. Consequently, other significant factors that may work with hypothesized factors at each level may be neglected. For example, perceived barriers as a personal level construct may be influenced by other social cognitive factors at the same level such as attitudes, self-efficacy, and intention; neglecting these constructs may result in an incomplete picture and consequently biased results. Unfortunately, these important social cognitive constructs were rarely investigated within the ACS context (Sirard & Slater, 2008); it might be time to put these factors back into equation.

Another weakness of the research was the divergence between conceptualization and operationalization of perceived barriers. Only one study clearly defined perceived barriers; most authors took it for granted that readers knew what "perceived barriers" meant. With this assumption, most of the studies skipped the conceptualization stage and directly operationalized perceived barriers by describing survey items that were used to measure the construct. When a construct is poorly conceptualized, however, it is very unlikely that the construct is properly operationalized. To make the situation even worse, most of the reviewed studies did not conduct a validity test. Consequently, the quality of construct measurement and the interpretation of results were questionable. For future ACS studies, improving the conceptualization and operationalization of investigated constructs should be a high priority.

Limitations and strengths

This review is not without limitations. First, we limited our search to articles published in English, and therefore relevant literature published in other languages was excluded. Second, with the heterogeneity in the definition of ACS and the absence of standardized measurement tools of perceived barriers, inter-study comparisons must be considered with caution. Furthermore, this review was limited by the relatively small sample of articles to evaluate trends in theory use over years and to compare studies by sub-groups or disciplines. Despite the limitations, the strengths of this review need to be recognized. First, it used an extensive search strategy to locate articles in 6 databases and rigorously screened articles through well-defined inclusion/exclusion criteria. Second, the instruments that we developed for assessing the methodological and theoretical qualities of existing ACS literature were based on well-established instruments and tailored for ACS studies. The instruments served well to capture existing discrepancies in literature and provided detailed insight for future studies.

Conclusions

Following rigorous assessment process, this systematic review has provided a detailed discussion of empirical, methodological, and theoretical issues in the current literature of active transport, particularly in regard to perceptions of barriers preventing children from ACS. Based on our findings and in light of the limitations of this review, we have several empirical, methodological, and theoretical recommendations for advancing the quality of future ACS studies.

Empirically, increasing the diversity of study regions and samples should be a high priority, particularly in Asian countries and among rural residents. Regarding the relation between individual perceptions and ACS behavior, more prospective and interventions studies conducted at multiple time points are needed to determine the causal mechanism liking the perceived factors and ACS. Moreover, future researchers should also include policy-related barriers into their inquiries. *Methodologically*, the conceptualization of ACS should be standardized or at least well rationalized in future studies to ensure the comparability of results. Favorably, definitions of ACS need to reflect the frequency and magnitude of the behavior more accurately. Second, authors' awareness need to be increased for improving the methodological rigor of studies, especially in regard to appropriate statistical analysis techniques, control variable estimation, multicollinearity testing, and reliability and validity reporting. *Theoretically*, future researchers need to first ground their investigations in theoretical foundations. Further, efforts should be devoted to make sure theories are used thoroughly and correctly. Important theoretical constructs, in particular, also need to be conceptualized and operationalized appropriately to ensure accurate measurement. By reviewing what has been achieved, we hope this review offers insights for more sophisticated active transport studies in the future.

CHAPTER III

A SELF-EFFICACY APPROACH TO CHILDREN'S ACTIVE COMMUTING TO SCHOOL

Introduction

Recently, the National Poll on Children's Health (2012) recognized childhood obesity as the leading health concern among parents in the U.S., topping drug abuse and smoking. The prevalence of obesity nearly tripled among American children and adolescents in the past 30 years, which has brought along various health problems that were not seen until adulthood, including high blood pressure, type 2 diabetes, and elevated blood cholesterol levels. (Reilly, 2003; Ogden et al., 2012). Considering the serious health consequences of childhood obesity and that more children are becoming overweight, preventing and reducing childhood obesity is an important public health challenge.

Recent research has acknowledged the role of active commuting to school (ACS), e.g., walking or biking to/from school, in promoting children's physical activity and its potential for preventing and reducing childhood obesity (Lee, Orenstein & Richardson, 2008; Mendoza et al., 2011). For example, Mendoza et al. conducted a cluster randomized controlled trial of the Walking School Bus program in Texas and reported significant increases of daily moderate-to-vigorous physical activity to the intervention students compared with the control students (Mendoza et al., 2011). Despite the health benefits of ACS, the percentage of children who walk or bike to school has declined dramatically in the U.S. over the past few decades, from 47.7% in 1969 to 12.7% in 2009 (McDonald et al., 2011). It is critical that effective interventions be developed and conducted to reverse the declining trend.

In the past decades, researchers in various disciplines, e.g., health, urban planning, and transportation, have identified multiple personal, environmental, and social factors associated with ACS (Sirard & Slater, 2008; Pont et al., 2009). However, little research has been carried out into investigating psychological factors that may influence children's ACS (Sirard & Slater, 2008). Examination of psychological factors within the ACS context is critical to understanding and implementing effective interventions, because 1) most interventions that placed emphasis on structural or environmental improvements have proved insufficient in changing children's commuting behavior to school (Chillón, 2011) and 2) research has established the predictive power of multiple psychological factors on promoting children's physical activity, including attitudes, perceived barriers, and self-efficacy (Sallis et al., 2000; Van Der Horst et al., 2007).

Self-efficacy (SE) is one of the strongest and most widely acknowledge determinants of health behavior in general (Bandura, 2001). Among children and adolescents, SE has also been identified as a consistent variable associated with physical activity (Van Der Horst et al., 2007). As a social ecological construct, SE refers to individuals' self-belief in their ability to control their functioning, overcome difficulties, and perform specific tasks (Bandura, 1977). Previous ACS studies have confirmed the important role of parental SE in children's active commuting behaviors, showing that higher parental SE was positively associated with children's ACS (Mendoza et al., 2010; Mendoza et al., 2011). However, it remains unclear whether and how children's SE can influence their *own* behavior of ACS. Children, like adults, are able to contribute meaningful research data; their belief of their own abilities to navigate physical and social environments that they may encounter when actively commuting to school need to be recognized and investigated.

Further, previous studies focused mainly on parents based on the hypothesis that parents played a greater role than children in choosing the mode of travel to school (Stewart, 2011). However, there's no empirical evidence supporting this hypothesis. A comparison of parents' versus children's SEs in predicting children's ACS may provide supporting or opposing evidence for this hypothesis. Besides, parents' and children's SEs may influence each other. In order for more effective intervention strategies, it is important to examine the interacting effect of parents' and children's SEs.

Therefore, the purpose of this study was to investigate the roles of both children's and parents' self-efficacies in children's behavior of active commuting to school based on Bandura's social cognitive theory (SCT). Specifically, we aimed to 1) determine the association between children's SE and their ACS behavior, 2) explore the sources of children's SE, 3) compare the power of children's vs. parents' SEs on predicting/explaining children's ACS, and 4) examine the relationship between children's and parents' SEs.

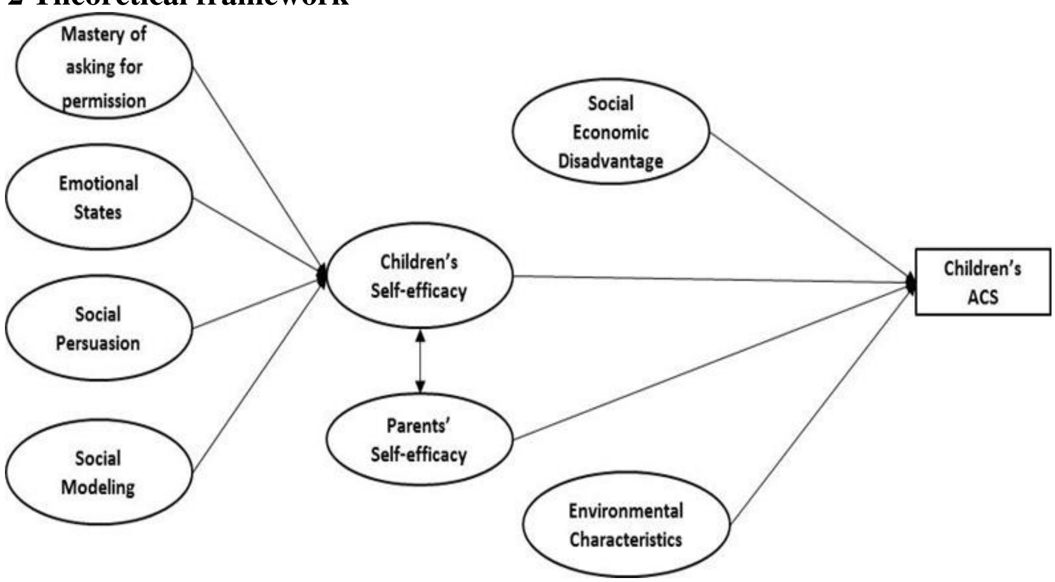
Theoretical framework

According to Bandura's SCT, individual's behavior is determined by the interaction among personal, behavioral, and environmental factors (Bandura, 1986). Developed within the framework of social learning theory (SLT) and SCT, self-efficacy theory postulates that the individuals' beliefs of their capabilities affect their decisions about whether a behavior will be adopted and maintained (Bandura, 1977). In the context of ACS, children's beliefs in their abilities for *scheduling* regular ACS, *seeking social support* for ACS, and overcoming different kinds of *barriers* to ACS may influence their active commuting behavior (Bandura, 2001; Ryan & Dzewaltowski, 2002).

Baudura also hypothesized that people's self-efficacies can be developed by different sources of influence, including mastery experience, vicarious experience or social modeling, verbal persuasion, and emotional and physiological states (Bandura, 2001). When applied to ACS, children may be more likely to adopt active transport if they have asked their parents for permission to ACS (*mastery experience*), if they observed that people around them walked or biked often (*vicarious experience/social modeling*), if their parents or schools had persuaded them to walk or bike (*verbal/social persuasion*), or if they felt safe or happy walking or biking to school (*emotional /physiological states*).

Based on our research questions, we developed a theoretical framework by integrating the SCT and the self-efficacy theory. As presented in Figure 2, we hypothesized that controlling for participants' sociodemographics and environmental characteristics, children's SE is positively associated with their ACS (Hypothesis #1); children's mastery experience, emotional states, the persuasive messages they received and social modeling contribute to their SE toward ACS (Hypothesis #2); compared with children's SE, parents' SE on allowing their children to actively commute has stronger correlation with children's ACS behavior (Hypothesis #3); and there's a positive correlation between children's and parents' SEs (Hypothesis #4).

Figure 2 Theoretical framework



Methods

Study design, participants, and procedures

The current study is part of the Texas Childhood Obesity Prevention Policy Evaluation (T-COPPE) project. The T-COPPE project is a five-year project aimed to evaluate the implementation of two key childhood obesity prevention policies in Texas:

1) the Safe Routes to School (SRTS) program administered through Texas Department of Transportation and 2) federal food allocation package administered through Texas Women, Infants and Children (WIC) Nutrition Program (T-COPPE, 2012). For evaluation of the SRTS program, researchers used a quasi-experimental design and recruited participants from 79 schools in 28 metropolitan and rural counties across Texas. The research team revised and updated school recruitment materials from their previous studies and approached the school districts and community groups first. Once school districts agreed to participate, a research staff member then contacted selected school individually and made arrangements for data collection.

Baseline data were collected in 2009, and the post-test data were collected in the 2011-2012 school year. Fourth-grade students and their parents participated in the project. Student surveys were adapted using available items from other validated surveys and the School Physical Activity and Nutrition (SPAN) surveys (Hoelscher et al., 2004). Student assessments included physical activity levels, dietary habits, perceived barriers and self-efficacy to ACS, etc. Parent surveys were adapted using available items from the SRTS parent surveys and other validated measures and included measures of sociodemographics, children's usual mode of transport to/from school, perceived self-efficacy and barriers to ACS, etc. Both English and Spanish versions of the questionnaires were available depending on participants' preference. Objective measures, e.g., distance from child's home to school and land use, were captured using geographic Information System (GIS) and the validated T-COPPE school environmental audit tool (Lee et al., 2013).

For the current study, we utilized the data from the pre-test survey, in which 3315 students and 2055 parents participated. Students whose parents also participated in the survey and provided geocodable home addresses were selected first. To control the effect of long distance as a major barrier to ACS, data of students and parents who lived beyond two miles from school (network distance obtained from GIS) were further excluded. The final analysis included 857 parent/child pairs from 74 schools who lived within two miles of school and didn't have any disability for walking in urban, suburban, and rural areas. The institutional review boards of The University of Texas and Texas A&M University approved the study.

