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RESEARCH ARTICLE

MAPPING ISOLATION OF RISK FOR SPORADIC CONDITIONS: ORAL CELLULITIS IN WESTERN AUSTRALIA

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ABSTRACT

The aim of this study was to apply geographic information system (GIS) models to predict risk of oral cellulitis. A risk isolation model using Western Australian real hospitalisation data for oral cellulitis from 1999 to 2009 (10 years), and socio-economic indicators, age and Indigenous status as risk indicators was developed. The fully integrated database was then computer geo-coded to allow the visualization of the data at three levels (core of the capital city Perth, Greater Metropolitan Perth, and State of Western Australia). Correlation coefficient analysis between the number of cases (over 10 years) and the relative risk location indicator was carried out. The GIS maps derived from application of the developed risk location indicator, demonstrate that the risk categorization paralleled the number of cases over the decade. Correlation coefficient analysis demonstrated moderate positive relationship (R2=0.55) between the number of cases (over 10 years) and the risk location indicator in metropolitan Perth.

KEYWORDS

Risk isolation; Sporadic condition; GIS; Poverty-related infections

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INTRODUCTION

Managing populations and health care are a complex interaction between prevalence incidence and access. There are conditions that although rare make significant imposts on health system in resource terms. For example, cellulitis of the mouth and submandibular region (oral cellulitis) is a rare, potentially fatal soft tissue infection of dental origin, mostly arising as a complication of a dental abscess. Its most severe presentation (Ludwig's Angina) could possibly lead to oedema, distortion, and obstruction of the airway. [1] Oral cellulitis can be used as an indicator of significant dental disease in a society [2], as it often reflects the end of spectrum of oral disease that starts with dental caries and ends with spread of infection to tissues surrounding the oral cavity.

Globally, a strong correlation between dental infections and poverty has been reported [3,4], with an Australian study showing hospitalisations for oral cellulitis being significantly more common in the lower socioeconomic groups of the society who could not afford private health insurance. [2] Furthermore, Aboriginal and Torres Strait Islander people were significantly more affected (7 times over represented) compared with non-Indigenous Australians. [2]

Sporadic medical conditions can be problematic for risk assessment, as they occur in small numbers, which poses a statistical challenge, and they tend to follow non-predictable patterns.

The science of geographic information system (GIS) is developing at a global level and has many applications to assist in health management decision making and resource targeting. This discipline can act as a decision-making tool in public health and contribute to the formulation of policies. Worldwide innovative ways are being developed to harness the data integration and spatial visualization power of GIS. [5]

GIS has been successfully used previously, to geographically isolate the risk areas for sporadic disease occurrence. [6] One of the steps towards management of oral cellulitis in poor communities and within Indigenous populations is to determine the location of the clusters at highest risk within the population. This targeting can help health services prepare planning for cases as well more systematic approach to prevention. In the case of Cellulitis, the prevention is focused on timely and appropriate care in the primary care sector.

In this study, the aim was to apply GIS models, (based on a risk location indicator developed from existing case data), to determine regions of Western Australia that are predicted to have a high number of oral cellulitis cases. This type of predictive model can assist in focusing primary health resources to areas of risk and thereby reduce the substantial costs, and risks, associated with treating this condition.

METHOD

Western Australia is Australia's largest State, geographically, with about 2.6 million inhabitants; about 75% of this population live in the capital, Perth.

The data used for the purposes of this study were collected from the Western Australian Hospital Morbidity Data System (HDMS)[7] under appropriate ethical approval (Ethics Committee of The University of Western Australia, approval number RA/4/1/5502) and covers a 10-year period, beginning from July 1999 to June 2009 (financial years). It was generated from recording every episode of discharge for cases of cellulitis of the mouth and submandibular region as the principal oral condition (K12.2), as classified by the International Classification of Diseases–tenth Australian Modification (ICD-10AM).[8] These data were collected from all public and private hospitals in the State of Western Australia. Other variables included in the data-set were patient's age, main place of residence at time of hospitalisation, and Indigenous status. An Indigenous person is a person of Aboriginal or Torres Strait Islander descent (the first peoples of Australia) who identifies as such.

In conjunction with the data collected from the HDMS, the data from the Australian Bureau of Statistics (ABS) 2006 Census were within the time range of our study and were incorporated into our analysis.[9] The rate calculations for Western Australian Hospitalisation were then calculated using population data obtained from the census. Age, Indigenous status and Socio-Economic Indexes for Areas (SEIFA) category were included as risk indicators. SEIFA, Australian national index system for economic disadvantage [10] is a national quintile index based on deciles of the total Australian population. In SEIFA, the lowest scoring 10% of areas are given a decile number of 1, the second-lowest 10% of areas are given a decile number of 2, up to the highest 10% of areas which are given a decile number of 10. [9] The 10 deciles were combined into 5 groups: 1- most disadvantaged; 2- above average disadvantaged; 3-average disadvantaged; 4-below average disadvantaged; and, 5-least disadvantaged. As the cellulitis cases per 100,000 people (Table 1) were 38 times over - represented in group 1 and about 5 times over represented in group 2, compared to the other 3 groups [2], only groups 1 and 2 were included in the risk assessment study.

