Essential Characteristics of a Knowledge Management Program

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Disclosure

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Wife is an employee of Wolters-Kluwer
Overview
Definitions, motivation, challenges
Knowledge Management Program
Knowledge modeling (requirements)
Conclusions
What is knowledge management?

“Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers.” [Gartner Group]

“Knowledge management (KM) as a collection of systematic approaches to help information and knowledge flow to and between the right people at the right time (in the right format at the right cost) so they can act more efficiently and effectively to create value for the organization.” [APQC – American Productivity & Quality Center]
Reported pitfalls

“Knowledge is tied up in politics and ego and culture”

“… most organizations just wanted to put in a system to manage knowledge, and that wasn’t enough to make knowledge flow and be applied.”

“… technology that organizations wanted to employ was Microsoft’s SharePoint.”

“Many people didn’t have the patience or time to find everything they needed. Ironically, the greater the amount of knowledge, the more difficult it was to find and use.”

“KM never incorporated knowledge derived from data and analytics.”

Approach within healthcare

“… make the knowledge so **readily accessible** that it **can’t be avoided.**”

“… the most promising approach is to **embed** it **into the technology** that knowledge workers use to do their jobs.”

“Embedding knowledge into everyday work processes is **time-consuming** and **expensive** … without a very good reason … surprisingly high numbers of medical **errors** and **adverse drug reactions**”

“Survival” of clinically important evidence

Context
Clinicians rely on systematic reviews for current, evidence-based information.

Contribution
This survival analysis of 100 meta-analyses indexed in ACP Journal Club from 1995 to 2005 found that new evidence that substantively changed conclusions about the effectiveness or harms of therapies arose frequently and within relatively short time periods. The median survival time without substantive new evidence for the meta-analyses was 5.5 years. Significant new evidence was already available for 7% of the reviews at the time of publication and became available for 23% within 2 years.

Implication
Clinically important evidence that alters conclusions about the effectiveness and harms of treatments can accumulate rapidly.

Knowledge explosion & quality

“Systematic reviews are growing exponentially: current estimates suggest that over 8,000 systematic reviews are published annually”

“A substantial number of SRs in acute management of moderate to severe TBI lack currency, completeness and quality”

Data comparability and consistency

“Progress on the road toward integrating big data — both high-volume genomic findings and heterogeneous clinical observations — into practical clinical protocols and standard healthcare delivery requires that providers, HIT vendors, federated knowledge resources, and patients can ultimately depend upon those data being comparable and consistent.”

- “Absent comparability, the data are more or less by definition not able to support inferencing of any scalable kind …”
- “Without consistency, users of complex biomedical data will have to spend added resources transforming the data into usable and predictable formats …”

Challenges for AI

“There is a great deal of interest in the potential of using the vast data sets represented in electronic health records (EHRs), in combination with AI algorithms …”

- “… AI can perform with great accuracy when the relationship between diagnostic data and the diagnosis is well defined, when the relationship between the data and the diagnosis suffers from error, variability or difficulty in discrimination, AI algorithms also perform less well.”

“Extreme care is needed in using EHRs as training sets for AI, where outputs may be useless or misleading if the training sets contain incorrect information or information with unexpected internal correlations.”

Relevance of data/knowledge engineering

“.. two viable solutions to address heterogeneous data:

• defining a “common representation” and transforming all data into that common interlingua, or
• adopting standards at the point of data generation to obviate the costs and confusion that often emerge from data transformation.”

“… inferences will have hugely more power and accuracy if we aim big data methods at information that shares names and values”

• “we do not want to waste analytic resources “discovering” that renal cancer behaves similarly to kidney cancer”

Promising preliminary results

“Low-volume, structured clinical data contain sufficient information to train classifiers to perform near physician-level.”

- 799 cases independently validated by more than 2 medical professionals (medical students and physicians)

“Collecting such data is possible through human computation that is independently useful to clinicians.”

Learning System

Adapted from Charles Friedmann & Tonya Hongsermeier
KNOWLEDGE MANAGEMENT PROGRAM
Clinical Knowledge Management (CKM)

**Systematic** and **sustainable** acquisition, representation, and management of knowledge (content)

- Assets → clinical decision support, population management, analytics, etc.

