Deployment of a computerized ward visitor registration system in coronavirus disease 2019 epidemic: Experiences of a large academic medical center in Taiwan

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Abstract

Background: Visitors to hospitalized patients during an epidemic might themselves be carriers and are therefore likely to spread the disease in wards. Although measures were taken to restrict hospital visits, traditional paper-based registration is insufficient to screen and monitor the numbers of visitors to a large hospital.

Methods: Throughout March 2020, during the coronavirus disease 2019 crisis, a computer system was deployed in the 2800-bed Taipei Veterans General Hospital (Taipei, Taiwan) to register, screen, and monitor inpatient visitors. This system comprised three parts: online registration form, entrance check-in interface, and registration database. The early utilization of this newly deployed system was then analyzed.

Results: A total of 22,336 visits were recorded between March 11, 2020, and March 31, 2020, with 1064 a day on average. Out of these visits, 18.1% (n = 4049) had made online reservations within 48 hours. On the other hand, of all 4941 online reservations, 18.1% (n = 892) were no-shows. In the last 12 days of the study period, eight prospective visitors were identified as ineligible by the computer system, and so their visits were denied.

Conclusion: Using a computer system, the hospital was able to enforce restrictions on hospital visits. Although the online registration system had not been fully used yet in the early phase of adoption, its superiority from the standpoint of disease control should enable hospital managers to consider abolishing on-site visitor registration.

Keywords: Coronavirus; Information services; Severe acute respiratory syndrome; Visitors to patients

1. INTRODUCTION

The outbreak of coronavirus disease 2019 (COVID-19) poses an immense global threat. Data show that more than 740,000 confirmed cases had been recorded up until March 31, 2020, including more than 35,000 deaths.[1,2] Numerous measures have been taken to contain this disease;[3,4] in Taiwan, unnecessary travel to foreign countries was prohibited[5] for medical personnel, and admitted patients are required to report detailed travel, occupation, contact, and cluster (TOCC) history upon their arrival at hospital. The Taiwan Centers for Disease Control (CDC) announced a ward visitor regulation policy on March 3, 2020, that mandated only three time slots a day were available for hospital visits. One of these slots should not be longer than 1 hour, at most two visitors can visit one patient in a time slot, and all should also report their TOCC history. Numerous hospitals adopted higher restriction standards.

Hospitals have previously usually relied on a paper-based recording system at each ward to monitor patient visitors. This traditional approach, however, has two significant defects during an epidemic.[6,7] In the first place, it takes time for nurses or administrative staff to ask and confirm the TOCC history of visitors. Second, it is difficult to process paper documents to enable hospital-wide surveillance. A computer system to speed up visitor management is therefore urgently needed.

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The aim of this study is to initially illustrate the deployment and early utilization of a computerized system for the registration of ward visitors at a large academic medical center in Taiwan during the COVID-19 pandemic. The experience reported here will likely be of crucial importance to hospitals facing similar crises around the world.

2. METHODS

Taipei Veterans General Hospital is the largest public academic medical center in Taiwan. As of March 2020, this hospital had 2800 beds served by a staff of 6670 people. Subsequent to the announcement of ward visitor regulation policies by Taiwan CDC, the hospital limited visiting hours to one time slot between 18:00 and 19:00 daily and allowed a maximum of two visitors to each inpatient. A computerized ward visitor registration system was deployed within two days and officially launched on March 10, 2020. This system comprised three parts, an online registration form, a registration database, and an entrance check-in interface (Fig. 1).

2.1. System design

2.1.1. The online registration form

The online registration form (Fig. 2) was open to prospective visitors using an authorization code given to an admitted patient. This authorization code was generated uniquely for each patient upon admission and was printed on an identification wristband. The form was accessed either via a web browser or via official application to the hospital; both routes led to the same interface.

Inputting a patient's name, authorization code, and visitor's National ID number meant that a prospective incoming individual was able to register online. The prospective visitor was then also asked to report their TOCC history. The system then ran eligibility checks on both the patient and prospective visitor (Fig. 1); if all criteria were met, then a reservation was made on the selected date in the registration database.