The age variable was divided into six sub-sets: 0-4,5-14,15-19, 20-34, 35-49 and 50-69 years. The study did not include subjects over 69-year-old as the numbers were very low. The Indigenous status variable has two sub-sets: Indigenous and Non-Indigenous. In Western Australia, there are 155 geographic areas, which do not overlap, known as statistical local areas (SLAs). A total of 24 distinct rates (cases per 100,000 people) of cellulitis were computed dependent on the mix of the variables sub-sets (Table 2).

TABLE 1: ANNUAL RATES PER 100,000 CAPITA AND NUMBER OF ADMISSIONS FOR ORAL CELLULITIS IN WESTERN AUSTRALIA FOR THE PERIOD 1999-2009 FOR SEIFA GROUPS (FROM GROUP 1 MOST DISADVANTAGED TO GROUP 5 LEAST DISADVANTAGED).

SEIFA	ANNUAL RATES †	POPULATION	ADMISSIONS/10 YEARS
GROUP 1	77.1	33719	260
GROUP 2	9.6	149531	144
GROUP 3	1.8	747283	135
GROUP 4	2	524578	106
GROUP 5	2	497652	103

TABLE 2: ANNUAL ADMISSION RATES PER 100,000 POPULATION FOR ORAL CELLULITIS BY INDIGENOUS STATUS, AGE AND DISADVANTAGE.

AGE GROUPS	INDIGENOUS POPULATION		NON-INDIGENOUS POPULATION	
	SEIFA1	SEIFA2	SEIFA1	SEIFA2
0-4	79.8	0	113	8.5
5-14	34.4	3.9	15.5	2.1
15-19	94.2	44.5	82	12.3
20-34	164.1	47.7	179	17.5
35-49	103.7	36.5	76.8	13.1
50-69	44.3	19.4	43.7	6.2

IBM SPSS Statistics V21.0 was used to produce the required population-based rates. Population data across each of the 155 SLAs from the Australian Bureau of Statistics (ABS) 2011 Census [9] were distributed by age, Indigenous status and SEIFA. Using Excel v2003 (Microsoft; Redmond, WA, USA), the hospitalisation rate for each population subset derived from the Western Australian morbidity data was applied to the appropriate population subset (age, health Indigenous status, SEIFA) within each SLA.

The integrated database was then geo-coded using QGIS (version 2.14) (www.qgis.org) to allow the visualization of the fully integrated data model. SLA geographic locations were obtained from 2006 ABS census. Both real cases of cellulitis occurring between 1999 and 2009 and Western Australian areas were mapped and demonstrated at three levels (core of the capital city Perth, Greater Metropolitan Perth and State of Western Australia). The levels are according to a nationally agreed accessibility and remoteness index: the core is inner urban, greater metro is outer urban, and rest of state is regional/rural. [11]

The risk location indicator (RLI) developed, rested on three fundamental known risk factors, determined from a previous study [2] being poverty, Indigenous status and age. The specific variable values used to determine the risk indicator for each area, were obtained from census data and enabled the calculation of oral cellulitis risk for each SLA. The calculated risk indicator values have no upper boundary, and higher numbers represent higher risk of oral cellulitis.

Using SPSS, Pearson's correlation coefficient was calculated to determine the levels of correlation between the number of cases (over 10 years) and the risk location indicator (RLI) for metropolitan Perth (36 SLA's), as well as for the rest of the State.

RESULTS

Over the 10 years of data available for this study there were 762 cases of oral cellulitis. On average this was approximately 76.2 cases per year in a population of approximately 1.96 million people (Census 2006)

FIGURE 1: TOP LEFT: CENTRAL PERTH-GEOGRAPHIC DISTRIBUTION OF THE ABSOLUTE NUMBER OF CASES (CIRCLES) AND THE AREA RELATIVE RISK FOR ORAL CELLULITIS. (INDICATED BY BACKGROUND COLOR) (CROSS HATCHED STATISTICAL LOCAL AREAS ARE THE CITY OF PERTH). TOP RIGHT: METROPOLITAN PERTH: BOTTOM LEFT: STATE OF WESTERN AUSTRALIA

