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A rapid epidemiological assessment of dental erosion to assist in settling an industrial dispute

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SUMMARY

A Rapid Epidemiological Assessment (REA) of industrial dental erosion was undertaken with the aim of formulating a range of treatment strategies which could be used to settle an industrial dispute. This dispute concerned compensation for a group of adult male metalworkers who had complained of dental sensitivity and that their teeth had been "eaten by acid" at their workplace, an electroplating factory in Springs near Johannesburg, South Africa. The REA methods employed included a clinical examination, a structured socio-demographic questionnaire and colour photographs of each subject. Sixty per cent of the subjects reported pain and/or sensitivity to eating and/or drinking, 76 per cent showed varying degrees of loss of tooth structure, and 25 per cent reported teeth had been lost as a result of the industrial erosion. The project involved negotiating with mine management and trade union representatives, each with conflicting interests, and with people's oral health and large sums of money at stake. In this context, the aim of the research was to design an instrument to resolve conflict and to promote oral health at an industrial site, while retaining scientific objectivity and rigour. As a result of the REA, the workers who were examined are in the process of being compensated, while the National Union of Mineworkers and mine management are engaged in reaching a settlement. Preventive measures have been initiated at the factory. The area has been declared a "respiratory zone", which makes the wearing of respiratory masks obligatory.

OPSOMMING

Hierdie artikel rapporteer oor 'n epidemiologiese bepaling van industriële tanderosie wat onderneem is met die doel om 'n reeks strategieë te formuleer vir gebruik in die skikking van 'n industriële dispuut. Die dispuut het gehandel oor kompensasie aan 'n aantal volwasse manlike metaalwerkers wat gekla het van tandsensitiwiteit en dat hulle tande 'weggevrete was deur sure' by hulle werkplek, 'n elektroplateringsaanleg in Springs naby Johannesburg. Die metodes wat gevolg is, het 'n kliniese ondersoek, 'n gestruktureerde sosiodemografiese vraelys en kleurfoto's van elke persoon ingesluit. Sestig persent van die persone het oor pyn gekla wanneer geëet of gedrink word 76 persent het verskillende grade van verlies van tandstruktuur getoon, en 25 persent het gerapporteer dat hulle tande verloor het as gevolg van die industriële erosie. Onderhandelings is gevoer met die mynbestuur en vakbondvertegenwoordigers, elk met eiesoortige belange en met beide die werkers se mondgesondheid en groot bedrae geld op die spel. In hierdie verband was die doel van die navorsing om 'n instrument te ontwerp om konflik op te los en om mondgesondheid op 'n industriële perseel te bevorder, met die behoud van wetenskaplike objektiwiteit en dissipline. As gevolg van hierdie ondersoek gaan kompensasie aan die werkers betaal word, terwyl die mynbestuur en die Nasionale Unie van Mynwerkers oor 'n skikking onderhandel. Voorkomende maatreëls is by die aanleg ingestel en die area is verklaar as 'n gebied waar die dra van beskermende asemhalingsmaskers verpligtend is.

INTRODUCTION

In 1993, the Department of Community Dentistry of the University of the Witwatersrand, Johannesburg, was approached by a mining company and the National Union of Mineworkers (NUM) to provide an independent dental examination of metal workers who had complained of nose bleeds, tooth sensitivity and the "wearing down" of their teeth as a result of exposure to acid. The union was demanding compensation on behalf of these workers who had been dismissed from their jobs after taking part in a strike to highlight these complaints.

The workers were mainly migrant labourers who, when dismissed from their jobs, returned to the rural areas of the Transkei and KwaZulu. Every effort was made by the company and the trade union to locate and bring the workers to Johannesburg for the examination.

The request to the Department of Community Dentistry came forty eight hours before the workers were due to arrive in Johannesburg for examination. This meant that very few preparations could be made. The authors did not know what to expect, but suspected some form of dental erosion, which proved to be the case. The services of a professional photographer were requested in order to record the severity of the lesions. The research team decided that a rapid epidemiological assessment (REA) would be the methodology of choice in this investigation.

