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ORIGINAL RESEARCH

Use of a Kiosk-Model Self-Triage System for COVID-19 Triage

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Purpose: Pandemics put healthcare workers (HCWs) at risk of infections, making emergency department (ED) triage critical. This study aims to compare smart innovative self-kiosk triage (SKT) with routine triage (RT).

Patients and Methods: COVID-19-suspected ED patients enrolled. Volunteers received RT after completing SKT. The key outcomes were HCW exposure and total exposure time (TET). Secondary outcomes included participants' satisfaction with SKT.

Results: The study included 115 patients with a mean age of 32.54±10.84 years old. SKT significantly reduced HCW exposures (median 0 [IQR 0–1] vs 2 [IQR 2–3], p<0.0001) and triage time (median 3 [IQR 2–3] vs 8 [IQR 5–10] minutes, p<0.0001), compared to RT. Elevated body temperature increased RT time (p=0.003), while higher education levels reduced SKT time (p=0.019). Oxygen saturation influenced HCW exposure in both methods, with higher saturation decreasing HCW exposure during RT (p=0.008) and increasing it during SKT (p=0.017). A PCR-positive status was associated with increased RT time but fewer HCW exposures. 80.0% of participants completed SKT independently. The majority of participants (72.8–82.9%) agreed or strongly agreed, based on a 4-point Likert scale, that the SKT procedure was user-friendly (mean score: 3.40±1.08), with clear instructions (3.35±1.16), easy-to-use oximetry and thermometer (3.12±1.29 and 3.31±1.16, respectively), and a reasonable time requirement (3.37±1.23).

Conclusion: Our findings suggest that emergency department self-kiosk triage can minimize medical staff exposure and time spent with COVID-19-risk patients, without compromising patient satisfaction.

Plain Language Summary: The COVID-19 pandemic created significant challenges for healthcare systems worldwide, particularly in reducing contact between patients and healthcare workers to prevent virus transmission. To address this, we developed a self-triage medical kiosk, designed to minimize face-to-face interactions and enhance safety in emergency departments (EDs). In our study, 115 patients (mean age 32.54±10.84 years, 52.2% female) used the kiosk for initial health assessments and COVID-19 risk scoring before seeing a healthcare professional. The results showed that the self-kiosk triage (SKT) significantly reduced triage time (median 3 minutes vs 8 minutes for routine triage, p<0.0001) and healthcare worker exposure (median 0 vs 2 hCWs exposed, p<0.0001). Multivariable analysis revealed that patient education level, body temperature, and oxygen saturation influenced triage times and HCW exposure. Notably, the kiosk maintained high patient satisfaction, with more than 80% of participants completing self-triage independently and reporting the system as user-friendly, with clear instructions and easy-to-use devices. In conclusion, our research suggests that self-triage kiosks can improve safety and efficiency in emergency department operations during pandemics by minimizing direct contact while maintaining high-quality patient care.

Keywords: telehealth, self-kiosk triage, emergency department, COVID-19

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Introduction

The COVID-19 pandemic has posed unprecedented challenges to healthcare systems globally.[1,2] During pandemics, high patient loads can quickly overwhelm health service capacity. Intensive patient-patient, and patient-healthcare worker (HCWs) contact can facilitate rapid disease transmission, especially in hospitals, starting with emergency departments (ED).[3,4] Frontline HCWs in the ED are at high risk of exposure, making it essential to streamline triage processes and reduce pre-triage waiting times.[5]

Telemedicine, a subset of telehealth, refers to delivering healthcare services through electronic communication and software.[6] While telehealth adoption was quite slow before COVID-19, the pandemic dramatically accelerated its use at the point of care.[6] Telemedicine tools, particularly in resource-limited settings, offer significant advantages in improving patient triage and care during pandemics.[7] Research indicates that telehealth systems can provide services such as prevention, screening, triage, diagnosis, treatment, and follow-up during pandemics.[8] Telemedicine also offers HCWs in the ED a critical tool for reducing COVID-19 exposure risk while continuing patient care.[9–11]

Recent studies highlight the potential of computerized symptom checkers in improving triage decisions.[12] For example, a prototype symptom checker demonstrated superior performance to patients in determining appropriate care settings, achieving significant accuracy and safety outcomes.[12] Its use reduced unnecessary hospital visits by 55%, though a small risk of delayed care (2–3%) remains.[12] These findings underscore the growing role of digital tools in optimizing patient flow and ensuring timely care delivery, particularly in high-demand settings such as EDs.

