Informatics-based learning health system for temporomandibular disorders

Richard Ohrbach, DDS PhD OdontDr (hc)
University at Buffalo

Brad Rindal, DDS MS
HealthPartners Institute

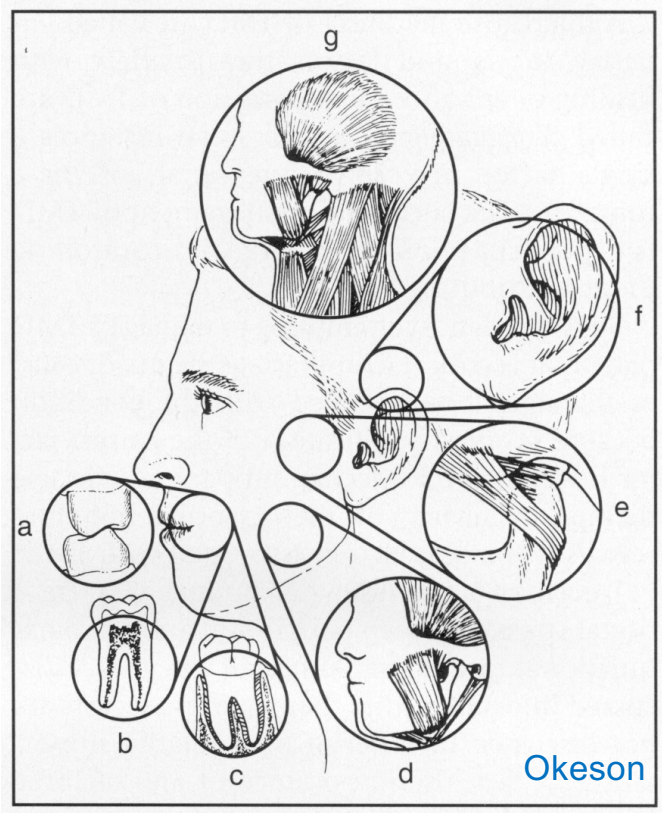
Characteristics of the prevalent TMDs

Symptoms (obtained from pain history)

- Pain reported in the facial and preauricular area, and may include headache
- Pain aggravated by jaw function
- Clicking or locking of the TMJ

Signs (clinical examination)

- Provocation-elicited (palpation, mobility) pain in muscles and joints
- Limitation of jaw movement
- Mechanical problems in the TMJ, including noise and locking



Prevalent disorders

- Pain disorders
  - ❖ Myofascial pain
  - ❖ Arthralgia
  - ❖ Secondary headache
- Mechanical joint problems
  - ❖ Disk displacement
  - ❖ Subluxation
- Degenerative joint disease

What is a Learning Health System?

… healthcare systems that continuously:

1. collect data from routine practice,
2. analyze it for insights, and
3. feed the knowledge back to clinicians to improve care.

… typically provides health care providers with real-time, evidence-based information such as:

1. clinical decision support tools,
2. quality metrics and outcomes dashboards,
3. patient risk stratification, and
4. research findings integrated into care processes.

… provides access to providers for:

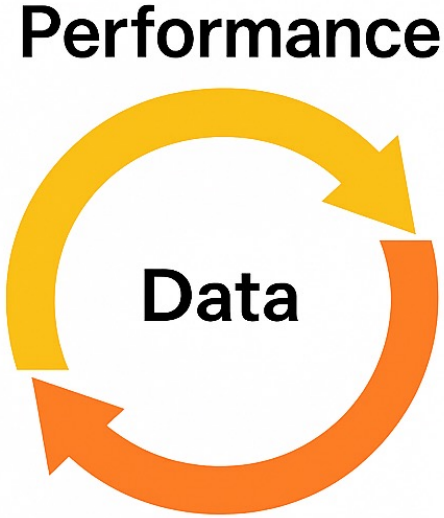
1. insights via electronic health record (EHR) integrations,
2. clinical dashboards, and
3. performance reports.

… simplifies a key goal – for clinicians to use this information for:

1. better decision-making,
2. quality improvement, and
3. research.

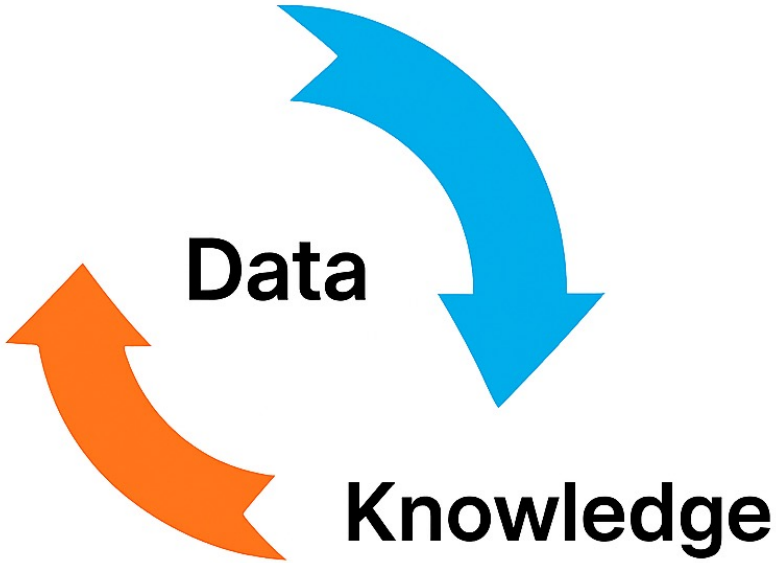
McDonald et al, Data to knowledge to improvement: creating the learning health system. BMJ 2024;384:e076175
Nash et al, Learning health systems in primary care: a systematic scoping review. BMC Fam Pract 2021;22:126

