Relationship Between Factors Associated with Toxic Stress and Child Behavior in the Dental Office

Thesis

Presented in Partial Fulfillment of the Requirements for the Degree Masters in Science in the Graduate School of The Ohio State University

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Abstract

**Purpose:** To determine the relationship between toxic stress from negative social determinants of health and behavior of children at the initial dental visit.

**Methods:** Using a 17-state sample of children 4-5 years-old, behavior ratings, using a 4-point scale, applied by trained dental professionals at initial dental visits were analyzed using bivariate and multivariate logistic regression models as well as Naïve Bayes classification and chi-squared tests. Each child’s behavior rating was correlated with social determinants using geographic mapping for racial/ethnic status, violence, education level, income, living conditions and other factors known to influence health.

**Results:** Behavior ratings for 4-year-old (n=17,486) and 5-year-old (n=19,613) children were obtained for first dental visit over a five year period (2009-2013). Behavior was good (n=11,999) and not good (n=25,100). The odds ratio correlating individual socioeconomic factors to behavior showed that children with more negative behavior were more likely to experience violent crime (P=.0004), parental unemployment (P=.0002), less parental education (P=.0006), high expense on food and transportation per capita income (P=.0005), living in a more densely populated area (P=.028), non-homeowner (P=.0001), with a greater amount spend on housing per capita income (P=.0009), African-American (P=.0008), and a lower median household age (P=.0003). Children with good behavior rating were more likely to be of Latino or white ethnicity.
(P=.0002), come from homes owned by parents (P=.007), having a male to female ratio closer to 1:1 (P=.031), spent a greater amount on health related expenses (P=.015), and a larger average home size (P=.0002).

**Conclusion**: This study of 37,099 4-and-5-year-old children, found poorer behavior at initial dental examination for children exposed to violence crime, parental unemployment, less parental education, high expense on food and transportation per capita income, non-homeowners with a short length of residence in the current domicile, African-American, in a more densely populated area, with a lower median household age. Children of Latino or white ethnicity, greater parental income, parents owning current residence, greater home size, and a male to female ratio approaching 1:1, were more likely to be rated “good” at the initial dental visit.
Acknowledgments

I would first like to acknowledge Dr. Paul Casamassimo for his guidance and vision. Dr. David Vieth and Kool Smiles for their immense contribution in making this research robust and comprehensive. To Nationwide Childrens Hospital Research for the betterment of children and specifically Wei Chen and his analytic bequest which give the data its voice.
Vita

2005 .......................................................... Flathead High School

2009 .......................................................... B.S. Neuroscience and Biomedical Science,

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                                         Hospital

Publications

Dawson, G., Palermo, T., et al. *Longitudinal course and impact of insomnia symptoms in
adolescents with and without chronic pain*. J Pain. 2012 Nov;13(11): 1099-106. doi:

Fields of Study

Major Field: Dentistry
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Chapter 1: Introduction

According to the World Health Organization (WHO), in 2012, the US ranked 36th out of 194 countries in life expectancy, which is a drop from 28th in 1990. [1] The Institute of Medicine (IOM) recently released research comparing the US to 16 similar high-income countries. The US consistently has the worst health outcomes, with child mortality rate for children aged 0-5, maternal mortality rate, and rate of obesity highest across all age groups. The US has the second highest rates of death due to coronary heart disease, lung disease, and non-communicable diseases. [2] Research also indicates that overall health in the US is getting worse. The number of adults with 2-3 chronic conditions rose from 17.9% to 19.1% while the percentage of adults with 4 or more chronic conditions rose from 3.6% to 4.3%. [3] Despite the US falling to the number 2 position in the world for most obese individuals per capita, the numbers have steadily risen. In 1997, 19.4% of adults over age 20 were obese compared to 28.9% in 2013. [4] The number of individuals with diabetes doubled from 1997 to 2013. [5]

