Notifiable diseases interoperable framework toward improving Iran public health surveillance system: Lessons learned from COVID-19 pandemic

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Abstract:
BACKGROUND: Direct transmission of notifiable disease information in a real-time and reliable way to public health decision-makers is imperative for early identification of epidemiological trends as well as proper response to potential pandemic like ongoing coronavirus disease 2019 crisis. Thus, this research aimed to develop of semantic-sharing and collaborative-modeling to meet the information exchange requirements of Iran's notifiable diseases surveillance system.

MATERIALS AND METHODS: First, the Iran’s Notifiable diseases Minimum Data Set (INMDS) was determined according to a literature review coupled with agreements of experts. Then the INMDS was mapped to international terminologies and classification systems, and the Health Level seven-Clinical Document Architecture (HL7-CDA) standard was leveraged to define the exchangeable and machine-readable data formats.

RESULTS: A core dataset consisting of 15 classes and 96 data fields was defined. Data elements and response values were mapped to Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT) reference terminology. Then HL7-CDA standard for interoperable data exchange were defined.

CONCLUSION: The notifiable disease surveillance requires an integrative participation of multidisciplinary team. In this field, data interoperability is more essential due to the heterogeneous nature of health information systems. Developing of INMDS based on HL7-CDA along with SNOMED-CT codes offers an inclusive and interoperable dataset that can help make notifiable diseases data more comparable and reportable across studies and organizations. The proposed data model will be further modifications in the future according probable changes in Iran’s notifiable diseases list.

Keywords: Coronavirus, COVID-19, health information exchange, notifiable disease, public health surveillance, semantic interoperability

Introduction
Surveillance of notifiable diseases like current coronavirus disease 2019 (COVID-19) pandemic is a foundation of public health practice.¹² A notifiable condition is the one for which ongoing, continuing, and timely information regarding individual new cases legally mandated to notify public health authorities. The time interval for notifiable diseases varies from 1 day until 1 month depending

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on their urgency.\[14\] Notifiable reporting leads to prompt reaction to disease epidemics and triggering control actions.\[9\] In Iran, the Ministry of Health and Medical Education (MOHME) determined a list of diseases for mandatory reporting at three levels, including immediate, routine, and international.\[6\]

Nowadays, informatics is creating opportunities to improve public health surveillance. Public health departments are facing many challenges to leverage the modern information and communication technology innovations and maximize potential benefits of them to readily and reliably exchange public health data.\[7,8\] The Centers for Disease Control and Prevention has also emphasized promoting innovative and modern technologies for disease surveillance.\[9\] Electronic Support for Public Health (ESP) and Electronic Laboratory Reporting (ELR) are basis for public health monitoring. These systems are the most common information systems that are used in public health surveillance.\[10-13\] Use of such electronic health information sources in the context of the National Notifiable Disease Surveillance System greatly boosts data quality dimensions of notifiable disease reporting.\[14\]

Technological and analytical innovations have significantly transformed the notifiable disease reporting from manual tedious, error-prone data transcription to automated, technology-driven approaches that substantially enhance the surveillance quality.\[15-17\] In this respect, Dixon et al. in their study demonstrated that completeness, timeliness, and accuracy of notifiable disease reporting varied in terms of the technologies used from 19.1 when transferring them with traditional technology (e.g., Fax, Telephone and e-mail, etc.) to 84.4% when using interoperable information systems (e.g., ELR, EPS, etc.).\[18\] Effective notifiable disease management requires a coalition of triangle of hospitals, laboratories, and public health organizations.\[19\] Meanwhile, notifiable disease data are confined among these spectra of healthcare settings with different data formats and repositories, as well as various access methodologies, complicating the exchange of healthcare information.\[20\]

Despite the abundance of health information systems (HISs) to electronically capture and reporting of notifiable diseases, interoperability between them is still a challenge.\[21\] An interoperability framework is essential to providing a specific set of standards, protocols, procedures, best practices, and policies to improve the cost-effectiveness of the electronic-health (E-Health) solutions.\[22\] Interoperability challenges are aggravated when dealing with data infrastructures that serve a wide range of stakeholders and partners potentially involved in this very wide and sometimes discrepant situation.\[23\] Hence the objective of this manuscript is to design a comprehensive and customized data exchange protocol using Health Level seven Clinical Document Architecture (HL7-CDA) messaging standard to overcome the above limitations and applicable for current COVID-19 and possible future pandemics.

