Predictors of Developmental Screenings for Young Children

Janice Chandler Ranne
Old Dominion University

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PREDICTORS OF DEVELOPMENTAL SCREENINGS

FOR YOUNG CHILDREN

by

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Old Dominion University in Partial Fulfillment of the
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ABSTRACT

PREDICTORS OF DEVELOPMENTAL SCREENINGS 
FOR YOUNG CHILDREN 

Janice Chandler Ranne 
Old Dominion University, 2010 
Dissertation Committee Director: Dr. James Alan Neff 
Committee Members: Dr. Qi (Harry) Zhang 
Dr. Martha L. Walker 

This study examines the usefulness of the New Model of Children’s Health and its Influences for the identification of predictors for health service effectiveness. Health service effectiveness is measured by probability estimations of whether young children receive formal or informal developmental screenings. Screenings lead to prevention of communication delays in later childhood. Formal screenings with standardized questions are preferred over informal screenings, which are knowledgeable observations. The theoretical framework is a child-centered socio-ecological theory that is untested for use in health service effectiveness studies until the present one. Four developmental concepts of the theoretical framework, social environment, physical environment, biological history, and child behavioral history, are tested through secondary analysis of longitudinal data.

Multivariate analysis by Cox regression is used to determine whether predictor variables from any of the four conceptual areas of the framework explain young children’s receipt of formal or informal screenings. Cox regression is also used to examine the magnitude of differences on probability estimates generated by the predictor variables for the time of formal or informal screening receipt.
The results show that the social environment predictors, maternal depression, maternal race, and maternal age and the child behavioral predictor, infant fussiness and irritability are significantly related to formal screening receipt and the model as a whole is significant. The social environment predictor, maternal depression, and the biological history predictor, birth weight, are significantly related to informal screenings and were the sole contributors to the informal model significance as a predictor of screenings. For both models, maternal depression consistently is associated with early screening receipt. Multiple correlation squared ($R^2$) strength of association measures between the models and survival were weak.

The implication of these findings is that the New Model of Children’s Health and its Influences is useful in identifying predictors of health service effectiveness and may improve in predictive value under different conditions. Another implication is that when children are very young, maternal depression is a prevalent condition which may create the need for increased health services for children. Alternatively, health policymakers may increase support for new mothers with the aim of decreasing a lengthy need of services for children as they grow and develop.
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To my fellow students who turned into dear friends and who have provided so much support and encouragement over the years, I offer my love and thanks. Thank you so much, Susan Tweed, Ph.D., Yan Zhang, Ph.D., Cynthia Kratzke, Ph.D., Adwoa B-H-Sam, Ph.D., and Jewel Goodman Ph.D. Very special thanks to my patient husband, Wayne.
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CHAPTER I
INTRODUCTION

STATEMENT OF THE PROBLEM

The National Research Council and Institute of Medicine (2004) identified gaps in performance measures of health services for children. “Health service effectiveness” was identified as one of nine areas in which performance measurement needs improvement [National Research Council and Institute of Medicine (NRC & IOM), 2004]. Effectiveness in health services involves achievement of desired outcomes or results through care or service intervention (NRC & IOM, 2004).

PURPOSE OF THE STUDY

The purpose of this research study was to test sections of the theoretical framework, the New Model of Children’s Health and its Influences (NMCHI) for relationships between childhood developmental influences and health service effectiveness, measured by whether young children receive developmental screenings (NRC & IOM, 2004). Selected data sets from the Healthy Steps for Young Children Program National Evaluation (Guyer, Barth, Bishai, Caughy, Clark, Burkom, et al., 2003) were used to measure the relationships between various influences on childhood development and health service effectiveness. For this study, the desired outcome was receipt of developmental screenings. Study of this outcome was important as a vehicle for examination of health service effectiveness for the youngest and most vulnerable members of society.

The NMCHI, a recently developed ecological model for the study of children’s health issues, provided the framework for measurement of health service effectiveness
through heuristic examination of the model concepts. The conceptual framework of the NMCHI defined the childhood influences as social environment, physical environment, biological history, and child behavioral history. For the present study, the children sampled were infants and toddlers, from birth to approximately 1100 days old.

The theoretical framework was tested to determine health service effectiveness as measured by the receipt of the developmental screenings used to assess the presence or absence of developmental delays. Developmental screenings are brief checklists or procedures which may identify children with potential delays in developmental progress (Centers for Disease Control, 2005). Developmental delays are problems in communication and cognitive functioning, such as speech and language impairments, hearing impairment, autism, specific learning disabilities, and mental retardation (Rossetti, 2001). Measurement of childhood receipt of developmental screenings is specifically identified as an area of need by the NRC & IOM (2004).

BACKGROUND

Communication delays are among the most prevalent childhood disabilities in the United States [American Speech-Language Hearing Association (ASHA), 2004]. Delay in communication development may be related to speech and language impairments, hearing impairment, autism, specific learning disabilities, and mental retardation (Rossetti, 2001). Children with disabilities related to speech and language disorders, autism, cerebral palsy, mental retardation and learning disabilities are considered developmentally delayed (Rossetti, 2001; Sices, Feudtner, McLaughlin, Drotar, & Williams, 2004).
According to Rossetti (2001), 5 to 10 percent of children under three years old are affected by some level of delay in the development of communication skills. Tomblin, Smith, & Zhang (1997) reported that 7 percent of the birth-to-three year old group displayed communication delays. The communication skills of infants and toddlers are predictive of later performance in school, and for level of intelligence (Rossetti, 2001).

Approximately 599,678 (5 percent) of preschool children three to five years old were reported to have developmental delays (twice the number of infants and toddlers), with communication impairment as the leading problem (Bailey, Hebbeler, Scarborough, Spiker, & Mallik, 2004; United States Department of Education, 2002). Among school-aged children 6-21 years old, 5,775,722 (11 percent) received special education services in 2000, with 71 percent of that group receiving services for communication delays; (Bailey, Hebbeler, Scarborough, Spiker, & Mallik, 2004; United States Department of Education, 2002). Table 1 describes the progression of children in need of services for communication delays.

Table 1: Prevalence of Children Receiving Special Services in School; Percent with Communication Delays in the United States, 2000.

<table>
<thead>
<tr>
<th>Age</th>
<th>Prevalence of children in receipt of special services</th>
<th>Percent with Communication Delays (from speech and language impairment, hearing impairment, autism, specific learning disabilities)</th>
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<tr>
<td>0-3 years</td>
<td>230,853**</td>
<td>5%-10%*</td>
</tr>
<tr>
<td>3-5 years</td>
<td>599,678**</td>
<td>55.2%**</td>
</tr>
<tr>
<td>6-21 years</td>
<td>5,775,722**</td>
<td>71%**</td>
</tr>
</tbody>
</table>


The rise in receipt of services as age increases suggests that the children were either misdiagnosed or not diagnosed as demonstrating delays at earlier ages (Bailey,
Hebbeler, Scarborough, Spiker, & Mallik, 2004). Special preventive services were provided by community early intervention programs for children in the birth to 3 year old range and by special education services in schools. The failure to diagnose children with communication delays very early in life indicates multiple missteps in health service effectiveness going back to infancy (NRC & IOM, 2004).

Costs of preventive services

Preventive services for children under the special education designation in the United States draw nearly one-fifth of all public spending dollars for education at more than $80 billion annually (Belfield, 2004). The financial demands to support special education students often lead to cuts in a variety of different educational program offerings, such as art, music and physical development, for all school children in various states and cities (Belfield, 2004). The diminished costs related to students in special education placements resulting from early identification and treatment (Belfield, 2004) stresses the importance of examining health service effectiveness through early and frequent receipt of developmental screenings. However, costs to the public as related to ineffectiveness in health service care are beyond the scope of the present study.

In summary, early identification of communication delays will improve young children’s ability to obtain intervention therapy in order to functionally communicate. Early intervention therapy often prevents the emergence of secondary disabilities in behavior, learning, reading, and social development (Downey, Mraz, Knott, Knutson, Holte, & Van Dyke., 2002; Farel, Meyer, Hicken, & Edmonds, 2003). The failure of adequate and timely early identification and subsequent referral of infants and toddlers at-risk for communication delay is the largest obstacle to helping the children gain
functional communication skills through early intervention (Hess, Dohrman, & Huneck, 1997).

**Early intervention**

Children experience a sensitive and critical period of communication development (Bleile, McGowan, & Bernthal, 1997). In this window of development, the brain rapidly develops neural connections for a number of mental operations and needs stimulation to develop (Bleile, McGowan, & Bernthal, 1997; NRC & IOM, 2004; Ruben, 1997). During this sensitive and critical period, mental operations must be enhanced in order for infants and toddlers to acquire the necessary language skills for learning. This is a particularly important time for young children who demonstrate developmental delays (Bleile, McGowan, & Bernthal, 1997; McLeod and Bleile, 2003). The sooner children with potential problems are identified and referred to early intervention programs for full evaluation and treatment, the less likely special education placement in school will be required (Helm & Shishmanian, 1997).

Often children birth to 3 years old are not identified as having developmental delays, particularly in the area of communication, until after major developmental milestones are missed, such as producing single words [American Academy of Pediatrics (AAP), 2001]. The developmental milestones are conceived as building blocks: when one block is missed, the foundation is incomplete to support development of the next milestone. For example, the ability to speak is founded on the early production of sounds which are then formed into spoken words (Owens, 2001). In order to remediate problems in the development of milestones, early intervention services are advisable.
Early intervention is a system of coordinated services that promotes children’s growth and supports families during the critical early years of development (Shonkoff & Meisels, 2000). Enrollment of infants and toddlers and their families into early intervention services improves children’s development and education potential (Guralnick, 1998). Early intervention is responsible for the successful achievement of developmental milestones in a number of children, particularly for those who begin intervention as very young infants (Campbell & Ramey, 1994; Hess, Dohrman, & Huneck, 1997; Ramey & Ramey, 1998). Initiation of intervention within the first year of life improves intellectual development and academic achievement through the seventh grade, the age frame at which Campbell and Ramey (1994) concluded a cohort study. Early intervention also reduces future costs of special education, rehabilitation, and health care needs (Derrington, Shapiro, & Smith, 1999). In addition, early intervention reduces families’ feelings of isolation, stress and frustration, and helps infants and toddlers with developmental delays increase productivity in speech and language development (Guralnick, 1997).

Policy

Assistance to young children in need has a long history in the United States. Public laws addressed primary, secondary and tertiary prevention of problems related to developmental delays. The Children’s Bureau was established in 1912, to address the problems of vulnerable populations, children at-risk for disabilities, and children with established disabilities (Guralnick, 1997).

The Social Security Act, Title V of 1935 (PL-74-271), established systems of care for both children and mothers and delineated responsibilities for each state (Shonkoff &
Meisels, 2000). In 1986, the Education for All Handicapped Children Act Amendments provided children with disabilities and those children at-risk for educational failure a "free and appropriate education in the least restrictive environment," starting from birth (United States Department of Education, 2002). In addition to defining the provisions for all children with disabilities, physical impairments as well as developmental delays, the law was the first policy developed specifically for infants and toddlers at biological or environmental risk (Guralnick, 1997). The law also emphasized the importance of family interaction in the intervention process (Guralnick, 1997).

Part C of the Individuals with Disabilities in Education Act (IDEA) (PL-101-476) of 1990, was legislated to improve service delivery to families and children (Harbin, McWilliam, & Gallagher, 2000). The IDEA law emphasized family-centered service delivery to change the way in which professionals interacted with the families. Thus the law demonstrated recognition that social and physical environments were critical to children's development (Harbin, McWilliam, & Gallagher, 2000). In addition, IDEA was passed to ensure that all children in need will receive appropriate services and, importantly, to improve the timeliness of identification and intervention (Harbin, McWilliam, & Gallagher, 2000). Federal policy makers and the medical community joined with the American Speech-Language Hearing Association (ASHA) to examine prevention of communication delays. ASHA produces a number of position papers and tutorials on the promotion of health to support communication development and to address professional responsibilities in regard to prevention of communication delays and disorders (American Speech-Language Hearing Association, 1988; American Speech-Language Hearing Association, 1991).
Recent research in the early intervention health services field indicates that the earlier intervention or treatment is accessed and utilized, the more likely the risks of communication delay may be averted (NRC & IOM, 2004; Ramey & Ramey, 1998). Health services in the form of early intervention can direct healthy development or modify or reduce problems that result in developmental delays (NRC & IOM, 2004). Infants and toddlers with developmental delays may achieve improvement in measures of communication, cognition, and self-help milestones after a single year of early intervention services (United States Department of Education, 2002). However, before early intervention can occur, the developmental problems must be identified through developmental screenings.

DEVELOPMENTAL SCREENINGS

Developmental screenings are brief measurement procedures that assess receptive and expressive communication, cognition, social skills, adaptive skills and fine motor skills (Cantu, 2004). Screenings identify children who should receive more intensive assessments (Cantu, 2004). Developmental screenings are usually in the form of a questionnaire, either given to parents to fill out or administered by physicians (Glascoe, 2001). Numerous developmental screening tools that are standardized, reliable and show valid results are available for use by physicians (Glascoe & Shapiro, 2005). Appropriate screening tools have statistically proven high levels of sensitivity and specificity (Glascoe, 1995).

High levels of sensitivity and specificity measures in developmental screenings are important for provider confidence in decision-making about whether to recommend children for more intense developmental evaluations. The power of a screening to
correctly identify children with developmental delays compared to those without aids in improving health service effectiveness. Children who are identified through screenings as having developmental delays can be correctly recommended for prompt intervention for amelioration of the problems.

A single, one-time developmental screening test early in life provides only a 'snapshot' of the developmental processes (AAP, 2001). Children progress through the stages of development at different rates and a single screening does not capture changes in development. Consequently, periodic observation using a formal screening test is recommended for all infants and toddlers (birth to 3 years old) (AAP, 2001).

Surveillance, a term used by the American Academy of Pediatrics to describe routine formal and informal monitoring of children’s health, should include the use of formal developmental screening tests (Glascoe & Shapiro, 2005).

Only 20 to 30 percent of children with communication delays are identified before entering school, all infants and toddlers should be screened by physicians at every well-child visit (Berry, Butler, & Burdetti, 2001; Brunk, 2004; Glascoe & Shapiro, 2005).

Approximately 25 percent of pediatricians in the United States utilize standardized screening tools despite American Academy of Pediatrics guidelines for all pediatricians to use such tools (Brunk, 2004). Roughly 71 percent of pediatricians rely on personal clinical judgment to screen for developmental delays (Brunk, 2004).

Identification by developmental screenings

Developmental communication delays are the most common problems in very young children with delayed development (Wetherby, Goldstein, Cleary, Allen, & Kublin, 2003). Consequently, early and timely identification of delays related to
communication problems is critical for children to receive treatment (Wetherby, Goldstein, Cleary, Allen, & Kublin, 2003). Communication delays often occur concomitantly with delays in social and cognitive development (Dunkle & Vismara, 2004).

Potential communication delays are typically identified during administration of developmental screenings (Glascoe, 1995). Developmental screenings administered in infancy offer health care providers the opportunity to identify communication problems before they become entrenched and expensive to society in terms of years in special education classrooms (Dunkle & Vismara, 2004).

The federal government, state governments, and many local governments mandated support for early identification and referral for subsequent intervention (Guralnick, 1998). The United States Department of Education and public health policies specifically support the identification and referral of infants and toddlers exhibiting signs of communication delay to early intervention services for remediation (U.S. Department of Education, 2002).

Communication development

Development of initial milestones for infants derives from the complex interaction of a variety of physiological, social, and biological factors. These essential factors influence developmental progress for communication ability. Neuroscientists report that early experiences and interactions directly affect brain development by influencing the number and growth-direction of nerve synapses in infant brains (Shore, 1997). Synapses are the connections between nerve cells that allow signals to pass through the brain and body via neurotransmitters. Repeated stimulation of synapses allows development and
maintenance of specific neural pathways (Shore, 1997). The majority of synapses created in the brain occur during the first three years of life (Shore, 1997). The direction of neural pathway development affects the way infants gather, process, and store information which will later be used for communication activities (Shore, 1997). Rapid development of neurological connections in the infant brain before birth and in the first few months following birth prepares the infant for sensory input that will be used for communication (Hadders-Algra, 2004).

*Emotional, behavioral and social environment.* In order to develop communication skills, infants depend upon the ability to discriminate inputs from environments through perceptual, or sensory, development (Owens, 2001; Plante, 1999). Infants use perceptual/sensory abilities (i.e. hearing, seeing, touching) to develop pre-communication skills, such as localizing and discriminating sounds, looking at caregivers, imitating facial movements and engaging in reciprocal vocalizations (Owens, 2001).

Infants and toddlers develop states of emotional, behavioral and social regulation through interaction with parents and the environment (Ogletree & Daniels, 1995). Such states of development are closely related to communication development and are equally important for overall child health and development (Crnic, Hoffman, Gaze, & Edelbrock, 2003; Ogletree & Daniels, 1995). Although there are small individual variations in the timing of pre-communication and communication skill acquisition, infants and toddlers progress through a general pattern of predictable communication development to achieve the speech and language milestones that comprise communication (Rossetti, 2001).
Delays in communication development. Infants born with health problems may have difficulty taking in the sensory information needed to develop communication (Crais, 1999; Rossetti, 2001). Sensory input through hearing, vision, touch, taste and smell aids the infant in learning about the world (Owens, 2001). Hearing acuity impairment, often related to otitis media with effusion or other middle and inner ear conditions, is a common health problem in infants and toddlers (Feldman, Dollaghan, Campbell, Colborn, Janosky, Kurs-Lasky, et al., 2003). Hearing impairment from otitis media is significantly related to delays in communication development (Yoshinaga-Itano, Sedley, Coulter, & Mehl, 1998).

Infant health problems also inhibit motor development throughout the head and body which support neuromuscular development for gesture activities such as reaching, grasping and pointing, and to vocal and verbal communication [American Speech-Language Hearing Association (ASHA), 2004]. Some communication delays are related to speech sound production difficulties resulting from problems in neuromuscular oral functioning, respiration, and to an inability to decode the communication of others (ASHA, 2004).

Risk factors for delays

A number of risk factors were identified that indicate when and whether children present with communication delays (Rossetti, 2001). Children experience risk factors which are categorized as established risk or at-risk, depending upon the children’s biological, social, physical and behavioral history (Rossetti, 2001).

Established risk for developmental delay. Infants born with chromosomal and genetic disorders, neurological disorders, congenital malformations, inborn errors of
metabolism, as well as sensory disorders, evidence of severe toxic exposure, chronic medical illness, and severe infectious disease are considered to have an *established risk* for developmental delay because problems in global development are expected to arise from such conditions (Rossetti, 2001). Infants identified as having established risks for developmental delays, are usually identified at birth and routinely should receive intervention (Rossetti, 2001). For example, children with established risks may be those born with such immediately observable problems as Down syndrome, spina bifida, neurofibromatosis, microcephaly, and seizure disorders (Rossetti, 2001).

*At-risk for developmental delay.* Children who are *at-risk* for experiencing developmental delays, especially in communication development, are those who experience biological and/or environmental circumstances of any kind that interfere with the child’s ability to interact with the environment (Rossetti, 2001). For example, children *at-risk* for demonstrating developmental delays are those for whom parents expressed concerns regarding development, children with chronic otitis media and other middle and inner ear problems, family crisis, parent education of less than 9th grade, no health insurance, family history of developmental problems, social isolation of the parent, and observable poor parenting styles (Rossetti, 2001). Children at-risk for delays may not exhibit any overt physical, behavioral or social attributes that indicate the potential for developmental delays, particularly in communication skills (Rossetti, 2001).

