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Who Attends a Children's Hospital Emergency Department for Dental Reasons? A two-step cluster analysis approach

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Abstract

Background: Emergency Departments (EDs) have been identified as key providers of dental care although few studies have examined patterns of attendance or clusters of characteristics. The aim was to identify the reasons for visits to an ED, whether these remained stable over time, and characterise clusters of patients by socio-demographic and attendance variables.

Methods: Pseudonymised data were obtained for children who attended the ED in 2003-4, 2004-5 and 2012-2013. Presenting complaint was categorised as attending for dental or non-dental reasons. Other variables analysed included patient (age, sex, ethnicity and deprivation) and attendance characteristics (distance travelled, season, nature of complaint, time elapsed since onset of symptoms, day of week and hours of attendance), together with treatment outcome (advice, antibiotics, referral). To assess trends over time, analyses were conducted on patient, attendance and treatment outcome variables. In order to examine whether patients could be characterised by socio-demographic and attendance variables, a 2-step cluster analysis was undertaken on 2003-4 dataset, and validated on 2004-5 and 2012-13 datasets.

Results: In 2003-4, 550 children attended the ED for dental reasons rising to 687 in 2012-13. The most important predictors of dental attendance were: nature of complaint, ethnicity, time elapsed, sex, and deprivation of the area in which children lived. The analysis showed 2 clusters: cluster 1 was comprised of children who attended the ED for dental injury, were of white ethnicity, and attended within 24 hours of onset of symptoms. Children in this cluster were likely to be from the least or less deprived areas (compared to Cluster 2) and were more likely to be males. Cluster 2 comprised of children attending the ED for caries, oral mucosal lesions or other complaints, were likely to be of other (non-white) ethnicities, and were likely to attend more than 24 hours after symptoms began. Children in this cluster were more likely to come from the most deprived areas, and were both males and females. The clusters varied according to treatment outcome; those patients in Cluster 2 were more likely to be prescribed medication; whilst those children in Cluster 1 were more likely to be referred to another specialty.

Conclusions: A significant number of visits to the ED were for dental reasons with 2 clusters of children. The results have identified groups of patients for whom appropriate dental provision is lacking and where targeted services are needed to improve outcomes for children and reduce the burden on EDs.

Introduction

Worldwide, inequalities exist in patterns of oral health service utilisation [1]. In the majority of countries, people with higher incomes are more likely to seek dental care than those with lower incomes, irrespective of their dental needs [2]. Emergency Departments (EDs) have been identified as a key provider of dental care for some people on low incomes [3]. Several studies, conducted in the US, have examined the profile and attendance patterns of patients who visit EDs for dental problems. Overall, an estimated 1-3% of all ED attendances in the US were found to involve patients with a diagnosis of a dental condition [4-6]. Related costs were estimated at about $760 per visit (at 2010 rates) and, during 2008-2010, these amounted to an expenditure of around $2.7 billion across the US [7]. Nearly three-quarters (71%) of all dentally-related visits were from people living in low-income areas; with people on lower incomes more likely to seek care from an ED, while people with higher incomes were more likely to seek care from a dentist [8]. In Canada, approximately 5.4% of the general population reported visiting an ED in the past for a dental problem excluding those who had reportedly experienced a traumatic dental injury [9]. The predictors of visits to an ED for dental reasons included a history of an inability to afford dental care [10].

In recent years, trends in the US have shown a per-capita increase in visits to EDs for dental reasons with dental ED visits also growing as a proportion of all ED visits [11, 12]. From 2001-2008, ED dental attendance rates increased the most for young adults, those from a Black African/Black Caribbean ethnic group and those without health insurance. Visits to EDs for children remained stable, possibly due to the availability of publicly-funded dental care programmes for this age group. Few studies, involving relatively small samples, have specifically investigated children's dental visits to an ED. In 2003, 0.8% of all ED visits in the US were from patients aged 0-18 years visiting for dental reasons [13]. In general, traumatic dental injury and dental caries were the main reasons prompting dental visits. In the US, children who are taken to an ED for dental reasons have been typically characterised as being young (under seven years), non-White, being without a dentist, living close to the hospital and from low income households [14]. Another North American ED study, conducted in 1998, focussed on children with caries-related pain (n=300) and found a disproportionate number were from low income households or minority ethnic groups [15]. Of note was the fact that that only 18% of these young patients had received definitive treatment for their presenting complaint.