Materials and Methods

This research was an applied-descriptive study that was conducted in 2020 in two steps.

Report template designing

The notifiable disease reporting core data fields have been determined based on literature review coupled with the expert consensus. To find relevant citations six databases, Google Scholar, Elsevier, Science Direct, Scopus, Cochran, and PubMed were explored. Included citations for this stage were valid articles related to notifiable disease data fields in the base of disease registries; surveillance, monitoring and HISs were examined. The following search terms were (“Core data set” OR “Essential data set” OR “Minimal basic data set” OR “Minimum data set” OR “Data field”) AND (“Notifiable diseases”) AND (“information system” OR “Registry system”, OR “Surveillance”) AND (“reporting”). In this stage, a checklist was used to extract the potential data fields and their values. Sampling was not performed at this stage, while all the relevant literature was retrieved and evaluated based on the inclusion criteria (full-text English articles between 2009 and 2020). Short articles, letters to the editor, papers accepted in conferences, and reports extracted from blogs were not included in this study. To determine the final Iran’s Notifiable diseases Minimum Data Set (INMDS) to disease reporting, data fields were chosen by 20 experts including epidemiologists, public health practitioners, and infectious disease specialists through a two round Delphi survey. The participating experts were asked to score the data fields according to the importance perceived by them based on a five-point Likert scale. In this scale, a score of 1 naturally represented the “lowest level of importance” while a score of 5 indicated the “highest level of importance”. The content validity of the questionnaire was evaluated by four experts, including two medical informatics and two epidemiologists. Test-retest reliability (with a 10-day interval) was performed to determine the reliability of the questionnaire. Accordingly, data fields with <50% agreement were excluded in the first round while those with >75% agreement were included in the primary round. Those with 50% to 75% agreement were surveyed in the second round and if there was 75% consensus over a subject, it was regarded as a final data field. Finally, the collected
data were analyzed using Statistical Package for the Social Sciences (SPSS) version 19 (IBM corporation: USA, New York).

**Semantic coordination**

After designing the INMDS of notifiable disease reporting, the information content was coded using selected classification or nomenclatures. For this purpose, printed coding systems and online terminology browser e. g. Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT) NPXR Online Browser, Regenstrief LOINC Mapping Assistant and RxNAV (RxNORM browse (were considered. In the next step, all scattered preferred codes were mapped to integrated SNOMED-CT reference codes using Mind Maple software. This software is a graphic user interface to define ontologies that represent relationships between concepts.\[24\] In particular, it visualizes the thesaurus mapping between multiple codes into reference SNOMED-CT unit code.\[25\]

Finally, integrated reference codes were structured into HL7-CDA standard framework in order to provide syntactic interoperability. The CDA template was proposed as an optimal and consistent framework for transferring information in comprehensive Public Health Information Exchange infrastructure of Iran.\[15\] Accordingly, all SNOMED-CT reference codes and terms were structured in the form of CDA body and title. Finally, the extensive markup language (XML) rules were defined to standardize the message structure. It provides a comprehensive and standardized human–machine-readable resource, which formally define and represents information as a set of concepts in a given domain.\[26\]

**Results**

The findings of this study have been categorized into four sections: 1-data field selection, 2-coding the data fields, 4-data mapping, and 5-message structuring.

**Data field selection**

In order to identify a preliminary list of data fields, an extensive literature review was performed. The designed INMDS in this study was divided into three hierarchical layers, including data categories (general level), data classes (detailed level), and data fields (atomic level). The proposed reporting template was classified in two data categories called nonclinical and clinical with six and nine data classes plus 49 and 74 data fields respectively. To determine the final INMDS, data fields were chosen by 30 samples of medical and public health experts through a two-round Delphi survey. A number of data fields were excluded after the second round of Delphi. Thus, the final data fields for nonclinical and clinical categories were 39 and 57 respectively [Figure 1].

**Coding the data fields**

The data field content was coded using selected classification and nomenclature systems as follows: International Classification of Disease–tenth revision (ICD10) or its Clinical Modification version (ICD10-CM), International Classification of Functioning, Disability and Health (ICF), Normalized Notations for Clinical Drug (RxNORM), Logical Observation Identifiers Names and Codes (LOINC), International Classification of Disease–Ninth Revision, Clinical Modification (ICD9-CM), Diagnostic and Statistical Manual of Mental Disorders (DSMs), and Read Code Classification (RCC). These tools were used for coding the diseases and other related disorders, health conditions, drugs and prescriptions, laboratory and evaluation findings, medical and surgical procedures, and mental as well as general and specific statuses, respectively. The SNOMED-CT reference terminology covered all these terms and codes.