Includes the **adaptation** (localization) knowledge assets to reflect local and institutional requirements, resources, and priorities

Follows a well-defined **lifecycle**, including specific stages for documentation, testing, and monitoring – supported by integrated set of tools and resources

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Utilization of knowledge assets

Reference knowledge selection and retrieval
  • e.g., infobuttons, crawlers

Information aggregation and presentation
  • e.g., summaries, reports, dashboards

Data entry assistance
  • e.g., forcing functions, calculations, evidence-based templates for ordering and documentation

Event monitors
  • e.g., alerts, reminders, alarms

Care workflow assistance
  • e.g., protocols, care pathways, practice guidelines

Descriptive or predictive modeling
  • e.g., diagnosis, prognosis, treatment planning, treatment outcomes
Program guiding principles

Objectively improves safety, quality, and efficiency

Supported by evidence, clinical best practices, and sound clinical thinking

Aligns with and promotes clinical & business goals

Acceptable to end users (workflow integration)

Adheres to informatics and KM best practices

Best utilizes talent, resources, and capital

(Supports research and teaching missions)
Scope of CKM activities

- **CDS**
  - alerts, reminders, medication warnings, duplication warnings, therapeutic alternatives, infobuttons, etc.

- **Data Templates**
  - forms, flowsheets, documentation templates, data fields, calculators, etc.

- **Data Definitions**
  - value sets and classification rules for problems, medications, procedures, etc.

- **Terminologies & Ontologies**
  - master files, dictionaries, translation tables, and reference ontologies (e.g. SNOMED CT, ICD-10-CM, LOINC)

- **Software Infrastructure**
  - editors, portals, repositories, virtual collaboration tools, knowledge retrieval services, rule execution engines
Complexity =

Heterogeneity +
  • Different types of assets

Connectivity +
  • Assets are highly interconnected (interrelated)

Rate of change +
  • Assets change frequently

Quantity
  • Large quantities of assets

• Resources ↔ effort ↔ scope
Successful KM Program?

Effectively utilize knowledge-driven computer systems
Overcome knowledge engineering and implementation challenges

KM Program challenges

Governance and stewardship are difficult to implement
- Domain experts (SMEs) frequently have limited commitment
- Cost of not having knowledge is frequently overlooked
- Lack of a systemic view promotes overlapping efforts (variation)

Processes and tools to create and manage assets are inadequate
- Knowledge once deployed for use is not easily accessible (locked)
- Maintenance of knowledge assets is an afterthought
- Processes for configuring and vetting assets not explicitly defined

Liability from outdated or incorrect assets not recognized

Analytics regarding effect on clinical processes and outcomes generally not available
Analytics on knowledge acquisition and engineering processes generally not available
CKM governance options

Centralized (top-down)
- Corporate sanctioned groups
- Dedicated central resources
- Assets pre-approved & pre-prioritized
- Enterprise implementation

Grassroots (bottom-up)
- Front-line clinicians
- Shared central resources
- Central asset approval & prioritization
- Enterprise implementation

Distributed (decentralized)
- Local sanctioned groups
- Shared central resources
- Local approval & prioritization
- Enterprise implementation

Independent (autonomous)
- Local resources & governance
- Dedicated local resources
- Local approval & prioritization
- Local implementation

Outsourced (menu based)
- 3rd party assets
- Dedicated central resources
- Central or local approval & prioritization
- Enterprise implementation
Optimal governance?

