A Comparison between Chinese and US Electronic Health Records Database Structures

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BACKGROUND

Electronic health records (EHRs) facilitate the delivery and quality of healthcare services. The **American Society for Testing and Materials Standard Practice for Content and Structure of EHRs E1384** (ASTM Standard) is one US standard for designing EHRs. The US has also adopted a standard for EHR functionality, referred to as **Meaningful Use** (MU), which promotes clinical and safety quality. As part of its 2009 national health reform, China is also developing similar EHR standards.

OBJECTIVE

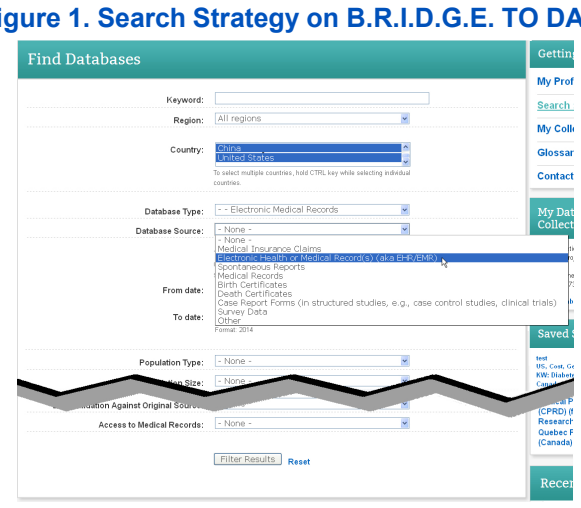
To compare data elements and concordance with EHR data categories in Chinese and US EHR databases (DBs).

METHODS

B.R.I.D.G.E. TO DATA® (www.bridgetodata.org) is a centralized compendium of population healthcare DB profiles worldwide that utilizes **standardized data fields** to describe the types of information captured within a DB, including EHRs.

1. EHRs were identified by the following criteria (**Figure 1**):
   Database Type = *Longitudinal population database* and *EHR*;
   OR Database Source = *EHR/EMR*;
   AND Country = *China* or *USA*.
2. Search results were screened for inclusion/exclusion criteria.
   Inclusions: China or USA coordinating country
   Exclusions: Other DB types, such as registries

Figure 1. Search Strategy on B.R.I.D.G.E. TO DATA®



3. Relevant elements from China EHR standards[1], US ASTM Standard[1], and MU core objectives[2] were mapped to ≥1 DB field in B.R.I.D.G.E.
4. Each selected profile (i.e., US/Chinese EHRs) was manually compared to their respective national EHR standards and MU core objectives. Concordance to each standard was calculated as:
   %Concordance = 100 x (Total standards met / Total standards in analysis).
5. A data structure comparison was done between US and Chinese EHRs.

RESULTS – Part 1

- The initial search yielded a total of 112 (48%) out of a total 233 DBs profiled in B.R.I.D.G.E. Further screening of the 112 profiles led to the exclusion of non-US/-Chinese DBs (40; 36%) and non-EHRs (61; 54%).
- The final study set included 1 Chinese (Shanghai FDA Hospital Medical Record DB) and 10 US EHRs.

Table 1 shows elements from US and Chinese EHR standards mapped to DB fields used in B.R.I.D.G.E profiles. This analysis utilized 18 of the 19 ASTM Standard and 23 of the 25 Chinese standards. EHR standards marked in **green** were utilized by ≥75% of the 10 US EHRs, and those in **red** represent <25% utilization.