Performance → Data



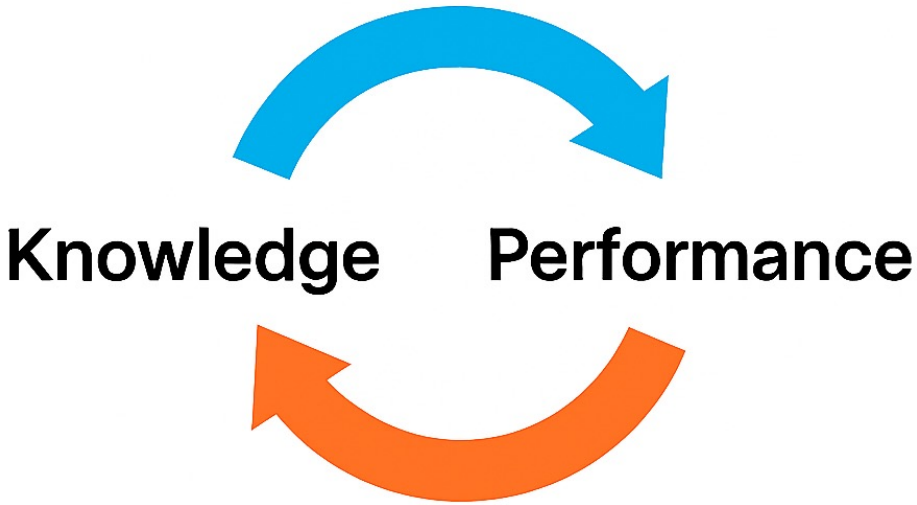
- Routine data capture
- PROs
- Context capture

Data → Knowledge



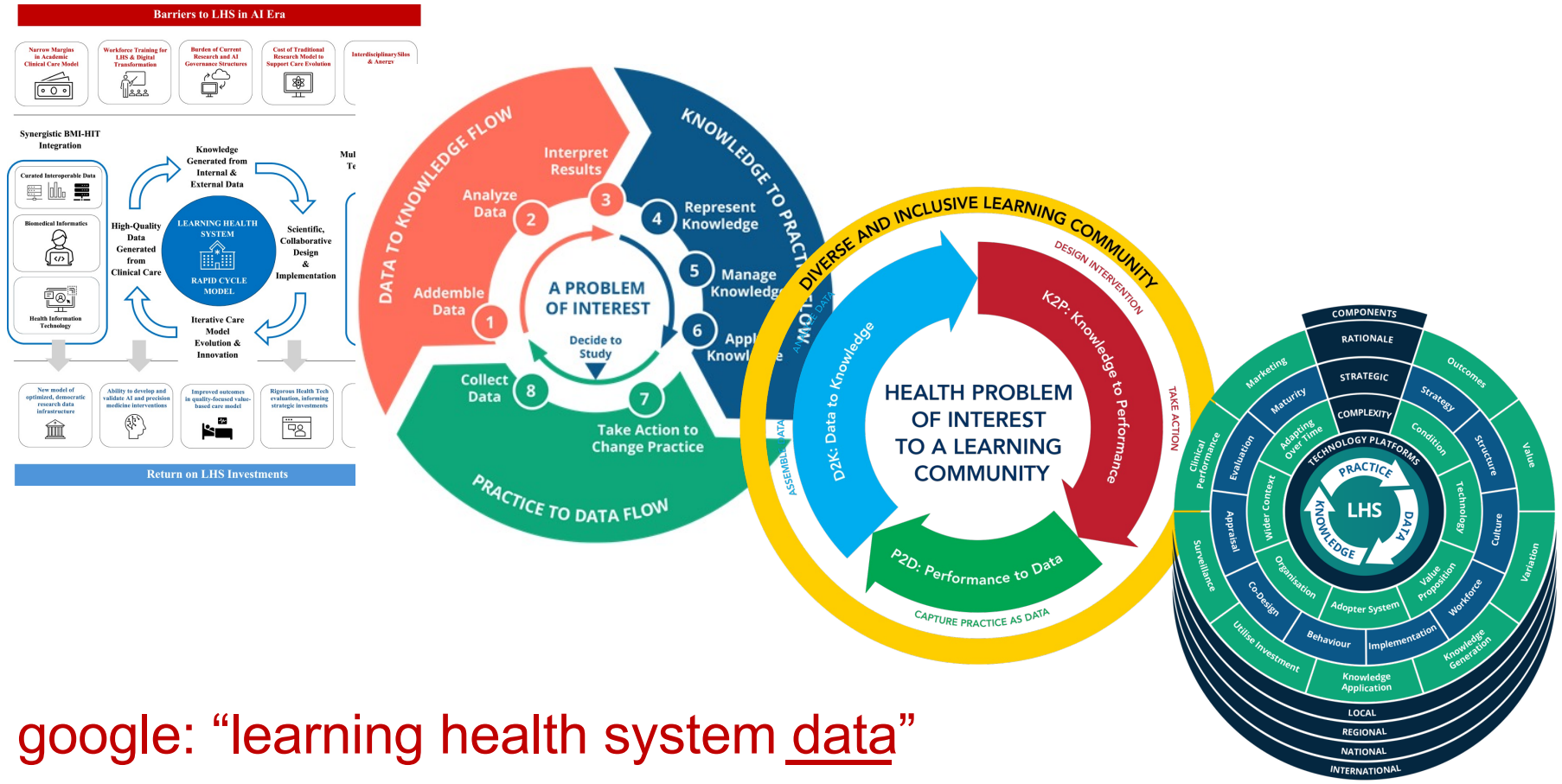
- Analysis
- Evidence generation
- Pattern identification

Knowledge → Performance



- CDS tools
- Application in practice
- Continuous monitoring / Closing the loop

google: “learning health system”



google: “learning health system data”

LHS in Action

- Geisinger Health System implemented
  - comprehensive, team-based diabetes care model
  - across 38 primary care sites in Pennsylvania.

- The initiative used an “all-or-none” bundled care approach: patients received all 9 evidence-based interventions (e.g., HbA1c, BP, LDL control, eye exams, immunizations) at each visit.