Alignment with **business needs** and overall **clinical strategy** – expected differentiation and **competitive advantage**

Appropriate decision **autonomy** and **communication** – streamlined approval and prioritization (**transparency**)

Empowerment of frontline clinicians (knowledge workers) – tangible **benefits** to **stakeholders** and **end-users**

Reasonable implementation costs (customization) – consistency and **long-term maintainability**

Single process will likely not support expectations

- Optimal allocation of resources to each governance process
- Resolution of potential conflicts between processes
Lifecycle models with “outsourcing”

Knowledge
Content only

- Import
- Update
- EHR with CDS
- Configure

Knowledge
Services + Content

- Integrate
- EHR with CDS
- Configure

Both require content localization (configuration)
KNOWLEDGE MODELING
Modeling concepts

- **Vaccine**
  - CVX code: string

- **Disease**
  - ICD Code: string

- **Instances**
  - Pneumococcal conjugate PCV 13
    - CVX code: 133
  - Pneumococcal meningitis
    - ICD code: G00.1

- Prevents:
  - Pneumococcal conjugate PCV 13 prevents Pneumococcal meningitis

Modeling assets

Vaccine
- CVX code: string
- Manufacturer: [MVX]
- Date approved: dateTime
- Route: [vaccine route]
- Type: [vaccine type]
- ...

Provenance
Identifier(s)
Designation(s)
Context(s)
Reference(s)
Properties
Associations
Additional Requirements

Knowledge Representation

• Links (dependencies)
• Lifecycle (evolution)
• Versioning
• Integrity

Knowledge Management
Asset integrity

The integrity of the knowledge repository should be enforced

- Referential
- Structural
- Semantic

- Increases efficiency
- Decreased maintenance efforts $\rightarrow$ quick ROI
- Supports on demand content dissemination
Asset versioning

- **v1**: Pneumococcal conjugate PCV 7
  - When content evolves, changes should be reflected by new asset versions
  - Need to be able to revise individual assets (in addition to complete collections)

- **v2**: PCV 7 by Wyeth
  - Version history must be accessible

- **v3**: PCV 7 retired
  - Clear definition of when to create new versions vs. create new (different) assets
Asset lifecycle

Standardized process from asset creation to publication to deactivation

- **In progress**: Changes without new versions should only be possible in an initial phase.
- **Approval**: The lifecycle must include review & vetting and approval states.
- **Publication**: The lifecycle must identify state where asset is published for effective use.

Terminal states should be immutable.
Asset links

- When assets evolve independently, links must remain valid (correct)
- Checking links (dependencies) must be manageable
- Must be possible to refer to a specific version of an asset, but also the “most current” one
Example 1: data collection form (~1,876 assets)

- 1 form with 8 sections
- 22 data elements (fields)
- 5 value sets
- 87 primary concepts with 120 mappings
- 899 linked concepts with 734 mappings
Example 1: implementation - semantic relationships

- UMLS (n = 91 + 614)
- MedDRA (n = 223)
- ICD-10-CM (n = 37)
- SNOMED (n = 260)
- NCI Thesaurus (n = 288)
- caDSR (n = 87 + 120)
Example 2: “simple” CDS rule

Do not test for amylase in cases of suspected acute pancreatitis. Instead, test for lipase.

Amylase and lipase are digestive enzymes normally released from the acinar cells of the exocrine pancreas into the duodenum. Following injury to the pancreas, these enzymes are released into the circulation. While amylase is cleared in the urine, lipase is reabsorbed back into the circulation. In cases of acute pancreatitis, serum activity for both enzymes is greatly increased.

Serum lipase is now the preferred test due to its improved sensitivity, particularly in alcohol-induced pancreatitis. Its prolonged elevation creates a wider diagnostic window than amylase. In acute pancreatitis, amylase can rise rapidly within 3–6 hours of the onset of symptoms and may remain elevated for up to five days. Lipase, however, usually peaks at 24 hours with serum concentrations remaining elevated for 8–14 days. This means it is far more useful than amylase when the clinical presentation or testing has been delayed for more than 24 hours.

