How Cloud Electronic Health Records (EHRs) Support Research

Lynn Johnson, University of Michigan, USA
Heiko Spallek, University of Sydney, Australia
Mark Genuis, ICE Health Systems, Canada
Nigel Pitts, Kings College London, UK
Today’s Agenda

- Introductions
- How the EHR can Support Oral Health Research
- Discussion
- Case Study: An EHR that Supports Research through Collaboration
- Discussion
- The Case for a Caries Standard for EHRs
- Discussion
Disclosures

Lynn Johnson, from the University of Michigan, and Heiko Spallek, from the University of Sydney, as well as representatives from the universities of North Carolina and Pittsburgh and Internet2, are collaborating with Mark Genuis of ICE Health Systems to add functionalities that support oral health patient care and research. The universities have no financial benefit; ICE Health Systems will eventually receive income from purchases of its EHR.

Nigel Pitts is co-Chair of the ICDAS Foundation which is a non-profit charity which promotes the ICCMS, a caries management system and international harmonization of caries detection, assessment and management systems in order to improve patient outcomes.
How EHR Data can Support Oral Health Research

Professor Heiko Spallek
Faculty of Dentistry
The results are in from a national oral health survey, completed by the University of Adelaide, and they aren’t good. The research found that 25 per cent of children in Australia under the age of 11 have untreated tooth decay.

The National Child Oral Health Survey 2012-2014, over data from 24,000 children between the ages of five and fourteen across the nation. The study is the first to cover such widespread data in the last 25 years.

The Australian Research Centre for Population Oral Health—based at the University of Adelaide's School of Dentistry—teamed up with state and territory services to collate the results.

“This study is one of the biggest and most comprehensive of its kind in the world, giving us important and timely insights into the trends occurring in child oral health and behaviours of Australian children and their families,” said Associate Professor Loc Do, co-organiser of the survey who presented the results at two-day workshop.

“We found that tooth decay affected a significant proportion of children: over 40 per cent of children aged five-10 years had decay in their primary (baby) teeth. One quarter of children in that same age group had never had a dental visit.”
What was the problem?  

~10 years ago  

“Care that is important is often not delivered. Care that is delivered is often not important.”

“... our limited capacity for timely generation of evidence on the relative effectiveness, efficiency, and safety of available and emerging interventions.”

How information systems should support the information needs of general dentists in clinical settings: suggestions from a qualitative study

Mei Song¹, Heiko Spallek¹, Deborah Polk², Titus Schleyer¹, Teena Wali¹

Abstract

Background: A major challenge in designing useful clinical information systems in dentistry is to incorporate clinical evidence based on dentists’ information needs and then integrate the system seamlessly into the complex clinical workflow. The purpose of this study is to identify general dentists’ information needs and the information sources they use to meet those needs.

Methods: A semi-structured interview was conducted with a convenience sample of 18 general dentists in the Pittsburgh area during their daily practice. The interview was transcribed and used to identify categories and themes regarding information needs and information source use patterns.

Results: Two top-level needs. To meet the administrative needs, dentists used four types of information sources: clinical information/tasks, patient education, professional development, and patient satisfaction. Major themes of dentists’ unmet information needs included: (1) timely access to information on various subjects; (2) better visual representations of dental problems; (3) access to patient-specific evidence-based information; and (4) accurate, complete and consistent documentation of patient records.
We tried to fix it

$19 billion HIT funding in ARRA

Health IT Costs Per Doctor Annually
(doctor-owned multi-specialty practices)

2010: $15K
2013: $18K
2014: $21K
2015: $32K

(Steven Ross Johnson in Modern Healthcare, 2015
http://www.modernhealthcare.com/article/20150924/NEWS/150929920/ehr-costs-squeeze-independent-doc-practices

Bruce Japsen in Forbes, 2016
https://www.forbes.com/sites/brucejapsen/2016/08/10/health-it-costs-surpass-32k-per-doctor-annually/)
How are data collected in dentistry?

Dental Records: WORN—write once read never
What data can we collect?