When evaluating the world’s health care systems, the Commonwealth Fund reports that among 11 similar countries, the US has the most expensive and poorest performing health care system. For the past 12 years, the US ranked last overall, last on measures of efficiency, and 9th on measures of access. [6] Unfortunately, the maladies of Americans don’t stop at poor physical health. The US boasts incredible rates of mental illness and substance abuse. According to WHO, the US has the highest rates of mental
half of Americans will develop a mental health problem or addiction in their lifetime. In any given year, 40.3% of adolescents meet the necessary criteria for a DSM-IV disorder.[8]

The number of Americans living in poverty continues to increase as well. In 2012, 15% of the population, or nearly 47 million people, lived in poverty. The US currently has the sixth highest child poverty rate (21.8%) of the 34 Convention on the Organization for Economic Cooperation and Development (OECD) countries. [9] As is usually the case, American children in the impoverished living situation suffer most. In 2012, 678,810 children were abused or neglected, a rate of 9.2/1,000. Children under 1 year of age had the highest rate of abuse at 21.9/1,000 with 1,640 deaths in 2012. Over 70% of these children were under age 3. [10]

**Stress Response**

This public health crisis may be the most significant challenge of the 21st century. The interaction between one’s environment and genetic biology has been well documented as profound and permanent. One of the most profound effects on developmental biology is stress. How an individual responds to stress and its subsequent long-term impact is dependent on their personal biological susceptibility and the environment.
Through thousands of generations, humans have developed a stress response system that is acutely aware of danger. The physical responses to stress are manifested through the nervous and endocrine system resulting in elevation of cortisol and inflammatory mediators, activation of the hypothalamic-pituitary-adrenocortical (HPA) axis stress system, increased heart rate, respiratory rate, and other bodily systems as our body engages the “fight or flight” response. This response has protected humans for generations in the instance of danger. However, when exposed to prolonged levels of stress or severe adversity, without appropriate relational support, the stress can become toxic. That is, relational health, as described by the American Academy of Pediatrics (AAP), in early childhood is the ability to form secure attachments with engaged, responsive caregivers in a safe, stable, and nurturing emotional environment.[11] It is an essential protective factor for the development of emotional regulation and resilience and the ability to cope with adversity during an individual’s lifetime.[12] Lack of relational health, continual activation of the hypothalamic-pituitary-adrenocortical (HPA) axis stress system, and chronic elevation of cortisol and inflammatory mediators damage brain structures and energy metabolism leading to a ‘dysregulation’ of the stress response system. [13] This dysregulation of physiologic mediators (too much cortisol and inflammatory mediators) has its biggest effect on the developing brain. [14]
The Prefrontal Cortex

The prefrontal cortex (PFC) is the cerebral cortex located at the anterior part of the frontal lobe and is responsible for what is known as executive functions. Executive functions are a set of cognitive processes which include three basic principles: working memory (the ability to hold relevant information and goals in mind), inhibition (attention control and inhibitory control provide the ability to not act on impulses in service of future goals), and cognitive flexibility (the ability to switch or update goals based on relevant information).[15] The executive functions are employed when problem solving, reasoning, and planning which are necessary for the cognitive control of behavior when selecting and successfully monitoring behaviors that facilitate attaining goals.[16, 17] The PFC is known to have an extended developmental period from birth through late adolescence and therefore has greater potential to be shaped, in both structure and function, based on an individual’s experience.[18-20]

The Prefrontal Cortex and SES

Studies have shown a link between the parental socioeconomic status (SES) and prefrontal function in childhood.[21] These studies demonstrate that aspects of the environment associated with SES impact prefrontal function.[20] The chronic stress during early childhood development is associated with an impaired development and function of the prefrontal cortex as well as its ability to suppress the amygdala, the “on switch” for the stress response. [22] Prefrontal lobe dysfunction impairs executive control
of affect regulation and impulsive behavior, and the epigenetic, anatomic, and neuroendocrine disruption related to chronic toxic stress may impair learning, behavior, and interpersonal relationships. [24] Executive functioning is associated with better performance in school [25] and fewer negative health behaviors. [26] Existing research suggests this impaired self-regulation leads to maladaptive behaviors such as smoking, excessive alcohol intake, overeating, promiscuity, and substance abuse that may cause morbidity and early mortality.