RAPID EPIDEMIOLOGICAL ASSESSMENT

In 1981, BOSTID (the Board on Science and Technology for International Development, USA) initiated an international programme to stimulate research in certain areas of science and technology that were important for economic development, and one of these areas was the development of the rapid epidemiological assessment. The concept of a REA is a relatively new idea which has emerged as a result of the need for better epidemiological techniques for assessing health problems in developing countries (Selwyn *et al.*, 1989). The REA programme was set up "... to develop REA methods for health planning and decision-making and to develop or validate more efficient or innovative epidemiologic methods for making timely decisions about health problems and programmes for health care or disease control" (Selwyn *et al.*, 1989).

One of the main reasons for the emergence of REA was to develop improved methods of epidemiologic assessment to assist in the appropriate allocation of scarce resources "... and subsequently improve health status in the under-served areas of the world" (Selwyn *et al.*, 1989).

REA has "... proved to be a collection of epidemiologic methods that can greatly improve knowledge about health problems and the effectiveness of their solutions by providing high-quality data within shorter periods of time" (Smith, 1989). Another central tenet of REA is that the provision of better information can lead to improved decision-making in terms of providing "... responsive and responsible policies" (Smith, 1989), and adequate and appropriate health services.

The dynamic nature of REA allows for the utilization of any of a combination of standard epidemiologic instruments, enabling quick changes of tactics to be adopted, which means that any study can be continually adapted with the objective of getting an appropriate answer to the posed question.

AN OVERVIEW OF EROSION

Dental erosion is defined as the loss of tooth substance by a chemical process that does not involve bacterial action (Rugg-Gunn, 1993). Erosion is most frequently the result of the introduction and constant exposure of tooth surfaces to acids from either a dietary source (Eccles and Jenkins, 1974), gastric regurgitation (Järvinen *et al.*, 1988) and acids in the work environment (Ten Bruggen Cate, 1968). Eccles (1982) has pointed out that erosion occurs in the absence of dental plaque and differs from caries which is a sub-surface phenomenon.

Dental erosion in industry can occur in a number of occupations. In industrial settings, the parts of the anterior teeth exposed to the acid atmosphere are affected and may be completely dissolved (Dental Health Committee, 1959). Industries which are hazardous include the following: plating munitions manufacture, soft drink manufacture, enamel manufacture, crystal glassworks, acid pickling, sanitary cleanser manufacture, battery manufacture and sanitary glassware plants (Ten Bruggen Cate, 1968; Zero, 1996).

Erosion can lead to disfigurement, pain, loss of function, destruction of the crown to gum level and loss of teeth (Nunn, 1996). The clinical appearance of erosion is distinctive. The earliest change is a diminished lustre, leading to smoothing out of developmental pits and grooves in the enamel. Advancing erosion leads to exposure of dentine, rough or sharp teeth, pain and intractable hypersensitivity. On the occlusal and incisal surfaces, the typical concavities of dentine surrounded by enamel are known as 'cupping'. Both horizontal and vertical dimensions of jaw relations may be affected due to tooth surface loss (Watson and Tulloch, 1985). Brushing soon after acid exposure,

before remineralization can take place, will exacerbate the effects (Zero, 1996). More recently, studies have shown a correlation between laryngeal cancer and exposure to acid mists (Steenland *et al.*, 1988).

The purpose of the study was to measure the prevalence and severity of dental erosion in workers exposed to acid mists; to determine their perceptions about any possible restrictions in oral health function as a result of dental erosion, and to formulate a range of dental treatment strategies which would be acceptable to both the NUM and the employers.

MATERIALS AND METHODS

A descriptive, cross-sectional REA was undertaken, consisting of a clinical observation the administration of a socio-demographic questionnaire as well as colour photographs of each participant.

The questionnaires, drawn up by the authors before the examination, gathered demographic data, specific job description, length of service in the acid mist environment, and any personal habits which might be a factor associated with dental erosion. It was also a means of determining worker perception of oral function, particularly in relation to eating and drinking restrictions, pain and sensitivity. The questionnaires were administered to workers through an interpreter.