Measures

Multiple theoretical constructs were measured: children's SE comprising sub-scales of scheduling SE, barrier SE and support-seeking SE, mastery experience, social persuasion, social modeling, emotional states, environmental constraints, and parents' SE. Matching items from parent and child surveys that assessed the same construct(s) were included. Selection of observed variables for each construct was based on their theoretical relevance or the results from reliability and correlation tests (Lee, 2006). A description of these scales and subscales, including all items and their associated internal consistency or correlation coefficients, is provided below.

Children's SE was a second-order factor collectively measured by three first-order factors: *scheduling SE*, *barrier SE* and *support-seeking SE*.

Scheduling SE was measured by three items asking children how sure they were that they could walk to school to and from school at least once a week, 2-4 days, or every day of the week. The response format included a 3-point Likert scale ranging from "not sure", "a little sure", to "very sure." A reliability analysis for data on these three items resulted in a Cronbach's α of 0.83.

Barrier SE was a 6-item subscale that queried children about their beliefs in their abilities to walk to school even if 1) they lived far from school, 2) there was a lot of traffic, 3) it was hot outside, 4) it was cold outside, 5) it was raining outside, and 6) their friends or classmates did not walk to school. The items were also scaled on a 3-point response format, from "not sure", "a little sure", to "very sure." Cronbach's α for the six items was 0.84, indicating good internal consistency.

Support-seeking SE was loaded on four items, asking children how sure they were that they could walk to school with their parents, with their friends or classmates, by themselves, or without their parents. A reliability test for these items resulted in a Cronbach's α of 0.73, indicating good internal consistency. Response options included "not sure", "a little sure", to "very sure."

Mastery experience was measured by two items ($\rho = 0.22$, $p < 0.001$), asking children how often they asked their parents if they could walk or ride a bike to school. Responses for the first item included "never", "sometimes", "always or almost always" and "I am already walking to school most days." Responses for the second item included "never", "sometimes", "always or almost always", "I am already riding a bike to school most days" and "I don't have a bike to ride." The Spearman's ρ was reported here rather than Cronbach's α, which was deemed inappropriate and meaningless for two-item scales (Verhoef, 2003; O'Brien, Buikstra & Hegney, 2008).

Emotional states was measured by two items ($\rho = 0.53$, $p < 0.001$) relating to children's perceptions about their neighborhood safety (i.e., whether they felt safe walking and biking in the neighborhood during the day). A 4-point response format was used for the two items, from "never", "some of the time", "most of the time", to "all of the time."

Social persuasion was assessed by two items ($\rho = 0.15$, $p < 0.01$). One asked children whether their teachers or other school staff had encouraged them to walk or ride to or from school, and the other asked whether schools had a Walking School Bus or a similar program where a group of children walk to or from school together with adults. Response options included "no", "yes", and "don't know."

Social modeling asked children 1) if many people walked or biked in their neighborhood and 2) how many of their friends usually walked or biked to school ($\rho = 0.20$, $p < 0.001$). Response options for the first items were "never", "some of the time", "most of the time", and "all of the time", and the second item was scaled on a 6-point response format, ranging from "none" to "five or more."

Environmental constraints were represented by seven objectively measured environmental variables ($\alpha = 0.67$), including home-to-school distance, negative land uses, traffic safety, and social environmental safety en route to school. These variables have been commonly used in active commuting research as indices of environment walkability (Saelens & Handy, 2008). Data were derived in 2010-2012 using ArcGIS and ESRI Business Analyst (ESRI, 2013).

Distance referred to the shortest network distance from each parent/child pair's home to school obtained by ArcGIS. The 200 feet buffer along the shortest home-to-school route of each child was used as the spatial unit of measurement for negative land uses and physical and social safety. Negative land uses, obtained from the ESRI Business Analyst, consisted of three composite observed variables, including automobile-related land use, construction and manufacturing-related land use, and general commercial-related land use within home-to-school route buffer. All of the three land use variables were dichotomized as "yes" or "no", indicating the presence of certain negative land uses or not. Traffic safety comprised of two items: the presence of highway and the presence of crashes within the route buffer (0 = No, 1 = Yes), which were obtained from the Texas Department of Transportation. Social environmental safety was measured by one item: the presence of sex offenders per acre within the route buffer (0 = No, 1 = Yes), the data of which were derived from the State Department of Public Safety of Texas. A detailed description of the built environmental variables of the T-COPPE project is available elsewhere (Lee et al., 2013).

Parents' SE. In agreement with child's SE, parents' self-efficacy was a second-order factor loaded on three first-order factors: *parents' scheduling SE*, *parents' barrier SE* and *parents' support-seeking SE*. Matched items for assessing different categories of children's SE were used here. Crobach's α for the three first-order factors were .95, .86, and .76 respectively.

ACS. Parents were asked how their 4th grade children arrive at school and leave school on most days of a week, and responses included walk, bike, school bus, family vehicle, carpool, transit, and others. The outcome variable was dichotomized as ACS or not (i.e., whether or not a child walked or biked to or from school on most days of a week).

Control variables included participants' social economic disadvantage, environmental constraints, and school settings. Participants' SES was measured by two items: number of different types of assistance that a child's family received, e.g., WIC, Medicaid/Texas Health Steps and food stamps, and parental report of the child's ethnicity (i.e., White or non-White). School settings included urban/suburban and rural settings.

Statistical analysis

Descriptive statistics. Both parents' and children's sociodemographic information were retrieved from parents' surveys. Prior to conducting more complicated statistical analyses, we examined the frequencies for nominal/ordinal variables and distribution and normality of continuous variables. No statistically significant deviation from the normality assumption was detected in any continuous variable.

Modeling. Structural equation modeling (SEM) was selected to test the hypothesized pathways using M*plus* 7.0 (Muthén & Muthén, 2012). SEM allows researchers to examine relationships among latent variables with multiple observed measures and, more importantly, provides flexibility in testing theory-driven models with empirical data (Buhi, Goodson, & Neilands, 2007). As a powerful and flexible analytic software, M*plus* handles missing data appropriately and provides estimates for analyzing binary/dichotomous outcome variables, e.g., ACS or not (Muthén & Muthén, 2012). M*plus* also has the flexibility to estimate mixture modeling (i.e., to simultaneously handle binary, ordinal, and continuous measures). When binary or ordinal variables are present, as in the current study and most health behavioral studies, M*plus* will set up optimal thresholds to ensure a latent factor can have a normal distribution and utilize varying weighted contributions from the variables (Wang & Wang, 2012).

Two SEM models were tested for the current study; Model 1 tested Hypotheses #1 and #2, and Model 2 tested Hypotheses #3 and #4. We followed a two-step method for both of the SEM models (Kline, 2011). In step 1, measurement models were built and evaluated to confirm the factor structure of the latent variables. The mean and variance-adjusted WLS (WLSMV), a more generalized weighted least square based robust estimator, was used for testing measurement models. WLSMV is available in M*plus* and can be applied to a combination of binary, ordered categorical and continuous indicators (Muthén & Muthén, 2012; Wang & Wang, 2012). Higher order CFA modeling was used for children's SE and parents' SE on both theoretical and empirical bases. Theoretically, Bandura postulated that people's beliefs in their own abilities are various (Bandura, 2001); empirically, we conducted collinearity diagnostics for observed variables under each construct and found two variables (i.e., "at least once every week" and "everyday of the week") under parents' SE had tolerance levels below 0.2 and VIFs greater than 5.0. Given that higher order CFA is a common way to deal with collinearity problems, we introduced higher order factorial structures (Wang & Wang, 2012).

In step 2, multilevel modeling was performed to test the hypothesized pathways in the two SEM models. A two-level structure of children nested within schools was employed based on the assumption that similar active commuting patterns may be clustered among children attending the same schools (Panter et al, 2010). Again, WLSMV was used as the recommended and default estimator in M*plus* for modeling binary outcomes (e.g., ACS or not in the current study). Model fit was evaluated based on the following fit indices: the Bentler comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA) and its 90% confidence interval, and the weighted root mean square residual (WRMR) (Muthén & Muthén, 2012; Yu, 2012). When robust estimators, such as WRMRs, are used for model estimation, the chi-square difference test cannot be directly used for model comparison (Wang & Wang, 2012). To improve model fit, we respecified the models based on modification indices. Item-to-factor loadings, factor correlations, and path coefficients for the measurement and structural models were inspected for sign and/or for magnitude.

Missing data. No missing value is present for objective data obtained by GIS, including distance, environmental constraints, and school setting. For the other observed variables, missing data ranged from 0% to 6.0%. By default, data containing missing values are listwise deleted when modeling binary outcome using WLSMV estimator in M*plus* (Muthén & Muthén, 2012).

Results

Sample characteristics and descriptive statistics

Sample characteristics are presented in Table 8. Of the 857 4th grade students, 49.2% were boys and 50.3% were girls; and the majority were non-White (79.9%). Approximately 70% of the children's families received at least one type of assistance. Over 80% of the children were from schools located in urban or suburban areas, with only 13.9% from rural schools. Over 18% of the students were active commuters, while 78.8% were not.

Table 8. Social demographic characteristic of participants

Characteristics	% or mean (SD)
Child's gender	
Boy	49.2
Girl	50.3
Child's ethnicity	
White	19.5
Non-white	79.9
Number of assistance a family received	1.67 (1.49)
School settings	
Urban/suburban	86.1
Rural	13.9
Modes of commuting to school	
Active (i.e., walk or bike)	18.1
Non-active	78.8

Table 9 presents the coding scheme and descriptive statistics for latent and observed variables that were used. Most of the observed variables were categorical or ordinal, and few were continuous variables.

Table 9. Coding scheme and descriptive statistics for latent and observed variables (N = 857)

Description	Latent and Observed Variables	Coding Schemes and Descriptive Statistics
Types of children's SE	*I'm sure that I can walk to or from school:*	
Scheduling SE	At least once every week	0: Not sure (48.8%), 1: A little sure (21.7%), 2: Very sure (26.1%)
	At least 2-4 days of the week	0: Not sure (54.7%), 1: A little sure (19.1%), 2: Very sure (23.1%)
	Every day of the week	0: Not sure (57.9%), 1: A little sure (13.0%), 2: Very sure (24.9%)
Barrier SE	Even if I live far from school	0: Not sure (69.3%), 1: A little sure (15.2%), 2: Very sure (13.4%)
	Even if there is a lot of traffic	0: Not sure (70.6%), 1: A little sure (16.3%), 2: Very sure (10.3%)
	Even if it is hot outside	0: Not sure (43.2%), 1: A little sure (25.2%), 2: Very sure (28.8%)
	Even if it is cold outside	0: Not sure (56.4%), 1: A little sure (22.4%), 2: Very sure (18.7%)
	Even if it is raining outside	0: Not sure (68.1%), 1: A little sure (15.2%), 2: Very sure (13.7%)
	Even if my friends or classmates do not walk to school	0: Not sure (49.9%), 1: A little sure (20.3%), 2: Very sure (26.4%)
Support-seeking SE	With my parents	0: Not sure (37.3%), 1: A little sure (19.5%), 2: Very sure (40.1%)
	With my friends or classmates	0: Not sure (39.3%), 1: A little sure (19.5%), 2: Very sure (38.3%)
	By myself	0: Not sure (57.1%), 1: A little sure (16.2%), 2: Very sure (25.1%)
	Without my parents	0: Not sure (52.7%), 1: A little sure (16.7%), 2: Very sure (27.2%)
Sources of children's SE		
Mastery experience	How often do you ask your parents if you can walk to school?	0: Never (50.1%), 1: Sometimes (22.5%), 2: Always (11.4%); 3: Already walked to school (14.8%)
	How often do you ask your parents if you can bike to school?	0: I do not have a bike (19.7%), 1: Never (49.5%), 2: Sometimes (16.3%), 3: Always (9.8%), 4: Already biked to school (4.1%)
Emotional States	Do you feel safe walking in your neighborhood during the day?	0: Never (15.5%), 1: Sometimes (23.8%), 2: Most of the time (20.9%); 3: All of the time (39.1%)
	Do you feel safe riding a bike in your neighborhood during the day?	0: Never (15.5%), 1: Sometimes (20.4%), 2: Most of the time (18.8%); 3: All of the time (44.8%)
Social Persuasion	Have your teachers or other school staff encouraged you to walk or ride to or from school?	0: No (67.2%), 1: Yes (13.3%), 2: Don't know (18.6%)
	Does your school have a Walking School Bus or a similar program?	0: No (41.9%), 1: Yes (15.3%), 2: Don't know (42.2%)
Social modeling	Do many people walk or ride bikes in your neighborhood?	0: Never (7.1%), 1: Sometimes (46.8%), 2: Most of the time (25.1%); 3: All of the time (20.8%)
	How many of your friends usually walk or ride a bike to school?	Mean: 1.77, SD:1.82