- Key LHS strategies included:
  - EHR-integrated decision support and automated patient registries.
  - Monthly performance feedback and provider incentives (up to 20% of compensation).
  - Multidisciplinary care teams with delegated responsibilities and standardized workflows.

- Outcomes (3-year follow-up):
  - ↓ 23% in myocardial infarction (HR 0.77)
  - ↓ 21% in stroke (HR 0.79)
  - ↓ 19% in retinopathy (HR 0.81)

Compare to the self-management treatment model needed as generic therapy for prevalent TMDs

- Bloom FJ Jr, et al. Primary Care Diabetes Bundle Management: 3-Year Outcomes for Microvascular and Macrovascular Events. Am J Manag Care. 2014;20(6):e175–e182.
- Bloom FJ Jr, et al. Redesign of a Diabetes System of Care Using an All-or-None Diabetes Bundle to Build Teamwork and Improve Intermediate Outcomes. Diabetes Spectrum. 2010;23(3):165–169.

Information from LHS that is available to the provider

1. EHR-Integrated Decision Support

- Providers receive real-time prompts and alerts within the electronic health record (EHR) to ensure all components of the diabetes care bundle are addressed during each visit.
- Clinical decision support tools guide medication adjustments, lab ordering, and preventive care based on up-to-date guidelines.

2. Automated Patient Registries

- A continuously updated diabetes registry tracks all patients with diabetes across the system.
- Providers can view individual and population-level data, including trends in HbA1c, blood pressure, LDL cholesterol, and care gaps.

3. Patient "Report Cards"

- Generated automatically during visits, these summaries display key metrics (e.g., HbA1c, BP, LDL) and care goals.
- Used to engage patients in shared decision-making and self-management.

TMDs





Information from LHS that is available to the provider

TMDs

4. Monthly Performance Dashboards

- Providers and care teams receive monthly reports showing their performance on the “all-or-none” diabetes bundle.
- Dashboards include comparisons to peers and system-wide benchmarks, enabling targeted quality improvement.

5. Team-Based Workflow Tools

- Standardized workflows assign specific tasks (e.g., foot exams, immunizations, lab orders) to appropriate team members (e.g., nurses, medical assistants).
- Standing orders and pre-visit planning tools ensure that routine care is completed efficiently.

6. Incentive Alignment

- Provider compensation is partially tied to performance on diabetes care metrics, reinforcing adherence to best practices.

Monitoring Multi-Clinic Quality Improvement Initiative Increases Continuous Glucose Me

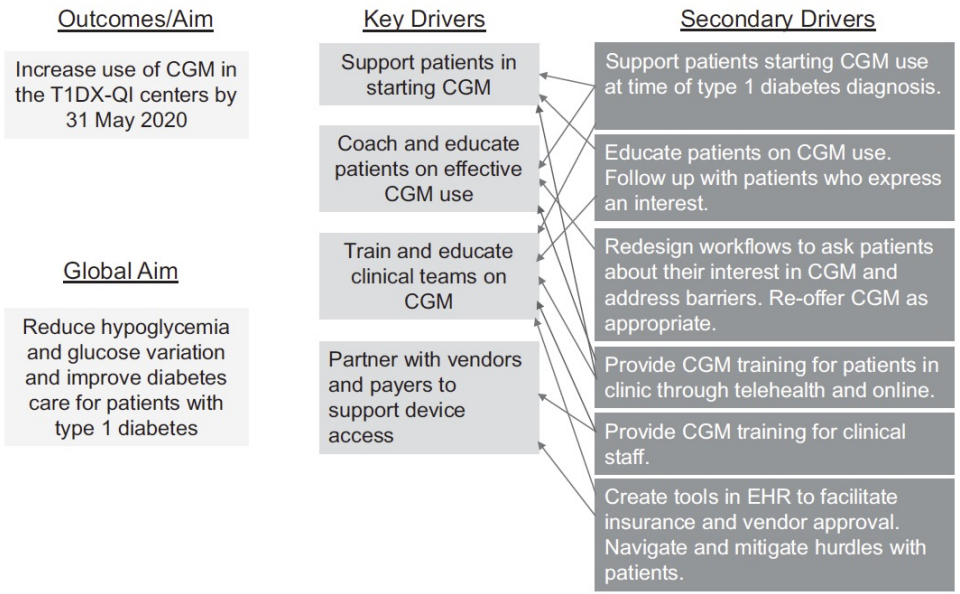
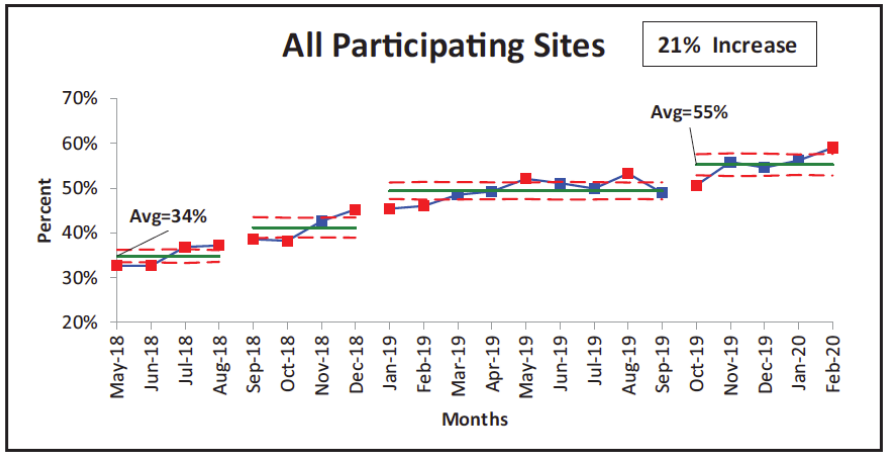


FIGURE 1 Key driver diagram for increasing CGM uptake across the T1DX-QI collaborative. The secondary drivers are interventions to support the key drivers.

