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Using electronic dental records to establish a surveillance system for dental decay in rural Western Alaska

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Abstract

Objectives: Previous surveys have demonstrated high rates of early childhood caries (ECC) in the Alaska Native (AN) population of western Alaska. There are many challenges to providing dental care in this road-less Yukon-Kuskokwim Delta region. The regional Tribal Health Organization implemented an electronic dental record (EDR) system in the late 1990s. We explored use of the EDR to establish an oral health surveillance system in children.

Methods: We contracted with EDR software developers to implement calculation of a summary count of decayed (d), missing (m) or filled (f) primary (dmft) score for each individual. We calculated the yearly average dmft scores for 2011–2019 for children aged 3 and 5 years with a comprehensive exam in a given year. We also assessed the number of children undergoing full mouth dental rehabilitation (FMDR). We used US census data population estimates for these age groups to calculate rates.

Results: Over the 9-year period, 2,427 3-year-old children (47 percent of all 3-year olds over this period), received a comprehensive exam; increasing from 24 percent in 2011 to 62 percent in 2019. Their average dmft score over the 9-years was 6.4 with a significant annual decline over this period. Seventy percent of AN children who turned 6 between 2015 and 2019 had received at least one FMDR.

Conclusions: An oral health surveillance system has been established in western Alaska using the Electronic Dental Record. High rates of ECC and FMDR were observed. This surveillance system will allow assessments of ECC prevalence and impact of dental interventions.

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Conflict of interest

No authors report any conflict of interest.

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Keywords

dental caries; early childhood caries; dental records; surveillance; Alaska Native; dental health aide therapist

Introduction

For many American Indian and Alaska Native (AI/AN) children, the prevalence of dental cavities (caries), or early childhood caries (ECC) is high.[1] ECC, the presence of one or more decayed, missing, or filled tooth surfaces in any primary tooth in a preschool-aged child, is recognized by the American Dental Association (ADA) as an important public health issue.[2] If ECC remains untreated, oral health-related quality of life, body weight, growth, school attendance and school performance can be affected.[3] Children with ECC, who require treatment under general anesthesia, also have a higher predisposition to develop dental caries in permanent dentition.[4]

The Yukon-Kuskokwim Health Corporation (YKHC) is a tribal health organization in western Alaska. YKHC manages the healthcare system for a population of 23,000 Alaska Native (AN) people in 58 communities in the Yukon-Kuskokwim Delta, a region the size of Oregon. YKHC's healthcare delivery system includes 41 community clinics staffed by Community Health Practitioners, sub-regional clinics in five larger communities, a regional hospital, dental, and other services.[5] The YK region is the traditional homeland to the Yup'ik Eskimo, who constitute 85 percent of the population. Approximately 30 percent of the communities have no in-home piped running water and sanitation services and only five communities currently have a fluoridated water system. The rural communities are accessible only by air or boat and have limited medical and dental resources.

In 2008, a survey of dental caries was conducted among children in five communities in the YK region.[6] The survey found that 87 percent of AN children aged 4–5 years had caries with a mean of 7.3 decayed and filled teeth compared to 1.6 in same aged US children.[6] Although there are periodic statewide Indian Health Service (IHS) surveys approximately every 4 years,[1] there are no ongoing surveillance systems in Alaska monitoring prevalence of dental caries. A recommendation of the 2008 YKHC survey[6] was to explore use of the YKHC electronic dental record (EDR) for oral health surveillance to monitor trends and evaluate interventions. YKHC introduced an EDR in the late 1990s, which captures dental claims data for all dental encounters in the region.