Classes of data
1. structured in traditional databases
2. unstructured, e.g. images, video, voice, GIS
3. Internet of Things (IoT)

Internet of Dental Things (IoDT)

WORLD’S FIRST CONNECTED ELECTRIC TOOTHBRUSH W/ 3D MOTION SENSORS

Discover Ara
The 1st Toothbrush With Artificial Intelligence

- Proprietary AI technology in the toothbrush
- 3-D motion sensors, accelerometer, gyroscope and magnetometer
- Offline data capture, date, time, duration and zones brushed
- Bluetooth 4.0 (Bluetooth Low Energy) for easy connection and synchronization

Data gets pushed via Bluetooth®
→ into a data cemetery
Data Cemeteries ➔ Sources of Knowledge

"ensuring that electronic repositories become valuable resources rather than expensive investments that are quickly ignored”


Steps
- interoperability = connectedness
- standardization
- data stewardship

We need to educate decision makers about this!
What do physicians do with BigData?

By integrating claims, clinical, socio-demographic and care management data, you receive both a retrospective and prospective view of your patients and your patient populations.

Clinical data of nearly

50 MILLION PATIENTS

Longitudinal claims data of

20 YEARS

Claims data covering over

109 MILLION LIVES

- Identify at-risk patients earlier
- Preserve patient health
- Reduce costs
- Prevent complications

Mayo Clinic (59,000 employees) + UnitedHealth Group ($122 billion corporation) + Optum Labs:

$300m research study over 5 years:
repeated in hours, same result

https://www.optum.com/optumlabs/research-principles.html
Why data is a key economic resource

“The fact that data can be shared, used and reused an unlimited number of times (it is ‘non-rivalrous’ in consumption) makes it an especially valuable resource.”
Discussion

For 5 minutes:

1. Discuss current barriers of data access that prevents meaningful research.
2. Star the most important barrier and be prepared to report it.
Case Study: An EHR that Supports Research through Collaboration

Mark Genuis
ICE Health Systems
Collaboration for Health Information Technology

- 2011 - Formation begins
- 2013 - ICE Health Systems invited to participate.

“Collaboration” guides actions.
Collaboration Development

Company Selection

2011

Requirements Documentation

2012

Architecture

2013

Business Agreement & Security Review

2014

Development and Continuous improvement

2015

Launch - Include more Collaborators

2016

ONGOING - Innovation to EXTEND the EHR

2017

www.collaboration4hit.org
Vision / Requirements
Listening/Promising NOT Enough

Efficient clinical experience
Vision / Requirements

Listening/Promising NOT Enough

Support learning

www.collaboration4hit.org
Vision / Requirements

Listening/Promising NOT Enough

Dynamic data access

– Please see Dr. Pitts
Stakeholder selected HIT Standards

- ICDAS
  - Dr. Pitts and Dr. Fontana

- SNO DDS
  - American Dental Association

- ICH Guideline for Good Clinical Practice (2016)
  - Collaboration Advisory Board

- ISO 27001 Certification
  - Internet2

- Emphasis on structured data for forms, progress notes, medications ...
  - All stakeholders in an effort to move from Data cemeteries to sources of knowledge
Vision / Requirements

Listening/Promising NOT Enough

Excellence in collaboration and communication

- Clinical Specialties
- Data Migration
- Advisory Board
- Patient Care Deans
- Advanced Mentoring
- Standards Committees
- Technology Committees
- Security Audit
- Instructional Design
- Configuration & Implementation

www.collaboration4hit.org
Vision / Requirements

Listening/Promising NOT Enough

Exceed security regulations
**Vision / Requirements**

*Listening/Promising NOT Enough*

**Foremost software engineering practices**

- **Is bug related to original JIRA?**
  - **Yes**
    - Approved
  - **No**
    - Retest Successful ?
      - **Yes**
        - Retest Fix and related Test Cases
        - Status: Ready for QA
        - Status: Code Review Approved & Ready for Build
        - Status: Ready for Review
      - **No**
        - Issue Found
          - Confirmed ?
            - **Yes**
              - Create New JIRA
                - Status: Open
            - **No**
              - Fix required for Current Release ?
                - **Yes**
                  - Add to Board
                    - Status: To Do
                - **No**
                  - Remain in Backlog
- **Create Sub-Bug**
  - Developer picks JIRA and assign to himself
    - Status: In-Progress
Vision / Requirements