Table 9. Continued

Environmental constraints	Percentage of highway	0: No (82.4%), 1: Yes (17.6%)
	Automobile related land use	0: No (66.7%), 1: Yes (33.3%)
	Construction and manufacturing related land use	0: No (64.9%), 1: Yes (35.1%)
	General commercial related land use	0: No (58.0%), 1: Yes (42.0%)
	Presence of crashes per acre	0: No (67.9%), 1: Yes (32.1%)
	Presence of sex offenders per acre	0: No (72.1%), 1: Yes (27.9%)
	Network distance	Mean: .80, SD: .48
Types of parents' SE	*I'm sure that I can allow my child to walk to or from school:*	
Parent scheduling SE	At least once every week	0: Not sure (59.7%), 1: A little sure (16.5%), 2: Very sure (18.1%)
	At least 2-4 days of the week	0: Not sure (64.6%), 1: A little sure (13.8%), 2: Very sure (15.5%)
	Every day of the week	0: Not sure (70.1%), 1: A little sure (10.5%), 2: Very sure (13.7%)
Parent barrier SE	Even if we live far from school	0: Not sure (87.8%), 1: A little sure (4.9%), 2: Very sure (2.9%)
	Even if there is a lot of traffic	0: Not sure (86.1%), 1: A little sure (6.3%), 2: Very sure (2.8%)
	Even if it is hot outside	0: Not sure (63.5%), 1: A little sure (20.7%), 2: Very sure (11.1%)
	Even if it is cold outside	0: Not sure (72.0%), 1: A little sure (16.9%), 2: Very sure (6.1%)
	Even if it is raining outside	0: Not sure (83.8%), 1: A little sure (6.7%), 2: Very sure (3.5%)
	Even if other children do not walk to school	0: Not sure (75.1%), 1: A little sure (12.6%), 2: Very sure (6.9%)
Parent support-seeking SE	With me	0: Not sure (27.5%), 1: A little sure (17.2%), 2: Very sure (50.6%)
	With friends or classmates	0: Not sure (55.8%), 1: A little sure (20.4%), 2: Very sure (18.6%)
	Alone, without other children or adults	0: Not sure (78.4%), 1: A little sure (8.1%), 2: Very sure (7.9%)
	Without me	0: Not sure (67.8%), 1: A little sure (14.9%), 2: Very sure (11.6%)

Measurement and structural models

Measurement models were assessed with confirmatory factor analysis (CFA) to confirm the factor structures of all model constructs. Standardized item-to-factor loadings were examined and variables that had poor factor loadings (below 0.30) and non-significant relationships ($p > 0.05$) with individual latent factor were removed (Hair et al, 1998).

Structural Model 1 for Children's SE. Two hypotheses were tested in structural model 1: children's SE is positively associated with their ACS (Hypothesis #1), and children's mastery experience, emotional states, the persuasive messages they received, and social modeling contribute to their SE toward ACS (Hypothesis #2).

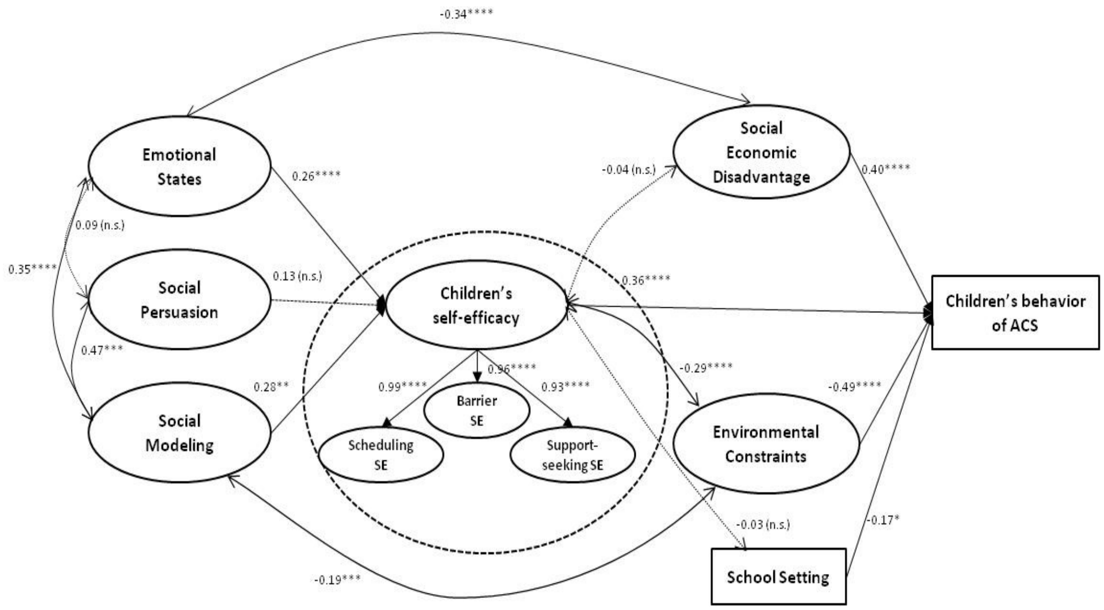
Table 10 displays the standardized item-to-factor correlations for Structural Model 1, with weak relationships removed. The latent factor, *mastery experience*, was removed from further modeling analyses because of the poor factor loadings of the two items attempting to refer it. Presence of sex offenders within route buffer per acre was further removed because of small factor loading. In order to improve model fit, we also created another latent factor, SES, which was captured by the number of assistances that a child's family received and child's ethnicity.

Table 10. Standardized item-to-factor correlations for structural model 1: children's self-efficacy model (N = 857)

Description	Latent factor/Observed variables	Factor loading	P-value
Types of Children's Self-efficacy	**Scheduling Self-efficacy (3 items)**		
	I'm sure that I can walk to and from school:		
	At least once every week	.78(.02)	0.000
	At least 2-4 days of the week	.87 (.02)	0.000
	Every day of the week	.91 (.02)	0.000
	Barrier Self-efficacy (6 items)		
	Even if I live far from school	.69 (.03)	0.000
	Even if there is a lot of traffic	.70 (.03)	0.000
	Even if it is hot outside	.83 (.02)	0.000
	Even if it is cold outside	.80 (.02)	0.000
	Even if it is raining outside	.77 (.03)	0.000
	Even if my friends or classmates do not walk to school	.87 (.02)	0.000
	Support-seeking Self-efficacy (4 items)		
	With my parents	.40 (.05)	0.000
	With my friends or classmates	.80 (.02)	0.000
	By myself	.91 (.01)	0.000
	Without my parents	.91 (.01)	0.000
Sources of Children's Self-efficacy	**Emotional States (2 items)**		
	Do you feel safe walking in your neighborhood during the day?	.83(.05)	0.000
	Do you feel safe riding a bike in your neighborhood during the day?	.64(.05)	0.000
	Social Persuasion (2 items)		
	Have your teachers or other school staff encouraged you to walk or ride to or from school?	.78 (.26)	0.000
	Does your school have a Walking School Bus or a similar program?	.38 (.12)	0.000
	Social Modeling (2 items)		
	Do many people walk or ride bikes in your neighborhood?	.44 (.06)	0.000
	How many of your friends usually walk or ride a bike to school?	.46 (.07)	0.000
Social Economic Disadvantage	Number of assistance that a child's family received	.47 (.09)	0.000
	Ethnicity (White or non-white)	.61 (.12)	0.000
Environmental Constraints	Percentage of highway (binary)	.64 (.09)	0.000
	Auto-related land use (binary)	.73 (.08)	0.000
	Construction and manufacturing land use (binary)	.46 (.07)	0.000
	General commercial land use (binary)	.68 (.07)	0.000
	Presence of crashes per acre (binary)	.31 (.08)	0.001
	Network distance	.87 (.07)	0.000

Figure 3 displays the final structural model, which proved excellent fit to the data (CFI = 0.99, TLI = 0.99, RMSEA = 0.02, WRMR = 0.84). Among this sample of children, the model accounted for 65.4% of the variance in the final outcome (i.e., ACS). As hypothesized, the relationship between children's SE and their ACS behavior was significant and positive ($\beta = 0.26$, $p < 0.001$). Emotional states ($\beta = 0.36$, $p < 0.001$) and social modeling ($\beta = 0.28$, $p < 0.01$) had direct pathways to children's SE, but there was no direct pathway between social persuasion and children's SE ($\beta = 0.13$, $p = 0.25$). Moreover, emotional states ($\beta = 0.09$, $p = 0.001$) and social modeling ($\beta = 0.10$, $p = 0.028$) also had significant indirect effects on children's active commuting behavior via children's SE. In other words, the effects of emotional states and social modeling on children's ACS were mediated by children's SE.

Figure 3 Structural model 1 for children's self-efficacy (N = 857)



Note: Parameter estimates are standardized regression weights. A regression weight with a positive sign means the expected value of the dependent variable (i.e., child behavior of ACS) is increased when the predictor value increases. Model Fit Statistics: CFI=0.99; TLI=0.99; RMSEA = 0.02; WRMR = 0.84. *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.005$, ****$p \leq 0.001$, n.s. = not significant.

All of the three latent and observed control variables, i.e., social economic disadvantage ($\beta = 0.40$, $p < 0.001$), environmental constraints ($\beta = -0.49$, $p < 0.001$), and school setting ($\beta = -0.17$, $p = 0.029$), had statistically significant direct effects on children's ACS. Specifically, children from social economic disadvantaged families were more likely to walk or bike to school compared with those from higher social economic families. Environmental constraints was negatively associated with children's ACS; children with fewer environmental constraints were more likely to walk or bike to school. Compared with children from urban or suburban schools, children from rural schools were more likely to commute actively. The relationship between environmental constraints and children's SE was also significant ($\beta = -0.29$, $p < 0.001$), indicating that children's SE increased when environmental constraints decreased.

Other significant relationships included social economic disadvantage and emotional states ($\beta = -0.34$, $p < 0.001$), social modeling and emotional states ($\beta = 0.35$, $p < 0.001$), social persuasion and social modeling ($\beta = 0.47$, $p = 0.004$), and school setting and social modeling ($\beta = -0.19$, $p < 0.001$).

Structural Model 2 for Children's SE vs. Parents' SE. The other two hypotheses were tested in structural model 2: compared with children's SE, parents' SE on allowing their children to actively commute has a stronger correlation with children's ACS behavior (Hypothesis #3), and there's a positive correlation between children's and parents' SEs (Hypothesis #4)

Table 11. Standardized item-to-factor correlations for structural model 2: children's self-efficacy vs. parents' self-efficacy model (N = 857)