A literature review searching "electronic dental records and dental surveillance" through Pubmed, Medline, and Cochrane report found only one peer-reviewed article addressing use of EDR for dental surveillance. The Rochester Epidemiology Project in southeastern Minnesota and west central Wisconsin formed a collaboration of healthcare providers to systematically link medical and dental records, facilitating research studies examining the role of oral health in overall health and quality of life.[7] Population-level oral health surveillance is difficult because many EDR systems are designed primarily for billing purposes and private practice offices vary in the software used to maintain records, making standardization challenging. It is also difficult to define the population denominator for

individual private practices, particularly in an urban setting. Thus, rate calculations are unavailable for most private-practice dental clinics.

Tribal health organizations (THOs) with EDR systems are well situated for establishing population-level oral health surveillance systems using programmatic data. The YKHC dental services are provided by dentists and dental health aide therapists (DHATs). The DHAT program, initiated in 2004, established a mid-level cadre of the dental work force who receive 2 years of training to provide routine dental services in under-served regions, including community-based oral health preventative care and education, basic restorations, cleanings, and nonsurgical extractions.[8, 9] The YKHC dentists are based in the region's largest town (Bethel, population 6,000) and periodically visit outlying communities. Most DHATs reside and work in one of the outlying communities with a sub-regional outpatient clinic and make visits to smaller surrounding communities. The one dentist in the region working outside the YKHC system primarily serves the non-Alaska Native population. Additional dental care is available in Anchorage, a 1-hour flight from Bethel. Dental encounters entered in the EDR include those conducted by dentists, DHATs and other dental staff at the main Bethel site, sub-regional and community clinics served by YKHC.

The goals of this project were to determine whether we could adapt an existing EDR to establish a pediatric oral health surveillance system, generate, and demonstrate data using this system and provide an assessment of this surveillance system using criteria commonly used to evaluate surveillance systems.[10]

Methods

This work was deemed nonresearch by the Alaska Area Institutional Review Board. The manuscript has been approved by ANTHC and YKHC publication review committees. We aimed to describe the use of the electronic dental record (EDR) to capture the extent of oral health disease in the population of children encountering the YKHC dental system between 2011 and 2019.

Estimating decayed, missing and filled teeth scores

The project used data from the electronic dental records (EDR) of AN children who received treatment through YKHC. The YKHC dental unit uses proprietary software, Clinical Product Suite by Quality Systems Inc (QSI, CA), for its EDR. The initial software lacked a summary of decayed (d), missing (m) or filled (f) primary teeth (dmft) or permanent teeth (DMFT) score for individual patients. YKHC contracted with QSI to code the status of each tooth in the mouth as decayed, missing or filled, based on condition or procedure codes. The software now provides decayed, missing, or filled status for each tooth for an individual, with a unique patient id and date of examination. Total numbers of decayed, missing, or filled teeth for each child are then reported as dft and dmft scores. Status refers to tooth not individual tooth surfaces. Most children have 20 primary teeth, which start to erupt by 6 months and begin to shed by 72 months. A dft score specifies the number of teeth with untreated decay or fillings, yielding a range of 0–20; 0 indicates that none of a child's primary teeth has ever had cavities. The dmft scores were similarly created, except that the total score was also incremented if a tooth was missing (again yielding a range of 0–20). In

our analysis “missing teeth” refers only to teeth that are removed, but not teeth that have not yet erupted. The project team validated the QSI-calculated dft and dmft scores by manually reviewing dental records of all 3-year-old children who received a comprehensive dental examination in 2015. Dmft and dft scores are only recorded/updated during comprehensive dental exams (which usually include dental radiographs) as other dental encounters typically do not record the status of every tooth in the mouth. We restricted this analysis to describe the extent of caries in the primary dentition. We calculated average dmft and dft scores for children born in the same calendar year, at ages 3 and 5 years.

Full mouth dental rehabilitations

Full mouth dental rehabilitations (FMDRs) are usually performed under general anesthesia on pre-cooperative children or children who require extensive dental treatment involving multiple extractions of teeth and/or restorative procedures such as fillings or crown placement across multiple sextants. A referral for FMDR, either in Bethel or Anchorage, and the subsequent change in dmft score caused by completion of the FMDR are recorded in the YKHC EDR regardless of where the procedure occurs. The number of children referred for FMDR was calculated by calendar year for 2011 through 2019. The percentage of children who had had at least one FMDR completed prior to age 6 years was calculated for children born in 2009–2013.