Medical kiosks are easily accessible computing devices that can provide health information, conduct clinical measurements, facilitate self-monitoring, and enable remote consultation.[13] However, medical kiosks have not been extensively studied or deployed in pandemic settings. To address this gap, we developed a medical kiosk for self-triage, designed to minimize patient-HCW contact and improve triage efficiency during the COVID-19 pandemic. The self-triage kiosk, located at the ED entrance, collects data on patient identification, sociodemographic, comorbid conditions, symptoms, body temperature, and blood oxygen saturation. The system assesses COVID-19 risk using self-reported data based on the COVID-19 Patient Triage Guideline.[14] Measurements are taken through integrated devices such as a non-contact infrared wrist thermometer and a pulse oximeter. This innovation aimed to address challenges posed by the pandemic, including minimizing patient-HCW contact, reducing pre-triage waiting times in the ED, and providing a COVID-19 risk stratification tool based on self-recorded patient data. By streamlining the triage process, self-kiosk triage seeks to overcome limitations of routine triage (RT), which relies on face-to-face interaction with HCWs for data collection and measurement of vital signs. Unlike RT, self-triage kiosk minimizes patient-HCW contact, reduces pre-triage waiting times, and lessens HCW exposure. However, routine triage allows for more personalized patient interactions, which might address nuances that automated systems cannot.

This study aimed to evaluate the feasibility and benefits of self-kiosk triage (SKT) compared to routine triage procedures. While SKT may offer advantages, it is not without limitations. The study was conducted in a single ED with a specific population, potentially limiting generalizability. Future research should explore the adaptation of self-kiosk systems to other diseases and settings, including multilingual capabilities and integration with broader telemedicine platforms. Wider adoption of self-kiosks could ease patient management, particularly in resource-constrained or high-demand healthcare environments.

Materials and Methods

Study Participants

This study was conducted at Bursa Uludag University Medical Faculty Emergency Medicine Department in Turkey between March 8, 2021, and July 8, 2021. Patients suspected of having COVID-19, aged ≥18, who were admitted to the ED and willing to participate were included.

Patients suspected of having COVID-19 were defined according to the Ministry of Health 2020 COVID-19 Management Guideline as individuals meeting one or more of the following conditions:[14]

A: Presence of at least one symptom (fever, cough, shortness of breath, sore throat, headache, muscle pain, loss of taste or smell, or diarrhea), inability to relate the clinical presentation with another condition, and a history of being in or in close contact with someone from a high-risk area within the past 14 days.

B: Presence of at least one symptom (as described above) and close contact with a confirmed COVID-19 case within the 14 days prior to symptom onset.

C: Presence of fever and at least one symptom of severe acute respiratory infection (eg, cough or respiratory distress), requiring hospitalization, with no other identifiable cause for the clinical presentation.

D: Presence of at least two symptoms (as described above) and inability to relate the clinical presentation with another condition, whereas a confirmed case was defined as cases meeting the suspected case definition in which SARS-CoV-2 was detected using molecular methods. Ethical approval (2021-5/11) was obtained from the Bursa Uludağ University Institutional Ethical Committee. All of the study participants provided informed consent following the Declaration of Helsinki.

Study Procedures and Outcomes

All of the patients first completed self-kiosk triage (SKT) by the Pandemic Mobile Intelligent Kiosk (PandeMIK®) system, followed by routine triage (RT) procedures (Figure 1).

Self-Kiosk Triage (SKT) Procedure

Pandemic Mobile Intelligent Kiosk (PandeMIK®), is a stand-alone system, located at the entrance of the emergency department in a secure location to ensure the privacy of the participants (Figure 1). The kiosk operates through a monolingual touch screen in Turkish. Patients were required to input their identification numbers, phone numbers, sociodemographic features, comorbid conditions, and symptoms into the system. The system then guided patients through a series of questions for COVID-19 triage, listed in a supplementary table (Table S1). The survey items were aligned with the COVID-19 Patient Triage Guideline, as summarized in Table 1.[14] Body temperature and blood oxygen saturation were measured using a non-contact infrared wrist thermometer (Uniview OET-213H-BTS1-BDWrist IR

