SOA Research Institute

Using Social Determinants to Identify Profiles of U.S. Children with Low Dental Expenditures and High Medical Expenditures with Clusters

Health Care Cost Trends

Diversity, Equity and Inclusion

November 2021

Using Social Determinants to Identify Profiles of U.S. Children with Low Dental Expenditures and High Medical Expenditures with Clusters

Authors Marjorie Rosenberg, PhD, FSA
Assurant Health Professor of Actuarial Science,
University of Wisconsin-Madison

Seulkee Yun
University of Wisconsin-Madison

Sponsor Health Care Cost Trends Strategic Research Program

Caveat and Disclaimer

The opinions expressed and conclusions reached by the authors are their own and do not represent any official position or opinion of the Society of Actuaries Research Institute, Society of Actuaries, or its members. The Society of Actuaries Research Institute makes no representation or warranty to the accuracy of the information.

CONTENTS

Using Social Determinants to Identify Profiles of U.S. Children with Low Dental Expenditures and High Medical Expenditures with Clusters

Executive Summary

In this report, we explore the impact of clustering using the Medical Expenditure Panel Study (MEPS) data for children (aged 5 to 17) to build a bridge between oral health and overall health using dental and medical expenditures. We include social determinants of health as cluster input variables using the Partitioning around Medoids (PAM) method to identify children and their families who could potentially benefit from population health management related to oral health. We consider demographic and health variables of both the children and the respondent to the survey (the person most knowledgeable of the family who answers the survey questions), as well as household-level variables, such as income, education, and food security.

We connect these clusters to outcomes, including dental and net total expenditures (total minus dental), as well as to the health status and behavioral issues at home and school of the child. We omit expenditures and insurance status when creating the clusters.

We label the clusters based on the children's dental expenditure rank from highest to lowest (i.e., low rank labels indicate higher expenditures). Our results focus on those clusters that are ranked lowest in dental expenditures (as measured by the 75th percentile) and highest (also as measured by the 75th percentile) in net total expenditures for the children. We find that those children in the lowest dental expenditure and highest net total expenditure clusters indicate more behavioral issues at home and school than the aggregate population.

As our population of interest is children, we observe that higher dental and higher medical expenditures are not necessarily signals of poor outcomes but could be signals of prevention. For instance, going to the dentist and physician for check-ups, and other preventive care, increases costs, but can also add to health in the short and long run that could reduce costs as adults. We also see that having low costs for dental and medical are also not signals for good health but could indicate a lack of access to care.

For those clusters with low dental expenditures and high net total expenditures, we see a difference of profiles from the aggregate distribution (having one big cluster for the data), and from each of the other clusters. We note the similarity in distribution in rank of expenditures for the children and their respondents. We also note substantial differences in characteristics among clusters.

We use respondent characteristics as cluster input variables to help explain outcomes for their children. Respondent input variables include their inability to obtain dental care or a delay in necessary care as a proxy for their views of obtaining care for their children. We also included variables for the respondent's overall and mental health statuses to serve as a guide to their health needs and its relationship to their child's health.

We explore the choice of the number of clusters and find that choosing a number of clusters larger than that suggested by published metrics is more effective to identify profiles of potentially at-risk children who could perhaps benefit from interventions such as school-based dental programs or access to dental providers. By increasing the number of clusters created, we are able to divide the population into smaller subsets to create more homogenous

clusters of children. However, care needs to be taken to ensure that there are sufficient numbers of observations in each cluster to achieve credible results.

Our results are representative of the U.S. and based on a diverse set of children. We see that cluster profiles differ from the aggregate profile, and that cluster profiles for those clusters of interest differ from cluster 1 and the lowest ranked cluster for cluster dental expenditures. These clusters of interest showed similar ranked outcomes for expenditures between the child and the respondent. We find that social determinants of health such as education, income and food insecurity are influential factors in poor outcomes. These clusters of interest show to poorer overall and mental health status for the children, more school days missed, more issues at schools, and issues at home or being happy. We note that structural household relationships, such as the number of adults in the household, or even whether a child is living with a parent is also related to outcomes. We found that a large percentage of respondents are unaware that their children have pediatric dental care as provided by the Affordable Care Act. Ways of better disseminating the information could result in more prevention for oral health and potentially improve health outcomes in the future.

Insurers, with longitudinal data, can create clusters on their data to study the improvement of population health when interventions are made on clusters meeting established criteria. These clusters can be examined over time to determine the success of the interventions.

Introduction

The 2000 Surgeon General's Report on Oral Health in America referred to dental and oral disease as a silent epidemic due to the absence of symptoms until extreme pain occurs. When pain occurs, people require more extensive health resources and treatment (U.S. Department of HHS. 2000). Children are an especially vulnerable group, as they are dependent on their parents, or other household members, to help them implement good oral health practices and to obtain needed dental care.

In this work we utilize the 2016 Medical Expenditure Panel Study, a publicly available data set. One of our aims is to create clusters of similar children (aged 5 to 17), and their family, based on social determinants. These clusters are examined based on the dental expenditures of the children and their net total expenditures (total minus dental). We relate these clusters to available behavioral outcomes of the children. Our results focus on clusters of children with low dental expenditures and high medical expenditures, as we wanted to examine any relationship between expenditures and lack of prevention activities for children.

As a secondary purpose, we examine different measures proposed for use to determine the recommended number of clusters. We compare the cluster profiles, their expenditures, and their outcomes to show the marginal improvement of identifying population subgroups of interest when the number of clusters is increased.

LITERATURE REVIEW

Prior studies have documented the link between dental cavities that could lead to infections and pain, or periodontal disease that is associated with other conditions, such as diabetes, health disease, cardiovascular disease, and adverse pregnancy outcomes (U.S. Surgeon General 2000; Humphrey et al. 2008). The World Health Organization defines oral health as "a state of being free from chronic mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, tooth decay, tooth loss, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial wellbeing." [1]

Oral health issues in children are generally preventable with inexpensive care. As such, Healthy People 2030 oral health goals for children are to "(1) Reduce the proportion of children and adolescents with lifetime tooth decay experience in their primary or permanent teeth; and (2) Reduce the proportion of children and adolescents with active and currently untreated tooth decay in their primary or permanent teeth."[2] Between 2013 and 2016, 13.4% of children aged 3 to 19 had untreated tooth decay in their primary and permanent teeth. [3]

The cumulative impact of poor oral health for children extends beyond their child-years and into adulthood (U.S. Surgeon General 2000). Poor oral health leads to low self-esteem (Huff et al. 2006), worse outcomes in education (Guarnizo-Herreño and Wehby 2012; Jackson et al. 2011), worse potential future employment success (Gleid and Neidell 2010), and poorer overall health outcomes (Cabrera et al. 2005). A woman's oral health during her pregnancy can impact her health, as well as the health of her unborn child (Hartnett et al. 2016). As children age, there is a relationship between their oral health and that of their mother (Dye et al. 2011; Isong 2010).

Some prior studies assessed differentials in access and outcomes (Edelstein and Chinn 2009; Gupta et al. 2019; Valachovic 2018). Food insecurities and diet impact oral health (Gundersen and Ziliak 2015). The absence of fluoridation in the water has been shown to more adversely impact the poor (Sanders et al. 2019). Studies have been published assessing oral health-related quality of life of children and adolescents (Hettiarachchi et al. 2018;

[1] https://www.who.int/news-room/fact-sheets/detail/oral-health
[2] https://health.gov/healthypeople/objectives-and-data/browse-objectives/oral-conditions
[3] https://health.gov/healthypeople/objectives-and-data/browse-objectives/oral-conditions

Zaror et al. 2018) School-based dental sealant programs have been shown to prevent cavities and are cost effective (Griffin et al. 2016). Understanding the complexity of the determinants of oral health can help guide future interventions that are cost effective.

When we think about an individual's overall health status, we may not view it from the perspective of one's oral health. The 2000 Surgeon General's Report on Oral Health states that "the mouth reflects general health and well-being and that oral diseases are progressive and cumulative" (U.S. Surgeon General 2000). Cohen and Jago motivate the importance to study issues related to oral health as it reflects the lifestyles of individuals whose preventive actions could limit chronic disease (Cohen and Jago 1976). There are billions of dollars in direct medical care and indirect costs of chronic conditions related to poor oral health, with additional psychological effects and impact of low self-esteem and pain (U.S. Surgeon General 2000).

Methods

We combine children and household information from the 2016 Medical Expenditure Panel Study (MEPS) data[4] using clusters, an unsupervised machine learning method. These clusters result in a profile of the collection of input characteristics of the children and their families that connect to their expenditure use. The data used to create the clusters and the outcomes to reflect the differences among the clusters are shown in the Data section. Our results are reflective of children aged 5 to 17 in the U.S. civilian non-institutionalized population.

Our work builds on recent research (Agterberg et al. 2020; Zhong et al. 2021; Rosenberg and Zhong 2021) where we create clusters of adults, ages 20 and 59, based on their demographic, social determinants, and behavioral health information from the National Health Interview Survey (the survey from which MEPS data are drawn). Our prior work explored two clustering methods, k-medoids and k-means.

For this study, we chose the Partitioning around Medoids (PAM), a k-medoids approach, to form the clusters. In this algorithm, the centers of the clusters, the medoids, are an actual person, or in our case, a child, along with their family characteristics. We explore the impact on the choice of the number of clusters to see the resulting cluster compositions, and the relationship to the external behavioral and social outcome variables by cluster.

As we did in our previous work, we utilize the Goodall 3 distance metric. This metric compares characteristics of two children and calculates a similarity measure. If the characteristic is rare, there is a greater similarity between two children than if the match is more common. (For example, two children who are white are less similar than two children who are Black/African American Black.)[5]

To aid in our description of the clusters, we label the clusters based on the child's dental expenditures. We label the clusters from the highest 75th percentile of child dental expenditures (cluster 1) to the lowest. We chose the 75th percentile as it is not sensitive to outliers and reflects a compromise choice from the average or the median. These labels do not change when reviewing the child's net total expenditures, as well as the respondent's dental and net total expenditures.

Our secondary goal for this work explores the information gained from expanding the number of clusters chosen for the analysis. We found in our previous work that increasing the number of clusters allowed for a greater differentiation of the characteristics of the clusters from the mean of each of the variables for the entire dataset. With a greater diversity of profiles among the clusters, we can better examine the outcome variables across the set of cluster profiles.

As with other statistical methods, like regression, there is not one unique measure to determine the optimal number of clusters. Historically several indexes have been introduced to help determine the number of clusters. In an ideal situation, children in the cluster would be similar to one another as much as possible, and children in other clusters would have a different profile. These criteria have been labeled compactness and separation (Halkidi,

[4] https://meps.ahrq.gov/mepsweb/

[5] The Society of Actuaries prefers different terminology for races and ethnicities than MEPS used. We report using the SOA's preferred terms.

SOA Preferred Term	MEPS Term
Race/ethnicity	Race
Asian American	Asian
Black/African American	Black
Hispanic/Latino	Hispanic

Batistakis and Vazirgiannis 2001). It is notable that a particular index does not necessarily converge to a particular number, nor do different indexes agree on similar choices of the number of clusters.

Our approach is to examine a number of the indexes with detailed results shown in detail in a separate appendix.

Data

The study utilizes the 2016 MEPS that links person-level, household-level demographics, and social determinants with their health care utilization/cost and other outcome variables. [6] The MEPS data are the only governmental source data available to the public that contain person-level dental and medical expenditures, and are also the only data set to capture expenditure information about the uninsured (Aizcorbe 2012).

In this work, our units of observation are children between ages 5 and 17. We use data from the Household Component file, as well as data from the more detailed supplementary files (dental, medical conditions, and food security files).

A broad summary of the variables used as inputs to create the clusters are shown in Table 1. More granular-level details of the 39 cluster input variables are found in Appendix A. We include child-level variables, such as age, sex,[7] race,[8] along with some dental utilization indicators of treatment (such as preventive care, treatment of fillings, or more intensive care), and health-related variables (such as preventive care activities, presence of specific medical conditions, or special needs).

Table 1
CLUSTER INPUT VARIABLES

Child	Respondent	Household
Demographic	Demographic	Geographic Region
Dental Utilization	Dental Utilization	Highest Level of Education
Health-Related	Health-Related	Income
	Identification of Respondent & Reference	Food Security
		Employment
		Family Structure

We leverage the MEPS design by also including respondent-level variables and variables related to the household. The respondent is the person who answers the questions for the entire household. [9] We hypothesized that the

[6] https://meps.ahrq.gov/data_files/publications/mr33/mr33.pdf
[7] MEPS used the term "gender" but content using the terms male/female refers to "sex." We report sex to be consistent with the content.
[8] The Society of Actuaries prefers different terminology for races and ethnicities than MEPS uses. We report using the SOA's preferred terms.

SOA Preferred Term	MEPS Term
Race/ethnicity	Race
Asian American	Asian
Black/African American	Black
Hispanic/Latino	Hispanic

[9] There is another MEPS variable for the reference person. The reference person is defined as the person who owns or rents the dwelling unit. We chose to highlight the respondent's characteristics as we deemed those more attuned to the person most knowledgeable of those in the household and potentially the one who is directing care.

respondent's view of the importance of preventive care for both medical and dental could impact the level of care for the child. In addition, the health of the respondent, both physical and mental health, could also be a driver in having the energy and time to obtain care for themselves and for their children.

Household-level variables include education, income, food security, and employment. The set of variables for family structure address the marital status and other changes that could have occurred in the household over the year.

As with our prior work, we did not exclude missing data, but create a separate category in each variable when responses are missing. By not removing the missing data, we are not assuming that the data are missing at random.[10]

The variables used as outcomes are shown in Table 2, with more details of the 15 outcomes variables shown in Appendix A. We focus on the children but reflect on expenditures of the respondent to provide a proxy on their attitude of seeking medical or dental care, or the accessibility of the care with the presence of insurance.

Table 2
OUTCOME VARIABLES

Child	Respondent
Expenditures	Expenditures
Insurance	Insurance
Health-Related	
School-Related	
Behavioral	
Dental Accessibility	

[10] If we removed those observations with missing data in some variables, we would dramatically reduce our sample size. In addition, because of potentially sensitive questions, such as income or employment, some respondents may respond "don't know" or "refused." These missing data responses appear to be connected with other responses that are not favorable to overall health. As all of the variables are categorical, adding a missing category integrates easily into the model approach.

Results

In this section, we summarize results for a selection of clusters to indicate the information gained by increasing the number of clusters beyond what the metrics indicate.