Analyses

To estimate rates, we used Alaska Population estimates categorized by Age, Race (alone or in combination), Hispanic Origin, Sex, and Borough/Census Area for 2011–2019 from the Alaska Department of Labor and Workforce Development, and from the US Census Bureau.[11] For each year we calculated the percentage of children receiving ANY dental services; as well as the percentage receiving comprehensive oral evaluation, defined as patients with codes DO120 (periodic oral evaluation), DO145 (oral evaluation, age 0–2 years with counseling), or DO150 (oral evaluation comprehensive, age 3+ years). We examined trends in these measures over the period of 2011–2019 for both 3 and 5 year olds. We assessed changes in proportions (e.g., proportion of children receiving comprehensive exams) using Cochran-Armitage trend tests and changes in count data for dmft scores using a negative binomial model.

In order to determine number of dental provider full time equivalents (FTE) for each year we obtained a listing of all dental providers (DDS, DMD, and DHAT) and number of days worked. We calculated FTE assuming a 40-hour work week for 52 weeks per year. We examined changes in FTE over the years and association between FTE, comprehensive exams and dmft scores of 3-year olds using a Spearman correlation. Data analyses utilized SAS 9.4 (SAS Institute Inc., Cary, NC) and R version 3.5.1.[12]

Results

Using census data, we estimate that there was an annual average of 3,090 Alaska Native children aged 0–5 years from 52 communities in the YKHC region between 2011 and 2019. Among the estimated 2,974 AN children in the region for whom we have oral health data for

the entire first 6 years of life, 2,882 (97 percent) had at least one comprehensive exam before they were 6 years old (mean age first comprehensive exam of 2.6 years, SD = 1.2 years). Between 2011 and 2019, a mean of 33.1 dental providers (DDS, DMD, DHAT) worked for YKHC each year contributing to a mean of 14.6 full time equivalents (FTE) each year during this period. There was no significant change in FTE over the time period.

Among children under 2 years of age 1,277 (12 percent, range: 5–17 percent) received a comprehensive exam during the 9-year period (Table 1). Over the same period, 2,427 3 year olds (47 percent) received a comprehensive exam, increasing from 23 percent in 2012 to 62 percent in 2019. Among 5 year olds, 2013 (39 percent) received a comprehensive exam, increasing from 17 percent in 2011 to 47 percent in 2019 (high of 52 percent in 2017).

Among 3 year olds who had a comprehensive exam during the 9-year period, the average dmft score was 6.4 with a significant decline over the 9 years from 8.9 in 2011 to 6.6 in 2019 (Table 2). However, there was a significant decline in the percent of decayed and filled teeth that were filled (f/dft) (64 percent in 2011 and 36 percent in 2019). There was no significant correlation between dental FTE and number of comprehensive exams or dmft scores. The average dmft score for 5 year old over the same period was 10.2 with no significant change seen over the 9 years (Table 3). Among 5 year olds, the average percentage of decayed and filled teeth that were filled (f/dft) was 72 percent with no significant change in percent filled over the 9 years (range 60–80 percent).

We examined the percentage of children who had at least one FMDR before their sixth birthday. Among the 3,267 AN children born between 2009 and 2013, 2,302 (70 percent) of them were treated with FMDR between 2010 and 2019 (Table 4). Children were most likely to receive FMDRs when age 3 and 4 years.

In order to determine whether the surveillance data obtained are representative of the population we compared the proportion of children with a given range of dmft scores obtained through this EDR-based surveillance system with the 2008 YKHC convenience sample survey of the same age (4–7 years) children in the same four communities, excluding Bethel (see Figure 1). These two different approaches to estimating the extent of caries in this population showed no significant difference in the proportion of children with given dmft scores.