Despite a wide range of indicators for potential developmental delays in young children, and despite decades of recommendations to administer developmental screenings, children with communication delays are not being identified at the earliest possible times. This results in lack of identification until school age, at which time costly
special education classes become the only option for learning (King, Rosenberg, Fuddy, McFarlane, Sia, & Duggan, 2005).

Impediments to Screenings

A survey of pediatricians reveals that most feel confident about advising parents on developmental issues (Brunk, 2004). However, many pediatricians report on several barriers to the specific provision of developmental screenings: lack of confidence in the ability to conduct the screenings, especially with public insurance patients and non-white populations; lack of desire because of reimbursement concerns; lack of time; and lack of training, according to a survey of pediatricians in 2000, by the American Academy of Pediatrics (AAP). In addition, experienced pediatricians who use staff for screening administration and parent counseling may be overconfident in their staffs' ability to detect and address parent concerns regarding developmental issues (AAP, 2000).

Generally, physicians choose to provide developmental screenings for infants and toddlers based on certain known risk factors for communication delays and upon reports of parent concerns (Dunkle & Vismara, 2004). Mothers tend to suspect and report concerns about a possible communication delay with accuracy (Glascoe & Dworkin, 1995). However, parents are often frustrated by responses that they interpret as dismissive by physicians (Lindsay & Dockrell, 2004). In general, pediatric clinicians show poor performances in the use of formal screening tools to identify children at-risk for developmental communication delays (Glascoe & Dworkin, 1995). Unless parents directly express concerns about potential communication delays, physicians generally are not moved to provide developmental screenings (Kochanek & Buka, 1995). Bailey, Hebbeler, Scarborough, Spiker, & Mallik (2004), report that infants, on average, are 7.4
months old when parents initially report concerns about communication delays to physicians. Unfortunately, the infants must wait to receive developmental screenings with a possible diagnosis until approximately 1.4 months later, with subsequent referral to early intervention services occurring at approximately 5.2 additional months after the possible diagnosis (Bailey, Hebbeler, Scarborough, Spiker, & Mallik, 2004). Glascoe and Dworkin (1995) recommend that physicians inquire of parents about developmental concerns rather than wait for parents to initiate discussions, because parental reports of children’s daily activities and behaviors will be expert and revealing.

In an analysis of audio recordings taken during pediatrician and parent discussions in the course of health maintenance or follow-up visits, pediatricians and parents both frequently and unfortunately misinterpreted words that each used during discussions (Clayman & Wissow, 2004). Neither the pediatricians nor the parents requested clarification of terms, misunderstandings arose, the misunderstandings were not resolved by clarification, and parents interpreted the problem as dismissive behavior by the pediatricians (Clayman & Wissow, 2004).

*Cultural barriers.* Parents are limited in addressing problems about developmental concerns for a variety of cultural reasons related to communication of thoughts and concerns with authority-type figures. Conditions and contexts within both urban and rural settings in the United States contribute to impairment in communication development (Garbarino & Ganzel, 2000). The divergence and convergence of ethnicities, cultural groups, and economic groups throughout the United States lead to different experiences impacting the communication development of infants and toddlers (Coll & Magnuson, 2000; Guralnick, 1997).
Highly developed urban settings are typically composed of population groups from an array of cultures and ethnicities with variations in social and economic status (Guralnick, 1997). Many urban groups have available the educational media through which to receive communication development information and early intervention services (Guralnick, 1997). However, the personal capabilities of many parents, particularly among the poor, in terms of ability to communicate concerns and to understand dauntingly complex health system processes, may leave many children with both established and at-risk conditions without an advocate (Rossetti, 2001).

Families in slowly developing rural areas often lack many social services such as educational programs on childhood development (Garbarino & Ganzel, 2000). The families have little opportunity to learn from available health education programs because of a dearth of trained social service professionals and public transportation opportunities (Garbarino & Ganzel, 2000). Additionally, some rural areas have little sense of community identity through which to generate supportive groups for the purpose of requesting educational programs (Garbarino & Ganzel, 2000). Halfon (2003) concluded that community service agencies and physician groups must work collaboratively to educate the public if children are to receive services. Family and community characteristics and views on health care and child developmental milestones are intertwined with the contexts within which different health care systems operate.

*Health care system.* Several issues impede the medical health care industry’s ability to effectively identify delays early in childhood development. Infants and toddlers achieve developmental milestones differentially, within time ranges rather than at exact points in time (Shonkoff, 2003). These variations lead many physicians to allow time,
without surveillance, for children to attain the specific milestones or skills (Christakis, Johnston, & Connell, 2001).

The issue of context in child health creates an additional dimension of consideration for developmental progress in children (Christakis, Johnston, & Connell, 2001). Physicians must consider the effects of family and society on children’s health and communication development (Christakis, Johnston, & Connell, 2001). Advice and counseling to parents in regard to developmental progress must be tailored by physicians who may not have the opportunity to consistently interact with the family and children (Christakis, Johnston, & Connell, 2001).

Another issue lies within the vision of health as dictated by health delivery systems, in which only single, one-time assessments are reimbursed by insurance companies (Christakis, Johnston, & Connell, 2001). Children who are seen by the same physician at each well-child, sick child and other health visits are more likely to stay healthy and to be administered developmental screenings than children who are seen by a different health provider at each visit (Christakis, Wright, Koepsell, Emerson, & Connell, 1999; Inkelas, Schuster, Olson, Park, & Hafliom, 2004; Minkovitz, Strobino, Scharfstein, Hou, Miller, & Mistry, 2005). While most children 4 to 35 months old have regular health care settings, only 46 percent are seen by a specific clinician each visit (Inkelas, Schuster, Olson, Park, & Hafliom, 2004).

Parents of children with specific clinical providers in health systems are more likely to express developmental concerns and to routinely bring the children for health visits of any kind (Minkovitz, Strobino, Mistry, Scharfstein, Grason, Hou, et al., 2007; Minkovitz, Strobino, Scharfstein, Hou, Miller, & Mistry, 2005; Mustard, Mayers, Black,
Following a national survey, the Zero To Three: National Center for Infants, Toddlers and Families (2002) organization revealed parent reports of little knowledge and information about children's emotional, intellectual and social development and, as a result, parents' lack confidence in reporting concerns to health care providers. Health care systems in which stringent allowances of time for child health visits are permitted tend to inhibit parent-physician interaction opportunities (Minkovitz, et al., 2007). Parents' inhibited ability to communicate concerns to physicians, the failure of health delivery systems to reimburse for screenings, and interference with continuity of care impact the ability of physicians to observe developmental progress in young children and the ability to provide developmental screenings (Inkelas, Schuster, Olson, Park, & Halfon, 2004).

Prevention

The established risk and at-risk conditions which impair development of communication skills may be lessened if health care professionals follow the American Academy of Pediatrics recommendations for regular and sequential developmental surveillance and administration of screenings, despite health delivery system obstructions (AAP, 2001; Sameroff & Fiese, 2000). Developmental surveillance is described as a continuous process, flexible in adherence by which health care providers use their knowledge to make judgments about developmental progress over time (Dworkin, 2006). For example, the American Academy of Pediatrics (AAP) currently recommends that providers undertake surveillance of developmental progress each time a young child is seen, with immediate developmental screenings if any concerns arise (AAP, 2006). Further, the AAP recommends that all young children at 9-, 18-, and 30-months old
routinely receive developmental screenings (AAP, 2006). However, a visit at 30 months old frequently is not reimbursable by third-party payers, as the 30-month visit has not been incorporated into the recommended preventive care system by most of the payers. Consequently the AAP recommends a developmental screening at 24 months (AAP, 2006). Experts in childhood development recommend administration of formal developmental screenings at each clinical visit (Glascoe & Shapiro, 2005).

Unfortunately, there is frequently a lack of understanding among health care providers for the probability of communication delays in the children with both established risk and at-risk conditions (Rossetti, 2001). The children with established risks, along with the children at-risk for communication delays may be neither identified nor referred for intervention (Christakis, Wright, Koepsell, Emerson, & Connell, 1999).

HEALTH SERVICE EFFECTIVENESS

Conceptually, health service effectiveness concerns whether health treatments, evaluations, assessments and health management schemes are appropriate, cost-effective, and equitable for all socioeconomic groups (Cochrane, 1972). Most health service effectiveness measurement is singularly focused on the intervention of a specific clinical quality, based upon the best evidence from research and practice (ASHA, 2004; Bethell, Reuland, Halfon, & Shore, 2004; MacDonald & Carroll, 1992; NRC & IOM, 2004). Health service effectiveness in regard to young children’s developmental progress is based upon the medical community’s vision of finding a health problem and then fixing it (NRC & IOM, 2004).

Research on the effectiveness of health services typically involves tertiary intervention through essential innovative medical treatments that improve or change the
course of diseases (NRC & IOM, 2004). Traditional health service effectiveness measurement focused on the revelation of disparities between population groups in the areas of access to, and use of health care (NRC & IOM, 2004). However, health service effectiveness measurement may concern whatever benefits individuals gain from the health services (St Leger, Schnieden, & Wallsworth-Bell, 1993). Thus, early detection of developmental delays in very young children by health service providers is critical for initiation of intervention therapies by speech-language pathologists, mental health specialists, and other professionals.

The gain of receiving developmental screenings is that children with potential developmental communication problems will be identified and will receive remediation to address the problems before the start of formal schooling (Dunkle & Vismara, 2004). Regardless of community size and location, the problem of communication delays can be addressed through many community-based prevention programs (ASHA, 2004). ASHA position papers have long supported the public health view of primary (educate the public on risks), secondary (screenings, treatments), or tertiary (special education classes) prevention models to help reduce the incidence of communication problems (ASHA, 1988).

This study will seek to expand the definition of health service effectiveness through examination of whether young children receive developmental screenings. Further, this study will examine various influences associated with receipt of the screenings.

Review of the Problem
Early identification of developmental delays and early intervention treatments repeatedly has been demonstrated as effective for very young children to achieve critical developmental milestones (Guralnick, 1997; Glascoe, 2004). United States public laws delineate guidelines to States for provision of early intervention services to all infants and toddlers identified as having developmental delays, including communication delays (Guralnick, 1997). Physical health in infants and toddlers is routinely and expertly scrutinized at well-child health visits; communication, social, and behavioral/emotional abilities usually are not assessed (Halfon, Regalado, Sareen, Inkelas, Reuland, Glascoe, et al., 2004). Only 20-30 percent of infants and toddlers receive developmental screenings. Knowledge is lacking about when and whether children receive developmental screenings to indicate potential developmental delays in communication acquisition. Exploration of factors related to developmental screening receipt is important for expansion of the health service effectiveness knowledge.

The aim of this study is to use a theoretical framework to examine whether the developmental influences of social environment, physical environment, biological history problems and behavioral history problems in children's lives, as guided by the New Model of Children's Health and its Influences, were related to developmental screenings as a measure of health service effectiveness. This study used the Healthy Steps for Young Children National Program Evaluation data to examine the relationships between childhood influences and developmental screenings.

THEORETICAL FRAMEWORK OVERVIEW

The theoretical framework, New Model of Children’s Health and its Influences (NMCHI) is comprised of the following influences which may affect different aspects of
children's health from birth: social and physical environments, biology, behavior, policy, and services, measured over time (NRC & IOM, 2004). Figure 1 shows the schematic representation of the framework.

**Figure 1: New Model of Children’s Health and its Influences.** (National Research Council & Institute of Medicine 2004) Reprint permission granted.

The framework permits examination of relationships between the various influences on developmental processes. The NMCHI is described as a kaleidoscope, in which children's developmental progress is impacted by age and by internal and external influences (NRC & IOM, 2004).
Most health promotion theoretical frameworks for children are altered versions of adult-focused theories of health promotion (NRC & IOM, 2004). The NMCHI specifically addresses the rapidly changing features in children’s lives and the influences of those features (NRC & IOM, 2004).

Review of the study purpose

The purpose of this research study is to test sections of the theoretical framework, the New Model of Children’s Health and its Influences (NMCHI), using a secondary data set, through examination of whether the various framework-defined influences on young children’s development are associated with developmental screening receipt. The framework concepts, described as ‘influences,’ are social environment, physical environment, biological history, and child behavioral history. The policy concept of the framework was not tested because the initial study from which the data sets were derived did not address policy questions.

SIGNIFICANCE OF THE STUDY

This study is important because it addresses the specific health service problem of under-identification of very young children with developmental communication problems. In addition, this study used a child-centered theoretical framework for guidance, critical for defining childhood developmental influences. The health service effectiveness problem of too few developmental screenings has been identified by the National Research Council and the Institute of Medicine, the American Academy of Pediatrics, the American Speech, Language, and Hearing Association, and United States Federal and State government policymakers (NRC & IOM, 2004).
Identification of developmental communication problems in very early childhood ensures that very young children can begin treatment for the communication problems before the problems become entrenched, social and educational progress are inhibited, and costs increase for society (Campbell & Ramey, 1994). Early treatment or intervention services, critical for those young children identified with delays, are mandated under federal policy and are financially supported. Early intervention of communication problems can lessen the risk, not only of delayed educational progress but also likely referral to special education services upon reaching school age (Campbell & Ramey, 1994). Consequently, a study of the composite effects of childhood influences on developmental screenings receipt may reveal important determinants contributing to omissions in other childhood health services.

Use of the child-centered framework, the NMCHI, with the childhood influences defined, permitted identification of variables for measurement. This is the first research study to use the four primary childhood influences as guided by the NMCHI to examine gaps in the effectiveness of health services, measured here by receipt of developmental screenings. Although over 20 other studies have used the data sets from the Healthy Steps for Young Children Program National Evaluation, this was the first study to use the data sets to examine the relationships between childhood influences within the network defined by the NMCHI. Testing of a child-centered theoretical framework is important for future research into explanations of whether childhood developmental influences are related to the effectiveness of health services for young children.

RESEARCH QUESTIONS
In testing the explanatory usefulness of portions of the New Model of Children’s Health and its Influences (NMCHI), this research study sought to answer the overall question, “Which early childhood developmental influences are related to health service effectiveness as indicated by the receipt of developmental screenings?” The NMCHI includes four areas of childhood influences that have been used to describe developmental progress in very young children: social environment, physical environment, biological history, and child behavioral history. The Healthy Steps for Young Children National Program Evaluation data sets were accessed for use in addressing the research questions:

1. What are the relationships between the predictor variables of the four areas of developmental influence and the outcome variable, formal or informal developmental screenings?

2. How well do the four areas of developmental influence (social environment, physical environment, biology, and child behavior) of the NMCHI model predict young children’s receipt of developmental screenings through identification of predictor variables?
CHAPTER II
THEORETICAL FRAMEWORK AND LITERATURE REVIEW

This chapter introduces a novel theoretical framework, the New Model of Children’s Health and its Influences (NMCHI). The framework is used as a guide to explain relationships between childhood developmental influences and children’s receipt of developmental screenings, a health services outcome. The historical development of the framework is discussed in the background section of this chapter. Four concepts of the framework are used to guide selection of childhood influence variables for the study. The literature review identifies previous studies that support the four concepts of childhood developmental influence. There are no published studies that use the NMCHI to identify patterns of which children receive developmental screenings. Research hypotheses are presented at the chapter’s end.

THE NEW MODEL OF CHILDREN’S HEALTH AND ITS INFLUENCES

Theoretical frameworks that permit exploration and explanation of children’s health issues are rare. The theoretical framework guiding this study, the NMCHI, was recently developed and is yet untested regarding health service effectiveness until this present study.

The theoretical framework for this study is a new conceptual framework developed by experts in the early childhood development field (NRC & IOM, 2004). Figure 1 depicts the framework. This new framework is designed to specifically reflect the developmental processes of children and the impact on health from various internal and external influences (NRC & IOM, 2004). The NMCHI was selected for this study because it focuses on the continuously changing health and development of children over
time, as impacted by the various influences. Additionally, components of the new definition of children’s health proposed by the framework’s authors are related to communicative ability. The new definition: "Children’s health is the extent to which individual children or groups of children are able or enabled to (a) develop and realize their potential, (b) satisfy their needs, and (c) develop the capacities that allow them to interact successfully with their biological, physical, and social environments;" (NRC & IOM, 2004). The ability to “realize potential” arises from the capacity to learn and adapt to the world through personal competencies in communication (NRC & IOM, 2000). The ability to “satisfy their needs” emerges from the ability to engage in unintentional and then, intentional, communicative efforts (Owens, 2001). Neonates cry to signal caregivers for such care as feeding and comfort; they progress to cooing and smiling to garner attention and affection (Owens, 2001). Children learn to request desired activities and items using gesture, vocalization or verbalization (Hess, Dohrman, & Huneck, 1997; Lahey, 1988; Owens, 2001). Development of “capacities that allow children to interact successfully” within personal environments is related to cognitive, emotional, and biological health. Neuromuscular development, breathing, and other physiological aspects of biological health permit infants to feed normally as well as develop movement skills (Crais, 1999). The ability to feed normally supports reciprocal interaction and emotional attachment to caregivers (Crais, 1999). Feeding also supports the breathing and oral movements needed for speech (Crais, 1999).

The new definition of children’s health is further defined as consisting of three overall health ideas: health condition, health functioning, and health potential (NRC & IOM, 2004). “Health condition” is the level of health status such as the presence or
absence of illnesses, disorders, impairments, or diseases of any of the systems of the body (NRC & IOM, 2004). “Health functioning” refers to the effects of health conditions, treatments, and multiple health problems, which directly or indirectly impact on children’s daily living and general childhood activities (NRC & IOM, 2004). Functioning includes physical, psychological, cognitive, social abilities and capacities (NRC & IOM, 2004). Psychological and social functioning are used for problem-solving, language ability and the ability to play and learn through social interactions, achieved through communicative acts (NRC & IOM, 2004). The third global health idea, “health potential”, refers to the personal resources through which children can manage any challenges to health, such as physical, psychological, social and at-risk conditions (NRC & IOM, 2004). Personal resources intensify vulnerability to additional health and functioning problems or can reflect resilience (NRC & IOM, 2004).

BACKGROUND OF THE THEORETICAL FRAMEWORK

The NMCHI was developed from empirical and observational research in children’s development. The conceptual idea that various influences in daily life will affect health emerged from the health promotion conference that produced the Ottawa Charter of 1986 (NRC & IOM, 2004). In addition, the NMCHI includes enhanced information from the Healthy People 2010 model (NRC & IOM, 2004).

The Healthy People 2010 model shows that relationships and associations exist between the influences of social and physical environments, biological history, and child behavioral history (NRC & IOM, 2004). The Healthy People 2010 model posits that health policies affect access to quality health care (NRC & IOM, 2004). The Committee on Evaluation of Children’s Health [(CECH) NRC & IOM, 2004] enhanced the 2010
model to include the concept of “services” that children and families receive as important processes which can impact children’s health (Coll & Magnuson, 2000; NRC & IOM, 2004). In addition, cultural influences serve as mediating influences on childhood developmental progress (Coll & Magnuson, 2000; NRC & IOM, 2004).

As an ecological framework, the NMCHI accentuates the complex features which affect developing children (NRC & IOM, 2004; Sameroff & Fiese, 2000). The NMCHI is viewed as a kaleidoscope model because child health is continuously changing as a result of various influences at different stages of development (NRC & IOM, 2004). The examination of various influences on children’s health beginning at birth and at successive intervals will generate a “health trajectory” that will aid in planning for health care and educational needs (NRC & IOM, 2004).

The CECH chose the concepts of social and physical environments, biological history and behavioral history for inclusion in the model as a means of organization (NRC & IOM, 2004). Research supports connections between the particular areas of developmental influence and the health of children (Kochanek & Buka, 1995; NRC & IOM, 2004). The NMCHI is an ecological framework because it concerns the large number of environmental influences on developing children (Sameroff & Fiese, 2000).