**Terminology mapping**

The general paths of mapping from the preferred thesaurus onto the reference terminology include: (1) Mapping administrative information onto RCC; (2) Mapping disease and problem situation to ICD10; (3) Mapping medication terms onto RxNORM; (4) Health and welfare situation mapping to ICF; (5) Mapping diagnostic, medical, and surgical procedures to ICD9-CM; (6) Mapping laboratory and evaluative measures onto LOINC; and (7) Mapping mental situation to DSM codes. Finally, all preferred codes are mapped to the SNOMED-CT reference codes or names [Figure 2].

Tables 1 and 2 list the data categories, data classes, data fields and their content, data field format and values, preferred codes, and reference SNOMED-CT code for notifiable disease reporting.

**Message structuring**

The notifiable disease report structure definition was categorized in two sections and three layers including, 1-free text CDA templates (first CDA level) [Table 2] and 2-designing XML hierarchical (second and third CDA levels) [Figure 3] and XML tags [Figure 4]. Figure 2 presents XML based CDA framework related to notifiable disease reporting.

**Free text clinical document architecture template**

After normalizing the information content by thesaurus mapping, they were structured in standard formats. The HL7-CDA standard was employed for standardization of the message structure. Table 3 presents the CDA format for the information content of data fields in notifiable disease reporting. In the structure of CDA, the demographic, contact, identification, and report information classes related to identification of entities
involved in notifiable disease reporting were placed in the heading of documents. The body of documents included detailed information associated with the information classes of patient disposition, diagnosis/problem, life situation, exposure information, being high risk/at risk group, laboratory information, time period, history, prescription, and subsidiary programs data fields [Table 3].

Structured extensive markup language schemas
XML schemas of notifiable disease report provide a means of defining the structure, content, and semantics of exchange reports. The report template is divided into two clinical and nonclinical data categories. Figure 3 presents XML based CDA framework related to notifiable disease reporting. A sample of XML tags based CDA document related to notifiable disease presented in Figure 4.

Discussion
In this study, we presented the INMDS containing core data elements for capturing and exchanging information about notifiable diseases by using standardized data structures (HL7 CDA), international terminologies and disease classification systems. The INMDS dataset is an important step toward interoperability of notifiable disease data. It can enable harmonized data collection and analysis across multiple organizations and IT systems.

The need to data interoperability across different HISs has been considered in recent years in Iran. In this regard considerable activities have been followed in Iran to determining the minimum data elements required for uniform reporting of specific health conditions as a step toward achieving interoperability. Given that Iran MOHME intends to implement E-Health, both EHR (known as SEPASS) and Mobile Health projects; there is more deliberation on interoperability solutions. One of the main areas that highly emphasized to be interoperable is notifiable disease reporting to prevent disease outbreak and reduce public health crises. For timely case reporting of notifiable diseases and then taking preventive actions, multiple organizations, stakeholders, and partners at the different layers of reporting structure must work in collaboration. This shared goal will lead to real-time and evidence-based decisions for controlling strategies of notifiable diseases. Thus, the coalition of partners requires sharing or exchanging notifiable disease reporting explicitly comprehensible to individuals. In Iran, notifiable disease reporting is based on passive and manual reporting, which results in poor data quality as well as delayed submission of reports with many omissions and errors. Thus, unified, standardized, reusable, and interoperable solutions are necessary though not sufficient for fulfilling the paradigm shift from passive disease surveillance to efficient, comprehensive, and automated electronic data interchange. In the provision of smart disease surveillance, the main objective is to achieve semantic interoperability. It deals with an ability where two or more IT systems share information with each and perceiving common understanding of the exchanged content. The absence of standardization requirements is the most important barrier to E-Health implementation in Iran. Iran’s E-Health system has only met the basic levels of interoperability requirements, but is still coping with some challenges to reach a machine-computable level. Further, there is no appropriate strategy for using medical terminology standards such as SNOMED CT, LOINC, and RxNORM in Iran’s E-Health strategy.