**Behavior**

In regard to the link between toxic stress and childhood behavior, an association has been made clear between childhood poverty and diagnosis of conduct disorders [27] and ADHD. [28] Children with conduct disorders and ADHD/ADD have been demonstrated to have higher rates of oppositional defiance and callous-unemotional traits. [29] Numerous studies done in elementary schools have found that children from areas of low SES have higher rates of disciplinary action taken against them. [30] Those same studies cited a correlation between family structure and troublemaking behavior. It was found that youths who live with two natural parents are less likely to be disruptive in elementary school than those who live with just their mother or where stepparents are part of the family. [31] Truancy/chronic absenteeism from school has been well researched and a strong predictive nature exists between decreasing SES and increase in truancy. [32]
Recent research has associated an increase in caries with negative social factors and low SES.[33] The association of toxic stress with behavioral alteration [30, 31] and the presence of negative social determinants of health in a high-risk caries population [34] prompted an evaluation of the behavior of children in the dental setting.
Chapter 2: Materials and Methods

Collaboration

This study was approved by the IRB of Nationwide Children’s Hospital and The Ohio State University and funded in part by the Center for Transitional Science Award (CTSA) grant administrated through the Center for Clinical & Translational Sciences at the Ohio State University (OSU) and The OSU Center for Clinical and Translational Sciences (CCTS).

This retrospective, nationwide study utilizes a large data set and advanced geomapping software to analyze information gathered from 109 locations across the US. The research team is comprised of principal investigators and co-authors Dr. Gabriel Dawson, a Pediatric Dental resident at Nationwide Children’s Hospital and The Ohio State University and Dr. Paul Casamassimo, Professor of Pediatric Dentistry at The Ohio State University College of Dentistry. Also on the research committee, Dr. Dennis McTigue Pediatric Dentist at Nationwide Children’s Hospital and a Professor of Pediatric Dentistry The Ohio State University College of Dentistry and Dr. Arthur Nowak Professor of Pediatric Dentistry University of Iowa.

The analysis was performed July 2015 – June 2016 with statistical analysis performed by Dr. Wei Chen PhD who specializes in public health, data mining and artificial intelligence.
Subjects

Kool Smiles is a dental service organization (DSO) based in Marietta, Georgia, and has over 100 offices located across 17 states. Kool Smiles operates dental clinics located in low-income communities providing general dentistry for both children and adults. The company employs general dentists, pediatric dentists, endodontists, and oral surgeons. [35]

Data was compiled retrospectively from the existing dental software used at Kool Smiles to include all children treated at the Kool Smiles locations across 17 of the affiliated states. The dataset included patients age, sex, race, address of child, office location (in which the child received treatment), year of treatment, and behavior rating (4-point scale). Inclusion criteria for our study were children with an assigned behavior rating, aged 4-5 years old, first dental visit to this location, and treated between years 2009-2013.

Children aged 4-5 were selected for our study based on the unique timing of psychosocial development. Children aged 3 and under tend to lack cooperative ability and are in the “precooperative” phase. While children aged 3-8 are in a latent period considered to be “potentially cooperative”. When the child is in the potentially cooperative stage he/she may now possess pre-logical reasoning and has the ability to reflect, reason and understand logical relationships.[36] According to Vygotsky, a child’s brain in this stage of development is conducive to explanation, modeling and guided
practice in order to achieve objectives. In addition to a specific age range, we also opted to include only those children seen for the first time at a Kool Smiles facility. It is not uncommon for children to require several dental visits in order to complete the necessary dental treatment. And, it has been well documented that as the number of required dental visits increases, behavior decreases and more advanced management techniques are employed, ie. conscious sedation or general anesthesia. By capturing those children seen only the first time for dental treatment, we mitigate the sensitization bias seen in children treated multiple times.

