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Research Article

Early Dental Caries and Their Associated International Classifications of Disease Morbidity: A 16-Year Population Study

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ABSTRACT

Objective: The study objective was to examine the relationship between dental caries diagnosed before the age of four and ICD diseases over a 16-year period.

Methods: The sample of approximately 33,531 (48% female) individuals having a total of 2,864,790 physician diagnoses over 16 years comprised a the cohort two groups, one with (2.7% of the sample) and one without dental caries (dependent variable) that were under the age of four years in the first two years of the sample data. Categories of dental caries and associated gingivitis and periodontal disease were based on the International Classification of Disease (ICD Version 9) diagnostic codes 521-523. The sample was described. Odds ratios comparing those with and without dental caries and the main ICD classes were calculated. Additionally, the ratio of each ICD diagnosis frequency comparing the cohort groups were calculated and represented the diagnoses assigned over the first 15 physician visits.

Results: Males had proportionally more dental caries diagnosed. Diagnoses were made predominantly by general practitioners. Within the dental caries cohort group, associated ICD diagnoses were over-represented in both odds ratios and within individual ICD diagnoses on the first diagnosis and over the first 15 diagnoses in time.

Conclusion: Dental caries diagnosed in very young children before the age of four are associated with multi-morbidity over subsequent years. Sex differences and patterns of associated morbidity may contribute to a better understanding of early life vulnerability to dental caries and their sequelae.

Introduction

Over the years some effort has gone into understanding factors associated with the diagnosis of dental caries in the very young [1, 2]. Most studies have focused on the occurrence and proximal causes of dental caries across childhood [3-8]. Proximal causes are thought to be related to multiple factors, including diet, malnutrition, parenting feeding practices and education [9-26]. Over time, most study has focused on risk factors, including socioeconomic risk and prevention, yet preventable pediatric dental caries in early life remains an ongoing global issue [3, 27, 28]. Absent from this body of work has been the prospective study of the multi-morbidity associated with early dental caries. Multi-morbidity is an emerging field in the management of disease in terms of understanding its etiology, sequelae, and potential mechanisms, notwithstanding the relationship of early dental caries to the preventable burden of disease [9, 29-33]. To date examination of the relationship of epidemiological investigation to mechanism pertaining to early dental caries has not included study of multi-morbidity [34-38]. The main goal of the present paper is to describe in a regional population the broad spectrum of prospective multi-hyper-morbidity associated with dental caries diagnosed by physicians in the very young.

Methods

Data for this study was collected under ethics ID REB15-1057, representing the health seeking population from the Calgary Health Zone

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in Alberta, Canada between April 1993 and November 2010. Alberta physicians directly bill for payment the provincial health plan for each patient visit (even private clinics and practitioners). For each patient visit the data consisted of a record including an anonymous, encrypted, unique patient identifier, an International Classification of Diseases (ICD-9) diagnosis code, age, date, and sex. The analysed data consisted of a sample with two groups under the age of four years before January 1995. The two cohorts were those with and without early dental caries this age group. The sample of approximately 33,531 (48% female) individuals having a total of 2,864,790 physician diagnoses over 16 years was made up of two cohorts with dental caries (2.7% of the sample) and without dental caries (dependent variable) who were under the age of four years in the first two years sample data. Employing the encrypted unique identifiers for each of these two groups permitted merging all other patient-linked ICD diagnoses in the data set for the cohorts with and without dental caries. Given that physician billing was between 1993 and 2010, members of each cohort could have diagnoses up to the ages of 16-19 years. Within the cohort the median index age of diagnoses denoting membership in the dental caries group was one year of age for both males and females.

Categories of dental caries and associated gingivitis and periodontal disease were based on the following International Classification of Disease (ICD) diagnostic codes: 520- Disorders of tooth development and eruption; 521- Diseases of hard tissues of teeth; 522- Diseases of pulp and periapical tissues; 523- Gingival and periodontal diseases. Of note is that in Alberta Canada, from where the data derives, dentistry is funded independently from physician-based health care, hence the data informing this study likely represent the most serious cases identified incidentally in clinic visits primarily by general practice physicians (Table 1).

