Institution: King's College London

Unit of Assessment: Uo3 - Dentistry

Title of case study: Towards world-wide standardisation of caries detection, assessment and preventive management

1. Summary of the impact

King's College London (KCL)-led research has both underpinned and helped to develop and test an *International Caries Detection and Assessment System* (ICDAS) and complementary *International Caries Classification and Management System* (ICCMS™). Now increasingly accepted and used worldwide, these assessment and management systems are important to clinicians and researchers in detecting, preventively managing and monitoring caries as well as in framing research investigations and evaluating outcomes. They are valuable tools for public health planning and assessing incidence and prevalence of caries (tooth decay), the most ubiquitous disease across the globe. Equally importantly, they now facilitate professional curricula and public education programmes.

2. Underpinning research

Dental caries occurs as a result of the complex interactions within acid-producing bacterial biofilms fermenting dietary sugars, leading to episodic demineralisation at and below the tooth surface, which may then cause further destruction of the hard tissues of the teeth. Research into aspects of caries diagnosis and management has been carried out at King's College London (KCL) by Prof Avijit Banerjee (1995-present, Professor of Cariology & Operative Dentistry), Prof Raman Bedi (2001-present, Professor of Transcultural Oral Health), Prof Nigel Pitts (2013-present, Professor of Dental Health), Dr Christopher Longbottom (2013-present, Innovation & Translation Research Fellow), Prof Edwina Kidd (1982-2004, Professor of Cariology), Prof David Ricketts (1991-1999, Lecturer & Research Associate in Conservative Dentistry) and Prof Kim Ekstrand (1996-7, Visiting Fellow and 2013-present, Visiting Professor). A pivotal 1993 review of caries from KCL researchers Kidd and Ricketts, working with Pitts, linked basic science and clinical observations with treatment and epidemiological implications. It motivated a series of studies that elucidated the stages of caries development from inception (where non-invasive management is possible) to an end-stage cavitated lesion (where invasive operative restoration is indicated). As part of these studies, it was noted that some initial lesions become inactive, never progressing to end-stage.

Following his work on visual ranked caries scoring in Denmark, Visiting Fellow Prof (then Dr) Ekstrand worked with KCL researchers in the late 1990's on combining strategies to develop and then validate the approach. In one study three examiners tested the reproducibility and accuracy of a visual ranked caries scoring system using 100 occulsal surfaces of extracted teeth. The new system showed good inter- and intra-examiner reproducibility and high correlation with an electronic caries scoring system (ECM) and it could detect very early lesions by air drying (1). In another study, occlusal surface caries on 35 *in-situ* third molars was recorded using the visual ranked caries scoring system, ECM and radiographs. Histological measurements on then extracted teeth showed strong relationships between the assessment types and both lesion depth and lesion activity. Clinicians were able to detect lesions, predict activity and severity and define a logical management of occlusal caries on the basis of a single clinical examination (2). In a third study, the visual scoring system was presented as a clinical tool that allows the dentist to judge lesion depth, to differentiate active from arrested lesions and to relate the ranked scoring system to the level of dentine infection. Taken together, these components provided a score, with appropriate management for each discussed (3). Subsequent studies extended and validated the System for approximal lesions (4) and explored relationships between caries, marginal ditching and colour change to the level of infection of the dentin beneath the margins of both amalgam (5) and tooth-coloured restorations (6).

A complementary area of underpinning research from KCL was the *Futures Study of Dental Caries*, which employed modelling of caries epidemiology and prevention data to estimate the health gain achievable if all preventive interventions were optimised (7). This study informed the setting of caries prevention targets now used worldwide by the *Alliance for a Cavity Free Future*.

3. References to the research

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3. Ekstrand KR, Ricketts DN, Kidd EA. Occlusal caries: pathology, diagnosis and logical management. Dent Update 2001;28(8):380-7. Pdf on request (26 Scopus citations)
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5. Kidd EA, Joyston-Bechal S, Beighton D. Marginal ditching and staining as a predictor of secondary caries around amalgam restorations: a clinical and microbiological study. J Dent Res 1995;74(5):1206-11. Doi: 10.1177/00220345950740051001 (67 Scopus citations)
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7. Bedi R (Ed). Reforming Dental Services in England: Policy Options. Health Education Journal Vol 64 (4) December 2005 (Supplement) ISSN 0017 8969

***Note**: this core underpinning research portfolio was developed in an interface area by a range of collaborators and not by traditional grant funding. The stakeholders who supported the research activity include KCL, the Department of Health and the FDI World Dental Federation.*

4. Details of the impact

World-wide Standardisation of Caries Detection, Assessment & Preventive Management

The work of KCL researchers on a way to visually rank caries greatly informed the development of the *International Caries Detection and Assessment System* (ICDAS). Prior to this, dentists had mostly used use G.V. Black's caries lesion classification and disease management system that is more than 100 years old. Following from a 2002 International Consensus Workshop on Caries Clinical Trials, where it was concluded that there was a great need to detect dental caries at the non-cavitated stages, an ICDAS Coordinating Committee was formed with an aim to develop a standardized system 'to inform decisions about diagnosis, prognosis, and clinical management of dental caries at both the individual and public health levels.' The studies detailed above, along with integration of other caries criteria systems, formed the basis for creating a systematic approach to categorising the stage of caries progression based on the clinical visual appearance: the ICDAS.