All the workers were screened for presence or absence of erosion and photographs were taken of their anterior teeth. The clinical records and photographs were utilized to assess the loss of tooth structure. Correlation between clinical diagnosis of erosion and evaluation of colour slides has been described by Skogedal *et al.*, (1977) as good. Although the first signs of erosion may not be revealed by this method, the screening of patients with extensive erosion involving the dentine may be based on slides. This method is useful in that more people can be examined in a shorter space of time.

Informed consent from participants was obtained through the use of an interpreter. Ethical approval for the study was obtained retrospectively from the Committee for Research on Human Subjects, University of the Witwatersrand, Johannesburg (M940522).

MEASUREMENTS

The degree of erosion was assessed from photographic slide records using the following grading (Eccles and Jenkins, 1974):

Grade 0 no clinical evidence of erosion.

Grade 1 loss of surface features of the labial,

lingual or occlusal enamel surface, giving a smooth glazed surface, with no dentine involvement.

Grade 2 involvement of the dentine for less than one third of the area of the tooth surface.

Grade 3 involvement of the dentine for more than one third of the area of the smooth surface.

The number of missing teeth, if any, was also recorded.

The prevalence and severity of dental erosion was recorded by age, length of service and occupation. A Chi-Square test and logistic regression was employed to test for differences in levels of significance with the variables used.

RESULTS

Out of the 150 workers who were dismissed, sixty were able to be present on the day of the examination but only 58 records of the examination were complete. They were all male with an average age of 37 years, and a range of 21 to 62 years. All the participants had been employed in the "cell house" of the factory where they had been exposed to sulphuric acid mists, a by-product of the electroplating process. Their length of employment at the factory ranged from 3 months to 22 years.

Two-thirds of the participants ($n=40$) complained of pain and sensitivity on their teeth. More than a third of the participants ($n=22$) reported that they experienced difficulties with eating. Thirteen of the participants said they had had teeth extracted since working for the company. The reason given for the extractions was that their "teeth were spoilt by acid".

The examination of slide records revealed dental erosion of anterior upper and lower teeth. The teeth of only one person could not be diagnosed as eroded (Table I).

Table I: Number of persons affected by erosion.

Grade	0	1	2	3	Loss of teeth
Number of persons ($n=58$)	1	27	20	10	13

No clear pattern could be detected in the prevalence and severity of erosion when examined by age group. Statistical analysis, however, showed that the younger age groups had lost significantly more teeth than the older age groups ($p<0.05$).

Table II: Prevalence and severity of erosion by age group

Age Group	Grade 0	Grade 1	Grade 2	Grade 3	Loss of teeth
20-30 years ($n=14$)	1	10	2	1	2
31-40 years ($n=24$)	0	9	12	3	6
41-50 years ($n=10$)	0	3	3	5	0
more than 50 years old ($n=9$)	0	5	3	1	5
Total $n=58$	1	27	20	10	13

When comparing length of service with prevalence and severity of erosion no clear relationship could be established.

Table III: Prevalence and severity of erosion by length of service

Years of service	Grade 0	Grade 1	Grade 2	Grade 3	Loss of teeth
0-3 years (n=18)	1	11	4	2	2
3-6 years (n=7)	0	3	3	1	2
6-9 years (n=6)	0	3	3	0	2
9-12 years (n=12)	0	6	4	2	4
more than 12 years (n=15)	0	4	6	5	3
Total n=58	1	27	20	10	13

A comparison of the prevalence and severity of erosion by occupation revealed that those workers known as strippers, who worked closest to the source of the acid fumes were more severely affected by erosion than the other categories of workers, such as cell cleaners, forklift drivers, labourers and other support staff, who were not directly exposed to the acid fumes (Table IV). A Chi-square test showed a significant difference between strippers and non-strippers ($p < 0.05$). The odds ratio was 5.19 — the strippers were five times more likely to have a severe form of erosion than other categories of workers.

Table IV: Prevalence and severity of erosion by occupation.

Occupation	grade 0	grade 1	grade 2	grade 3	loss of teeth
Stripper (n=30)	0	11	10	9	9
other categories (n=28)	1	16	10	1	4
TOTAL (n=58)	1	27	20	10	13

The number of upper and lower anterior teeth (canine to canine) affected by the various grades of erosion is shown in Table V.