As a note, the weighted plots for the respondents, for other than three clusters, shows one less boxplot than the number of total clusters. The reason for this result is that there is one cluster that is formed where the respondent information is missing.

We follow-up this summary, with a detailed look at one analysis that used 38 clusters to explore the relationship between the profiles of children with low dental expenditures and high net total (total minus dental) expenditures.

INCREASING THE NUMBER OF CLUSTERS

We focus on those clusters with low dental and high net total expenditures for children (called clusters of interest). In addition, we show the results for cluster 1 (the highest 75th percentile for child dental expenditures), as well as the lowest for comparison purposes.

To determine what to illustrate for this study, we explored the plots shown in the separate appendix to evaluate the indexes. The BK plot, Calinski-Harabasz index and the Category Utility index indicated three clusters as the best choice; the PSFM/PSFE and silhouette plots were in the neighborhood of two to three clusters. However, the Dunn index indicated that very high numbers of clusters would be better, such as over 40. The Cluster Cardinality index indicated that 10 or 11 clusters might be appropriate. In the end, the Dunn index and the BK index showed that there are many reasonable choices for the number of clusters ultimately selected.

For this report, we focus on analyses with an aggregate number of clusters of 3, 11, 24, and 38, as shown in Figure 1. The percentages in the circles are the percentage of the children captured by the particular cluster. With only three clusters, cluster 1 has 55% of the children, while clusters 2 and 3 have the rest of the children split equally between the two clusters.

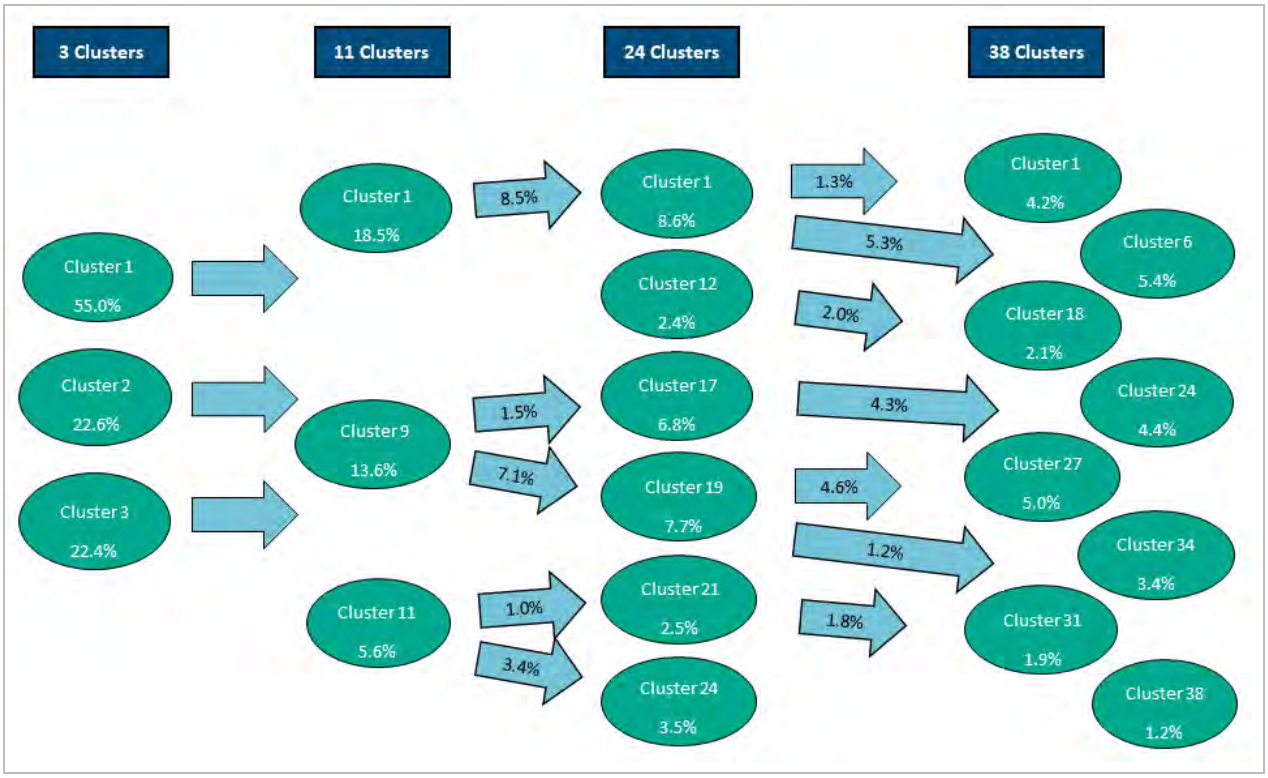
These three clusters migrate to 11 clusters, where we only focus on clusters 1, 9, and 11. Once we move to examine 24 clusters, we see that the clusters of interest result from clusters of interest of a smaller set of clusters. For example, moving from 11 clusters to 24 clusters, we see that 8.5 percentage points of cluster 1's 18.5 percentage points moves to cluster 1 of 24 clusters. Here, cluster 1 of 24 clusters is nearly an entire subset of cluster 1 of 11 clusters. We see similar movement from 24 to 38 clusters. Here 5.3 percentage points of cluster 1's 8.6 percentage points move to cluster 6.

Thus, as we increase the number of clusters, in some cases, we are isolating profiles of similar children in a new cluster. For example, cluster 19 of 24 clusters almost entirely moves to form a large percentage of clusters 27 and 34 of 38 clusters.

We examine the characteristics of some clusters in Figure 1.

Figure 1

CLUSTER NUMBERS EXPLORED IN THE STUDY AND THEIR CONNECTIONS TO OTHER CLUSTERS: FLOW CHART OF DIFFERENT NUMBERS OF CLUSTERS



EXAMPLE: HIGHLIGHTING THE VALUE OF MORE CLUSTERS

For example, suppose we examine cluster 11 (of 11 clusters), that moves to clusters 21 and 24 (of 24 clusters), and then to cluster 31 (of 38 clusters). Tables 3, 4 and 5 contain a comparison of the clusters for a subset of the variables used to form the clusters that reflect differences among the four clusters for the child, respondent and household input variables.

These tables are set up similarly with the children's dental cluster shown, the corresponding rank of the children's net total expenditure, and the rank of the respondents' net total expenditure. The number in bold in the body of the tables for each of the variables indicates the medoid (that is, the characteristic of the center of the cluster). The characteristic for the medoid generally is the mode frequency of the variable.

Cluster 11 (of 11 clusters) shows that the child net expenditure ranks 10 out of 11 clusters, with the respondent's rank of 9. However, when we move to 24 clusters from 11, we see that cluster 11 (of 11 clusters) moves 1.0 percentage points to cluster 21 and 3.4 percentage points to cluster 24, with the addition of some children from other clusters. Essentially, cluster 24 is entirely based on cluster 11 input, and cluster 21 is about 50% from cluster 11 input. The results for the variables shown, sex, doctor advised a regular dental visit, BMI, visits for specific medical conditions, and whether the child has special needs are very similar between clusters 11 and 24. The relative ranks of the child and respondent net total expenditure for the number of clusters in the analysis are also similar.

However, the results for cluster 21 are very different. For cluster 21, the ranking of the child expenditure now is five out of 24, while the respondent's rank is two. And, the profiles are very different for cluster 21, compared to cluster

24. The medoid in cluster 21 is female (not male), there are considerably more children being advised by their doctor to go the dentist, there are more normal weight children, but who have specific medical conditions and special needs. When we go from 24 to 38 clusters, cluster 31 resembles that of cluster 21 (of 24 clusters).

We notice the same patterns among the clusters when we examine the results for the respondent in Table 4, where cluster 21 (of 24 clusters) and cluster 31 (of 38 clusters) are more similar to one another, and different from cluster 24 (of 24 clusters), as well as the originating cluster 11 (of 11 clusters). For clusters 21 and 31, the respondents are older, with a greater percentage never going to the dentist, a considerable percentage with fair or poor overall and mental health, more having ADL or IADL limitations, who are obese, and have several medical conditions.

Similarly, the same pattern is present for the household variables in Table 5. More mothers are unemployed in clusters 21 and 31, with the employment status of the father missing, as the household is generally a single parent household. The income of the household is poor, with almost half of the households being food insecure. Most of the households are composed of a single mother being the only adult with about two children.

Table 3

PROFILE SUMMARIES FOR CHILD INPUT VARIABLES FOR THOSE IN CLUSTER 11 (OF 11), 21 (OF 24), 24 (OF 24), AND 31 (OF 38)

		Overall	From 11 Clusters	From 24 Clusters	From 24 Clusters	From 38 Clusters
Child's Dental Cluster			11	21	24	31
Rank of Child Net Total Expenditure			10	5	24	8
Rank of Respondent Net Total Expenditure			9	2	22	1
Cluster Percentages		100%	5.6%	2.5%	3.5%	1.9%
Variables	**Attributes**	**Overall**	**11 (OF 11)**	**21 (OF 24)**	**24 (OF 24)**	**31 (of 38)**
Sex	Male	51.0%	**64.2%**	45.5%	**64.6%**	47.6%
Sex	Female	49.7%	35.9%	**54.5%**	35.4%	**52.4%**
Doctor Advise Regular Dental Visit	Yes	61.3%	38.2%	45.6%	35.4%	50.1%
Doctor Advise Regular Dental Visit	No	36.7%	**58.2%**	**49.0%**	**61.1%**	**49.0%**
Doctor Advise Regular Dental Visit	Missing	2.1%	3.6%	5.4%	3.5%	0.9%
BMI	Missing	25.2%	**45.1%**	**29.4%**	**44.1%**	**28.3%**
BMI	Obese	13.2%	21.2%	23.6%	20.1%	24.4%
BMI	Overweight	10.9%	9.5%	11.6%	10.4%	11.8%
BMI	Normal	44.3%	16.4%	29.5%	14.7%	29.5%
BMI	Underweight	6.5%	7.9%	5.9%	10.8%	6.0%
Visits for Specific Medical Conditions	Yes	19.1%	18.2%	58.7%	10.6%	55.9%
Visits for Specific Medical Conditions	Visits, but other reasons	51.7%	30.1%	30.9%	26.9%	31.6%
Visits for Specific Medical Conditions	No Medical Visits	29.2%	51.7%	10.5%	62.5%	12.5%
Special Needs	Need	28.6%	24.4%	**68.3%**	16.7%	**75.0%**
Special Needs	No Need	71.4%	**75.2%**	30.0%	**83.3%**	25.1%
Special Needs	Missing	0.1%	0.4%	1.7%	0.0%	0.0%

Table 4

PROFILE SUMMARIES FOR RESPONDENT INPUT VARIABLES FOR THOSE IN CLUSTER 11 (OF 11), 21 (OF 24), 24 (OF 24), AND 31 (OF 38)

	Overall	From 11 Clusters	From 24 Clusters	From 24 Clusters	From 38 Clusters
Child's Dental Cluster		11	21	24	31
Rank of Child Net Total Expenditure		10	5	24	8
Rank of Respondent Net Total Expenditure		9	2	22	1
Cluster Percentages	100%	5.6%	2.5%	3.5%	1.9%

Variables	Attributes	Overall	11 (OF 11)	21 (OF 24)	24 (OF 24)	31 (of 38)
Age	13–17	0.2%	1.0%	0.5%	1.2%	0.6%
Age	18–30	9.6%	**42.9%**	13.1%	**51.1%**	12.8%
Age	31–40	40.9%	24.2%	**51.0%**	22.7%	**48.1%**
Age	41–50	35.8%	19.0%	19.5%	15.3%	23.6%
Age	51–60	9.7%	8.5%	9.8%	6.7%	10.6%
Age	61–70	2.7%	3.3%	4.1%	2.7%	3.9%
Age	71–90	0.5%	1.1%	2.1%	0.3%	0.5%
Age	Missing	0.8%	0.0%	0.0%	0.0%	0.0%
Race/Ethnicity	White	54.7%	24.5%	29.0%	22.1%	30.8%
Race/Ethnicity	Hispanic/Latino	21.9%	13.7%	9.8%	5.9%	6.3%
Race/Ethnicity	Black/African American	13.9%	**57.3%**	**53.1%**	**68.0%**	**54.4%**
Race/Ethnicity	Asian American	5.4%	0.8%	0.4%	0.0%	0.5%
Race/Ethnicity	Others	3.4%	3.7%	7.8%	4.0%	8.0%
Race/Ethnicity	Missing	0.8%	0.0%	0.0%	0.0%	0.0%
Number of Dental Checkups	Never	12.1%	18.4%	24.3%	14.6%	25.2%
Number of Dental Checkups	<1 per year	18.1%	**36.5%**	20.6%	**41.4%**	26.2%
Number of Dental Checkups	1 per year	26.2%	23.1%	**43.2%**	21.3%	**35.5%**
Number of Dental Checkups	2+ per year	42.5%	21.5%	10.6%	22.8%	11.4%
Number of Dental Checkups	Missing	1.1%	0.5%	1.3%	0.0%	1.8%
Overall Health Status	Poor	4.5%	6.6%	18.2%	5.4%	18.4%
Overall Health Status	Fair	14.9%	21.6%	**60.4%**	10.7%	**64.1%**
Overall Health Status	Good	37.4%	**50.1%**	11.3%	**57.9%**	8.5%
Overall Health Status	Very Good	32.0%	13.2%	6.0%	16.6%	4.2%
Overall Health Status	Excellent	10.5%	8.5%	4.1%	9.4%	4.8%
Overall Health Status	Missing	0.8%	0.0%	0.0%	0.0%	0.0%
Mental Health Status	Poor	2.3%	4.8%	14.1%	3.5%	15.1%
Mental Health Status	Fair	9.1%	14.8%	32.2%	13.0%	29.7%
Mental Health Status	Good	37.0%	**48.1%**	**33.2%**	**47.6%**	**34.1%**
Mental Health Status	Very Good	31.1%	17.1%	10.3%	20.2%	11.7%
Mental Health Status	Excellent	19.8%	15.2%	10.2%	15.8%	9.5%
Mental Health Status	Missing	0.8%	0.0%	0.0%	0.0%	0.0%
ADL or LADL Limitations	Yes	14.8%	19.0%	**66.0%**	9.1%	**70.0%**
ADL or LADL Limitations	No	83.3%	**80.5%**	34.0%	**90.2%**	30.0%