Table 1. B.R.I.D.G.E. Elements Mapped to US & China EHR Standards

Segments of US ASTM E 1384 Standard	Top Level Data Groups of China EHR Standards	Examples from B.R.I.D.G.E.
1. Demographic/Administrative [2. Legal Agreements - N/A]	1. Demographics 2. Contact person 3. Address 4. Medical insurance [5. Document identifier - N/A]	Age, % Age Group, Gender, % M/F, Race, Geography, DOB, Sociodemographic, Death
3. Provider/Practitioners	6. Healthcare practitioner 7. Healthcare institution	Physician ID, Physcian Specialty, Pharmacy ID, Demographic, Physician Institution
4. Administrative/Diagnostic Summary	8. Diagnosis 9. Four Diagnostic methods in Traditional Chinese medicine [10. Service object identifier - N/A]	Diagnosis (Dx) , Birth Defects, Cancers, Infections
5. Chief Complaint Present Illness/Trauma Care 6. Scheduled Appointments/Events 7. Problem List 8. Progress Notes/Clinical Course 9. Exposure to Hazardous substances	11. Chief complaints 12. Event summary 13. Encounters/episodes notes 14. Present illness history	Dx Coded, Dx Dates, Dx Max Codes Allowed, Medical Hx, Family Hx, Pregnancy, Environmental Exposures
10. Assessments/Exams 11. Disposition	15. Physical exam 16. Assessments 17. Specific exam	Physical Exam Findings, Death certificate/Autopsy info, Discharge, Death
12. Family/Prenatal/Cumulative Health/Medical/Dental/Nursing History	18. Past medical history	Behavioral
13. Procedures 14. Care/Treatment Plans and Orders	19. Procedures 20. Nursing service 21. Health guidance 22. Care/treatment plans	Procedures Coded, # Procedure Codes, Procedure dates
15. Diagnostic Tests	23. Lab data	Lab info
16. Medications 17. Immunizations 18. Therapies	24. Medications	Drug Names, OTC/Rx/Other, Manufacturer, Drug dates, Regimen & Route, Dosage, Days Supply, Rx Max Codes Allowed, Primary/Secondary Rx Codes, Other Rx data
19. Financial	25. Financial information	Cost, Denomination, Type of Cost data, Surrogate Cost Data Link

The EHRs largely conformed to their respective country's standards:

- The Chinese EHR utilized 96% of the China standards.

RESULTS – Part 2

- All 10 US EHRs had ≥50% concordance (range 61%-100%) with the ASTM Standard, including 100% concordance by *Regenstrief (RMRS)* and *Rochester Epi (REP)*. ASTM Standards marked in **green** (**Table 1**) were utilized by ≥75% of the 10 US EHRS, and Progress Notes/Clinical Course (**red**) was the least utilized standard (21%).

Table 2 shows the MU core objectives mapped to DB fields used in B.R.I.D.G.E. profiles. This analysis included 21 of 23 MU core objectives. MU objectives marked in **green** were utilized by ≥75% of the 10 US EHRs, and those in **red** represent <25% utilization.

Table 2. Examples of B.R.I.D.G.E. elements that map to MU Core Objectives

Meaningful Use Core Objectives	Examples from B.R.I.D.G.E.
1. Use CPOE for medication orders entered by HCP	Drug Data, Brief DB Description
2. Implement drug-drug and drug-allergy interaction checks Maintain 3. Active medication list, 4. Active allergy list	Drug Data, Drug Additional Information, Brief DB description
5. Maintain an up-to-date problem list of current and active diagnoses	Diagnoses (Dx) Data, Dx: Max Codes Allowed
Record Demographics: 6. Preferred language, 7. Gender, 8. Race, 9. Ethnicity, 10. Date of Birth, 11. Date and preliminary cause of death	Other Demographic Data, Gender, Race, Age, Death Recorded/Death Certificate
Record: 12. Height, 13. Weight, 14. Blood Pressure, 15. BMI (with calculation), 16. Growth chart for children, 17. Smoking (age ≥13 yrs)	Physical Exam Findings, Behavioral Data
18. Report hospital clinical quality measures	Brief DB Description, Data Validation
19. Implement 1 clinical decision support rule for high priority condition & track compliance	Brief DB Description
20. Capability to exchange key clinical information among patient's HCPs	Brief DB Description, DB Linkage Capabilities, Access to Med Records
21. Protect electronic health information (via certified EHR technology)	Brief DB Description
[22. Provide patients with copy of their electronic health information]	N/A
[23. Provide patients with their discharge information]	N/A

Adoption of the MU core objectives was incomplete by EHRs in both countries:

- Only 3 US EHRs had ≥50% concordance (range 29%-62%) with the MU core objectives (*RMRS* 62%, *REP* 57%, and *MedMining* 52%). The objectives most utilized by US EHRs were Active Medication and Diagnosis lists, and Demographic data (Gender, Race/Ethnicity, and DoB). Some objectives were not followed by any of these EHRs: Preferred language, Reporting hospital clinical quality measures, Clinical information exchange, and Protecting e-health information.
- The Shanghai FDA Hospital Medical Record DB had only 33% concordance with MU core objectives. As MU objectives are evolving, they are not fully implemented in China yet.

Cross-country comparisons showed that US EHRs currently capture more details on death, behavioral, and drug manufacturer data (**Table 3**).