The behavior rating was assigned to the child based on the assessment of the treating doctor at the first dental visit. The Frankl Behavior Rating Scale assesses children’s behavior using a 4-point scale. “A rating of 1 or “poor”: refusal of treatment, forceful crying, fearfulness, or any overt evidence of extreme negativism; 2 = “fair”: reluctance to accept treatment, uncooperative, some evidence of negative attitude but not pronounced; 3 = “good”: acceptance of treatment; cautious behavior at times; willingness to comply with the dentist, at times with reservation, but follows the dentist’s directions cooperatively; 4 = “excellent”: good rapport with the dentist, interest in the dental procedures, laughter and enjoyment.” Each treating doctor assigned the behavior rating at the end of the appointment depending on how the child tolerated the procedure.

Upon employment, each treating doctor at Kool Smiles is educated and calibrated on the 4-point behavior rating system prior to delivering patient treatment. The most
The Frankl Behavior Rating is a valuable tool used in pediatric dentistry to evaluate the most appropriate course of treatment. Similar to an x-ray radiograph or caries risk assessment, the behavior rating is part of an equation used to determine how to best deliver treatment. For example, if a child has multiple large carious lesions and/or an existing infection that would require multiple visits, combined with an assigned low Frankl Behavior Rating, then putting the child through 4-5 dental visits to complete the treatment could be both traumatic for the child and the provider. In contrast, if a child were to have multiple large carious lesions and/or existing infections that would require multiple visits, combined with an assigned high Frankl Behavior Rating, then the course of treatment could be very different. Therefore, the behavior rating in pediatric dentistry is a very useful and fluid measurement.

**Geomapping**

Socioeconomic status (SES) is a composite measure aimed to capture social standing, which is typically estimated by identifying an individual’s income, education level, and current job status. When measured during adulthood, SES is reliably associated with health outcomes.[40] Due to the fact that these measures do not apply to children, in
order to infer SES in childhood, family SES can be estimated by measuring these variables with parent reports of household income and education level. Previous studies have shown higher incidence of risky health behaviors and lower academic performance for the child when low parental SES is reported. [41-43]

SES was extracted for each participant from the Geographic Information System (GIS) software Alteryx based on the address of each participant. The SES data for each patient was represented by the SES of the neighborhood in which the patient lives. The geographic level of the neighborhood we used was the census block. Previous studies suggested that neighborhood SES can be correlated to the SES of individuals living in the neighborhood. [44] Therefore, we found the census block, the smallest census area, an appropriate geographic level for estimating individual level SES.

The specific data examined in the census block level included: population density, age, income, crime, employment status, marital status, race (black, white, latino), education level, household size (number of residents), percent of income spent (education, healthcare, transportation), home ownership vs renting, vehicle ownership, number of vehicles, housing value, length of residence in current domicile, and average time to work. These specific measurements were included because they have been implicated in previous studies defining SES and subsequent effects on health outcomes as well as premature mortality.[45-49]
Statistics

Each child’s behavior rating was then correlated with these social determinants using multivariate logistic regression. Binary outcomes were defined: bad behavior (which includes only the rating of poor) and good behavior (including fair, good, and excellent). The odds ratio represented the correlation between the SES variable and the behavioral outcomes.

Multivariate Analysis

The social risk factors listed in tables 1 and 2 remained significant independent predictors of children’s behavior ratings in multivariate logistic regression models with some attenuation in the magnitude of the associations. While table 3 shows the social determinants of health that were not statistically significant in predicting a child’s behavior rating.

The chi-square test seen in table 4 is the difference in -2 log likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.
Chapter 3: Results