Indeed, one of the serious oral health implications of attending an ED for a dental problem is the lack of definitive treatment provision with care often limited to the prescription of analgesia or antibiotics [16]. Inequalities of care are further compounded by the need for patients to then find a dentist and pay for definitive treatment [8]. A lack of satisfaction about aspects of ED care, such as long waiting times and the temporary nature of the care received, has been voiced by ethnic minority and low income groups [17]. In addition, the implications of increasing trends in dentally-related ED visits include

growing costs of funding these visits, which are an expensive way of providing routine dental care [11]. Furthermore, inappropriate use of the limited resources of hospital EDs has wider implications for capacity and quality of care offered to other patients [7]. Further research into the patterns of dental visits to EDs has been recommended to ensure that patients' oral health needs are addressed in a timely and appropriate manner and that ED resources can be more directed towards other health problems [6].

While many studies have investigated income and other patient variables including the nature of the dental condition, insurance status, ethnicity, gender and the timing and outcome of visits by adults to ED for dental reasons [5-7, 17], few studies have examined patterns of attendance at ED by children and no previous studies have investigated whether clusters of patient characteristics can be identified.

Indeed, cluster analysis remains under-utilised in dental research, yet it is a useful exploratory technique for classifying large amounts of individual-based clinical, behavioural, psychological or social information into meaningful groups whilst taking into account inter-relationships between key study variables. Indeed, it has been used increasingly in health-related studies to explore health-related behaviours [18], hospital readmissions [19] and quality of life [20]. The use of such an approach could provide dental researchers with a useful way of identifying groups or profiles of patients who might benefit from specific or targeted service provision.

The aim of this study was two-fold; firstly, to examine trends over a 10-year period in children attending Children's Hospital Emergency Department and secondly, to identify and characterise clusters of patients attending a Children's Hospital Emergency Department.

The objectives were to:

1. describe the socio-demographic and attendance variables of children who attended a Children's Hospital Emergency Department for dental reasons and determine whether these changed over time;
2. investigate whether clusters of patients characterised by different socio-demographic and attendance variables could be identified among those attending for dental reasons;
3. statistically validate these clusters in attendance data over ten years.

Methods

Sample

Pseudonymised data were obtained from Sheffield Children's Hospital, UK, for all children (0-18 years) who attended the Emergency Department in 2003-4, 2004-5 and 2012-2013. Three data sets

were chosen to enable changes in individual patient variables and clusters of variables to be analysed over a ten year period.

Variables

Of those available, the 10 variables for inclusion were selected based on those studied in the previous literature, which included patient socio-demographic, attendance-related and treatment outcome variables (see Table 1).

Patient socio-demographic variables

Age, sex, ethnicity and deprivation were determined for all patients. Age was calculated from the patient's date of birth and grouped into four categories (0-3, 4-7, 8-11, and 12-18 years) based on the development of the dentition and sex was noted as male or female. As codes for recording ethnicity had changed over the ten year period and due to the small numbers of patients in some ethnic groups, ethnicity was categorised as 'white' or 'other' based on the ethnicity reported by the patient or parent/carer. Postcodes provided by the patient or parent/carer were used to determine the Index of Multiple Deprivation (IMD) score of the neighbourhood in which patients lived. The IMD is an area-based composite measure of deprivation where the 'least deprived' and 'most deprived' quintiles consist of those neighbourhoods falling among the least or most deprived 20% in England.

Attendance variables

Attendance variables were extrapolated from the hospital patient database and included: distance travelled, season, day of week, hours of attendance, nature of the complaint and time elapsed since onset of symptoms. Distance travelled was the straight line distance they had travelled to the hospital in miles. Hospital data were used to calculate the season (winter or summer), the day of attendance and whether the visit was in- or out-of-office hours (09.00-17.00 hours or 18.00-0.800 hours respectively). The presenting complaint, as reported by the patient or parent/carer, was categorised as attending for dental (related to the teeth or mouth) or non-dental reasons. Complaints which included the teeth or mouth with a concurrent non-dental complaint were categorised as non-dental reasons for attendance. Dental complaints were further categorised as caries-related, oral mucosal lesions, traumatic injuries or other non-specified complaints. The time that the patient or parent/carer reported had elapsed since the child's complaint had started was also obtained and was summarised as within 24 hours or longer than 24 hours.