Table 3. Excerpt from B.R.I.D.G.E. TO DATA® Comparing Data Elements in 2 US EHRs and 1 Chinese Medical Records DB

FIELD NAMES	Shanghai FDA Hospital Medical Record Database (CHINA)	MedMining (formerly Geisinger) (USA)	Regenstrief Medical Record System (RMRS) (USA)
Brief Database Description	The Shanghai FDA Hospital Medical Record DB is part of the Shanghai Drug Monitoring and Evaluative System (SDMES), a mutlifunctional evaluation and surveillance system initiated by the Shanghai Center for ADR Monitoring in 2001. The DB contains inpatient data from 10 hospitals in Shanghai and includes demographic, clinical, diagnostic & medication information.	MedMining licenses custom, de-identified, EHR-based data extracts. Representing both inpatient and outpatient settings, from primary to specialty care, the database includes a lot of standard data routinely captured at point-of-care. Specialty data are found in areas of Oncology, Pulmonology, Rheumatology, Cardiology, Geriatrics, etc. MedMining licenses medical, hospital, and pharmacy claims data for patients carrying Geisinger Health Plan (GHP) insurance.	The Regenstrief Medical Record System/Indiana Network for Patient Care (RMRS/INPC) is an EMR system containing data since 1972. Hospitals include Eskenazi Hospital and others have been added over the years. By early in the decade of 2000-2010, data from ERs of the 5 major hospital systems, accounting for more than 95% of emergency department visits, in Indianapolis were connected to the RMRS/INPC. Additionally, the RMRS/INPC currently allows emergency department physicians to view as a single virtual record all previous care at any of the participating hospitals. Note: Paper charts are still used in some locations in Indiana.
Database Type	Longitudinal Population Database, Drug and Diagnosis Data, Medical and Pharmacy Insurance Claims, Inpatient only	Longitudinal Population Database, Electronic Medical Records, Outpatient and Inpatient	Longitudinal Population Database, Drug and Diagnosis Data, Electronic Medical Records, Outpatient and inpatient
Database Source	(Electronic) Medical Records	Electronic Health Records	EMRs, Medical Insurance Claims, as well as other data sources
Years Covered	2003 - Present	1996 - Present	1972 - Present
Patient Type	Inpatient	Inpatient and Outpatient Emergency Room	Inpatient & Outpatient, Emergency Room (ER/ED), Homeless Clinics, Mental Health Sites, Wellness Centers, Public Health Dept., etc.
Database Population Size (Range)	<0.5 Million (~496,780 inpatient cases through 2011)	1 - 5 Million (1996-2012 = 3.9 Million distinct patients in DB; 2004-2012 = 1.36 Million distinct patients in DB.)	5 - 20 Million - RMRS/INPC has >10 million unique patients with >2 billion observations, >35 million full text reports, >140 million radiology reports
Age of Patients Age Breakdown Gender Data	Yes - DOB and Gender Data are provided; Breakdown by age or gender available upon request	Yes - Current Age provided; <18 years = 19.7%; >65 years = 20.1%; Gender data - M = 47%; F = 53%	Yes, age is provided; <18 years = 26%; >65 years = 11%; Gender data - M = 48%; F = 52%
Date of Birth Recorded	Yes (M/D/Y)	Yes - (D/M/Y) but de-identified data only show Year or Age	Yes
Death Recorded Availability of Death Certificate / Autopsy Info	Yes - For deaths that occur at the hospital	Yes - Vital Status (Alive/Deceased) & Day of Death as well as Death Certificate are available	Yes - Information about deaths is available from the Indiana State Health Department as well as from the Social Security Administration (SSA); also to some extent from hospitals
Other Demographic Data	Yes - Occupation, marital status	Yes - Employment Status, Median Income by zip, Tobacco Status, Allergies, Immunizations, Marital Status, Religion, Social History, Parent Linkage	Yes - Medical Insurance type - for some RMRS/INPC institutions; Patient residence information; For pediatrics, informant is mentioned (i.e., parent, guardian).
Physician ID	No - Physician name may be recorded in the original EMR, but not always available for review to researchers	Yes - De-identified unique ID per physician is recorded	Yes - Physician name is recorded
Diagnosis Data	Yes	Yes	Yes - Inpatient diagnoses [admit/discharge notes, nurse call center notes, appointment records, hospital/clinic notes (e.g., dermatology, operative, obstetric), and allergies]
Diagnoses Coded	Yes, documented as text in Chinese (not standardized)	Yes, ICD-9-CM	Yes - E.g., Local Regenstrief codes, ICD-9-CM, CPT-4, HL7, LOINC®
Physical Examination Findings	Yes	Yes - Discrete and non-discrete data	Yes - For some institutions - e.g., Vitals, General Condition, Abdomen, Neuro, Gait, Pediatric patient data.
Birth Defect, Cancer, Infectious Disease Data	Yes	Yes - Child data can be linked to mother data; Cancer data (Site, Stage, Tumor Size, Dx Date, Tx, Recurrence, etc.); organism culture, lab tests, antibiotic use info available	Yes - For some institutions - Birth defect data; Cancer data available via tumor registry; Infectious Disease diagnostics as well as proof of non-infection with TB upon discharge to a nursing home.
Environmental Exposures	Yes - Occupational exposure	Yes	Yes - At some sites Allergies recorded; exposures related to Dx
Behavioral Data Elements	No	Yes - Smoking; alcohol use	Yes - Some sites record this data, including for pediatric patients
Procedure Data	Yes, documented as text in Chinese (not standardized)	Yes, procedure data are recorded using CPT-4, HCPCS, ICD-9	Yes, some institutions record Inpatient Procedures and Imaging data using LOINC®, CPT-4, Other coding systems
Laboratory Information	Yes	Yes - Labs ordered and lab results are available (for 1,110+ types of labs)	Yes - E.g., EEG, EKG, EMG; Radiology reports/images; Cardiac echoes; Dermatology; Allergies; Nuclear medicine; Obstetrics, Operative reports; Stool occult; Surgical Pathology reports; GI endoscopy.
Drug Data	Yes: Prescription & OTC. Data are also available on Chinese traditional and herbal medicines.	Yes: Prescription & OTC. Data are also available on Illicit, Biologics, and Immunizations/Vaccines.	Yes: Prescription & OTC. Some institutions record data on all prescriptions written. All active medications are recorded.
Drug: Manufacturer	No	Yes - For some medications tracked using bar code system	Yes - For some institutions brand name is included, so manufacturer can be derived
Type of Cost Data	Yes - Billing and Payment	Yes - Actual encounter-level, provider, hospital, medication administration, and performed procedure costs to healthcare system	Yes - Inpatient charges captured from hospital's case abstract and billing systems. Some healthcare payers also provide charge data from claims.
Access to Medical Records	Yes - Medical records available through DB Manager	Yes - Available via licensed de-identified data extracts	Yes - Upon submission of request and approval
Linkage to Other Databases	Yes - Through unique patient ID, linkage to 1) Elderly population health survey DB, and 2) Spontaneous (ADR) reporting DB under SDMES	No	Yes - Death certificate information available via linkage to Indiana State Department of Health & other sources (SSA)
Sponsoring Government Agency	Shanghai Food and Drug Administration (SHFDA), and Shanghai Municipal Science and Technology Commission	Not applicable	Various, including NLM / NIH & AHRQ