A review of current literature and research findings relevant to the concepts of the theoretical framework is presented. Review of research related to the concepts of the NMCHI assisted in the identification of study variables that are measures of the theoretical concepts and constructs. In addition, research results concerning the influences on children’s health, social and physical environments, biological, and behavioral histories, are presented in support of the theoretical framework. Table 2 shows
the selected predictor variables for this study by area of developmental influence as defined by the theoretical framework.

### Table 2: Predictor Variables that Influence Childhood Development

<table>
<thead>
<tr>
<th>Social Environment</th>
<th>1. Maternal education</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Demographics)</td>
<td>2. Child’s gender</td>
</tr>
<tr>
<td></td>
<td>3. Maternal race</td>
</tr>
<tr>
<td></td>
<td>4. Marital status</td>
</tr>
<tr>
<td></td>
<td>5. Maternal age at time of first survey</td>
</tr>
<tr>
<td>(Processes)</td>
<td>6. Maternal reported feelings of depression (baby age 2-4 months).</td>
</tr>
<tr>
<td>Physical Environment</td>
<td>7. Place child is cared for during the day</td>
</tr>
<tr>
<td></td>
<td>8. Father smokes</td>
</tr>
<tr>
<td>Biological History</td>
<td>9. Child received specialty medical care</td>
</tr>
<tr>
<td></td>
<td>10. Birth weight</td>
</tr>
<tr>
<td>Child Behavioral History</td>
<td>11. Frequency baby is fussy, daily/difficult to calm/soothe</td>
</tr>
</tbody>
</table>

Source: 1995 Healthy Steps for Young Children National Program Evaluation

Social environment variables

The first social environment for newborns is the family (Rossetti, 2001). The Committee on Evaluation of Children’s Health (CEHC) posits that variables of the social environment are either “demographic” or “processes” features. Demographic features include parent education, income, and family composition. Processes include parenting styles, parent health and care habits, and mental health (NRC & IOM, 2004). These variables are discussed below with emphasis on the demographic and process features of mothers because they are considered to have the most influence on a child’s social environment (Rossetti, 2001).
Maternal education. Demographic variables of the social environment include parent educational levels of achievement and learning ability, features of socioeconomic status (SES), and family composition and size (NRC & IOM, 2004). The research varies on the impact mother’s level of educational attainment has on young children’s communication development. Primarily, most researchers found that lower maternal education levels are associated with communication delays in the young children. A study of 36 month old children showed significant relationships between lower maternal education levels and children with speech and language delays (Dollaghan, Campbell, Paradise, Feldman, Janosky, Pitcairn, et al., 1999). First-time mothers with a high school education or less had low-paying jobs and their children were more likely to demonstrate language delays than children whose first-time mothers had either higher paying jobs or higher levels of education (Hershberger, 1996). Zill (1996) reported that educational level of achievement is more predictive of social, emotional, economic and physical health for children than income level, single parenthood or size of family. Further, any type of communication delays in very young children can be attributed to such parent characteristics as a positive history of language and learning problems (Tomblin, Records, Buckwalter, Zhang, Smith, & O’Brien, 1997).

However, Fenson, Dale, Reznick, Thal, & Pethick (1994) identified a wide range of communicative ability in mothers with varying levels of education. Some of the poorly educated mothers demonstrated a fairly expressive and communicative interaction style, resulting in adequate infant and toddler communication ability on some measurement tools (Feldman, Dollaghan, Campbell, Kurs-Lasky, Janosky, & Paradise, 2000; Fenson, Dale, Reznick, Thal, & Pethick, 1994). In a heritability study of 2800 same-sex twin pairs
from all income levels, language delay in the first two years of life was found to be positively related to the educational achievement levels of the mothers rather than shared genetic history. In particular, the language-delayed two year old children, whose mothers had low levels of educational achievement and who did not seek professional help for their children, were more likely to continue to demonstrate language delays at three and four years old. The environmental aspects of language used in the home were compounded by the mothers’ poor ability to be advocates for their children. In this study, neither parents nor physicians had expressed concern about the children’s language development (Bishop, Price, Dale, & Plomin, 2003). In general, mothers with expressive communication problems tend to have infants and toddlers with similar communication delays (Lahey & Edwards, 1995).

*Child’s gender.* Previous research studies show that boys tend to have more communication problems than girls (Pinborough-Zimmerman, Satterfield, Miller, Bilder, Hossain, & McMahon, 2007; Zubrick, Taylor, Rice, & Slegers, 2007). The reported ratio of boys to girls with language delays ranges from 1.3:1 - 3.2:1 (Nelson, Nygren, Walker, & Panosha, 2006).

*Maternal race.* The children of adolescent mothers of any race other than Caucasian are more likely to be placed in special education classes because of increased risks for delays related to a range of socio-demographic factors (Gueorguieva, Carter, Ariet, Roth, Mahan, & Resnick, 2001). Different cultural traditions drive mother-child interaction styles, parenting styles and mother health habits (Black, Cureton, & Berenson-Howard, 1999). Cultural traditions influence caregiving such as cuddling, feeding and early stimulation for intellectual and communication development of infants and toddlers.
Race and ethnicity are viewed as robust social variables that influence children’s health and interact in different ways with socio-economic status factors to predict health (AAP, 2000). However, race and ethnicity should not be used alone as explanatory variables (American Academy of Pediatrics, 2000). The problem with using race and ethnicity as variables without the context of a number of factors from respective cultures is that overgeneralizations tend to arise (Coll & Magnuson, 2000). In addition, researchers tend to accentuate differences instead of similarities (Coll & Magnuson, 2000).

Use of race and ethnicity as variables without context also generates a tendency to neglect identification of individual differences of race and ethnic group members (Coll & Magnuson, 2000). Infants and toddlers of African-American, adolescent mothers living in low-income circumstances experience developmental declines because of the effect of environmental influences, even if the children demonstrate typical developmental skills in the first few months of life (Hess, Papas et al., 2004). African-American mothers with middle socio-economic status (SES) tend to use a greater variety of vocabulary words and are more verbally interactive and responsive with infants than low SES African-American mothers, although both groups of mothers talk to the infants with similar frequencies (Hammer & Weiss, 1999).

Marital status. Young children reared in families composed of two biological parents receive more attention, stimulation and guidance, and have a higher SES than single parent families (McLanahan & Sandefur, 1994). Single mothers are more likely to be poor and more likely to have psychological problems (McLanahan & Sandefur, 1994). A study of mothers living in 100% poverty in rural communities, found that the mostly
single mothers were ignorant of the infants' and toddlers' needs for interaction and failed to understand the children's cues (Horodynski & Gibbons, 2004).

Maternal age. In addition to level of education, parent age correlates with communication and interaction capabilities. Adolescent mothers are less verbally expressive than older mothers and are less sensitive to the communicative intentions of infants (Olswang, Rodriguez, & Timler, 1998). In addition, adolescent mothers tend to show negative affect and tend to subscribe to punitive child-rearing attitudes, all behaviors that inhibit communication development (Olswang, Rodriguez, & Timler, 1998; Shonkoff & Meisels, 2000). Hershberger (1996) found that expressive and receptive communication skills in young children can be predicted by mothers' age at the time of giving birth to the first child.

Maternal depression. The quality of parent-infant interactions can mediate relationships between risk factors and cognitive development despite a number of risk factors leading to poor cognitive development and communication deficits in infants and toddlers, such as adolescent motherhood and poverty conditions (Poehlmann & Fiese, 2001). Infants learn how to respond and interact with others from their first caregivers, usually mothers (Kessler & Dawson, 1999). Inconsistencies in mother's responsiveness have been found to influence brain maturation in the infant (Boyce, Frank, Jensen, Kessler, Nelson, Steinberg, et al., 1998). Delayed development in brain function, with subsequent delayed communication skills, creates a reciprocal negative social environment (Carson, Perry, Diefenderfer, & Klee, 1999). Parents with communication-delayed toddlers, at 2 years old, were less nurturing overall to those toddlers, and rated the toddlers as less sociable than toddlers without delays. The poor nurturing pattern
persisted when measured again when the children were 5-6 years old (Carson, Perry, Diefenderfer, & Klee, 1999). Poor parent health and behavior habits create family environments that are inhospitable for developing infants and toddlers (Boyce, Frank, Jensen, Kessler, Nelson, Steinberg, et al., 1998).

Early home environment variables have long been predictive of the children who require special education placement in school (La Paro, Olsen, & Pianta, 2002; Tomblin, Hardy, & Hein, 1991; Walker, Greenwood, Hart, & Carta, 1994). A mother’s capacity for the level of responsiveness or sensitivity to the needs and communication of children are critical elements for children’s progress in language development (La Paro, Justice, Skibbe, & Pianta, 2004). Further, the responsiveness of mothers in caring for their children by providing daily care and routine health care may be mediated by the influences of depressive feelings (La Paro, Justice, & Pianta, 2004). In a study examining the reasons for children’s absence from routine health care visits, Minkovitz, Strobino, Scarfstein, Hou, Miller, & Mistry (2005) found that mothers who reported symptoms of depression when their infants were 2-4 months old tended to use acute health care services as needed for their infants rather than routine child care visits. The mothers with depressive symptoms usually failed to engage in preventive health services for their infants, such as well-child checkups and immunization visits, more than mothers who were not depressed (Minkovitz, Strobino, Strobino, Scarfstein, Hou, Miller, & Mistry, 2005).

Parents with mental and emotional problems were found to use drugs, have poor education histories, and who live in poverty typically fail to develop relationships that are reciprocal and responsive with infants (Crais, 1999). Sadly, a home environment with a
drug-dependent parent is more predictive of developmental delays and behavioral disorders in infants and toddlers because of deprivation, than because of prenatal drug exposure, unless the neurological damage is severe (Ornay, Michailevskaya, Lukashov, Bar-Hamburger, & Harel, 1996).

Mothers are the primary caregivers. Consequently, most research studies that look at communication development in the context of family interactions address mother-child interaction skills, parenting styles, physical health, and mental health as predictor variables. Maternal physical health, in terms of lifestyle and health habits when children are infants and toddlers, is positively related to the good health and developmental progress of children (Zuckerman, Parker, Kaplan-Sanoff, Augustyn & Barth, 2004).

Girolametto, Weitzman, Wiigs, & Pearce (1999) reported that improved maternal responsiveness can improve communicative competence in toddlers with communication delays. Infants are at increased risk for overall health problems and communication delays because of poor parenting and an inclination towards neglectful and abusive behavior by mothers who demonstrate five out of the following ten risk factors: maternal depression, domestic violence, nondomestic violence, large family size, incarceration, no significant other in the home, negative life events, psychiatric problems, homelessness and severity of drug use (Kelley, 2003).

Physical environment variables

Physical environment influences that place infants and toddlers at risk for developmental communication delay refer to chemical, physical and biological factors that are external to children and impact the body in some manner (NRC & IOM, 2004). External influences may be taken in through physical contact, ingested, breathed and
absorbed (NRC & IOM, 2004). Examples of such influences are lead, methyl mercury, pollutants such as pesticides and carpet preservatives, air pollution, ultraviolet light, physical abuse, noise, and odors (NRC & IOM, 2004). Physical environment also refers to the daily emotional caregiving environment of a child’s own home, a relative’s home, or a day care center.

Place of child’s daycare. Children’s bodies are small with proportionally greater functioning of the skin and lungs, because of greater proximity to surfaces and more rapid air exchanges than adults (Bearer, 1995; Bearer, Emerson, O’Riordan, Roitman, & Shackleton, 1997). Young children also have different metabolic rates which causes uptake of risk agents in greater amounts than in adults (Bearer, 1995; Landrigan, Claudio, Markowitz, Berowitz, Brenner, Romero, et al., 1999). Certain types of exposure at different stages of development are related to unique physical risk factors associated with changing locations (e.g., home, daycare), levels of mobility (e.g., lying, rolling, crawling), oxygen consumption, eating patterns and interactive behavior (Bearer, 1995). In addition to biological and viral contaminants, child stress related to day care away from home may impede interactive communication development (Lee, 2006) and lead to increased illness (Boyce, Chesney, Alkon, Tschann, Adams, Chesterman, et al., 1996).

The research literature shows that children in day care centers away from home were found to have increased levels of the stress hormone, cortisol. The cortisol levels decrease when the children return home (Watamura, Kryzer, & Robertson, 2009). Increased levels of cortisol are also associated with poorer quality day care (Watamura, Kryzer, & Robertson, 2009) and increased over-controlling, and intrusive behavior by the caregivers (Gunnar, Kryzer, Van Ryzin, & Phillips, 2010). The increased cortisol levels
were related to anxious and hyper-vigilant behavior in girls and with aggressive and angry behavior in boys (Gunnar, Kryzer, Van Ryzin, & Phillips, 2010).

*Father smokes.* Respiratory diseases are of the most common causes of disability for young children and are serious health problems (Newacheck & Halfon, 1998). Infant mortality has been related to respiratory problems from air pollution exposure without effects of SES, birth weight or gestational age (Bobak & Leon, 1999). Infant and toddler breathing problems from asthma have long been positively associated with exposure to tobacco smoke by either father or mother (Batshaw & Perret, 1994). Impaired respiration impacts inspiration volume for vocalizations and verbalizations and communication development may be inhibited (Batshaw & Perret, 1994; Owens, 2001; Blackburn, Bonas, Spencer, Coe, Dolan, & Moy, 2005).

Physical environment factors may affect different ethnic groups dissimilarly (AAP, 2000; Jenni & O'Connor, 2005). Although African-American children generally experience a lower exposure rate to tobacco smoke than White children, comparison of blood levels revealed that the African-American children have much higher levels of cotinine than White children (Wilson, Kahn, Khoury, & Lanphear, 2005). Cotinine is a chemical produced by the body in response to nicotine exposure (Knight, Eliopoulos, Klein, Greenwald, & Koren, 1996). The increase in cotinine levels is associated with elevated risks of developmental disorders because of changes in neural receptors in the midbrain and at the cellular level of organ development (DiFranza, Aligne, & Weitzman, 2004; Wilson, Kahn, Khoury, & Lanphear, 2005). Lung development and function is particularly affected by pre- and post-natal maternal exposure to nicotine. In addition to
breathing diseases in children, behavioral and cognitive disorders are associated with nicotine exposure (DiFranza, Aligne, & Weitzman, 2004).

Biological history variables

Prenatal events, prenatal environment, postnatal problems, and genetic mutations may alter and shape biological functions of infants, such as the central nervous system, oral structures, and cardiovascular structures and result in impaired development (Hertzman, 1999; NRC & IOM, 2004).

*Child needed specialty medical care.* Fetal health is related to a number of subsequent, long-term health problems in infants and toddlers such as poor intellectual development (Bearer, Emerson, O'Riordan, Roitman, & Shackleton, 1997). Infants born prematurely tend to develop respiratory distress syndrome (RDS), which usually leads to broncho-pulmonary dysplasia (BPD), the biological marker that places infants at risk for feeding and communication problems because of slow oral motor development and poor lung function (McNab & Blackman, 1998).

Fetal infection contracted in utero from such diseases as cytomegalovirus or rubella, may result in deafness or hard of hearing problems, placing infants and toddlers at extreme risk for development of communication disabilities (National Institute on Deafness and Other Communication Disorders, 2004). Chemical problems of mothers also may affect development of fetuses. Mothers who have low dopamine levels and are depressed during pregnancy often have infants who demonstrate low scores on a developmental interaction scale (Field, Diego, Dieter, Hernandez-Reit, Schanberg, Kuhn, at al., 2001).
A number of genetic changes at conception, such as Down syndrome and Fragile-X, are responsible for established communication delays (Rossetti, 2001). Genetic factors are now associated with specific language impairment (SLI), an expressive communication delay in which there are no explanatory factors other than heredity from either parent (Bartlett, Flax, Logue, Vieland, Bassett, Tallal, et al., 2002). Positive relationships were found to exist between parents with a history of reading impairments and children with SLI (Flax, Reape-Bonilla, Hirsch, Brzustowiz, Bartlett, & Tallal, 2003). In addition, families with history of SLI tend to have autoimmune diseases (Choudhury & Benasick, 2003).

*Birth weight.* Expressive and receptive communication skills can be predicted by birth weight, gestational age, and days the infant remained in a hospital (Fiese, Poehlmann, Irwin, Gordon, & Curry-Bleggi, 2001). Some low birth weight infants are categorized as “small for gestational age”; these are infants who are atypically small without prematurity and who exhibit developmental delays. Low birth weight is not always predictive of cognitive and language delays, however.

In one birth weight study, parent-infant interactions were found to predict cognitive and communicative outcomes more than maternal socio-demographic characteristics and birth-weight (Poehlmann & Fiese, 2001). These results were documented even in preterm low birth weight (< 5 lbs. 8 oz.) and very low birth weight infants (<3 lbs. 5 oz.) who had experienced invasive and traumatic medical procedures (Poehlmann & Fiese, 2001). Comparison research of communication abilities in children born at very low birth weight with those born at normal birth weight (>5 lbs. 8 oz. grams) indicated in many studies that both groups performed similarly on developmental
communication assessments (Aram, Hack, Hawkins, Weissman, & Borawski-Clark, 1991). Indeed, the increased sound level in the neonatal intensive care unit (NICU) is more predictive of poor communication development than gestational age, birth weight or family SES (Stromswold & Sheffield, 2004).

Child behavioral history variable

Children's behaviors are posited to be the emotions, beliefs, attitudes, behaviors, and cognitive abilities exhibited in relation to health outcomes (NRC & IOM, 2004). For infants, behaviors are reported as levels of fussiness, crying, passivity, self-calming, contentment, and eye-gazing with parents (NRC & IOM, 2004). Toddlers have been associated with disruptive behavior such as temper tantrums, aggression, and little self-regulation (Smith, Calkins, 2004).

Child's fussiness and irritability daily. Research into the etiology of infant and toddler behavior has frequently explored the early attachment between mothers and infants as they interact with each other (Braungart-Rieker, Garwood, Powers, & Wang, 2001; Quinlivan & Evans, 2005; Schenk, Kelley, & Schenck, 2005).

Attachment is the emotional bonding between mother and infant, a process of interaction that first flows from mother to infant and then quickly becomes a reciprocal interaction (Schenk, Kelley, & Schenck, 2005). Attachment begins prenatally as pregnant mothers begin to think about the infants soon to be born and continues following birth, as mothers and infants learn about each other during caregiving routines of feeding, diapering and cuddling (Huth-Bocks, Levendosky, Bogat, & von Eyes, 2004). Depressed mothers tend to show maladaptive parenting skills and the consequence is that the infants may be undernourished and neglected (Crais, 1999). Underfed infants tend to make little
eye contact, rarely vocalize, dislike cuddling, and engage in self-stimulatory acts, all behaviors which inhibit communication development (Crais, 1999).

Mothers are usually sensitive to, and provide care for the needs of the infants, thus ensuring a feeling of security and contentment for the infants (Kiviljarvi, Raiha, Virtanen, Lertola, & Piha, 2004). However, some infants have difficulty in accepting and responding to the love and care of their mothers, developing insecure and somewhat distressed levels of attachment (Zelenko, Kraemer, Huffman, Gschwendt, Pageler, & Steiner, 2005). Low birth weight infants tend to be more fussy and smile less than term infants, a situation that interferes with attachment development as mothers are less drawn to these infants and increasingly become less responsive and less sensitive to infant needs (Hadadian, 1996).