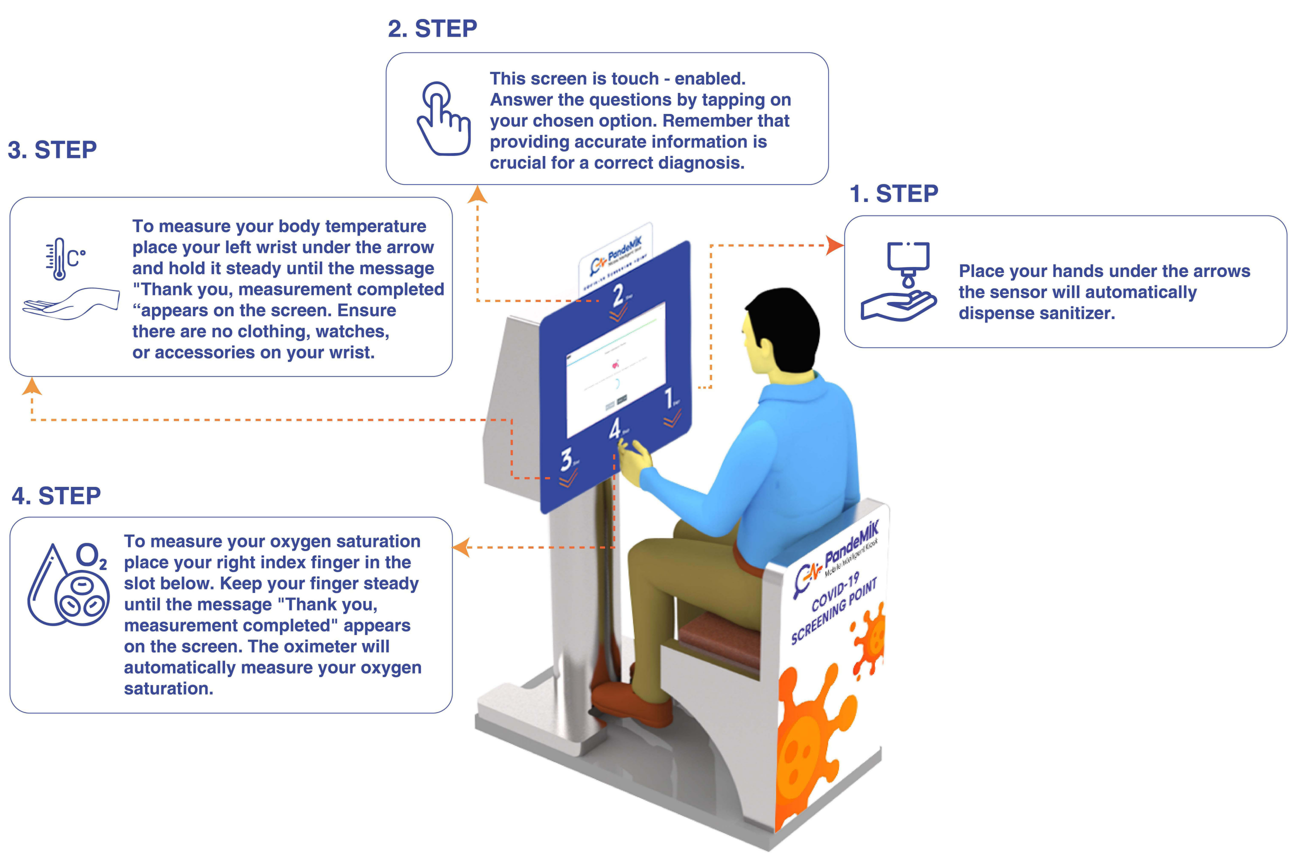

Figure 1 Schematic design of PandeMİK® self-kiosk triage.

Table 1 Sociodemographic and Clinical Characteristics of the Study Participants (N=115)

	N (%)
Sex, M/F	55/60
Age, mean ± SD	32.5 ± 10.8
Participants reporting primary language as Turkish	115 (100)
Educational status	
Primary school	7 (6)
High school	44 (38.3)
University	64 (55.7)
Comorbidity	
Chronic heart disease	3 (2.6)
Hypertension	6 (5.2)
Diabetes mellitus	4 (3.5)
Chronic obstructive pulmonary disease	1 (0.9)
Asthma	4 (3.5)
PCR confirmed COVID-19	29 (25.2)

Temperature, Uniview Technologies Co., Ltd., Hangzhou, China) and a pulse oximeter (Nonin Model 7500, Nonin Medical Inc. Plymouth, MN, USA) integrated into the kiosk. The duration of total time spent in the kiosk for each patient was recorded by the system. HCWs provided additional assistance if the patient was unable to finish the SKT procedure on their own. If assistance was provided, the number of HCWs who helped the patient was noted. The supplementary table provides information on the nature of the software, functionality, and data collection of the kiosk (Supplementary file, Table S2).