Treatment outcome variable

Treatment outcomes were categorised as advice (verbal or written), prescription of any medication (e.g. antibiotics or analgesics), referral to other specialty, or other procedure (e.g. debridement, suture or glue injury).

Permissions

The project was registered by Sheffield Children's NHS Foundation Trust as a service evaluation, Trust reference number SE411.

Data analysis

To examine whether there were trends over time for the socio-demographic, attendance and treatment outcome variables (Objective 1), a series of chi-square analyses were conducted across the three data sets (2003-4, 2004-5, 2012-13).

To examine whether clusters of patients could be identified (Objective 2), a cluster analysis was carried out on the first dataset from 2003-4 using SPSS 22.0 (SPSS, Inc, Chicago IL, USA). The 2-step cluster analytic method was chosen as it allows for the identification of groups in large datasets containing both categorical and continuous variables, and without having to pre-select the number of clusters [21]. Following the procedures outlined by Norusis, Step 1 involved pre-clustering in which the original cases were 'sorted' into pre-clusters (based on log-likelihood). Step 2 involved standard hierarchical clustering on the pre-clusters formed in Step 1 based on Schwartz's Bayesian Information Criterion (BIC). The number of clusters was chosen based upon change in BIC being small between adjacent clusters [21].

Following the cluster formation, two validation tests were carried out: (1) examination of the silhouette coefficient, which contrasts the average distance to elements in the same cluster (within-cluster cohesion) with the average distance to elements in other clusters (between-cluster separation), which should be ≥ 0.02 [21]; (2) χ^2 tests to identify the importance of variables in a cluster and indicate significant differences between clusters. If between-cluster tests for a variable were not significant, the cluster analysis was re-run with the variable deleted. In this way, this iterative process looked for the most relevant variables which would add to an interpretable solution [22]. Accordingly, several analyses were run for selection of variables and a number of variables were excluded as they were not found to be important in cluster partitioning.

Finally, to validate the cluster formation and to examine whether the size, number and characteristics of the clusters remained stable over time (Objective 3), the final cluster model identified above was tested with data from 2004-5 and 2012-13.

Result*s*

Objective 1: To describe socio--demographic and attendance variables of children who attend a Children's Hospital Emergency Department for dental reasons and whether these changed over time

In 2003-4, 550 children attended the ED for dental reasons with an increase over the ten year period to 687 in 2012-13 (Table 1). Over this ten year period there was an increase in the actual number of children attending the ED for dental reasons although the percentage of dentally-related visits as a proportion of all ED visits was stable at 1.3% in 2003-4 and 2012-13 and 1.6% in 2004-5. The number of children attending the ED for any reason rose from 43,884 in 2003-4 to 52,814 in 2012-13 (Appendix A).

Around one half of children attending the ED for dental reasons were under 3 years with an increase in this age group over time from 45.3% in 2003-4 to 53.3% in 2012-13 (χ^2 (6) = 23.84, p = .001) (Table 1). In 2003-4, 78.2% were reported to be white, this proportion decreased to 67.1% in 2012-13 (χ^2 (2) = 23.84, p < .001). Around 60% were male. Almost half of the children attending the ED for dental reasons were living in areas which are in the most deprived quintile in England. Most children lived within three miles. There were no significant changes over time in deprivation, sex or distance travelled.

The nature of the presenting complaint differed significantly over time (χ^2 (6) = 54.77, p <.001). As a proportion of attendances at the ED for dental reasons, caries was the main diagnosis for 7.5%, 10.6% and 6.3% in 2002-3, 2004-5 and 2012-3. Attendance of children with oral mucosal lesions increased over time from 19.5% to 22.2% to 32.5%. In 2003-4 this was significantly less than expected, whilst in 2012-2013 this proportion was significantly more than expected. Attendance for traumatic dental injury was the most common reason prompting a dental visit overall, accounting for 66.2%, 59.1% and 49.9% of all episodes. The proportion decreased over time with attendance being significantly less than expected in 2012-13.