Infants with responsive mothers are found to demonstrate more self-regulation and calming skills, greater regulation of heart rate and less negative affect (a person’s externally displayed mood) than infants with unresponsive mothers. Additionally, the infants of consistently responsive mothers typically engage in more interactive behavior than infants of minimally responsive mothers (Haley & Stansbury, 2003). Infants who demonstrate passive inattentiveness to interactions and to feeding because of undocumented health problems tend to cause confusion in mothers (Black, Cureton, & Berenson-Howard, 1999). The mothers tend to terminate feeding prematurely, leaving a hungry and neglected infant (Black, Cureton, & Berenson-Howard, 1999). When mothers cease feedings prematurely, or do not provide feeding at regular intervals, infants often fail to develop secure attachments (Crais, 1999). Infants who demonstrate behavior that is listless/apathetic or demanding/aggressive, or watchful/hypervigilant are associated with
mothers who were unresponsive to infant smiles and cooing (Satter, 1999). Infants and toddlers with attachment problems behave with excessive anxiety, irritability, and clinging behaviors or excessive familiarity or affection when a physician approaches. Such behaviors inhibit normal reciprocal interaction and communication (Robinson, 2002). Once established, social and emotional problems are highly resistant to change and the window of opportunity for infants is lost (Squires & Nickel, 2003).

In a study of adolescent mothers with “disrupted” maternal behavior (i.e., does not soothe infant; laughs when infant cries, demands affection from infant; handles infant as though inanimate), the infants typically showed poor and disorganized attachment relationships (Madigan, Moran, & Pederson, 2006). Mothers’ quality of caregiving, measured by interactive, responsive behavior toward infants and toddlers, robustly predicts distractibility, a precursor of hyperactivity, more than any biological or temperament variables (Carlson, Jacobvitz, & Sroufe, 1995). Children with hyperactivity have difficulty learning (Carlson, Jacobvitz, & Sroufe, 1995). In addition, behavior problems in young children appear positively related to language delays in the preschool years and beyond (Cohen, Davine, Horodezky, Lipsett, & Isaacson, 1993).

Policy section of the model

Public Health policies may be developed for specific health care services such as immunizations or for other areas which affect health (NRC & IOM, 2004). Policies for health services include improvement of the environment and public safety, or relief from the debilitating effects of poverty, to improve subsequent health and education care and levels (NRC & IOM, 2004). A National Research Council and Institute of Medicine (2004) report indicates that research studies that measure the effectiveness of policy on
children’s health are few. Consequently, little is known about the performance of many health policies for children. Although health policy knowledge is important for assurance that health care meets the needs of all United States citizens, measurement of health policy was not part of the present study.

HEALTH SERVICES

Health services are important for improvement of individual health conditions (NRC & IOM, 2004). Measurement of health service effectiveness is critical in order to determine whether children’s health is actually improving as a result of screenings and treatments or whether different services should be introduced (NRC & IOM, 2004). Barnett (2000) reports that early intervention services for very young children with delays are less costly than all day in-school services for those children who were not identified early enough to receive early treatment services. Implementation of prevention-oriented or treatment-oriented services can modify the developmental direction of children and can minimize the risks of developmental delay through intervention (Guralnick, 1997; NRC & IOM, 2004).

The costs of children’s health services are enormous and include federal funding for Medicaid, the State Child Health Insurance Program (SCHIP), nutrition programs such as Women, Infant, Children (WIC), food stamps, child care, social services such as Healthy Families, as well as funding that individual states and communities provide for health education and promotion, and special education in public schools (NRC & IOM, 2004). The costs of children’s attendance in special education classrooms are high for state governments. When children with developmental delays are identified early and referred to early intervention programs there is a likely reduction in the need to attend
special education classes (Belfield, 2004). Between $2,591 and $9,547 per child is saved if the child is not placed in special education classes, with the cost off-set due to early intervention at 41-62 percent (Belfield, 2004). For each age cohort, from kindergarten-12th grade, the cost-savings would be between $555 million and $828 million per state (Belfield, 2004). In addition, children and families benefit from a decreased incidence of special education, prevention of grade repetition, improvement of educational productivity, and enhancement of children’s well-being (Belfield, 2004).

Services may operate through long-term, home and community-based care (NRC & IOM, 2004). Developmental screenings are part of the prevention-oriented aspect of services. Additional research is needed to determine the effectiveness of such services in terms of case finding and referral, to assess whether the children’s’ services actually improve their developmental skill acquisition, or whether new initiatives should be instituted (NRC & IOM, 2004). Services are defined by the receipt of developmental screenings, the outcome variable in this study of health service effectiveness.

SUMMARY

The New Model of Children’s Health and its Influences (NMCHI) is a recently developed socio-ecological framework based on health promotion frameworks from past health models. The NMCHI is different from most frameworks because it focuses on the various, changeable factors that influence children’s health and mediate developmental processes over time. The framework has been untested for use in measurement of health service effectiveness until this present study.

The research literature revealed that the various areas of influence on infant and toddler development, as described in the NMCHI, may impact developmental processes
and progress. The research findings support the theory that children’s continuous
development is a kaleidoscope of developmental changes. This manner of childhood
developmental processing may create a measure of confusion for physicians about
children’s appropriate or delayed developmental progress. The research literature noted
in this review is replete with studies from each area of influence. Each study in the
literature review provides more depth to the theory by supporting each conceptual area.

The present research study will add to the health service effectiveness literature
through examination of whether infants and toddlers were administered developmental
screenings for communication delays. In addition, use of the NMCHI for theoretical
guidance will contribute to research knowledge on the usefulness of child-centered
theoretical frameworks.

RESEARCH HYPOTHESES

Despite previous research into childhood developmental processes, disorders, and
delays in children’s communication progress, and the importance of early identification
of developmental problems, limited numbers of young children receive developmental
screenings for identification of communication problems. The main hypothesis of this
study is that the New Model of Children’s Health and its Influences (NMCHI) will
identify the areas of developmental influence, specifically the social and physical
environments, biological and child behavioral histories, as the areas that relate to or are
associated with developmental screenings. Examination of children’s maternal, child, and
family characteristics will provide the basis for analysis of young children’s receipt of
developmental screenings, whether formal or informal.
Hypothesis #1. The Social Environment area of developmental influence. Demographics: It is hypothesized that developmental screenings will be positively associated with:

- a) lower maternal education.
- b) male gender.
- c) White race.
- d) mothers who are married.
- e) younger maternal age.
- f) higher levels of maternal depression.

Hypothesis #2. The Physical Environment area of developmental influence. It is hypothesized that developmental screenings will be positively associated with:

- a) daycare in child’s own home.
- b) fathers who smoke cigarettes.

Hypothesis #3. The Biological history area of developmental influence. It is hypothesized that developmental screenings will be positively associated with:

- a) child’s specialty medical care.
- b) lower birth weights.

Hypothesis #4. The Child Behavioral history area of developmental influence. It is hypothesized that developmental screenings will be positively associated with:

- baby is fussy and irritable during the average day, ½ the time to almost always.

Multivariate hypotheses.

The two multivariate hypotheses provide the structure by which to examine all areas of influence considered together as a whole in the formal or informal model.
Multivariate hypothesis #5a. To what extent do the four areas of developmental influence of the NMCHI, when considered together in one model, explain young children’s receipt of formal developmental screenings?

Multivariate hypothesis #5b. To what extent do the four areas of developmental influence of the NMCHI, when considered together in one model, explain young children’s receipt of informal developmental screenings?
CHAPTER III

METHODS

The overall goal of the present study was to test portions of the New Model of Children's Health and its Influences (NMCHI) for explanatory usefulness in predicting health service effectiveness. Discussions of the research design and data source are followed by descriptions of the study sample, and the rationale for use of secondary data in analyses. Following identification of the variables and operational definitions of the variables, the statistical analysis plan is described.

RESEARCH DESIGN

This study used an observational, retrospective research design to test relationships and associations of specific concepts as proposed by the NMCHI. These concepts are the four different areas of influence on childhood development, social environment, physical environment, biological history, and child behavioral history. Secondary, longitudinal data were used for this study. The longitudinal data were collected at specific points in time over a three-year time period.

PROTECTION OF HUMAN SUBJECTS

This study was reviewed by the Old Dominion University, College of Health Sciences Human Subjects Review Committee. The Committee approved the study as ‘exempt’ from full university Institutional Review because the study was retrospective, used secondary data, and involved no contact between the participants and the researcher (APPENDIX A).
DATA SET DESCRIPTION

The data were obtained from the Inter-University Consortium for Political and Social Research (ICPSR) maintained by the Institute for Social Research at the University of Michigan (Inter-University Consortium for Political and Social Research ICPSR 2005). The data are from the Healthy Steps for Young Children Program National Evaluation performed by the Bloomberg School of Public Health, Johns Hopkins University (Guyer, 2005). The ICPSR Study Number is 4049.

The Healthy Steps (HS) Program, started in 1995, was primarily developed and supported by The Commonwealth Fund to improve pediatric care for birth to three year old children, at 24 sites in the United States. The HS program evaluation focused on changing parents' knowledge, beliefs and behaviors through intervention programs for the parents, with no intent to directly address childhood development (Guyer, 2005). The program evaluation analysis of 15 of the HS program sites, from which the data were obtained, consisted of convenience samples of participants matched by age (newborn) from experimental and quasi-experimental sites (all pediatric care of different service types). By matching the participants at all of the sites on the demographic characteristic of newborn age, the researchers were able to exert statistical control on the variables that could influence outcome measures (Creswell, 2003).

Through rolling enrollment at the experimental sites, newborn infants were randomly assigned to either the intervention groups and received the attentions of developmental specialists, or to the control groups, which consisted of all the other infants. At the quasi-experimental sites, all infants at entire pediatric practices received the intervention and for the control groups, none of the infants received the intervention.
at pediatric practices which were parallel in location and number of children to the intervention pediatric practices. Parents of the intervention group children were provided direct preventive developmental services as well as behavioral information (Guyer, Hughart, Strobino, Jones, Scharfstein, & The Healthy Steps Evaluation Team, 2000).

The program evaluation examined intervention results at 15 of the 24 sites, between 1996 and 1998 (Guyer, Barth, Bishai, Caughy, Clark, Burkom, et al., 2003). Parents were given questionnaires to fill out prior to the child’s birth or at the first office visit for the newborn questionnaire and at the office visits for successive questionnaires. The two in-depth interviews were conducted by telephone (Guyer, 2005).

Secondary data analysis

The Healthy Steps data were collected over a period of three years. The data sets provide an optimal opportunity for testing the ability of the New Model of Children’s Health and its Influences (NMCHI) to describe, examine, and explain relationships and associations in the present study. Use of a large, secondary data set is optimal for research on children, as children change rapidly and attain developmental milestones at different rates, with many of the developmental changes influenced by family and community inputs (Christakis, Johnston, & Connell, 2001).

Analysis of secondary data from longitudinal, developmental studies was an excellent way to answer questions not originally generated in the first study (Brooks-Gunn, Phelps, & Elder, 1991). In the field of children’s development, most studies in the past were small. The call now is to test theories in the developmental literature with larger samples that better represent the population of young children (Brooks-Gunn, Brown, Duncan, & Moore, 1995). In addition, national studies provide a large enough
sample size to adequately engage in retrospective studies, as in this present study (Duncan, 1991)

SAMPLE CHARACTERISTICS

The entire initial sample for the HS prospective study included 5,563 newborns evaluated from birth to 36 months old for the program evaluation (Guyer, Barth, Bishai, Caughy, Clark, Burkom, et al., 2003). The HS team collected data through parent questionnaires at the children’s ages of Newborn, 6 Months, and 12 Months; by extensive in-depth telephone interviews at 2-4 Months and 30-33 Months; and by review of Medical Records. The present study utilized quantitative data from only the control groups of children \( n = 2601 \) in order to obtain outcomes that were not influenced by the HS intervention program (Creswell, 2003).

VARIABLES FOR ANALYSIS

The dependent variable is whether or not young children receive either formal or informal developmental screenings. Predictor variable selection was based upon the study’s aim which was to use relevant variables from the four conceptual areas of developmental influence described by the New Model of Children’s Health and its Influences to test the explanatory usefulness of the model (Bradburn, et. al, 2003). The dependent and predictor variables with corresponding operational definitions are described in the following text and tables.

Dependent variable

The dependent variable is the receipt of developmental screenings for possible communication delays, through use of a formal screening (Denver Developmental Screening Test II: DDST-II) or informal screenings (physician observations). This
dependent variable (Table 3) was measured by whether young children did or did not receive a formal or informal screening within the time frame of birth to approximately 1100 days old. The Early Periodic Screening, Diagnosis, and Treatment (EPSDT) program under the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services recommends that children receive their first developmental screening by 270 days, or 9 months, old (Glascoe & Shapiro, 2005). For this study, screenings that are received before the 270 days old time are designated as “early” screenings and those received after 270 days are designated as “late” screenings.

As noted at the outset of the study in Chapter I, developmental screening receipt was specifically identified as one of the areas of health service effectiveness that needs improvement according to the National Research Council and Institute of Medicine (2004).

### Table 3: Dependent Variable

<table>
<thead>
<tr>
<th>Concept</th>
<th>Operation Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developmental Screening</td>
<td>Formal screening receipt</td>
</tr>
<tr>
<td></td>
<td>Informal screening receipt</td>
</tr>
<tr>
<td></td>
<td>(Time: birth to about 1100 days old.)</td>
</tr>
</tbody>
</table>

Predictor variables

The predictor variables (Table 4) for this study were grouped by application of the theoretical model into four conceptual areas of developmental influence: social environment, physical environment, biological history, and child behavioral history.
Social environment area of influence. The predictor variables selected for analyses in the social environment concept area were represented by the following:

1) The six levels of Maternal educational (Education) attainment was recoded into a dichotomous variable in which 1 = less than high school and 0 = high school graduate and any additional education (reference);

2) Child’s gender (Gender): girl is the reference group;

3) Maternal race/ethnicity (Race) was grouped into White (0) or Other (1), a category that combined Black, Hispanic, American Indians, Alaska Natives and Asian Pacific Islanders.

4) The marital status variable (Marital status) was dichotomized as 0 = Unmarried, which includes widowed, divorced and never married (reference group) 1 = Married;

5) The variable for Maternal age (Maternal age) at the time of the first survey was a continuous variable; the mothers’ ages ranged from 14 – 47 years old. For bivariate analysis, the age variable was recoded into a dichotomous variable, 0 = < 26 years old or 1 = ≥ 26 years old, but maintained as a continuous variable for multivariate analysis.

6) Maternal depression (Depression) was measured by the Center for Epidemiological Studies Depression Scale (CES-D) when the children were 2-4 months old. Scores were derived from the scale range of 0 (rarely or never) to 3 (most of the time). A score of ≥ 11 points indicated the presence of depression feelings (Guyer, 2005). Although this variable was a continuous predictor for multivariate analyses, it was recoded into a dichotomous variable for bivariate analysis as, 0 = ≥ 11 points (reference group) and 1 = < 11 points.
Physical environment area of influence. The two predictor variables selected for analysis in the physical environment area were the following:

7) The Place where the child is cared for during the day (Place) variable was dichotomized into a single variable: child’s own home/relative’s place = 0 (reference), or non-relative’s place of care = 1.

8) The other variable, Father Smokes (Smokes), was selected partly from the literature review, which noted the harmful effects of smoking on children’s development and on the obvious concern of the HS program evaluation team which asked the smoking question on every questionnaire and survey (Guyer, 2005). The smoking variable was dichotomized into: 1 = yes (smokes), 0 = no (does not smoke); ‘no’ is the reference group.

Biological history area of influence. The child’s biological history area was concerned with the genetic and biological medical history of children. There were two variables in the data set that addressed health problems:

9) One variable indicated a medical concern shown by the children’s treatment by specialty physicians other than the pediatricians. The variable was coded as child received Specialty Medical Care (Specialty care): 1 = yes, 0 = no (reference group).

10) The second variable was Birth weight (Birth weight), a continuous variable for multivariate analyses but dichotomized for bivariate analysis into ≤ 5 lbs. and > 5 lbs.

Child behavioral area of influence. The fourth conceptual area of developmental influence addressed children’s behavioral problems as judged by the mothers.

11) The variable in this area of influence was ‘frequency baby is fussy and irritable during the average day’ (Fussiness). The variable was dichotomized as 0 = almost never,
less than ½ the time (reference group); 1 = ½ the time, more than ½ the time, almost always. Table 4 displays the predictor variables coded for analyses by conceptual area of developmental influence and operational definitions.

Table 4: Predictor Variables

<table>
<thead>
<tr>
<th>Area of Influence</th>
<th>Variable</th>
<th>Operational Definition</th>
<th>Categories</th>
<th>Reference Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment;</td>
<td>Education</td>
<td>Mother's educational level of achievement</td>
<td>Less than High School (1); HS grad + (0)</td>
<td>HS grad +</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>Child Gender</td>
<td>Boys (1), Girls (0)</td>
<td>Girls</td>
</tr>
<tr>
<td></td>
<td>Race</td>
<td>Mother’s race</td>
<td>White (0), Other (1)</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>Marital status</td>
<td>Mother’s marital status</td>
<td>Married (1)</td>
<td>Unmarried</td>
</tr>
<tr>
<td></td>
<td>Age</td>
<td>Mother’s age at first survey</td>
<td>&lt; 26 years old (0)</td>
<td>&lt; 26 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Continuous in multivariate)</td>
<td>≥ 26 years old (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depression</td>
<td>Maternal Depression</td>
<td>≥ 11 points (0)</td>
<td>≥ 11 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Continuous in multivariate)</td>
<td>&lt; 11 points (1)</td>
<td></td>
</tr>
<tr>
<td>Physical Environment</td>
<td>Place of care</td>
<td>Place child cared for</td>
<td>Child’s/relative’s home (0)</td>
<td>Child’s Non-relative’s (1)</td>
</tr>
<tr>
<td></td>
<td>Smokes</td>
<td>Father smokes cigarettes</td>
<td>Yes (1), No (0)</td>
<td>No</td>
</tr>
<tr>
<td>Biology</td>
<td>Specialty care</td>
<td>Specialty medical care for child</td>
<td>Yes (1), No (0)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Birth weight</td>
<td>Child’s birth weight (lbs.)</td>
<td>≤ 5 lbs. (1)</td>
<td>&gt; 5 lbs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Continuous in multivariate)</td>
<td>&gt; 5 lbs. (0)</td>
<td></td>
</tr>
<tr>
<td>Child Behavior</td>
<td>Fussiness</td>
<td>Mother’s judgment, fussy, irritable baby</td>
<td>Never - &lt; ½ time (0); ½ time - always (1)</td>
<td>Never - &lt; ½ time</td>
</tr>
</tbody>
</table>

Source: 1995 Healthy Steps for Young Children National Program Evaluation

Variable distribution, outliers, and missing data

Frequency distributions, spread, shape, and skew of the data for each variable were examined both numerically and graphically. The nature of longitudinal data was that the distribution, spread and shape of the data was non-normal because the large
number of participants at the outset of a study decreases over time. Consequently, the sample distribution in this study formed a positive skew, to the left, with the initial participant number at n = 2601 and an ending number at n = 775.

**Outliers.** Outliers in the original data sets were marked with numerical codes and were associated with participants whose data were collected slightly past the general time frame of the three year HS study, or related to very small groups which showed an n < 5% of any group within the variables. The variables for education, race, marital status, place of caregiving, and baby's fussiness/irritability all displayed outliers. Variable transformation for each of the variables either incorporated outlier values into a near category or eliminated the outliers by coding them as ‘system-missing’. Variable recoding and transformation techniques also were used to collapse categories and create dummy variables as needed for analysis (Weinberg & Abramowitz, 2002). The variables with Likert-type scales, such as the CES-D scores, were summed. In addition to examination of variable distribution and outliers before initiation of statistical analyses, the data were reviewed for problems such as random or systematic patterns of missing values (Cohen, Cohen, West & Aiken, 2003).

