

Managing Pandemics with Health Informatics

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Summary

Objective: To summarize significant research contributions on managing pandemics with health informatics published in 2020.

Methods: An extensive search using PubMed and Scopus was conducted to identify peer-reviewed articles published in 2020 that examined health informatics systems used during the global COVID-19 pandemic. The selection process comprised three steps: 1) 15 candidate best papers were first selected by the two section editors; 2) external reviewers from internationally renowned research teams reviewed each candidate best paper; and 3) the final selection of three best papers was conducted by the editorial committee of the International Medical Informatics Association (IMIA) Yearbook.

Results: Selected best papers represent the important and diverse ways that health informatics supported clinical and public health responses to the global COVID-19 pandemic. Selected papers represent four groups of papers: 1) Use of analytics to screen, triage, and manage patients; 2) Use of telehealth and remote monitoring to manage patients and populations; 3) Use of EHR systems and administrative systems to manage internal operations of a hospital

or health system; and 4) Use of informatics methods and systems by public health authorities to capture, store, manage, and visualize population-level data and information.

Conclusion: Health informatics played a critical role in managing patients and populations during the COVID-19 pandemic. Health care and public health organizations both leveraged available information systems and standards to rapidly identify cases, triage infected individuals, and monitor population trends. The selected best papers represent a fraction of the body of knowledge stemming from COVID-19, most of which is focused on pandemic response. Future work will be needed to help the world recover from the pandemic and strengthen the health information infrastructure in preparation for the next pandemic.

Keywords

Pandemics, COVID-19, public health informatics, medical informatics

Yearb Med Inform 2021:69-74

<http://dx.doi.org/10.1055/s-0041-1726504>

1 Introduction

The global COVID-19 pandemic began as a localized outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in late 2019 in Hubei Province, China. To date, COVID-19 has affected more than 160 million individuals worldwide, and it has been attributed to more than 3.5 million deaths globally. The global pandemic challenged every health system in the world, stressing facilities, medical equipment supplies, and clinicians. Public health authorities were also challenged to track disease transmission, model forecasts across multiple waves of the

pandemic, and distribute available vaccines to populations. Policymakers and citizens alike were challenged to adapt to ever-changing guidance from public health authorities and mitigation strategies as the scientific process played out in real-time as if it were featured in a reality-style television program.

Throughout the COVID-19 pandemic, health information systems played critical roles in aiding clinicians manage their patients, health care administrators manage resources, and public health authorities manage populations [1, 2]. It is precisely for this reason that the International Medical Informatics Association (IMIA) Yearbook editors chose

“Managing Pandemics with Health Informatics” as this year’s theme [3-Reference to the YB Editorial paper]. The special section of the Yearbook focuses on the various ways that informatics contributed to pandemic response efforts among global health systems, especially public health authorities and healthcare delivery organizations that were both on the frontlines of the battle with SARS-CoV-2.

2 Methods

A health sciences librarian performed literature searches using PubMed and Scopus in January 2021. Queries were developed to broadly search biomedical and non-biomedical journals for articles at the intersection of the COVID-19 pandemic and information systems. Both controlled vocabulary terms (e.g., MeSH) and text words were used. We employed Boolean logic to identify articles published in English language between January 1, 2020 and December 31, 2020, that contained at least one information science term *AND* one pandemic term. The full queries are included as **Appendix A**.

Information retrieval yielded 965 articles (471 from PubMed; 497 from Scopus). Using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia), search results were merged (222 duplicates removed), and the editors performed initial screening of titles and abstracts. Screening removed 551 studies that did not pertain to managing pandemics with health informatics. Both editors reviewed the 183 remaining articles and categorized them into three groups

(accept, discuss, and discard) based on their innovativeness, scientific and/or practical impact, and methodological quality. This process yielded 18 articles for discussion, of which the editors agreed to accept 15 articles as candidate best papers. In accordance with the IMIA Yearbook selection process, the 15 candidate best papers were further evaluated by the two section editors, the chief editor of the section, and by additional external reviewers (at least four reviewers per paper) with expertise in medical and/or public health informatics.

3 Results

The search yielded a large corpus of papers in which information systems were utilized to capture, store, manage, analyze, and share data or information relevant to the COVID-19 pandemic. Journals and their editors were indeed overwhelmed with the volume of submissions in 2020 as the academic world focused their collective efforts on tracking disease spread, modeling disease forecasts, managing severely ill patients, developing therapeutics, exploring disease course pathways, and developing vaccines for disease prevention. While information systems were used in support of all of these pandemic response activities, a much smaller set of articles focused on core health informatics methods, innovations, research, and practical application by health systems and public health agencies. Also, we found several strong papers on the role of health informatics for managing a pandemic were editorials or opinion pieces, which are excluded from the selection of the Best Papers.