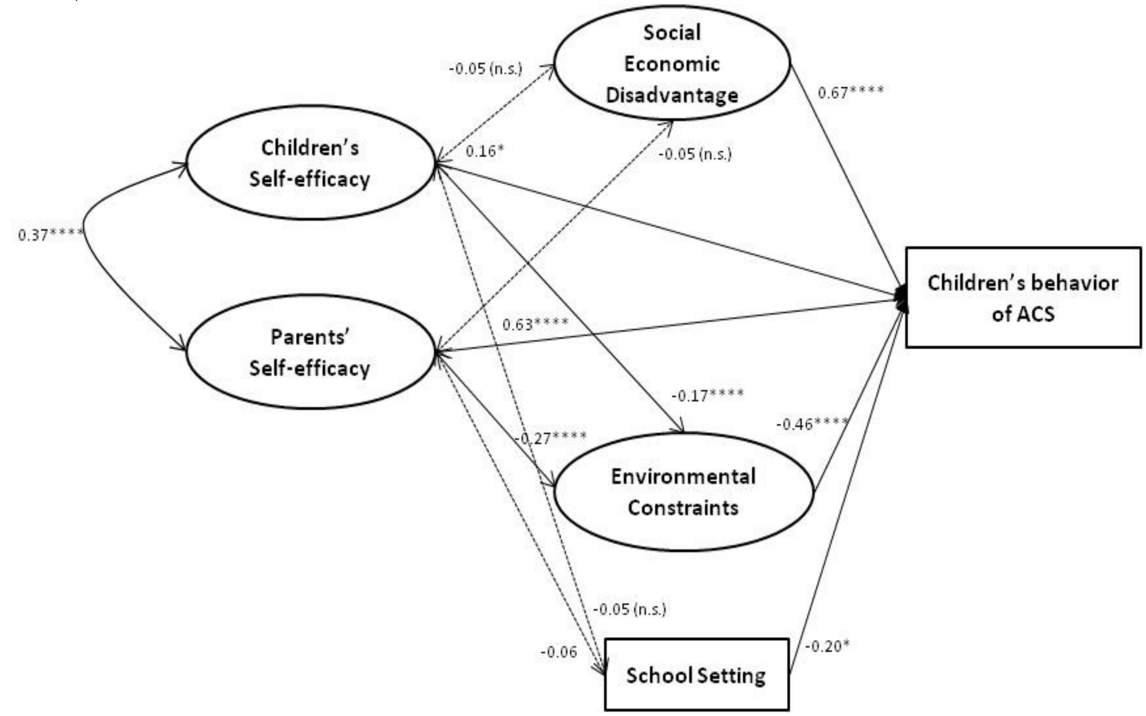
Description	Latent factor/Observed variables	Factor loading	P-value
Types of Children's Self-efficacy	**Scheduling Self-efficacy (3 items)**		
	I'm sure that I can walk to and from school:		
	At least once every week	0.77 (0.02)	0.000
	At least 2-4 days of the week	0.87 (0.02)	0.000
	Every day of the week	0.92 (0.01)	0.000
	Barrier Self-efficacy (6 items)		
	Even if I live far from school	0.68 (0.03)	0.000
	Even if there is a lot of traffic	0.69 (0.03)	0.000
	Even if it is hot outside	0.82 (0.02)	0.000
	Even if it is cold outside	0.78 (0.03)	0.000
	Even if my friends or classmates do not walk to school	0.87 (0.02)	0.000
	Support-seeking Self-efficacy (4 items)		
	With my parents	0.28 (0.05)	0.000
	With my friends or classmates	0.77 (0.03)	0.000
	By myself	0.87 (0.02)	0.000
	Without my parents	0.88 (0.02)	0.000
Types of Parents' Self-efficacy	**Scheduling Self-efficacy (3 items)**		
	I'm sure that I can allow my child to walk to or from school		
	At least once every week	0.96 (0.01)	0.000
	At least 2-4 days of the week	0.98 (0.01)	0.000
	Every day of the week	0.98 (0.01)	0.000
	Barrier Self-efficacy (6 items)		
	Even if we live far from school	0.67 (0.03)	0.000
	Even if there is a lot of traffic	0.76 (0.03)	0.000
	Even if it is hot outside	0.88 (0.02)	0.000
	Even if it is cold outside	0.82 (0.02)	0.000
	Even if other children do not walk to school	0.93 (0.02)	0.000
	Support-seeking Self-efficacy (4 items)		
	With me	0.54 (0.04)	0.000
	With friends or classmates	0.90 (0.01)	0.000
	Alone, without other children or adults	0.90 (0.02)	0.000
	Without me	0.92 (0.01)	0.000
Social Economic Disadvantage	Number of assistance that a child's family received	0.36 (0.12)	0.003
	Ethnicity (White or non-white)	0.82 (0.25)	0.001
Environmental Constraints	Percentage of highway (binary)	0.64 (0.08)	0.000
	Auto-related land use (binary)	0.70 (0.08)	0.000
	Construction and manufacturing land use (binary)	0.49 (0.07)	0.000
	General commercial land use (binary)	0.65 (0.07)	0.000
	Presence of crashes per acre (binary)	0.31 (0.08)	0.001
	Network distance	0.90 (0.05)	0.000

Table 11 exhibits the standardized item-to-factor correlations for Structural Model 2, with two observed variable with low factor loadings removed ("I'm sure that I can walk to or from school even if it is raining outside" and "I'm sure that I can allow my child to walk to or from school even if it is raining outside"). Although the item "I'm sure I can walk or bike to or from school with my parents" had a factor loading less than 0.3, it was statistically significant ($p < 0.001$). Further considering its theoretical importance further, we decided to retain this item in the model.

Figure 4 depicts the final structural model, which demonstrated good fit to the data (CFI = 0.995, TLI = 0.995, RMSEA = 0.02, WRMR = 0.98). Overall, the model accounted for 82.2% of the variance in the final outcome variable ACS. As we hypothesized, compared with children's SE ($\beta = 0.16$, $p < 0.001$), parents' SE ($\beta = 0.63$, $p < 0.001$) had a stronger influence on children's active commuting behavior. There was also a significant correlation between children's SE and parents' SE ($\beta = 0.37$, $p < 0.001$). In agreement with Structural Model 1, all of the three control variables, i.e., social economic disadvantage ($\beta = 0.67$, $p < 0.001$), environmental constraints ($\beta = -0.46$, $p < 0.001$), and school setting ($\beta = -0.20$, $p < 0.001$), had statistically significant direct effects on children's SE. The directions of the relationships between the control variables and ACS were the same with those in Structural Model 1.

Other significant relationships included environmental constraints and children's SE ($\beta = -0.17$, $p < 0.001$), and environmental constraints and parents' SE ($\beta = -0.27$, $p < 0.001$).

Figure 4 Structural model 2 for children's self-efficacy vs. parents' self-efficacy (N = 857)



Note: Parameter estimates are standardized regression weights. A regression weight with a positive sign means the expected value of the dependent variable (i.e., child behavior of ACS) is increased when the predictor value increases. Model Fit Statistics: CFI = 0.995; TLI = 0.995; RMSEA = 0.02; WRMR = 0.98. *p $\leq$ 0.05, **p $\leq$ 0.01, ***p $\leq$ 0.005, ****p $\leq$ 0.001, n.s. = not significant.

Discussion

This study is one of the first to simultaneously model the relationships between children's self-efficacy, parents' self-efficacy, social economic disadvantage, environmental constraints, and children's ACS. Our study confirmed the determinant roles of both the children's and parents' SEs in children's active commuting behavior and verified that, compared with children's SE, parents' SE had a greater effect on children's active commuting behavior. The models also revealed multiple personal, social, and environmental factors that can influence both children's SE and children's ACS behavior.

In agreement with previous investigations showing that school age children's perceived self-efficacy is related to their physical activity (O'Loughlin et al., 1999; Van Der Horst, 2007), we found that children's beliefs in their own abilities to overcome various barriers directly predicted their active commuting behavior. Quite often, children's perceptions and attitudes as "key informants" in matters related to their health are ignored, based on the assumption that children are not mature enough to self report their views (Darbyshire et al., 2005; Fusco et al., 2012). Subsequently, the prevailing approach to researching children's experience is grounded in "research on" rather than "research with" children (Darbyshire et al., 2005; Fusco et al., 2012). The positive association that we revealed between children's SE and ACS may reassure health behavior researchers that children had the cognitive abilities to contribute meaningful and insightful research data. We propose, therefore, that more sophisticated child-centered ACS studies be conducted to assess self-reported psychological variables with children. Further, future interventions targeted at promoting ACS also need to include strategies that can increase children's SE.

The findings of our study proposed four potential strategies that can be applied to increase children's SE. First, community-based interventions are encouraged to secure neighborhood safety, which promises to develop children's SE. As reported in our study, when children felt safe walking or biking in their neighborhood, they were more confident in themselves and thereby more likely to be active commuters. We recommend that schools, families, and communities work collaboratively to develop effective monitoring mechanisms to foster a sense of security in children.

Second, children's SE may be promoted by increased exposure to supportive role models and positive peer influence, as substantiated by the positive effect between social modeling and children's SE. Programs should attempt to involve adults, particularly parents, as role models for children through active commuting. An example of such a program is the Walking School Bus program, in which a group of students walking to/from school with adults (Zhu & Lee, 2009). By engaging parents and children in active commuting together, the Walking School Bus program may provide enough social motivation to increase children's desire and SE to actively commute (Heelan et al., 2008).

Despite the potential importance of the Walking School Bus program, it is worth mentioning that social persuasion, measured by school encouragement and Walking School Bus program availability at schools, was not a significant predictor of children's SE in this study. However, the small number of students (15.3%) reporting that their schools had such a program might have limited statistical power to detect any difference that might exist. Further considering that 84.1% of the students mentioned either their schools did not have such a program or they didn't know whether there's such an initiative in their schools, we recommend that schools raise awareness and increase the practice of the program among students.

Third, the positive correlation between children's SE and parents' SE implied that children's SE can be promoted by increasing parents' SE. Limited by the use of secondary data, we didn't investigate the sources of parents' SE. We call for future studies to examine factors that can influence parents' SE to facilitate effective interventions for promoting children's SE and subsequently active commuting behavior.

Fourth, children's SE can be strengthened by reducing physical and social environmental constraints. Previous research has established the effects of the environmental factors included in our study on children's active commuting behavior, but no study has examined the relationship between these factors and children's SE toward ACS (Saelens, Sallis & Frank 2003; Saelens & Handy, 2008). The negative association between environmental constraints and children' SE suggests a need for approaches to improve physical and social environments. For example, land use plans need to be strategized to allow for easy walking or biking in school areas; traffic safety should be improved to reduce the number of crashes; and parents are encouraged to send their children to nearby schools to facilitate active commuting.

In agreement with findings from previous studies, this study showed a positive association between parents' SE and children's ACS (Mendoza, 2010; Mendoza, 2011). And, not surprisingly, compared with children's SE, parents' SE played a more important role in determining children's active commuting behavior. This supported the previous hypothesis that parents are usually the main decision-makers for their children's commuting mode choice to school (D'Haese et al., 2011). Nevertheless, children's SE can have a potential influence on their parents' SE, as established by the significant association between the two SEs. Therefore, we emphasize that children's perceived SE be considered when planning interventions for ACS.

Congruent with previous research, there is a significant association between participants' social economic disadvantage and children's active commuting behavior in this study. Compared with White children and children from a high SES background, non-White children and children from social economic disadvantaged families were more likely to be active commuters (Davison, Werder & Lawson, 2008). Considering that children from social economic disadvantaged families were less likely to feel safe walking or biking in their neighborhoods, as reported in this study, we call for future ACS interventions targeted at improving safety in low SES neighborhoods in order to promote ACS.

Previous studies have reported that children living in urban neighborhoods with supportive infrastructure (e.g., availability of sidewalks and positive land uses) and social norms were more likely to walk or bike to schools (Davison, Werder & Lawson, 2008). However, our data suggested that children from rural schools were more likely to be active commuters. With a small percentage of children from rural schools (13.9%), we failed to conduct a multiple group comparison; future studies with larger sample sizes are needed to detect the underlying reasons preventing rural children from walking or biking to school.

Limitations and strengths

The findings of this study should be interpreted in light of the following limitations. First, this is a secondary analysis of data from a larger study, thus we had no control of variables. For example, we had several latent constructs assessed with only two items, which might not have enough power to capture the multidimensional nature of the construct. The validity of the constructs could be improved by measuring a more comprehensive list of variables. Second, all the variables that we used to measure SE were ordinal. This was inconsistent with Bandura's (2006) guidelines that measurement should capture the strength of SE, which is usually measured on a scale ranging from 0% to 100%. However, refinement of a psychometric survey is typical in social and behavioral sciences, and a set of ordinally scaled items is often used to assess a psychological construct (Flora & Curran, 2004). Third, we didn't compare the relationships between different types of SE (i.e., scheduling SE, barriers SE and support-seeking SE), and children's ACS, as it's not part of our research questions. Future studies are needed to investigate and compare the relationships among different types of SE and their influences on children's ACS.

Nevertheless, this study has several major strengths. First, it was built upon well-established social cognitive framework and self-efficacy theory, which guided the data analysis and interpretation. Second, we used SEM for data analysis, which allows for simultaneous assessment of relationships among different factors and provides flexibility in testing theory-driven models. Third, we included both children and parents as participants, which allowed for direct comparisons.

Conclusions

Findings of this study confirmed the predictive ability of children's SE on their active commuting behavior and suggested potential interventions that may be effective in promoting children's SE. While we supported the role of parents as the key decision-makers regarding ACS, this study demonstrated that children can also contribute valuable research data and their beliefs in their own capabilities should be considered when planning ACS programs. The work reported here provides support for the continuing exploration of the role of SE in children's ACS.

CHAPTER IV

ACTIVE COMMUTING TO SCHOOL: A TEST OF A MODIFIED INTEGRATIVE MODEL OF BEHAVIOR PREDICTION

Introduction

According to the Nation Poll on Children's Health (2012), obesity is now the top health concern of parents for kids in the U.S., followed by smoking and drug abuse. Active commuting to school (ACS), e.g., walking or biking to/from school, can promote children's physical activity, which may contribute to preventing and reducing childhood obesity (Lee, Orenstein & Richardson, 2008; Mendoza et al., 2011). However, the percentage of children who walk or bike to school has declined dramatically in the U.S., from 47.7% in 1969 to 12.7% in 2009 (McDonald et al., 2011). Given the health benefits of ACS, it is imperative to identify factors that can influence children's ACS and develop effective interventions to promote it.