**Missing values.** Missing values patterns were first visually observed in the data set. The missing values were primarily attributed to: 1) participants who left the during the longitudinal data collection time period of three years; and 2) responses that were coded in the data set as ‘don’t know’ and ‘not applicable (N/A), which were recoded as “system missing” during variable transformation. In order to ensure that each participant case included values for each of the predictors, a statistical listwise exclusion summary to
eliminate cases with missing values was completed. The remaining participant cases, n = 261, all displayed values for each of the predictors.

DATA ANALYSIS PLAN

The analyses were conducted with the Statistical Package for Social Sciences (SPSS/PASW) software, Version 18.

Bivariate and multivariate statistical tests provided analysis of the longitudinal data in order to test relationships of the New Model of Children's Health and its Influences. Bivariate analyses examined relationships between the outcome (screening) and the time measurement variables. In addition, bivariate analyses examined direct relationships between the predictor and outcome variables without the influence of time. The multivariate analyses were conducted using the survival analysis technique of Cox regression to examine relationships between the concomitantly applied predictor variables and the outcome variable, children's receipt of formal or informal developmental screenings within the birth to 1100 days old time frame. The predictors are entered into the Cox regressions using a stepwise analysis by which the predictors are grouped by area of developmental influence (AI) according to the theoretical framework.

Survival/Time-to-Event Analysis

Survival, or time-to-event analysis, was selected as the multivariate method of statistical analysis for the present study. Survival analysis is used to estimate the passage of time until a study-defined event occurs. This study examines the time until a developmental screening (the event) was received by a young child. The data shows that some children received more than one screening with some of the children receiving both formal and informal screenings. Because repeated measures analysis is not a feature of
Cox regression, only the first instances of screening receipt comprised the dependent variable. The original name for the statistical technique is survival analysis because its original function predicted the time until a study participant died in medical studies. Survival analysis is the optimal statistical technique for the present study because longitudinal data are easily managed through this technique; there are no rigid assumptions regarding distribution of data; and the technique generates probability estimates on the passage of time until the event of interest occurs.

This study had the three methodological elements deemed necessary for use of survival analysis techniques, according to Singer & Willett (2003): a target event; a starting point or beginning of time; and a meaningful scale by which to “clock time”. The target event was developmental screening receipt, with the starting point at birth, and time was measured by children’s age in days old.

The Cox regression statistic is considered a semi-parametric technique because the betas are displayed but the outcome distribution is unknown (Kleinbaum & Klein, 2005). The values of the outcome variable are estimated from the predictor values through the use of likelihood measurement. Likelihood is the probability of outcome variable value predictions based on observed predictor variable values (Tabachnick & Fidell, 2001). The Cox regression model can assess event occurrence when a number of predictors are included and in addition, can estimate the strength of effect for each of the predictor components (Bradburn, Clark, Love, & Altman, 2003). In Cox regression, explanatory predictors may be categorical (e.g., race), ordinal (e.g., education levels), binary (e.g., gender) and continuous (e.g., age). In addition, event occurrence permits the researcher to address the problem of “censoring” that occurs in longitudinal data sets.
Censoring is the term applied when the event of interest never happens for some individuals during a study, either because the individuals experienced the event after the study was completed or never had the experience at all (Singer & Willet, 2003). The problem of censoring inhibits the use of the many traditional analysis techniques (Clark, Bradburn, Love, & Altman, 2003) because the participants cease to be present in the study.

The basis of Cox regression analysis is that it is used to examine the relationships between the outcome variable in which the passage of time is controlled for, and a variety of explanatory predictor variables. The outcome variable is measured in continuous time for the duration of time intervals until the study-defined event occurs (Cohen, 2003). The relationships are expressed as hazard rates which are probability predictions that an individual will experience the event by a time period \( t \) (Clark, et al., 2003). The hazard probability rate, shown as \( h(t) \) is described as the probability that an individual at time \( t \) would experience the event at that time and is a rate of occurrence (Clark, et al. 2003). For this study, the hazard was used to measure the probability that children would receive the event, developmental screenings. The Cox regression mathematical model is the following:

\[
h(t) = h_0(t) \times \exp \{b_1x_1 + b_2x_2 + \cdots + b_px_p\}
\]

in which \( h(t) \) is the baseline hazard function and the \( x \) and \( \beta \) represent the vectors of the predictor, or predictor variables (Kleinbaum, 1996; Bradburn, et al., 2003). The regression coefficients represent the relative effect of every predictor variable on survivor function (Tabachnick & Fidell, 2001).
A predictor is positively associated with the event probability when the $b_i$ is greater than zero, or the hazard ratio is greater than 1, in which the hazard of risk increases, and consequently, has a negative association with length of survival (Bradburn, et al., 2003). As the value of the predictor increases, the hazard of event occurrence increases which results in the time to the event decreasing (Bradburn, et al., 2003). A hazard ratio less than one indicates that the risk of the event occurring is decreased (Allison, 2005).

**Strength of association**

Log-likelihood (LL) results contribute to testing a hypothesis. The LL results also contribute to examination of variability between the predictors and survival in a model. The explanatory power for the two overall models is calculated from the commonly used formula for explained variation, generalized $R^2 \left[ R^2 = 1 - \exp(X_{LR^2})/n \right]$ in which $(X_{LR^2})$ is the likelihood ratio test chi-square statistic for the model as a whole and $n$ is the number of participants (Gillespie, 2006). The final chi-square of each Cox regression, found in the Cox regression SPSS output as “Change from Previous Block,” is used for the $(X_{LR^2})$ (Tabachnick & Fidell, 2001). The likelihood-ratio chi-square statistics were used for comparison of the formal and informal screening models.

For this study, the $R^2$ statistic was used as an indicator of association between the predictor variables as they comprise each model as a whole and survival (Tabachnick & Fidell, 2001) rather than as a measure of variance as in linear regressions. The $R^2$ ratio was used to explain that proportion of the dependent variable variability which was not explained by the model (Freese & Long, 2006). An $R^2$ closer to 1 than to 0 indicated the
strength of association of the predictor variables in the whole models to the dependent variables.

Power analysis

Power analysis in statistical testing is described as the probability that the statistical testing will find differences or relationships between variables which can be acknowledged as statistically significant if the differences or relationships truly exist (Munro, 2001; Cohen, Cohen, West & Aiken, 2003). Power analysis is related to the probability of rejecting a null hypothesis when it should be rejected, avoiding a Type II error. Effect size, the measurement of the strength of the relationships between variables, significance criterion (α); and sample size are interrelated concepts of statistical inference associated with statistical power (Munro, 2001). For a standard multiple regression with a significance criterion of .05, 11 predictors, a medium (.15) anticipated effect size, and desired power level of .80, the minimum sample size should be at least n = 122 (Soper, 2010). This study had a sample size of n = 260 for formal screenings and n = 261 for informal screenings.

However, in survival analysis, power corresponds to the number of events that are found to occur at the end of the study, rather than the number of study participants (Bradburn, et al., 2003). The online power calculators for survival analysis focus on the binary, longitudinal logrank statistical test rather than the multivariate Cox regression analysis. Thus, power estimations for the current study are difficult to ascertain. This study has a sample size of n = 260 - 261, significance criterion (α) of .05, anticipated effect size of .15, and 11 predictor variables. The number of events for formal screenings is n = 35; for informal screenings the event number is n = 101. The standard number of
events per predictor in Cox regression has been 10 events for each predictor although there is some controversy on this topic (Vittinghoff & McCulloch, 2006).
CHAPTER IV
RESULTS

This chapter begins with a display of the frequency distribution of parent responsiveness to initial questionnaire and the two in-depth telephone interviews. The frequency distributions of formal and informal screenings are presented. Next, bivariate results of the relationships between the predictor and outcome variables are shown. Finally the multivariate results are shown with respect to how well the formal and informal models predict screening receipt. The corresponding estimated survival curves are displayed.

At the outset of the HS study, 100 percent (n = 2601) of the parents responded to the Newborn questionnaire. Participants were lost to the original study over time through good health with little need for health care visits other than well-child checkups, health insurance changes, relocation, parents not receiving the questionnaires, parents’ failure to fill out and return the questionnaires, and parent lack of interest in continuing to participate (Guyer, 2005).

In the original (HS) study, parents responded better to the two in-depth telephone interviews conducted by the HS program evaluation team than to parent questionnaires mailed to the family homes. Observation of the data showed that the first telephone interview took place when the infants were 2-4 months old with 70 percent (n = 1826) of the parents responding. For the second telephone interview, at the 30-33 month old time period, 30 percent (n = 775) continued to participate in the HS study. Table 5 shows the distribution of parent responsiveness to the initial questionnaire and to the in-depth telephone interviews.
Table 5: Parent Response to In-depth Telephone Interviews

<table>
<thead>
<tr>
<th>Child Age</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>2601</td>
<td>100</td>
</tr>
<tr>
<td>2-4 months</td>
<td>1826</td>
<td>70</td>
</tr>
<tr>
<td>30-33 months</td>
<td>775</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: 1995 Healthy Steps for Young Children National Program Evaluation

Receipt of formal and informal screenings and no screening of either kind, are displayed in Table 6. Informal screenings were received more frequently (33.4%; n = 870) than formal screenings (10.3%; n = 268), with both kinds of screenings fairly low in frequency for the size of the total sample (n = 2601).

Table 6: Percent and Number of Developmental Screenings

<table>
<thead>
<tr>
<th>Developmental Screening</th>
<th>Screening Receipt</th>
<th>No Screening</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>N</td>
<td>Percent</td>
</tr>
<tr>
<td>Formal</td>
<td>10.3</td>
<td>268</td>
<td>89.7</td>
</tr>
<tr>
<td>Informal</td>
<td>33.4</td>
<td>870</td>
<td>66.6</td>
</tr>
</tbody>
</table>

Source: 1995 Healthy Steps for Young Children National Program Evaluation

BIVARIATE RESULTS

Screening group differences

The Kruskal-Wallis $H$ test was used to compare whether variability existed among the distributions of the screenings by age received by each group (formal, informal, no screening). A significant result was found ($H(2) = 121.8$, $p = 0.000$) indicating that the three groups differed from each other, the observations were from a single sample, and the samples were approximately the same distribution. The formal
screening group showed the largest mean rank at 1625.26, followed by the no screening group rank at 1361.74, with the informal screening group at the lowest rank, 1099.28.

Table 7 shows the ranked results.

Table 7: Screening Group Ranks by Child Age

<table>
<thead>
<tr>
<th>Screening Group</th>
<th>N</th>
<th>Mean Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal</td>
<td>266</td>
<td>1625.26</td>
</tr>
<tr>
<td>No screening</td>
<td>1466</td>
<td>1361.74</td>
</tr>
<tr>
<td>Informal</td>
<td>869</td>
<td>1099.28</td>
</tr>
</tbody>
</table>

Mean age of screening

Children's age in days old is the continuous variable used as the time indicator for the outcome variable (Table 8). The children ranged in age from birth/zero days old to ±1100 days old. The mean age of children who received formal screenings was older (515 days old) than the mean age children who received informal screenings (276 days old).

Calculation of two independent t tests compared the mean age for formal screenings/no formal screenings and informal screenings/no informal screenings. There were significant differences between the two groups, with p = 0.000 for each.

Table 8: Age by Formal or Informal Screening

<table>
<thead>
<tr>
<th>Screening</th>
<th>Child's Age in Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Formal</td>
<td>515</td>
</tr>
<tr>
<td>No Formal Screening</td>
<td>346</td>
</tr>
<tr>
<td>Informal</td>
<td>276</td>
</tr>
<tr>
<td>No Informal Screening</td>
<td>407</td>
</tr>
</tbody>
</table>
Screenings by social environment predictors

The chi square test of independence was used to determine whether the likelihood of screening varied across categories of predictor variables for social environment predictors (AI-1). The results for all social environment predictors are shown in Table 9.

*Maternal education.* Maternal educational accomplishment was not significantly related to formal or informal screenings.

*Gender.* Child’s Gender was not significantly related to formal or informal screenings.

*Race.* There was not a significant relationship between formal or informal screening receipt and Race.

*Marital status.* There was not a significant relationship between Marital status and formal or informal screenings.

*Maternal age.* There was not a significant relationship between maternal age and formal or informal screenings.

*Maternal depression.* There was not a significant relationship between maternal depression and formal and informal screenings.

Screenings by Physical Environment Predictors

Calculations to compare the frequency of events for formal and informal screening receipt with each predictor variable of the physical environment area of developmental influence (AI-2) was achieved through use of the chi square statistic. The results for physical environment predictors are shown in Table 10.

*Place of care.* No significant relationships were found between child’s places of daycare and formal or informal screenings
Father smokes. There was no significant relationship between formal and informal screenings and paternal smoking.

Table 9: Formal or Informal Screening Receipt by Social Environment Predictors

<table>
<thead>
<tr>
<th>Predictor Category</th>
<th>Formal Screening (n)</th>
<th>Informal Screening (n)</th>
<th>No Screenings (n)</th>
<th>χ²</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; HS</td>
<td>8.8% (44)</td>
<td>33.6% (168)</td>
<td>57.6% (288)</td>
<td>1.463</td>
<td>2</td>
<td>.481</td>
</tr>
<tr>
<td>HS Grad+</td>
<td>10.6% (222)</td>
<td>33.4% (699)</td>
<td>56.0% (1173)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girl</td>
<td>9.5% (127)</td>
<td>32.8% (437)</td>
<td>55.0% (697)</td>
<td>2.483</td>
<td>2</td>
<td>.289</td>
</tr>
<tr>
<td>Boy</td>
<td>11.0% (139)</td>
<td>34.1% (432)</td>
<td>57.7% (769)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>10.8% (153)</td>
<td>34.4% (486)</td>
<td>54.7% (773)</td>
<td>3.716</td>
<td>2</td>
<td>.156</td>
</tr>
<tr>
<td>Other</td>
<td>9.6% (111)</td>
<td>31.9% (368)</td>
<td>58.5% (675)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>10.1% (97)</td>
<td>32.1% (308)</td>
<td>57.8% (555)</td>
<td>1.455</td>
<td>2</td>
<td>.483</td>
</tr>
<tr>
<td>Unmarried</td>
<td>10.4% (169)</td>
<td>34.2% (557)</td>
<td>55.4% (903)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 26 years</td>
<td>9.8% (126)</td>
<td>33.0% (427)</td>
<td>57.2% (739)</td>
<td>.948</td>
<td>2</td>
<td>.623</td>
</tr>
<tr>
<td>≥ 26 years</td>
<td>10.8% (140)</td>
<td>33.6% (437)</td>
<td>55.7% (725)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 11 points</td>
<td>11.6% (135)</td>
<td>34.7% (404)</td>
<td>53.7% (624)</td>
<td>.239</td>
<td>2</td>
<td>.887</td>
</tr>
<tr>
<td>&lt; 11 points</td>
<td>11.0% (84)</td>
<td>35.6% (271)</td>
<td>53.4% (406)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10: Formal or Informal Screening Receipt by Physical Environment Predictors

<table>
<thead>
<tr>
<th>Predictor Category</th>
<th>Formal Screening (n)</th>
<th>Informal Screening (n)</th>
<th>No Screenings (n)</th>
<th>χ²</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place of Daycare</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child's/relative</td>
<td>11.9% (65)</td>
<td>35.5% (194)</td>
<td>52.6% (278)</td>
<td>.082</td>
<td>2</td>
<td>.960</td>
</tr>
<tr>
<td>Non-relative's</td>
<td>11.3% (17)</td>
<td>36.7% (55)</td>
<td>52.0% (78)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal Smoking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>10.5% (188)</td>
<td>33.5% (603)</td>
<td>56.0% (1008)</td>
<td>.192</td>
<td>2</td>
<td>.909</td>
</tr>
<tr>
<td>Yes</td>
<td>9.9% (68)</td>
<td>33.8% (233)</td>
<td>56.4% (389)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Screenings by biological history predictors

Table 11 shows the results of the frequency comparisons by chi square analyses of biological history predictors (AI-3) and child’s receipt of formal or informal developmental screenings.

Specialty care. There was a significant relationship between formal and informal screenings and Specialty care \( \chi^2 (2) = 6.783, p = 0.034 \). Children who needed some form of Specialty care (6.5%) were significantly less likely to receive formal screenings than children who did not need the special care (13.6%).

Birth weight. There was no significant relationship between formal and informal screenings and birth weight at the \( p < .05 \) significance level.

Table 11: Formal or Informal Screening Receipt by Biological History Predictors

<table>
<thead>
<tr>
<th>Predictor Category</th>
<th>Formal Screening (n)</th>
<th>Informal Screening (n)</th>
<th>No Screenings (n)</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialty</td>
<td>No</td>
<td>13.6% (81)</td>
<td>37.4% (223)</td>
<td>49.1% (293)</td>
<td>6.783</td>
<td>2</td>
</tr>
<tr>
<td>Medical Care</td>
<td>Yes</td>
<td>6.5% (9)</td>
<td>34.8% (48)</td>
<td>58.7% (81)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight</td>
<td>≥ 5 lbs.</td>
<td>10.3% (235)</td>
<td>32.8% (749)</td>
<td>56.9% (1301)</td>
<td>5.546</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>&lt; 5 lbs.</td>
<td>10.9% (29)</td>
<td>39.5% (105)</td>
<td>49.6% (132)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Significant at the \( p < 0.05 \) level

Screenings by child behavioral history predictors

A chi square calculation to compare formal and informal screening receipt and the child behavioral predictor (AI-4) resulted in the data presented in Table 12.

Fussiness. A significant relationship was found between formal and informal screenings the fussiness predictor \( \chi^2 (2) = 6.245, p = 0.044 \). Children reported as fussy/irritable daily in less than \( \frac{1}{2} \) of the time to almost never (13.1%) were more likely
to receive formal screenings than children who were fussy more than \( \frac{1}{2} \) the time to almost always (9.5%)

**Table 12: Formal or Informal Screening Receipt by Behavioral History Predictors**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Category</th>
<th>Formal Screening (n)</th>
<th>Informal Screening (n)</th>
<th>No Screenings (n)</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fussy/irritable</td>
<td>&lt; ( \frac{1}{2} ) time - 13.1% (134)</td>
<td>34.4% (352)</td>
<td>52.4% (536)</td>
<td>6.245</td>
<td>2</td>
<td>.044**</td>
<td></td>
</tr>
<tr>
<td>daily</td>
<td>almost never;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt; ( \frac{1}{2} ) time - 9.5% (85)</td>
<td>35.9% (322)</td>
<td>54.6% (490)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>almost always</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Significant at the p < 0.05 level**

**Bivariate Results Summary**

Slightly over 10% of children received formal screenings at an average age of 515 days old. More than 33% received informal screenings, at the average age of 276 days old. Most children received neither a formal screening (89%) nor an informal screening (66%). Neither social nor physical environment areas of influence predictors were related to formal and informal screenings. Results show that predictors from both the biological and child behavioral history areas of influence were related to screening receipt. Table 13 summarizes the bivariate results according to the structure of the New Model of Children’s Health and its Influences (NMCHI).