Considering the problems to be solved as described above, in this study, initially, most required data fields and their attributes associated with Iran’s notifiable diseases were determined through wide consensus of public health practitioners and medical experts. The standard datasets like INMDS is important to be validating from scientific perspective. To ensure a high acceptance of the dataset, the development of INMDS therefore included experts from a multi disciplines and professional in public health, medical specialist as well as epidemiologist.

The developed dataset in the present study is needed to meet the data standardization requirements of Iran’s notifiable diseases reporting. In this study, notifiable disease data fields’ and their corresponding contents
| Data classes        | Data field       | Content definition                          | Data format | Vocab coding system | Preferred codes | References code |
|---------------------|------------------|---------------------------------------------|-------------|---------------------|-----------------|-----------------|
| Demographical       | Name, surname    | Patient name                                | String      | RCC                 | XaLVa           | 371484003       |
|                     | Father name      | Person name                                 | String      | RCC                 | XaLVa           | 734006007       |
|                     | Age              | Middle age: 62 Y                            | Categorical | RCC                 | X24AI           | 28288005       |
|                     | Infants: X<1Y, Child: 1Y<X<5Y |                           |             |                     |                 |                 |
|                     | Teenage: 5Y<X<17Y |                           |             |                     |                 |                 |
|                     | Young: 17Y<X<34Y  |                           |             |                     |                 |                 |
|                     | Middle age: 34Y<X<65Y, Aged: X>65Y |                     |             |                     |                 |                 |
|                     | Date of birth    | DD/MM/YYYY                                  | Integer     | RCC                 | 9155            | 184099003       |
|                     | Sex              | Male: 1                                     | Binary      | RCC                 | X768D           | 703117000       |
|                     |                 | Female: 0                                   |             | RCC                 |                 |                 |
|                     | Marital status   | Married                                     | Categorical | RCC                 | XE0oa           | 87915002       |
|                     |                 | Single                                      |             | RCC                 |                 |                 |
|                     |                 | Married                                     |             | RCC                 |                 |                 |
|                     |                 | Widow                                       |             | RCC                 |                 |                 |
|                     | Race/Nationality | Iranian/Persia                              | String      | RCC                 | Xa6gS           | 297553001       |
| Contact             | Place of birth   | Iran/Tehran                                 | String      | RCC                 | XaG3t           | 315446000       |
|                     | City             | Tehran                                      | String      | RCC                 | 134Z            | 433178008       |
|                     | Address          | City-street-alley-house no                  | String      | RCC                 | 9153            | 184097001       |
|                     | Postal/Zip code  | xxxxx-xxxxxx                                | Numerical   | RCC                 | 9158            | 184102003       |
|                     | Phone number     | +98 xxx-xxxxxxx                             | Numerical   | RCC                 | XaZ4q           | 824551000000105 |
|                     | Fax number       | 021-xxxxxxx                                 | Numerical   | RCC                 | Xa1Iw           | 445666005       |
|                     | Email address    | Yahoo.com@xxxxxxx                           | String      | RCC                 | XaYak           | 424966008       |
| Identifier          | Patient ID       | National ID: xxx-xxxxxxx-xxxx              | Numerical   | RCC                 | XE2Hj           | 422549004       |
|                     | Medical record number | xx-xx-xx                                | Numerical   | RCC                 | Xn73J           | 398225001       |
|                     | Visit number     | xxx/xx                                     | Numerical   | RCC                 | 915D            | 722248002       |
|                     | Physician ID     | xxxxx                                      | Numerical   | RCC                 | Xabhz           | 713578002       |
|                     | Reporting organization ID | Hospital reference no. xxxx | Numerical   | RCC                 | 9R6K            | 185975009       |
|                     | Recipient organization ID | Public health no. xxx                   | Numerical   | RCC                 | XaC8K           | 719051000000105 |
|                     | Sample ID        | Sample ID no. xx-xx                        | Numerical   | RCC                 | 4j33            | 719051000000105 |
| Socioeconomic       | Occupation       | Farmer                                      | String      | RCC                 | X30GS           | 106388008       |
|                     | Literacy rate    | Illiterate literacy level                   | Categorical | ICD10               | Z550            | 707843000       |
|                     |                 | Under diploma                               |             |                     |                 |                 |
|                     |                 | Diploma                                     |             |                     |                 |                 |
|                     |                 | Bachelor                                    |             |                     |                 |                 |
|                     |                 | Master of science or above                  |             |                     |                 |                 |
|                     |                 | Unspecified                                 |             |                     |                 |                 |
|                     | Income           | Low income                                  | String      | ICD10               | Z59.6           | 424860001       |
|                     | Health/Welfare level | Inadequate workplace welfare               | String      | RCC                 | Ua0UZ           | 224440003       |
|                     | Religion         | Islam/Shia                                  | Categorical | RCC                 | XM1b9           | 28010004       |
|                     |                 | Islam                                       |             |                     |                 |                 |
|                     |                 | Shia                                        |             |                     |                 |                 |
|                     |                 | Sonny                                       |             |                     |                 |                 |
|                     |                 | Christian                                   |             |                     |                 |                 |
|                     |                 | Other religious                              |             |                     |                 |                 |