LIMITATIONS: This analysis was a limited EHR sampling using DBs currently profiled within B.R.I.D.G.E. TO DATA®. More profiles of data sources are continually being added to B.R.I.D.G.E. Future analyses can provide a more fair comparison. For some EHR and MU standards, exact mapping to DB fields in B.R.I.D.G.E. could not be done.

CONCLUSIONS

❖ Hospital & physician conformity to EHR MU standards is important to enhance interoperability & patient safety, especially in large, heterogeneous nations as US & China. EHR standards are in development worldwide, including China. While many Chinese hospital EMR DBs exist, medical informatics expertise is required to transition from text to coded data. In this analysis, B.R.I.D.G.E. served as a tool to categorize data fields used in EHRs and identify additional fields to complement China EHR standards.

❖ One (1) Chinese & 10 US EHRs generally conformed to their respective national EHR standards, while adoption of MU core objectives was much lower. This is expected as China is currently in their 2010-2016 EHR "preparation/trial phase." Exchange of clinical information, a key MU objective, was missing in all EHRs. This analysis also showed that US & Chinese EHRs differed on level of detail captured for death, behavioral, and drug manufacturer data. *B.R.I.D.G.E. serves as a guide to help EHR developers identify and standardize categories of medical data that would facilitate global comparisons and coordinate transnational studies.*

References: (1) Xu W *et al*. Int J Med Inform. 2011 Aug;80(8):555-61.
(2) Lei J *et al*. BMC Med Inform Decison Making. 2013;13:96-104.

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