Table 1: Social Determinants Associated with “not good” Behavior Rating

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Std. Error</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp (B)</th>
<th>95% Confidence Interval for Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good: Intercept</td>
<td>-.688</td>
<td>.028</td>
<td>596.128</td>
<td>1</td>
<td>.000</td>
<td>1.215</td>
<td>1.167 - 1.265</td>
</tr>
<tr>
<td>Good: Parental Unemployment</td>
<td>.195</td>
<td>.021</td>
<td>89.511</td>
<td>1</td>
<td>.000</td>
<td>1.215</td>
<td>1.167 - 1.265</td>
</tr>
<tr>
<td>Good: Violence Exposure</td>
<td>.156</td>
<td>.021</td>
<td>58.201</td>
<td>1</td>
<td>.000</td>
<td>1.169</td>
<td>1.123 - 1.217</td>
</tr>
<tr>
<td>Good: Less Parental Education</td>
<td>.119</td>
<td>.029</td>
<td>16.970</td>
<td>1</td>
<td>.000</td>
<td>1.127</td>
<td>1.064 - 1.192</td>
</tr>
<tr>
<td>Good: Transportation Expense</td>
<td>.798</td>
<td>.062</td>
<td>166.705</td>
<td>1</td>
<td>.000</td>
<td>2.222</td>
<td>1.978 - 2.508</td>
</tr>
<tr>
<td>Good: Per capita income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good: No Home Ownership</td>
<td>.148</td>
<td>.041</td>
<td>13.227</td>
<td>1</td>
<td>.000</td>
<td>1.160</td>
<td>1.071 - 1.256</td>
</tr>
<tr>
<td>Good: Black</td>
<td>.372</td>
<td>.108</td>
<td>11.807</td>
<td>1</td>
<td>.000</td>
<td>.689</td>
<td>.558 - .852</td>
</tr>
<tr>
<td>Good: Population Density</td>
<td>.043</td>
<td>.020</td>
<td>4.838</td>
<td>1</td>
<td>.028</td>
<td>1.044</td>
<td>1.005 - 1.086</td>
</tr>
<tr>
<td>Good: Population Density (increasing)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good: % Spent on Food</td>
<td>.158</td>
<td>.040</td>
<td>15.223</td>
<td>1</td>
<td>.000</td>
<td>1.171</td>
<td>1.082 - 1.267</td>
</tr>
<tr>
<td>Good: Housing Expense (per capita income)</td>
<td>.456</td>
<td>.038</td>
<td>147.534</td>
<td>1</td>
<td>.000</td>
<td>1.577</td>
<td>1.465 - 1.697</td>
</tr>
<tr>
<td>Good: Median household age (decreasing)</td>
<td>.127</td>
<td>.035</td>
<td>13.455</td>
<td>1</td>
<td>.000</td>
<td>1.136</td>
<td>1.061 - 1.215</td>
</tr>
</tbody>
</table>
Table 2: Social Determinants Associated with “good” Behavior Rating

<table>
<thead>
<tr>
<th>ba2^a</th>
<th>B</th>
<th>Std. Error</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp (B)</th>
<th>95% Confidence Interval for Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
<td>Upper Bound</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>-.663</td>
<td>.060</td>
<td>121.130</td>
<td>1</td>
<td>.000</td>
<td>.515</td>
<td>.458 - .580</td>
</tr>
<tr>
<td>Home Size</td>
<td>-.331</td>
<td>.048</td>
<td>46.903</td>
<td>1</td>
<td>.000</td>
<td>.718</td>
<td>.653 - .790</td>
</tr>
<tr>
<td>Male to Female Ratio (closer to 1:1)</td>
<td>-.042</td>
<td>.019</td>
<td>4.630</td>
<td>1</td>
<td>.031</td>
<td>.959</td>
<td>.924 - .996</td>
</tr>
<tr>
<td>% Spent on health related expenses</td>
<td>-.130</td>
<td>.053</td>
<td>5.955</td>
<td>1</td>
<td>.015</td>
<td>.878</td>
<td>.790 - .975</td>
</tr>
<tr>
<td>Average time to work</td>
<td>-.061</td>
<td>.023</td>
<td>7.026</td>
<td>1</td>
<td>.008</td>
<td>.941</td>
<td>.899 - .984</td>
</tr>
<tr>
<td>Home Ownership</td>
<td>-.733</td>
<td>.079</td>
<td>85.302</td>
<td>1</td>
<td>.000</td>
<td>.480</td>
<td>.411 - .561</td>
</tr>
<tr>
<td>White</td>
<td>-.500</td>
<td>.096</td>
<td>27.284</td>
<td>1</td>
<td>.000</td>
<td>.607</td>
<td>.503 - .732</td>
</tr>
<tr>
<td>Latino</td>
<td>-.372</td>
<td>.051</td>
<td>15.384</td>
<td>1</td>
<td>.000</td>
<td>.818</td>
<td>.740 - .905</td>
</tr>
</tbody>
</table>
Table 3: Social Determinants Not Statistically Significant