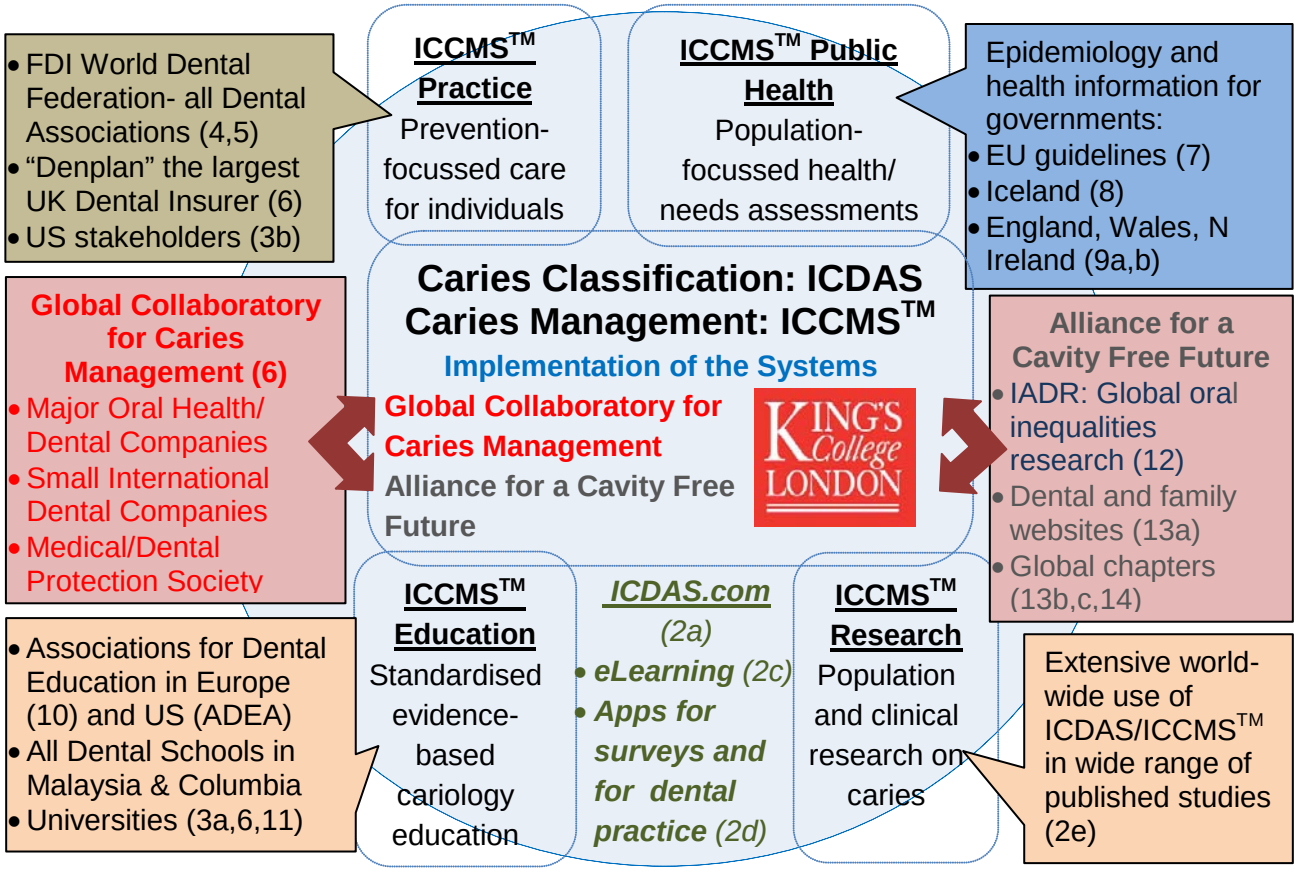
The ICDAS was developed with national and international partners to create a unified, validated approach that detects six stages of the carious process and is divided into sections covering coronal caries, root caries and caries associated with restorations and sealants. The complementary *International Caries Classification and Management System* (ICCMS™) functionalises ICDAS by adding recommendations for clinical care based on caries risk- and patient-dependent factors. It provides a way for dentists, dental associations and dental schools to deliver the new approach of 'caries as a continuum' in order to improve dental caries prevention and management (1). Dissemination of the ICDAS has been led by the charitable ICDAS Foundation, set up to promote the system and to keep it open and available (2a). Outlines of how the ICDAS was put together include reference to a number of the KCL studies detailed above (2b).

The beneficial impacts of ICDAS/ICCMS™ can be seen in three main areas (3a)

- Significantly influencing the philosophy of minimally invasive dentistry to now seek to stop or reverse the progression of early caries and to preserve as much tooth structure as possible, extending the probability of the tooth surviving for the patient's lifetime
- Providing a shared assessment system permitting world-wide comparisons of caries incidence and prevalence as well as measuring efficacy of public policy and treatment modalities
- Providing a basis for measuring preventive treatment outcomes for health care systems (e.g., NHS, insurance systems) thereby influencing both quality assessments and payment structures.