Variables	Attributes	Overall	11 (OF 11)	21 (OF 24)	24 (OF 24)	31 (of 38)
ADL or LADL Limitations	Missing	2.0%	0.5%	0.0%	0.7%	0.0%
BMI	Missing	2.7%	3.0%	1.7%	3.3%	2.4%
BMI	Obese	35.9%	**43.8%**	**58.1%**	**42.8%**	**64.1%**
BMI	Overweight	30.3%	30.0%	25.7%	33.3%	24.4%
BMI	Normal	30.0%	22.1%	11.1%	19.8%	5.5%
BMI	Underweight	1.0%	1.0%	3.4%	0.9%	3.7%

Table 5

PROFILE SUMMARIES FOR HOUSEHOLD INPUT VARIABLES FOR THOSE IN CLUSTER 11 (OF 11), 21 (OF 24), 24 (OF 24), AND 31 (OF 38)

		Overall	From 11 Clusters	From 24 Clusters	From 24 Clusters	From 38 Clusters
Child's Dental Cluster			11	21	24	31
Rank of Child Net Total Expenditure			10	5	24	8
Rank of Respondent Net Total Expenditure			9	2	22	1
Cluster Percentages		100%	5.6%	2.5%	3.5%	1.9%
Variables	**Attributes**	**Overall**	**11 (OF 11)**	**21 (OF 24)**	**24 (OF 24)**	**31 (of 38)**
Employment Status of Mother	Missing	8.0%	11.2%	6.1%	7.3%	7.0%
Employment Status of Mother	Unemployed	19.4%	21.7%	**50.7%**	16.2%	**54.6%**
Employment Status of Mother	Partially Employed	12.0%	23.2%	23.9%	25.5%	22.0%
Employment Status of Mother	Fully Employed	60.6%	**43.9%**	19.4%	**51.0%**	16.4%
Employment Status of Father	Missing	28.2%	**90.6%**	**89.7%**	**91.7%**	**87.4%**
Employment Status of Father	Unemployed	4.0%	1.9%	3.9%	1.7%	3.9%
Employment Status of Father	Partially Employed	5.1%	2.7%	5.3%	3.4%	7.3%
Employment Status of Father	Fully Employed	62.8%	4.8%	1.1%	3.2%	1.5%
Household Income	Poor	17.6%	**59.7%**	**71.7%**	**54.7%**	**74.8%**
Household Income	Near Poor	5.0%	8.6%	10.2%	8.5%	10.4%
Household Income	Low Income	16.2%	16.2%	9.3%	21.5%	6.6%
Household Income	Medium Income	30.8%	12.9%	8.5%	12.2%	8.3%
Household Income	High Income	30.4%	2.6%	0.3%	3.1%	0.0%
Food Insecurity	Insecure	21.1%	23.9%	45.5%	24.1%	**48.5%**
Food Insecurity	Secure	75.9%	**70.5%**	**48.1%**	**71.9%**	44.2%
Food Insecurity	Missing	3.0%	5.5%	6.5%	4.0%	7.4%
# of Adults in Family (>17 in age)	0	1.0%	1.6%	1.4%	1.8%	0.9%
# of Adults in Family (>17 in age)	1	18.9%	**56.6%**	**60.0%**	**55.0%**	**67.9%**

Variables	Attributes	Overall	11 (OF 11)	21 (OF 24)	24 (OF 24)	31 (of 38)
# of Adults in Family (>17 in age)	2	61.4%	26.6%	25.9%	27.0%	20.4%
# of Adults in Family (>17 in age)	3	14.0%	11.1%	7.5%	11.1%	6.0%
# of Adults in Family (>17 in age)	4+	4.7%	4.1%	5.3%	5.2%	4.8%
# of Children in Family (<17 in age)	0	0.0%	0.0%	0.0%	0.0%	0.0%
# of Children in Family (<17 in age)	1	24.4%	25.0%	23.6%	22.0%	26.9%
# of Children in Family (<17 in age)	2	39.9%	**36.8%**	**40.3%**	**38.5%**	**41.7%**
# of Children in Family (<17 in age)	3	23.2%	20.1%	20.5%	20.6%	20.5%
# of Children in Family (<17 in age)	4+	12.6%	18.2%	15.6%	19.0%	10.9%
Marital Status Mother	Missing	8.0%	11.2%	6.1%	7.3%	7.0%
Marital Status Mother	Never Married	14.6%	**61.0%**	**57.2%**	**70.2%**	**54.0%**
Marital Status Mother	W/D/S (This Year)	4.6%	6.8%	11.6%	4.1%	11.6%
Marital Status Mother	W/D/S	9.5%	17.4%	18.9%	15.7%	18.6%
Marital Status Mother	Married	63.4%	3.7%	6.2%	2.7%	8.9%
Marital Status Father	Missing	28.1%	**90.6%**	**89.7%**	**90.2%**	**87.4%**
Marital Status Father	Never Married	4.7%	6.5%	3.8%	8.2%	4.4%
Marital Status Father	W/D/S (This Year)	2.4%	1.0%	4.4%	0.5%	5.3%
Marital Status Father	W/D/S	2.5%	0.6%	1.0%	0.2%	1.4%
Marital Status Father	Married	62.4%	1.3%	1.1%	0.9%	1.5%

WEIGHTED EXPENDITURES

The next set of graphs examine the clusters (for 3, 11, 24, and 38 clusters) by dental expenditure and net total expenditure for both the children and the respondents. Note that the cluster labeling is set by the child's dental expenditures, with the other box plots retaining the same labeling, but sorted in descending order of the top 75% percentile. The diamond in each boxplot represents the average expenditure, with the solid line representing the median. The vertical dotted line in each graph indicates the middle number of clusters for identification of the top half and lower half of cluster dental expenditure distributions. The yellow-highlighted clusters indicate those clusters that show in Figure 1.

From the results using three clusters in Figure 2, we see that cluster 1 for the children have higher dental and net total expenditures than the other two clusters. The respondent's information for dental is similar to the children, but the net total expenditures for cluster 2 have the highest 75th percentile (while the boxplots look almost identical). The average net total expenditures are not materially different among the three clusters. The plots for the respondents look nearly identical for the net total expenditures.

What is gained by moving to 11 clusters is that we see some child clusters in Figure 3 with nearly zero dental expenditures, and other clusters showing different distributions. Cluster 9 shows the highest net total expenditure.

We notice that cluster 1 for the children is second ranked for net total expenditures and cluster 11 ranked 10th. A similar result holds for the respondent for the net total expenditures. [11]

With 24 clusters in Figure 4, we see a greater spread of expenditure distributions for both the child and the respondent. We note that cluster 19 is formed from cluster 9 in Figure 1 and clusters 21 and 24 are formed from cluster 11, as we discussed earlier. Note that clusters 1, 12, 19, and 21 are among the top net expenditure clusters for both children and their respondents.

Finally, moving to 38 clusters in Figure 5, we note that clusters 18, 27, 31, and 34 are among the top clusters for net total expenditures for both children and respondents.

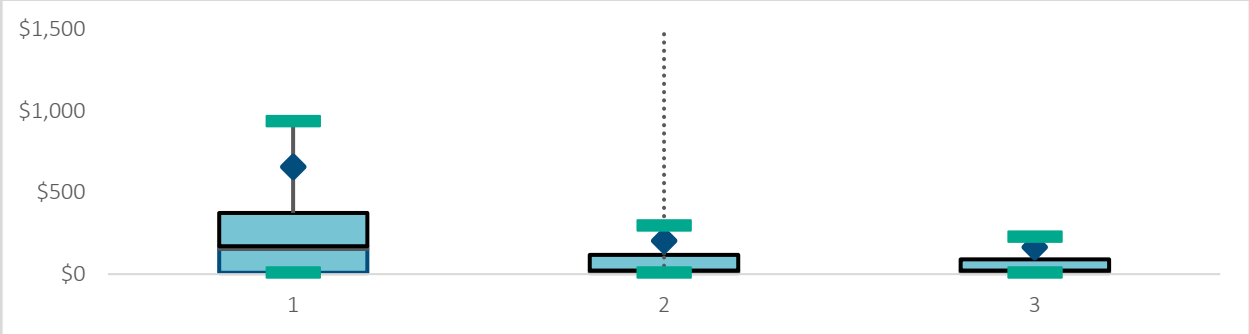
In all of these plots, we see that the lowest ranked cluster were generally among the lowest for dental and net total expenditures for both children and respondents.

[11] There are only 10 clusters shown for the respondent, with cluster 5 missing. Cluster 5 is the cluster of children who are missing a respondent.

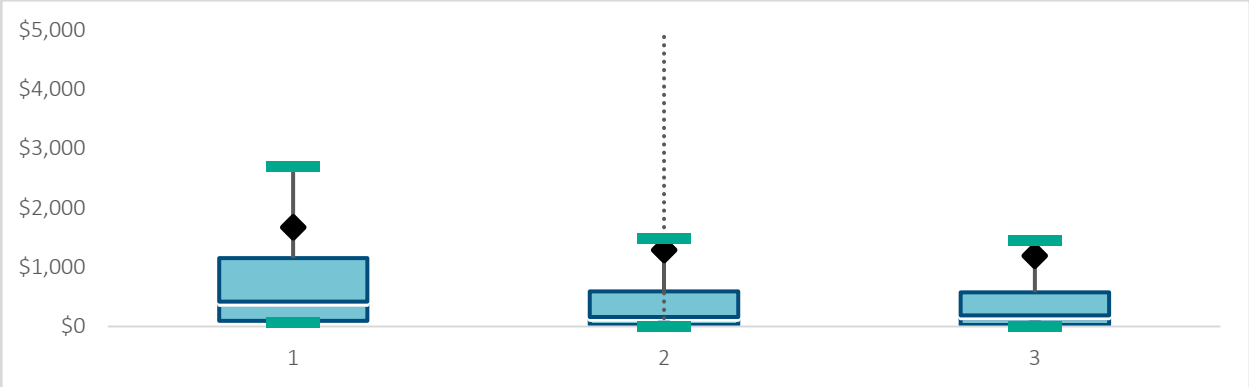
Figure 2

WEIGHTED BOX PLOTS FOR CHILD AND RESPONDENT: THREE CLUSTERS

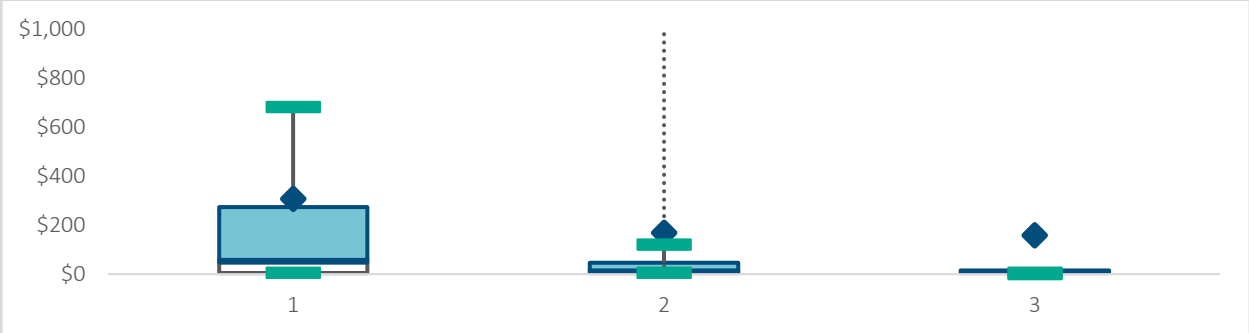
DENTAL EXPENDITURE OF CHILDREN (K=3)



NET TOTAL EXPENDITURE OF CHILDREN (K=3)



DENTAL EXPENDITURE OF RESPONDENTS (K=3)



NET TOTAL EXPENDITURE OF RESPONDENTS (K=3)

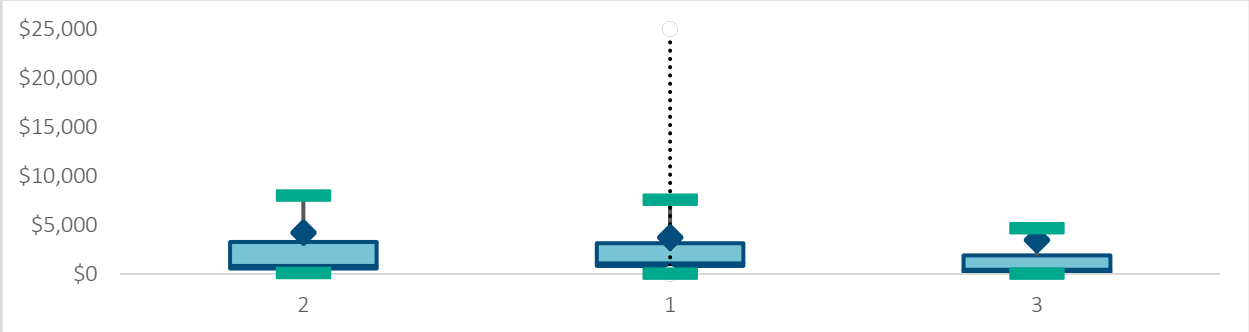
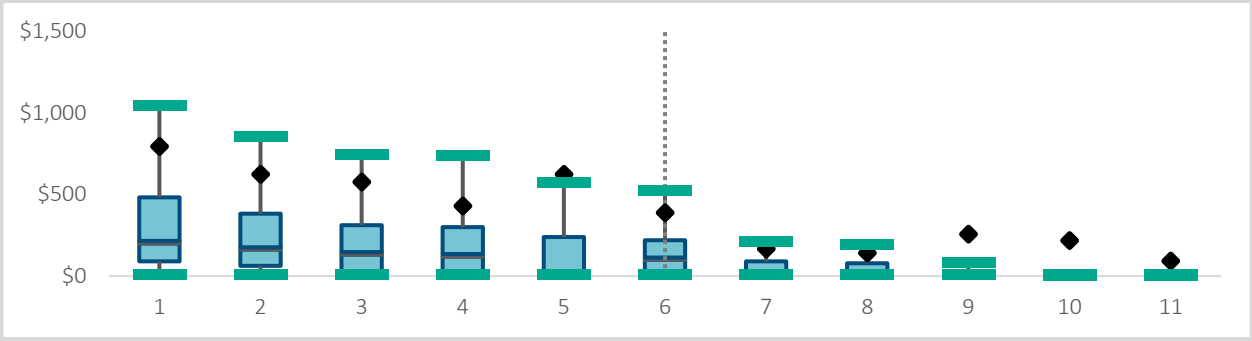