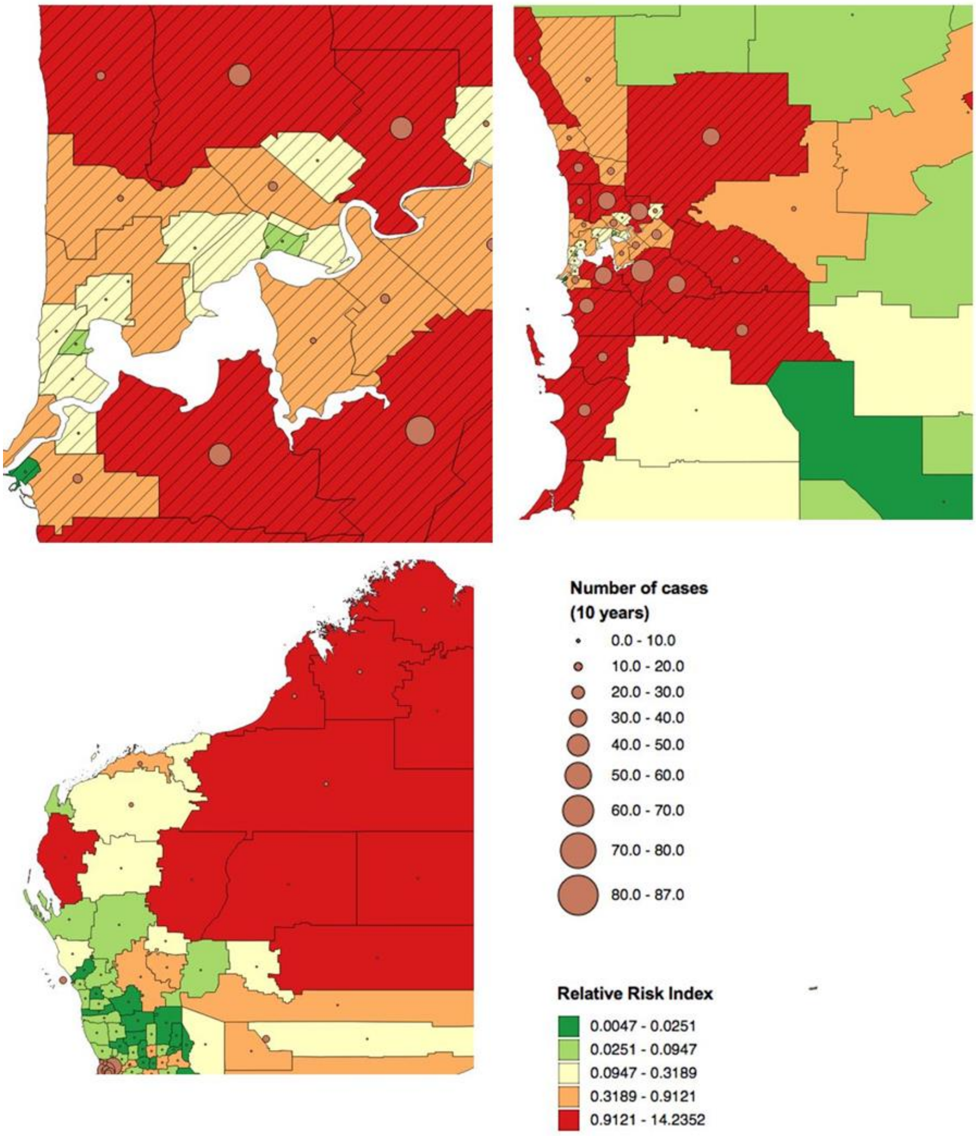
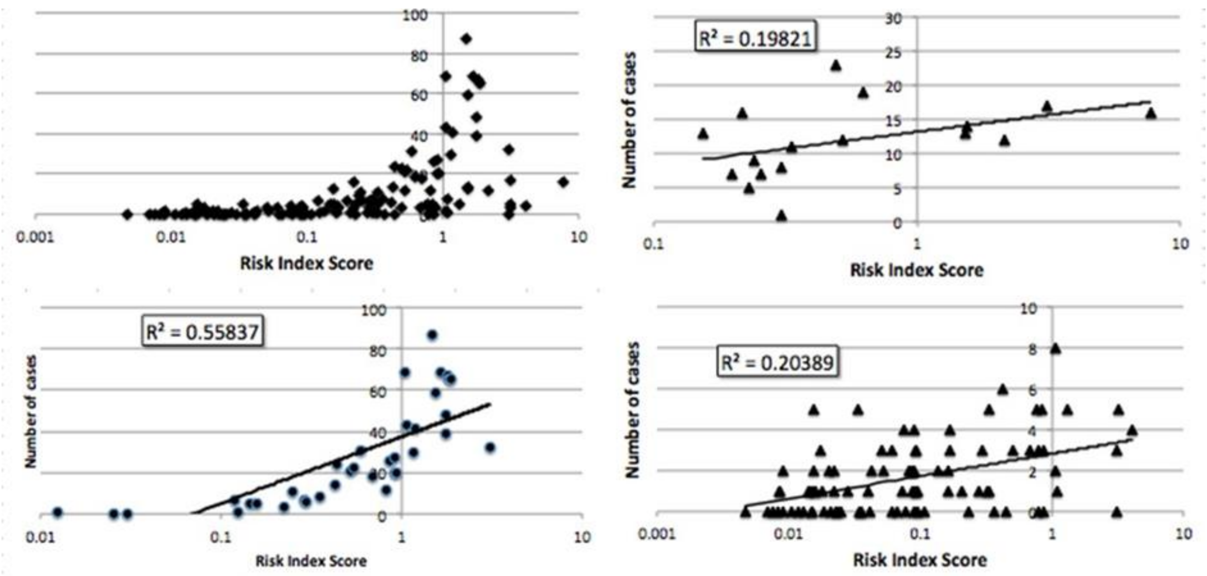