2.1.2. The entrance check-in interface

A check-in interface was operated at the main hospital entrance by staff for identity verification and for the on-site registration of inpatient visits (Fig. 2).

An arriving visitor was asked to provide their National ID card or health smart card. The hospital check-in interface then interrogated the registration database using the National ID number of each visitor.

In cases where a registered visit was recorded for this visitor on the same date, entrance to the hospital was allowed and entered into the database. In contrast, if a visitor was not registered on a given date, on-site action was required, and the visitor was asked to provide the admitted patient's name, ward, and bed number and was required to complete a paper-based questionnaire similar to the online registration form. A similar eligibility check for each visitor and patient was also conducted (Fig. 1). The interface then made a registration in the database, and the visitor was allowed to enter the hospital.

2.1.3. The registration database

The registration database used a MySQL system to store visits. This was accessed directly through an online registration form in addition to the check-in front desk interface for the registration and verification of new visitors. The system also recorded the entrance of each visitor during opening visiting hours each day.

2.2. Data processing

The system described in this article was deployed on March 10, 2020. Data were retrieved from the registration database for the

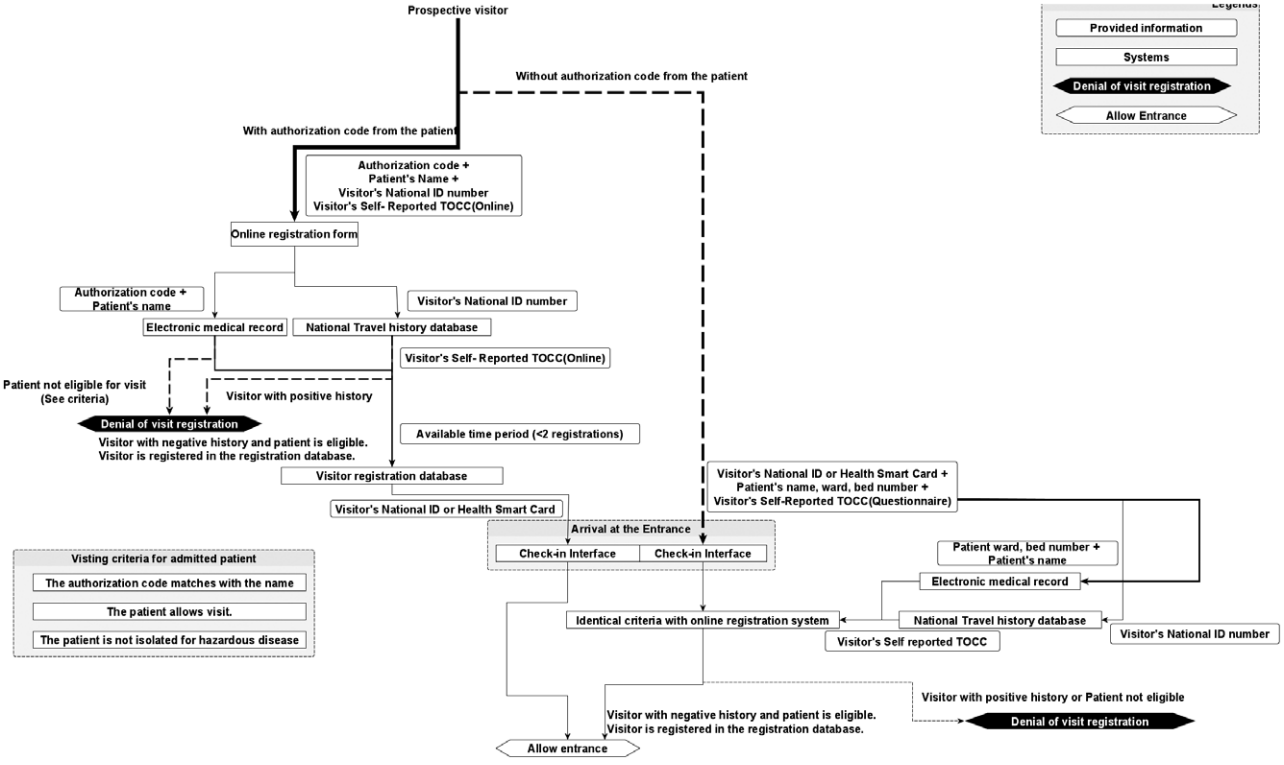

Fig. 1 Ward visitor registration system infrastructure.