California	New York
Colorado	Ohio
Michigan	Pennsylvania
Missouri	Texas



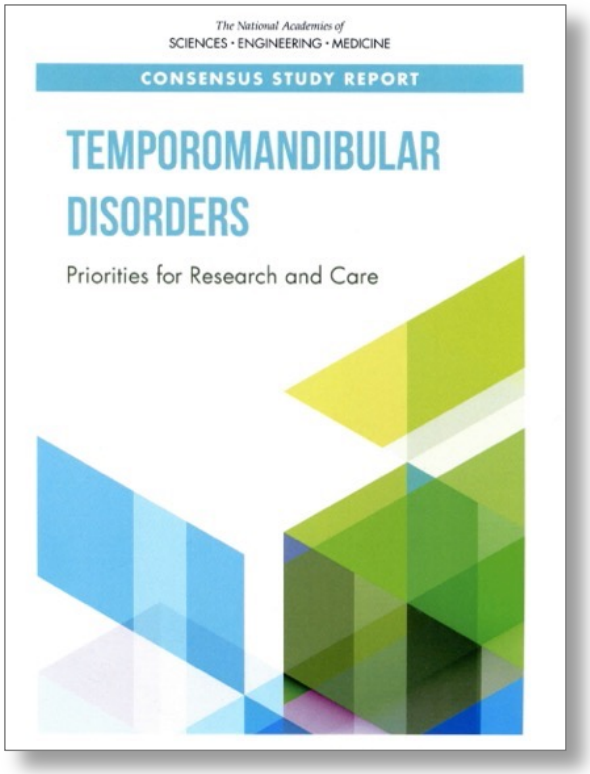
Prahalad et al, Multi-Clinic Quality Improvement Initiative Increases Continuous Glucose Monitoring Use Among Adolescents and Young Adults With Type 1 Diabetes. Clinical Diabetes

A Learning Health System principle: Involvement in PBRN research leads to evidence adoption

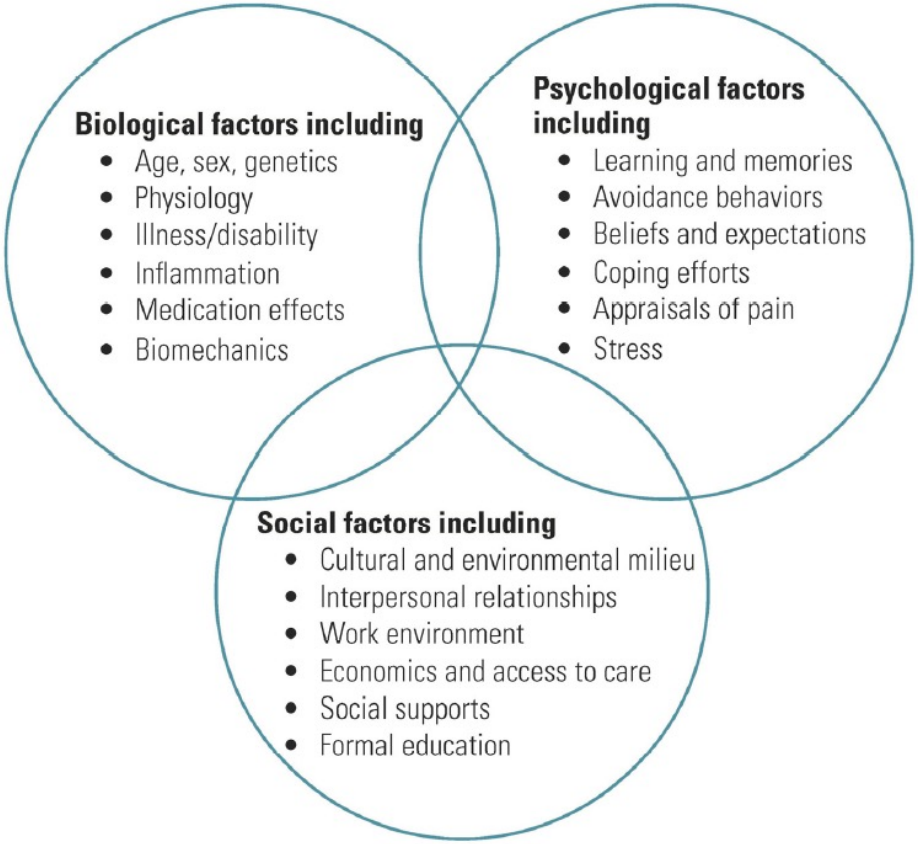
(a model to be applied to TMD care?)

Community knowledge changes provider beliefs	Gilbert et al., *Gen Dent,* 2010	After a network-wide meeting, a majority of participating dentists reported intent to shift toward more conservative caries treatment (less drilling), a sharp increase compared to pre-meeting intentions.
Community knowledge and engagement changes provider behavior	Gilbert et al., *Community Dent Oral Epidemiol,* 2013	Over ~3 years, dentists highly **engaged in PBRN studies & meetings** showed significant shifts toward **less invasive** caries management in 4 of 6 clinical scenarios (vs. minimal change among less-engaged practitioners).
Community engagement changes provider behavior which extends to colleagues	Rindal et al., *Implement Sci,* 2014	Real-world EHR data confirmed **PBRN-participating dentists** reduced aggressive interventions (~15%) for early caries far more than non-participants (~7%). These practice changes were **sustained** over time and even **transferred over** to colleagues in the same clinics who hadn't attended the PBRN training, indicating peer-to-peer influence.

