

## Impact case study (REF3)

<b>Institution:</b> King's College London		
<b>Unit of Assessment:</b> UoA3		
<b>Title of case study:</b> Erosive Tooth Wear – enabling understanding and change for policy makers, commercial companies, dentists, patients and the public		
<b>Period when the underpinning research was undertaken:</b> 1 January 2000 to 31 July 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
David Bartlett	Professor of Prosthodontics & Head of Centre: Oral, Clinical & Translational Sciences	1991 – Present
Rebecca Moazzez	Reader/Hon Consultant and Director of the Oral Clinical Research Unit	1998 – Present
Rupert Austin	Senior Lecturer/Hon Consultant	2015 – Present
Jose Rodriguez	Hon Senior Lecturer/Consultant	2018 – Present
Saoirse O'Toole	Clinical Lecturer	2017 – Present
<b>Period when the claimed impact occurred:</b> 1 August 2013 to 31 December 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> N		

**1. Summary of the impact**

Erosive tooth wear (ETW) is the 3rd most common destructive dental condition (1 in 3 European adults have signs), but has often been poorly recognised by both dentists and patients until complex, expensive treatment is needed. King's College London researchers devised a unifying ETW screening tool, the "BEWE" index. Together with the Erosive Tooth Wear Foundation, a King's-led implementation charity, as an international, Industry-Academic Partnership, we have: 1) facilitated the collection of epidemiological data to inform policy makers and guidelines; 2) stimulated ETW innovation, sales and Corporate Social Responsibility activities with multiple global companies; 3) helped dentists to recognise, prevent and manage ETW and 4) raised awareness of prevention and treatment amongst patients and the public.

**2. Underpinning research**

Erosive tooth wear (ETW) is the premature wearing of teeth due to softening of the dental enamel from dietary or stomach acids, combined with mechanical wear. Severe ETW can completely destroy people's teeth, affecting their smile, confidence and reducing the quality of life at any age. Although preventable by simple lifestyle changes, ETW is the 3rd most common destructive dental condition (after tooth decay and gum disease, our research showing 1 in 3 European adults have signs), and across the life-course gives rise to significant health, quality of life and economic burdens to people and health systems. However, ETW, was up until 10 years ago, poorly understood by multiple stakeholders (dentists, the public and public health authorities), with both the prevalence and importance of the condition being underestimated. The condition has typically not been recognised until complex, expensive treatment is needed and the opportunity for prevention missed.

Understanding of the condition had been compromised for many years by the fundamental challenges associated with measuring its severity, extent and in monitoring changes over time. This was further hampered by the lack of a unifying method to allow systematic assessment of ETW. These factors limited the understanding of ETW at the population and patient levels, as well as in laboratory and clinical research and compromised industry's understanding of the market opportunities around ETW.

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The King's ETW Research Team have been contributing to research on this topic for over 30 years. Since 2000, the team has expanded and attracted more than £3M in serial Industry funding for inter-disciplinary studies to become an International Centre for ETW research with extensive academic/industry partnerships. In 2008 the King's team created and launched the Basic Erosive Wear Examination (BEWE) **(1)**, a simpler, easier, primary care-friendly index developed through global consensus. Since then, and particularly during this REF period, the team has developed a unique multi-faceted research portfolio encompassing epidemiology, clinical trials and laboratory research to understand the mechanistic process of ETW as well as its prevention and management. The team has explicitly collaborated with research across disciplines - with public health academics, psychologists, gastroenterologists, respiratory clinicians, engineers, metrologists, chemists and tribologists.

### **Our research contributions can be described under four headings:**

**1. Population contributions** – King's developed the BEWE index **(1)** and standardised questionnaires that have facilitated the collection of comparable global epidemiology data and country-specific risk factors across ethnicities for the first time in Europe **(2)**, and for China, Arab populations **(3)** and Latin America. Rather than offering vague preventive advice, we have categorised the risk factors into dietary risk factors (odds ratio 13x associated with 3 or more acidic snacks), stomach acid risk factors (linking those with gastric reflux and vomiting eating disorders to the condition) and wear risk factors (showing the interaction between toothbrushing and acid-softened enamel). We have shown that people with ETW have a different lifestyle compared to those with dental decay; they are usually from higher socio-economic groups and have healthy diets snacking on healthy fruits/acidic drinks e.g. fruit tea.