Over the past decades, researchers in different disciplines, e.g., public health, urban planning, and transportation, have identified multiple personal, environmental, and social determinants of ACS (Saelens, Sallis, & Frank, 2003; Sirard & Slater, 2008). Based on these empirical findings, various interventions have been developed and conducted. However, most of the interventions have proved insufficient in changing children's commuting behavior to school (Chillón, 2011). A detailed evaluation of the literature revealed three notable limitations of previous studies examining perceived predictors of ACS, i.e., lack of theoretical basis, short of investigations of psychological factors, and limited use of advanced analytic techniques, which might account for the ineffectiveness of most subsequent interventions (Chapter 2).

First, many studies lack theoretical grounding or used theories superficially. As reported in Chapter 2 of this dissertation, more than half of the 39 studies on perceived barriers of ACS that we reviewed didn't use a theoretical framework to direct inquiry. Theories of behavior prediction provide a framework for indentifying determinants of a particular health behavior, which represents a critical first step in the development of successful interventions (Fishbein & Cappella, 2006). Without a comprehensive and accurate assessment of the determinants of a health behavior, development of effective interventions to promote the behavior is not likely.

Second, few investigations have examined predictors of children's ACS at the intrapersonal level, especially psychological factors. Examination of psychological factors within the ACS context is critical because most interventions that placed emphasis on environmental improvements have proved insufficient in promoting children's ACS (Chillón, 2011), and research has established the predictive power of multiple psychological factors on promoting children's physical activity (Sallis et al., 2000; Van Der Horst, 2007). For example, two meta-analyses has confirmed intention, an indicator of an individual's willingness and readiness to perform a behavior, as the most immediate predictor of physical activity, and self-efficacy, i.e., an individual's self-belief in their ability to perform specific tasks, as one of the most important predictors of intention (Ajzen, 1991; Bandura, 1997; Hagger, Chatzisarantis, & Biddle, 2002; Downs & Hausenblas, 2005). However, the influence of these two psychological factors on children's active school travel has rarely been investigated (Van Der Horst, 2007; Mendoza et al., 2010; Mendoza et al, 2011).

Third, although previous studies acknowledged that predictors of ACS are complex and multifaceted, few studies adopted advanced analytic techniques, e.g., structural equation modeling (SEM), to model multiple variables and diverse pathways among them (Chapter 2). Instead, most studies used multiple or logistic regression analyses, in which mediator and outcome effects cannot be tested simultaneously (Kline, 2011). As a multivariate analysis tool, SEM goes beyond ordinary regression models and provides an approach to examine the complex relationships among multiple observed and latent variables simultaneously (Kline, 2011). More importantly, SEM allows for testing of theoretical models, which is particularly applicable for social and behavioral studies (Buhi, Goodson & Neilands, 2007).

In this study, we aimed to address the three limitations of previous ACS studies. Specifically, we used the SEM technique to test a modified integrative model of behavior prediction (IM) for explaining parents' intentions toward ACS and children's subsequent commuting behavior to school.

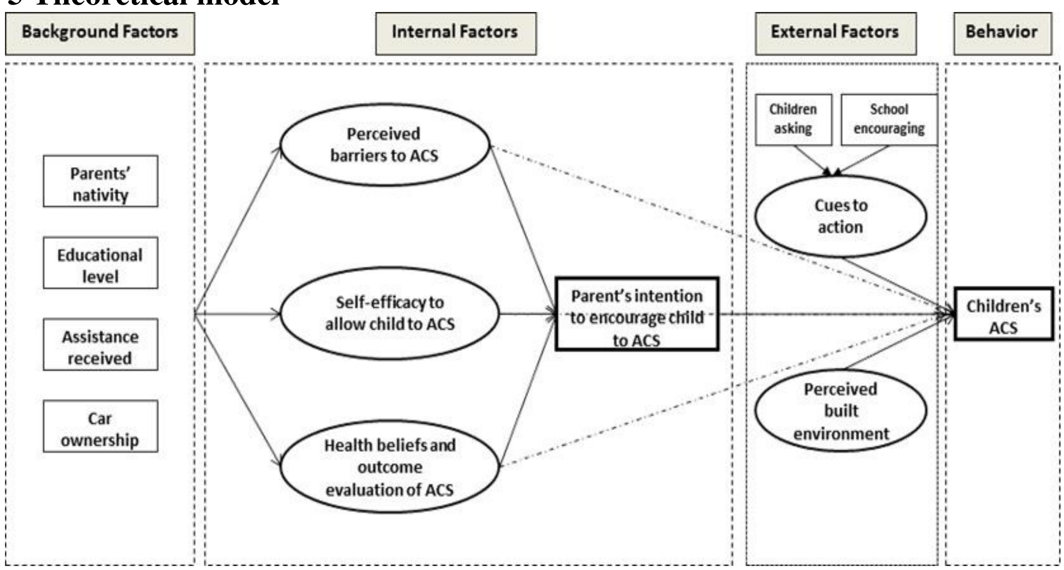
Theoretical framework

The IM was developed following a theorists' workshop sponsored by the National Institute of Mental Health in 1991 (Fishbein, 2000; Fishbein et al., 2001). At the workshop, five leading behavioral theorists were asked to identify a set of factors that serve as key determinants of any behavior and behavioral change (Buhi & Goodson, 2007). They concluded that eight factors "appear to account for most of the variance in any given deliberate behavior" (Fishbein et al., 2001). After the workshop, Fishbein (2000) conceptualized the framework and termed it an integrative model. Based primarily on the Theory of Reasoned Action and the Theory of Planned Behavior (Fishbein 1967; Fishbein & Ajzen, 1975; Ajzen, 1991), as well as on Bandura's Social Cognitive Theory (1997) and the Health Beliefs Model (Becker, 1974), the IM is assumed to be applicable to the understanding of any given behavior in different populations (Fishbein, 2000; Fishbein et al., 2001).

According to the IM, a given behavior is most likely to occur if one has a strong *intention* to perform the behavior, if a person has the necessary *skills* necessary to perform the behavior, and if there are no *environmental constraints* preventing behavioral performance; If strong intentions to perform the behavior have not been formed, there are three primary determinants of intention: the *attitudes* toward performing the behavior, *perceived norms* concerning performing the behavior, and one's *self-efficacy* with respect to performing the behavior; in turn, attitudes, perceived norms, and self-efficacy are all functions of underlying beliefs and valuations about the outcomes of performing the behavior (Fishbein et al., 2001).

For this study, we proposed a modified IM as applied to children's commuting behavior to school (Figure 5). The model is based on the premise that parents are the main decision-makers for children's commuting mode to school (D'Haese et al, 2011; Chapter 3). One major assumption underlying this model is that parents' intention, i.e., their willingness or desire to encourage children to walk or bike to school, is the proximal determinant of children's ACS. Parents' intention, in turn, can be influenced by three intrapersonal psychological factors, i.e., perceived barriers, self-efficacy, and health beliefs/outcome evaluation of ACS, with self-efficacy as the most significant determinant. Besides intention, background factors such as parents' sociodemographics and external factors, including cues to action and parents' perceptions of the built environment, can also directly influence their decisions to allow children to walk or bike to school.

Figure 5 Theoretical model



As shown in Figure 5, multiple constructs in the original MI were modified. For example, subjective norm, indicating an individual's perceived pressure from important social referents to perform an action, was removed because of its general weak predictive power on intention (Armitage & Conner, 2001; Gao & Kosma, 2008). Skills were changed for cues to action because 1) it didn't make sense to use "parents' skills" to predict "children's ACS," 2) the external factors were not well defined in the original

IM, and 3) cues to action, which refers to the stimulus needed to trigger the decision-making process to perform a recommended health behavior, is closely related to likelihood of taking action (Becker, 1974; Fishbein et al., 2001). Perceived barriers, which indicates an individual's estimated level of challenges related to performing a behavior, was further added to the model because of its key predictive role in people's intention and health behavior (Godin et al, 1994). Finally, parents' health beliefs and outcome evaluation of ACS, i.e., parents' judgment of the health benefits and assessment of the impact of ACS, were modified from the construct of attitude in the original IM.

The purpose of this study was to 1) test the adequacy of the modified IM in explaining parents' intention toward ACS and children's subsequent ACS, and 2) identify factors contributing to parents' intention and children's ACS. Specifically, the following four hypotheses were tested:

Hypothesis 1: Parents' sociodemographic characteristics, intention toward ACS, cues to action, and perceived built environment all contribute to their children's ACS, with intention as the most powerful predictor;

Hypothesis 2: Parents' perceived barriers, self-efficacy, and beliefs regarding ACS influence their intention toward ACS, with self-efficacy as the most significant determinant;

Hypothesis 3: Parents' intentions mediate the effects of their perceived barriers, self-efficacy, and health beliefs/outcome evaluation on children's ACS; and

Hypothesis 4: The modified IM is robust when tested against a sub-set of the sample data.

Methods

Study design, participants, and procedures

The current study is part of the Texas Childhood Obesity Prevention Policy Evaluation (T-COPPE) project, a five-year project aimed to evaluate the implementation of two key childhood obesity prevention policies in Texas: 1) the Safe Routes to School (SRTS) program administered through Texas Department of Transportation and 2) federal food allocation package administered through Texas Women, Infants and Children (WIC) Nutrition Program. For evaluation of SRTS program, researchers used a quasi-experimental design and recruited Fourth-grade students and their parents across Texas. Baseline data were collected in 2009, and the post-test data were collected in the 2011-2012 school year.

Only parent surveys were investigated in this study. Parent surveys were adapted using available items from the SRTS parent surveys and other validated measures and included measures of sociodemographics, children's usual mode of transport to/from school, perceived self-efficacy and barriers to ACS, etc. Both English and Spanish versions of the questionnaires were available. Objective measures, e.g., distance from child's home to school and land use, were captured using Geographic Information System (GIS).

For this study, we utilized the data from the pre-test survey, in which 3315 students and 2055 parents participated. Parents who provided geocodable home addresses were selected first. To control the effect of long distance as a major barrier to

ACS, data of participants who lived beyond two miles from school were further excluded. The final analysis included 857 parents of students from 74 schools who lived within two miles of school and didn't have any disability for walking in urban, suburban, and rural areas. The institutional review boards of The University of Texas and Texas A&M University approved the study.

Measures

Perceived barriers. The construct was measured by 15 indicators of problems that might affect parents' decision to allow or not allow their 4^{th} grade children to walk or bike to or from school. Items included distance, convenience of driving, time, children's before or after-school activities, speed of traffic, amount of traffic, adults or other children to walk or bike with, sidewalks or pathways, safety at intersections and crossings, crossing guards, violence or crime, weather, dangerous animals, cost of driving, and children's disability. Response options included "not a problem", "sometimes a problem", and "always a problem." A reliability test for these items resulted in a Cronbach's α of 0.83, indicating good internal consistency.

Self-efficacy. This construct contained 15 items asking participants to indicate how sure they were to allow their children to walk to or from school under different conditions. Eight items asked parents whether they would allow their children to use ACS in face of barriers, including living far from school, a lot of traffic, hot weather, cold weather, raining, other children not walking, parents unable to walk with children, and parents having worries or problems. One item was about competing option, asking whether parents would allow children to walk even if they could drive children to and from school. Three items queried parents whether they could schedule regular active commuting for children, including at least once a week, two to four days of the week, and every day of the week. The other three items assessed support-seeking SE, asking parents if they could allow children to walk with them, with children's friends or classmates, or alone. Responses included "not sure", "a little sure", and "very sure." The scale had a good Cronbach's α of 0.94.

Health beliefs and outcome evaluation. Parents were asked whether they believed that their children would 1) be healthier, 2) get more physical activity, 3) not become overweight, 4) cross the street safely, 5) be ready to learn in school, 6) be on time for school and that 7) parents themselves would have more time for other things, if children walked to and from school. Reponses were "not sure", "a little sure", and "very sure." A Cronbach's α of 0.86 demonstrated good internal consistency of the seven items.

Cues to action. This construct was loaded on two items ($\rho = 0.22$, $p < 0.001$), asking parents 1) whether their children had asked them for permission to walk or bike to or from school in the last year, and 2) in general, how much their children's schools encouraged or discouraged walking or biking to or from school. Responses for the first item were "no" and "yes", and the second item was assessed on a 5-point scale ranging from "strongly discourage" to "strongly encourage." A response option of "I am unsure or don't know" was also included and treated as missing data in the analysis. The Spearman's ρ was reported here rather than Crobach's α, which was deemed inappropriate and meaningless for two-item scales (Verhoef, 2003; O'Brien, Buikstra & Hegney, 2008).