We noted several groups of papers relevant to health informatics as a discipline from which we selected candidate papers. These groups align with those identified in the survey paper by Tilahun et al. [4- REF survey Special Section] First, we observed a large number of articles in which machine learning and other analytics methods were utilized to categorize COVID-19 patients for triage or clinical management [5, 6]. Many of these papers demonstrate excellent application of analytics methods to real-world clinical problems, although only a few papers were innovative from a methodological standpoint or advanced our understanding of how machine learning

modeling can be adapted for use in clinical settings [7, 8]. Many of the papers we reviewed were also considered by other sections of the IMIA Yearbook: Public Health and Epidemiology Informatics [9-PHEI Synopsis], Clinical Information Systems [10-CIS Synopsis] and Decision Support [11-DS Synopsis].

Second, many health systems rapidly scaled their telehealth infrastructure and functionalities to triage COVID-19 patients and minimize exposure for patients without COVID-like illnesses [12]. Telemedicine demonstrated itself to be a critical component of health care delivery during a pandemic, including remote monitoring for vulnerable populations [13]. Two of the best papers described the deployment and use of telehealth [14, 15].

A third group leveraged EHR systems and administrative information systems to better manage the internal operations of a hospital or health system. These papers often described a centralized incident command center or operations team that integrated data from multiple information systems to drive organizational decisions as the pandemic unfolded in their service area [16, 17]. Rapid assessments and visualization of data were helpful to organizational leaders who used chains of command to distribute information quickly to service line leaders, enabling the organization to update clinical screening and therapeutic guidelines as the evidence evolved over the course of the pandemic. One of the best papers represents this group of papers [14].

A final group of papers focused on methods and systems for public health authorities to capture, store, manage, and visualize data on COVID-19 infections, hospitalizations, and deaths among populations. The pandemic highlighted that many public health authorities, especially in low- and middle-income countries, are deficient in their information infrastructures [18]. Limited resources inhibit core functions of public health, especially integrated disease surveillance and response. Response to COVID-19 required access to up-to-date controlled terminologies and case definitions as well as the deployment of standards-based solutions for data management and visual analytics. Because of public health authorities' critical role in managing pandemics, two of the best papers were selected from this group [19, 20]. Public health applications often involve spatial visualization and analysis, and we noted a strong review article on geographic information systems [21].

The final four papers selected by the section editors as best papers are summarized in Table 1. Final selection was based on these criteria: 1) reviewer ratings and comments; 2) equity across nation and world region; and 3) content balance with other sections of the IMIA Yearbook. Several candidate articles for the special section were also considered by other sections given the theme cut across all Yearbook sections. A content summary of the selected best papers can be found in **Appendix B** of this synopsis.

Table 1 Best paper selection of articles for the IMIA Yearbook of Medical Informatics 2021 in the special section 'Managing Pandemics with Health Informatics'. The articles are listed in alphabetical order of the first author's surname.

Section

Managing Pandemics with Health Informatics

- Ahmed K, Bukhari MA, Mlanda T, Kimenyi JP, Wallace P, Okot Lukoya C, Hambion EL, Impouma B. Novel approach to support rapid data collection, management, and visualization during the COVID-19 outbreak response in the World Health Organization African Region: development of a data summarization and visualization tool. *JMIR Public Health Surveill* 2020;6(4):e20355.
- Garcia M, Lipskiy N, Tyson J, Watkins R, Esser ES, Kinley T. Centers for disease control and prevention 2019 novel coronavirus disease (COVID-19) information management: addressing national health-care and public health needs for standardized data definitions and codified vocabulary for data exchange. *J Am Med Inform Assoc* Jul 2020;27(9):1476-87.
- Gong M, Liu L, Sun X, Yang Y, Wang S, Zhu H. Cloud-based system for effective surveillance and control of COVID-19: useful experiences from Hubei, China. *J Med Internet Res* Apr 2020;22(4):e18948.
- Reeves JJ, Hollandsworth HM, Torriani FJ, Taplitz R, Abeles S, Tai-Seale M, Millen M, Clay BJ, Longhurst CA. Rapid response to COVID-19: health informatics support for outbreak management in an academic health system. *J Am Med Inform Assoc* Jun 2020;27(6):853-9.

4 Conclusions and Outlook

The best papers on managing pandemics with health informatics in 2020 represents only a fraction of the strong scientific articles relevant to this topic. Foundational work on syndromic surveillance [22] and other core public health informatics methods and systems [23] preceded the global COVID-19 pandemic. These core public health information systems were undoubtedly useful and important in managing the response to the COVID-19 pandemic. Prior pandemics, including Ebola virus disease, H1N1, and the previous multi-national outbreaks of SARS-CoV-1, have spurred innovation and research in health informatics. Several high-quality health informatics articles have been published in 2021 on COVID-19, and we anticipate additional high-quality articles in the future on this topic.

