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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. [1,2] 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.[3,4] Notifiable reporting leads to prompt reaction to disease epidemics and triggering control actions.[5] 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 heath 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) NPEX 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

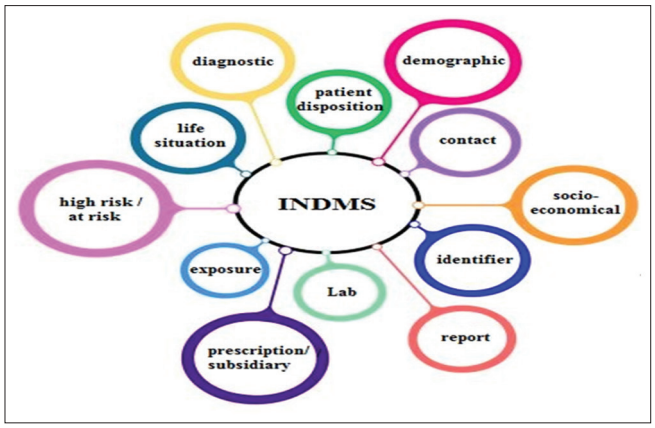

Figure 1: INMDS data classes

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.[27] 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.[27,28] 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.[28-30] One of the main areas that highly emphasized to be interoperable is notifiable disease reporting to prevent

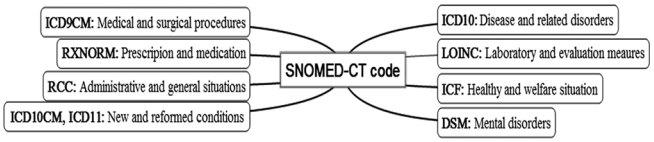

Figure 2: Mind maple routes

disease outbreak and reduce public health crises.[31] 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. [4,6,11,16,32] 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.[1]

In the provision of smart disease surveillance, the main objective is to achieve semantic interoperability.[33] It deals with an ability where two or more IT systems share information with each and perceiving common understanding of the exchanged content. [34,35] 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. [36,37]

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

Table 1: Nonclinical 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
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
	Infant: 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	M	Binary	RCC	X768D	703117000
	Female: 0					
	Marital status	Married	Categorical	RCC	XE0oa	87915002
	Single					
	Married					
	Widow					
	Race/Nationality	Iranian/Persia	String	RCC	Xa6g5	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-xxxxx	Numerical	RCC	9158	184102003
	Phone number	+98 xxx-xxx-xxxx	Numerical	RCC	XaZ4q	824551000000105
	Fax number	021-xxxxxxxx	Numerical	RCC	Xa1iW	445666005
	Email address	Yahoo.com@xxxxxxx	String	RCC	XaYak	424966008
Identifier	Patient ID	National ID: xxx-xxxxxx-x	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
	Illiterate					
	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	Islam/Shia	Categorical	RCC	XM1b9	28010004
	Shia					
	Islam					
	Sonny					
	Christian					
	Other religious					

Contd...

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	716931000000107
	Report goal	Urgent reporting of cholera	String	RCC	XaC8K	370894009
	Report ID	xxx-x-xx	String	RCC	Xbn9Z	439272007
	Report Date (Alert)	DD/MM/YYYY	Integer	RCC	Uc35Z	399651003
	Reporter user ID	Personnel ID: xxxx	String	RCC	Xabhz	713578002
	Recipient user ID	Personnel ID: xxxx	String	RCC	Xabhz	713578002
Patient disposition	Admission cause	Dehydration	String	ICD10	E86.0	34095006
	Admission date	DD/MM/YYYY	Integer	RCC	Xa0cK	399423000
	Admission type	Inpatient care	String	RCC	XaABh	313071000000104
	Discharge/referral source	Discharged from hospital	String	RCC	XaW0K	712671000000101
	Discharge/referral place	Discharge to home	String	RCC	XaApt	306689006
	Discharge/referral date	Date of discharge	String	RCC	XaZuU	442864001
	Discharge status	Post-discharge follow-up	String	RCC	Xaat1	406151001

RCC=Read code classification

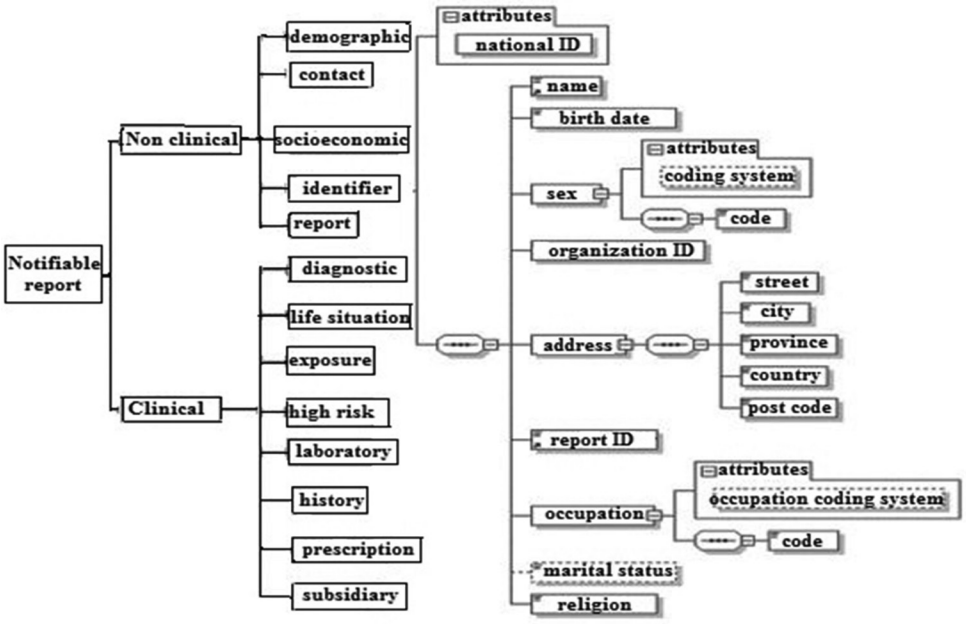

Figure 3: Notifiable report's hierarchical structure in extensive markup language schema