**2. Clinical contributions** – Kings and Guy's and St Thomas' Trust has the largest clinical centre of excellence for managing ETW in Europe, and as such have a unique patient population. Using advanced *in vivo* data capture techniques **(4,5)**, we have tested the placement of protective coatings on teeth to delay ETW progression. We have shown that in those with gastric reflux, the use of chewing gum as a simple, non-invasive measure after a high-fat meal, limited the stomach acid entering the mouth. We have also successfully pioneered dietary behavioural interventions showing that personalised planning of reduction of acidic snacks between meals results in delayed ETW progression **(6)**. Our group have published clinical studies on the progression of tooth wear in patients **(5)** showing: a) 14% reduction in wear following dietary advice, b) the cost of care being seven times higher in private practice compared to NHS hospitals (2018) and c) that the take up of the BEWE was better with recently qualified dentists compared to older dentists.

**3. Laboratory advancements** – In order to understand the mechanistic process of wear, we have co-created world-leading techniques in collaboration with Southampton University Mechanical Engineering and the National Physics Laboratory. We are able to measure very small changes, less than 1µm, to determine the protective effects of fluoride (2014-2019 and 30% reduction in ETW). We are able to measure interaction with saliva (2014-2019 and 50% reduction in ETW). Finally, we are currently leading in the use of 3D mapping of the complex surface of teeth, using super-imposition and subtraction techniques **(7)**.

**4. Industry-linked joint research** – Due to the expertise in the above areas, our team has been chosen by a number of companies to undertake joint research studies through a range of commercial grants. These have investigated the action of fluoride (Unilever and their product "Regenerate"), measurement of wear on enamel (GSK and their product "Pronamel") and patient-based studies that have identified risk factors (P&G and their range of Oral B products),

### **3. References to the research**

**1. Bartlett D**, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. *Clin Oral Invest* (2008) 12 (Suppl 1):S65–S68

**2. Bartlett DW**, Lussi A, West NX, Bouchard P, Sanz M, Bourgeois D. Prevalence of tooth wear on buccal and lingual surfaces and possible risk factors in young European adults. *J Dent*. 2013;41(11):1007–13.

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3. Awad MA, El Kassas D, Al Harthi L, Abraham SB, Al-Khalifa KS, Khalaf ME, Al Habashneh R, **D Bartlett**. Prevalence, severity and explanatory factors of tooth wear in Arab populations. *J Dent*. 2019;80:69–74.
4. Mylonas P, **Austin RS**, **Moazzez R**, Joiner A, **Bartlett DW**. In vitro evaluation of the early erosive lesion in polished and natural human enamel. *Dent Mater*. 2018 Sep 1;34(9):1391–400.
5. **Rodriguez J**, **Austin R**, **Bartlett DW**. The in vivo measurements of tooth wear over 12 months. *Caries Res* 2011;46:9-15
6. **O’Toole S**, Newton T, **Moazzez R**, Hasan A, **Bartlett D**. Randomised Controlled Clinical Trial Investigating the Impact of Implementation Planning on Behaviour Related to the Diet. *Sci Rep*. 2018 Dec 23;8(1):8024.
7. **Moazzez R**, **Austin R**, Rojas-Serrano M, Carpenter G, Cotroneo E, Proctor G, Zaidel L, **Bartlett DW**. Comparison of possible protective effect of the salivary pellicle of individuals with and without dental erosion. *Caries Res* 2014;48:57-62

#### 4. Details of the impact

Despite the clinical, social and economic burdens of this widespread preventable condition, ETW has often been poorly recognised by both dentists and patients until complex, expensive treatment is needed. Our research illustrates that the cost to restore worn teeth in private practice can reach over £30K per patient and is rarely offered within NHS practice. King’s has developed a unique and broad expertise in ETW research, which has been recognised by industry, public health bodies and dentists. Through these efforts the public are becoming more aware of ETW, 10 years ago it was uncommon for patients to ask about the condition, now it’s normal.

In June 2017 King’s led the implementation of the *Erosive Tooth Wear Foundation* (ETWF), a UK registered charity whose objectives are to: promote the good health of the public and advance education for the public benefit on how best to prevent and treat ETW. In addition to the trustees from King’s (Bartlett and Pitts), the Foundation draws scientific expertise from: Professor Adrian Lussi, (University of Bern, Switzerland), Professor Dom Zero, (Indiana University, USA) and Professor Carolina Ganss (University of Giessen, Germany). ETWF also engages with experts in the area worldwide and convenes an Advisory Panel with representation from industry supporters GSK, P&G and Unilever. It has been able to build non-competitive working relationships between several multi-national companies and other international academic centres; all working for public and professional benefit. We are not aware of any similar model in oral health where such relationships have been established and maintained. A key tool in communicating information and educational material across the stakeholder beneficiaries has been a dedicated, free-to-access [website](#) (A). Together, the research team and Foundation now comprise an unusual, international, Industry-Academic Partnership designed to enable understanding and change for a series of impact beneficiaries.