Response to COVID-19 is only one phase of the health system's interaction with a pandemic. As noted in a framework from Snowdon et al. [2], there are two additional pandemic phases in which health informatics will also play critical roles: recovery and preparedness. Because the virus continues to impact the world while organizing this year's special section, many nations are not yet ready to enter the next phase—recovery. The next challenge for informatics and health information systems is to support the management of COVID-19 survivors' long-term health and downstream impacts of the pandemic, including mental health and delayed care for chronic diseases. Health informatics methods and systems will also be crucial to global preparedness for the next pandemic.

Acknowledgements

The special section editors wish to thank the internationally acclaimed researchers for their service as reviewers for the survey paper as well as the 15 candidate papers. Their feedback and critical review were vital to the integrity and rigor of this year's special section. We further recognize the amazing support and talent of Rachel Hinrichs, MS, MLS, who serves as the Health Sciences Librarian at Indiana University-Purdue University Indianapolis (IUPUI). She managed the retrieval of candidate papers along with metadata.

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Appendix A: Search Queries Constructed for PubMed and Scopus to Identify Candidate Papers for Review

PubMed

("Medical Informatics"[Majr] OR "Information Systems"[Majr] OR informatics[title/abstract] OR "information systems"[title/abstract] OR "information system"[title/abstract])

AND

((("COVID-19"[Mesh] OR "COVID-19 Vaccines"[Mesh] OR "COVID-19 Testing"[Mesh] OR "SARS-CoV-2"[Mesh] OR 2019-ncov*[tiab] OR 2019ncov*[tiab] OR 2019-novel-cov*[tiab] OR coronavirus[ti] OR coronavirus-2*[tiab] OR coronavirus-disease-19*[tiab] OR corona-virus-disease-19*[tiab] OR coronavirus-disease-20*[tiab] OR corona-virus-disease-20*[tiab] OR covid-19*[tiab] OR covid19*[tiab] OR covid-20*[tiab] OR covid20*[tiab] OR ncov-2019*[tiab] OR ncov2019*[tiab] OR new-coronavirus[tiab] OR new-corona-virus[tiab] OR novel-coronavirus[tiab] OR novel-corona-virus[tiab] OR sars-2*[tiab] OR sars2*[tiab] OR sars-cov-19*[tiab] OR sars-cov19*[tiab] OR sarscov19*[tiab] OR sarscov-19*[tiab] OR sars-cov-2*[tiab] OR sars-cov2*[tiab] OR sarscov2*[tiab] OR sarscov-2*[tiab] OR ("Coronavirus"[mh] OR "Coronavirus Infections"[mh] OR betacoronavirus[tiab] OR beta-coronavirus[tiab] OR beta-corona-virus[tiab] OR corona-virus[tiab] OR coronavirus[tiab] OR sars*[tiab] OR severe-acute-respiratory*[tiab]) AND (2019[tiab] OR 2020[tiab] OR wuhan*[tiab] OR hubei*[tiab] OR china*[tiab] OR chinese*[tiab] OR outbreak*[tiab] OR epidemic*[tiab] OR pandemic*[tiab]))) AND 2019/12:3000[dp])

NOT ("preprint"[Publication Type] OR editorial[Publication Type] OR "letter"[Publication Type] OR "news"[Publication Type])

Limits: English, Abstracts-included

Scopus

TITLE-ABS-KEY ((informatics OR "information systems" OR "information system") AND (covid-19 OR covid19 OR sars-cov-2 OR coronavirus OR 2019-ncov* OR 2019ncov* OR 2019-novel-cov* OR coronavirus OR coronavirus-2* OR coronavirus-disease-19* OR corona-virus-disease-19* OR coronavirus-disease-20* OR corona-virus-disease-20* OR covid-19* OR covid19* OR covid-20* OR covid20* OR ncov-2019* OR ncov2019* OR new-coronavirus OR new-corona-virus OR novel-coronavirus OR novel-corona-virus OR sars-2* OR sars2* OR sars-cov-19* OR sars-cov19* OR sarscov19* OR sarscov-19* OR sars-cov-2* OR sars-cov2* OR sarscov2* OR sarscov-2*)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019)) AND (LIMIT-TO (LANGUAGE , "English"))

Searches run on 1/20/2021

Appendix B: Content Summaries of Selected Best Papers for the 2021 IMIA Yearbook, Special Section on Managing Pandemics with Health Informatics

Ahmed K, Bukhari MA, Mlanda T, Kimenyi JP, Wallace P, Okot Lukoya C, Hamblion EL, Impouma B

Novel approach to support rapid data collection, management, and visualization during the COVID-19 outbreak response in the World Health Organization African Region: development of a data summarization and visualization tool

