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Information Technology Systems for Infection Control in German University Hospitals—Results of a Structured Survey a Year into the Severe Acute Respiratory Syndrome Coronavirus 2 Pandemic

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Abstract

Background Digitalization is playing a major role in mastering the current coronavirus 2019 (COVID-19) pandemic. However, several outbreaks of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in German hospitals last year have shown that many of the surveillance and warning mechanisms related to infection control (IC) in hospitals need to be updated.

Objectives The main objective of the following work was to assess the state of information technology (IT) systems supporting IC and surveillance in German university hospitals in March 2021, almost a year into the SARS-CoV-2 pandemic.

Methods As part of the National Research Network for Applied Surveillance and Testing project within the Network University Medicine, a cross-sectional survey was conducted to assess the situation of IC IT systems in 36 university hospitals in Germany.

Results Among the most prominent findings were the lack of standardization of IC IT systems and the predominant use of commercial IC IT systems, while the vast majority of hospitals reported inadequacies in the features their IC IT systems provide for their daily work. However, as the pandemic has shown that there is a need for systems that can help improve health care, several German university hospitals have already started this upgrade independently.

Conclusions The deep challenges faced by the German health care sector regarding the integration and interoperability of IT systems designed for IC and surveillance are unlikely to be solved through punctual interventions and require collaboration between educational, medical, and administrative institutions.

Keywords
- health information technology
- medical informatics
- infection control
- interoperability
- health IT
- public health

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Introduction

Although pandemic management plans have been established in Germany since 2007,[1] the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has hit the German health system in an unprecedented way bringing a strenuous burden both for workers and health services all over the country. During the first months of the pandemic, several outbreaks occurred in hospitals all over Germany,[2] and hospitals had to react quickly with limited resources to address the pandemic situation.[3]

Health information technology (IT) systems (or medical digital systems) have been proven effective and cost-efficient in handling large quantities of data. These have acted as important aids in health care services and infection control (IC) before and during the SARS-CoV-2 pandemic.[4–7] However, studies have documented limitations and barriers to the implementation of IT systems by health services all around the globe.[8–10] With the presented study, we aim to assess the main IT systems for IC that were applied during the first year of the SARS-CoV-2 pandemic in the German University Hospitals and explore the current state of health IT systems in the country.

For this purpose, a survey was developed within the Network University Medicine (NUM) and the National Research Network for Applied Surveillance and Testing (B-FAST), which included topics on various IT systems used in hospital operations with an explicit focus on the SARS-CoV-2 pandemic. The main objective of the survey was to understand relevant information about the IT systems used in IC and surveillance by university hospitals within Germany during the first year of the SARS-CoV-2 pandemic. Furthermore, the survey aimed to statistically analyze this information with the expectation of obtaining a detailed understanding of the current status of the use of modern IC IT systems in the country. With the survey and the associated analysis of the current state of the IC IT systems at university hospitals, B-FAST is pursuing the goal of the Medical Informatics Initiative (MII, https://www.medizininformatik-initiative.de/). The survey thus helps to identify problems and challenges related to the use of appropriate surveillance systems in practice and at the same time reveals positive empirical values that can be further expanded in the future.

There is no general definition for digital IC systems; we focus in this study on IT systems and software that can be characterized by two concepts. The concept of health IT (or HIT) has been defined as "the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data, and knowledge for communication and decision making"[14]. This general definition of health IT systems is specified for systems that support IC in the frame of the definition of IC systems that are defined by their use to prevent and manage the spread of health care-associated infections and to guide quality improvement.[15] Therefore both very specialized IC systems and more general-purpose HIT that supports IC are regarded here.

Among other important initiatives, the MII is already creating the conditions for German university hospitals and partner institutions to network research and care data across Germany.[11] It also addresses a wide range of diseases more sustainably in the future to improve patient care with the help of better and more in-depth knowledge of available patient data.[12,13]

Methods

Study Design

We conducted an exploratory, observational, cross-sectional study investigating the use of IT systems during the coronavirus 2019 (COVID-19) pandemic. This was done using an anonymized online survey. The results presented here are thus descriptive, as we refrained from formulating a hypothesis.