Perceived built environment. Represented by 10 items (Cronbach's α = 0.87), this construct evaluated parents perceptions regarding the built environment or facilities related to ACS in their home neighborhoods and near their children's schools. Three items measuring perceived neighborhood environment asked parents whether there were sidewalks on most of the streets in their neighborhood, whether the sidewalks were well maintained, and whether there were safe road crossings. The other seven items evaluated parents' perceived school environment, e.g., "are there sidewalks on the streets near your 4th grade child's school", "are the sidewalks well maintained", "are there trees along the streets", and "are there bike lanes/paths or trails". Responses included "no", "yes, a few", and "yes, many."

Intention. This construct was represented by one item scaled 1 to 5 that asked how often parents encouraged their children to walk or bike to school. Responses ranged from "never" to "all of the time."

Sociodemographic characteristics. Participants' sociodemographics included their nativity, education level, and number of assistances that a family received, e.g., WIC, Food Stamp, and car ownership. School settings, i.e., whether a student's school was located in urban, suburban, or rural areas, were also examined.

Distance. Although we had excluded participants who lived beyond two miles from school, distance can still be a confounder. To further control the effect of distance, we included it as a control variable in our analysis. Distance refers to the shortest network distance from each child's home to school obtained by ArcGIS. Geocodable home addresses were obtained from all the participants in the current study.

ACS. Parents were asked how their 4th grade children arrive at school and leave school on most days of a week, and responses included walk, bike, school bus, family vehicle, carpool, transit, and others. The outcome variable was dichotomized as ACS or not, i.e., whether or not a child walked or biked to or from school on most days of a week.

Statistical analysis

To make sure the study variables were appropriate for data analysis, we examined all variables by frequency or distribution, and transformed as necessary. Structural equation modeling (SEM) was adopted to test the hypothesized pathways using M*plus* 7.0 (Muthén & Muthén, 2012). The analytic software M*plus* was selected for SEM modeling, because it handles missing data appropriately and provides estimates for analyzing binary/dichotomous outcome variables, e.g., ACS or not in this study (Muthén & Muthén, 2012). M*plus* also has the flexibility to estimate binary, ordinal, and continuous measures simultaneously in a model. When binary or ordinal variables are present, as in the current study and most health behavioral studies, M*plus* will set up optimal thresholds to ensure a latent factor can have a normal distribution and utilize varying weighted contributions from the variables (Wang & Wang, 2012).

We followed a two-step method for the SEM modeling (Kline, 2011). In the first step, measurement models were built and evaluated with confirmatory factor analysis (CFA) to confirm the factor structure of the latent variables. The mean and variance-adjusted WLS (WLSMV), a more generalized weighted least square based robust estimator, was used for testing measurement models, because it can be applied to a combination of binary, ordered categorical and continuous indicators (Muthén & Muthén, 2012; Wang & Wang, 2012). Standardized item-to-factor loadings were examined and variables with poor factor loadings (below 3.0) and non-significant relationships ($p > 0.05$) with individual latent factor were removed (Hair et al, 1998).

In the second step, SEM modeling was performed to test the hypothesized pathways among the observed and latent variables. WLSMV was used as the recommended and default estimator in M*plus* for modeling binary outcomes, e.g., ACS or not. Model fit was evaluated mainly based on the following fit indices: the Bentler comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA) and its 90% confidence interval, and the weighted root mean square residual (WRMR) (Muthén & Muthén, 2012; Yu, 2002). There are no universally agreed-upon cutoff values for these goodness-of-fit indices (Hu & Bentler, 1999; Yu, 2012). For this study, we considered a model adequately fit to the data when three of the following cutoff values were achieved: CFI ≥ 0.95, TLI ≥ 0.95, RMSEA ≤ 0.05, and WRMR ≈ 1.0 (Hu & Bentler, 1999; Yu, 2012). When robust estimators, such as WLSMV, are used for model estimation, the chi-square discrepancy function cannot be directly used for model comparison (Wang & Wang, 2012). It is worth mentioning that WRMR is a relatively new and experimental fit index, the cutoff criteria of which has not been extensively investigated and established in SEM (HSU, 2009). There appears only one unpublished dissertation evaluating the effectiveness of WRMR (Yu, 2002).

To improve model fit, we refined the models based on modification indices. Item-to-factor loadings, factor correlations, and path coefficients were inspected for sign and/or for magnitude. To avoid confirmation bias and test the robustness of the SEM model (Kline, 2011), we used the urban set of sample data (i.e., data of participants whose children's schools were located in urban areas) (n = 414) to validate the modified integrative model that we obtained.

By default, data containing missing values are listwise deleted when modeling binary outcome using WLSMV estimator in M*plus* (Muthén & Muthén, 2012). No missing value is present for the variable of school settings and objective data obtained by GIS, i.e., the network distance.

Results

Sample characteristics and descriptive statistics

Table 12 presents the sociodemographic characteristics of the participants. Among the 857 participants, 65.0% were born in the U.S., and 27.4% were not. Regarding educational attainment, only 24.7% of participants had an educational level above high school. Around 4% of the families did not have any vehicles, while 92.5% had at least one vehicle. The mean number of types of assistance a family received (e.g., WIC, Medicare, Food Stamps) was 1.67 (SD = 1.49). Nearly half of the students (48.3%) were from urban schools, 37.8% were from suburban schools, and 13.9% were from rural schools. Regarding modes of commuting to school, 18.1% were active commuters (e.g., walker or biker) and 78.8% were non-active commuters (e.g., car or bus riders).

Table 12. Sample characteristics (N = 857)

Characteristics	% or mean (SD)
Nativity	
Born in the U.S.	65.0
Not born in the U.S.	27.4
Education level	
High school or below	58.0
Above high school	24.7
Car ownership	
No vehicle	3.9
At least one vehicle	92.5
Number of assistance a family received	1.67 (1.49)
School settings	
Urban	48.3
Suburban	37.8
Rural	13.9
Modes of commuting to school	
Active (i.e., walk or bike)	18.1
Non-active	78.8

Table 13 lists all the latent constructs and observed variables tested in the final SEM model. As indicated by the coding schemes and descriptive statistics (Table 2), most of the study variables were categorical or ordinal.

Table 13. Coding scheme and descriptive statistics for latent and observed variables (N = 857)

Latent Factors and Observed Variables	Coding Schemes and Descriptives
Perceived barriers (11 items)	
Which problems have affected your decision to allow or not allow your child to walk or bike to or from school:	*0: Not a problem, 1: Sometimes, 2: Always*
Distance (how far it is to walk or bike)	0: 45.2%, 1: 17.0%, 2: 35.2%
Time (amount of time it takes to get to or from school)	0: 72.6%, 1: 14.1%, 2: 8.8%
Speed of traffic along route	0: 36.8%, 1: 34.3%, 2: 26.1%
Amount of traffic along route	0: 33.4%, 1: 34.7%, 2: 28.2%
Adults or other children to walk or bike with	0: 52.5%, 1: 21.5%, 2: 20.5%
Sidewalks or pathways	0: 47.8%, 1: 23.1%, 2: 24.5%
Safety at intersections and crossings	0: 39.0%, 1: 34.1%, 2: 23.3%
Crossing guards	0: 56.1%, 1: 23.1%, 2: 16.1%
Violence or crime (e.g., bullying, gangs)	0: 61.3%, 1: 25.6%, 2: 9.2%
Weather or climate	0: 35.4%, 1: 56.8%, 2: 4.6%
Stray or dangerous animals	0: 53.9%, 1: 35.2%, 2: 8.1%
Self-efficacy (14 items)	
I am sure that I can allow my child to walk to or from school:	*0: Not sure, 1: A little sure, 2: Very sure*
Even if we live far from school	0: 87.7%, 1: 4.9%, 2: 2.9%
Even if there is a lot of traffic	0: 86.1%, 1: 6.3%, 2: 2.8%
Even if it is hot outside	0: 63.5%, 1: 20.7%, 2: 11.1%
Even if it is cold outside	0: 72.0%, 1: 16.9%, 2: 6.1%
Even if it is raining outside	0: 83.8%, 1: 6.7%, 2: 3.5%
Even if other children do not walk to school	0: 75.1%, 1: 12.6%, 2: 6.9%
Even if I cannot walk with my child	0: 67.8%, 1: 14.9%, 2: 11.6%
Even if I have worries or problems	0: 76.9%, 1: 11.2%, 2: 6.1%
Even if I can drive my child to and from school	0: 58.1%, 1: 16.6%, 2: 19.4%
At least once every week	0: 59.7%, 1: 16.5%, 2: 18.1%
At least 2-4 days of the week	0: 64.6%, 1: 13.8%, 2: 15.5%
Every day of the week	0: 70.1), 1: 10.5%, 2: 13.7%
With me	0: 27.5%, 1: 17.2%, 2: 50.6%
With my child's friends or classmates	0: 55.8%, 1: 20.4%, 2: 18.6%
Alone, without other children or adults	0: 78.4%, 1: 8.1%, 2: 7.9%
Beliefs and outcome evaluation (7 items)	
If my 4th grade child walks to or from school:	*0: Not sure, 1: A little sure, 2: Very sure*
My child will be healthier	0: 22.4%, 1: 27.3%, 2: 45.0%
My child will get more physical activity	0: 16.6%, 1: 25.6%, 2: 53.1%
My child will not become overweight	0: 28.5%, 1: 28.8%, 2: 37.2%
My child will cross the street safely	0: 42.7%, 1: 24.2%, 2: 27.8%
My child will be ready to learn in school	0: 33.1%, 1: 25.0%, 2: 35.9%
My child will be on-time for school	0: 43.3%, 1: 21.0%, 2: 30.1%
I will have more time for other things	0: 56.8%, 1: 19.6%, 2: 17.3%
Cues to action (2 items)	
Has your 4th grade child asked you for permission to walk or bike to or from school in the last year?	0: No (45.0%), 1: Yes (52.4%)

Table 13. Continued

In general, how much does your 4th grade child's school encourage or discourage walking or biking to or from school?	5-point Likert scale: Strongly discourage to strongly encourage. Mean:0.90, SD: 1.29
Perceived built environment (10 items)	*0: No, 1: Yes, a few, 2: Yes, many*
Are there sidewalks on most of the streets in your neighborhood?	0: 33.1%, 1: 26.8%, 2: 39.2%
Are the sidewalks in your neighborhood well maintained?	0: 27.1%, 1: 28.2%, 2: 29.1%
Are there safe road crossings (in your neighborhood)?	0: 30.6%, 1: 40.7%, 2: 22.1%
Are there sidewalks on the streets near your child's school?	0: 21.5%, 1: 39.1%, 2: 37.5%
Are the sidewalks near your child's school well maintained?	0: 15.9%, 1: 37.8%, 2: 34.8%
Are there trees along most of the streets near your child's school?	0: 18.0%, 1: 49.2%, 2: 28.8%
Are there bike lanes/paths or trails near your child's school?	0: 64.6%, 1: 22.4%, 2: 8.1%
Are the bike lanes/paths or trails near your child's school well maintained?	0: 35.5%, 1: 21.2%, 2: 11.2%
Are there bike racks at or near your child's school?	0: 31.9%, 1: 48.9%, 2: 11.3%
Are there safe road crossings (near your child's school)?	0: 19.4%, 1: 56.2%, 2: 21.1%
Intention (1 item)	
How often did you encourage your 4th grade child to walk or bike to school?	5-point Likert scale: "Never" to "all of the time." Mean:3.22, SD: 0.91
Socio-economic status (3 items)	
Educational level (High school or below vs. above high school)	0: Below (58.0%), 1: Above (24.7%)
Assistance (Receiving assistance or not)	0: No (27.4%), 1: Yes (71.5%)
Nativity (Not born in the U.S. or born in the U.S.)	0: No (27.4%), 1: Yes (65.0%)
Distance	Mean: 0.80 miles, SD: 0.48
ACS	0: Non-active (78.8%), 1: Active (18.1%)

Assessment of the measurement and structural models

As stated, measurement models were evaluated with confirmatory factor analytic approach. Items with standardized factor loadings below 3.0 and non-significant relationships ($p > 0.05$) with individual latent factor were removed from further analysis. Examples of deleted variables included "cost of driving" and "my child has a disability or health condition," two of the variables used to assess the latent construct *perceived barriers*. One latent construct, socio-economic status (SES), was created and measured using three sociodemographic variables, i.e., participants' educational level, receiving any assistance or not, and being born in the U.S.. Recoding and transformation of the three variables were performed to improve model fit. Table 14 displays the standardized item-to-factor correlations for the hypothesized measurement models, with weak relationships removed.