Analysis

Males and females were analyzed separately. In addition to the physician types making the index diagnoses (Table 1) and a description of the sample (Table 2), odds ratios and their 95% confidence intervals were calculated for the 17 independent major classes of ICD disorder comparing within the cohort those with and without membership in the dental caries group (Table 3). Odds ratios were based on counts of individual membership in one of four cells (2X2): a) neither dental caries nor the ICD major class; b) Major ICD class only; c) dental caries group only; d) membership in both dental caries and the ICD major class. The odds ratio is given by the formula [(a*d)/(b*c)].

Further, the ratio of the frequency of diagnoses within each group ([(total # diagnoses within ICD diagnosis category)/(cohort sample size)]) was calculated for all unique ICD diagnoses where both groups were represented. ICD diagnoses arising only in the dental caries group were noted. This analysis permitted a standardized comparison of the differences in the intensity (unit frequency) of all diagnoses in sequence over time when represented by physician visit. Two graphical representations show proportional diagnosis ratios comparing the groups with and without dental caries within the cohort for the first (diagnosis) visit (Figure 1) and the first 15 visits in time for each sex (Figure 2). This approach to analysis represents a novel representation of temporal hyper-morbidity.

Results

Index dental caries diagnoses were predominantly made by general practitioners and pediatricians (Table 1), presumably at early life checkups, once first teeth begin to erupt or have developed.

Table 1: Total dental caries diagnosed by medical specialization for under the age of 4 years before 1995.

Specialization	Frequency	% Total
General Practitioner	885	84.77
Pediatrician	134	12.84
Anaesthesiologist	14	1.34
Emergency Medicine Specialist	6	0.57
Anatomical Pathologist	3	0.29
Otolaryngologist	2	0.19
Total	1,044	100

Table 2 indicates that there were proportionally more males than females with dental caries diagnoses and associated ICD diagnoses (Chi Square $p < 0.05$).

Table 2: Description of the cohort sample groupings.

Groupings	Female	Male
Unique Individuals - with Dental Caries Diagnoses	386	509
# Dental Diagnoses before age 4 years	445	599
# Dental Associated Diagnoses over 16 years	41,422	52,417
Unique Individuals - without dental caries diagnosis	15644	16,992
# Diagnoses over 16 years	1,355,274	1,415,677

The odds ratios ranked from highest to lowest are presented in (Table 3) for females (upper) and males (lower) odds ratios.

Table 3: Ranked odds ratios of dental caries (+/-) by ICD Main Class (+/-) by Sex.

Sex	ICD Main Class	a	b	c	d	Odds Ratio (95% CI)
Females	Skin And Subcutaneous Tissue[X]	7246	24969	39	347	2.58 (1.85, 3.6) *
	Injury And Poisoning[X]	7122	25093	41	345	2.39 (1.73, 3.3) *
	Infectious/Parasitic[X]	5505	26710	33	353	2.2 (1.54, 3.15) *
	Nervous System/Sense Organs[X]	3536	28679	21	365	2.14 (1.38, 3.33) *
	Genitourinary System[X]	16513	15702	133	253	2 (1.62, 2.47) *
	Mental Disorders[X]	21292	10923	201	185	1.79 (1.47, 2.19) *
	Musculoskeletal System[X] Connective Tissue	16471	15744	144	242	1.76 (1.43, 2.16) *
	Other Dental Diseases[X]	24451	7764	263	123	1.47 (1.19, 1.83) *
	Blood/Blood Organs[X]	29591	2624	343	43	1.41 (1.03, 1.95) *
	Circulatory System[Y]	29690	2525	345	41	1.4 (1.01, 1.94) *
	Respiratory System	1705	30510	14	372	1.48 (0.87, 2.54) ns
	III Defined Conditions	2766	29449	23	363	1.48 (0.97, 2.26) ns
	V Codes	2776	29439	24	362	1.42 (0.94, 2.15) ns
	Complications Of Pregnancy	30728	1487	362	24	1.37 (0.9, 2.08) ns
	Congenital Anomalies	28851	3364	337	49	1.25 (0.92, 1.69) ns
	Endocrine, Nutritional and Metabolic Diseases, and Immunity Disorders	27354	4861	320	66	1.16 (0.89, 1.52) ns
	Neoplasms	27854	4361	332	54	1.04 (0.78, 1.39) ns
	Perinatal	26878	5337	357	29	0.41 (0.28, 0.6) ns
Males	Respiratory System[Z]	2307	42333	5	504	5.49 (2.27, 13.27) *
	Nervous System/Sense Organs[X]	4709	39931	16	493	3.63 (2.21, 5.98) *
	III Defined Conditions	3923	40717	14	495	3.41 (2, 5.8) *
	Injury And Poisoning[X]	8463	36177	33	476	3.37 (2.37, 4.81) *
	Skin And Subcutaneous Tissue[X]	10766	33874	61	448	2.33 (1.78, 3.05) *
	Infectious/Parasitic[X]	8196	36444	47	462	2.21 (1.64, 2.99) *
	Blood/Blood Organs[X]	41120	3520	437	72	1.92 (1.5, 2.48) *
	Musculoskeletal System Connective Tissue[X]	24098	20542	203	306	1.77 (1.48, 2.11) *
	Genitourinary System[X]	29184	15456	276	233	1.59 (1.34, 1.9) *
	Neoplasms[Z]	39284	5356	421	88	1.53 (1.22, 1.93) *
	Other Dental Diseases[X]	32063	12577	321	188	1.49 (1.25, 1.79) *
	Endocrine, Nutritional and Metabolic Diseases, and Immunity Disorders[Z]	38513	6127	414	95	1.44 (1.15, 1.81) *
	Mental Disorders[X]	27708	16932	271	238	1.44 (1.21, 1.71) *
	Complications of Pregnancy	43724	916	494	15	1.45 (0.86, 2.43) ns
	Circulatory System	41036	3604	460	49	1.21 (0.9, 1.63) ns
	Congenital Anomalies	38489	6151	436	73	1.05 (0.82, 1.34) ns
	V Codes	3999	40641	47	462	0.97 (0.72, 1.31) ns
	Perinatal	35003	9637	468	41	0.32 0.23, 0.44) ns