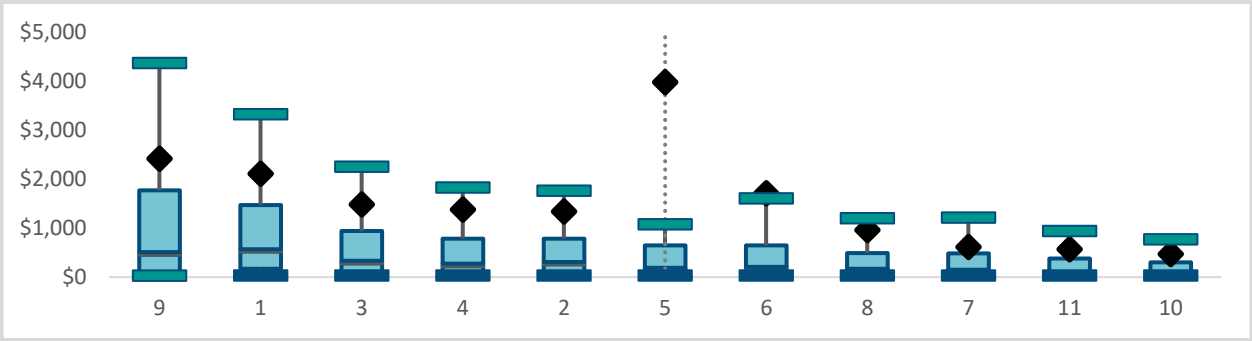
Figure 3

WEIGHTED BOX PLOTS FOR CHILD AND RESPONDENT: 11 CLUSTERS

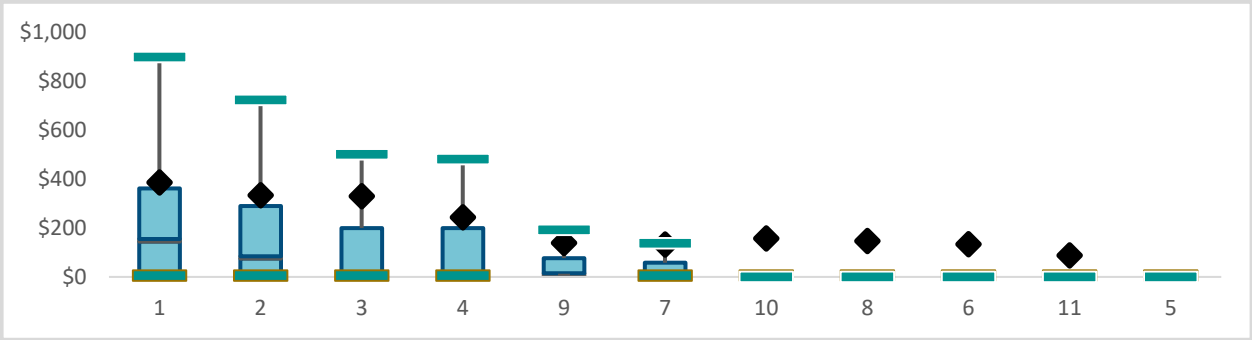
DENTAL EXPENDITURE OF CHILDREN (K=11)



NET TOTAL EXPENDITURE OF CHILDREN (K=11)



DENTAL EXPENDITURE OF RESPONDENTS (K=11)



NET TOTAL EXPENDITURE OF RESPONDENTS (K=11)

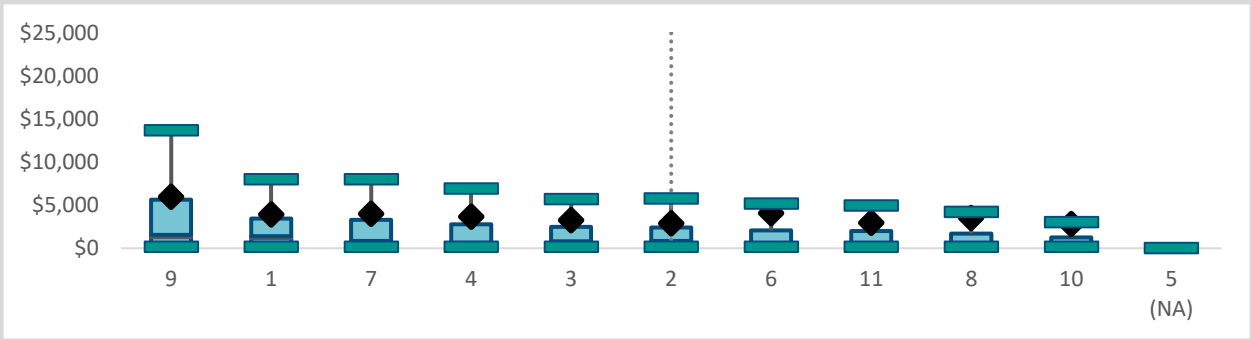
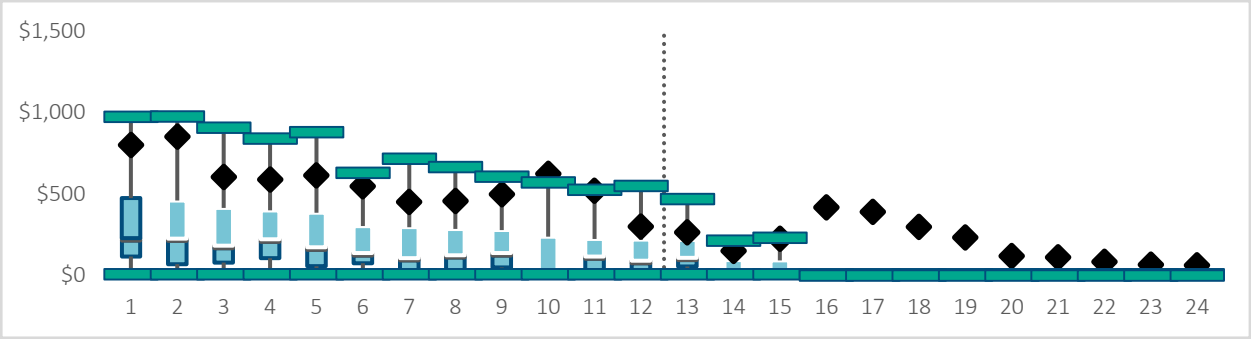


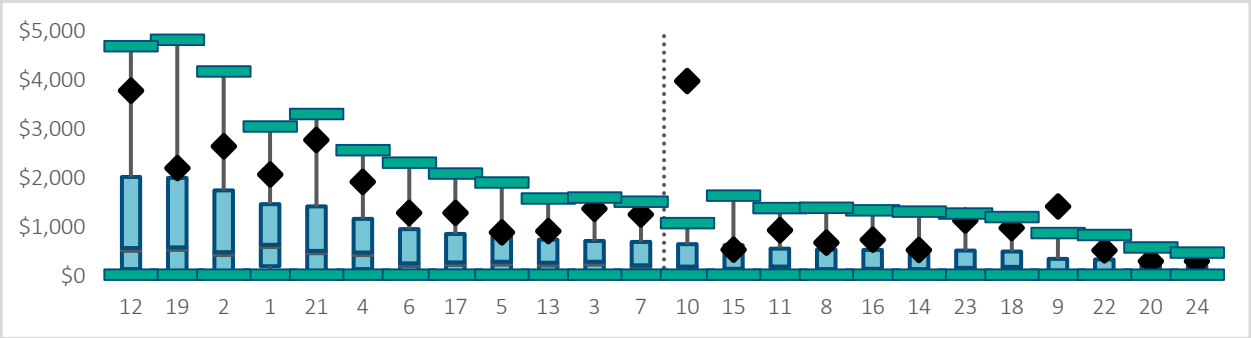
Figure 4

WEIGHTED BOX PLOTS FOR CHILD AND RESPONDENT: 24 CLUSTERS

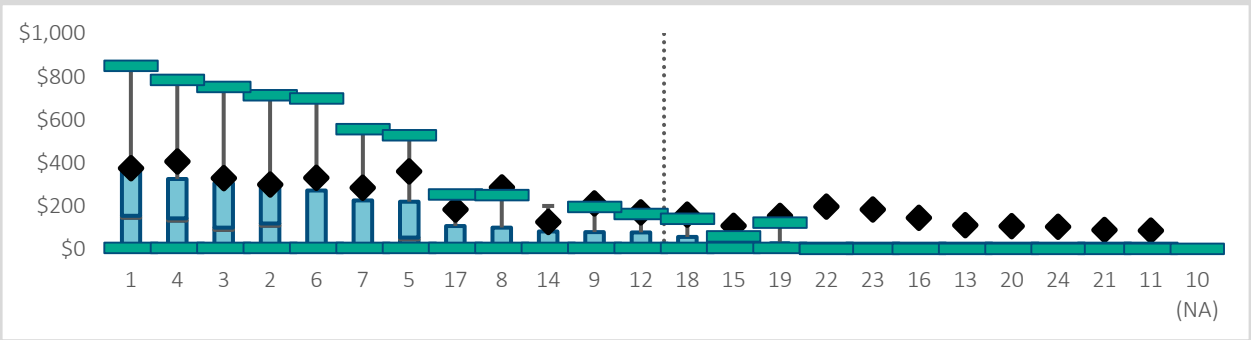
DENTAL EXPENDITURE OF CHILDREN (K=24)



NET TOTAL EXPENDITURE OF CHILDREN (K=24)



DENTAL EXPENDITURE OF RESPONDENTS (K=24)



NET TOTAL EXPENDITURE OF RESPONDENTS (K=24)

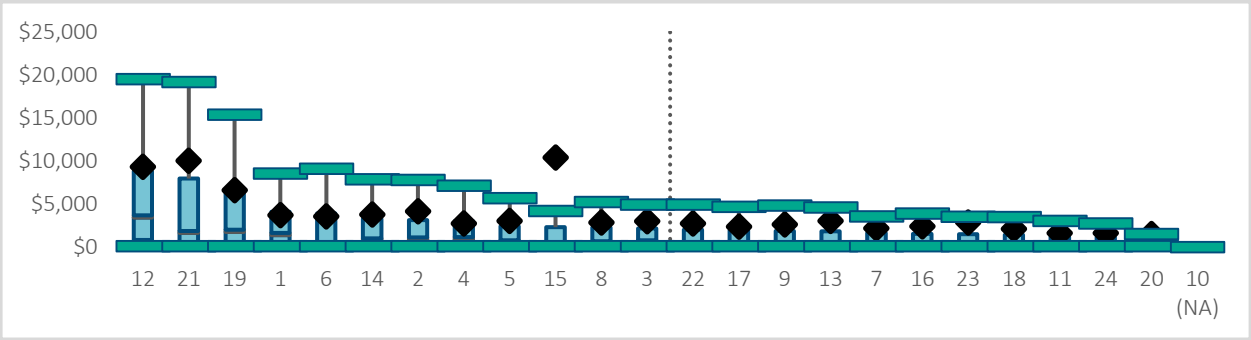
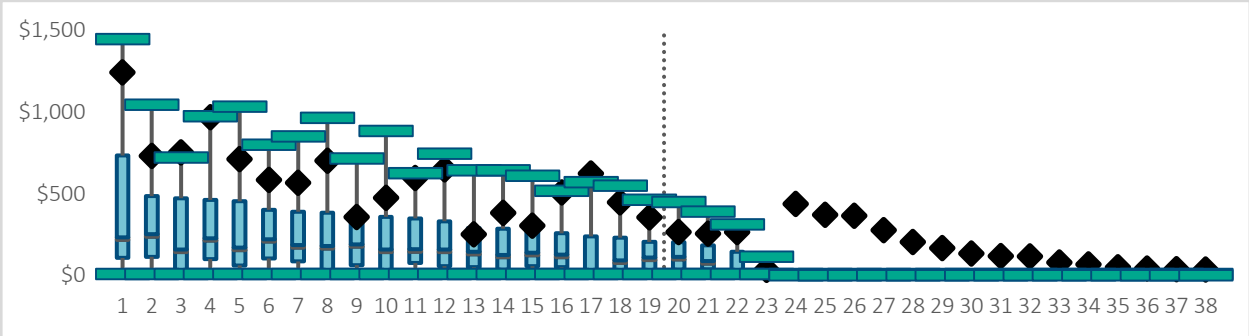


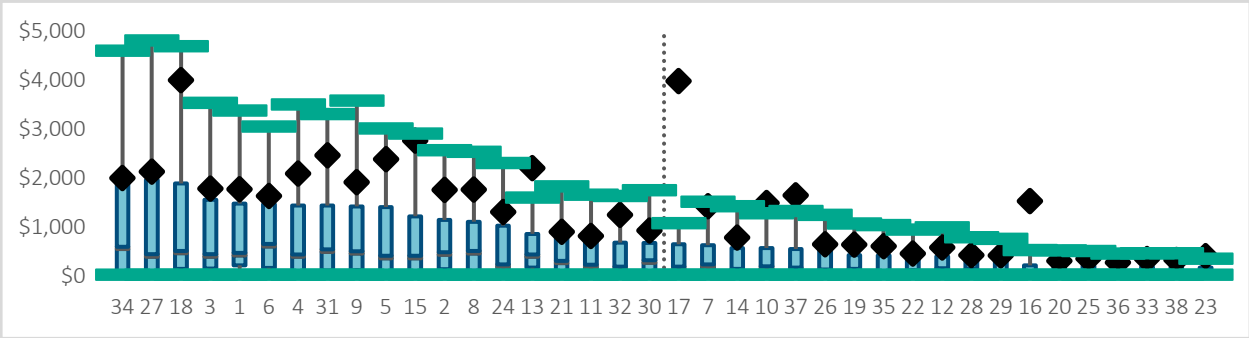
Figure 5

WEIGHTED BOX PLOTS FOR CHILD AND RESPONDENT: 38 CLUSTERS

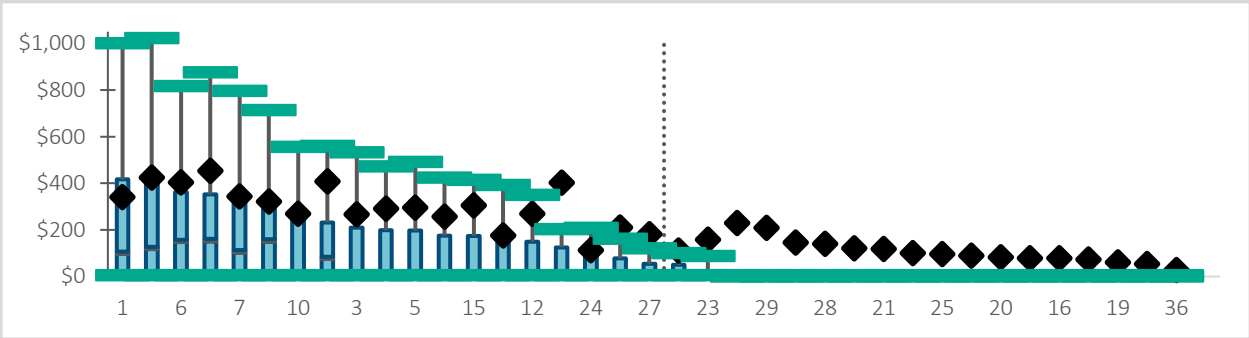
DENTAL EXPENDITURE OF CHILDREN (K=38)