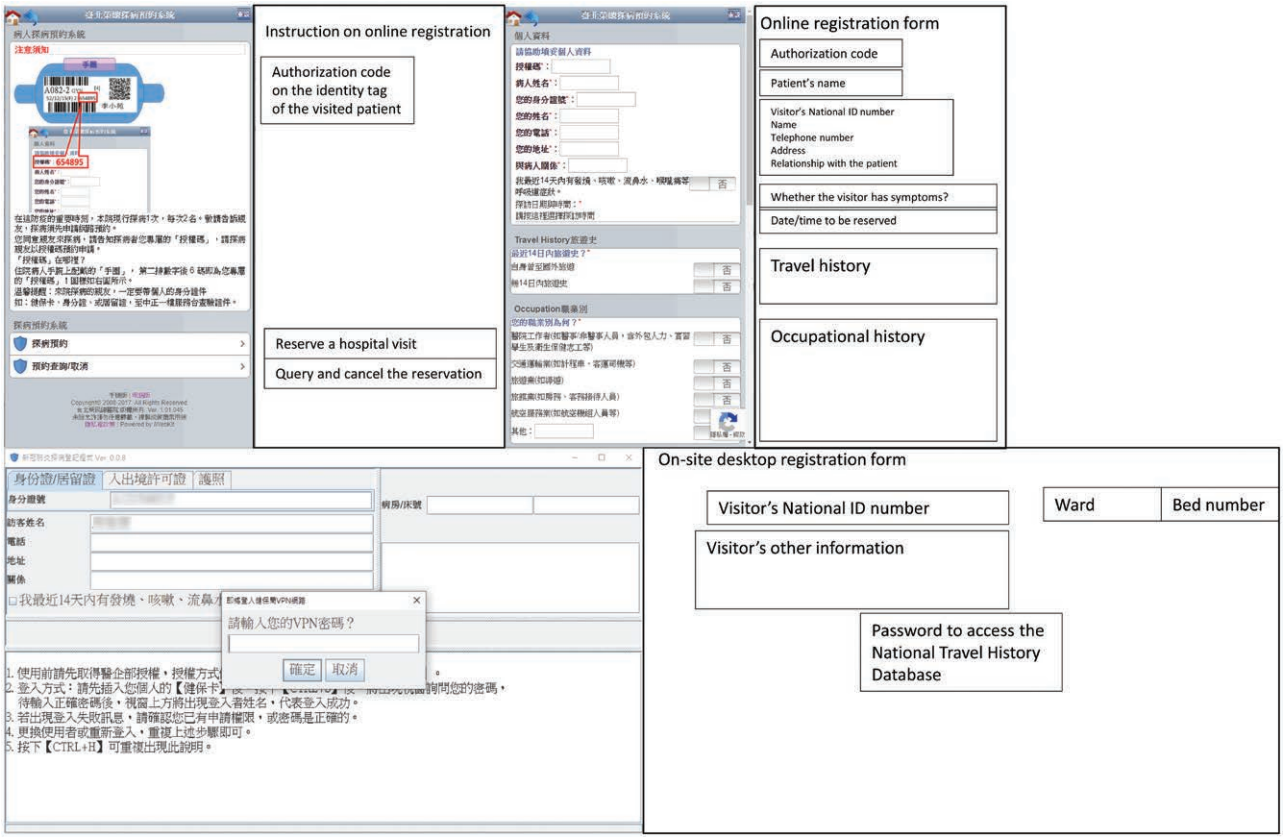

Fig. 2 Screen shot of the online registration form and check-in interface.

period between March 11, 2020, and March 31, 2020. All registrations and visitor entries to admitted patients that occurred during open visiting hours were extracted.