Two predictors showed significant relationships to screening receipt indicating that the predictors were not independent of the screening event variables. The non-significant results of the remaining relationships indicate that there was no relationship between these predictors and the screening variable. APPENDIX B shows the variables by label from the data sets.
Table 13: Bivariate Results Summary for Screening Receipt

<table>
<thead>
<tr>
<th>NMCHI Areas of Influence (AI)</th>
<th>Variable</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment (AI-1)</td>
<td>Education</td>
<td>0.481</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
<td>0.289</td>
</tr>
<tr>
<td></td>
<td>Race</td>
<td>0.156</td>
</tr>
<tr>
<td></td>
<td>Marital Status</td>
<td>0.483</td>
</tr>
<tr>
<td></td>
<td>Maternal Age</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>Maternal Depression</td>
<td>0.887</td>
</tr>
<tr>
<td>Physical Environment (AI-2)</td>
<td>Place of Daycare</td>
<td>0.960</td>
</tr>
<tr>
<td></td>
<td>Father Smokes</td>
<td>0.909</td>
</tr>
<tr>
<td>Biological History (AI-3)</td>
<td>Specialty Medical Care</td>
<td>0.034**</td>
</tr>
<tr>
<td></td>
<td>Birth weight</td>
<td>0.062</td>
</tr>
<tr>
<td>Child Behavioral History (AI-4)</td>
<td>Fussy, irritable daily</td>
<td>0.044**</td>
</tr>
</tbody>
</table>

** Significant at the p < 0.05 level

MULTIVARIATE RESULTS

Cox regression analysis was used to estimate the hazard ratios for the effects of predictor variables on the event occurrence of developmental screening receipt. The hazards were the dependent variable, likelihood of screening receipt within some time period. As each predictor by area of influence (AI) was added to the regression, the model was reviewed. Predictors which contributed to the model were maintained in the model; predictors which detracted from the significance of the model and the number of events were removed.

The regression coefficients, hazard ratios, significance levels, and 95% confidence intervals for each predictor variable are presented. Each coefficient ($b_i$) represents the mean difference between the reference group and the comparison group. A negative coefficient ($b_i$) or a hazard ratio (HR) of any point less than one (1) is indicative
of a decreased probability that the event will occur (Allison, 2005). Conversely, the HR of more than one (1) not only reveals an increased probability that the event will occur, but will occur early in time. Singer & Willet (2003) report that “precise event times” are not relevant; it is the rank order that is important in Cox regression. The formal model and survival curve are shown first, followed by the informal model and survival curve.

MODEL OF FORMAL SCREENINGS

All of the predictor variables were entered into the Cox regression analysis by AI in blocks for analysis. The Gender variable showed a high p-value at > 0.9. Chi square analysis of Gender with each of the dummy predictor variables showed pervasive multicollinearity associated with Gender. Consequently, the predictor was dropped.

The remaining predictors were added to the model in blocks by NMCHI conceptual areas of influence (AI). Table 14 shows the variables in the equation. Maternal depression (p = 0.000) and Race (p = 0.028) were significant predictors and show evidence of early screening by the hazard ratios greater than 1. The residual $X^2$ for this model = 8.926, 5 df, and $p = 0.112$.

**Table 14: Formal Screenings by Area of Influence-1**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/ HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.057</td>
<td>.036</td>
<td>2.492</td>
<td>1</td>
<td>.114</td>
<td>.945</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.121</td>
<td>.033</td>
<td>13.679</td>
<td>1</td>
<td>.000</td>
<td>1.129</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-1.038</td>
<td>.572</td>
<td>3.294</td>
<td>1</td>
<td>.070</td>
<td>.354</td>
</tr>
<tr>
<td>Maternal Race</td>
<td>1.064</td>
<td>.484</td>
<td>4.830</td>
<td>1</td>
<td>.028</td>
<td>2.897</td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-.584</td>
<td>.608</td>
<td>.922</td>
<td>1</td>
<td>.337</td>
<td>.558</td>
</tr>
</tbody>
</table>

Table 15 shows the contribution of the physical environment AI to the model. The 2 predictors added to the model (now AI-1, 2) continued to show the model as significantly (p = 0.000) related to screenings. Maternal depression and Race continued to
show significance as predictors. The three predictors not included in the model yet (Birth weight, Specialty care, and Fussiness) comprised the residual $X^2 = 5.959$, 3 df, and $p = 0.114$.

Table 15: Formal Screenings by Areas of Influence-1, 2

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.057</td>
<td>.036</td>
<td>2.550</td>
<td>1</td>
<td>.110</td>
<td>.944</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.122</td>
<td>.034</td>
<td>12.572</td>
<td>1</td>
<td>.000</td>
<td>1.130</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.792</td>
<td>.608</td>
<td>1.695</td>
<td>1</td>
<td>.193</td>
<td>.453</td>
</tr>
<tr>
<td>Maternal Race</td>
<td>1.116</td>
<td>.484</td>
<td>5.311</td>
<td>1</td>
<td>.021</td>
<td>3.052</td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-.362</td>
<td>.625</td>
<td>.336</td>
<td>1</td>
<td>.562</td>
<td>.696</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>.466</td>
<td>.441</td>
<td>1.114</td>
<td>1</td>
<td>.291</td>
<td>1.593</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>.794</td>
<td>.597</td>
<td>1.767</td>
<td>1</td>
<td>.184</td>
<td>2.212</td>
</tr>
</tbody>
</table>

The contribution of the biological history (AI-3) predictors to the developing overall model is shown in Table 16, AI-1, 2, 3. The model remained significantly related to formal screening receipt with $p = 0.000$. Maternal depression and Race continued to show significance with concomitant displays of increased likelihoods of early screenings. The residual $X^2 = 4.168$, 1 df, and $p = 0.041$.

Table 16: Formal Screenings by Areas of Influence-1, 2, 3

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.058</td>
<td>.035</td>
<td>2.718</td>
<td>1</td>
<td>.099</td>
<td>.943</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.119</td>
<td>.034</td>
<td>12.542</td>
<td>1</td>
<td>.000</td>
<td>1.126</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.751</td>
<td>.612</td>
<td>1.506</td>
<td>1</td>
<td>.220</td>
<td>.472</td>
</tr>
<tr>
<td>Maternal Race</td>
<td>1.091</td>
<td>.489</td>
<td>4.985</td>
<td>1</td>
<td>.026</td>
<td>2.977</td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-.312</td>
<td>.630</td>
<td>.245</td>
<td>1</td>
<td>.621</td>
<td>.732</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>.557</td>
<td>.448</td>
<td>1.547</td>
<td>1</td>
<td>.214</td>
<td>1.745</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>.903</td>
<td>.595</td>
<td>2.307</td>
<td>1</td>
<td>.129</td>
<td>2.467</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>-.194</td>
<td>.148</td>
<td>1.721</td>
<td>1</td>
<td>.190</td>
<td>.823</td>
</tr>
<tr>
<td>Specialty Medical Care</td>
<td>.170</td>
<td>.557</td>
<td>.093</td>
<td>1</td>
<td>.761</td>
<td>1.185</td>
</tr>
</tbody>
</table>
The final addition to the model, AI-4, included the predictor, Fussiness (Table 17). The whole model (AI-1, 2, 3, 4) was significantly associated with formal screenings with the overall p-value at 0.000. The final predictor, Fussiness, was a significant predictor (p = 0.045) of formal screenings. Table 18 shows the final areas of influence and predictors that contributed to the model significance.

Table 17: Formal Screenings by Areas of Influence-1, 2, 3, 4

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-0.069</td>
<td>0.035</td>
<td>2.718</td>
<td>1</td>
<td>0.099</td>
<td>0.943</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>0.141</td>
<td>0.034</td>
<td>12.542</td>
<td>1</td>
<td>0.000</td>
<td>1.126</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-0.891</td>
<td>0.612</td>
<td>1.506</td>
<td>1</td>
<td>0.220</td>
<td>0.472</td>
</tr>
<tr>
<td>Maternal Race</td>
<td>1.065</td>
<td>0.489</td>
<td>4.985</td>
<td>1</td>
<td>0.26</td>
<td>2.977</td>
</tr>
<tr>
<td>Maternal Education</td>
<td>-0.574</td>
<td>0.630</td>
<td>0.245</td>
<td>1</td>
<td>0.621</td>
<td>0.732</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>0.849</td>
<td>0.448</td>
<td>1.547</td>
<td>1</td>
<td>0.214</td>
<td>1.745</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>0.849</td>
<td>0.595</td>
<td>2.307</td>
<td>1</td>
<td>0.129</td>
<td>2.467</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>-0.230</td>
<td>0.148</td>
<td>1.721</td>
<td>1</td>
<td>0.190</td>
<td>0.823</td>
</tr>
<tr>
<td>Specialty Medical Care</td>
<td>0.054</td>
<td>0.557</td>
<td>0.093</td>
<td>1</td>
<td>0.761</td>
<td>1.185</td>
</tr>
<tr>
<td>Fussy/irritable Daily</td>
<td>0.820</td>
<td>0.409</td>
<td>4.032</td>
<td>1</td>
<td>0.045</td>
<td>2.272</td>
</tr>
</tbody>
</table>

Table 18: Cox Regression of the NMCHI as a Whole: Formal Screening Events

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient (b_i)</th>
<th>Hazard Ratio exp(b_i)</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race [White]</td>
<td>1.065**</td>
<td>2.902</td>
<td>0.026</td>
<td>1.133, 7.430</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal Age</td>
<td>-0.069**</td>
<td>0.933</td>
<td>0.048</td>
<td>0.871, 0.999</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>0.141***</td>
<td>1.151</td>
<td>0.000</td>
<td>1.074, 1.234</td>
</tr>
<tr>
<td>Physical Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological History</td>
<td>No significant predictors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Behavioral History</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fussy, irritable Problem</td>
<td>0.820**</td>
<td>2.272</td>
<td>0.045</td>
<td>1.020, 5.060</td>
</tr>
</tbody>
</table>

N/Events = 35
** Significant at the p < 0.05 level; ***Significant at the p < 0.01 level
NOTE: Brackets [ ] = reference group
Social environment area of influence

Three social environment variables, maternal race, maternal age, and maternal depression were found to significantly predict formal screening receipt.

Race. Maternal race measured the effects of the Other race group compared to the White race group. The maternal race variable significantly predicted ($p = 0.026$) an increased likelihood of formal screening receipt. The hazard ratio (2.902) showed that the rate of formal screening receipt of the Other race group was 90.2 percent times that of the White group. The alternative interpretation ($1/HR$) is that children with mothers from the White group had 0.344 times less the rate of screenings than children whose mothers were in the Other race group. The positive regression coefficient ($b_1$) and the HR with a value greater than 1 indicated the probability of a shorter time to formal screenings.

Age. The maternal age variable was a significant predictor of formal screening receipt ($p = 0.048$). The results for this continuous predictor represent the impact of maternal age on children’s receipt of formal screenings at the time of the event. That is, the hazard ratio estimate of 0.933 indicates that for each year older the mother is, the estimated hazard of formal screening receipt is 0.93 times for children one day younger. This result was also interpreted in a percentage statement created by the formula: $100(\text{HR} - 1)$. Thus, $100(0.933 - 1) = -6.7$ percent. The percentage showed that the estimated hazard of screening receipt was 6.7 percent lower for each year increase in maternal age at the time the screening event occurred.

Maternal depression. The final significant variable in the social environment area of influence, maternal depression, not only significantly predicted a greater likelihood of formal screenings ($p = 0.000$), but a greater likelihood of early screenings. The positive
coefficient value and the HR = 1.151 indicated that higher maternal depression scores were predictive of a 15.1 percent increase in likelihood that the screenings will occur early in childhood. Thus, for each point more on the maternal depression scale, the hazard ratio estimate for formal screenings increased 15.1 percent.

Physical environment area of influence

Neither of the two physical environment variables showed significant predictive likelihoods that formal screening events would occur.

Biological history area of influence

The biological history area of influence was not predictive of screening receipt.

Child behavior area of influence

The single variable for this area of influence was Fussiness, which was a significant predictor of formal screening receipt (p = 0.045). The positive estimated hazard at 2.272 indicates a 27.2 percent increase in the likelihood of screenings for babies who ‘almost always’ are fussy and irritable every day. Alternatively stated by 1/HR, babies who were ‘almost never’ fussy and irritable daily had 0.440 times less the estimated rate of formal screenings. The positive regression coefficient and estimated hazard ratio indicate an increased likelihood of early screening receipt.

Formal model strength of association. The $R^2$ calculated from the log-likelihood chi-square statistic for the formal model as a whole indicates strength of association between the predictor variables in the areas of influence and the outcome. The results indicated the total proportion of variability in survival explained by the model. Although the number of cases varied greatly by area of influence, the overall model number of cases was 197, the value used for the overall model $R^2$ calculation. As each area of
influence (AI) was added in stepwise blocks, each successive model continued to show significance as predictive of formal screenings at \( p = 0.000 \) and the overall model remained significant \( ( p = 0.000 ) \). The -2 log-likelihood (-2LL) values decreased with each AI addition, from the null of -2LL = 293.577 before the first block to -2LL = 260.819 for the final block. Typically the value of the -2LL increases as each block of predictors is added to the model. The generalized \( R^2 \) showing the association of the formal model as a whole with survival until screening receipt was the \( R^2 \) value = 0.28.

Summary of formal screening results

The four conceptual areas of developmental influence were considered together in one multivariate model. Two of the areas, social environment and child behavioral history showed variables that were significantly predictive of formal screening receipt. Maternal race, age and depression and baby’s fussiness and irritability predicted children’s receipt of formal developmental screenings. The hazard ratio values for maternal depression, race, and baby’s fussiness/irritability all showed an increased likelihood of early screening receipt rather than delayed screening likelihood. The assessment of how well the predictors in the model as a whole were associated with variability in survival until receipt of formal screenings showed strength of association by the \( R^2 \) results.

Formal screenings survival curve

The cumulative survival curve for the formal screenings by duration of time is shown in Figure 2. The curve reflected the contributions of the predictor variables. Participants were entered into the study at birth, shown at the zero point on the x-axis. The number of participants in the study at the outset on the y-axis began at 1.0, with the
total number at, \( n = 2601 \). The number of formal screening events was \( n = 35 \). The survival function shown on the x-axis referred to the percentage of participants that remained in the study until a certain point in time. The flat aspect of the line indicated that time was passing without receipt of screenings. Each drop in the curve line reflected the cohort age and number of participants who received the formal screenings.

As each screening took place, Cox regression recalculated the proportion of children still available to receive screenings. Visual inspection showed that several participants first received formal screenings between 175 - 180 days old (about 6 months old) followed by very few at about 200 days old. The curve flattened out when the probability of screening receipt declined and then dropped again when several

**Figure 2: Formal Screenings Survival Curve**

participants received screenings at about 380 days old (a little over 1 year old), and so on. From about 540-570 days, a series of events occurred. From about 920-960 days, a
number of participants, individuals or small cohorts, received formal screenings shown by the series of flat lines followed by sharp drops in the curve.

*Summary of the formal curve.* Visual inspection of the curve decrements indicated a likelihood that the majority of the participants received formal screenings at the times typically associated with well-child checkups, specifically 3 months (90 days), 6 months (180 days), 12 months (360 days) and so on. The curve indicated the likelihood that many of the screenings occurred between the 900-1095 days old (30-36 months/3 years old) time frame, when young children leave the study and prepare to attend preschool. Table 19 shows the correlation matrix of the formal screening regression coefficients.

APPENDIX C shows the Kaplan-Meier log-rank survival curves group comparisons of the predictor variables. Parallel lines which cross or move close together indicated very little difference between groups. Parallel lines that are separate indicated significant differences between groups.

**Table 19: Formal Screening Correlation Matrix of Regression Coefficients**

<table>
<thead>
<tr>
<th>Maternal Age</th>
<th>Depression</th>
<th>Maternal Status</th>
<th>Race</th>
<th>Educ</th>
<th>Daycare Place</th>
<th>Father Smokes</th>
<th>Birth Weight</th>
<th>Special Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>-.136</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital</td>
<td>.261</td>
<td>-.007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>-.287</td>
<td>.261</td>
<td>.097</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>.254</td>
<td>.008</td>
<td>-.007</td>
<td>.206</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daycare Place</td>
<td>-.066</td>
<td>.266</td>
<td>-.036</td>
<td>.039</td>
<td>.061</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father Smokes</td>
<td>-.021</td>
<td>-.014</td>
<td>.274</td>
<td>.070</td>
<td>.174</td>
<td>.131</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth Weight</td>
<td>.067</td>
<td>.007</td>
<td>.029</td>
<td>.000</td>
<td>-.011</td>
<td>-.132</td>
<td>-.047</td>
<td></td>
</tr>
<tr>
<td>Special Care</td>
<td>.008</td>
<td>-.011</td>
<td>.183</td>
<td>-.027</td>
<td>.092</td>
<td>-.029</td>
<td>.126</td>
<td>.086</td>
</tr>
<tr>
<td>Fussy Baby</td>
<td>-.176</td>
<td>.320</td>
<td>-.119</td>
<td>-.009</td>
<td>-.214</td>
<td>.300</td>
<td>-.018</td>
<td>-.138</td>
</tr>
</tbody>
</table>
MODEL OF INFORMAL SCREENINGS

Cox regression analysis on the informal screening model began with each of the predictor variables entered into the analysis in stepwise block progression by area of influence (AI). Child Gender was previously removed because of multicollinearity. The social environment predictors, Education and Race, were eliminated because the p-value levels for both predictors rose to very high values (> 0.95), multicollinearity was observed between each other and predictors in different areas, and the model was not significant. When the education and race predictors were removed, the model as a whole showed a significant relationship to informal screenings. There were 101 informal screenings.

The 3 predictors for the social environment (AI-1) are shown in Table 20. The model was not a significant predictor of screenings (p = 0.170), with none of the 3 predictors approximating significance. The 5 predictors ‘not in the equation’ yet show a \(X^2 = 11.213\), 5 df, and \(p = 0.047\).

Table 20: Informal Screenings by Area of Influence-1

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/ HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.009</td>
<td>.018</td>
<td>.275</td>
<td>1</td>
<td>.600</td>
<td>.991</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.035</td>
<td>.021</td>
<td>2.819</td>
<td>1</td>
<td>.093</td>
<td>1.036</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.389</td>
<td>.265</td>
<td>2.151</td>
<td>1</td>
<td>.142</td>
<td>.678</td>
</tr>
</tbody>
</table>

The physical environment (AI-1, 2) predictors were combined with those of the social environment. Table 21 shows the coefficients, p-values and hazard ratios of interest. None of the predictors were significant for indicating relationships with informal screenings. The ‘variables not in the equation’ chart (not shown) indicated that Birth
weight continued to show significance before it was added to the model, creating a residual chi square significance of $p = .012$, $X^2 = 11.029$, and 3 df.

**Table 21: Informal Screenings by Area of Influence-1, 2**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.010</td>
<td>.018</td>
<td>.324</td>
<td>1</td>
<td>.569</td>
<td>.990</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.035</td>
<td>.021</td>
<td>2.729</td>
<td>1</td>
<td>.099</td>
<td>1.035</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.366</td>
<td>.273</td>
<td>1.793</td>
<td>1</td>
<td>.181</td>
<td>.694</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>-.003</td>
<td>.229</td>
<td>.000</td>
<td>1</td>
<td>.989</td>
<td>.997</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>.099</td>
<td>.250</td>
<td>.156</td>
<td>1</td>
<td>.692</td>
<td>1.104</td>
</tr>
</tbody>
</table>

Area of Influence-1, 2, 3 was comprised of the biological history predictors added to the two previous blocks of predictors. The model that AI-1, 2, 3 represented was a significant predictor of informal screenings with $p = 0.037$. Table 22 shows the results. The residual $X^2 = 1.922$, 1 df, and $p = 0.166$.