Listening/Promising NOT Enough

Robust Interoperability

- Google Glass 2
- Lexicomp
- Medical Support
- PACS systems
- EMRs
- E-Prescriptions
- iOS Apps
- ... Internet of Dental Things
Vision / Requirements

Listening/Promising NOT Enough

- Efficient clinical experience
- Support learning
- Dynamic data access
- Support research standards
- Excellence in collaboration and communication
- Exceed security regulations
- Foremost software engineering practices
- Robust Interoperability
Discussion

For 5 minutes:

1. Now that we have an EHR with:
   • Standards,
   • Integrates with other software, and
   • Calls upon the Internet of Dental Things for data collection,
   What improvements are possible with your research?

2. Star the most important suggestion and be prepared to report it.
The Case for a Caries Standard for EHRs

Nigel Pitts
Kings College London
Overview
The Case for a Caries Standard for EHRs

● Need for international caries standardization: practice and research
  ● i.e. ICDAS & ICCMS caries standards work

● EHR examples (ICE) and caries research

● What type of research questions can be answered by these systems?
International Consensus Workshop on Caries Clinical Trials

- Agreeing Where the Evidence Leads -
Loch Lomond, Scotland, January 6-10th 2002

- **Mission** To reach consensus about the designs of protocols for caries clinical trials which are scientifically acceptable as pivotal evidence of the anti-caries efficacy of oral care products.

- **Outcome** - multidisciplinary forum produced & **agreed** detailed Consensus Statements

- **Dissemination** - peer reviewed Supplement containing 25 review papers & the Consensus Statements published in *Journal of Dental Research* in 2004
Terminology: ICW-CCT Consensus Statements

The consensus was to separate out three key terms:

- **lesion detection** (which implies an objective method of determining whether or not disease is present)

- **lesion assessment** (which aims to characterise or monitor a lesion, once it has been detected)

- **caries diagnosis** (which should imply a human professional summation of all available data)

Need for international caries standardization: practice and research i.e. ICDAS & ICCMS caries standards work

- 2002 International Consensus Workshop on Caries Clinical Trials – Could NOT compare trial data!

- ICDAS Foundation formed in 2002 – International Caries Detection and Assessment System
  - Four Domains:
    - Research, Practice, Education and Public Health

- ICCMS™ - International Caries Classification and Management System - an integrated Clinical System: 4Ds:
  - Determine patient-level caries risk
  - Detect & Assess lesion stage and activity
  - Decide on a personalised care plan
  - Do tooth preserving prevention & control interventions
The Evidence Base in Caries Detection and Assessment

Reliable inclusion of clinical visual *enamel* & *dentine* caries detection is *not* new

- Backer Dirks 1951 >
- Marthaler 1966 >
- WHO 1979
- Pitts & Fyffe 1988
- Ismail 1992
- Ekstrand, Ricketts & Kidd 98
- Fyffe et al 2000
- Nyvad 2001
- And many, many more
  (see Systematic Reviews NIH CDC and ICW-CCT)

Since 2002
Four Domains of the International Caries Classification and Management System ICCMS™

ICDAS & ICCMS™
Research
Population and Clinical Research on caries and caries management

ICDAS & ICCMS™
Public Health
Population focussed Health Promotion, Prevention & Needs Assessment

ICDAS & ICCMS™
Practice
Prevention-focussed Clinical Care for individual patients

ICDAS & ICCMS™
Education
Standardized and EBD Cariology Education

Basic Reporting Tool
Merged Codes Recording System
Full ICDAS codes Recording System