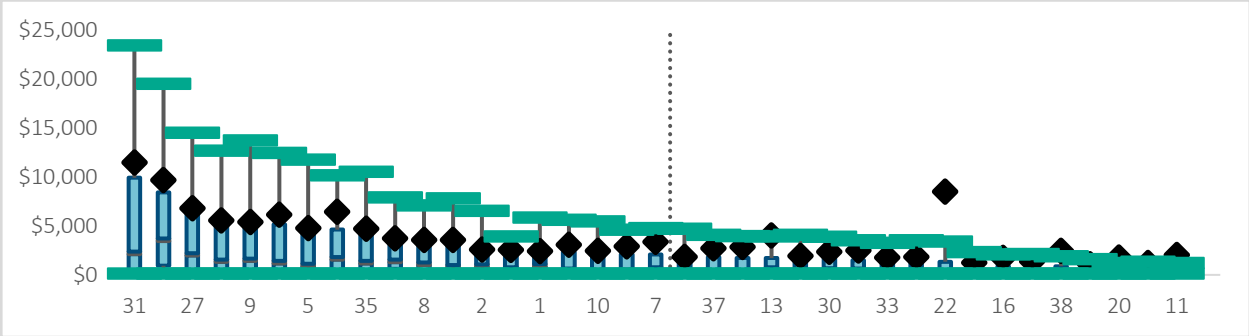
NET TOTAL EXPENDITURE OF CHILDREN (K=38)



DENTAL EXPENDITURE OF RESPONDENTS (K=38)



NET TOTAL EXPENDITURE OF RESPONDENTS (K=38)



A CLOSER LOOK AT CLUSTERS OF INTEREST FOR 38 CLUSTERS

In this section, we explore the cluster profiles for those clusters highlighted in Figure 5 for 38 clusters, the maximum number of clusters that we explored in this analysis. Tables 6 to 8 reflect a subset of the input variables for the child, the respondent, and the household, while Table 9 reflects a summary of the outcome variables by cluster. Recall that the outcome variables are not included in the creation of the clusters. These outcome variables include expenditures and insurance.

The tables have the same format, with the rank of the child dental expenditures on the first row, sorted by the child's net total expenditure (total minus dental) that is shown in the second row for all but clusters 1 and 38. We separate clusters 1 and 38, as they represent the highest dental expenditure cluster and the lowest. We also include the respondent's net total expenditure on the third row that, along with the child's net total expenditures, can serve as a proxy of the health of the household. The fourth row indicates the size of the cluster, noted as a percentage of the children in the study. As with Tables 3 to 5, the bolded numbers represent the medoid for the variable, the actual observation that serves to group similar children in a cluster.

A CLOSER LOOK AT CLUSTERS 1 AND 38

As a foundation, we first describe clusters 1 and 38 profiles. Cluster 1 children are 81% white, who get preventive dental care, with about half of the children getting orthodontics, and 69% of the children are between 13 and 17 inclusive. The children receive medical care and their doctor generally advises them to see a dentist (77%). Sixty-nine percent of the children have a normal BMI, with 27.5% of the children visiting the doctor due to a chronic disease.[12] The respondent generally receives at least two check-ups a year and can get dental care when they need it, with no delay. Their overall health status is excellent for 60% of the respondents, with more than 90% having either excellent or very good. The respondents' mental health status is similar, with 73% saying that they have excellent mental health. The respondents have no ADL or IADL limitations (95%), with 64% being of normal weight. The cluster is highly educated, with 62% of the households having someone with a graduate degree. Their income is high (73%) and they are food secure (94%). There are two adults in the household (74%) who are married, and more than half have two children.

From an outcome perspective, as shown in Table 9, cluster 1 children have similar excellent and very good overall and mental health statuses as the respondents. Eighty percent of the children miss minimal school days, with 77% having no issues at school. However, about half of the children have behavioral issues at home, and may have issues in having fun, being happy, feeling nervous or afraid. Ninety percent of the children have private medical insurance and 70% have dental insurance, with similar percentages for the respondents.

Those in cluster 38 provide a stark contrast to cluster 1. Cluster 38 are predominately Hispanic/Latino (77%), whose children do not get preventive dental care, do not report the children's BMI, and whose children do not go for medical care. The respondents in cluster 38 are predominately not born in the U.S. (74%), with more than half having less than one dental visit per year (and another 17% never going to the dentist). Respondents' overall and mental health statuses are generally good (close to 70%), but about 70% are either overweight or obese (19% are obese). Half of the families in cluster 38 have no degree from school, with 46% being poor and only 22% having medium or high incomes. Yet 79% of households are food secure. There are two adults in the household (72%), who are married, with half of the families having four or more children.

[12] These diseases include asthma, uncomplicated diabetes, obesity, loss of weight, paralysis, depression, ADHD, ADD, cystic fibrosis, cystic development disorders, hyperkinetic disorders, or conduct disorder.

Again, in contrast to cluster 1 outcomes, cluster 38 outcomes show a wider spread of health status for the children (both overall and mental), with fewer children reporting excellent health and more reporting good of fair. The number of days missed at school is nearly the same as cluster 1, but 9% of the respondents did not answer this question. There are fewer reported issues with schoolwork than for cluster 1, and much fewer behavioral issues at home. The presence of issues of being happy are considerably fewer for cluster 38 children than cluster 1 children. Yet 11% of the children are uninsured, with another 62% on public insurance; almost three-quarters of the children report having no dental insurance. Whereas for the respondent, 37.5% are uninsured, with another 29% on public insurance, and three-quarters report no dental insurance.

A CLOSER LOOK AT CLUSTER 6

Cluster 6 is included in the clusters of interest to illustrate the advantage of increasing the number of clusters. Recall from Figure 1 that cluster 6 was formed from cluster 1 of 24 clusters (which also is related to cluster 1 of 11 clusters). Cluster 1 of 24 clusters can be portrayed as splitting to clusters 1 and 6 of 38 clusters.

We see in Table 6 to Table 9 that there are many similarities between clusters 1 and 6 (of 38 clusters), but differences as well. The children frequency distributions are similar for age of the child, sex, race, and preventive dental care. However, 84% of the children in cluster 6 do not have orthodontic care, compared to 49% of cluster 1 children. These children have not received advice by a doctor to go to the dentist (65%). The respondents are generally of the same age as in cluster 1, but a greater percentage are female (92% versus 80%). Cluster 6 shows most of the respondents responding as very good overall and mental health status, compared to cluster 1 responses as excellent. Here, half of the respondents are obese, whereas more than half of cluster 1 respondents are of normal weight. From a household perspective, clusters 1 and 6 are similar with regards to education, income, food security, and the numbers of children and adults in the household.

Cluster 6 children have more favorable overall and mental health statuses than cluster 1, yet the children are missing more school days, more issues with schoolwork, and more behavioral issues at home. Slightly more of the children in cluster 6 are uninsured and on public insurance than for cluster 1 children. A larger percentage of cluster 6 respondents are uninsured (8%) compared to cluster 1 respondents (0.6%), with a third of cluster 6 respondents having no dental insurance.

A CLOSER LOOK AT CLUSTERS 27 AND 34

As a broad overview of the tables, the clusters of interest (18, 24, 27, 31, and 34) have very different profiles from the overall distribution.

Again, from Figure 1, we see that clusters 27 and 34 resulted from cluster 19 (of 24 clusters), which also came from cluster 9 (of 11 clusters). These clusters have highly ranked net total expenditures (i.e., as the highest 75th percentile) for both the children and the respondent in the 24 and 11 cluster analyses (see Figures 3 and 4). For 38 clusters, clusters 34 and 27 are the highest ranked clusters for the children and near to the top for the respondent (see Figure 5).

While the age of the children, sex, and the frequency of visits for the children for certain conditions differ between clusters 27 and 34, the race, preventive dental care, orthodontic care, BMI, and whether a doctor advised to see a dentist are similar for the children input variables. The age and sex of the respondents follow the results of the children. Yet these two clusters differ on the number of check-ups reported and their overall health status. Seventy percent of cluster 34 report good health, while 43% report good health for cluster 27 (with another 11% reporting poor overall health). More cluster 27 respondents report having ADL or IADL limitations. Yet more cluster 34 respondents report being obese (64% versus 57%). These health distributions may help to explain the ranking of the

respondents' expenditures being three for cluster 27 and six for cluster 34. At the household level, cluster 34 is generally more educated than cluster 27, has higher income, and is more food secure.

Table 9 shows that the children have a more favorable overall and mental health status in cluster 34 than those in cluster 27. However, the other outcomes are very similar between the two clusters with regards to school and behavioral issues at home and at school. More of the children and respondents are uninsured with a greater percentage lacking dental insurance in cluster 27 than in cluster 34.

A CLOSER LOOK AT CLUSTER 18

Cluster 18 has the third highest child net total expenditures and the second highest respondent net total expenditures. The origins of this cluster are shown as emanating from cluster 12 of 24 clusters, a different starting point than for clusters 27 and 34. In comparison to clusters 27 and 34, cluster 18 children have considerably more preventive dental care and more orthodontics care. A greater percentage of cluster 18 children are obese, or their BMI information is missing.

In this cluster, the respondents are generally older (greater than age 51), and who have never had a dental check-up, or had less than one check-up per year. Among the clusters shown, 16% of the respondents are unable to get needed dental care. Almost 40% of respondents report fair or poor overall health, and over half have ADL or IADL limitations. As with clusters 27 and 34, more than half of respondents are obese.

Households in cluster 18 are for the most part poor or of low income, with half having some food insecurity. Half of the households have two adults and one child. The children are living with someone other than their parents, thus the marital status of the mother and father are shown as missing.

The children are generally at least of good overall or mental health. However, the children miss more school than those in other clusters. There are issues in completing schoolwork for the children in the cluster, similar to that of clusters 27 and 34. The children also are reported to have a high level of behavioral issues at home (72%). Most of the children are on public insurance with the respondents' coverage divided two-thirds for private insurance and one-third for public insurance.

A CLOSER LOOK AT CLUSTER 31

We described the input variables for cluster 31 in Tables 3, 4, and 5. The low ranking for this cluster indicates little to no dental visits for the children. However, the respondents have fair to poor overall health, with a majority having good to poor mental health. Seventy percent of the respondents in the cluster had ADL or IADL limitations and 64% are obese. Seventy five percent of the households are poor, with almost half being food insecure. For the most part, there is one adult in the household.

For this cluster, there are more children who reported their overall and mental health status as between very good and fair. Of the clusters listed, this cluster shows that half of the children have some issues with their schoolwork. The children also have behavioral issues at home and issues having fun. These children and the respondents are predominately on public insurance, without dental insurance.

A CLOSER LOOK AT CLUSTER 24 (COMPARED TO CLUSTER 27)

From Figure 1, we see that clusters 24 and 27 have roots to cluster 9 (of 11 clusters). We note that the rankings of net total expenditures for both the children and the respondents are very different. Table 6 shows that cluster 24 and 27 differ in age, sex, and visits for specific conditions. The respondents in cluster 24 are more concentrated in the 31–40 age bracket, and their overall health status is much more favorable than for cluster 27 respondents, as 72% rate their health as very good, compared to 43% as fair in cluster 27. The cluster 24 respondents' mental health

status is also better than cluster 27 respondents (62% of cluster 24 as very good versus 61% of cluster 27 as good). And most of cluster 24 respondents have no ADL or IADL limitations, and a smaller percentage are obese. Those in cluster 24 are more educated than cluster 27, but their household incomes are comparable. Yet food insecurity is not an issue in cluster 24, but it is for one-third of the households in cluster 27.

Compared to cluster 27, the children in cluster 24 have considerably better overall and mental health. As such there are fewer school days missed by cluster 24 children, fewer issues of completing their school work, and fewer behavioral issues of children in cluster 24 relative to cluster 27. More of the children and respondents in cluster 24 have private medical insurance and have dental insurance than cluster 27.