The difference in season was significant (χ^2 (2) = 26.76, p< .001) with the use of the ED for dental reasons during the winter months decreasing, whilst summer visits increased.

There was a significant difference in the time elapsed since the complaint began (χ^2 (2) = 9.62, p<.01); more people had a greater time elapsed (> 24 hours) in later data sets than earlier ones (25.9% in 2012-13 compared to 18.9% in 2003-4). There were no significant changes in either day of the week or hours (in- or out-of-hours) attended.

Around three-quarters of children who attended the ED for dental reasons received advice only which included the recommendation that they see a dentist (see Table 1). A notable finding was the marked increase in prescription usage from 6.2% in 2003-04 to 19.2% in 2012-13.

Objective 2: To investigate whether clusters of patients characterised by different variables could be identified among those children attending an emergency department for dental reasons

The 2-step cluster analysis was conducted as outlined in the data analysis section above. The analysis included all of the socio-demographic and attendance variables (see Table 1); however, given the potential overlap between hour of attendance and day of the week, the latter was excluded. The analysis produced a two cluster solution with a fair average silhouette measure of 0.2 (see Table 2 – first solution). A series of χ^2 tests were carried out to examine whether there were significant differences between the two clusters in each of the socio-demographic and attendance variables and to identify the importance of variables in the clusters. The variables ranged in importance to the determination of clusters with nature of the complaint, time elapsed, sex and ethnicity the most important. χ^2 tests revealed no significant difference between the two clusters for distance travelled or hours of attendance. The cluster analysis was therefore re-run with these two variables deleted and the process of χ^2 tests repeated. These further analyses revealed that age and season did not significantly differ between the two clusters. The cluster analysis was re-run with these variables deleted and this final solution can be seen in Table 2, which shows the ratio of distance measures, average silhouette of the model, predictor importance values, together with between-cluster χ^2 tests and variable specific eta^2 values for both the first and final cluster solution. As can be seen, in the final model, presenting complaint was the best predictor for cluster formation, followed by ethnicity and time elapsed, and then sex and deprivation. The following variables were excluded from the final cluster formation as they were not found to play an important role in cluster partitioning; season, age, distance travelled and hours of attendance.

The two clusters by socio-demographic and attendance classification variables can be seen in Table 3. Description of clusters was as follows:-

Cluster 1 was the largest cluster with 291 children (52.9%) comprising those who attended the emergency department for dental injury, were of white ethnicity, and attended within 24 hours of the appearance of symptoms. Children in this cluster were likely to be from the least or less deprived areas (compared to Cluster 2) and were more likely to be males.

Cluster 2 was smaller with 259 children (47.1%) comprising those attending the emergency department for caries, oral mucosal lesions or other complaints (not dental injury), were likely to be of other (non-white) ethnicities, and were likely to attend more than 24 hours after symptom appearance. Children in this cluster were more likely to come from the most deprived groups, and were both males and females.

To examine the cluster relationship to the treatment outcome variable, a χ^2 test was undertaken which showed a significant difference between the two clusters (χ^2 (3) = 19.71, $p < .001$). Examination of

the treatment outcome variable in Table 3 indicates that those in Cluster 2 were more likely to be prescribed medication (antibiotics/analgesia) than children in Cluster 1 (79.4 & 20.6% respectively). Children in Cluster 1 were more likely than those in Cluster 2 to be referred to another specialty (62.3 & 37.7% respectively).

Objective 3: Validate these clusters in attendance data over ten years

To validate the final cluster formation and its stability, the 2-step cluster analysis was repeated as outlined above with the data from 2004-5 and 2012-13. In both datasets, the predictors of importance for cluster formation stayed the same although their order changed over the 10-year period. The predictor importance was as follows for 2004-5 and 2012-13 respectively; presenting complaint (1.00, 1.00), time elapsed (0.40, 0.39), ethnicity (0.03, 0.08), deprivation (0.01, 0.03) and sex (0.01, 0.02). Comparing these to 2003-4, presenting complaint and time elapsed remained as important over the 10-year period; whilst sex, ethnicity and time elapsed were less significant for cluster formation in later years. However, follow-up χ^2 tests indicated that there was a significant difference between clusters for each of the variables in both datasets: for 2004-5 and 2012-13 respectively; outcome (χ^2 (3) = 661.71/614.78, $p < .001$; eta² = 0.96/0.95), time elapsed (χ^2 (1) = 253.32/229.98, $p < .001$; eta² = 0.59/0.58), ethnicity (χ^2 (1) = 14.81/45.52, $p < .001$; eta² = 0.14/0.26), deprivation (χ^2 (4) = 12.08/24.85, $p < .05$; eta² = 0.13/0.19) and sex (χ^2 (1) = 5.29/8.08, $p < .05$; eta² = 0.09/0.11).