Contd...
was integrated through preferred classification or nomenclature systems for local purposes and then mapping onto SNOMED-CT references codes and names. Subsequently, the XML-based CDA schema was used for structuring the reports. If inconsistencies are found in the related attributes in different standards, then they must be solved through mapping. Terminology mapping serve as a tool for representing certain ontology domains and contributes to semantic interoperability. It transforms multiple terms related to one concept into a reference term and a corresponding code. SNOMED-CT has been recommended as vocabulary standard for Iranian EHR system, so-called SEPAS project. Use of SNOMED-CT will enhance the data quality dimensions which along with other lexicon standards (e.g., ICD10, LOINC and RxNORM) will form EHRs ontology. The present study similarly used these selected classification or nomenclature systems to normalize notifiable disease reporting. Finally, all contents were integrated into the corresponding SNOMED-CT unique codes. Further, the communication protocol used in this study has been developed based on HL7-CDA standard. HL7-CDA is a simplified and optimal human-computer understandable format, playing an increasingly important role in the exchange of a wide variety of data in healthcare environments. Furthermore, this standard uses a language that defines the structure and semantics of clinical documents for information exchange known as XML. XML provides consistent public health data exchange through structuring the message framework between heterogeneous systems. Notifiable disease reporting communication protocol was applied to

### Table 1: Contd...

| Data classes | Data field | Content definition | Data format | Vocab coding system | Preferred codes | References code |
|--------------|------------|--------------------|-------------|---------------------|----------------|-----------------|
| Report       | Report heading | Notification disease reporting | String | RCC | Xa4H9 | 71691000000107 |
| Report       | Report goal | Urgent reporting of cholera | String | RCC | Xa8BK | 370894009 |
| Report       | Report Date (Alert) | DD/MM/YYYY | Integer | RCC | Xbc5Z | 399651003 |
| Reporter user ID | Person ID: xxx | | String | RCC | Xbhz | 713578002 |
| Recipient user ID | Person ID: xxx | | String | RCC | Xbhz | 713578002 |
| Admission cause | Dehydration | | String | ICD10 | E86.0 | 34095006 |
| Admission date | DD/MM/YYYY | Integer | RCC | XatcK | 399423000 |
| Admission type | Inpatient care | String | RCC | Xabhz | 31307100000104 |
| Discharge/referral source | Discharged from hospital | | String | RCC | XaApt | 306689006 |
| Discharge/referral place | Discharge to home | | String | RCC | XaZuU | 442864001 |
| Discharge/referral date | Date of discharge | | String | RCC | Xaat1 | 406151001 |

RCC=Read code classification
Table 2: Clinical data elements of Iran’s Notifiable diseases Minimum Data Set