Current guidelines and recommendations indicate that lipase should be preferred over total and pancreatic amylase for the initial diagnosis of acute pancreatitis and that the assessment should not be repeated over time to monitor disease prognosis. Repeat testing should be considered only when the patient has signs and symptoms of persisting pancreatic or peripancreatic inflammation, blockage of the pancreatic duct or development of a pseudocyst. Testing both amylase and lipase is generally discouraged because it increases costs while only marginally improving diagnostic efficiency compared to either marker alone.
**Example 2: implementation**

<table>
<thead>
<tr>
<th>Event</th>
<th>Required elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Order: Amylase</td>
<td>• Lab tests (discrete codes) mapped to LOINC concepts</td>
</tr>
<tr>
<td>Condition</td>
<td>• Diagnoses (value set) mapped to SNOMED or ICD-10-CM concepts</td>
</tr>
<tr>
<td>• Diagnosis: Acute Pancreatitis</td>
<td></td>
</tr>
<tr>
<td>Action</td>
<td>What else?</td>
</tr>
<tr>
<td>• Order: Lipase (instead)</td>
<td>• Clinical presentation delay?</td>
</tr>
<tr>
<td></td>
<td>• Testing delay?</td>
</tr>
<tr>
<td></td>
<td>• Repeated order?</td>
</tr>
<tr>
<td></td>
<td>• Exceptions based on signs and symptoms?</td>
</tr>
</tbody>
</table>

**Additional details**

- Delayed clinical presentation or testing ( > 24 hours )
- Not repeat to monitor prognosis ( with exceptions )
Example 3: “complex” CDS rule

Implementation Guide

USPSTF Statin Use for the Primary Prevention of CVD in Adults

Prepared for:
Agency for Healthcare Research and Quality
U.S. Department of Health and Human Services
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Example 2: “complex” CDS rule

**Inclusions**
- Patient is $\geq 40$ and $\leq 75$ years of age
- AND 1 or more risk factor:
  - LDL-C lab result $> 130$ mg/dL (MOST RECENT value within the past 6 years)
  - OR HDL-C $< 40$ mg/dL (MOST RECENT value within the past 6 years)
  - OR Diabetes (Type 1 or Type 2)
  - OR Hypertension
  - OR Smoking (MOST RECENT value within the past 6 years)
  - AND 10-Year CVD risk score $\geq 7.5\%$ (MOST RECENT value within the past 6 years)

**Exclusions**
- Diagnosis of CVD
- OR LDL-C lab result $> 190$ mg/dL (MOST RECENT value within the past 6 years)
- OR Known Familial Hypercholesterolemia
- OR Diagnosis of Active Pregnancy OR Pregnancy Observation in the past 42 weeks
- OR Diagnosis: Breastfeeding OR Breastfeeding Observation in the past year
- OR Diagnosis of End Stage Renal Disease
- OR Actively undergoing dialysis (i.e., within past 7 days)
- OR Diagnosis of Active Cirrhosis
- OR Already receiving a statin (Medication is Active or has been Ordered)
Example 2: implementation

28 value sets
- LDL Test, Diabetes, Hypertension, Ischemic vascular disease, Breastfeeding, etc. (VSAC)

38 statements (logic)
- Age group, most recent LDL, has Diabetes, most recent Smoking Status, has familial Hypercholesterolemia, etc.

6 display messages

Logic is not complex: age + risk factors + risk score
- However, data and terminology dependencies make implementation (and maintenance) quite difficult
CONCLUSIONS
Implementation sequence

Inventory
Catalog
Consolidation
Lifecycle
Refinement
Evolution

Provenance
Indexing
Linking
Management
Semantics
Reasoning
Knowledge has to “follow” the patient

Clinical systems might have very similar CDS features, but are frequently not configured the same way

- CDS triggered in one setting may not be confirmed or re-enacted in subsequent settings

Without continuity and consistency across settings and institutions, interventions have decreased effectiveness for disseminating evidence and reducing unwarranted variability
CKM Program: core activities

Establish governance for essential asset types

Define and optimize curation processes (lifecycle)

Implement software platform integrated with asset sources and consumers

Monitor & evaluate interventions and processes

Seek alignment with standards, maximizing interoperability and external collaborations

Collaborate with other institutions to help amortize operational costs and promote innovation
Successful CKM Program

Enables health care institutions to **effectively utilize** computer systems with **embedded knowledge**

- Improve care safety and quality
- Keep pace with frequent scientific advances
- Embrace new care delivery models
- Promote continuous learning
- Enable collaboration among institutions

Overcome (mitigate) **complexity**
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