ICDAS - Full code format +/- = activity status

II
Obvious decay
C+/-
Extensive decay
6 +/-
5 +/-

B+/-
Moderate decay
4 +/-
3 +/-

I
No Obvious decay
A+/-
Initial stage decay
2 +/-
1 +/-

0
Sound
0

www.icdas.org
# American Dental Association Caries Classification System

<table>
<thead>
<tr>
<th>Clinical Presentation</th>
<th>AMERICAN DENTAL ASSOCIATION CARIES CLASSIFICATION SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No clinically detectable lesion. Dental hard tissue appears normal in color, translucency, and gloss.</td>
<td>Sound</td>
</tr>
<tr>
<td>Earliest clinically detectable lesion compatible with mild demineralization. Lesion limited to enamel or to shallow demineralization of cementum/dentin. Mildest forms are detectable only after drying. When established and active, lesions may be white or brown and enamel has lost its normal gloss.</td>
<td>Initial</td>
</tr>
<tr>
<td>Visible signs of enamel breakdown or signs the dentin is moderately demineralized.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Enamel is fully cavitated and dentin is exposed. Dentin lesion is deeply/severely demineralized.</td>
<td>Advanced</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Labels</th>
<th>Infection Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>No surface change or adequately restored</td>
<td>None</td>
</tr>
<tr>
<td>Visually noncavitated</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Established, early cavitated, shallow cavitation, microcavitation</td>
<td>Possible</td>
</tr>
<tr>
<td>Spread/disseminated, late cavitated, deep cavitation</td>
<td>Present</td>
</tr>
</tbody>
</table>

### Appearance of Occlusal Surfaces (Pit and Fissure)

- **ICDAS 0**: No radiolucency
- **ICDAS 1**: E0\textsuperscript{$f$} or R0\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin.
- **ICDAS 2**: E1\textsuperscript{$f$} or RA1\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin. Note: radiographs are not reliable for mild occlusal lesions.
- **ICDAS 3**: E2\textsuperscript{$f$} or RA2\textsuperscript{a} radiolucency extends into the middle one-third of the dentin.
- **ICDAS 4**: D1\textsuperscript{$f$} or RA3\textsuperscript{a} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 5**: D2\textsuperscript{$f$} or RB4\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 6**: D3\textsuperscript{$f$} or RC5\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.

### Accessible Smooth Surfaces, Including Cervical and Root

- **ICDAS 0**: No radiolucency
- **ICDAS 1**: E0\textsuperscript{$f$} or R0\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin.
- **ICDAS 2**: E1\textsuperscript{$f$} or RA1\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin. Note: radiographs are not reliable for mild occlusal lesions.
- **ICDAS 3**: E2\textsuperscript{$f$} or RA2\textsuperscript{a} radiolucency extends into the middle one-third of the dentin.
- **ICDAS 4**: D1\textsuperscript{$f$} or RA3\textsuperscript{a} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 5**: D2\textsuperscript{$f$} or RB4\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 6**: D3\textsuperscript{$f$} or RC5\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.

### Radiographic Presentation of the Approximal Surface

- **ICDAS 0**: No radiolucency
- **ICDAS 1**: E0\textsuperscript{$f$} or R0\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin. Note: radiographs are not reliable for mild occlusal lesions.
- **ICDAS 2**: E1\textsuperscript{$f$} or RA1\textsuperscript{a} radiolucency may extend to the dentinoenamel junction or outer one-third of the dentin.
- **ICDAS 3**: E2\textsuperscript{$f$} or RA2\textsuperscript{a} radiolucency extends into the middle one-third of the dentin.
- **ICDAS 4**: D1\textsuperscript{$f$} or RA3\textsuperscript{a} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 5**: D2\textsuperscript{$f$} or RB4\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.
- **ICDAS 6**: D3\textsuperscript{$f$} or RC5\textsuperscript{f} radiolucency extends into the inner one-third of the dentin.