| Data classes          | Data field                          | Content definition                                                                 | Data format | Vocab coding system | Preferred codes | References code |
|-----------------------|-------------------------------------|-------------------------------------------------------------------------------------|-------------|---------------------|-----------------|-----------------|
| Diagnosis/ problem    | Primary diagnosis                   | Foodborne botulism                                                                  | String      | ICD10               | A05.1           | 4E+08           |
|                       | Final diagnosis                     | Cholera                                                                            | String      | ICD10               | A00.1           | 6.4E+07         |
|                       | Date of diagnosis                   | DD/MM/YYYY                                                                         | Integer     | RCC                 | XaaLd           | 4.3E+08         |
|                       | Signs and symptoms                  | Diarrhea                                                                           | String      | ICD10               | A09.0           | 6.2E+07         |
|                       | Symptom onset date                  | DD/MM/YYYY                                                                         | Integer     | RCC                 | XaR6r           | 5.2E+14         |
|                       | Chief Complaint                     | Dehydration                                                                        | String      | ICD10               | E86.0           | 3.4E+07         |
|                       |                                    | Intestinal infection due to Vibrio cholera                                          | String      | ICD10               | A00.1           | 4.5E+08         |
| Comorbidities         |                                    | Pre-diabetes                                                                       | String      | ICD10               | R73.0           | 8.6E+14         |
|                       |                                    | Fecal-oral transmission                                                            | String      | RCC                 | 4.2E+08         |
| Disease category      |                                    | Bacterial infectious                                                               | String      | ICD10               | A498            | 8.8E+07         |
| Type of pathogen      |                                    | Vibrio cholera                                                                     | String      | RCC                 | X73Mv           | 7.8E+07         |
| Disease certainty level|                                    | On examination- suspicious                                                         | Categorical | ICD10               | R465            | 1.6E+08         |
| Final                 |                                    | Suspicious                                                                         |             |                     |                 |                 |
|                       |                                    | Probable                                                                           |             |                     |                 |                 |
| Medical/surgical procedure |                                    | Resuscitation using intravenous fluid                                             | String      | ICD9-CM             | 99.18           | 4.3E+08         |
| Immunization/vaccination |                                    | Vaccination not done                                                               | String      | ICD10               | Z28.8           | 9E+13           |
| Treatment outcome     |                                    | Patient’s condition improved                                                       | String      | ICF                 | d4563           | 2.7E+08         |
| Mental condition      |                                    | Anxiety                                                                            | String      | DSM                 | 309.24          | 7.4E+07         |
| Life situation        | The current state of life           | Alive                                                                              | Categorical | RCC                 | Xa07V           | 4.4E+08         |
|                       | 1- alive                            | -                                                                                  |             |                     |                 |                 |
|                       | 2- deceased                         | -                                                                                  |             |                     |                 |                 |
| The underlying cause of death |                                    | -                                                                                  |             |                     |                 |                 |
| Date of death         |                                    | -                                                                                  |             |                     |                 |                 |
| Exposure information  | Exposed groups/High risk groups     | Exposure to polluted water, occupational                                          | String      | ICD10               | Z58.2           | 1E+08           |
|                       | Cause of exposure                   | Occupational hazard                                                               | String      | ICD10               | Z57.8           | 1.6E+16         |
|                       | Exposure                            | Exposure to Vibrio cholera                                                        | String      | ICD10               | Z20.0           | 4.4E+08         |
|                       | Activity on exposure                | Farm worker                                                                       | String      | RCC                 | XE0Pi           | 7.8E+07         |
|                       | Date of exposure                    | DD/MM/YYYY                                                                        | Integer     | RCC                 | XaOck           | 4.1E+08         |
|                       | Location of exposure                | Agricultural site                                                                 | String      | RCC                 | XM0Ks           | 2.7E+08         |
|                       | Number of exposure                  | frequently                                                                        | String      | RCC                 | Ubo2V           | 2.3E+08         |
| High risk/at risk group| Intraavenous injection/blood transfusion | Intraavenous injection of antimicrobial substance                             | String      | RCC                 | XaM27           | 4.3E+08         |
|                       | Addiction status                    | Former cigarette                                                                  | String      | RCC                 | Z86.4           | 1.6E+08         |
|                       | Sexual orientation                  | Sexual orientation unknown                                                        | String      | RCC                 | XaPO2           | 4.4E+08         |
|                       | Mental status                       | Obsessive behavior                                                                | String      | RCC                 | F42.0           | 3.7E+08         |
|                       | The amount of travel                | Does not travel                                                                   | String      | RCC                 | Xa7IO           | 3E+08           |
|                       | Pregnancy status                    | Sexual incompatibility                                                             | String      | RCC                 | X76xd           | 9.2E+07         |
| Laboratory information| Routine LAB test                    | Complete Blood Count                                                              | String      | LOINC               | 24317-0         | 2.7E+07         |
|                       | Specialty LAB test                  | Stool culture - vibrio only                                                        | String      | LOINC               | 6579-7          | 1E+08           |
|                       | Test type                           | Stool culture test                                                                | String      | LOINC               | 82305-4         | 7E+08           |
|                       | Test time                           | DD/MM/YYYY, xx: xx                                                                | Integer     | RCC                 | X77V           | 2.5E+08         |
|                       | Sample type                         | Feces (substance)                                                                 | String      | RCC                 | XaObh           | 3.9E+07         |
|                       | Sampling time                       | DD/MM/YYYY, xx: xx                                                                | Integer     | RCC                 | 4132            | 1.7E+08         |
|                       | Sampling location                   | Anal canal                                                                        | String      | RCC                 | X755X           | 3.4E+07         |
|                       | Test result                         | Stool culture positive                                                            | String      | ICD10               | R19.5           | 1.7E+08         |
Table 2: Contd...