<table>
<thead>
<tr>
<th>ba2$^a$</th>
<th>B</th>
<th>Std. Error</th>
<th>Wald</th>
<th>df</th>
<th>Sig.</th>
<th>Exp (B)</th>
<th>95% Confidence Interval for Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound</td>
</tr>
<tr>
<td>Property Crime</td>
<td>-.027</td>
<td>.017</td>
<td>2.493</td>
<td>1</td>
<td>.114</td>
<td>.974</td>
<td>.942</td>
</tr>
<tr>
<td>Married</td>
<td>.033</td>
<td>.040</td>
<td>.663</td>
<td>1</td>
<td>.415</td>
<td>1.033</td>
<td>.955</td>
</tr>
<tr>
<td>% of pop. Completed zero school</td>
<td>.022</td>
<td>.029</td>
<td>.084</td>
<td>1</td>
<td>.772</td>
<td>1.022</td>
<td>.882</td>
</tr>
<tr>
<td>% spent on education</td>
<td>-0.047</td>
<td>.054</td>
<td>.766</td>
<td>1</td>
<td>.381</td>
<td>.954</td>
<td>.860</td>
</tr>
<tr>
<td>Percentage of renting</td>
<td>0$^b$</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle Ownership</td>
<td>.053</td>
<td>.035</td>
<td>2.226</td>
<td>1</td>
<td>.136</td>
<td>1.054</td>
<td>.984</td>
</tr>
<tr>
<td>Number of Vehicles</td>
<td>.053</td>
<td>.029</td>
<td>.733</td>
<td>1</td>
<td>.392</td>
<td>.975</td>
<td>.921</td>
</tr>
<tr>
<td>Year residence was built</td>
<td>.087</td>
<td>.031</td>
<td>8.134</td>
<td>1</td>
<td>.004</td>
<td>1.091</td>
<td>1.028</td>
</tr>
<tr>
<td>% of population not in labor force</td>
<td>.022</td>
<td>.027</td>
<td>.677</td>
<td>1</td>
<td>.411</td>
<td>1.023</td>
<td>.969</td>
</tr>
<tr>
<td>Appointment Type</td>
<td>-1.174</td>
<td>.109</td>
<td>2.564</td>
<td>1</td>
<td>.109</td>
<td>.840</td>
<td>.679</td>
</tr>
<tr>
<td>Gender (F)</td>
<td>.067</td>
<td>.027</td>
<td>6.117</td>
<td>1</td>
<td>.113</td>
<td>1.070</td>
<td>1.014</td>
</tr>
<tr>
<td>Gender (M)</td>
<td>0$^b$</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age = 4</td>
<td>-.125</td>
<td>.028</td>
<td>19.834</td>
<td>1</td>
<td>.204</td>
<td>.883</td>
<td>.836</td>
</tr>
<tr>
<td>Age = 5</td>
<td>0$^b$</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4: Chi Square Analysis

<table>
<thead>
<tr>
<th>Effect</th>
<th>Model Fitting Criteria</th>
<th>Likelihood Ratio Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2 Log Likelihood of Reduced Model</td>
<td>Chi-Square</td>
</tr>
<tr>
<td>Intercept</td>
<td>105345.859</td>
<td>1287.387</td>
</tr>
<tr>
<td>Parental Employment Status</td>
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<td>Home Ownership</td>
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<td>African American</td>
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Behavior ratings for 4-year-olds (n=17,486) and 5-year-old (n=19,613) children were obtained for first dental visit from 2009-2013. Binary behavior outcomes were defined as “good” and “not good” by combining “excellent”, “good” and “fair” into category “good”. While “poor” is isolated into category “not good”. Behavior was good (n=11,999) and not good (n=25,100). Individual breakdown of behavior rating were, excellent (n=604), good (n=3090), fair (n=8305), and poor (n=25,100).