JMIR Public Health Surveill 2020;6(4):e20355

This paper describes the development and deployment of a regional surveillance tool in low- and middle-income countries by the World Health Organization (WHO). The tool was created to support field data collection, contact tracing follow-up, and generating epidemiological information for decision makers in a timely manner; core functions of public health during a pandemic. The tool leveraged a wide variety of available information systems and open standards to enable each member state in the Africa region to contribute data, providing flexibility in reporting requirements. As member states submit data to the WHO Africa regional office, they are integrated into a data warehouse that then enables analysis. Information are visualized on a dashboard available to WHO and the Ministry of Health in each member nation. In addition, the WHO generates weekly situation reports and epidemiological updates. The paper nicely documents the data sources, information architecture, and processes used by public health authorities in leveraging health informatics to manage a pandemic. Furthermore, the paper is an important contribution from scientists based in Africa.

Garcia M, Lipskiy N, Tyson J, Watkins R, Esser ES, Kinley T

Centers for disease control and prevention 2019 novel coronavirus disease (COVID-19) information management: addressing national health-care and public health needs for standardized data definitions and codified vocabulary for data exchange

J Am Med Inform Assoc Jul 2020;27(9):1476-87

This article introduces readers to COVID-19 Information Management Resources Repository created by the U.S. Centers for Disease Control and Prevention (CDC). The free, online resource contains a wealth of information about emerging as well as harmonized data and information standards relevant to managing the COVID-19 pandemic. Health care and public health organizations needed to rapidly access information on data standards, including International Classification of Disease (ICD), LOINC (Logical Identifiers Names and Codes), and Current Procedural Terminology (CPT) codes, to apply in electronic health record (EHR) and other clinical information systems when documenting and/or sharing data on diagnoses, symptoms, and outcomes. The repository also contained documentation and details on CDC case definitions for confirmed and probably cases, as well as guidelines for defining patients under investigation (PUIs). These are critical resources for local jurisdictions as well as clinical organizations and researchers. The article nicely summarizes the variety of data, information, process, and workflow standards necessary for development by national public health authorities to support the management of patients and populations during a pandemic.

Gong M, Liu L, Sun X, Yang Y, Wang S, Zhu H

Cloud-based system for effective surveillance and control of COVID-19: useful experiences from Hubei, China

J Med Internet Res Apr 2020;22(4):e18948

This paper describes the development and deployment of a population surveillance

system in the city of Honghu located in Hubei province in China. The article details the various data sources and information systems deployed to detect, triage, screen, diagnose, and manage patients. Population questionnaires screened individuals outside of care settings, and these data were integrated with laboratory test results as well as EHR system data on patients in hospitals. A common data model was quickly developed to harmonize information into a cloud-based platform upon which analytics and modeling were deployed to inference population trends. The paper nicely illustrates the concept of integrated disease surveillance, in which health care and public health organizations work together to manage population health at the community level. The paper further discusses the facilitating factors and challenges faced by the informatics team asked to rapidly build and deploy the system within 72 hours. It was selected as a best paper, because it documents an impressive achievement and offers a schematic for how other jurisdictions might leverage health informatics systems to manage a pandemic.

Reeves JJ, Hollandsworth HM, Torriani FJ, Taplitz R, Abeles S, Tai-Seale M, Millen M, Clay BJ, Longhurst CA

Rapid response to COVID-19: health informatics support for outbreak management in an academic health system

J Am Med Inform Assoc Jun 2020;27(6):853-9

Hospitals in many nations were overwhelmed with patients affected by SARS-CoV-2. In response to the pandemic, hospitals leveraged multiple information systems to triage patients based on acuity, expand capacity to care for growing numbers of patients, and keep clinicians and other employees healthy. This case report from the University of California San Diego Health system summarizes the various activities many hospitals and health systems undertook to leverage the EHR and other information systems to manage their response to COVID-19. The case study highlights how a commercially used EHR

system was expanded to implement new order sets, triage protocols, and documentation templates rapidly. Upon establishing an Incident Command Center, the health system identified several operational areas that would benefit from expanded use of their informatics infrastructure. A dashboard streamlined access to data and information for clinical operations leaders, and a patient portal became a hub for virtual visits as ambulatory centers

were closed to allow for expansion of inpatient services for those severely ill from COVID-19. The EHR played a central role in collecting data and communicating information out to leaders and clinicians. This case study is also important because it detailed the many practical challenges the health system faced in deploying technologies in the wake of the pandemic. The evidence base for screening and treating COVID-19 patients changed almost daily.

Guidelines, order sets, and documentation requires rapidly changed, and there was no time to train staff on these frequent system updates. The Incident Command Center played a central role in disseminating information and identifying failures to inform iterations of the informatics tools. The lessons in this case report are important for the health system to note as the pandemic continues and preparedness begins for the next pandemic.