Registrations were further classified into those that led to actual visits and those that were no-shows. Each denied visit was also extracted along with the reason for nonadmittance for the last 12 days of the study period, between March 20, 2020, and March 31, 2020.

2.3. Statistical analysis

Descriptive statistics were presented using the software Microsoft Excel 2016.

3. RESULTS

A total of 4941 online reservations and 22,336 hospital visits were recorded between March 11, 2020, and March 31, 2020. Among these, data show that 4049 (18.1%) of visitors made a reservation through the online system while the remainder (18 287; 81.9%) were registered on-site through the check-in interface upon arrival (Table).

The total number of ward visitors increased from 771 on March 11, 2020, to 1151 on March 14, 2020, and remained stable around 1000 throughout the remaining study time period (Fig. 3). The use of the online registration system increased from 20 on March 11, 2020, to 192 on March 15, 2020. The number

Table

The total number of reservations and registrations

	11 Mar	12 Mar	13 Mar	14 Mar	15 Mar	16 Mar	17 Mar	18 Mar	19 Mar	20 Mar	21 Mar	22 Mar	23 Mar	24 Mar	25 Mar	26 Mar	27 Mar	28 Mar	29 Mar	30 Mar	31 Mar
Online reservations	70	137	162	205	231	200	228	206	216	174	254	243	211	225	264	229	265	359	383	323	356
Missed reservation	50	112	38	53	39	37	37	32	27	15	22	21	21	32	47	35	29	31	144	38	32
Online registered visitors	20	25	124	152	192	163	191	174	189	159	232	222	190	193	217	194	236	328	239	285	324
On-site registered visitors	751	763	798	999	915	776	856	859	766	843	980	916	862	800	853	714	915	1114	982	919	906
Total visitors	771	788	922	1151	1107	939	1047	1033	955	1002	1212	1138	1052	993	1070	908	1151	1442	1221	1204	1230
Online reserve rate of visitors	2.6%	3.2%	13.4%	13.2%	17.3%	17.4%	18.2%	16.8%	19.8%	15.9%	19.1%	19.5%	18.1%	19.4%	20.3%	21.4%	20.5%	22.7%	19.6%	23.7%	26.3%
Online reservation conversion rate	28.6%	18.2%	76.5%	74.1%	83.1%	81.5%	83.8%	84.5%	87.5%	91.4%	91.3%	91.4%	90.0%	85.8%	82.2%	84.7%	89.1%	91.4%	62.4%	88.2%	91.0%