##### 1) Benefits to policy decision makers and guidelines

*Erosive Tooth Wear information to inform policy decision makers:* The collection of comparable data on the global epidemiology of ETW has been facilitated by the use of the King’s-developed BEWE Index in a range of studies which have improved the professional and public health understanding of the prevalence and severity of ETW (B).

BEWE has also been adopted for use in epidemiology and policy studies by a range of organisations, including: Public Health England (PHE has agreed the use of BEWE for future National clinical Surveys of Adult Oral Health, the principal epidemiological survey of oral health and disease in England), the Colombian Consensus Standard Oral Health Record (agreed by the Ministry of Health), and the French equivalent to the NHS’s National evaluation of new prevention payment systems in General Practice.(B)

*Erosive Tooth Wear evidence of use in Guidelines:* In PHE Guidance for General Dentists “*Delivering Better Oral Health v3*”, 25% of all references about ETW are from King’s, who are also involved with the updated 2021 version. A testimonial from the clinical lead for the Chief Dental Officer England confirms our contribution to Post-COVID-19 NHS clinical guidance (C).

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A King's-led initiative brought together industry with all key UK dental stakeholders, including the British Dental Association, the Faculty of General Dental Practitioners, Dental Protection (a professional indemnity organisation), the British Hygienists & Therapists Association and International Dental Students Association. This initiative produced a joint publication advocating increased screening for tooth wear using the BEWE at every dental new examination in England. This has been developed into a range of actions in a campaign by these stakeholders, now reported on through a dedicated page on the ETWF website, **(A)** which provides guidance, tools and videos. This has improved the understanding and monitoring of ETW in Dental Practice **(C)**.

### 2) Benefits to industry

The King's ETW team has uniquely engaged with industry. This includes not only innovation, such as a joint industry-university patent **(D)**, but also extends to establishing the size of new markets (through epidemiological assessments) **(B)** and assessing the commercial opportunity for toothpastes to help prevent/control ETW. We have shown that ETW is a condition of the wealthy, health conscious and/or those with underlying medical conditions, giving industry specific markets to target. Industry believe this to be a good continuing return on investment, having allocated £3M in grant income to our team. Market research show growth in ETW toothpaste sales and in 2019 Sensodyne Pronamel was the 2nd leading toothpaste brand in the US, with annual sales of \$196.7M. This is up from it's previous standing of 9th leading brand in the US in 2014 with \$127.1M **(E)**. The clinical evidence we supplied showing the financial and personal cost of severe ETW has facilitated more aggressive marketing on early diagnosis and prevention. Testimonials from two of the largest international consumer oral care companies (GSK and Unilever) confirm our work has positively impacted sales and that two new toothpastes have been launched around these collaborations (Pronamel 2006 (GSK) and Regenerate 2012 (Unilever)) **(F)**. The team provided clinical and research images and text for patient information leaflets which were sent to all UK dental practices (12K). The number of leaflets internationally is currently over 21K leaflets worldwide for GSK and 8,350 in three different countries for Unilever **(F)**. We have also released BEWE Training apps for the dental team produced with GSK & Unilever in 2015 **(G)** with our images, text and advice given by King's (the sole University acknowledged within the apps). The GSK app has been downloaded 1K times and the Unilever app has had over 100K hits **(G)**. The research and social/professional profile of GSK, Unilever and P&G was also increased through their Corporate Social Responsibility donations of £230K over 5 years to the ETWF, as well as through expert contributions to the design of communication materials for dentists, patients and the public **(A)**. The many synergistic links between King's research and implementation activities in this area and those of the major global oral health companies is built around a shared desire and ethos to help maintain the oral health of the global community **(F)**.

### 3) Benefits to dentists

We have provided evidence-based, best-practice knowledge to dentists to enable change and to use the BEWE as a vehicle to engage with clinicians on the importance of ETW. This has been delivered through the development of the "*Health Professionals*" and "*BEWE*" sections of the ETWF website **(A)** to provide a "one-stop shop" for both dentists in training and General Practitioners to access CPD compliant e-learning modules. These cover how to recognise and measure ETW from the earliest stages, how to use the BEWE, and access and use information on risk factors and best practice for prevention and clinical management **(A)**.