Procedure and Study Population

Although the units of observation were all NUM university hospitals (NUHs) in Germany ($n = 36$), the target group within the university hospitals was IC and surveillance experts. An online survey was developed by an interdisciplinary team between September 2020 and February 2021 and later sent to all NUHs. The survey (►**Supplementary Appendix A**, available in the online version) consisted of 54 questions (24 of which appeared only as a function of previous responses) organized in 11 blocks that summarized key data about the participants and IC issues relevant to a hospital, such as follows:

1. Personal information.
2. Electronic health records.
3. General surveillance tools in the field of hospital hygiene and infectiology.
4. Software-based warning and control systems.
5. Software-supported admission control/screening of patients.
6. Software-supported support for ward and bed allocation.
7. Screening/testing for SARS-CoV-2 and transmission of analysis results.
8. Software-supported contact assessment/contact tracing of patients.
9. Software-supported contact assessment/contact tracing for employees.
10. Software-based support for vaccination for SARS-CoV-2.
11. Suggestions for surveillance tools in the field of hospital hygiene and infectious diseases.

The first 10 blocks of questions contained multiple-choice questions, while the remaining group of questions represented a matrix with multiple options on the *X* and *Y* axes. All questions were compulsory (except for the free text fields). To better summarize the questions, we divided the eleven blocks of questions into six broad themes: (1) characteristics of participating clinics, (2) software-based IC, (3) software-supported admission screening and ward assignment, (4) software-assisted testing, transmission of reporting, and vaccination, (5) software-based contact tracing, and (6) suggestions for further development.

The survey was first reviewed by a team of experts ($n = 5$) consisting of visual engineers, hospital hygiene experts, medical informaticians, virologists, and epidemiologists. It was subjected to pretesting before being sent out to the hospital representatives. The recipients of the survey were members of the crisis management committee and/or the quality/risk management departments of the NUHs.

Due to the different institutional structures of the university hospitals, we decided to hold a meeting with the heads of the task forces of the NUM member hospitals before sending out the survey to ensure that the survey was forwarded to the appropriate representative in each hospital. During this meeting, the use of the "LimeSurvey" survey platform (www.limesurvey.org) was demonstrated to the NUHs. Invitation letters were emailed to local task force leaders via the national task force administration in Berlin.

The actual anonymized survey took place between 1 and 26 March 2021. Although we were able to identify which token completed the survey and which did not, it was impossible to trace these tokens back to a specific hospital due to the anonymization process. Nevertheless, two reminders were sent during the survey period to those tokens that had not completed the survey to date.

While this paper summarizes the main findings of the survey, most questions allowed respondents to choose between the options: "yes," "no," and "not sure." Therefore the questions do not represent dichotomous variables.

Statistical Analysis

While the results were analyzed descriptively, the free text answers were presented as a list in ►**Supplementary Appendix B** (available in the online version) due to the heterogeneity of the responses. The descriptive statistical analysis was performed using IBM SPSS Statistics version 26. Diagrams were also produced using the same. Inductive statistical analysis was not performed.

Ethical Considerations and Data Protection

The survey of the participating clinics was anonymous, and there was no way to trace back the origin of the individual answers. All participants provided electronic consent. This study was funded by the German Federal Ministry of Education and Research under the funding code 01KX2021 B-FAST, at The University Medical Center Göttingen. The survey design was reviewed and approved in advance by the data protection officer. The study received ethical approval from the local committee under file no. B-FAST/tl 5/2/21, for the B-FAST work package 3.8.1.

Results

Each university hospital could only participate once in the survey to avoid bias in the results. In the case of university hospitals with several locations, a person from the site with the highest number of acute care beds answered on a representative basis. Due to the survey's extensive and specific questions, several hospitals reported that based on the question, other experts were consulted for support during survey completion (e.g., IT experts). In total, 33 of the 36 university hospitals completed the survey, representing 92% of the study population.

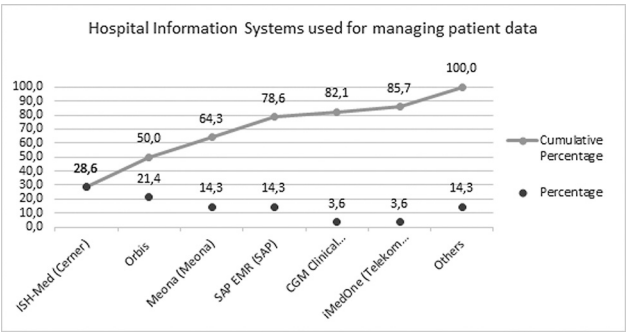

Fig. 1 Most common hospital information management systems at the Germans NUHs ($n = 28/33$).