**Table 22: Informal Screenings by Area of Influence-1, 2, 3**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.013</td>
<td>.018</td>
<td>.501</td>
<td>1</td>
<td>.479</td>
<td>.987</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.037</td>
<td>.020</td>
<td>3.364</td>
<td>1</td>
<td>.067</td>
<td>1.037</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.405</td>
<td>.274</td>
<td>2.179</td>
<td>1</td>
<td>.140</td>
<td>.667</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>.082</td>
<td>.233</td>
<td>.124</td>
<td>1</td>
<td>.725</td>
<td>1.085</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>.161</td>
<td>.247</td>
<td>.422</td>
<td>1</td>
<td>.516</td>
<td>2.174</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>-.253</td>
<td>.086</td>
<td>8.739</td>
<td>1</td>
<td>.003</td>
<td>.776</td>
</tr>
<tr>
<td>Specialty Medical Care</td>
<td>.174</td>
<td>.277</td>
<td>.392</td>
<td>1</td>
<td>.531</td>
<td>1.190</td>
</tr>
</tbody>
</table>

Area of Influence (AI-1,2,3,4) represented the informal model as a whole with the addition of the final conceptual area with the predictor, Fussiness (Table 23). The model as a whole was significantly related to informal screenings ($p = 0.033$). Two areas of influence were significant predictors of the informal screenings: social environment with Maternal depression as the contributing predictor variable, and biological history with
Birth weight as the significant contributory predictor variable.

Table 23: Informal Screenings by Area of Influence-1,2,3,4

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>SE</th>
<th>Wald</th>
<th>df</th>
<th>p-value</th>
<th>Exp(B)/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td>-.013</td>
<td>.018</td>
<td>.534</td>
<td>1</td>
<td>.465</td>
<td>.987</td>
</tr>
<tr>
<td>Maternal Depression</td>
<td>.042</td>
<td>.020</td>
<td>4.315</td>
<td>1</td>
<td>.038</td>
<td>1.043</td>
</tr>
<tr>
<td>Marital Status</td>
<td>-.415</td>
<td>.276</td>
<td>2.261</td>
<td>1</td>
<td>.133</td>
<td>.660</td>
</tr>
<tr>
<td>Place of Child Care</td>
<td>.142</td>
<td>.238</td>
<td>.359</td>
<td>1</td>
<td>.549</td>
<td>1.153</td>
</tr>
<tr>
<td>Father Smokes</td>
<td>.137</td>
<td>.248</td>
<td>.305</td>
<td>1</td>
<td>.581</td>
<td>1.147</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>-.261</td>
<td>.086</td>
<td>9.100</td>
<td>1</td>
<td>.003</td>
<td>.770</td>
</tr>
<tr>
<td>Specialty Medical Care</td>
<td>.178</td>
<td>.278</td>
<td>.412</td>
<td>1</td>
<td>.521</td>
<td>1.195</td>
</tr>
<tr>
<td>Fussy/Irritable Daily</td>
<td>.292</td>
<td>.211</td>
<td>1.911</td>
<td>1</td>
<td>.167</td>
<td>1.339</td>
</tr>
</tbody>
</table>

Estimations of hazard ratios for the likelihood of informal screenings were achieved by Cox regression. The predictors were considered together in one model and the results are the following, shown in Table 24. The final informal screening model, which included all of the predictors in the regression, showed only the significant predictors of the screenings. Maternal depression and birth weight were the only two predictors associated with informal screenings.

Table 24: Cox Regression of the NMCHI as a Whole: Informal Screening Events

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient ($b$)</th>
<th>Hazard Ratio $\exp(b)$</th>
<th>p-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CES-D (0-40)</td>
<td>0.042**</td>
<td>1.043</td>
<td>0.038</td>
<td>1.002, 1.085</td>
</tr>
<tr>
<td>Physical Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biological History</td>
<td>No significant predictors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (lbs.)</td>
<td>-0.261***</td>
<td>0.770</td>
<td>0.003</td>
<td>0.650, 0.913</td>
</tr>
<tr>
<td>Child Behavioral History</td>
<td>No significant predictors</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N/Events = 101
**Significant at the p < .05 level; ***Significant at the p < 0.01 level
NOTE 1: Brackets [ ] = reference group
Social environment area of influence

Table 24 shows the hazard ratios, confidence intervals, regression coefficients, and significance levels for each of the predictors in the multivariate model. A single predictor from this area of influence is related to informal screenings.

*Maternal depression.* Maternal depression significantly predicted the probability of informal screening receipt ($p = 0.038$) in the social environment area. Maternal depression was estimated to predict a 4.3 percent increased likelihood of early screenings because the hazard ratio is greater than 1 at $HR = 1.043$ and the regression coefficient is a positive value (Table 24). The impact of this predictor on informal screenings was related to the unit increase of points on the maternal depression scale. With each increase in point value on the depression scale, the hazard ratio estimate increased 4.3 percent for informal screenings.

Physical environment area of influence

Neither of the two physical environment variables showed significant predictive likelihoods for informal screenings.

Biological history area of influence

A single variable from the biological history area was indicated as predictive of informal screenings.

*Birth weight.* Table 24 shows that Birth weight was significantly predictive of an increased likelihood of informal screening receipt ($p = 0.003$). The hazard ratio estimate of 0.770 indicated a rate increase of informal screenings 0.77 times for children for each one pound less in birth weight. The percentage statement is $100(0.770 - 1) = -23$ percent, indicating that informal screening receipt was 23 percent lower for each lower unit of
Birth weight. The negative regression coefficient and the HR < 1 indicated the likelihood that informal screening events will occur at a future time, such as closer to kindergarten age.

Child behavior area of influence

The single variable for this area of influence, Fussiness, was not a significant predictor of informal screenings.

Informal model strength of association

The relative association between the predictor variables and survival was calculated using the generalized R² from the chi-square statistic of the likelihood ratios at each block of analysis (Gillespie, 2006). The participant number used as the denominator for the overall model R² calculations was n = 261, the value identified in the case processing summary. The null -2 log likelihood (-2LL) was high at 997.535 and gradually decreased to 981.559 in block 4, when the child behavioral area was added. The R² for the informal model is 0.08, showing that just 8 percent of the variability in survival was explained by the model. The social environment predictor, Maternal depression, and the biological history predictor, Birth weight were the only significant predictors of survival until the time of screening receipt.

Summary of informal screening results

Variables from two of the four areas of influence, social environment (Maternal depression) and biological history (Birth weight), were significantly predictive of the increased likelihood that informal screenings would be received when participants stayed in the study. The informal model as a whole was significantly associated with informal screenings. The association between the model and survival was weak.
Informal screenings survival curve

Figure 3 is the graphic display for the informal screening cumulative survival curve. The duration of time until the informal screening event was received was measured by children’s age in days old, starting from birth. There were 101 informal screenings.

**Figure 3: Informal Screenings Survival Curve**

The shape of the survival curve indicated the timing of informal screening receipt. The zero point represented the time (birth) that participants were enrolled in the original study. Time was measured by participant’s age in days old on the x-axis. The cumulative survival range on the y-axis reflected the number of participants in the study, with the most complete number (n = 2601) represented by 1.0 (100%) at the top of the y-axis. Survival function dropped along the x-axis showing the proportion of the participants by
age remaining in the study following each informal screening, or groups of screenings. Figure 3 showed that informal screening events occurred within a few days of birth, indicated by the small drop just after the y-axis 1.0 location. Each time the curve flattened out, the probability was low that informal screenings were likely to be received. A large drop showed the likelihood that several children received informal screenings as a cohort, all at the same approximate age. A series of very slight bumps at about 280 days (about 9 months) in the curve, again at around 400-550 days (12 months old), and from about 580-730 (around the 20 month old time), indicated the likelihood that a number of individuals or small cohorts of individuals received informal screenings as the duration of time continued. Approximately 760 days (25 months) into the study, a few individual, informal events occurred, shown by the small flat areas followed by sharp drops in the curve as the proportion declined of the number of participants still available to experience the event. The y-axis could not be set to zero for the graph because survival of the cohort ceased before approaching the end of the study.

Summary of the informal curve

Visual inspection of the curve indicated that the likelihood of informal screenings appeared somewhat random. The lack of sharp drops in the line and undulating curves instead suggested a decreased probability of systematic informal screening receipt. APPENDIX D shows the Kaplan-Meier log-rank group comparisons of the dummy variables that comprised the overall survival curve. A correlation matrix of the informal screening regression coefficients is shown in Table 25.
Table 25: Informal Screening Correlation Matrix of Regression Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Maternal Age</th>
<th>Depression</th>
<th>Marital Status</th>
<th>Daycare Place</th>
<th>Father Smokes</th>
<th>Birth Weight</th>
<th>Special Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>-.031</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td>.369</td>
<td>.000</td>
<td>.084</td>
<td>-.121</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daycare Place</td>
<td>-.077</td>
<td>.014</td>
<td>.150</td>
<td>.200</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father Smokes</td>
<td>-.096</td>
<td>.051</td>
<td>.092</td>
<td>-.151</td>
<td>-.071</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth Weight</td>
<td>.051</td>
<td>-.017</td>
<td>.092</td>
<td>-.151</td>
<td>.011</td>
<td>.033</td>
<td></td>
</tr>
<tr>
<td>Special Care</td>
<td>-.032</td>
<td>.009</td>
<td>.125</td>
<td>-.107</td>
<td>.011</td>
<td>.033</td>
<td></td>
</tr>
<tr>
<td>Fussy Baby</td>
<td>-.008</td>
<td>.193</td>
<td>-.023</td>
<td>.179</td>
<td>-.065</td>
<td>-.067</td>
<td>.010</td>
</tr>
</tbody>
</table>

SUMMARY OF RESULTS

Approximately 10 percent of the participants in the study received formal developmental screenings and 33 percent received informal screenings from the total number (n = 2601) of participants at the outset of the study. The average age for receipt of formal screenings was 515 days old (17 months old) and 276 days old (9 months old) for informal screenings.

Table 26 summarizes the bivariate analyses results on the hypotheses supported by the four areas of developmental influence of the New Model of Children’s Health and its Influences (NMCHI). Some of the hypotheses which were not supported at the bivariate level were later found at the multivariate level to display significant relationships between the predictors and the outcome variables. Race, Age, and Maternal depression were significantly related to screening receipt at the multivariate level. In addition, the two predictors, Fussiness and Birth weight supported the hypotheses at the multivariate level.
### Table 26: Bivariate Hypotheses Support Summary

<table>
<thead>
<tr>
<th>Area of Influence</th>
<th>Hypotheses</th>
<th>Formal Supported (Yes/No)</th>
<th>Informal Supported (Yes/No)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment</td>
<td>Receipt of developmental screenings will be associated with: a) lower maternal education.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: b) male gender.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: c) White race.</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: d) mothers who are married.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: e) younger maternal age.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: f) maternal depression.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Physical Environment</td>
<td>Receipt of developmental screenings will be associated with: a) daycare in child's own home.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: b) fathers who smoke cigarettes.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Biological History</td>
<td>Receipt of developmental screenings will be associated with: a) child's specialty medical care.</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Receipt of developmental screenings will be associated with: b) lower birth weight.</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Child Behavioral History</td>
<td>Receipt of developmental screenings will be associated with: - frequency baby is fussy and irritable daily, ½ the time to almost always.</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 27 summarizes the multivariate analyses results. The multivariate analyses results on the longitudinal models are summarized by whether individual predictors, when considered together in the models as a whole, support the hypotheses for the formal and informal screening models. The results also indicate whether the predictors are associated with estimates for an increased or decreased likelihood of the child receiving the screenings.

Two of the four conceptual areas of influence from the NMCHI were estimated to significantly predict formal screening receipt, the social environment and the child behavioral history. The significant social environment area predictors were Race, Age, and Maternal depression, and Fussiness in the child behavioral history area of influence.
Maternal depression, Race, and Fussiness indicated an increased likelihood of children receiving the formal screenings very early in childhood by hazard ratios greater than 1. The physical environment and biological history predictors showed no relationship to formal screenings.

As a whole, the informal screening model was significantly associated with screening receipt. The probability estimate results showed that two areas of influence from the NMCHI were significantly associated with estimates for informal screenings, the social environment and the biological history areas. The social environment predictor, Maternal depression, indicated an increased likelihood of informal screenings. The likelihood estimates show that the biological history area of influence predictor, Birth weight, was significantly related to informal screening receipt but the probability of an early screening was decreased.

Although both formal and informal models were related to screening receipt, neither model supported the hypotheses that all areas of influence, when considered together in the respective models, showed estimates of likelihood for screening receipt.
Table 27: Multivariate Hypotheses Support Summary

<table>
<thead>
<tr>
<th>Area of Influence</th>
<th>Variable</th>
<th>Hazard of Formal</th>
<th>Hypothesis Support</th>
<th>Hazard of Informal</th>
<th>Hypothesis Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Environment</td>
<td>&gt; high school education</td>
<td>Increase</td>
<td>No</td>
<td>Increase</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Male Gender</td>
<td>Increase</td>
<td>No</td>
<td>Decrease</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Race</td>
<td>Increase</td>
<td>Yes</td>
<td>No difference</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Married Mothers</td>
<td>Increase</td>
<td>No</td>
<td>Increase</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Maternal Age</td>
<td>Decrease</td>
<td>Yes</td>
<td>Decrease</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Maternal Depression</td>
<td>Increase</td>
<td>Yes</td>
<td>Increased</td>
<td>Yes</td>
</tr>
<tr>
<td>Physical Environment</td>
<td>Place of Daycare</td>
<td>Decrease</td>
<td>No</td>
<td>Decrease</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Father smokes</td>
<td>Decrease</td>
<td>No</td>
<td>Decrease</td>
<td>No</td>
</tr>
<tr>
<td>Biological History</td>
<td>Specialty Medical care</td>
<td>Decrease</td>
<td>No</td>
<td>Decrease</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Birth Weight</td>
<td>Decrease</td>
<td>No</td>
<td>Decrease</td>
<td>Yes</td>
</tr>
<tr>
<td>Child Behavioral History</td>
<td>Fussy/Irritable Daily</td>
<td>Increase</td>
<td>Yes</td>
<td>Decrease</td>
<td>No</td>
</tr>
</tbody>
</table>
CHAPTER V
DISCUSSION AND CONCLUSIONS

The purpose of this study was to examine the usefulness of the concepts included in the New Model of Children's Health and its Influence (NMCHI) for identifying predictors of health service effectiveness. Health service effectiveness in this study was measured by whether participants received formal or informal developmental screenings. This discussion includes review of the utility of the theoretical framework for the type of study. Also, comparisons are discussed of the similarities and differences between the two areas of key research findings, formal and informal developmental screening receipt and adequacy of the model fit. In addition, the study limitations, policy implications, and future research are discussed and followed by study conclusions.

The overall research question posed at the outset of this study is, "Which early childhood developmental influences were related to health service effectiveness as indicated by the receipt of developmental screenings?"

USEFULNESS OF THE NEW MODEL OF CHILDREN'S HEALTH AND ITS INFLUENCES

The National Research Council and Institute of Medicine (2004) presented the theoretical framework as a kaleidoscope of childhood development in which the influences on childhood development are unequally represented at different points in time. The conceptual structure of the NMCHI provided a comprehensive foundation for guidance of predictor variable selection. The four conceptual areas tested, social environment, physical environment, biological history and child behavioral history, were proposed under the NMCHI as universal socio-ecological areas of childhood
development which all children experience from birth to adulthood (Halfon, et al., 2004). As such, the evolving structure of the NMCHI (Figure 4) provided a framework into which predictor variables selected from the Healthy Steps for Young Children National Program Evaluation longitudinal data were fit for use in this study.

This study was important because it added to the knowledge of potential predictor variables which can be useful for studies measuring health service effectiveness for children. The study provided increased understanding of fitting longitudinal data to a theoretical framework that was founded upon the changing developmental processes of children and to explanations of variability in such models. The measurement of developmental screening receipt in the present study provided a foundation for future research to examine additional predictors of screenings as well as other measures of health service effectiveness. Utilization of a wide variety of predictors guided by the NMCHI assisted in measurement of a neglected area of health research, health service effectiveness (NRC & IOM, 2004).

This study was based on the whole child construct of the NMCHI with the selected predictors represented by more than a single area of child development. Inclusion of more than a single area of development can increase understanding of how to measure health service effectiveness through examination of the world of the child as a whole rather than on more traditional single measures (Lieu & Newman, 1998). One of the guiding points of the telescoping nature of NMCHI was the clear potential for use of various statistical analysis techniques.
The survival analysis technique, Cox regression, was well-suited for the evolving developmental phases described by NMCHI because the likelihood estimates summarized the effects of the predictors on the outcome event with comparative rather than absolute statements related to survival (Bradburn, Clark, Love, & Altman, 2003). The hazard ratios generated from the regression corresponded to unit differences in the values of the predictors with the estimated, comparative statements made about the magnitude of difference of the predictor on the hazard or risk of the event (Singer & Willet, 2003). The probability that children will receive formal or informal developmental screenings at some point in time was estimated from each one-unit difference of the predictors. In addition, Cox regression tolerated uneven distributions of prognostic characteristics in the predictor variables (Marubini & Valsecchi, 2004). The majority of the predictor variables in this study were unequal in distribution.
INTERPRETATION AND EXPLANATION OF RESULTS

Formal developmental screenings are checklist-type screenings that are standardized, have some measure of reliability, and generally take about 20 minutes to administer. Informal developmental screenings are physician observations of childhood development typically noted during medical visits. The results from the two Cox regression models identify which predictors most influence survival until formal or informal screening receipt by very young children. The results of the two regression models are compared in the following discussion.

Formal and informal screening model comparisons

The predictive models developed in this study showed measurement of the association between the collective areas of developmental influence and survival until screenings were received. The formal and informal models, with all areas of influence considered together as a whole for each model, were significantly related to screening receipt (formal: \( p = 0.000 \); informal: \( p = 0.033 \)). However, examination of the models showed differences in association related to the contributions of the NMCHI conceptual areas of influence as well as to the survival of the sample.

Social environment. The influence of the social environment area centers on the finding that maternal depression was a powerful predictor of estimates for the increased likelihood of receipt of both formal and informal screenings. Cox regression hazard ratio estimates (HR >1) showed depression as the only significant predictor in the model with an increased likelihood of early formal and informal screenings.

In the formal model, the depression variable predicted screenings from the first block entry into the Cox regression with a significance level for the block and the model
at $p = 0.000$. The model continued to display significance as a predictor of survival for formal screenings as each successive block of variables was added, showing the powerful effect of maternal depression on the subsequent predictor additions of the other areas of influence. Race was also a significant predictor of screenings at the outset of the regression and was maintained for the entire regression. As the other three areas of influence were added to the model as a whole and the predictors controlled for, Age became a significant predictor of formal screenings in the final model. The regression results found that the Race and Age predictors, however, were estimated to predict screening receipt at some distant time, as shown by the hazard ratio values of $< 1$.

For the informal model, Maternal depression was controlled for by other predictors until more estimated survival time had passed. Maternal depression only became significant as a predictor upon addition of the final area of influence, child behavioral history. The predictors in block 1, the social environment, showed that only Age and Marital status increased the likelihood estimates of screening receipt but neither predictor was significant. The Education and Race predictors were removed from the informal model because multicollinearity problems increased the p-values to $> 0.97$ at block 1 entry into the regression.

Informal screenings based on social environment predictors were initially estimated to be received at the youngest ages, less than 2 months old, and formal screenings estimates were for later receipt, starting at about 6-9 months old. The likelihood estimates of the predictor variables reflected the survival time until screening events as much as they reflected receipt of the screenings themselves. As a predictor,
Maternal depression was well-established as significantly related to various child outcomes.

Previous studies found significant relationships between Maternal depression and child health maintenance. Studies showed that attendance at well-child visits, incorporation of home and travel safety measures, and daily caregiving were related to Maternal depression, corroborating the results of this study for the importance of examining Maternal depression as a critically important feature of early childhood (Minkovitz, et al., 2005; Sices, 2007).