Table V: Numbers of anterior teeth affected by erosion.

Grade	0	1	2	3	Teeth lost
Numbers of teeth	46	447	113	35	55

The lower incisors (n=27) were more severely affected (grade 3) than any of the other teeth. The teeth next most severely affected were the upper incisors (n=8 for grade 3).

SUGGESTED TREATMENT RANGE

The photographic and clinical records were utilized to assess treatment needs. The principles for deciding on the treatment range were (a) to minimize further loss of tooth structure; (b) to ensure minimal dependence on professional intervention, (c) to encourage self-care and (d) to prevent further harm.

The range included: no treatment (n=32), professional fluoride applications (n=60), extractions (n=23), prosthetic replacement (n=28) and scaling and polishing (n=6).

DISCUSSION

The characteristic finding of the dental conditions of the workers was erosion of the anterior teeth, accompanied by varying degrees of disfigurement, pain, loss of function and loss of teeth. The finding that age does not seem to play a significant role in the prevalence severity of erosion is similar to that of Ten Bruggen Cate (1968). The upper incisors were the most severely affected. This could be due to mouth breathing especially as the workers are expected to work at a fast pace.

This project, involving a REA of the erosion damage occurring in an adult community of metalworkers for the purposes of deciding workers compensation, is very unusual in the sense that it is seldom that a dental research team is asked to do action research in an arena of industrial conflict. The methodology used, REA, is also a relatively new area in the field of epidemiology, and as yet, rarely used in dental research.

The project involved negotiating with mine management and trade union representatives, each with conflicting interests, and with people's oral health and large sums of money at stake. In this context, the aim of the research was to design an instrument to resolve conflict and to promote oral health at an industrial site, while retaining scientific objectivity and rigour.

As a result of the REA, the workers who were examined are in the process of being compensated, with the NUM and mine management engaged in reaching a settlement. Preventive measures have been initiated at the factory. The area has been declared a "respiratory zone", making the wearing of respiratory masks obligatory to ensure that the erosion due to acid mists does not recur.

RECOMMENDATIONS

The management of erosion on a long term basis in an industrial setting should include the following preventive measures:

- isolation of the teeth from the cause (the wearing of mouthguards or respirators whilst working)
- the application of fluoride through its addition to the drinking water or in the form of a gel applied to the teeth
- alkaline mouth washes immediately after exposure to the acid mists

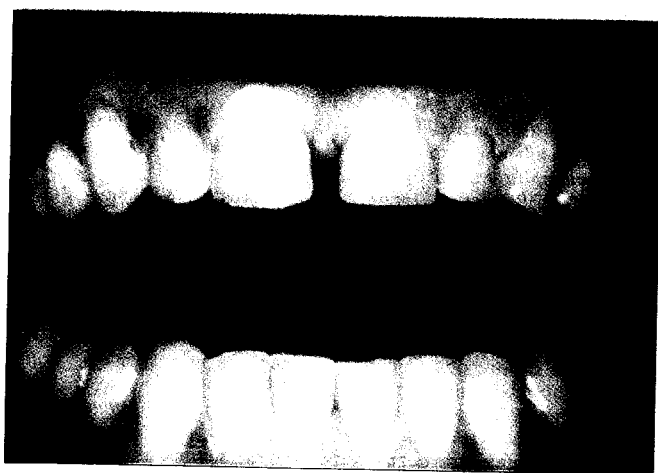


Fig. 1: An illustration of Grade 1 erosion. The photograph shows loss of surface features, including the smoothing out of developmental pits and grooves on the enamel of the labial surface of the anterior teeth, giving a smooth glazed surface with no dentine involvement.