Examining the variable specific eta values above suggests that whilst all five variables remained important to cluster formation, the contribution of variables across the 10-year period did change. Ethnicity, for example, was the characteristic that varied the most, with eta values of 0.56, 0.14, and 0.26 for 2003-4, 2004-5, and 2012-13 datasets respectively. Inspection of the frequencies for white and other groups (see Tables 3 and 4) demonstrates that, in accordance with the higher eta value, the clusters were more differentiated in 2003-4; Cluster 1 consisted of only children in the white ethnicity group, whilst Cluster 2 was predominately of 'other, non-white' ethnicities. In 2004-5, corresponding to a lower eta value, both Clusters 1 and 2 had a greater mix of both 'white' and 'other' ethnicity groups; whilst in 2012-13 corresponding to a medium eta value, Cluster 1 consisted of more of the white ethnicity group and Cluster 2 of more 'other' ethnicity group.

With regard to the treatment outcome variable, χ^2 tests revealed a significant difference between the two clusters for 2004-5 (χ^2 (3) = 30.01, $p < .001$), with a similar pattern as observed for the 2003-4 dataset (see Table 4). Interestingly, however, the difference between clusters was not significant for 2012-13 (χ^2 (3) = 4.39, $p = .222$). Examination of the data (Table 4) indicates that whilst there was still disparity in referrals between clusters, referral rates had decreased overall in the dataset (to 2.0% of outcomes); thus having less of an effect overall. In addition, unlike earlier datasets, medication rates were similar for both clusters in 2012-13.

In summary, across the 10-year period of this study, from 2003 to 2013, two clusters of children visiting a hospital emergency department for dental reasons were identified based on five key variables; nature of the presenting complaint, time elapsed since appearance of symptoms, ethnicity, sex, and deprivation quintile. These five key variables remained important over the 10 year period of this study, although the order and magnitude of importance did change.

Discussion

Overall, this study found that a significant number of visits to the Children's Hospital ED were for dental reasons and the number of children attending for dental reasons increased over the 2003-2013 period. There were two distinct clusters of child patients attending with a reported dental problem and these clusters were validated over the ten year period.

Around 1.3% of visits to the ED in Sheffield were for dental reasons, which are similar to findings of studies in the US [4-6]. The majority of children attending for dental reasons were under four years, with increases in this young age group seen over time. In general, children attending for dental reasons were younger than those attending for non-dental reasons. It may be assumed that many of these young children were not registered with a family dentist, necessitating a visit to the ED for dental treatment. Data from the recent survey of children's dental health in UK would tend to support this hypothesis as 37% of parents/carers of 5-year olds stated that they had not taken their child to a dentist until at least 3-years [23]. This is in contrast to dental advice which recommends dental attendance for infants from when the first teeth erupt.

While the majority of children attending the ED for dental reasons were of white ethnic group, this proportion decreased over time. In 2012-3 the proportion of children from other ethnic groups attending the ED for dental reasons was 32.9% compared to 30.0% attending for non-dental reasons. Considering that black and ethnic minority groups make up 19% of the current Sheffield population, there was disproportionately high representation from non-white children within the ED case mix [24]. Nearly half of the children who attended for both dental and non-dental reasons were living in areas which are amongst the most deprived areas of England. However, these findings were not unexpected, given the known associations between caries and deprivation, and the high caries experience seen in the primary dentition of some ethnic minority children [25, 26].