Discussion

We have demonstrated the ability to adapt an electronic dental record to establish an oral health surveillance system to monitor AN children receiving dental services throughout the YKHC region. The EDR-based surveillance system reports the number of children receiving a comprehensive exam and provides a cumulative decayed, missing, or filled tooth (dmft) score for each child. This report covers the years 2011–2019.

Comprehensive exams

While the overall proportion of 3- and 5-year-old children receiving a comprehensive exam was only 47 percent and 39 percent, respectively, over the 9 years (Table 1), the proportion

getting an exam increased significantly over the 9 years in both age groups. This increase could be attributed to the expansion of the DHAT program which has been described in a previous study.[13] One concern is the low proportion of children <2 years who are getting comprehensive exams where opportunities exist to provide prevention counseling and care.[13] These missed opportunities may account for the finding that most of the caries in this 0–5 year age group occurred by age 3 years.

Decayed, missing, and filled teeth scores

There was a significant decline in dmft score among 3 year olds, possibly driven by the increasing proportion of children with less disease getting exams; however, the mean dmft scores for 5-year-olds in the region was high (average dmft = 10.2) and did not change over the 9 years (Table 3). While the proportion of decayed and filled teeth (dft) that were filled (f) was higher among 5 year olds compared to 3 year olds in each year, the proportion that were filled declined each year for the 3-year-old age group. This suggests that as the dental system was seeing more patients it was not able to address the amount of disease being seen, an argument for ensuring adequate numbers of dentists and training of more DHATs who live and work out in the remote communities. The high average annual dmft scores are considerably higher than those reported in the 2014 IHS oral health survey (mean dmft score = 6.1 for AI/AN children aged 5 years). However, the IHS dmft score reflects combined data from 12 IHS regions and only 282 Alaska Native children aged 5 years, thus reflecting the importance of regional data.[1]

Full mouth dental rehabilitations

A total of 2,302 AN children, representing 70 percent of all AN children in the YK region born between 2009 and 2013 received at least one FMDR by age 6 years. By comparison, an analysis of ambulatory surgery in New York State using 1996–1999 data from the Statewide Planning and Research Cooperative System (SPARCS) showed 0.19 percent children younger than 6 years of age had restorations performed under general anesthesia, primarily for ECC; a 368-fold difference.[14] Regulations in New York State require all hospital-based ambulatory surgery services be reported to SPARCS.[12] While the challenges of access to dental care may be a factor in decisions about treatment, YKHC dentists follow the indications for use of general anesthesia as defined by the American Association of Pediatric Dentistry (AAPD).[15] Previous studies have indicated high use of sugar-sweetened beverages by AN children in this region, which may contribute to the high burden of disease seen in this region.[16] Previous studies[17] estimate the average cost for a FMDR at YKHC to be $9,000.

Future use of the electronic dental record-based surveillance system

This EDR-based surveillance system meets the vision of a Learning Health System using electronic data as a foundation for continuous improvement.[18] This surveillance system can help the YKHC dental department make staffing adjustments, monitor the impact of interventions using their own data, and determine how best to allocate scarce dental public health resources, For example, since this system has been in place, silver diamine fluoride (SDF) has been added to the treatments offered in the YKHC dental clinics. SDF is

supported by the AAPD as part of caries management[19] and may reduce the number of AN children referred for FMDR.

A recent study used these data to evaluate the impact of prenatal vitamin D on ECC.[20]

Future analyses using data derived from this EDR-based surveillance system are proposed to evaluate the impact of expansion of the DHAT program, promotion of regular dental visits early in life, application of fluoride and seal-ants on primary molars, and community-specific interventions such as installation of piped water systems, increasing the number of communities with fluoridated water systems, and interventions to decrease sugar sweetened beverage consumption. We restricted our analysis to the primary dentition in the pediatric population; however, this surveillance system also captures the condition of permanent teeth in older children and adults.