*Lower 95% CI greater than the value 1.0 ($p < 0.05$); superscript [X]: Overlap between males and female; superscript [Y]: Females only; superscript [Z]: Males only.

NS: Not Significant.

Females (Table 3, upper) had odds ratios greater than the value 1 in ten ICD main classes. Males (Table 3, lower) had odds ratios greater than the value 1 in fourteen ICD main classes. Odds ratios greater than the value one indicated significantly greater representation of individuals with dental caries-associated ICD diagnoses within each ICD main class. Males and females overlapped in nine ICD main classes (superscript X), however the order of magnitude of the odds ratios differed. Circulatory system diagnoses were only significantly represented among females (superscript Y), whereas nervous system and sense organs, neoplasms, and endocrine diagnoses were significantly represented in only males (superscript Z in Table 3). While males and females have greater morbidity within ICD main classes, males and females are not significantly different from one another, other than in the noted differences where each has within ICD main class lower 95% CIs greater than the value one.

Figures 1 & 2 show respectively for males and females the sample proportion ratios for diagnosis (on visit) one and up to diagnosis (on visit) fifteen. What may be seen is that males and females differ to some degree in the profile of unique ICD diagnoses compared to one another in (Figure 1) for the first diagnosis. Also, within each sex it is apparent that the order of diagnoses varies considerably over the first fifteen physician visits. Only the first fifteen diagnoses are represented for the purpose of visualizing differences rather than illustrating all differences over all diagnoses. Within each sequence, while the maximum truncates at the upper range of 200 times higher in the ratio of proportions, the

upper limit plateaus illustrate where the ratio for a particular sequence is greater.