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\[f\text{ The ICDAS notation system links the clinical visual appearance of occlusal caries lesions with the histologically determined degree of dentinal penetration using the evidence collated and published by the ICDAS Foundation over the last decade; ICDAS also has a menu of options, including 3 levels of caries lesion classification, radiographic scoring and an integrated, risk-based caries management system ICCMS. (Pitts NB, Ekstrand KR. International Caries Detection and Assessment System [ICDAS] and its International Caries Classification and Management System [ICCMS]: Methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol 2013;41[1]:e41-e52. Pitts NB, Ismail AI, Martignon S, Ekstrand K, Douglas GAV, Longbottom C. ICCMS Guide for Practitioners and Educators. Available at: https://www.icdas.org/uploads/ICCMS-Guide_Full_Guide_US.pdf. Accessed April 13, 2015.)\]

\[a\text{ Cervical and root includes any smooth surface lesion above or below the anatomical crown that is accessible through direct visual/tactile examination.}\]

\[\text{Simulated radiographic images.}\]

ICDAS–based personalised care in Japan
The International Caries Classification and Management System is a health outcomes focused system that aims to maintain health and preserve tooth structure. It uses a simple form of the ICDAS Caries Classification model to stage caries severity and assess lesion activity in order to derive an appropriate, personalised, preventively based, risk-adjusted, tooth preserving Management Plan.

The system includes:
- **DETECT & Assess**: Caries Staging & Activity (CLASSIFICATION & INTRA-ORAL RISK)
- **DETERMINE**: Patient-level Caries Risk (HISTORY)
- **DO**: Appropriate Tooth Preserving Caries Prevention & Control Interventions (MANAGEMENT)
- **DECIDE**: Personalised Care Plan: Patient & Tooth Levels (DECISION MAKING)

**ICCMS™ 4D**

*Caries Management*
EHR examples (ICE) and caries research

- Here to have slides of ICE implementation of ICCMS™

- Powerpoints or videoclips in case we lose Internet link in the hall
EHR examples (ICE) and caries research
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<table>
<thead>
<tr>
<th>Name</th>
<th>BMI</th>
<th>Gender</th>
<th>Primary Clinic</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billy Jones</td>
<td>5 - Obese I</td>
<td>Female changed to Male</td>
<td>Clinic B</td>
<td>403.555.7777</td>
</tr>
<tr>
<td>Deangelo Wohlrab</td>
<td>4 - Overweight</td>
<td>Female</td>
<td>Clinic A</td>
<td>776.338.4269</td>
</tr>
<tr>
<td>Della Tandon</td>
<td>4 - Overweight</td>
<td>Unknown</td>
<td>Clinic A</td>
<td>575.551.2141</td>
</tr>
<tr>
<td>Healthy Smile1</td>
<td>3 - Normal</td>
<td>Female changed to Male</td>
<td>Clinic A</td>
<td></td>
</tr>
<tr>
<td>Healthy Smile2</td>
<td>6 - Obese II</td>
<td>Female changed to Male</td>
<td>Clinic B</td>
<td></td>
</tr>
<tr>
<td>Nigel Tonnar</td>
<td>4 - Overweight</td>
<td>Male</td>
<td>Clinic A</td>
<td>614.189.8747</td>
</tr>
</tbody>
</table>
What type of research questions can be answered by these systems?

Caries Management Questions:
- At what stage of caries severity are dentists intervening operatively?
- At what stage of caries severity are dentists intervening operatively for different risk groups?
- How well do specific preventive interventions work?
- How long do restorations last (by size/surfaces involved and by caries risk group)

Broader Questions:
- Are there benefits in preventive diet advice across Caries, Diabetes and Obesity?
- How do different skill mix combinations affect the cost-effectiveness of care
Discussion

For 5 minutes:

1. Select **ONE** question to discuss:

   1. How can you incorporate ICDAS/ICCMS into dental education and practice?
   2. Once the dental practitioners are using ICDAS/ICCMS what are the important research questions that can be answered?
   3. How can we use the EHR to understand in real time the changing caries trends?

2. Star the most important suggestion and be prepared to report it.
How Cloud Electronic Health Records (EHRs) Support Research

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