Characteristics of the Participating Hospitals

The survey respondents had the opportunity to select several answers since being part of the hospital hygiene department does not preclude simultaneously occupying another role in the hospital. Hospital hygiene is a cross-sectional discipline. Therefore, nearly half of the respondents ($n = 14$, 38.9%) claimed to be working in the field of hospital hygiene, while the remaining respondents were active within the fields of microbiology ($n = 7$, 19.4%), infectiology and antibiotic stewardship ($n = 5$, 13.9%), risk management ($n = 8$, 22.2%), and emergency department ($n = 2$, 5.6%). However, only two (5.6%) of the representatives claimed to possess knowledge in the subjects of informatics or information technology.

Of the 33 hospitals that responded to the survey, 22 (66.6%) reported having a complete electronic health record (EHR) system, 6 (18.2%) had a partial EHR system, and 5 (15.1%) hospitals did not use an EHR system. The four most commonly used Hospital information systems were used by 22 of the 28 hospitals that answered this question (►**Fig. 1**).

Software-Based Infection Control

Most respondents ($n = 26$, 78.7%) reported using an IT system to analyze IC data. The various forms of the software modules from "HyBASE Clinic" (among other modules: statistical, laboratory, and clinical) were the most common, followed by more rudimentary databases such as self-designed Excel spreadsheets and Access databases (►**Fig. 2**). A total of 28 (84.8%) NUHs reported having an electronic quality assurance system, while 26 (78.8%) hospitals reported having a warning system for patients requiring isolation on readmission. Moreover, two (6%) hospitals reported not knowing such a system. Most of the hospitals ($n = 25$, 75.7%) had already set up an alert system before the start of the SARS-CoV-2 pandemic, while only one reported having set up an electronic alert system during the pandemic. Of the 25 reported electronic alert systems, only one could perform syndromic surveillance to assist staff in assessing COVID-19 infections. However, nine hospitals declared having an IC IT system for molecular surveillance, that is, a system that allows reporting on lineages and information on more

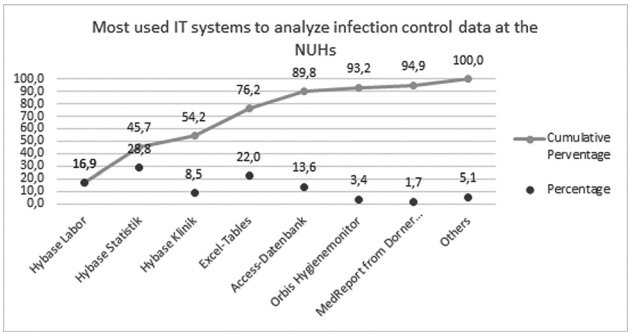

Fig. 2 Answer to the question: Which of the following IT-supported systems for recording findings with hospital-hygiene relevant pathogens (e.g., MRSA, 4MRGN, VRE, toxigenic Clostridium difficile, norovirus, influenza virus, SARS-CoV-2) do you use? (Multiple selections were possible; $n = 33$).

sophisticated strains. From these nine, a third of the IC IT systems could display epidemiological information about the different variants. Concerning quality assurance systems for hospital hygiene standards, 28 (84.8%) hospitals mentioned having an electronic system for this purpose, while only 4 (12.1%) indicated that they do not have such a system.

Software-Supported Admission Screening and Ward Assignment

One requirement to prevent nosocomial infections with SARS-CoV-2 is the control of infections in patients in the hospital. Of the total number of hospitals who answered the survey, eight (24.2%) NUHs used an app-based system to inquire about symptoms of SARS-CoV-2 infection in patients and visitors. Five (15.1%) hospitals used an app to collect information about possible exposure to SARS-CoV-2. No university hospital reported having an electronic system at the time of admission that integrates incidence data from the location of the patient's residence. While most university hospitals ($n = 26$, 78.7%) have software to track patients admitted with SARS-CoV-2 infection, six hospitals explicitly stated that they do not use such software. Twelve reported using software that additionally displays the number of SARS-CoV-2 inpatients admitted to other hospitals in the same region. Only three hospitals reported the exchange of data regarding transferred patients.