Routine Triage (RT) Procedure

In the routine triage, patients' sociodemographic features, comorbid conditions, symptoms, and responses to the COVID-19 triage survey (the same items with SKT procedure as shown in Table S1) were recorded manually by the HCWs. A physical examination was performed as part of the assessment. Body temperature and blood oxygen saturation were measured by an infrared thermograph (XRD-6808, Goodhope Pharmaceuticals, Lilongwe, Malawi) and vital signs monitor (Mindray, VS-900, Shenzhen, China).

Routine triage also included nasopharyngeal swab collection for PCR testing in patients meeting the criteria for suspected COVID-19 cases, as described above. The PCR testing was performed immediately following the completion of RT procedure. Additionally, routine blood tests and radiologic evaluations were conducted when deemed necessary by the attending physician. The total number of HCWs exposed to each patient and time spent in the triage process was recorded for each case.

In both procedures, PCR testing was carried out by a healthcare provider using a swab to collect respiratory material found in patients' nose and throats. After collection, the swab was sealed in a tube and then sent to the microbiology laboratory for analysis.

Thermometry and Oximetry

Before integrating the thermometer and the pulse oximeter in the medical kiosk we tested those two devices in our pulmonology ward with a small group of in-hospital patients over one day. Body temperature was measured consecutively using the non-contact infrared wrist thermometer (Uniview OET-213H-BTS1-BDWrist IR Temperature, Uniview Technologies Co., Ltd., Hangzhou, China) intended for use in the kiosk and the temporal scanner infrared thermometer (Exergen Corp, Watertown, Mass), which is routinely used for clinical thermometry. Similarly, oximetry was measured consecutively using the kiosk's pulse oximeter (Nonin Model 7500, Nonin Medical Inc. Plymouth, MN, USA) and the clinical pulse oximeter (Covidien, Nellcor Bedside, Dublin, Ireland) routinely used in the ward. Morning measurements were performed between 08.00 and 08.30 AM, evening measurements were performed between 08.00 and 08.30 PM.

Patient Feedback

A patient satisfaction survey, developed based on prior applications,[15,16] was included in the final section of the self-kiosk survey questions. A 5-item questionnaire assessed how the patients perceived the feasibility of the self-kiosk by a 4-point Likert scale (Table S3). Responses ranged from 1 (strongly disagree) to 4 (strongly agree). The purpose of the satisfaction survey was to determine the clarity of instructions, ease of use, and length of the procedure. The total time spent on the SKT was recorded by the system. If assistance was required for the procedure, the total number of HCWs exposed was recorded.

Primary and Secondary Outcomes

The primary outcomes were HCW exposure and total exposure time (TET). The secondary outcome of interest was focused on patient satisfaction. Total exposure time refers to the time HCWs spend with patients during face-to-face triage. HCW exposure refers to the total number of HCWs in contact with a patient during triage. TET in both procedures and the number of exposed HCWs were also recorded.

Statistical Analysis

Statistical analyses were performed using IBM Corp.'s SPSS program, version 23.0 (IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).[17] Visual (histograms, probability plots) and analytical (Kolmogorov-Smirnov /Shapiro–Wilk's test) techniques were used to examine the data to ascertain if the variables are normally distributed. For ordinal variables, descriptive analyses were presented using frequencies; for normally distributed variables, means and standard deviations; and for non-normally distributed variables, medians and interquartile ranges (IQR) (Table 1). Comparisons between SKT and RT for oxygen saturation and body temperature were conducted using Student's *t*-test (Table 2) after confirming the normality of data distribution. For the primary outcome measure variables, the TET and HCW exposure, which did not meet the normality assumption, the Mann–Whitney *U*-test was employed (Table 2, Figure 2A and B). To compare TET and HCW exposure among different educational status groups (primary, high-school, university graduates), Kruskal–Wallis tests were conducted, as these variables did not meet assumptions of normality (Table 3). For post-hoc pairwise comparisons, the Mann–Whitney *U*-test with Bonferroni correction for multiple comparisons was used. The Chi-square test or Fisher's exact test was used to compare proportions in study groups