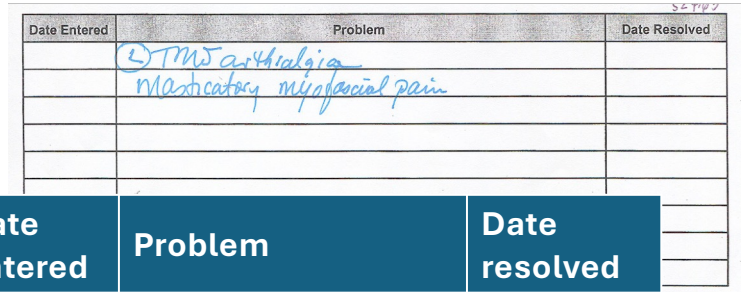
TMDs as complex diseases



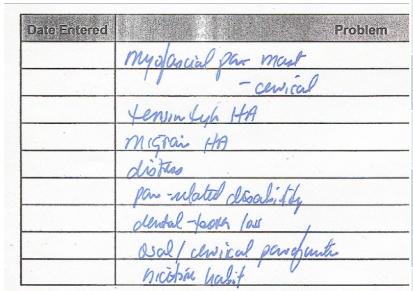
Published March 2020



Example problem lists for patients with a TMD



Date entered	Problem	Date resolved
	Left TMJ arthralgia	
	Myofascial pain: masticatory system	



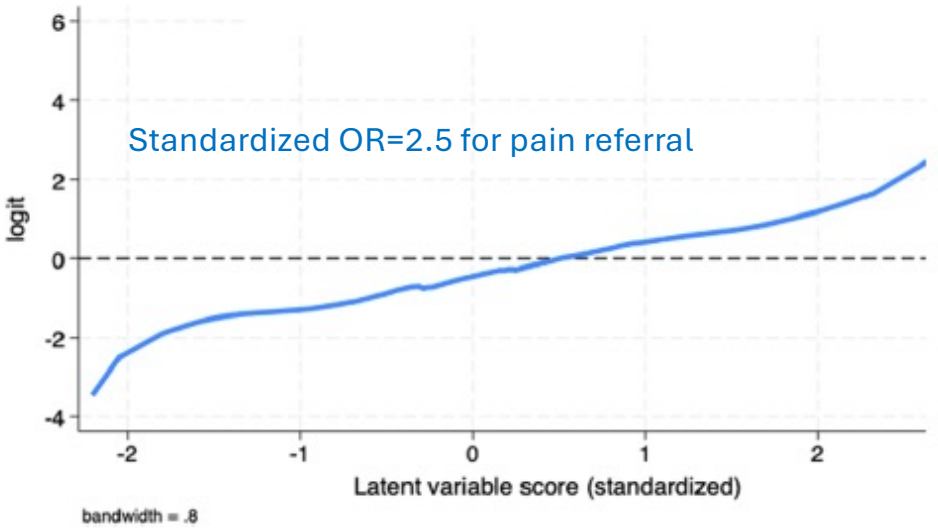
Date entered	Problem	Date resolved
	Myofascial pain: masticatory system	
	Myofascial pain: cervical system	
	Tension-type headache (chronic)	
	Migraine with aura	
	Distress	
	Pain-related disability	
	Masticatory and cervical parafunction	
	Nicotine addiction	
	Dental problems: tooth loss and chewing instability	

Integration of relevant evidence into clinical care

Nociceptive drive: component indicators

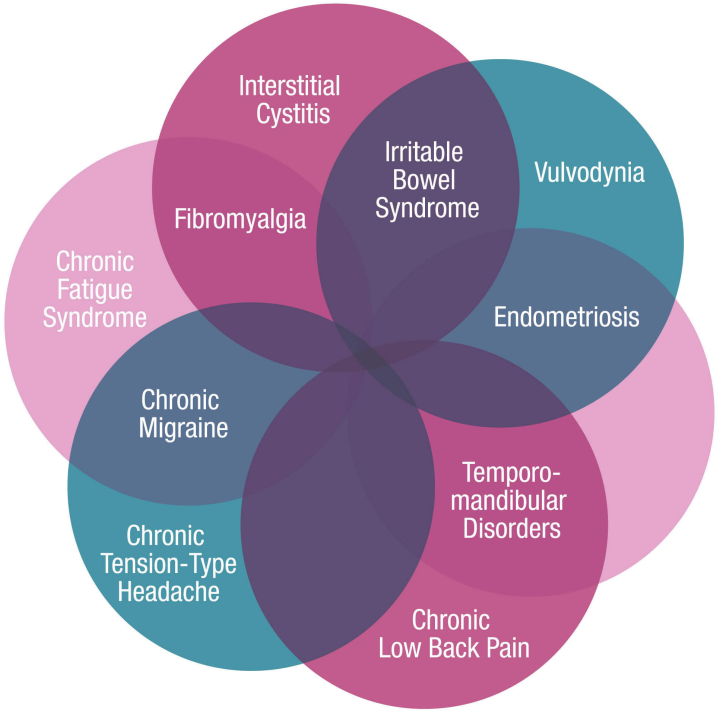
- non-specific orofacial symptoms
- pain-free opening
- pressure pain sensitivity of the trigeminal region
- hyperalgesia from mobility
- hyperalgesia from joint sounds
- number of pain manikin-sites from the neck and above