Concerning ward occupancy IT systems, roughly one-third ($n = 13$, 39.4%) of the surveyed hospitals have a surveillance system to collect and classify risk factors related to COVID-19 among inpatients. Only 10 hospitals indicated the use of such a system among outpatients. A considerable number of hospitals ($n = 22$, 66.6%) reported not having any software that allows them to exchange patient data with other hospitals, while three (9%) hospitals have declared to have such software.

Software-Based Contact Tracing

As expected, almost all ($n = 32$, 96.9%) NUHs perform contact tracing among patients and staff when a patient becomes unexpectedly positive for SARS-CoV-2. Interestingly, for patients and for hospital staff, these data are mainly recorded in spreadsheets using an Excel format (57% of hospitals). Only ($n = 20$, 60.6%) NUHs use an IT system to record nosocomial SARS-CoV2 infections in patients. Regarding the level of details that contact-tracing software is able to address, 18 (54.5%) NHUs declared to have software capable of reporting the room and possible station contacts of patients. Seven (21.2%) participants did not have such information and eight participants declared not to be sure if they had software with this capability.

Furthermore, 29 (87.8%) hospitals perform contact tracing among patients and staff when an employee becomes unexpectedly positive for SARS-CoV-2. However, only four NUHs use a system beyond the capabilities of Excel spreadsheets to trace previous contacts of a health care worker with a positive SARS-CoV-2 test. Eight NUHs use a similar system for patient contact tracing. Finally, 69.7% ($n = 23$) of survey participants declared missing IT systems with specific functions to integrate into their work, whereas 30% ($n = 16$) said they do not need additional functions. The hospital representatives expressed a heterogeneous range of specific functions that were missing, namely, central management of vaccination status for patients, automatic alerts for COVID-positive patients, automatic contract tracing alerts, and other functionalities (►**Supplementary Appendix B**, available in the online version).

Suggestions for Further Development

Twenty-four (72.7%) of the NUHs stated that their systems do not have more features than necessary, only the opposite opinion was represented. When asked if they missed any specific system features, 24 (72.7%) of the hospitals expressed that they lack certain features in their daily work ►**Fig. 3.**

Approximately, half of the hospitals that participated in the survey declared modifications in their IC IT systems since the beginning of the SARS-CoV-2 pandemic. Seven (21.2%) hospitals indicated that this was not the case, while another seven (21.2%) did not have enough information to make this statement. In terms of the IC systems features, 23 (69.7%) hospitals agreed that there should be an automatic alert in the future to warn hospital wards if a patient with a recent hospital stay tested positive for SARS-CoV-2. Six (18.1%)

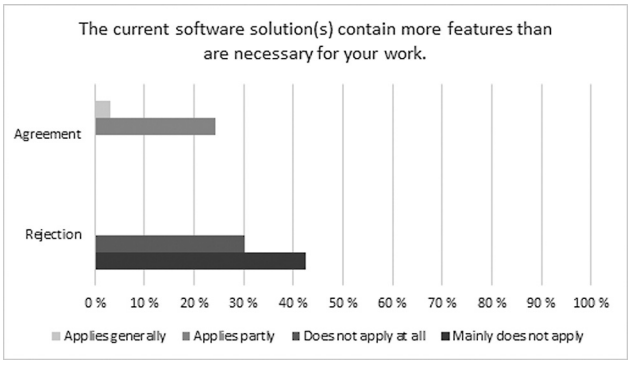

Fig. 3 Answers to the question): How true is the following statement? Your current software solution(s) contain more features than are necessary for your work ($n = 33$).

hospitals were against such an alert and four (12.1%) of the participants did not answer the question.

Discussion

The present work illustrates the status of German IT surveillance and IC systems at university hospitals 1 year after the World Health Organization (WHO) declared SARS-CoV-2 infection a global pandemic. With the participation of 33 of the 36 university hospitals in Germany, the survey provides a comprehensive overview of the situation of these institutions in the first year of the pandemic and shows the interest of these institutions in IT-based health systems and the upgradation of the same.