The odds ratio correlating individual socioeconomic factors to behavior showed that children with more negative behavior were more likely to be exposed to violent crime (P=.0004), parental unemployment (P=.0002), less parental education (P=.0006), high expense on food and transportation per capita income (P=.0005), living in a more densely populated area (P=.028), non-homeowner (P=.0001), with a greater amount spend on housing per capita income (P=.0009), African-American (P=.0008), and a lower median household age (P=.0003).

Children with good behavior rating were more likely to be of Latino or white ethnicity (P=.0002), come from homes owned by parents (P=.007), having a male to female ratio closer to 1:1 (P=.031), spent a greater amount on health related expenses (P=.015), and a larger average home size (P=.0002).
Chapter 4: Discussion

The environment in which it develops affects the growth and maturation of the prefrontal cortex. The executive functions (the primary responsibility of the prefrontal cortex) are therefore affected by that environmental growth and the subsequent behavior of the child. In our study we had the unique opportunity to have both an assigned behavior rating for every child and the address to which the child was raised. Combining these two pieces of data gives us a powerful look at the relationship between factors associated with toxic stress and child behavior in the dental office.

This study of 37,099 4-and-5-year-old children, found poorer behavior at initial dental examination for children exposed to violent crime, parental unemployment, less parental education, high expense on food and transportation per capita income, living in a more densely populated area, non-homeowner, with a greater amount spend on housing per capita income, African-American, and a lower median household age (P=.0003).

Children with good behavior rating were more likely to be of Latino or white ethnicity, come from homes owned by parents, having a male to female ratio closer to 1:1, spent a greater amount on health related expenses, and a larger average home size.

Numerous, high level studies performed across the US have consistently identified that dental caries, and overall dental health, is significantly worse for low SES communities than for medium and high SES communities. [50, 51] This existing data,
combined with our research further demonstrates the barriers in providing dental treatment to these children in the most need.

**Limitations**

Despite the fact that each doctor is educated and calibrated on assignment of a behavior rating there cannot be absolute consistency due to multiple factors. Kool Smiles employs hundreds of doctors and each varies in their ability to behavior manage children. In addition to inter-operative variability, the behavior rating scale employed by Kool Smiles is not the validated Frankl Behavior Scale but a similar 4-point scale. Although Kool Smiles relies on a near identical degree of cooperation and patient interaction as the Frankl Scale in order to determine an appropriate behavior rating for the child, it is important to note that it has not been validated. As of 2014, Kool Smiles has converted to the exclusive use of the Frankl Behavior Scale.

Dichotomizing the data into 2 categories, “good” and “not good” allowed us to run multivariate logistical regression models that produced easily digestible data but may limit our ability to analyze the results to a greater degree. In future tests, a non-dichotomized analysis should be performed and compared to dichotomized results.

**Strengths**

The strength of this research is due largely in part to the Kool Smiles dataset. The statistical power as a result of such large number affords us the ability to draw very strong associations. In addition, this dataset was unencumbered by governmental agency
filtering and bias giving us the advantage to evaluate raw data more representative of the population.

To further evaluate the strength of the association tests, an age analysis was performed comparing only patients age and behavior rating to demonstrate that as age increases, so too does behavior rating. A comparative analysis was performed by running the same multivariate logistical regression models with patients aged 13 years old. An association between social factors and behavior rating remained. Although the average behavior rating increased, a similar distribution is observed suggesting that perhaps the negative social determinants have an effect which continue to alter children’s behavior into their teenage years and beyond.

**Further Study**

There are many known barriers to providing necessary dental treatment to those children in most need. Access to care, inadequate insurance coverage, etc. Our study demonstrates that even when these children make it to the dental office, overcoming those barriers, they still have significant hurdles in the way of receiving treatment. A child exposed to toxic stress will need advanced behavior guidance, which will likely include sedation, or general anesthesia. Most dental insurance does not cover these procedures and a provider has no other option than restraint. A practice that is difficult and traumatic for both the child and practitioner. We must evaluate insurance coverage in our country and avoid further indemnification of those in need most.
References