Table 2 Clinical Characteristics Determined by SKT and RT (N=115)

	SKT	**RT**	**p**
Cough, n(%)	54 (47.0)	50 (43.5)	<0.0001
Dyspnea, n(%)	22 (19.1)	18 (15.7)	<0.0001
Recent history of travel abroad, n(%)	23 (20.0)	4 (3.5)	0.005
Recent contact with a COVID-19 case, n(%)	27 (23.5)	14 (12.2)	<0.0001
Body temperature, °C	36.1 ± 0.6	36.4 ± 0.5	<0.0001
SpO_2, %	96.9 ± 1.7	97.8 ± 1.3	<0.0001
Fever > 38.3°C	1 (0.9)	2 (1.7)	<0.0001
SpO_2 < 94%	6 (5.2)	2 (2.6)	0.026
Total exposure time during procedure, minutes, median [IQR 25–75]	3 [2–3]	8 [5–10]	<0.0001
Number of HCWs exposed during procedure, median [IQR 25–75]	0 [0–1]	2 [2–3]	<0.0001

Abbreviations: SKT, self-kiosk triage; RT, routine triage; SpO_2, oxygen saturation with pulse oximeter at room air; min, minutes; HCWs, health-care workers; IQR, inter-quartile ranges.

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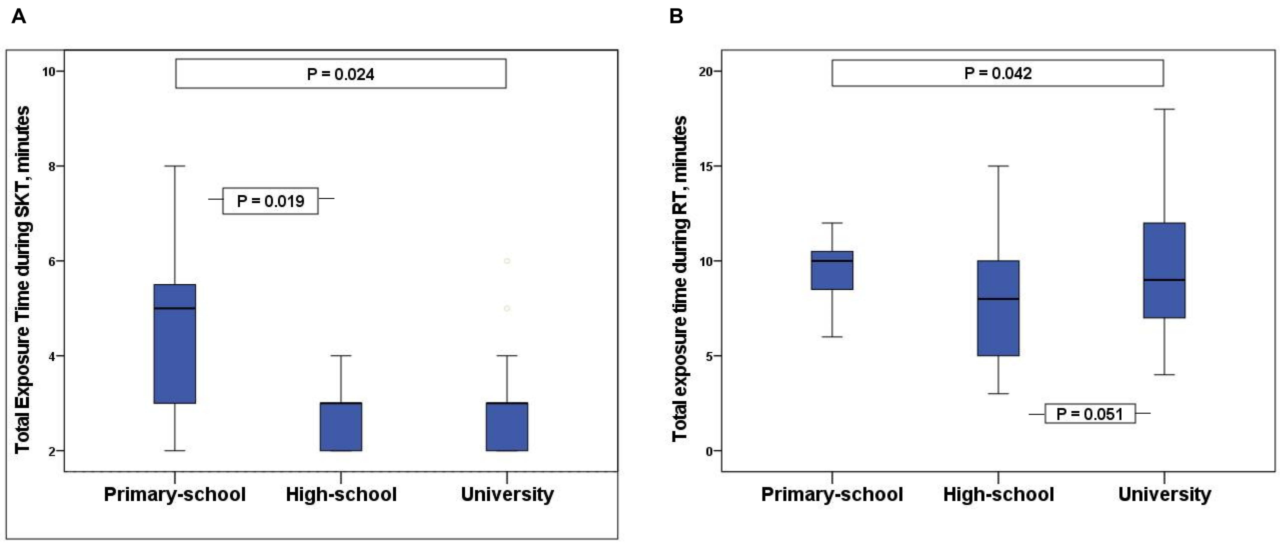

Figure 2 (**A**) Pair-wise comparisons for total exposure time in self-kiosk triage according to study participants' educational status. (**B**) Pair-wise comparisons for total exposure time in routine triage according to study participants' educational status.

(Table 2). General linear regression models were used to assess the relationships between total exposure time and number of HCWs exposed (independent variable) during both procedures and educational status, adjusting for age, sex, body temperature, peripheral oxygen saturation, and PCR status (Table 4). Morning and evening measurements between clinical and kiosk devices for thermometry and oximetry were assessed by using a paired *t*-test (Table S4). In order to establish statistical significance, we employed a 5% type-I error.