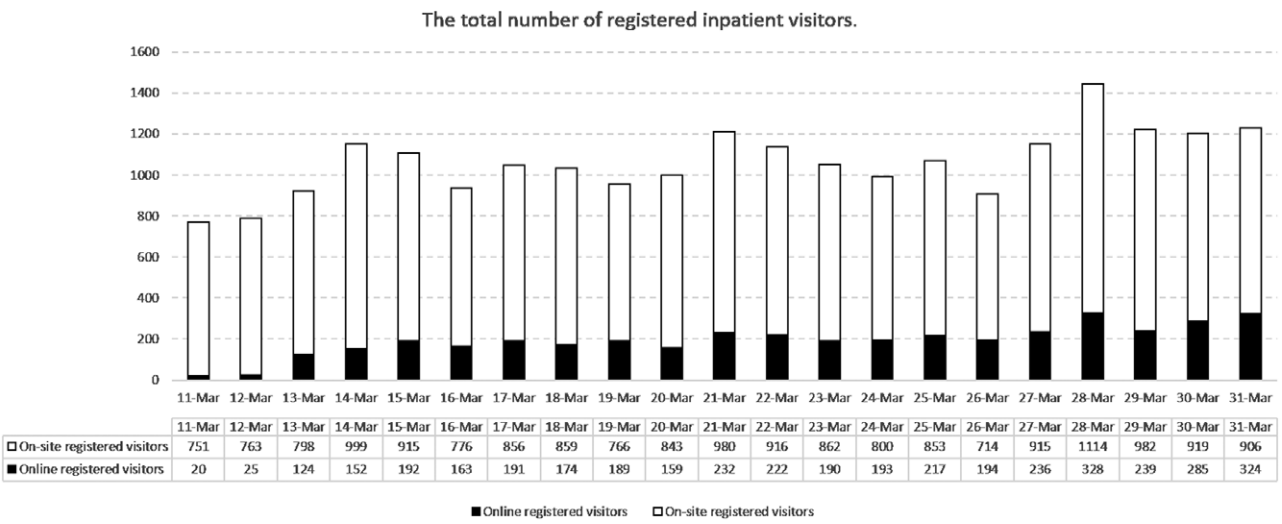

Fig. 3 The total number of registered inpatient visitors.

of registrations made through the online platform then remained stable around the 200 mark.

Data show that of all reservations made by prospective visitors, 20 out of 50 (28.6%) actually arrived at the hospital on the first day. The conversion rate of online reservations to actual visits decreased to 18.3% on the second day (March 12, 2020) and then abruptly increased to 76.5% (124 actual visits out of 162 online reservations). This rate then gradually increased with some fluctuations to 91.0% on March 31, 2020.

Eight prospective visitors were denied access to the hospital by the online system via the check-in interface. Seven of them traveled to at-risk countries, and one of them provided false identification information.

4. DISCUSSION

4.1. Monitoring ward visitors

The total number of visitors in a single day remained around 1000 throughout the study period. The highest number of recorded visitors was 1442 on March 28, 2020, whereas the lowest was 771 on March 11, 2020.

The total number of visitors prior to the deployment of this system remains unknown as records are paper-based and located in each ward. This new system allowed the real-time monitoring of current ward visitors and is therefore useful for policymakers to determine and alter hospital policies. Thus, if a hospital becomes crowded with visitors, their policy could be adjusted to allow only one ward visitor per admitted patient at any given time.

Patient visitor registration also means that a hospital is able to keep a clear record of contacts between visitors and patients. This is particularly important in the case of nosocomial cluster infections as records can be used to identify at-risk visitors.[8] The Taiwan CDC previously used the health smart card system to inform medical personnel when at-risk patients were encountered during the nosocomial cluster SARS outbreak. Recorded National ID numbers therefore likely enable a hospital to trace visitors diagnosed with COVID-19 infections subsequent to their visits.[9]

4.2. Separating ward visitors from the outpatient crowd

The entrance check-in interface allowed staff to efficiently verify the identity of incoming visitors. This system enabled the regulation and enforcement of ward visitors to between 18:00 and 19:00 hours each day but was unable to control entrance to the inpatient building because various other services are also provided here, including outpatient endoscopic examinations and the explanation of medical conditions. A system that allows for the efficient identification of visitors was also required to enforce the policy.

Once such a system has been deployed, a policy can then be successfully enforced. The main advantage of this system is that ward visitors can be isolated from the daytime outpatient crowd, and cross-infections between the two populations can be avoided.[10] It remains unknown, however, whether or not this policy reduces overall contacts and cross-infection rates as it is concentrated on all ward visitors within a single hour. The policy might therefore increase contacts and cross-infections within ward visitors.

4.3. Online registration system utilization

The online registration system reported here allowed the hospital to exclude ward visitors with relevant TOCC history prior to their arrival.[5,8] Thus, by denying registration using an online platform, this interface enabled direct contacts between at-risk visitors and the hospital staff to be avoided. These visitors would also be blocked at the main entrance by the check-in system in the absence of the online system. The arrival of these visitors at the hospital nevertheless still posed a risk of spreading the disease to the entrance desk staff and other ward visitors who waited in the same line.