Evaluation of the electronic dental record-based surveillance system

We assessed limitations and challenges by utilizing commonly used criteria for evaluation of a surveillance system,[10] including simplicity, acceptability, sensitivity, representativeness, and timeliness. Meeting these criteria would be essential in promotion of the use of the EDR for continued oral health surveillance.

Simplicity—This surveillance system was adapted from an existing EDR system primarily designed for billing purposes, which records dental procedures and the condition of teeth for planning of procedures. No additional work is required of the dental providers. The software calculates a dmft score based on established ADA transaction codes as well as diagnostic and condition data. Training is required to produce the surveillance report. The ADA updates their transaction codes annually. As codes are added, staff may need to include these codes in the configuration files to ensure accurate results over time.

Acceptability—This surveillance system is based on data from the existing EDR used for charting conditions and procedures and related billing; it requires no additional work by the dental providers. Further demonstration of the utility of this system will determine acceptability by the YKHC dental administration.

Sensitivity—The ability to detect disease in the population is dependent on a variety of factors, including completeness of reporting and accuracy of findings. The sensitivity of this EDR-based surveillance will be impacted by the number and proportion of children who receive a comprehensive oral health exam and the number, training, and calibration of the dental providers. The proportion of children with comprehensive exams is increasing. We did not explore the number of providers present from 2011 to 2019 or their dental experience levels. Because dental providers train at different institutions, comprehensive exams are charted differently and how dental providers report tooth status may be subjective. The surveillance may therefore lack calibration among dental providers and result in provider-specific variability, negatively affecting the quality of the surveillance system data.[10] A solution could be for each dentist to have new hire and annual training to establish consistency in coding of carious lesions and on the clinic standards for comprehensive

exams, including recording of exam findings. As mentioned earlier, the QSI code was modified to obtain 100 percent concordance between dmft score and manual review.

Representativeness—We see an increasing proportion of children getting comprehensive dental exams over the 9 years, thus capturing a more representative section of the population and increasing our confidence that the estimates of mean dmft and dft scores represent the mean dmft scores for all children in the region. We compared the proportion of children with a given range of dmft scores obtained through this EDR-based surveillance system for the years 2011–2015 with data obtained through the 2008 convenience sample survey of the same age children in the same four communities (see Figure 1). These two different approaches to estimating the extent of caries in this population were consistent. There was no significant difference in the proportion of children with given dmft scores to suggest that the EDR-based surveillance system is not representative of the target population. In addition, data derived from this YKHC EDR are more representative of the local population than the 2014 IHS survey which only included 282 Alaska Native children aged 5 years from across the state.[1]

Timeliness—Oral exams are entered into the EDR in real time both for exams in Bethel and exams done in the communities, thus the EDR-based surveillance reports could be provided when needed. Minimal data manipulation, entry or analysis is required. YKHC staff must enter date range of interest to create data tables for the report.

Conclusion

In conclusion, while oral health care in remote areas of Alaska is challenging, we were able to successfully adapt an EDR to provide population level oral health data, demonstrate use of that system to generate meaningful data, and establish a system that could be used to monitor interventions and inform improvements in care over time. YKHC is implementing advancements in dental treatments, expansion of the DHAT program and further education for communities on how to improve oral health, such as reduction in consumption of sugar-sweetened beverages. We believe that the criteria for a successful surveillance system have or can be met with minimal additional burden on the dental system and this EDR-based surveillance system can provide real-time data on the local population at minimal cost and will allow YKHC to track dental outcomes and trends in dental caries among the pediatric population and help address the huge disparity in oral health seen in Alaska Native children. Furthermore, the implementation of this surveillance system in the YK region and demonstration of its utility could encourage use by other THOs in Alaska, IHS, and entities providing dental care to large defined populations.