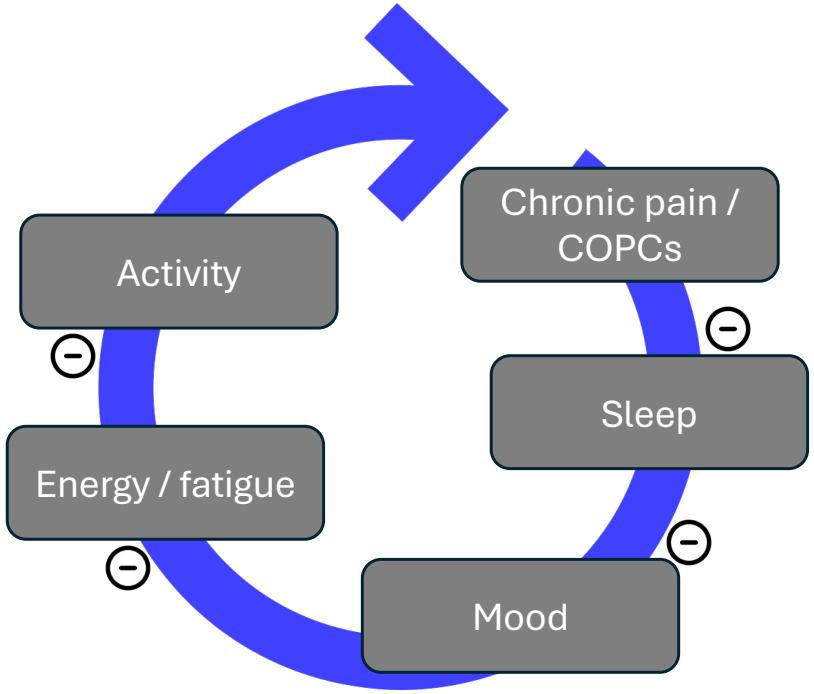
Latent variable: nociceptive drive



Zebda H, Gonzalez Y, Crow H, Ohrbach R. Myofascial pain with referral: role of nociceptive drive and central pain mechanisms. J Pain, 2026.

Chronic overlapping pain conditions (COPCs)

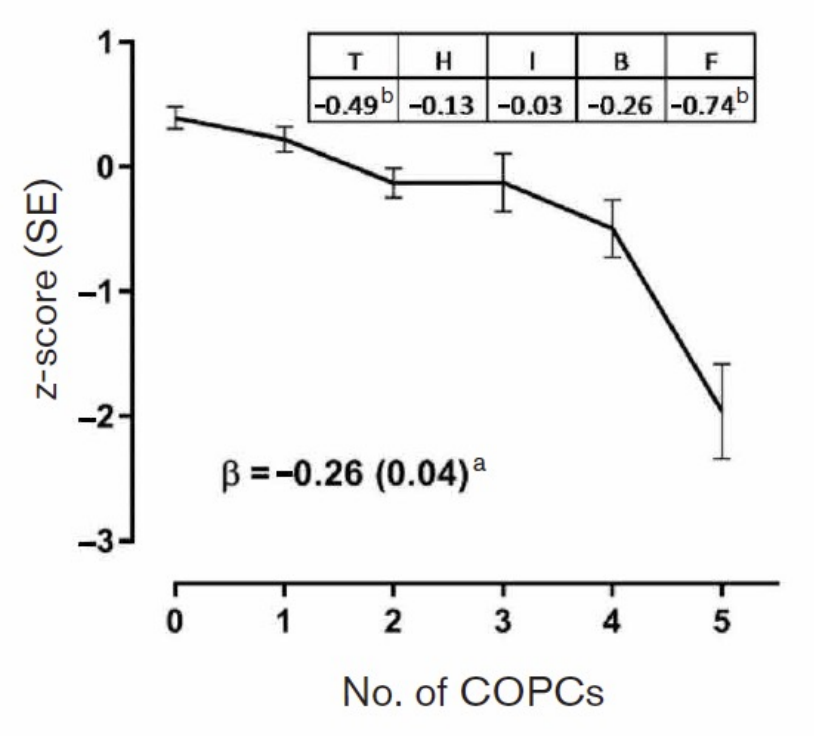




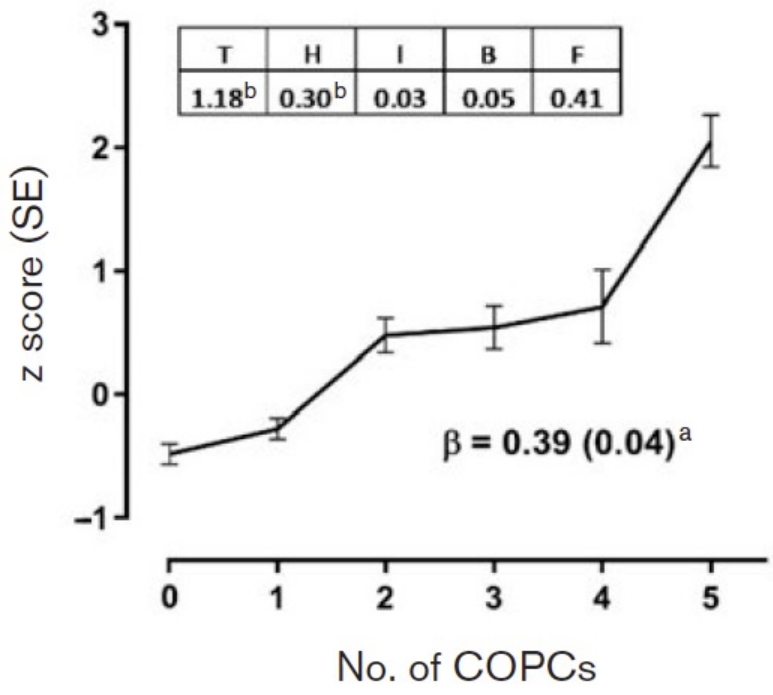
Veasley C et al (2015). Impact of Chronic Overlapping Pain Conditions on Public Health and the Urgent Need for Safe and Effective Treatment: 2015 Analysis and Policy Recommendations. Chronic Pain Research Alliance