| Data classes | Data field          | Content definition                                                                 | Data format | Vocab coding system | Preferred codes | References code |
|--------------|---------------------|----------------------------------------------------------------------------------|-------------|---------------------|----------------|-----------------|
| Time interval| The time between infection and diagnosis | Day/Week/Month/Year: 2 W                                                          | Numerical   | RCC                 | XaBBB          | 3.1E+08         |
|              | The time between diagnosis and treatment | Day/week/month/year: 2 D                                                          | Numerical   | RCC                 | XaBBB          | 3.1E+08         |
|              | The time between diagnosis and death     | -                                                                               | -           | -                  | -              | -               |
|              | The time between start treatment and death | -                                                                               | -           | -                  | -              | -               |
| History      | Disease history     | History of tonsillitis                                                              | String      | ICD10               | Z87.0          | 4.7E+08         |
| Procedure    | History of tonsillectomy                  | String                                                                           | RCC         | XaP9T               | 4.4E+08         |
| Prescription | Prescription name   | Ciprofloxacin                                                                      | String      | RXNORM              | C0008809       | 3.7E+08         |
|              | Prescription dose   | Ciprofloxacin 500 mg                                                               | String      | RXNORM              | C0039644       | 3.2E+08         |
|              | Tetracycline 250 mg | String                                                                           | -           | -                  | -              | -               |
|              | Administration Route | Oral tablet                                                                       | String      | RCC                 | XaB8B          | 4.2E+08         |
|              | Drug allergy/adverse effects              | Allergy to antiretroviral drug                                                    | String      | ICD10               | Z88.3          | 7.1E+08         |
| Compliance   | Drug compliance good                        | String                                                                           | RCC         | B3E                 | 1.8E+08         |
| Subsidiary   | Consultation programs                        | Work-related counseling                                                           | String      | ICD9-CM             | 89.09          | 3.1E+08         |
| Ancillary    | Ancillary services                             | Rehydration therapy                                                              | String      | RCC                 | X71bq          | 2.4E+08         |
| Support      | Support programs                             | Cholera screening                                                                 | String      | ICD10               | Z11.0          | 4.1E+08         |

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    </assignedEntity>
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  </performer>
</serviceEvent>

Figure 4: Extensive markup language schema for INMS reporting

identify the key elements and standardized vocabulary required to developing a national system of public health surveillance in Iran. The use of SNOMED-CT as a reference terminology in HL7-CDA template is highly compatible with the Iran’s E-health. It facilitates exchanging notifiable disease information from healthcare, laboratory, public health, and other related organizations in a unified reporting template for effective disease management and control. The current study had some limitations, however, this study only focused on informational aspects of a communication protocol in the form of semantic and syntactic rule definition, but the technical aspects for example authentication, error detection, and correction, as well as signaling remained to be resolved. Nevertheless, the interoperability considered in our study went beyond the basic level (electronic data interchange) and reached high interoperability (machine interpretable data). The urgency of reporting some notifiable diseases is likely to be changed due to mandatory report of new conditions or even excluded some diseases from the present list, which may necessitate modifications to the INMDS dataset in the future.

Conclusion

The INMDS dataset provides clinicians, public health practitioners, policy makers and researchers with a comprehensive and interoperable dataset for reporting, exchanging and analyzing notifiable disease data across institutions and software systems. This dataset developed by a multidisciplinary team of medical and
public health experts and customized based on medical terminologies, classifications and E-Health standards.

The main output of INMDS is available correct and timely new case reporting for informing public health authorities, especially in current ongoing COVID-19 pandemic. Well-defined and standardized information systems for notifiable disease reporting will improve interoperability, reusability, integrity, reliability, and quality criteria of data, thus eliminating unnecessary redundancies, and reporting burden on public health agencies. INMDS can thus help to improve the harmonization and coordination of scientific researches to successfully combat the diseases pandemic. Hence, further advances in surveillance are closely associated with both data collection and dissemination. Future inclusion of domain-specific extension modules will further expand the use of the INMDS dataset.

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Conflicts of interest

There are no conflicts of interest.

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