**Physical environment.** The two predictors for the physical environment area of influence, Father smokes cigarettes and the Place of child care, appeared important for controlling the effects of predictors on screening receipt in both models. Upon removal of either or both of the variables, the number of events (screenings) increased, the model significance level increased, and the predictors from all other areas of influence failed to become significant. Neither variable showed significant relationships to screenings (formal, smokes: \( p = 0.147 \); place of daycare: \( p = 0.073 \)). However, according to Marubini and Valsecchi (2004), the imbalance in the distributions of the predictors was the likely contributor to the lack of significance as the hazard ratios were greater than 1 in both predictors of both formal and informal models (formal: father smokes HR = 2.467, child care place HR = 1.745; informal: father smokes HR = 1.147, child care place HR = 1.153). These hazard ratio results indicated estimates of increased and early likelihood of screening receipt.

**Biological history.** The third conceptual area of influence, biological history, added both the Birth weight and the child ever needed Specialty medical care variables.
Birth weight alone showed significance as a predictor of informal screenings from the beginning of the regression, before it was included in the third block of predictor variables. This predictor had a significance value of \( p = 0.003 \) in the residual section of "variables not in the equation," when the regression was at the beginning of the social environment area of the calculations. Birth weight, with the rest of the areas of influence controlled for, was undoubtedly the reason for the informal model significance as a predictor of screenings. Low birth weight was shown as indicative of many developmental health, cognitive, and language problems for young children by Glascoe & Shapiro (2005) and Sices (2007). The estimations for informal screening receipt initiated from just after birth, the beginning of study enrollment. Although the estimates showed screenings as significantly predictive, the hazard ratio, HR = 0.770, showed that the informal screenings would not be received early in childhood; rather, the likelihood estimates showed that the children were more likely to receive screenings later in childhood. This situation may be related to the delays the children experienced in development and the acknowledgement that some children experience a greater passage of time until screenings were administered (AAP, 2000).

Neither Birth weight nor Specialty medical care showed significance for formal screenings. However, the Specialty care estimates of likelihood showed hazard ratios greater than 1 for both formal and informal models. The formal model Specialty care likelihood was HR = 1.185, an 18.5 percent increased likelihood of early formal screenings. Similarly, the HR = 1.195 value showed a 19.5 percent increase in the likelihood of early informal screenings. A review of the distributions between the groups
of those who needed specialty care and those who did not revealed unequal numbers of subjects, a situation that confounded significance (Marubini & Valsecchi, 2004).

Child behavioral history

A single predictor was fit into the final conceptual area of the NMCHI, Fussiness and irritability as reported by the mother. At the third block of regression in the "variables not in the equation" section, the fussiness variable began to display significance ($p = 0.041$) as a predictor of formal, but not informal, screenings. In the final model, Fussiness was significantly predictive of survival time for formal screenings at $p = 0.045$. The hazard ratio for likelihood of formal screenings associated with fussiness was $HR = 2.272$, an indicator that the participants had an estimated increased likelihood of formal screenings as young infants. The HR was considered a true indicator for the significant result, that early screenings were predicted from the behavioral area of the NMCHI. The receipt of a standardized formal, over informal, screenings indicated a level of concern related to either participant Fussiness or evidence of Maternal depressive symptoms, even if unmeasured (Zuckerman, Bauchner, Parker, & Cabral, 1990). A chi square analysis of the Fussiness variable and a dichotomized version of Maternal depression revealed a significant relationship between the two predictors at $p = .000$.

The Fussiness variable was not a significant predictor of informal screenings ($p = 0.167$). However, the hazard ratio for likelihood of informal screenings was $HR = 1.339$, a 33.9 percent increased likelihood of early screenings associated with Fussiness. The distribution between groups was unequal, a contributing factor to the absence of a significant value. In addition, the nature of the informal screening administration as somewhat spontaneous, non-standardized observations contributed to the non-significant
result and non-predictability than the variable distribution. Thus, because informal screenings were somewhat spontaneously administered, the level of fussiness for infants may not have been recorded.

Association

The $R^2$ measure that was calculated to examine the association between the formal model and the informal model as predictors of survival for screenings showed that little of the variability for the models was predicted. Gillespie (2006) presented the generalized $R^2$ as a way to "quantify the ability of prognostic factors to predict..." the time until the screening occurs. Consequently, the generalized $R^2$ was used as a measure of association between the predictors and survival in order to examine variability in the survival predicted by each model. The $R^2$ statistic was based on the Cox and Snell logistic regression strength of association measures used for comparison measurement but is not an explanation of proportion of variance as in regression statistics with intercepts (Allison, 1995). The $R^2$ results for predictions of survival based on the formal model was 0.28 and 0.08 for predictions of survival from the informal model. The small value of association between each of the whole models and survival until screening receipt was related to the diminishing number of participants.

Censoring

The censoring aspect of Cox regression impacted the $R^2$ associations more when censoring began early in the study (Gillespie, 2006). According to Gillespie (2006) the sensitivity of censored value proportions was decreased because of censoring. Further, $R^2$ values tended to decrease by greater than 20 percent when censoring was "heavy" at about 50 percent (Gillespie, 2006). Censoring in this study began early. The enrollment
Newborn questionnaire data showed 100 percent participation. By 2-4 months old, 88 percent of the participants remained in the study with the parents responding to an in-depth telephone interview. The 6-month old data showed a 65 percent participation rate and a 56 percent rate at 12 months, both in response to questionnaires mailed to parents or handed out at well-child health visits. At 30-33 months old, 67 percent of the parents again responded to in-depth telephone interviews. Both the formal and informal models utilized the same data set. As a result, the impact of censoring applied to both models.

The Newborn and 2-4 month data collections included the majority of the demographic data such as maternal age, maternal education, smoking practices, race/ethnicity, and marital status. Subsequent data collection events starting at the 2-4 month time (88% participation) gathered most of the remaining information for the predictor variables. A minimal 20 percent increase in $R^2$ values for both overall models would produce meaningful changes in the proportion of variability for each area of influence in this study. Thus, the estimated likelihood of formal or informal screening receipt reflected not only the number of participants in a study, but how long they were present in the study to receive the screenings, and which predictors were associated with the screening receipt at the time of the event. Gillespie (2006) advises that censoring in survival analysis was assumed to be random and that there was no statistical test that can check the assumption.

With the concept of the associations between predictors and survival and generalized $R^2$ in mind, a review of the formal and informal survival curves from this study (Figures 5 and 6), placed in close proximity to each other, graphically show the estimated differences in receipt for formal and informal screenings.
When looking at the overall shapes of the cumulative survival curves without concern about numerical value assignments, the formal screening curve (Figure 5) shows the survival as flat when no screenings occurred and with steps downward when one or more screenings were received, related to predictor effects. Overall, formal screenings appeared delayed. The informal screening curve (Figure 6) on the other hand, shows a fairly steady, downward movement of the line, indicating that the screenings were occurring early and frequently. As each screening or groups of screenings occurred, the Cox regression model dropped participants from the proportion of participants still available in the next instant for screenings. The informal screening curve (Figure 6) shows that the ending of the time line occurred earlier in time than the formal screening curve (Figure 5). Looking back to the fuller version of the curve, Figure 3 in the Results chapter, the x-axis values showed that the end time of the informal screenings occurred at around 760 days old or about the time of the participant two year old birthdays.

The basic theoretical differences between the two types of developmental screenings described in the two models explained the differences in the graphical representations of the survival curves with the impression of greater censoring for informal screenings. Informal screenings were spontaneously and quickly accomplished and utilized educated guesses to review developmental progress (Glascoe & Shapiro, 2005). Formal screenings required 1) a questionnaire form and direct questioning by the health care provider, or 2) provision of the questionnaire form to the parents to fill out with subsequent review for developmental concerns by the health care provider (Glascoe & Shapiro, 2005).
Summary of Formal and Informal Screening Model Comparisons

The significant results of the formal model were useful for representing which areas of developmental influence and which predictor variables within the areas explain variability of the model. The complete formal model was predictive of survival to the time of screening receipt. In particular, the three variables from the social environment and one variable from the child behavioral history area predicted the likelihood of formal...
screenings. The physical environment and biological history $R^2$ values were positive but displayed small contributions to the explanation of the model.

The informal model significance levels contributed to the explanation of a partial model with the social environment and biological history areas of influence represented in the explanation. The Maternal depression and Birth weight variables from each of the two contributing areas were significantly predictive of informal screenings, and thus, provided important knowledge that can be used in discussions of relevant features that add to the health service effectiveness literature. The physical environment and child behavioral history areas contributed little to the estimates of survival until informal screening receipt.

Maternal depression was the single predictor common to both the formal and informal screening models, indicating strength of association between maternal feelings of depression and care of children. Minkovitz, et al. (2005) conducted a study in which the symptoms of maternal depression were related to the receipt of health care for children less than 3 years old. The researchers found that mothers with depressive symptoms declined to take their children to preventive services for immunizations and well-child checkups. Mothers with depressive symptoms also used emergency room care more than regular office care for the children (Casey, Goolsby, Berkowitz, Frank, Cook, Cutts, et al., 2004; Kahn, Zuckerman, Bauchner, Homer & Wise, 2002; Minkovitz, et al., 2005). The hazard estimates in the present study showed concomitant significance for both formal and informal screening receipt based on maternal depression.
LIMITATIONS OF THE STUDY

A number of limitations were evident in this study. Because the original HS study answered different questions, there were inadequate numbers and kinds of variables to correspond to the physical environment, biological history, and child behavioral history areas of developmental influence in the theoretical model, the NMCHI. The physical environment area of influence had poor showings in the models because there were too few variables from which to select. Various limitations of the variables in the data hindered the number of variables that could be included in the models, limited the number of significant findings, and restricted the explanatory power of the models. In addition, more significant findings might have emerged had the variables permitted different or better measurement. For example, the family income data collected for the HS study was recorded into an ordinal variable instead of making it a useful, scale-level variable. This problem with secondary data use related to the lack of control over data collection and recording techniques. The Healthy Steps study focus was to improve parent knowledge about developmental behaviors, improve physician communication to parents, and improve parent behavior toward their children and these issues were part of the active data collections.

The collection of developmental screening data, on the other hand, was mined from medical records. A number of children received more than one screening with many of them receiving both informal and formal screenings. However, the data collection methods prohibited greater access to the screening data. Perhaps if the questionnaires had included two or three questions about whether the children received screenings and the results reported, the data would have been more useful for this study.
The questionnaires which were mailed or distributed to families were often not completed with the result that the sample size decreased. The smaller sample sizes for some of the variables prohibited use in longitudinal analysis. The variables with small samples could not be correlated with other, larger-sampled variables. The type or style of questionnaires that meet the needs of a research study and are not intrusive on the time of parents should become a focus of further study.

The nature of the longitudinal design in conjunction with the evolving developmental processes in the kaleidoscope view of childhood development guided by the NMCHI impacted the results of the study by the aspects of change that occurred at each level of measurement and each area of influence. However, even with so many variable factors, the predictive ability of three areas of the framework was identified in this study. The strength of association values between the overall models and survival were low, a result that was partially a function of censoring.

The focus of this study was to discover the explanatory power of the NMCHI. No priority was ascribed for the type of developmental screening provided to children, whether formal or informal. This study only sought to examine the predictors associated with formal or informal screenings. Additional research will examine the receipt of screenings by different predictors such as urban versus rural parameters and the size of a pediatric practice.

The findings of this study added to the literature on health service effectiveness for children, an under-researched area of study. The study of health service effectiveness with non-medical outcomes is an area of study that is beginning to become important for policy-makers and educators. This study increased understanding of the magnitude of
change in the predictor variables as a function of survival over time until screening receipt occurred. In addition, this study began to address the gap in measurement of health service effectiveness for young children but was unable to fully examine all aspects of the NMCHI, partly because of data limitations. Finally, the findings of this study in which four concepts of the NMCHI were tested has increased research knowledge about how to use the concepts for research studies.

HEALTH POLICY CONSIDERATIONS

Increased implementation of public and private policies which recommend early screenings of young children with potential communication delays is a community public health and education issue. Traditional ways of health service provision of developmental screenings appear inadequate. Coalition building within communities to address the issue of implementation of screening administration through non-traditional settings and sources can create a community public health and education foundation for meeting the needs of the youngest citizens.

The results of the Cox regression models showing the parameter estimates for the impact of maternal depression on the increased probability of formal and informal screening receipt indicated that children experience developmental problems when maternal depression compromises mental, physical and emotional care of young children. A number of studies show the association of maternal depression with child neglect and child maltreatment (Kahn, Zuckerman, Bauchner, Homer, & Wise, 2002). More attention and funding should be provided to ensure maternal emotional health, both prior to childbirth and for mothers of newborns. Expansion of local-level, city-centered
organizations to encourage and help families with newborns and provide training to community members may enhance young children’s developmental progress.

Health policymakers may want shift to support toward preventing maternal depression instead of expending funds later to remediate the disrupted lives of both mothers and children. Change in policy to ensure federal support for antenatal meeting groups for mothers may be judged too costly. However, the costs of warding off depressive symptoms should be balanced with other costs of not only healthcare, but of special education. Programs which train parents to identify developmental progress and to understand developmental issues and concerns would encourage preventive measures and avoid developmental problems that arise from within the family.

The present study showed that health services in the area of preventive screenings are not particularly effective for young children when so few of them receive developmental screenings. The reasons for failing to screen children are many and are documented by the American Academy of Pediatrics (2000). A change in service delivery from physicians and nurses to such organizations as the Healthy Families network may be in order. A policy to have developmental screenings administered to all children by a trained healthcare worker, many of whom are already performing the task, would free up physicians and nurses for the critical work they perform daily. Alternatively or in addition, training physicians on the childhood influences that affect development may increase physician awareness that screenings are important for health surveillance.

Communities can become more responsive to the needs of the young children and their families who reside within the community borders. Health policy changes to
improve children’s developmental progress should be generated by the local communities in order to ensure that children are not overlooked.

FUTURE RESEARCH

The results of this study identified areas of research need. A different paradigm for how and when developmental screenings are provided should be examined. Additional research might focus on finding ways to increase administration of screenings while keeping costs low. The Denver Developmental Screening Scale II (DDST II), the formal screening measure used in the Healthy Steps evaluations, is now being administered less often because of adequately high sensitivity (0.80) but poor specificity (0.43). Health care costs are increased when poor specificity rates inaccurately identify children as delayed but who in essence demonstrate no real delays. Alternatively, perhaps poor specificity would encourage more concern about children’s developmental progress and more thorough community and hospital-based programs could be developed to increase understanding of children’s issues. A study in which screening measures with poor specificity were used exclusively may identify additional areas of childhood developmental concern. Newer screenings require at least 20 minutes of time, about the time needed for critical biological assessments during an average well-child checkup. Research may include studies to examine which screenings are most amenable to the work styles of different physicians and medical practices. Mothers are excellent observers of their children’s growth and development; perhaps a study in which mothers were trained to administer screenings to their own children would not only reduce the costs of screening administration but also would change the locus of control from others back to the home.
This study tested selected concepts of the NMCHI. As a new theoretical framework, few studies have explored the structure of the NMCHI. One of the new concepts introduced into this child-centered framework is the concept of services as an outcome. Additional research which examines different areas of services for children would increase knowledge and understanding of when, how, how often, with whom and where services are implemented, administered and received. Additional research into which variables from the four conceptual areas of the model tested in this small study would increase the effectiveness of health services if the relationships and associations of health services for children are known. More longitudinal studies to examine how the confluence of different aspects of children’s daily lives can improve health service effectiveness over time and overall health for living well and for learning would enhance the small amount of knowledge gained in this study. In summary, future research studies into the following areas may improve screening receipt:

1. Examine non-traditional sources and settings of developmental screening administration.
2. Increase research in which measurement of health services for young children is an outcome.
3. Examine different family influences which improve early childhood communication abilities.
4. Improve the type of style of parent questionnaires.
5. Examine urban versus rural parameters of developmental screening administration.
CONCLUSIONS

Young children often experience physical, cognitive, emotional, social, and communication disorders and delays. The disorders and delays are often not identified until children begin to fail in their early school years. Consequently, children would benefit from receipt of developmental screenings at early ages to identify incipient developmental problems. Identification of variables which predict the need for screenings would help increase the number of children who receive screenings at early ages.

Each of the areas of developmental influence of the NMCHI, the social environment, physical environment, biological history and child behavioral history under examination in this study represents a broad window for a large number of potential variables from all aspects of early childhood.

This study, using the NMCHI for model guidance, was an important step toward increasing understanding and knowledge of the predictors of children’s receipt of developmental screenings. The independent variables used to predict the screenings in this study were partially useful for testing the theoretical framework and for explaining some of variability of the formal and informal screening models. The NMCHI, with its trajectory for childhood development, supports the use of longitudinal data for fitting the models and longitudinal data analysis techniques.

The use of the survival analysis technique, Cox regression, with its ability to generate likelihood estimates for the magnitude of time until the screenings are received, provides regression coefficients and hazard rates by which to examine model concepts. The values from the analyses were used to examine the explanatory power of the model
and the differences between the areas of developmental influence, the concept areas of
the NMCHI being tested.

This study was the first one to use the NMCHI to look at health service
effectiveness for young children. The literature provided prior research which supported
components of this study, such as the relationship between maternal depression and child
health outcomes. The results of the study indicated that few children received
developmental screenings. Some results of this study were useful in identifying a few
child and family predictors of screenings. The formal and informal models both were
found to predict screening receipt. Future research would benefit young children if more
predictors of screenings were identified. In addition, further research on the properties
and concepts of the NMCHI would guide increased knowledge of the childhood
processes which impact developmental progress.

Health care providers, educational specialists, and health policy makers should
attend to the focus on developmental screenings as a way to maximize childhood
developmental progress and learning and minimize developmental problems.
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Dear Dr. Houseman;

Your study, "Predictive Power of the 'New Model' of Children's Health and its Influences for Early Identification of Children At-Risk for Communication Delays" was approved as an exempt study by the College of Health Sciences Human Subjects Review Committee on April 25, 2005. Since this study is exempt, an annual renewal of the study proposal is not required.

Respectfully,

George Maihafer, Chair
School of Physical Therapy
Old Dominion University
APPENDIX B

DATASETS

Healthy Steps for Young Children Program National Evaluation, 1996-2001,
University of Michigan, ICPSR 4049

Parent Forms: Newborn

Medical Record Abstraction: Medical Visits

Medical Record Abstraction: Referral/Consultations

Parent Interviews: 2-4 Month

Parent Interview: 30-33 Month
APPENDIX C

KAPLAN-MEIER CURVES: FORMAL SCREENING

Father Smokes

Place of Child Care

Marital Status
Fussiness/Irritability Daily

Survival Function for patterns 1 - 2

Race

Survival Function for patterns 1 - 2

Maternal Education

Survival Function for patterns 1 - 2
Survival Function for patterns 1 - 2

Child's age at visit (days)

Cum Survival

Child over received any specialty medical care

- no
- yes
APPENDIX D

KAPLAN-MEIER CURVES INFORMAL SCREENING

Father Smokes

Place of Child Care

Specialty Medical Care
Fussiness/Irritability Daily

Marital Status
VITA

Janice Chandler Ranne

Education:

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1994  Master of Arts, Speech-Language Pathology
      University of Maryland, College Park, Maryland

1992  Bachelor of Arts (Summa Cum Laude),
      Speech Pathology and Audiology
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Professional Work Experience:

1996-2005  Speech-Language Pathologist, Early Intervention Programs
           Hampton, Newport News, Virginia Beach, Norfolk, Virginia
           Responsibilities: Evaluation and treatment of infants and toddlers
           with speech, language, cognitive, and swallowing disorders.
           Supervision of Master's Degree students in Speech-Pathology.

           Responsibilities: Evaluation and treatment of a variety of disorders
           and delays, including strokes, swallowing disorders, neurological
           disorders, voice disorders speech, language, fluency.

Other Professional Experience:

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