Data show that over the course of the time period analyzed here, the percentage of online registered visitors among all visits never exceeded 25%, with the highest being 22.7% (n = 328) on March 28, 2020. There are several possible underlying reasons for this including that, in the first place, the use of an authorization code from a patient could exclude some of ward visitors from the system. This means that an admitted patient had to be able to report their wristband authorization code to a prospective ward visitor. However, a patient might be in a coma or unable to communicate with a prospective incoming visitor; of course, this would preclude a prospective visitor from gaining access to the authorization code and he or she would therefore be unable to use the online registration system. It is also the case that visitors need Internet access as well as the ability to use the registration form; there might not be enough motivation for a visitor to make an online reservation as on-site registrations could still be made with relative ease upon arrival.

Similarly, even though hospital policymakers considered limiting the access of ward visitors to those who had preregistered using the online system, this was never enforced. This system could be used in the future to minimize disease spread.

4.4. Limitations and suggestions for future research

No statistics are available that record previous hospital ward visitors and so no comparable data can be presented versus extracted registrations from the new system. Current data also do not include which ward was visited in each case. Additional risk stratifications for each ward could be presented and analyzed in the future so that policymakers can adjust the situation in each case more precisely. This system also did not record the gender or age group of each visitor, limiting further analysis to improve online registration form utilization.[11]

The system reported here could also be further adapted to enable screening and monitoring across the entire visitor population, including those who arrive for other purposes such as outpatient department visits and medical condition explanations. A hospital could therefore monitor an entire visitor population. Additional analyses should be performed in the future to stratify and analyze visitor exposure risk at each hospital location.[12]

In conclusion, utilization of the computer system outlined in this article meant that the hospital was able to efficiently enforce visitor restrictions. Although the online registration system was not fully used yet in the early adoption phase, its superiority from the standpoint of disease control should ensure that hospital managers can consider abolishing on-site visitor registration.

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REFERENCES

1. Wu YC, Chen CS, Chan YJ. The outbreak of COVID-19: an overview. *J Chin Med Assoc* 2020;**83**:217–20.
2. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese Center for Disease Control and Prevention. *JAMA* 2020. Available at https://doi.org/10.1001/jama.2020.2648. Accessed March 25, 2020.
3. Wang CJ, Ng CY, Brook RH. Response to COVID-19 in Taiwan: big data analytics, new technology, and proactive Testing. *JAMA* 2020. Available at https://doi.org/10.1001/jama.2020.3151. Accessed March 25, 2020.
4. Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? *Lancet* 2020;**395**:931–4.
5. Chinazzi M, Davis JT, Ajelli M, Gioannini C, Litvinova M, Merler S, et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science* 2020. Available at https://doi.org/10.1126/science.aba9757. Accessed March 25, 2020.
6. Klompas M. Coronavirus disease 2019 (COVID-19): protecting hospitals from the invisible. *Ann Intern Med* 2020. Available at https://doi.org/10.7326/M20-0751. Accessed March 25, 2020.
7. Wilder-Smith A, Chiew CJ, Lee VJ. Can we contain the COVID-19 outbreak with the same measures as for SARS? *Lancet Infect Dis* 2020. Available at https://doi.org/10.1016/S1473-3099(20)30129-8. Accessed March 25, 2020.
8. Bai Y, Yao L, Wei T, Tien F, Jin DY, Chen L, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA* 2020. Available at https://doi.org/10.1001/jama.2020.2565. Accessed March 25, 2020.
9. Voirin N, Barret B, Metzger MH, Vanhems P. Hospital-acquired influenza: a synthesis using the Outbreak Reports and Intervention Studies of Nosocomial Infection (ORION) statement. *J Hosp Infect* 2009;**71**:1–14.
10. Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. *JAMA* 2020. Available at https://doi.org/10.1001/jama.2020.3972. Accessed March 25, 2020.
11. Chang MY, Pang C, Tarn JM, Liu TS, Yen DC. Exploring user acceptance of an e-hospital service: an empirical study in Taiwan. *Comput Stand Inter* 2015;**38**:35–43.
12. Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. *N Engl J Med* 2020;**382**:1268–9.