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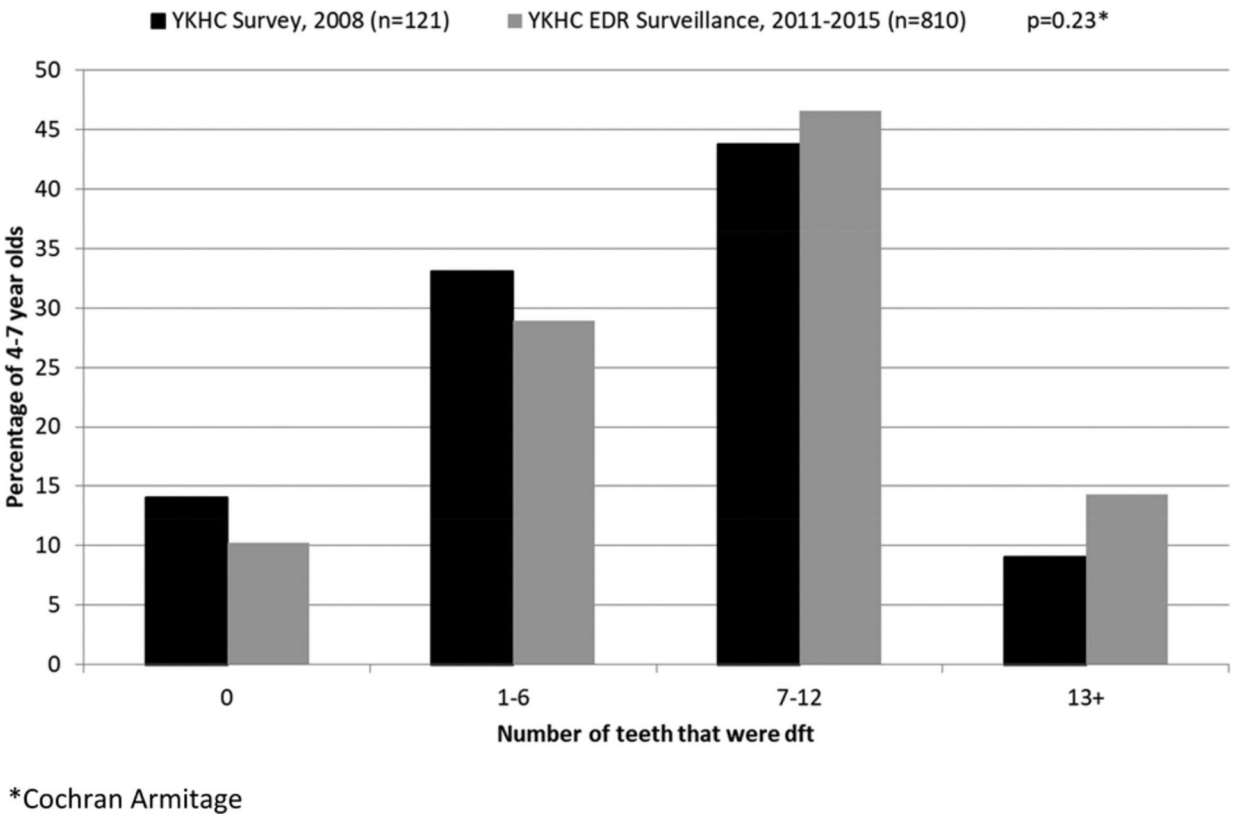

Figure 1.

Comparison between 2008 YKHC oral health survey and YKHC electronic dental record (EDR)-based surveillance (2011–2015). Proportion of 4–7 year olds with given decay, filled teeth (dft) in same four communities.