Table 14 Confirmatory factor analysis standardized factor loadings for the hypothesized measurement models (N = 857)

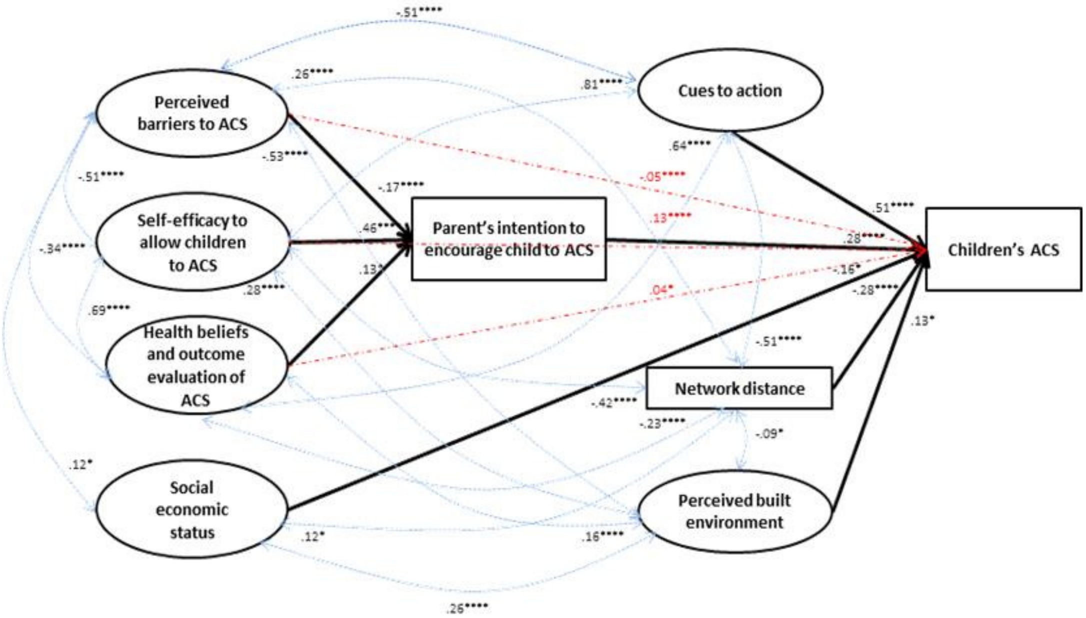
Latent factor	Factor loading	P value
Perceived barriers (11 items)		
Which problems have affected your decision to allow or not allow your child to walk or bike to or from school:		
Distance (how far it is to walk or bike)	0.83 (0.04)	0.00
Time (amount of time it takes to get to or from school)	0.54 (0.05)	0.00
Speed of traffic along route	0.51 (0.04)	0.00
Amount of traffic along route	0.54 (0.04)	0.00
Adults or other children to walk or bike with	0.67 (0.03)	0.00
Sidewalks or pathways	0.80 (0.03)	0.00
Safety at intersections and crossings	0.77 (0.03)	0.00
Crossing guards	0.70 (0.04)	0.00
Violence or crime (e.g., bullying, gangs)	0.45 (0.04)	0.00
Weather or climate	0.34 (0.05)	0.00
Stray or dangerous animals	0.52 (0.04)	0.00
Self-efficacy (14 items)		
I am sure that I can allow my child to walk to or from school:		0.00
Even if we live far from school	0.71 (0.04)	0.00
Even if there is a lot of traffic	0.79 (0.03)	0.00
Even if it is hot outside	0.84 (0.02)	0.00
Even if it is cold outside	0.80 (0.02)	0.00
Even if it is raining outside	0.81 (0.03)	0.00
Even if other children do not walk to school	0.90 (0.02)	0.00
Even if I cannot walk with my child	0.93 (0.01)	0.00
Even if I have worries or problems	0.85 (0.02)	0.00
Even if I can drive my child to and from school	0.81 (0.02)	0.00
At least once every week	0.93 (0.05)	0.00
At least 2-4 days of the week	0.94 (0.01)	0.00
Every day of the week	0.94 (0.01)	0.00
With me	0.59 (0.04)	0.00
With my child's friends or classmates	0.89 (0.01)	0.00
Alone, without other children or adults	0.90 (0.02)	0.00
Beliefs and outcome evaluation (7 items)		
If my 4th grade child walks to or from school:		
My child will be healthier	0.71 (0.03)	0.00
My child will get more physical activity	0.67 (0.04)	0.00
My child will not become overweight	0.49 (0.04)	0.00
My child will cross the street safely	0.82 (0.03)	0.00
My child will be ready to learn in school	0.83 (0.03)	0.00
My child will be on-time for school	0.92 (0.02)	0.00
I will have more time for other things	0.74 (0.03)	0.00
Perceived built environment (10 items)		
Are there sidewalks on most of the streets in your neighborhood?	0.65 (0.04)	0.00
Are the sidewalks in your neighborhood well maintained (paved, even, and not a lot of cracks)?	0.64 (0.04)	0.00
Are there safe road crossings (in your neighborhood)?	0.62 (0.04)	0.00

Table 14. Continued

Are there sidewalks on the streets near your child's school?	0.87 (0.02)	0.00
Are the sidewalks near your child's school well maintained (paved, even, and not a lot of cracks)?	0.85 (0.02)	0.00
Are there trees along most of the streets near your child's school?	0.41 (0.04)	0.00
Are there bike lanes/paths or trails near your child's school?	0.63 (0.04)	0.00
Are the bike lanes/paths or trails near your child's school well maintained (paved, even, and not a lot of cracks)?	0.69 (0.04)	0.00
Are there bike racks at or near your child's school?	0.43 (0.05)	0.00
Are there safe road crossings (near your child's school)?	0.66 (0.03)	0.00
Socio-economic status (3 items)		
Educational level (Below high school or above high school)	0.50 (0.08)	0.00
Assistance (Receiving assistance or not)	0.99 (0.1)	0.00
Nativity (Not born in America or born in America)	0.39 (0.07)	0.00
Cues to action (2 items)		
Has your 4th grade child asked you for permission to walk or bike to or from school in the last year?	0.49 (0.05)	0.00
In general, how much does your 4th grade child's school encourage or discourage walking or biking to or from school?	0.66 (0.05)	0.00

Following an iterative process of specifying, evaluating, and re-specifying, we identified a final SEM model which proved good fit to the data (CFI = .97, TLI = .97, RMSEA = .04, WRMR = 1.61). Figure 6 presents the final model with all the direct, indirect effects, and correlations among the exogenous and endogenous variables. Although the value for WRMR was a bit far from 1 (Yu, 2002), we chose to ignore it considering that the cutoff criteria of WRMR has not been extensively investigated in SEM, and all the other three well-established fit indices indicated good model fit (Hsu, 2009). Overall, the model explained 43.3% of the variance in intention and 83.6% of the variance in the final outcome variable ACS, which are considered to be large effect sizes in the social science research (Cohen, 1992).

Figure 6 Testing the modified IM for children's active commuting to school: data for children living within two miles from school (N = 857)



Note: Coefficients associated with straight lines and single-headed arrows are standardized regression weights that indicate the direct effect of one variable on another; those with red dash dotted lines and single-headed arrows are standardized regression weights that indicate the indirect effect of one variable on another; and those associated with dotted lines and double-headed open arrows represent correlations between variables.

A regression weight with a positive sign means the expected value of the dependent variable (i.e., intention to encourage Child ACS; or probability of child's behavior of walking or biking to school) is increased when the predictor value increases. Insignificant relationships were not included.

Model Fit Statistics: CFI = 0 .97; TLI = 0.97; RMSEA = 0.04; WRMR = 1.61.

**p* < 0.05, ***p* < 0.01, ****p* < 0.005, *****p* < 0.001

Hypothesis testing

In support of Hypothesis 1, parents' SES (β = - 0.16, p < 0.05), intention toward ACS (β = 0.28, p < 0.001), cues to action (β = 0.51, p < 0.001), and their perceptions regarding the built environment (β = 0.13, p < 0.05) all had statistically significant direct effect on children's ACS. Specifically, compared with those from high SES families, children from low SES families were more likely to be active commuters. When parents had higher intentions toward ACS, they were more likely to allow their children to walk or bike to school. The more cues of action that parents received from children or schools, the more likely they would allow their children to walk or bike to school. Finally, children were more likely to be active commuters for parents who observed better neighborhood and school environments. Contrary to our hypothesis that intention is the most immediate predictor of ACS, cues to action had the highest significant direct effect on children's active commuting behavior, followed by intention, SES, and perceived built environment.

Our results also supported the Hypothesis 2 that parents' perceived barriers ($\beta = -0.17$, $p < 0.001$), self-efficacy ($\beta = 0.46$, $p < 0.001$), and health beliefs/outcome evaluation ($\beta = 0.13$, $p < 0.05$) were significantly and directly related to children's ACS. Specifically, parents' intentions to encourage their children to walk or bike to school increased 1) when they perceived fewer barriers to ACS, 2) when they had confidence in children to walk or bike to school under different situations, and/or 3) if they believed ACS would bring health benefits or other positive outcomes. As we hypothesized self-efficacy had larger direct effect on parents' intention, followed by perceived barriers and health beliefs/outcome evaluation.

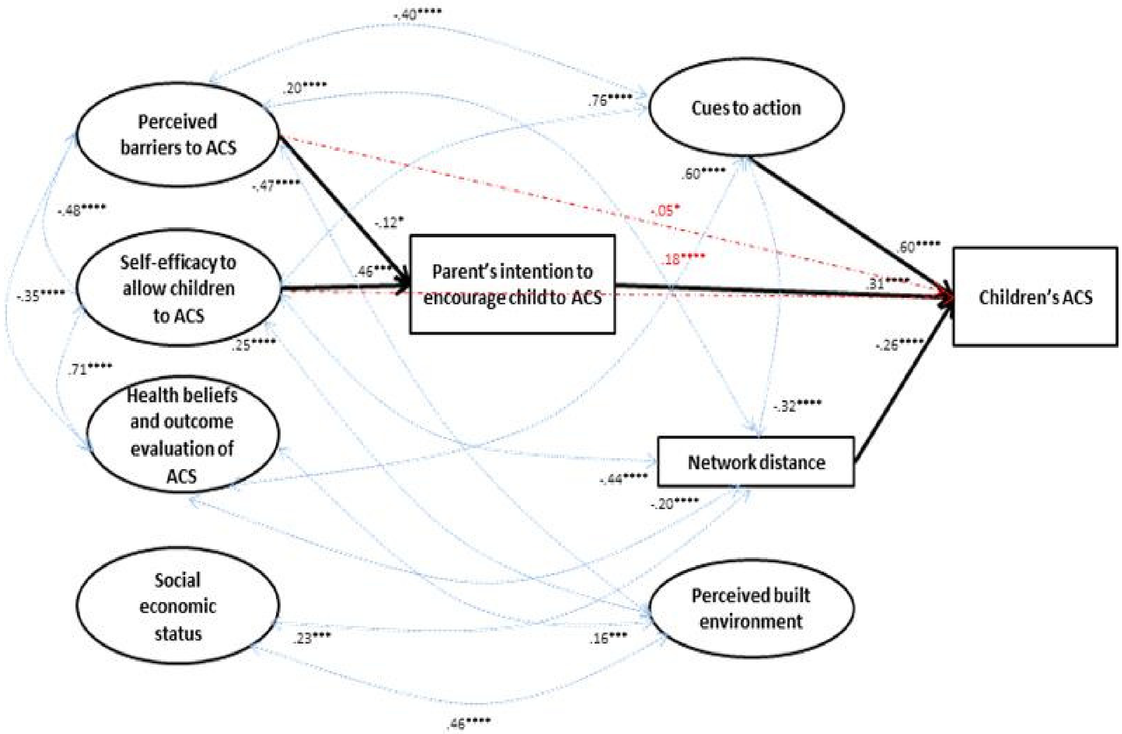
For Hypothesis 3, the mediating role of intention was confirmed by the statistically significant standardized total indirect effects of parents' perceived barriers ($\beta = -.05$, $p < .001$), self-efficacy ($\beta = 0.13$, $p < 0.001$), and health beliefs/outcome evaluation ($\beta = 0.04$, $p < 0.05$) on ACS via intentions. Self-efficacy had the largest direct effect on children's ACS via intentions, followed by perceived barriers, and health beliefs/outcome evaluation.

We used the urban set of sample data to validate it to test the robustness of the final model that we obtained (Hypothesis 4), and similar model fit emerged in the replication: CFI = 0.96, TLI = 0.96, RMSEA = 0.04, WRMR = 1.39. As illustrated in Figure 7, among the urban subsample, children's ACS were directly predicted by parents' intention ($\beta = 0.31$, $p < 0.001$) and cues to action ($\beta = 0.60$, $p < 0.001$), and indirectly by self-efficacy ($\beta = 0.18$, $p < 0.001$) and perceived barriers ($\beta = -0.05$, $p < 0.05$). Different from the full sample, the effects of SES and perceived built environment on ACS were not significant in the urban subsample, as well as the direct and indirect effects of health beliefs/outcome evaluation on intention and ACS.