Table 6

PROFILES FOR CHILDREN INPUT VARIABLES WITH 38 CLUSTERS

Rank of Child Dental Expenditure			34	27	18	6	31	24	1	38
Rank of Child Net Total Expenditure			1	2	3	6	8	14	5	37
Rank of Respondent Net Total Expenditure			6	3	2	10	1	20	15	34
Cluster Percentages			3.4%	5.0%	2.1%	5.4%	1.9%	4.4%	4.2%	1.2%
Variables	**Attributes**	**Overall**	**34**	**27**	**18**	**6**	**31**	**24**	**1**	**38**
Age	5–6	14.6%	9.0%	10.8%	10.1%	3.6%	7.3%	17.4%	5.8%	10.2%
Age	7–12	45.3%	**62.2%**	32.7%	**57.3%**	25.3%	**60.7%**	**57.1%**	25.1%	**71.1%**
Age	13-17	40.2%	28.8%	**56.5%**	32.7%	**71.2%**	32.1%	25.5%	**69.2%**	18.8%
		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sex	Male	51.0%	**80.8%**	**57.4%**	38.0%	**70.3%**	47.6%	34.4%	**64.9%**	39.0%
Sex	Female	49.1%	19.2%	42.6%	**62.0%**	29.8%	**52.4%**	**65.6%**	35.1%	**61.0%**
Race	White	49.9%	**76.8%**	**71.6%**	**68.6%**	**83.5%**	29.1%	**72.9%**	**80.9%**	6.4%
Race	Hispanic/ Latino	24.8%	8.9%	7.5%	12.1%	5.6%	7.7%	9.2%	4.2%	**76.6%**
Race	Black/African American	14.0%	7.7%	11.3%	13.4%	5.0%	**53.6%**	8.5%	4.6%	1.8%
Race	Asian American	4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	4.7%	1.0%
Race	Others	6.5%	6.6%	9.6%	5.9%	5.9%	9.5%	9.1%	5.6%	14.2%
Preventive Dental Care	Yes	53.8%	18.5%	15.9%	**60.9%**	**85.2%**	17.6%	15.7%	**78.1%**	18.7%
Preventive Dental Care	No	46.2%	**81.5%**	**84.1%**	39.1%	14.8%	**82.4%**	**84.3%**	21.9%	**81.4%**
Orthodontic Care	Yes	11.6%	2.3%	7.2%	14.7%	15.4%	2.3%	4.7%	**49.0%**	0.0%
Orthodontic Care	No	88.4%	**97.7%**	**92.8%**	**85.3%**	**84.6%**	**97.7%**	**95.3%**	51.0%	**100.0 %**
Doctor Advise Dental Visit	Yes	61.3%	**60.3%**	**66.2%**	**62.4%**	32.8%	50.1%	**67.4%**	**77.0%**	34.9%
Doctor Advise Dental Visit	No	36.7%	35.6%	31.7%	33.6%	**64.6%**	**49.0%**	30.8%	19.8%	**61.0%**
Doctor Advise Dental Visit	Missing	2.1%	4.2%	2.1%	4.0%	2.6%	0.9%	1.8%	3.2%	4.1%
BMI	Missing	25.2%	16.9%	13.7%	23.3%	8.5%	**28.3%**	19.4%	7.3%	**64.5%**
BMI	Obese	13.2%	20.1%	19.6%	**26.1%**	6.4%	24.4%	10.8%	8.2%	7.9%
BMI	Overweight	10.9%	13.5%	17.1%	17.4%	15.2%	11.8%	12.0%	8.9%	9.4%
BMI	Normal	44.3%	**44.2%**	**40.2%**	28.9%	**64.7%**	29.5%	**52.2%**	**69.1%**	12.0%
BMI	Underweight	6.5%	5.4%	9.4%	4.4%	5.3%	6.0%	5.6%	6.6%	6.2%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Visits for Specific Conditions	Yes	19.1%	**58.1%**	29.2%	32.0%	16.8%	**55.9%**	16.3%	27.5%	9.8%
Visits for Specific Conditions	No	51.7%	25.3%	**54.6%**	**58.5%**	**62.0%**	31.6%	**66.8%**	**51.7%**	22.8%
Visits for Specific Conditions	No Visits	29.2%	16.6%	16.2%	9.6%	21.2%	12.5%	16.9%	20.9%	**67.4%**

Table 7

PROFILES FOR RESPONDENT INPUT VARIABLES WITH 38 CLUSTERS

Rank of Child Dental Expenditure			34	27	18	6	31	24	1	38
Rank of Child Net Total Expenditure			1	2	3	6	8	14	5	37
Rank of Respondent Net Total Expenditure			6	3	2	10	1	20	15	34
Cluster Percentages			**3.4%**	**5.0%**	**2.1%**	**5.4%**	**1.9%**	**4.4%**	**4.2%**	**1.2%**
Variables	**Attributes**	**Overall**	**34**	**27**	**18**	**6**	**31**	**24**	**1**	**38**
Age	13–17	0.2%	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.0%	0.2%
Age	18–30	9.6%	6.6%	3.5%	1.1%	0.8%	12.8%	10.2%	0.0%	22.1%
Age	31–40	40.9%	23.2%	**53.5%**	6.1%	10.2%	**48.1%**	**69.6%**	17.7%	**63.2%**
Age	41–50	35.8%	**54.8%**	31.0%	18.3%	**73.3%**	23.6%	15.0%	**65.2%**	7.5%
Age	51–60	9.7%	11.0%	9.4%	**38.4%**	13.0%	10.6%	4.6%	15.3%	4.2%
Age	61–70	2.7%	3.6%	2.5%	31.7%	2.3%	3.9%	0.6%	1.8%	2.9%
Age	71–90	0.5%	0.9%	0.0%	4.4%	0.4%	0.5%	0.0%	0.0%	0.0%
Age	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sex	Male	21.4%	**71.4%**	10.6%	26.2%	8.3%	8.8%	12.9%	20.4%	13.5%
Sex	Female	77.9%	28.6%	**89.4%**	**73.8%**	**91.8%**	**91.2%**	**87.1%**	**79.7%**	**86.5%**
Sex	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Race	White	54.7%	**83.9%**	**73.5%**	**75.5%**	**89.4%**	30.8%	**77.4%**	**85.7%**	13.4%
Race	Hispanic/ Latino	21.9%	3.4%	6.4%	4.5%	4.7%	6.3%	9.7%	3.6%	**75.5%**
Race	Black/African American	13.9%	6.6%	12.0%	13.0%	3.4%	**54.4%**	8.8%	5.0%	0.8%
Race	Asian American	5.4%	2.1%	0.0%	0.0%	0.8%	0.5%	0.7%	3.7%	3.6%
Race	Others	3.4%	4.0%	8.2%	7.0%	1.7%	8.0%	3.3%	2.0%	6.8%
Race	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Born in the U.S.	Yes	75.9%	**97.6%**	**97.1%**	**97.9%**	**94.3%**	**96.4%**	**93.4%**	**89.7%**	25.5%
Born in the U.S.	No	23.2%	2.5%	2.9%	2.1%	5.8%	3.6%	6.6%	10.3%	**74.1%**
Born in the U.S.	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
Number of Dental Checkups	Never	12.1%	15.2%	13.5%	**35.9%**	4.1%	25.2%	13.3%	0.9%	17.1%
Number of Dental Checkups	<1 per year	18.1%	20.7%	31.8%	24.6%	11.6%	26.2%	20.3%	13.4%	**53.3%**
Number of Dental Checkups	1 per year	26.2%	**43.2%**	17.6%	17.3%	15.6%	**35.5%**	25.9%	13.7%	19.0%
Number of Dental Checkups	2+ per year	42.5%	21.0%	**37.2%**	22.2%	**68.7%**	11.4%	**40.6%**	**71.9%**	10.5%
Number of Dental Checkups	Missing	1.1%	0.0%	0.0%	0.0%	0.0%	1.8%	0.0%	0.0%	0.0%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Unable to get Dental Care	Yes	2.9%	0.0%	5.4%	16.0%	1.6%	8.4%	4.5%	0.3%	1.5%
Unable to get Dental Care	No	95.8%	**100%**	**94.6%**	**83.5%**	**96.3%**	**89.6%**	**92.7%**	**99.8%**	**98.5%**
Unable to get Dental Care	Missing	1.3%	0.0%	0.0%	0.5%	2.1%	2.0%	2.8%	0.0%	0.0%
Overall Health Status	Poor	4.5%	4.6%	11.3%	20.8%	2.4%	18.4%	0.9%	0.0%	4.0%
Overall Health Status	Fair	14.9%	13.6%	**43.4%**	17.9%	6.4%	**64.1%**	2.2%	2.4%	10.4%
Overall Health Status	Good	37.4%	**70.4%**	31.5%	**50.6%**	27.9%	8.5%	17.8%	14.0%	**68.8%**
Overall Health Status	Very Good	32.0%	8.1%	9.8%	6.8%	**59.3%**	4.2%	**72.1%**	23.8%	9.9%
Overall Health Status	Excellent	10.5%	3.4%	4.1%	3.9%	4.0%	4.8%	7.1%	**59.8%**	6.9%
Overall Health Status	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mental Health Status	Poor	2.3%	1.9%	5.3%	7.0%	0.3%	15.1%	0.0%	0.0%	0.0%
Mental Health Status	Fair	9.1%	6.3%	15.7%	24.9%	5.8%	29.7%	5.8%	0.7%	5.8%
Mental Health Status	Good	37.0%	**61.6%**	**60.5%**	**48.7%**	17.1%	**34.1%**	15.2%	18.5%	**69.5%**
Mental Health Status	Very Good	31.1%	14.3%	10.8%	15.4%	**67.7%**	11.7%	**61.6%**	8.0%	8.0%
Mental Health Status	Excellent	19.8%	15.9%	7.8%	4.0%	9.1%	9.5%	17.4%	**72.9%**	16.8%
Mental Health Status	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
ADL or IADL Limitations	Yes	14.8%	20.4%	32.5%	**56.3%**	11.0%	**70.0%**	10.0%	4.6%	8.4%
ADL or IADL Limitations	No	83.3%	**79.1%**	**65.6%**	42.2%	**88.2%**	30.0%	**88.0%**	**95.4%**	**91.6%**
ADL or IADL Limitations	Missing	2.0%	0.6%	1.9%	1.5%	0.7%	0.0%	2.1%	0.0%	0.0%
BMI	Missing	2.7%	1.1%	1.9%	2.7%	2.6%	2.4%	2.1%	3.4%	5.6%
BMI	Obese	35.9%	**64.2%**	**56.9%**	**55.2%**	**53.5%**	**64.1%**	14.2%	9.2%	19.2%
BMI	Overweight	30.3%	24.7%	19.1%	21.6%	21.5%	24.4%	**51.5%**	23.2%	**50.6%**
BMI	Normal	30.0%	9.7%	20.7%	16.8%	21.6%	5.5%	31.4%	**64.2%**	24.6%
BMI	Underweight	1.0%	0.3%	1.5%	3.7%	0.8%	3.7%	0.9%	0.0%	0.0%

Table 8

PROFILES FOR HOUSEHOLD INPUT VARIABLES WITH 38 CLUSTERS

Rank of Child Dental Expenditure	34	27	18	6	31	24	1	38
Rank of Child Net Total Expenditure	1	2	3	6	8	14	5	37
Rank of Respondent Net Total Expenditure	6	3	2	10	1	20	15	34
Cluster Percentages	3.4%	5.0%	2.1%	5.4%	1.9%	4.4%	4.2%	1.2%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Highest Level of Education in Family	No Degree	9.1%	0.1%	5.3%	8.4%	0.1%	20.0%	0.4%	0.0%	**50.3%**
Highest Level of Education in Family	High School	24.2%	23.8%	**58.2%**	32.0%	15.4%	**52.8%**	9.0%	2.0%	23.9%
Highest Level of Education in Family	Some College	25.3%	**46.2%**	15.0%	**45.3%**	16.9%	16.3%	**56.9%**	18.1%	15.0%
Highest Level of Education in Family	College Graduate	22.5%	15.1%	15.6%	12.4%	15.1%	8.0%	20.1%	17.8%	6.2%
Highest Level of Education in Family	Graduate-Level Degree	18.1%	14.7%	6.0%	1.9%	**52.5%**	2.9%	13.6%	**62.1%**	4.5%
Highest Level of Education in Family	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Household Income	Poor	17.6%	8.5%	8.7%	26.0%	2.4%	**74.8%**	9.8%	3.4%	**46.2%**

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Household Income	Near Poor	5.0%	6.0%	1.2%	2.2%	0.8%	10.4%	3.4%	0.0%	9.3%
Household Income	Low	16.2%	8.2%	11.4%	**33.0%**	5.4%	6.6%	13.7%	4.0%	21.3%
Household Income	Medium	30.8%	27.1%	**66.8%**	27.6%	25.5%	8.3%	**55.9%**	19.5%	18.9%
Household Income	High	30.4%	**50.2%**	11.9%	11.2%	**65.8%**	0.0%	17.2%	**73.1%**	4.3%
Food Insecurity	Insecure	21.1%	16.5%	33.2%	**52.7%**	6.7%	48.5%	14.3%	4.9%	17.0%
Food Insecurity	Secure	75.9%	**81.7%**	**65.7%**	44.5%	**91.5%**	**44.2%**	**85.7%**	**94.4%**	**79.4%**
Food Insecurity	Missing	3.0%	1.8%	1.1%	2.8%	1.9%	7.4%	0.0%	0.7%	3.6%
# of Adults in Family (>17 in age)	0	1.0%	0.0%	0.3%	2.2%	0.0%	0.9%	0.0%	0.0%	0.2%
# of Adults in Family (>17 in age)	1	18.9%	3.0%	1.3%	24.2%	1.3%	**67.9%**	0.2%	0.0%	4.5%
# of Adults in Family (>17 in age)	2	61.4%	**73.9%**	**74.1%**	**53.8%**	**80.9%**	20.4%	**88.4%**	**73.5%**	**72.2%**
# of Adults in Family (>17 in age)	3	14.0%	18.5%	20.9%	15.5%	14.8%	6.0%	7.1%	21.1%	9.8%
# of Adults in Family (>17 in age)	4+	4.7%	4.7%	3.5%	4.4%	2.9%	4.8%	4.2%	5.4%	13.3%
# of Children in Family (<17 in age)	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
# of Children in Family (<17 in age)	1	24.4%	24.8%	19.5%	**50.3%**	29.8%	26.9%	14.8%	23.7%	5.9%
# of Children in Family (<17 in age)	2	39.9%	**54.5%**	**61.2%**	22.7%	**44.3%**	**41.7%**	23.9%	**51.7%**	29.7%
# of Children in Family (<17 in age)	3	23.2%	15.4%	11.8%	16.5%	17.9%	20.5%	**45.4%**	12.4%	12.0%
# of Children in Family (<17 in age)	4+	12.6%	5.3%	7.5%	10.6%	8.0%	10.9%	15.9%	12.2%	**52.4%**
Marital Status Mother	Missing	8.0%	8.8%	3.6%	**86.4%**	2.9%	7.0%	3.0%	1.7%	1.8%
Marital Status Mother	Never Married	14.6%	3.5%	2.0%	4.6%	0.6%	**54.0%**	6.2%	3.3%	12.0%
Marital Status Mother	W/D/S	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%	14.1%
Marital Status Mother	Married	63.4%	**86.0%**	**86.3%**	2.6%	**93.2%**	8.9%	**90.4%**	**95.0%**	**85.9%**
Marital Status Father	Missing	28.1%	5.3%	6.9%	**69.6%**	2.8%	**87.4%**	2.9%	0.5%	6.1%
Marital Status Father	Never Married	4.7%	2.4%	2.2%	8.1%	0.4%	4.4%	6.4%	1.1%	9.4%
Marital Status Father	W/D/S	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%
Marital Status Father	Married	62.4%	**84.5%**	**87.1%**	2.6%	**94.1%**	1.5%	**90.4%**	**95.0%**	**82.8%**
Family Change	Change	2.2%	1.8%	3.3%	4.0%	1.3%	8.0%	0.0%	0.0%	1.0%
Family Change	No Change	97.8%	**98.2%**	**96.7%**	**96.0%**	**98.7%**	**92.0%**	**100%**	**100%**	**99.0%**