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 inconsistences 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.[25] It transforms multiple terms related to one concept into a reference term and a corresponding code.[38] 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,[39] which along with other lexicon standards (e.g., ICD10, LOINC and RxNORM) will form EHRs ontology.[40]

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.[41,42] Furthermore, this standard uses a language that defines the structure and semantics of clinical documents for information exchange known as XML.[43] XML provides consistent public health data exchange through structuring the message framework between heterogeneous systems.[44] Notifiable disease reporting communication protocol was applied to

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
		Projectile vomiting			R11	8579004
	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			A00.1	4.5E+08
	Comorbidities	Pre-diabetes	String	ICD10	R73.0	8.6E+14
	Transmission category	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	7.6E+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 cholerae	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	Xa0ck	4.1E+08
	Location of exposure	Agricultural site	String	RCC	XM0Ks	2.7E+08
	Number of exposure	frequently	String	RCC	Ub0zV	2.3E+08
High risk/at risk group	Intravenous injection/blood transfusion	Intravenous 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	Xa7fO	3E+08
	Pregnancy status	Sexual incompatibility	String	RCC	X76×d	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: xx	Integer	RCC	X77Vk	2.5E+08
	Sample type	Feces (substance)	String	RCC	Xa0bh	3.9E+07
	Sampling time	DD/MM/YYYY, xx: xx: xx	Integer	RCC	4I32	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

Contd...

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	XaB8B	3.1E+08
	The time between diagnosis and treatment	Day/week/month/year: 2 D	Numerical	RCC	XaB8B	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	History of tonsillectomy	String	RCC	XaP9T	4.4E+08
	Prescription history	Insulin lispro	String	RXNORM	C0043031	3.7E+08
	Exposure history	History of exposure to occupational risk factor	String	ICD10	Z57.8	7.1E+08
	Social history	No significant social history	String	RCC	Xa1ns	1.6E+08
Prescription	Prescription name	Ciprofloxacin	String	RXNORM	C0008809	3.7E+08
		Tetracycline			C0039644	3.2E+08
	Prescription dose	Ciprofloxacin 500 mg	String	RXNORM	C0706693	3.2E+08
		Tetracycline 250 mg			C0039644	3.2E+08
	Administration Route	Oral tablet	String	RCC	Xalj	4.2E+08
	Drug allergy/adverse effects	Allergy to antiretroviral drug	String	ICD10	Z88.3	7.1E+08
	Compliance assessment	Drug compliance good	String	RCC	8B3E	1.8E+08
Subsidiary	Consultation programs	Work-related counseling	String	ICD9-CM	89.09	3.1E+08
	Ancillary services	Rehydration therapy	String	RCC	X71bq	2.4E+08
	Support programs	Cholera screening	String	ICD10	Z11.0	4.1E+08

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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

Table 3: Free text Health Level seven-Clinical Document Architecture framework for INDMS reporting

Document heading
Report heading: Notifiable disease reporting, DOC AUTHOR: Physician/ID: 4501, DOC
CUSTODIAN: Hospital reference no. 4512, DOC RECIEVER: Iranian Ministry of health (SEPASS project), Report goal: Interoperable reporting of cholera, Report ID: 452-85-7, Report date of creation: 02/06/2019, Report content standard: SNOMED-CT
Document body-administrative
Demographical information: Patient name: Z. MR , Sex: 703117000, Age: 28288005, Date of birth: 01/10/1958
Socioeconomically information: Literacy rate: 707843000, Income : 424860001, Health/Welfare level: 224440003, Religion: 28010004, Nationality/Race: 297553001
Contact information: Address: Phone number: +98 912 xxxxx, Postal code: 57896-23511
Identification information: Patient Identifier (National ID): XXX-XXXXX-X, Medical record number: 21-36-01, Insurance ID: 44785233
Patient disposition: Admission cause: 34095006, Admission type: 313071000000104, Admission date: 21/08/2019, Discharge place: 306689006, Discharge date: 24/08/2018, Discharge status: 406151001
Document body- clinical
Diagnosis/problem: Chief compliant: 34095006, Final diagnosis: 63650001, Comorbidities: 858301000000107, Disease certainty level: 163614007, Type of pathogen: 75953000, Disease category: 87628006, Transmission category: 417403003, Procedure: 430701006, Treatment outcome: 268910001
Life situation: The current state of life: 438949009
Exposure information: Exposed groups: 102428006, Cause of exposure: 16090731000119102, Location of exposure: 272504001, Activity on exposure: 77715000, Date of exposure: , Number of exposure: 228863009
High risk/at risk group: intravenous injection: 427570004, Addiction status: 160617001, Sexual orientation: 440583007, The amount of travel: 300616000, Pregnancy status: 91525005.
History: Disease history: 472958002, Procedure history: 438759003, Prescription history: 372756006, Exposure history: 705133000, Social history: 160253009.
Laboratory information: Routine LAB test: 26604007, Specialty LAB test: 104191004, Test type: 703725008, Test time: 25/05/2019, Sampling time: 23/05/2019, Test result: 168319009
Prescription: Prescription name: 324606008, 324012004, Drug allergy/adverse effects: 713690006
Subsidiary programs: Consultation programs: 313080005, Support programs: 410156008

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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