Other significant effects/relationships

In both the full sample and the urban subsample, distance as a control variable had a direct negative effect on children's ACS ($\beta = -0.28$, $p < 0.001$ and $\beta = -0.26$, $p < 0.001$, respectively). In the full sample model, distance was correlated with all the latent variables, i.e., perceived barriers ($\beta = 0.26$, $p < 0.001$), self-efficacy ($\beta = -0.42$, $p < 0.001$), health beliefs/outcome evaluation ($\beta = -0.23$, $p < 0.001$), SES ($\beta = 0.12$, $p < 0.05$), cues to action ($\beta = -0.51$, $p < 0.001$), and perceived built environment ($\beta = -0.09$, $p < 0.05$) (Figure 6). In the urban subsample, distance was also correlated with all the latent variables, except for the perceived built environment (Figure 7).

Figure 7 Testing the modified IM for children's active commuting to school: Final structural model, data for children living within two miles from school in urban areas (N = 414)



Note: Coefficients associated with straight lines and single-headed arrows are standardized regression weights that indicate the direct effect of one variable on another; those with red dash dotted lines and single-headed arrows are standardized regression weights that indicate the indirect effect of one variable on another; and those associated with dotted lines and double-headed open arrows represent correlations between variables.

A regression weight with a positive sign means the expected value of the dependent variable (i.e., intention to encourage Child ACS; or probability of child's behavior of walking or biking to school) is increased when the predictor value increases. Insignificant relationships were not included.

Model Fit Statistics: CFI = 0.96; TLI = 0.96; RMSEA = 0.04; WRMR = 1.39.

**p* < 0.05, ***p* < 0.01, ****p* < 0.005, *****p* < 0.001

In the full sample model, participants' SES was positively correlated with their perceived barriers regarding children's ACS (β = 0.12, p < 0.05) and their perceived built environment (β = 0.26, p < 0.001) (Figure 6), indicating that parents of higher SES level perceived more barriers regarding children's ACS and reported better built environment than those of lower SES level. In the urban subsample model, however, the relationship between SES and perceived built environment was not significant (Figure 7).

In both the full sample and the urban subsample, cues to action was positively associated with self-efficacy ($\beta = 0.81$, $p < 0.001$ and $\beta = 0.76$, $p < 0.001$) and health beliefs/outcome evaluation ($\beta = 0.64$, $p < 0.001$ and $\beta = 0.60$, $p < 0.001$), and negatively associated with perceived barriers ($\beta = -0.51$, $p < 0.001$ and $\beta = -0.32$, $p < 0.001$). This implied that parents' self-efficacy and beliefs regarding ACS increased and perceived barriers decreased with the more triggers they received from their children or schools.

Further, in both the full sample and the urban subsample, participants' perceived built environment was positively associated with self-efficacy ($\beta = 0.28$, $p < 0.001$) and health beliefs/outcome evaluation ($\beta = 0.16$, $p < 0.001$), and negatively associated with perceived barriers ($\beta = -0.53$, $p < 0.001$). This indicated that parents' self-efficacy and beliefs regarding ACS increased and perceived barriers decreased when they perceived better neighborhood and school environments.

Other statistically significant relationships in both the full sample and the urban subsample included perceived barriers and self-efficacy ($\beta = -0.53$, $p < 0.001$ and $\beta = -0.53$, $p < 0.001$), perceived barriers and health beliefs/outcome evaluation ($\beta = -.34$, $p < 0.001$ and $\beta = -0.35$, $p < 0.001$), and self-efficacy and health beliefs/outcome evaluation ($\beta = 0.69$, $p < 0.001$ and $\beta = 0.71$, $p < 0.001$).

Discussion

This study represents the first test of the IM as applied to children's commuting behavior to school and provides new insights into the psychological determinants of this behavior. We confirmed the efficacy of the modified IM in explaining parents' intention and children's subsequent active commuting behavior and identified factors that can serve as targets for future interventions.

In both the full sample and the urban subsample, parents' intention had direct and mediating effects on children's ACS, which underscores the importance of intention in parents' decision-making regarding children's ACS. Previous studies have consistently reported intention as the most immediate determinant of health behavior. In this study, however, intention was not the strongest predictor of ACS (Armitage & Conner, 2001; Hagger, Chatzisarantis, & Biddle, 2002; Downs & Hausenblas, 2005). Given that this study is the first to examine the role of parents' intention in children's commuting behavior to school, our findings require further confirmation. More studies are needed to test the determinant role that parents' intention may play in children's active school travel.

Parents' self-efficacy was the most powerful determinant of their intention toward children's ACS, as substantiated in the full sample and the urban subsample. Self-efficacy also had the largest indirect effect on children's ACS via intention, compared with perceived barriers and health beliefs/outcome evaluation. As determinants of intention, the relative importance of the psychosocial variables depends upon both the behavior and the population being considered (Fishbein & Cappella, 2006).

In the context of ACS, therefore, parents' intention and children's subsequent ACS were mostly under self-efficacy control (Fishbein & Cappella, 2006). This is an important observation because self-efficacy, as an important social ecological construct, has rarely been investigated in ACS research. To our knowledge, only one study has reported the predictive role of parents' self-efficacy on children's ACS (Mendoza et al., 2010; Mendoza et al., 2011). More studies are needed to further explore the role of self-efficacy in children's ACS, and interventions should be focused toward improving parents' self-efficacy in order to increase parent's intention toward ACS and children's subsequent behavior.

Unexpectedly, cues to action were the most immediate predictor of children's ACS in both the full sample and the urban subsample. Coupled with the significant relationships between cutes to action and perceived barriers, self-efficacy and health beliefs/outcome evaluations, our findings highlights the necessity and importance of initiatives such as the SRTS program in raising parents' awareness of and intentions toward ACS. As mentioned early, this study is part of the T-COPPE project which aimed to evaluate the implementation the SRTS program administered through Texas Department of Transportation. Therefore, a future research question is whether the implementation of the program will increase children's ACS.

Interestingly, parents' SES and perceived built environment were both associated with children's ACS in the full sample; in the urban subsample, however, neither of the relationship was significant. The homogeneity of environmental conditions in urban setting and similarity of SES among urban residents may account for the lack of associations. Limited by the small size of suburban (n = 324) and rural subsample (n = 119), we were not able to do a multiple group comparison. Future studies with larger sample sizes are needed to confirm the significant/non-significant relationships between SES, perceived built environment and ACS in different settings and among diverse populations. It is also worth noting that compared with cues to action, intention, and SES, parents' perceived built environment had the smallest effect on children's ACS in the full sample model. This might provide an explanation to the insufficiencies of most previous interventions that placed emphasis on environmental improvements in promoting children's ACS (Chillón, 2011).

Similarly, in the full sample, parents' health beliefs/outcome evaluations of ACS had a direct effect on parents' intention and an indirect effect on children's ACS, but these effects were not revealed in the urban subsample. We do not know why there was a lack of association between urban parents' beliefs and their intention toward children's ACS, although smaller sample size could lead to a type II error.

In line with previous studies that reported distance as the most consistent physical environmental barrier to children's ACS, there is a reverse relationship between distance and children's ACS in this study (Sirard & Slater, 2008; Saelens, Sallis, & Frank, 2003; Pont et al., 2009). Also, distance was negatively associated with parents' self-efficacy and health beliefs/outcome evaluation, and positively associated with parents' perceived barriers. Despite the importance of distance, few interventions have accounted for distance in their study designs (Chillón et al., 2011). We suggest that future interventions take distance into consideration when designing their studies, e.g., either targeting the intervention toward children living within walking distance to school or tailoring their intervention strategies to meet the needs of children residing at various distances from school.

Limitations and strengths

The findings need to be interpreted in light of the potential limitations of this study. First, we used secondary data in this study, which has major limitations when testing theory (Goodson, 2010). Specifically, we used IM to guide analyses, but the T-COPPE instrument was not designed with IM as a guiding theoretical framework. Second, rural participants were underrepresented in this study, compared with urban and suburban participants. Primarily because of the small subsample sizes, we were not able to do a multiple group comparison and examine setting-specific predictors of the modified IM.

Despite the limitations, this study has several major strengths. First, we recruited participants from 74 schools in urban, suburban, and rural areas. The diverse settings and populations provide support to the external validity of our findings. Second, we used SEM, which allows for simultaneous assessment of relationships among different factors and provides flexibility in testing theory-driven models.

Conclusions

Overall, this study provides support for the application of the IM to children's active school travel behavior. Future research is needed to identify effective intervention strategies for changing the factors identified in this study, particularly parents' intention and self-efficacy, in order to promote children's ACS.

CHAPTER V

CONCLUSIONS

The overall purpose of this dissertation study was to examine the influence of psychological factors on children's ACS using theoretical perspectives. Specifically, the aims were to 1) critically assess the current literature of ACS and evaluate theory utilization and methodological quality of empirical studies on perceived barriers to children's ACS, 2) investigate the roles of children's and parents' self-efficacies in children's ACS based on the Self-efficacy Theory, and 3) test a modified integrative model of behavior prediction for explaining parents' intention toward ACS and children's subsequent commuting behavior to school.

Chapter 2 presents the first study: a systematic review of empirical, methodological, and theoretical evidence in the current literature of ACS, particularly in regard to perceived barriers preventing children from ACS. A detailed appraisal of the 39 quantitative studies examined revealed several empirical, methodological, and theoretical issues and suggested recommendations for advancing the quality of future ACS studies. *Empirically*, increasing the diversity of study regions and samples should be a high priority, particularly in Asian countries and among rural residents. Regarding the relation between individual perceptions and ACS behavior, more prospective and interventions studies conducted at multiple time points are needed to determine the causal mechanism liking the perceived factors and ACS. Moreover, future researchers should also include policy-related barriers into their inquiries. *Methodologically*, the conceptualization of ACS should be standardized or at least well rationalized in future studies to ensure the comparability of results. Favorably, definitions of ACS need to reflect the frequency and magnitude of the behavior more accurately. Second, authors' awareness need to be increased for improving the methodological rigor of studies, especially in regard to appropriate statistical analysis techniques, control variable estimation, multicollinearity testing, and reliability and validity reporting. *Theoretically*, future researchers need to first ground their investigations in theoretical foundations. Further, efforts should be devoted to make sure theories are used thoroughly and correctly. Important theoretical constructs, in particular, also need to be conceptualized and operationalized appropriately to ensure accurate measurement.

The empirical study presented in chapter 3 examines the roles of children's and parents' self-efficacies in children's ACS based on Bandura's social cognitive theory (SCT), in particular the self-efficacy theory. Findings of this study confirmed the predictive ability of children's SE on their active commuting behavior and suggested potential interventions that may be effective in promoting children's SE. While supporting the role of parents as the key decision-makers regarding ACS, this study demonstrated that children can also contribute valuable research data and their beliefs in their own capabilities should be considered when planning ACS programs. The work reported here provides support for the continuing exploration of the role of SE in children's ACS.

Chapter 4 displays the third study: a test of a modified integrative model of behavior prediction for explaining parents' intentions toward ACS and children's subsequent commuting behavior to school. A set of psychological factors that may serve as key determinants of any behaviors and behavioral changes were examined simultaneously in this study, including intention, self-efficacy, perceived barriers, health beliefs, and cues to action. The findings of this study confirmed the efficacy of the modified integrative model in explaining parents' intention and children's subsequent active commuting behavior and identified factors that can serve as targets for future interventions.

It is important to recognize limitations of this dissertation. First, even though I searched numerous databases and references sections in the systematic literature review, it is possible that some articles relevant were overlooked. Second, regarding the second and third studies, there were limitations in instrument and sample size. For example, constrained by using secondary data analysis, I had no control of variables and had to test theories using what was available from the dataset. Also, primarily limited by small sub-sample sizes in rural areas, we were not able to do a multiple group comparison and examine setting-specific predictors of ACS. Future research efforts should address these limitations by designing an instrument with a theory in mind and increasing sample sizes.

Despite the limitations, the strengths of this review need also to be recognized. First, the instruments that I developed for assessing the methodological and theoretical qualities of existing ACS literature in the first study were based on well-established instruments and tailored for ACS studies. The instruments served well to capture existing discrepancies in literature and provided detailed insight for future studies. Second, I grounded studies 2 and on theoretical bases, which provided theoretical guidance to the data analyses and interpretation. Third, I used SEM for data analysis, which allows for simultaneous assessment of relationships among different factors and provides flexibility in testing theory-driven models.

This dissertation, as a whole, builds upon current research and knowledge regarding children's ACS and offers insights for more sophisticated ACS studies in the future. The work reported here provides support for the continuing exploration of the roles of psychological factors in children's ACS using theoretical perspectives.

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