Table 9

OUTCOMES FOR THE 38 CLUSTERS

Rank of Child Dental Expenditure	34	27	18	6	31	24	1	38
Rank of Child Net Total Expenditure	1	2	3	6	8	14	5	37
Rank of Respondent Net Total Expenditure	6	3	2	10	1	20	15	34
Cluster Percentages	3.4%	5.0%	2.1%	5.4%	1.9%	4.4%	4.2%	1.2%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Overall Health Status (Child)	Poor	0.5%	0.4%	0.5%	1.1%	0.8%	3.5%	0.0%	0.0%	0.0%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Overall Health Status (Child)	Fair	3.7%	2.2%	5.0%	9.0%	1.1%	22.5%	0.7%	0.8%	4.9%
Overall Health Status (Child)	Good	25.9%	33.3%	41.0%	41.0%	16.7%	36.6%	15.6%	9.0%	41.1%
Overall Health Status (Child)	Very Good	35.7%	36.0%	29.7%	33.4%	45.9%	20.3%	45.2%	23.3%	25.8%
Overall Health Status (Child)	Excellent	34.2%	28.1%	23.8%	15.4%	35.5%	17.1%	38.6%	66.9%	28.2%
Mental Health Status (Child)	Poor	1.3%	0.6%	2.6%	4.9%	2.4%	9.9%	0.0%	0.0%	0.0%
Mental Health Status (Child)	Fair	4.7%	9.2%	10.1%	8.3%	4.0%	20.2%	4.4%	2.7%	3.8%
Mental Health Status (Child)	Good	26.5%	28.9%	40.5%	41.8%	20.4%	33.9%	14.9%	13.7%	39.2%
Mental Health Status (Child)	Very Good	30.2%	29.8%	19.8%	25.9%	41.6%	21.9%	41.7%	17.0%	24.0%
Mental Health Status (Child)	Excellent	37.3%	31.6%	27.0%	19.2%	31.7%	14.1%	39.1%	66.7%	33.1%
# School Days Missed	Missing	4.2%	2.9%	2.9%	5.8%	2.7%	5.5%	8.0%	0.7%	8.9%
# School Days Missed	8+	8.4%	13.2%	14.2%	23.1%	9.8%	16.4%	7.4%	7.0%	1.5%
# School Days Missed	3–7	23.3%	35.7%	30.7%	20.0%	27.4%	24.6%	19.9%	11.5%	8.4%
# School Days Missed	1–2	27.0%	25.5%	22.6%	30.0%	29.5%	23.3%	32.9%	35.4%	22.0%
# School Days Missed	0	37.1%	22.7%	29.7%	21.0%	30.6%	30.2%	31.8%	45.4%	59.3%
Issues at School or with Schoolwork	Yes	27.5%	41.3%	44.0%	46.7%	32.6%	50.7%	28.9%	23.0%	13.2%
Issues at School or with Schoolwork	No	69.8%	58.7%	55.6%	50.3%	67.1%	46.6%	69.1%	77.0%	84.1%
Issues at School or with Schoolwork	Missing	2.7%	0.0%	0.5%	3.0%	0.3%	2.7%	2.0%	0.0%	2.7%
Behavioral Issues at Home	Yes	50.3%	66.8%	61.1%	71.7%	64.8%	69.7%	51.3%	51.8%	26.5%
Behavioral Issues at Home	No	47.1%	33.2%	38.5%	25.3%	35.0%	27.7%	46.6%	48.2%	70.8%
Behavioral Issues at Home	Missing	2.7%	0.0%	0.5%	3.0%	0.3%	2.7%	2.0%	0.0%	2.7%
Issues Having Fun, Being Happy or Being Afraid	Yes	43.7%	51.8%	55.5%	58.2%	47.2%	62.5%	45.7%	45.4%	19.2%
Issues Having Fun, Being Happy or Being Afraid	No	53.6%	48.2%	44.0%	38.8%	52.5%	34.9%	52.3%	54.6%	78.1%
Issues Having Fun, Being Happy or Being Afraid	Missing	2.7%	0.0%	0.5%	3.0%	0.3%	2.7%	2.0%	0.0%	2.7%
Medical Insurance (Child)	Uninsured	4.0%	0.6%	8.4%	2.3%	5.9%	0.7%	3.7%	2.5%	11.2%
Medical Insurance (Child)	Public	37.6%	28.3%	33.1%	72.0%	8.1%	85.2%	24.3%	6.8%	61.5%
Medical Insurance (Child)	Private	58.5%	71.1%	58.5%	25.7%	86.0%	14.1%	72.0%	90.7%	27.3%

Variables	Attributes	Overall	34	27	18	6	31	24	1	38
Dental Insurance (Child)	No	56.1%	41.0%	56.5%	80.1%	37.0%	91.9%	43.7%	30.5%	74.7%
Dental Insurance (Child)	Yes	43.9%	59.0%	43.5%	19.9%	63.0%	8.1%	56.3%	69.6%	25.3%
Medical Insurance (Respondent)	Uninsured	10.7%	5.2%	9.9%	3.4%	8.1%	7.4%	5.6%	0.6%	37.5%
Medical Insurance (Respondent)	Public	20.0%	11.5%	21.9%	35.7%	1.8%	74.1%	12.5%	1.8%	29.2%
Medical Insurance (Respondent)	Private	68.6%	83.3%	68.2%	60.9%	90.1%	18.5%	82.0%	97.6%	33.3%
Medical Insurance (Respondent)	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Dental Insurance (Child)	No	50.0%	40.7%	53.6%	64.5%	34.8%	93.0%	33.6%	27.3%	74.2%
Dental Insurance (Child)	Yes	49.2%	59.4%	46.4%	35.5%	65.2%	7.0%	66.4%	72.7%	25.8%
Dental Insurance (Child)	Missing	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

DETAILED RESULTS FOR ALL ANALYSES

A separate appendix provides a detailed summary of the results for the input and outcome variables respectively for all cluster sized studies.

Discussion

Our approach in this study is to use a clustering method, PAM, to subdivide children and their families into different groups to examine their characteristics with an emphasis on the cost of care and their access to care. We note that expanding the number of clusters beyond what the evaluation measures indicate provides the ability to identify more at-risk clusters. We showed that characteristics related to the children, such as whether they go for a preventive care dental visit or their BMI, characteristics related to the respondent, such as their own health status, as well as characteristics of the household, such as education, income, and food security, all play a role in grouping similar children together in clusters. These clusters then show similar patterns for those who had low dental expenditures and high net total expenditures. While the initial target is children, we can also see the effect on respondents. Children with better oral health would reduce both dental and medical costs by eliminating future expensive complications of poor oral health.

However, merely examining expenditures is not sufficient. As we showed with cluster 38, access to insurance and dental care will impact health, even when current health conditions may be favorable. Prevention, both for dental and medical, is critical for overall health. For children, the lack of prevention could lead to a lifetime of health problems that could have been prevented with simply going to a dentist or physician for check-ups.

We saw that when children had public insurance, the response for the presence of dental insurance was generally in the negative. Preventive dental services for children are covered under the Affordable Care Act. It is unclear whether or not the respondents in the survey had knowledge of the coverage, or just did not seek preventive care or any necessary care. For instance, Wisconsin has a robust Medicaid benefit for children and adults. Yet 70% of children enrolled in Medicaid did not receive dental care during 2015. [13]

The peer-reviewed literature as well as the popular press (Otto 2017) describe the importance of access and affordability of dental care, as well as contributors to good oral health. All children who have Medicaid or SCHIP do not necessarily have the same dental profile nor health outcomes. The same can be said of children with private insurance.

The use of clusters to describe children and their household is novel, as the cluster can serve as a latent variable to better explain expenditures and other outcomes that could help in better understanding the interrelationships of children/household characteristics and outcomes. The cluster profiles are a reflection of the combined characteristics of the children and their household. While model-based cluster methods, like mixed models, impute a probability distribution, these unsupervised cluster methods are non-parametrically based. As such, cluster approaches may be able to better estimate more complex interactions between variables. The cluster determination is dependent on the method chosen (here we chose PAM) and the similarity measure (Goodall 3). There are many clustering methods from which to choose. We did explore using hierarchical clustering but decided that PAM is more robust for looking at trends over time.

There are a few limitations in this study. First, we do not consider the relationship among children in the same household when forming clusters. We treated each child as independent from another child in the same household. These children would be of different ages and potentially different health characteristics, but the respondent and household information would be the same. We chose to limit the analysis to at most 38 clusters. There is room for future research in exploring how to better decide on the number of clusters. We have shown, that depending on the

[13] https://www.wpr.org/dentists-slights-funding-respect-root-wisconsins-dental-care-disparity

purpose, the current metrics of choosing the number of clusters are insufficient. MEPS has some social determinant data, but does not have others, such as access to housing.

The 2020 Surgeon General's Report on Oral Health in America is being updated to reflect the progress made since the last report in 2000, and to address future goals (Albino, Dye and Ricks 2019). The introduction of children's dental benefits under the Affordable Care Act will potentially help increase access to preventive and necessary dental care (Satcher and Nottingham 2017). Our study using 2016 data may be too close to the 2014 ACA introduction to show improvements, but our study does show a snapshot of differences in children in 2016. Further, better oral health in children would reduce dental and medical costs regardless of the type of insurance (i.e., separate dental, Medicaid, SCHIP, or private medical) and for the uninsured. While dental care and dental insurance have historically been separated from medical care and medical insurance, the spillover effects of poor oral health lead to higher medical costs (Mertz 2016).

Our results are a snapshot of time, reflecting on one calendar year. Insurers, with longitudinal data, can create clusters on their data to study the improvement of population health when interventions are made on clusters meeting established criteria. These clusters can be examined over time to determine the success of the interventions.

Section 4: Acknowledgments

The researchers' deepest gratitude goes to those without whose efforts this project could not have come to fruition: the Project Oversight Group and others for their diligent work overseeing questionnaire development, analyzing and discussing respondent answers, and reviewing and editing this report for accuracy and relevance.

Project Oversight Group members:

Marinda Badenhorst, FSA

Toan Cao

Amine Elmeghni, ASA

Gavin Ferguson

Geof Hileman, FSA, MAAA

Becky Sheppard, FSA, MAAA

Society of Actuaries Research Institute Staff members:

Achilles Natsis, FSA, MAAA

Erika Schulty

Appendix A: Detailed Summary of Cluster Input Variables and Outcome Variables

Table A1

CLUSTER INPUT VARIABLES: CHILD RELATED VARIABLES

Variables	Description
Age	Age status as of end of year 2016
Sex	Male or Female
Race	White, Hispanic/Latino, Black/African American, Asian American or other
Born in U.S.	Whether a person was born in the U.S. (Yes or No)
Dental Visit	Whether a person had at least one dental care visit or not during a year (Yes or No)
Dental Care—Preventive	Whether a person had at least one preventive care dental visit during a year (Yes or No) Preventive care: exam, cleaning, x-ray, fluoride, sealant
Dental Care—Filling	Whether a person had at least one dental visit for fillings during a year (Yes or No
Dental Care—Severe Condition	Whether a person had at least one dental visit due to serious oral condition during a year (Yes or No) Severe condition: inlay, crown, root canal, gum surgery, extraction, implant, abscess, oral surgery, bridge, denture
Dental Care—Orthodontic	Whether a person had at least one dental care visit for orthodontics during a year (Yes or No)
Doctor Advise Regular Dental Visit	Whether doctor or other health provider ever advised a dental checkup or not
BMI	Child's body mass index: Underweight, normal, overweight, or obese
Preventive Care Activities	The number of child preventive care activities children received by doctor or other health provider (0–2, 3–7, 8+) 1. Ever measured child's height 2. Ever measured child's weight 3. Ever checked child's blood pressure 4. Ever given advice about child's healthy eating habits 5. Ever given advice about the amount and kind of exercise, sports or physically active hobbies the child should have 6. Ever given advice about using a safety seat when child rides in the car 7. Ever given advice about using a booster seat when child rides in the car 8. Ever given advice about using lap and shoulder belts when child rides in the car 9. Ever given advice about the child's using a helmet when riding a bicycle or motorcycle 10. Ever given advice about how smoking in the house can be bad for child's health
Visit for Specific Medical Conditions	Whether a child has a visit for one of the following: asthma, uncomplicated diabetes, obesity, loss weight, paralysis, depression, ADHD, ADD, cystic fibrosis, cystic developmental disorders, hyperkinetic disorders, and/or conduct disorder during a year. -Yes: if a child has visit - No conditions: if a child has at least one medical visit but it is not recorded as one of above - No medical visit: if a child has no visits during a year
Special Needs	Whether a child has needed to get any special health care (Yes or No) 1. Needs or uses prescribed medicines 2. Needs or uses more medical care, mental health, or education services than is usual for most children of the same age 3. Is limited or prevented in any way in ability to do the things most children of the same age can do 4. Needs or gets special therapy such as physical, occupational or speech therapy 5. Has an emotional, developmental or behavioral problem for which he or she needs or gets treatment or counseling

Table A2

CLUSTER INPUT VARIABLES: RESPONDENT RELATED VARIABLES

Variables	Description
Respondent & Reference Person	Identifying respondent and reference are among "father," "mother" and "other person"
Age	Age status as of end of year 2016
Sex	Male or Female
Race	White, Hispanic/Latino, Black/African American, Asian American or other
Born in U.S.	Whether a person was born in the U.S. (Yes or No)
Number of Dental Check-ups	Self-reported frequency of dental check-up per year: twice a year, once a year, less than once a year, or never
Any Delayed Dental Care	Whether a person has delayed in getting necessary dental care
Unable to Get Dental Care	Whether a person has been unable to get necessary dental care
Overall Health Status	Perceived overall health status (excellent, very good, good, fair, or poor)
Mental Health Status	Perceived mental health status (excellent, very good, good, fair, or poor)
ADL or IADL Limitations	Whether a person has any IADL, ADL, functional, or activity limitations in a year.
BMI	Child's body mass index: underweight, normal, overweight or obese
Diagnosed Specific Medical Conditions	Whether person has been diagnosed as having any medical condition below: 1. High blood pressure 2. Heart disease 3. Stroke 4. Emphysema 5. Chronic bronchitis 6. High cholesterol 7. Cancer 8. Diabetes 9. Joint pain 10. Arthritis 11. Asthma

Table A3

CLUSTER INPUT VARIABLES: HOUSEHOLD RELATED VARIABLES

Variables	Description
Geographic Region	Census region of end of year 2016: Northeast, Midwest, South, or West
Highest Level of Education Among Family Members	Highest education degree level among respondent, reference person, father and mother: No degree, High School, Some College, College Graduate, or Graduate-level Degree
Employment Status of Mother	- Fully employed during a year - Partly employed during a year (from employed to unemployed, from unemployed to employed, other) - Fully unemployed during a year
Employment Status of Father	- Fully employed during a year - Partly employed during a year (from employed to unemployed, from unemployed to employed, other) - Fully unemployed during a year
Household Income	Family's total income levels categorized based on percent of poverty line: Poor (<100%), Fair (<125%), Low Income (<200%), Medium Income (<400%), or High Income (>= 400%)
Food Insecurity	Whether households suffer food insecurity or not based on: 1. How often have they run out of food? 2. How often did food not last? 3. How often they could not afford balanced meals If households answer "often" or "sometimes" to at least one question, households are defined as suffering food insecurity.