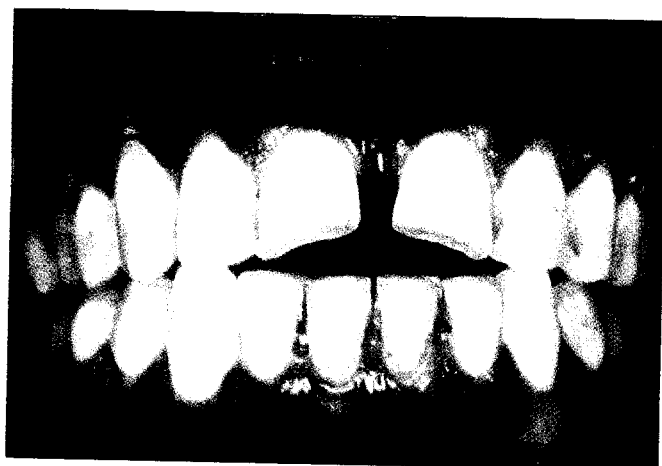


Fig. 2: An illustration of Grade 2 erosion. The photograph shows tooth surface loss with less than one third of tooth surface area affected. Tooth surface loss is seen on the anterior teeth with dentine exposure on the incisal edges of the maxillary incisor teeth and labial surfaces of canines and premolar teeth of the upper and lower jaw.

Occupational hygiene standards

Occupational exposure to sulphuric acid should be controlled and the threshold limit value as recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) be adopted as guidelines for good practice (ACGIH, 1996). The ACGIH Threshold Limit Value-Time Weighted Average (TLV-TWA) for sulphuric acid mist is 1 mg/m^3 , while the short-term exposure limit is 3 mg/m^3 (LV-STEL). A TLV-TWA is the time weighted average air concentration for a normal 8 hour workday and a 40 hour work week to which the workers may be repeatedly exposed day after day, without adverse effect. However, sulphuric acid may cause dental changes, even when it is at a concentration below what is considered the recommend standard (Gam-

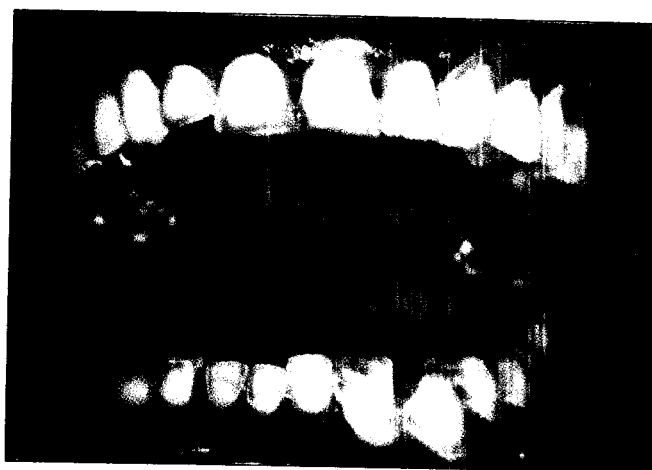


Fig. 3: An illustration of Grade 3 erosion. The photograph shows severe tooth surface loss involving more than a third of tooth loss on the lower incisors. The pattern of tooth surface loss on the lower incisors is due to the combined effects of erosion and attrition. Instead of an incisal edge on the lower anterior teeth we see an incisal surface surrounded by a sharp and rough edge. Note also the exposed dentine.

ble *et al.*, 1984) The TLV-STEL is defined as a 15 minutes TWA which should not be exceeded at any time during the workday even if the 8-hour TWA is within the TLV-TWA.

Processes generating sulphuric acid mist should be controlled to reduce the level of airborne sulphuric acid (Utidge, 1975). Exhaust systems, enclosures, surface active agents, chips, etc., could be effective. When the limits of exposure cannot be reduced further, a programme of protection to ensure the required protection of every worker exposed, must be implemented. This should include impervious clothing, rubber shoes, goggles, face shields and respiratory devices as appropriate to prevent acid contact with the skin, eyes or respiratory tract.

Occupational health

The National Institute of Occupational Health and Safety (NIOSH) in the United States of America recommends comprehensive replacement and annual medical examinations for all workers potentially exposed to sulphuric acid (NIOSH 1974). The examinations should include assessment of teeth, eyes, skin and the cardiopulmonary system. Particular attention should be focused on dental erosion and complaints of mucous membrane irritation and cough. There may also be an increased risk of lung cancer in workers exposed to acid mists (Beaumont *et al.*, 1987).

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