Results

The final sample included 115 patients (60 females, 55 males), with a mean age of 32.54±10.84 years. 24.3% of the study population had at least one co-morbid disease, such as hypertension, diabetes mellitus, chronic heart disease, asthma, or chronic obstructive pulmonary disease (Table 1). The sociodemographic and clinical features of the study participants are presented in Table 1. 25% of the patients enrolled were PCR (+), whereas the remaining tested negative.

The most common symptoms recorded were sore throat, myalgia, headache, and cough (60%, 55.7%, 54.8%, and 47% of the study population, respectively). This was followed by dyspnea (19.1%), fever (16.5%), anosmia (13%), taste loss (9.6%) and diarrhea (9.6%). SKT captured higher cough and dyspnea rates compared to RT (Table 2). During the SKT procedure, study participants reported a higher rate of recent history of travel abroad (20% vs 3.5%, p=0.005) and recent contact with a COVID-19 case (23.5% vs 12.2%, p<0.0001). Body temperature and peripheral oxygen saturation were measured significantly higher during the RT procedure than the self-measurement procedures in SKT (Table 2). The

Table 3 Total Exposure Time and Number of HCWs Exposed During Self-Kiosk Triage and Routine Triage According to Study Participants' Educational Status

	Total Exposure Time in the SKT, min	Total Exposure Time in RT, min	Number of HCWs Exposed During SKT	Number of HCWs Exposed During RT
Primary school	5 [3–6]	10 [7–11]	0 [0–0.7]	3 [2–4]
High school	3 [2–3]	9 [7–12]	0 [0–1]	3 [2–3]
University	3 [2–3]	8 [5–10]	0 [0–1]	2 [2–2.7]
p	0.024	0.042	0.489	0.002

Note: Group medians and interquartile ranges 25–75 are reported.
Abbreviations: SKT, self-kiosk triage; RT, routine triage; min, minutes; HCWs, health-care workers.

Table 4 Parameters That Effect Total Exposure Time and Number of HCWs Exposed During Each Triage Procedures by Multivariable Analysis

	Total Exposure Time - RT		Total Exposure Time - SKT		HCWs - RT		HCWs - SKT	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Sex								
Female	0.391 −1.091 – 1.873	0.605	−0.040 −0.365 – 0.284	0.808	0.124 −0.087 – 0.335	0.249	0.117 −0.085 – 0.319	0.257
Male	0		0	–	0	–	0	–
Age	0.011 −0.067 – 0.088	0.785	−0.002 −0.019 – 0.015	0.812	0.000 −0.011 – 0.011	0.931	0.004 −0.006 – 0.014	0.458
SpO_2	−0.239 −0.805 – 0.327	0.408	−0.082 −0.206 – 0.042	0.195	−0.110 −0.190 – −0.029	0.008	0.100 0.018–0.183	0.017
Body temperature	2.355 0.805–3.905	0.003	0.272 −0.068 – 0.612	0.117	−0.024 −0.245 – 0.197	0.830	0.072 −0.121 – 0.264	0.465
Educational status								
University	0.407 −3.094 – 3.908	0.820	−1.453 −2.220 – −0.686	<0.001	−0.685 −1.184 – −0.186	0.007	0.008 −0.456 – 0.473	0.972
High school	−1.557 −4.948 – 1.834	0.368	−1.686 −2.429 – −0.943	<0.001	−0.948 −1.431 – −0.465	<0.001	0.137 −0.322 – 0.596	0.560
Primary school	0	–	0	–	0	–	0	–
PCR positivity	0.13 −1.6 – 1.87	0.879	0.846 0.466–1.226	<0.001	−0.249 −0.496 – −0.002	0.048	−0.101 −0.317 – 0.115	0.360

Abbreviations: RT, routine triage; SKT, self-kiosk triage; HCWs, health-care workers; SpO_2, oxygen saturation with pulse oximeter at room air.

total number of patients with fever (body temperature≥38.3°C) was higher in the RT procedures as compared to SKT procedures (1.7% vs 0.9, p<0.0001). However, the frequency of patients with hypoxemia (SpO_2<94%) was higher in the SKT procedure than in the RT (5.2% vs 2.6%, p=0.026), whereas the self-triage kiosk determined fever less than HCW assessment (0.9% vs 1.7%, p=0.017). Total exposure time in the self-triage kiosk was significantly shorter than in the routine triage procedure (3 [IQR 25–75: 2–3] vs 8 [IQR 25–75: 5–10] minutes, p<0.0001). The number of exposed HCWs was lower in kiosk triage than in the routine triage procedure (0 [IQR 25–75: 0–1] vs 2 [IQR 25–75: 2–3], p<0.0001).