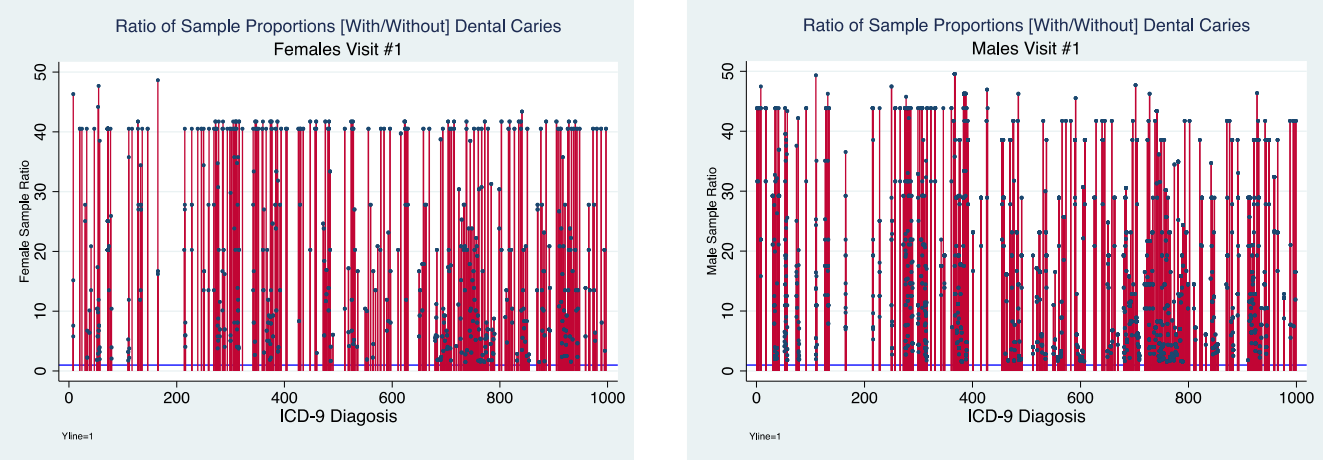

Figure 1: Proportion ratio profile of first diagnoses for females (upper) and males (lower).