Towards World-wide Acceptance: an overview of the many impacts of ICDAS/ICCMS™ and their significance can be gauged by its worldwide use and integration into healthcare standards

and policies across organisations in different countries and applications. The figure below summarises the engagement with stakeholders across the four ICDAS/ICCMS™ domains of ***Practice, Public Health, Education, Research***. Included at the mid points are the two KCL-led Implementation vehicles for ICDAS/ICCMS™ that feed multiple domains: the Global Collaboratory for Caries Management and the Alliance for a Cavity Free Future.



Practice Impacts: ICDAS is integrated into national and international guidelines and policy. In 2008, the FDI World Dental Federation adopted the ICDAS-coordinated glossary of key terms as a global standard (4) and in 2012 incorporated in into its new Caries Matrix (5). The FDI comprises 130 national dental association members that represent the majority of the 1 million dentists worldwide. The *Global Collaboratory for Caries Management,* supported by the KCL Policy Institute, has brought together an array of dental practitioners and educators from around the world with representatives from dental companies; all have agreed to implement ICCMS™ in practice and education (6). The Department of Health, scoping new contracts for General Dental Practitioners, is also participating, as is Denplan insurance; both have stated the wish to be ICCMS™ compliant.

Public Health Impacts: In addition to EU-wide standardisation (7) and Alliance for a Cavity Free Future-related work, ICDAS has been employed in a national survey of oral health in Iceland (8). Its enamel caries codes are also now incorporated into the 2013 Child Dental Health Survey of England, Wales & Northern Ireland (9a), which, the Chief Dental Officer for England has made clear, has impacts upon NHS policy (9b).

Education Impacts are evidenced by integration into a European standardised clinical survey guideline on training (7) and a European Cariology Curriculum (10) being adopted in an increasing number of countries worldwide. Open source materials (eLearning and software tools) are available at no cost via the ICDAS website (2c, 2d) as a resource to dentists, educators, researchers and those engaged in public health and policy formulation. Additionally, ICDAS features in the latest, 2011, edition of Pickard's Manual of Operative Dentistry, a key resource for dentists (11).

Research Impacts*:* As of 1 July 2013, ICDAS/ICCMS™ has been the subject of 114 peer-

reviewed published papers, with 78 different first authors from 22 countries (2e). ICDAS/ICCMS™ has been developed with input from the International Association for Dental Research (12) and formed the basis for a ground-breaking region-wide programme evaluating the extent of early and late stage caries in young children across ten Latin American countries to plan care programmes with Governments. The *Alliance for a Caries Free Future*, launched in 2010 and now a UK Charity, is extending the impact of KCL research by promoting unified caries prevention and management in dental education and practice worldwide through integrating experts from academia, policy bodies (WHO and Pan American Health Organization) and industry (13a). ICDAS/ICCMS™ underpins the measures of success of this Alliance. Since 2011, Alliance Chapters have been formed in Columbia, Mexico, Brazil, Venezuela, China and Europe (13b,c). Chapters work with regional dental schools, dental associations, public health groups, governments and other stakeholders. Impacts achieved include public education and joint community programmes in poor areas, such as one mounted with the Brazilian government (14).

5. Sources to corroborate the impact

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   (b) Rationale and Evidence for the ICDAS: https://www.icdas.org/downloads
   (c) ICDAS e-learning programme on coding. https://www.icdas.org/icdas-e-learning-course
   (d) ICDAS/ICCMS™ Software Tools. https://www.icdas.org/software-tools
   (e) ICDAS publications in world literature - overview: http://www.icdas.org/icdas-in-the-literature
3. (a) Pitts NB, Ekstrand KR. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS). Community Dent Oral Epidemiol 2013; 41: e41-e52. Doi: 10.1111/cdoe.12025
   (b) Ismail AI, et al. Caries management pathways preserve dental tissues and promote oral health. Community Dent Oral Epidemiol 2013;41:e12–e40. Doi:10.1111/cdoe.12024
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9. (a) Training for the 2013 Dental Health Survey of Children And Young People – NHS IC & ONS Consortium: http://www.kcl.ac.uk/dentistry/about/centres/dental-itc/cid.aspx
   (b) Open letter from Chief Dental Officer, Department of Health, England
10. Pitts N, et al. Caries risk assessment, diagnosis and synthesis in the context of a European Core Curriculum in Cariology. Eur J Dent Educ 2011;15 (suppl 1):23–31. Doi: 10.1111/j.1600-0579.2011.00711.x
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13. (a) Alliance for a Cavity Free Future website: www.AllianceforaCavityFreeFuture.org
   (b) ACFF Fact Sheet:http://www.allianceforacavityfreefuture.org/Caries/Consumer/en/us/whats-new/pdf/EU_Chapter_Caries_Fact_Sheet.pdf
   (c) ACFF European Chapter: http://www.kcl.ac.uk/newsevents/news/newsrecords/2013/07-July/Dental-experts-highlight-gaps-in-public-knowledge-of-tooth-decay.aspx
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