Influence of COPCs on TMD-specific characteristics

Pain-free jaw opening



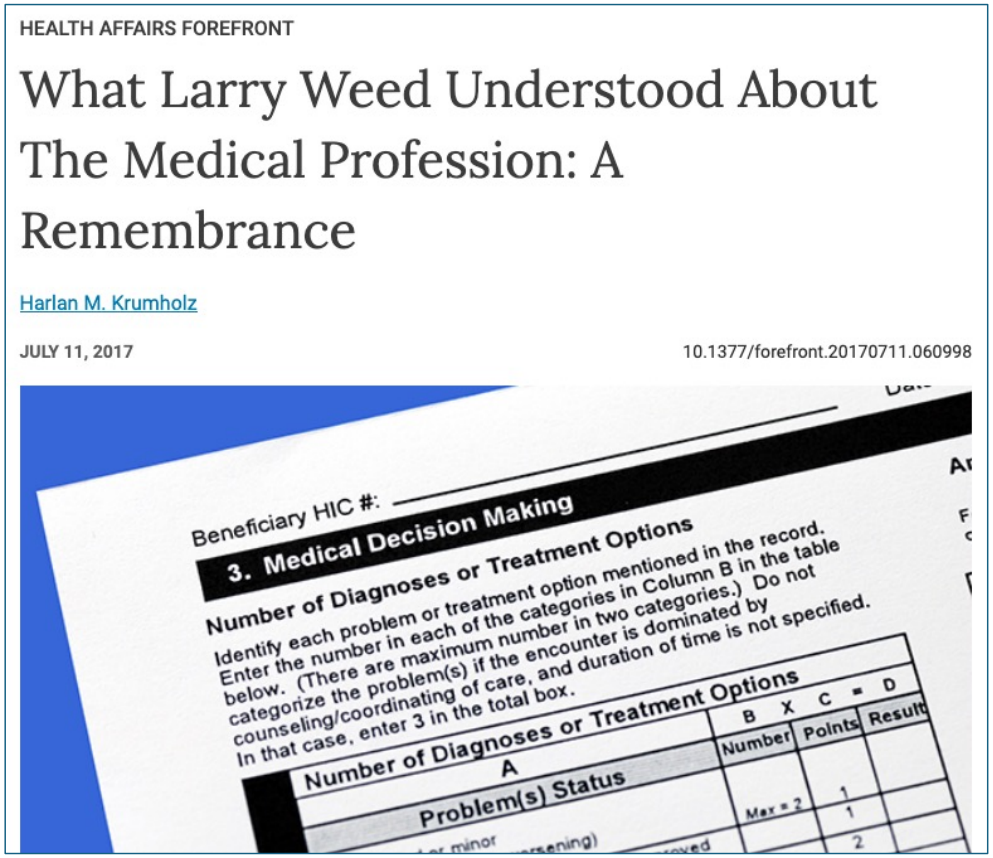
Non-specific orofacial symptoms



Sharma et al, Attributes germane to TMDs and their associations with 5 COPCs. JOFPH 2020

One early prototype for the LHS

Larry Weed using PROMIS touchscreen circa 1980



HEALTH AFFAIRS FOREFRONT

What Larry Weed Understood About The Medical Profession: A Remembrance

Harlan M. Krumholz

JULY 11, 2017

10.1377/forefront.20170711.060998

Beneficiary HIC #:

3. Medical Decision Making

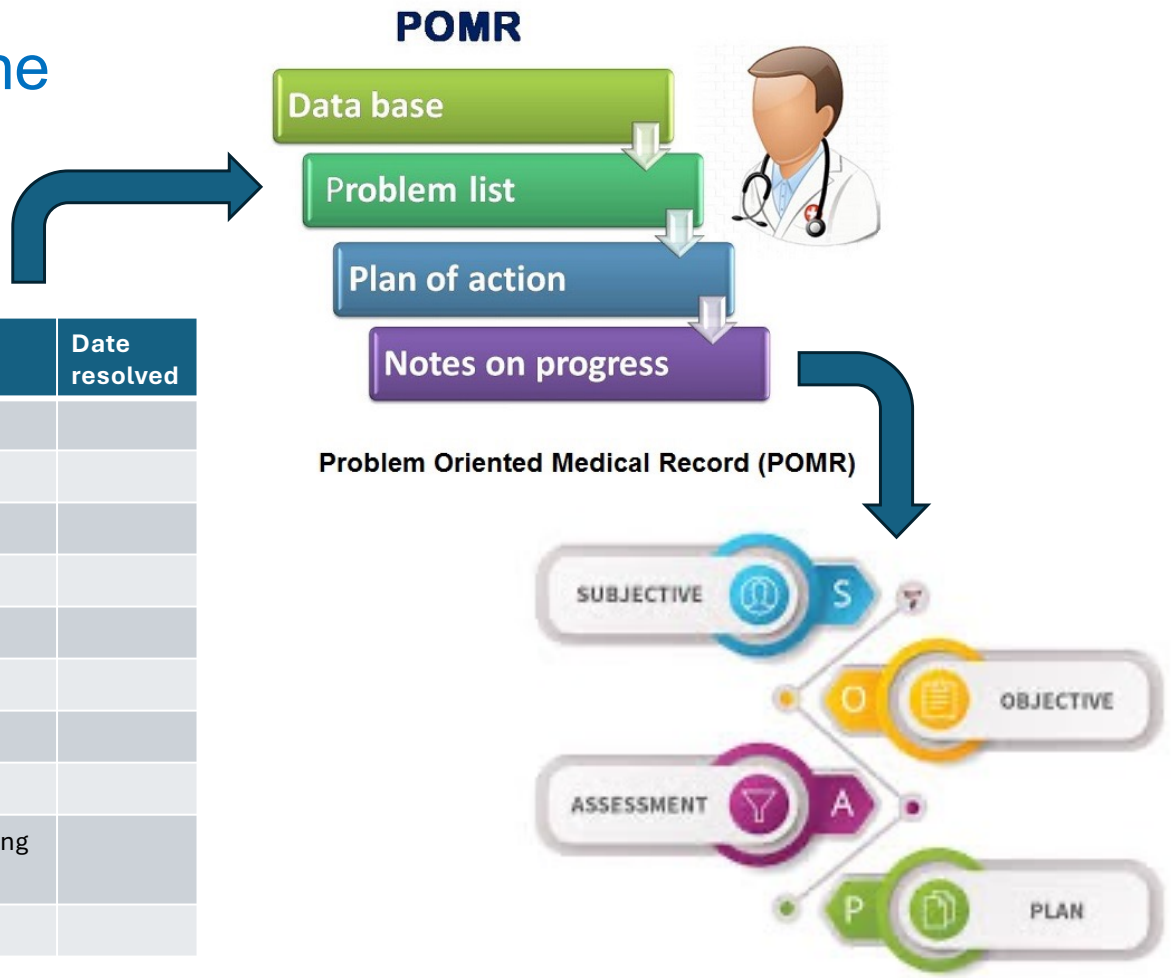
Number of Diagnoses or Treatment Options

Identify each problem or treatment option mentioned in the record. Enter the number in each of the categories in Column B in the table below. (There are maximum number in two categories.) Do not categorize the problem(s) if the encounter is dominated by counseling/coordinating of care, and duration of time is not specified. In that case, enter 3 in the total box.