Explicitly linked to the public health sector and epidemiology, we highlight the results displaying the lack of interoperability of IC data between university hospitals, where only three university hospitals can exchange data with other hospitals via IT systems. This outcome represents a key issue in information flow between hospitals, local public health authorities, and infection surveillance.[16] In the special case of a pandemic, which leads among other things to an exceptionally high workload for all hospital staff,[17] the implementation of software is capable of automating certain processes such as the transfer of data related to IC in the form of alarms or risk assessments. Furthermore, it could improve patient health care, reduce costs, and be of great benefit for the IC and infection surveillance of the hospital.[18–20]

The reported absence of an EHR system in five (15.1%) university hospitals was one of the most salient results from the survey. However, the explanation for this outcome might be a misinterpretation of the meaning of the EHR system. Nevertheless, we can also interpret the results as a partial lack of these IT resources at those hospitals. On the contrary, regardless of our previous interpretation, this result may indicate the lack of standardization and the knowledge of basic IT resources in German university hospitals, which is a plausible interpretation reflecting similar results in the United States.[9] From this perspective, much progress has been made in the last year, viz, the creation of new IT systems for pandemic management or the formation of a digital interface with the competent health authority.[21] However, there is still a long way to go before IT systems for IC and infection surveillance are used daily by every health care staff.

Looking to the future of medicine and the capabilities that IT-based IC and prevention systems, as well as syndromic surveillance, can offer today, it is also remarkable that only 1 of 25 hospitals was equipped with software that can perform these functions, after a year into the pandemic.

For IC, the data show that there are still heaps of work ahead. Furthermore, the widespread use of commercial IT systems is bound to costs that could explain why rudimentary systems are still widely used, even when they do not allow, in many cases, IT automation of certain processes. Thus, it limits the work possibilities of hygiene experts, increases the likelihood of errors, and puts both patients and health care personnel at risk. The fact that very few hospitals have IC IT systems with capabilities beyond Microsoft Excel that are able to perform contact tracing on patients and staff translates into an immense amount of effort and time for qualified staff on tasks that could be done (at least partially) by IT systems.

Among the results suggesting further development of possible IT systems for the university hospitals, we observed that most of the hospitals that miss specific features on their IC IT systems are the same ones who have answered that the current systems do not provide more features than necessary. Moreover, the heterogeneity of the improvement suggestions could be seen as a symptom of the task complexity and needs of the respective hospitals.

However, the result of the question of whether the COVID-19 pandemic led to changes in the IC IT systems used by the NHUs should be treated with caution. Primarily, we consider that the answer to this question depends heavily on the knowledge of the survey respondents, something that seems to be an issue in many of the answers on the survey. Nevertheless, the survey not only displays the need for German university hospitals to update their IT-based systems, especially those for IC and those handling the transfer of data between institutions, but also a greater willingness to do so.

Limitations

The study is not without limitations, some of which are inherent to the cross-sectional design that was employed in this research. Due to the characteristics of the respondents and the distribution of the survey, the study population may not be representative of the standard of information handled by the health care workforce and IC experts, and therefore, the generalizability of the results is limited. Even though the questions were clarified at the meeting that was held with the task force representatives before starting the survey, they were not necessarily the ones who filled out the survey. This situation could create the possibility that some of the answers may have arisen from a misinterpretation of the concepts and not from a lack of information. Linked to the recruitment distribution of the survey, the inability to allocate the respondents to clarify comprehension issues could be an important limitation as well. Moreover, some of the survey responses could be influenced by recall bias. However, the survey was anonymized to prevent participants from distorting their answers due to the feeling of being judged based on their responses. What is more, in a field as dynamic as medical technology, hospitals reporting on the use of IT solutions for IC and surveillance may vary widely at the time of publication of this article, so we need to reemphasize the aim of the study as a snapshot at a point in time.

Conclusions

The pandemic has further highlighted the problems related to IC IT systems in Germany and internationally. The previous discussion shows that there is still a need for improvement regarding the use of IT systems in German university hospitals. In addition, IT systems capable of automatizing IC

and surveillance tasks could improve patient health care.[18,19,22] However, the partial lack of IT literacy by the hospital staff and the ongoing need to improve and upgrade their health IT systems to make them more up-to-date, compatible and interoperable is not unique to Germany.[8,9,16,22,23] This issue represents an enormous challenge for the health care sector that needs to keep up with the speed and possibilities that technology generates. Especially, the implementation and actualization of IT systems designed for IC and surveillance should be addressed in hospitals and public health agencies. Moreover, policies should be enforced to develop and implement open source software while compelling commercial providers to meet technical interoperability standards.

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Conflict of Interest

None declared.

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