One of the most clinically important findings related to treatment outcomes, over two-thirds of patients attending for dental reasons were given advice only. This result should, however, be interpreted with caution as it could relate to two widely disparate scenarios: either the presenting complaint was of insufficient concern to warrant any intervention or the ED team lacked the resource or ability to manage the dental condition. If the former, then it would appear that EDs are being used inappropriately and families need to be supported to access more suitable emergency dental services.

If the latter, children may be disadvantaged by seeking dental care at an ED as their definitive treatment will be delayed, leaving them in pain for longer and potentially worsening the prognosis of their dental condition. Outcomes for the management of traumatic dental injuries are particularly dependent on evidence-based and expedient care, which may be more likely in specialist paediatric dentistry units or dental access centres, rather than the ED [27]. Finally, in the case of some oral mucosal conditions, it is also possible that parents felt that a medical input was warranted and lacked the belief that this fell within the scope of practice of a dentist.

This study was unable to provide definitive answers to these important questions, but serves to highlight the need for further qualitative enquiry into the preferences and perspectives of families who bring their child to the ED with an oral problem. Research with parents should seek to identify barriers to their utilisation of local primary care services which are free for children and were available throughout the city during the time period of this investigation. A theoretical framework should be used to guide this future research, such as Andersen's model of access [28]. Such research would, in turn, enable an intervention to be developed, based on behaviour change theory, to overcome these barriers and bring about changes in healthcare-seeking behaviours [29]. This intervention would need to be developed with parents living in the most deprived areas and be acceptable to black and minority ethnic groups.

It is also important to reflect on the increasing reliance placed on prescriptions for children presenting to the ED. A limitation of the data set was that the nature of the prescriptions was not known. Nonetheless, it is concerning that prescriptions increased almost four-fold over ten years. This trend raises questions as to the effectiveness of treatment received for dental conditions in an ED as well as wider issues relating to the misuse of antibiotics [30]. EDs in the UK do not generally have the staff or equipment necessary to provide restorative care resulting in limited options for relieving pulpal pain symptoms resulting in over-reliance on antibiotics and analgesics.

The economic implications from this study's findings are considerable. Based on the national tariff used in the National Health Service (NHS) to pay providers to deliver care, the average cost to the NHS of each visit to the ED was £54 resulting in a total 'dental' cost in 2012-13 of £37,098. It should be borne in mind, that the majority of children did not receive any treatment and may have gone to seek definitive treatment from another provider. An equivalent visit to a general dental practitioner for an examination of a child would cost, on average, £30, rising to £50 if treatment was carried out, confirming that the ED is an expensive way of providing dental care as previously stated [11].

A strength of this research was the use of the cluster analysis. While many previous studies have described the different socio-demographic and attendance variables of patients attending the ED none have been sought to investigate clusters of patients in a way that allows identification of groups of patients for whom appropriate dental care provision is currently lacking. The analysis of data from

three data sets over ten years, relating to nearly 2000 child visits ensures the external validity of the clusters derived in one data set has been checked against those in later data sets.

As with any exploratory analytic technique, however, the clusters reported here are but one 'fit' and could be improved upon. Indeed, as with all secondary analyses, the primary limitation of the current study is the information available and its format. For example, other variables not routinely collected may be important for predicting dentally-related attendance at an ED by children (e.g. transport links, current dental registration, previous use of an ED or emergency dental services, years of residency). In addition, many of the variables had to be dichotomised and, in so doing, important and detailed information was lost.

Nevertheless, these results highlight a number of important points. Firstly, they suggest inequalities in utilisation of the ED for dental reasons by families from deprived areas with the implications being that children are not receiving definitive treatment [8]. Secondly, that cluster analysis has proved a useful technique for classifying varying socio-demographic and attendance data into potentially useful predictive groups. As such it allows identification of groups of patients for whom appropriate dental care provision is currently lacking and where targeted service provision is needed. Such future insights are needed to ensure families utilise the most appropriate services for their child's dental complaint, thereby improving clinical- and patient-reported outcomes for children and reducing the burden on the ED.

Competing interests statement

The authors declare they have no competing interests.

Authors' contributions

ZM, HDR, DB and KJ conceived the idea for the project and acquired the data. ZM, HDR, DB, KJ, TB and SRB designed the study, and TB and SRB analysed the data. All authors were involved in the interpretation of the data and the drafting of the manuscript.

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