Number of Diagnoses or Treatment Options	B	X	C	=	D
A	Number		Points		Result
Problem(s) Status					
	Max = 2		1		
			1		
			2		

Weed's solution for the management of complex disease

Date entered	Problem	Date resolved
	Myofascial pain: masticatory system	
	Myofascial pain: cervical system	
	Tension-type headache (chronic)	
	Migraine with aura	
	Distress	
	Pain-related disability	
	Masticatory and cervical parafunction	
	Nicotine addiction	
	Dental problems: tooth loss and chewing instability	



The impact of computer technology on medical care
R.E. Dayhoff

The case fo
J.A. Reggia

NMR imagi
P.C. Lauterbur

Computers in medical education: present and future
G.O. Barnett;E.P. Hoffer;K.T. Famiglietti

Emerging Mosaic of Information Processing Standards for Computer Applic
Medical Care Systems
T.M. Kurihara

Technology in hospitals the effect of prospective reimbursement
D.W. Simborg

Making Me
T. Kehl

AHIS Plann
G.S. Coher

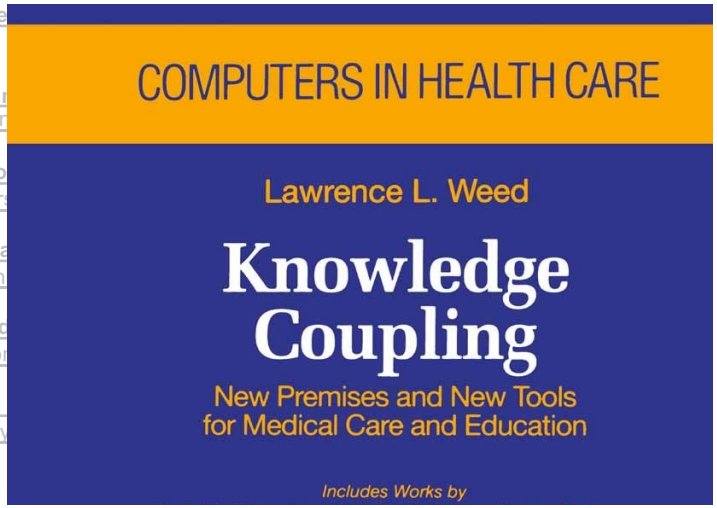
Methodolo
S.D. Jawors

An informa
W.R. Menn

Automated
J.E. Siemor

Sys/planr:
G. Kolenaty

The Seventh Annual Symposium on Computer Applications in Medical Care, 1983. Proceedings.
DOI: 10.1109/SCAMC.1983
23-26 Oct. 1983



A national survey of hospital data processing
R.R. Grams

AHIS implementation

Large scale implementation of-compatible hospital computer systems within the veterans administration
M.T. Ivers;G.F. Timson;H. von Blankensee;C. Whitfield;P.D. Kelly;C.N. Pfeil

The evolving marriage of a local area network (LAN) and a hospital information

The use and construction of problem-knowledge couplers, the knowledge coupler editor, knowledge networks, and the problem-oriented medical record for the microcomputer
L.L. Weed; R.Y. Hertzberg

W.T. Chave;R.E. Keefe

Computers in community hospitals -for patient care - for doctors - for nurses - for administrators
W.J. Ritter

The veterans administration's approach to hospital automation
J.F. Mcguire;R.M. Cooper

Automated Medical Records and Quality Assurance
K.J. Dickie

A Medical Utilization Review System for Ambulatory Care Based on Automated Claims Data
S. Silva;A. Berkowitz;S. Lizanich-Aro;P. Jenkins

1 2 3 4 5 6 7 8 9 10 > Next

A Simulation Study Of Automated Treatment Planning In A Mental Hospital
T.J. Craig;M.A. Richardson;R. Pass;F. Simpson;I. Summers

Major limitations in LHS that can be improved by incorporation of ontology into the LHS

LHS limitation	Ontology "remedy"
Semantic Heterogeneity and Interoperability Failure → Clinical data emerge from disparate systems → Inconsistent terminologies and data structures	✓ Creation of formally defined representations of clinical concepts and relationships ✓ Permits application of smart AI for integration of the data for this patient
Shallow phenotyping limits the quality of generated evidence → Utility of LHS knowledge is dependent on the richness of patient characterization → Current CDMs standardize structure but not semantic integration for precision medicine	✓ OBO Foundry E.g., Phenotype enrichment shifts detection sensitivity for specific symptom cluster in insomnia from 17% to 98%
Inability to share and replicate learning across networks → Generalizability Is assumed for transfer of knowledge across settings	✓ Develop an ontology for specification of shared conceptualization: ○ What an LHS is ○ How its components relate ○ What outputs yield generalizable knowledge

Aspirational list of LHS attributes (for complex diseases, TMDs)

Ontology !

1. Ensure core treatment goals are implemented well
2. Diagnostic test characteristics, disease sensitivity and specificity, given selected tests
3. Incorporate “umbrella” conditions (e.g., COPCs)
4. Monitor dDx
5. Tracking standard and patient-specific outcomes
6. Monitor Problem List
   - Integrate current data into the problems
   - Alerts for what is not being tracked
   - AI-enabled probe for reclassify and set new priorities in the problem list
7. Manage a SOAP-type documentation (ties to 3, 4, and 5)
8. Contribute to de-implementation as well as implementation

Thank you…

Acknowledgements

The CREATE team, part of TMD IMPACT Collaborative
Funding: U54-DE035413