We have also worked with four international software companies to incorporate the BEWE into routine electronic clinical records, making it easier for dentists to record it **(H)**. We are currently working with global dental education academies to consolidate ETW teaching in dental schools. Within the UK, all dental schools teach recording of ETW and of these, 40% promote the BEWE **(H)**. The campaign and guidance to integrate BEWE into every routine examination of dental patients led by all key UK dental stakeholders and the PHE guidance on Delivering Better Oral Health **(C)** have also driven the adoption and awareness raising of ETW amongst dentists. Practitioner-focussed evidence-based reviews have proved popular with General Dentists. Dentists also value and use the ETW Apps we have created – the Unilever app developed with King's is accessed on average 27 times per day with an average usage of six times per app download **(G.ii)**. Analysis by Stockdale Martin, a specialist communications company, from the ETWF website, key publications and social media channels shows "*a growing international profile with key messaging targeting professionals and consumers achieving an aggregated reach in*

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excess of 4.48 million potential global impressions, exceeding industry thresholds across all media channels”, that “this reach has been both domestic and international” and that social media undertaken by the Foundation has exceeded benchmark norms in terms of engagement and action (I).

### 4) Benefits to the public/patients

The ETWF website’s public-facing element (“Dental Erosive Tooth Wear and You”) provides independent, free, information based on the best evidence on how to recognise ETW, what is effective against tooth wear and simple diet and lifestyle changes individuals can make to limit the initiation and progression of the condition. The ETWF website has equal downloads from UK and USA with 3K visits in 5 months, with visitor traffic doubling over the last 12 months demonstrating the impact of recent social media investments. Increasing awareness of ETW by patients and public has been evidenced – “the Foundation has also been successful in achieving profile amongst the consumer audience, particularly in the UK” (A, I).

A patient representative (who became an advocate for our work having personally experienced extensive ETW, diagnosed in his late twenties and requiring two years of invasive and expensive treatment) has been involved with guiding some of our research projects. He feels that lay people “don’t have an awareness that dental wear is or could be an issue” and that they need more information. He reflects that “Now I am acutely aware of it and have made adjustments to my diet and my practices, but I wish I’d known a bit sooner, it wouldn’t have cost me so much time and heartache really” (J). The public reaction to publications about the links between ETW and Diet and Herbal Teas has been phenomenal.

The team and the ETWF has built Industry links over the years which have been instrumental to raise awareness of the condition. Through industry advertising campaigns, patients now recognise that acids wear away teeth, as evidenced by the increase in sales of ETW specific products (E). Our expertise has also informed industry’s patient information leaflets which have now been distributed to 85% of dental practices around the UK (F).

### 5. Sources to corroborate the impact

**A) Parts of the ETWF Foundation website (PDF) including:** i) landing page; sections on ii) “Health Professionals”; iii) “Erosive Tooth Wear and You”; iv) BEWE; v) “Our Knowledge Base”; vi) metrics of website and vii) confirmation of ETWF Foundation External Support.

**B) ETW information to inform policy decision makers (PDF):** i) Comparable global epidemiology papers using the BEWE index giving prevalence & severity, ii) BEWE adopted for use in epidemiology and policy studies.

**C) ETW evidence of use in Guidelines (PDF):** i) PHE – Delivering Better Oral Health version 3, ii) Testimonial from Clinical Lead representing CDO England for post-Covid19 Guidance for NHS primary care dentistry, iii) Guidance from Roundtable of Professional Stakeholder Organisations including a shared campaign to improve understanding and monitoring of ETW in Dental Practice

**D) Joint industry-university patent (Colgate, US patent number US9140708, 2015) (PDF)**

**E) Sales data for ETW Toothpastes:** i) Pronamel - GSK and ii) Regenerate - Unilever (PDF)

**F) Testimonials from Industry relating to the contributions of King’s researchers:** i) GSK and ii) Unilever

**G) BEWE Apps (PDF):** i) a GSK App; ii) a Unilever App; iii) A Dental Insurance company risk assessment tool DEPPA ; and iv) evidence of APP usage as outlined in the text.

**H) ETW incorporated into Dental Practice Software - BEWE chosen as tooth wear index of choice for clinical records and practice management software by 4 Companies (PDF):** i) Dentally; ii) Smile; iii) Software of Excellence; iv) Salud and BEWE adopted in UK Dental Schools.

**I) Report by Stockdale Martin Company on evidence of reach via the website, publications and social media channels across Health Professionals, Patients and Public (PDF)**

**J) Patient Representative Testimonial – transcript from Patient’s own video (PDF)**