Table 1

Number and Percent of Alaska Native Children in Each Age Group in the Yukon Kuskokwim Health Corporation Region, Alaska, Receiving Comprehensive Dental Examinations, 2011–2019

Age (yrs.)	2011 *n* (%)	2012 *n* (%)	2013 *n* (%)	2014 *n* (%)	2015 *n* (%)	2016 *n* (%)	2017 *n* (%)	2018 *n* (%)	2019 *n* (%)	2011–2019 *n* (%)
<2	79 (7)	62 (5)	117 (10)	103 (9)	190 (16)	196 (17)	178 (16)	192 (17)	160 (15)	1,277 (12)
3	141 (24)	132 (23)	217 (36)	246 (41)	331 (56)	328 (57)	359 (63)	332 (59)	341 (62)	2,427 (47)
5	97 (17)	122 (21)	138 (24)	235 (40)	284 (48)	288 (49)	304 (52)	274 (47)	271 (47)	2013 (39)

Table 2

Oral Health Status of 3-Year-Old Alaska Native Children in the Yukon Kuskokwim Health Corporation Region, Alaska, Who Received a Comprehensive Dental Exam, 2011 Through 2019

Year	No. of children receiving comprehensive dental exams *n* (%)*	Presence of any caries *n* (%)	Mean (Median) decayed, missing, filled teeth (dmft) score	Percent (f/dft)¶
2011	141 (24)	122 (87)	8.9 (9)	64
2012	132 (23)	106 (80)	7.3 (7)	61
2013	217 (36)	183 (84)	7.4 (6)	43
2014	246 (41)	207 (84)	7.5 (7)	35
2015	331 (56)	273 (82)	7.6 (8)	33
2016	328 (57)	228 (70)	5.9 (4)	35
2017	359 (63)	221 (62)	4.7 (3)	66
2018	332 (59)	211 (64)	4.7 (3)	52
2019	341 (62)	278 (82)	6.6 (5)	36
2011–2019 Trend test	<0.001†	<0.001†	0.003‡	↓0.02†

*Percent of all AN children in this age group.

†Cochran-Armitage Trend Test.

‡Negative binomial regression.

¶Percent: [mean filled (f)]/[mean decayed, filled teeth (dft)].

Table 3

Oral Health Status of 5-Year-Old Alaska Native Children in the Yukon Kuskokwim Health Corporation Region, Alaska, Who Received a Comprehensive Dental Exam, 2011–2019

Year	No. of children receiving comprehensive dental exams *n* (%)*	Presence of any caries *n* (%)	Mean (Median) decayed, missing, filled teeth (dmft) score	Percent (f/dft)¶
2011	97 (17)	91 (94)	10.3 (11)	80
2012	122 (21)	116 (95)	9.8 (10)	76
2013	138 (24)	125 (91)	9.0 (10)	66
2014	235 (40)	222 (94)	10.1 (11)	66
2015	284 (48)	266 (94)	10.2 (11)	60
2016	288 (49)	261 (91)	10.4 (12)	69
2017	304 (52)	279 (92)	10.5 (12)	79
2018	274 (47)	245 (89)	10.0 (11)	77
2019	271 (47)	250 (92)	11.0 (12)	80
2011–2019 Trend test	<0.001†	0.09†	0.85‡	0.35†

*Percent of all AN children in this age group.

†Cochran-Armitage trend test.

‡Negative binomial regression.

¶Percent: [mean filled (f)]/[mean decayed, filled teeth (dft)].

Table 4

Number of Alaska Native Children in the Yukon Kuskokwim Health Corporation Region, Alaska Receiving At Least One Full Mouth Dental Rehabilitation by Their Sixth birthday for Children Born Between 2009 and 2013

Year of birth **Total births**		**2009** **660**	**2010** **666**	**2011** **649**	**2012** **651**	**2013** **641**	**Total** **3,267**
Age (years) a: FMDR	1	3	7	6	14	3	33
	2	66	40	82	90	101	379
	3	110	154	194	206	175	839
	4	168	194	134	111	123	730
	5	89	70	56	45	61	321
Number (%) of children		436 (66%)	465 (70%)	472 (73%)	466 (72%)	463 (72%)	2.302 (70%)
Cochran-Armitage Trend Test $P = 0.01$							