FIGURE 2: CORRELATION COEFFICIENT ANALYSIS BETWEEN THE NUMBER OF CASES (OVER 10 YEARS – VERTICAL AXIS) AND THE RISK INDEX (LOGARITHMIC SCALE – HORIZONTAL). FOR ALL OF WESTERN AUSTRALIA (TOP LEFT), MAJOR CAPITAL CITY ONLY (BOTTOM LEFT), RURAL AREAS WITH SLA POPULATION ABOVE 10,000 (TOP RIGHT) AND RURAL AREAS WITH POPULATION BELOW 10,000 (BOTTOM RIGHT).



Correlation coefficient analysis was applied to city and country data separately (Figure 2). The correlation between total cases over the decade in the city was moderately positive (R2=0.55) whereas (not unexpectedly) the correlation for the rest of the State was lower (R2=0.27). Further analysis of the non-city-based data, by dividing it into larger (greater than 10,000) and smaller SLA's did not change the lower level of correlation in the non-metropolitan areas (Figure 2)

DISCUSSION

This research used data from both the Australian Bureau of Statistics (ABS) census and the Australian Classification of Disease coding system (ICD10) to develop high resolution maps for oral cellulitis risk. In each map, it is clear that a higher number of (real) cases were found in areas where the risk model proposed would be a high risk of oral cellulitis. The correlation was higher at the city level (Figure 2) than in rural/regional areas. This may indicate that there is more heterogeneity amongst the major city areas in Western Australia as compared to in the rural areas only. Those results show that this risk location indicator (RLI) for a sporadic condition could be a reliable measure of risk for oral cellulitis in cities, but less effective in the lower, more widely dispersed population mix of rural and remote regions.

The obtained maps, on multiple levels, could identify areas where oral health services might be needed, or delivered differently, across Western Australia. Oral cellulitis could be considered a measure of the extreme level of dental disease [2], and its analysis could be used to study the overall dental service uptake.

Non-normally distributed oral cellulitis is an example of how traditional single parameters, such as average and incidence, could not be properly applied to the over-all population. [12] When examining the over-all incidence of this condition in Western Australia over the last 10 years, as previously reported [2], the annual rates per million ranged between 25 and 60 cases, which was higher than UK rates for the same period. However, at the level of sub-groups, the picture looks more alarming, with poverty and Indigenous status strongly affecting the number and rates of this condition [2]. The most disadvantaged group shows an annual rate of 771 cases per million (77.1 per 100,000), which is over 30 times the rate of some of the richer (less disadvantaged) groups [2].

The major limitation of the study is the pooling of cases over 10-year period, which is due to the low number of cases of oral cellulitis. This is related to the rarity of this sporadic condition.

The majority of oral cellulitis cases arise from dental origin, mostly dental caries. Other dental conditions leading to cellulitis include periodontal disease, dental anomalies and dental trauma. [13-15] There are many factors that could contribute to caries leading to oral cellulitis, however, lack of water fluoridation and dental service availability might play a role. [16-19] Most of the Australian population have access to water with regulated levels of fluoride. [16] However, only 12.5% of Indigenous communities in Western Australia have access to water with tested fluoride levels of greater than 0.5 ppm [16], which may contribute to the higher levels of caries in these communities, and which may subsequently lead to higher rates of oral cellulitis. Dental practice to population ratio is significantly higher in wealthy populated areas in Western Australia [17-19], which makes it more difficult for people living in more disadvantaged (poorer) areas to access regular preventive dental care. The developed risk indicator will help health management in planning water fluoridation areas and determining the locations of need for public dental clinics.

CONCLUSIONS

In conclusion, the developed geographic risk index using existing data to predict disease risk on a regional basis can be used effectively as a health management planning tool for geographic isolation of risk related to oral cellulitis.

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