Number of Adults in Family (> 17 in age)	The number of adults in households (0, 1, 2, 3, 4+)
Number of Children in Family (<= 17 in age)	The number of children in households (0, 1, 2, 3, 4+)
Parent Status	Whether children live with both parents, only mother, only father or none of their parents.
Marital Status of Mother	Marital status of children's mother at the end of 2016. If a child does not live with their mother, the value is recorded as "missing." - Married - Widowed, divorced or separated (W/D/S) - Widowed, divorced or separated this year (W/D/S this year) - Never married
Marital Status of Father	Marital status of children's father at the end of 2016. If a child does not live with their mother, the value is recorded as "missing." - Married - Widowed, divorced or separated (W/D/S) - Widowed, divorced or separated this year (W/D/S this year) - Never married
Family Change	Whether households have any changes or not

Table A4

OUTCOME VARIABLES: CHILD RELATED VARIABLES

Variables	Description
Expenditures	Dental (used for cluster labeling), Net Total (total minus dental)
Overall Health Status	Perceived overall health status (excellent, very good, good, fair, or poor)
Mental Health Status	Perceived mental health status (excellent, very good, good, fair, or poor)
Limitations in Attending School	Whether a child has any limitation in attending school or doing school work
Number of School Days Missed	The number of school days missed due to illness or injuries
Behavioral Problems: at Home with Family Members	Whether a child has any behavioral problems with mother, father, brothers, sisters, or other adults or children
Behavioral Problems: at School or with Schoolwork Completion	Whether a child has any behavioral problems at school or with schoolwork
Behavioral Problems: In General, in Having Fun, Being Happy, or Feeling Nervous or Afraid	Whether a child has any behavioral problems with his/her emotions such as having fun, being happy or sad, or feeling nervous or afraid
Medical Insurance	Health insurance coverage among public, private or uninsured
Dental Insurance	Whether a person has dental insurance or not

Table A5

OUTCOME VARIABLES: RESPONDENT RELATED VARIABLES

Variables	Description
Expenditures	Dental (used for cluster labeling), Net Total (total minus dental)
Medical Insurance	Health insurance coverage among public, private or uninsured
Dental Insurance	Whether a person has dental insurance or not

References

U.S. Department of HHS. 2000. Oral Health in America: A Report of the Surgeon General. Technical report, U.S. Department of Health and Human Services National Institute of Dental and Craniofacial Research, National Institutes of Health.

U.S. Surgeon General. 2000. Oral Health in America: A Report of the Surgeon General. Technical report, U.S. Department of Health and Human Services National Institute of Dental and Craniofacial Research, National Institutes of Health.

Humphrey, Linda L., Rongwei Fu, David I Buckley, Michele Freeman, and Mark Helfand. 2008. Periodontal Disease and Coronary Heart Disease Incidence: A Systematic Review and Meta-analysis. *Journal of General Internal Medicine*, 23, no. 12:2079–86.

Agaku, Israel T., Bukola G Olutola, Akinyele O Adisa, Enihomo M Obadan, and Constantine I Vardavas. 2015. Association Between Unmet Dental Needs and School Absenteeism Because of Illness or Injury Among U.S. School Children and Adolescents Aged 6–17 Years, 2011–2012. *Preventive Medicine*, 72:83–88.

Allukian Jr., Myron. 2008. The Neglected Epidemic and the Surgeon General's Report: A Call to Action for Better Oral Health. *American Journal of Public Health* 98: S82–S85.

Cabrera, Claudia, Magnus Hakeberg, Margareta Ahlqwist, Hans Wedel, Cecilia Björklund, Calle Bengtsson, and Lauren Lissner. 2005. Can the Relation between Tooth Loss and Chronic Disease be Explained by Socio-economic Status? A 24-year Follow-up from the Population Study of Women in Gothenburg, Sweden. *European Journal of Epidemiology* 20, no. 3:229–236.

Chapple, Iain LC, Robert Genco, and Working Group 2 of the Joint EFP/AAP Workshop. 2013. Diabetes and Periodontal Diseases: Consensus Report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. *Journal of Clinical Periodontology* 40:S106–S112.

Edelstein, Burton L., and Courtney H. Chinn. 2009. Update on Disparities in Oral Health and Access to Dental Care for America's Children. *Academic Pediatrics* 9, no. 6:415–419.

Glied, Sherry and Matthew Neidell. 2010. The economic value of teeth. *Journal of Human Resources* 45, no. 2:468–496.

Guarnizo-Herreño, Carol Cristina and George L Wehby. 2012. Children's Dental Health, School Performance, and Psychosocial Well-being. *The Journal of Pediatrics* 161, no. 6:1153–1159.

Hirleman, Christa Elizabeth. 2018. The Impact of Dental Caries on the Oral Health-related Quality of Life in Children. PhD thesis, University of Iowa. *https://doi.org/10.17077/etd.1qf7xaze* [Huff, Marlene, Elizabeth Kinion, Mary Agnes Kendra, and Terry Klecan. 2006. Self-esteem: A Hidden Concern in Oral Health. *Journal of Community Health Nursing* 23, no. 4:245–255.

Jackson, Stephanie L., William F. Vann Jr., Jonathan B. Kotch, Bhavna T. Pahel, and Jessica Y. Lee. 2011. Impact of Poor Oral Health on Children's School Attendance and Performance. *American Journal of Public Health* 101, no. 10:1900–1906.

Mobley, Connie, Teresa A Marshall, Peter Milgrom, and Susan E Coldwell. 2009. The Contribution of Dietary Factors to Dental Caries and Disparities in Caries. *Academic Pediatrics* 9, no. 6:410–414.

Sánchez, Celia Monteagudo, Francisco Téllez, Leticia Heras González, Diana Ibañez-Peinado, Miguel Mariscal Arcas, and Fátima Olea Serrano. 2015. School Dietary Habits and Incidence of Dental Caries. Nutrición Hospitalaria 32, no. 1: 383–388.

Offenbacher, Steven, H.L. Jared, P.G. O'Reilly, S.R. Wells, G.E. Salvi, H.P. Lawrence, S.S. Socransky, and J.D. Beck. 1998. Potential Pathogenic Mechanisms of Periodontitis-Associated Pregnancy Complications. *Annals of Periodontology* 3, no. 1:233–250.

Hartnett, Erin, Judith Haber, Barbara Krainovich-Miller, Abigail Bella, Anna Vasilyeva, and Julia Lange Kessler. 2016. Oral Health in Pregnancy. *Journal of Obstetric, Gynecologic & Neonatal Nursing* 45, no. 4:565–573.

Dye, Bruce A., Clemencia M. Vargas, Jessica J. Lee, Laurence Magder, and Norman Tinanoff. 2011. Assessing the Relationship between Children's Oral Health Status and that of Their Mothers. *The Journal of the American Dental Association* 142, no. 2:173–183.

Isong, Inyang A. Katharine E. Zuckerman, Sowmya R. Rao, Karen A. Kuhlthau, Jonathan P. Winickoff, and James M. Perrin. 2010. Association between Parents' and Children's Use of Oral Health Services. *Pediatrics* 125, no. 3:502–508.

Gupta, Niodita, Marko Vujicic, Cassandra Yarbrough, and Brittany Harrison. 2018. Disparities in Untreated Caries among Children and Adults in the U.S., 2011–2014. *BMC Oral Health* 18, no. 1:30.

Valachovic, Richard W. 2018. Implications for the Dental Care of Vulnerable Populations if Medicaid is Cut Back. *Academic Medicine* 93, no. 5:687–689.

Gundersen, Craig and James P. Ziliak. 2015. Food Insecurity and Health Outcomes. *Health Affairs* 34, no. 11:1830–1839.

Sanders, Anne E., William B. Grider, William R. Maas, John A. Curiel, and Gary D. Slade. 2019. Association between Water Fluoridation and Income-Related Dental Caries of U.S. Children and Adolescents. *JAMA Pediatrics* 173, no. 3:288–290.

Hettiarachchi, Ruvini M. Sanjeewa Kularatna, Joshua Byrnes, and Paul A. Scuffham. 2019. Pediatric Quality of Life Instruments in Oral Health Research: A Systematic Review. *Value in Health* 22, no. 1:129–135.

Jokovic, A. D. Locker, M. Stephens, D. Kenny, B. Tompson, and G. Guyatt. 2002. Validity and Reliability of a Questionnaire for Measuring Child Oral-health-related Quality of Life. *Journal of Dental Research* 81, no. 7:459–463.

Jokovic, Aleksandra, David Locker, Marlene Stephens, David Kenny, Bryan Tompson, and Gordon Guyatt. 2003. Measuring Parental Perceptions of Child Oral Health-related Quality of Life. *Journal of Public Health Dentistry* 63, no. 2:67–72.

Lang, W. Paul Wenche S. Borgnakke, George W. Taylor, Marilyn W. Woolfolk, David L. Ronis, and Linda V. Nyquist. 1997. Evaluation and Use of an Index of Oral Health Status. *Journal of Public Health Dentistry* 57, no. 4:233–242.

Zaror, Carlos, Yolanda Pardo, Gerardo Espinoza-Espinoza, Àngels Pont, Patricia Muñoz-Millán, María José Martínez-Zapata, Gemma Vilagut, Carlos G. Forero, Olatz Garin, Jordi Alonso, et al. 2019. Assessing Oral Health-related Quality of Life in Children and Adolescents: A Systematic Review and Standardized Comparison of Available Instruments. *Clinical Oral Investigations* 23: 65–79.

Griffin, Susan, Shillpa Naavaal, Christina Scherrer, Paul M. Griffin, Kate Harris, and Sajal Chattopadhyay. 2016. School-Based Dental Sealant Programs Prevent Cavities and Are Cost-Effective. *Health Affairs* 35, no. 12:2233–2240.

Cohen, Lois K. and John D. Jago. 1976. Toward the Formulation of Sociodental Indicators. *International Journal of Health Services* 6, no. 4:681–698.

Agterberg, Joshua, Fanghao Zhong, Richard Crabb, and Marjorie Rosenberg. 2020. Cluster Analysis Application to Identify Groups of Individuals with High Health Expenditures. *Health Services and Outcomes Research Methodology* 20, no. 2:140–182.

Zhong, Fanghao, Marjorie Rosenberg, Joshua Agterberg, and Richard Crabb. 2021. Social Determinant–Based Profiles of U.S. Adults with the Highest and Lowest Health Expenditures Using Clusters. *North American Actuarial Journal* 25, no. 1:115–133.

Rosenberg, Marjorie and Fanghao Zhong. Using Clusters Based on Social Determinants to Identify the Top 5% Utilizers of Health Care. Working Paper (2021).

Halkidi, Maria, Yannis Batistakis, and Michalis Vazirgiannis. 2001. On Clustering Validation Techniques. *Journal of Intelligent Information Systems* 17, no. 2:107–145.

Aizcorbe, Ana, Eli Liebman, Sarah Pack, David M. Cutler, Michael E. Chernew, and Allison B. Rosen. 2012. Measuring Health Care Costs of Individuals with Employer-Sponsored Health Insurance in the U.S.: A Comparison of Survey and Claims Data. *Statistical Journal of the IAOS: Journal of the International Association for Official Statistics* 28, no. 1:43–51.

Otto, Mary. 2017. *Teeth: Beauty, Inequality and the Struggle for Oral Health in America*. New York: New Press.

Albino, Judith. Bruce Dye, and Timothy Ricks. 2020 Surgeon General's Report Oral Health in America: Advances and Challenges. Presented at National Institute of Dental and Craniofacial Research, International Association for Dental Research 97th General Session, June 21, 2019, Vancouver, BC, Canada.

Satcher, David, and Joyce H. Nottingham. 2017. Revisiting Oral Health in America: A Report of the Surgeon General. *American Journal of Public Health* 107, no. S1: S32–S33.

Mertz, Elizabeth A. 2016. The Dental–Medical Divide. *Health Affairs* 35, no. 12:2168–2175.

About The Society of Actuaries Research Institute

Serving as the research arm of the Society of Actuaries (SOA), the SOA Research Institute provides objective, data-driven research bringing together tried and true practices and future-focused approaches to address societal challenges and your business needs. The Institute provides trusted knowledge, extensive experience and new technologies to help effectively identify, predict and manage risks.

Representing the thousands of actuaries who help conduct critical research, the SOA Research Institute provides clarity and solutions on risks and societal challenges. The Institute connects actuaries, academics, employers, the insurance industry, regulators, research partners, foundations and research institutions, sponsors and non-governmental organizations, building an effective network which provides support, knowledge and expertise regarding the management of risk to benefit the industry and the public.

Managed by experienced actuaries and research experts from a broad range of industries, the SOA Research Institute creates, funds, develops and distributes research to elevate actuaries as leaders in measuring and managing risk. These efforts include studies, essay collections, webcasts, research papers, survey reports, and original research on topics impacting society.

Harnessing its peer-reviewed research, leading-edge technologies, new data tools and innovative practices, the Institute seeks to understand the underlying causes of risk and the possible outcomes. The Institute develops objective research spanning a variety of topics with its strategic research programs: aging and retirement; actuarial innovation and technology; mortality and longevity; diversity, equity and inclusion; health care cost trends; and catastrophe and climate risk. The Institute has a large volume of topical research available, including an expanding collection of international and market-specific research, experience studies, models and timely research.

Society of Actuaries Research Institute
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org