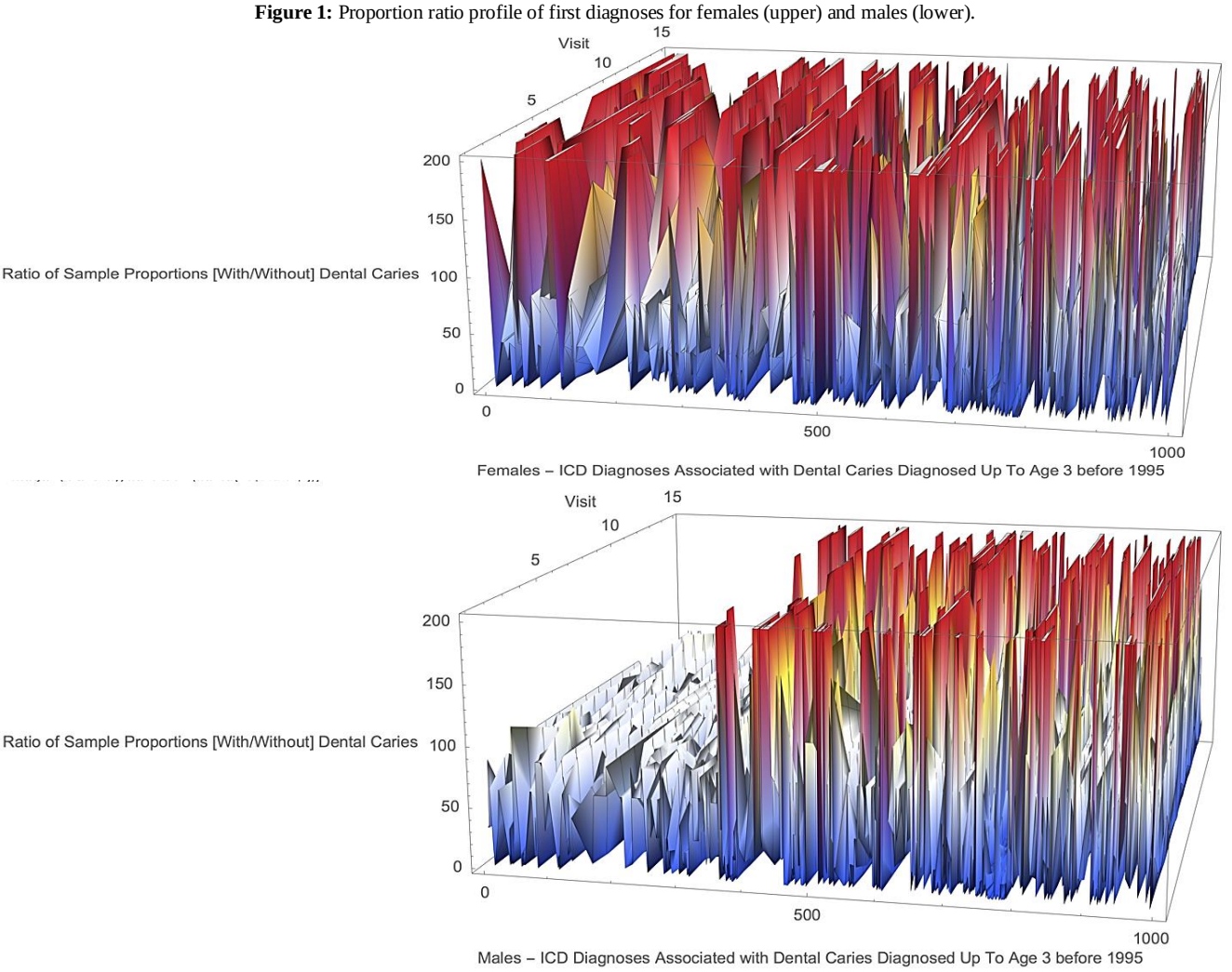

Figure 2: Proportion ratio profile of first 15 diagnoses for females (upper) and males (lower).

Discussion

As in other fields of medicine, the study of temporal hyper-multi-morbidity is emerging as a field important to the understanding of potential mechanism, health policy, as well as planning treatment via understanding the most frequent disorders ensuing from defined disease states, a field as relevant as metabolomics and genetics [29-31]. In the case of early dental caries defined and diagnosed before the age of four years and followed over the next 16 years provides a basis for understanding the subsequent accumulation of associated diseases that

would largely follow the initial diagnosis at a young age. However, it is also important in future study to consider the conditions where diseases and disorders arise temporally in advance of the onset of the index dental caries diagnosis. With autism, for example, there were diagnoses for boys and diagnoses for girls occurring before the index diagnosis of autism [29, 33, 39]. Even though the cut-point for the present study was before the age of four years, diseases that arise before the index diagnosis of dental caries may prove to play a mechanistic role in the emergence of serious dental problems. Temporal order was also found to be important in identifying diseases disorders and conditions that emerged in advance of the index diagnoses in separate studies (e.g., cancer) [31].

The odds ratios of diagnoses across the ICD main classes of disorder and disease are more prominent for males. While the ICD main classes largely overlap for females and males, the magnitude of the odds ratios within each vary and males have more ICD main classes represented in the dental caries cohort group. When examined on the basis of comparing the ratios of proportions of diagnosis frequencies between the cohort groups within each sex across the temporal sequence of diagnoses, more fine-grained differences are revealed. In comparison to this form of analysis, the odds ratios (ratios of counts of individuals within 2X2 cells) appears to be a rather blunt instrument. The temporal hyper-morbidity contribution of individual ICD disorders within the cohort group with dental caries is considerable within the ratios of proportions. The ratios of proportions provide and index of the diagnosis intensity (frequency) within individuals, whereas the odds ratios only provide counts of unique individuals.

The present study has limitations in that it considers only the groupings within the main classes of ICD disorder and only the temporal orders the first 15 visits showing the unique ratios of the ICD diagnoses represented in both cohorts. The bulk of disorders will tend to emerge after the age of four for individuals and the broad classes of ICD disorder which were considered in the present paper do not provide the detail level required to focus on any particular causal or sequelae mechanisms. Nevertheless, the significance of the results points by example to the relevance and subsequent need for more precise analysis based on this approach, as well as the conditional order of unique ICD diagnoses in the etiology and sequelae of dental caries.

Notwithstanding the limitations, the method presented provides a model to standardize and compare future morbidity research. The main contribution of the present paper, as with similar analyses of other serious diseases, is that the findings provide a broad stroke indication that standardized analyses may prove very useful in understanding with precision both the conditional etiology and the sequelae of temporal hyper-morbidity associated with dental caries arising in the very young [30, 31, 39, 40]. Finally, given the long-term impact on health status of early dental caries, understanding the epigenetic social and biomedical determinants of dental caries arising in individuals under the age of four years is of paramount importance in the formation of policy guiding both dental care and childcare standards. For example, should serious dental caries in the very young be an indicator of neglect?

Ethical Approval

The study was conducted under Ethics ID: REB15-1057.

Conflicts of Interest

None.

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