Measurement Accuracy of Thermometry and Oximetry Used in the Self-Kiosk

Body temperature measurements performed by kiosk devices and clinical devices were similar in the morning (36.56 ± 0.63°C vs 36.54 ± 0.58°C, p =0.607) and in the evening (36.57 ± 0.55°C vs 36.56 ± 0.51°C, p=0.650), respectively. Correlation coefficients were high (r = 0.962–0.985), indicating strong agreement between the two devices. Similarly, the mean differences between the kiosk and clinical pulse oximeter were 0.263% in the morning (94.84% ± 3.02 vs 94.58% ± 2.95) and −0.105% in the evening (93.68% ± 4.45% vs 93.79% ± 4.30), with no significant difference (p =0.172, p=0.578), and high correlations (r = 0.964–0.983), see Table S4.

Effect of Educational Status on Triage Procedures

Among the study population, 94% had completed at least high school, with 55.7% holding a university diploma, and 38.3% holding other types). The mean ages for primary school, high school, and university graduates were 47.29 ± 13.34, 35.16 ± 13.15, and 29.12 ± 6.08 years old (p=0.002), respectively. There was no significant difference in the male-to-female ratio among the three educational status groups (males for primary school, high school, and university graduates were, 42.9%, 52.3%, and 45.3%, (p=0.748). Primary school graduates were notably older than university graduates in the study population (p=0.004).

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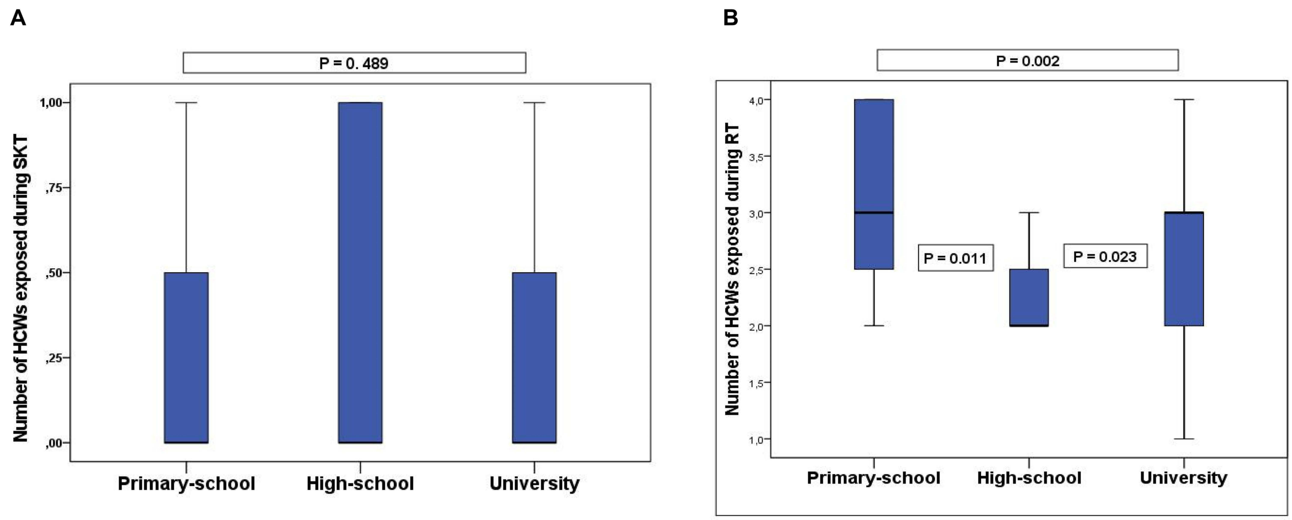

Figure 3 (**A**) Pair-wise comparisons for the total number of HCWs exposed during self-kiosk triage according to study participants' educational status. (**B**) Pair-wise comparisons for the total number of HCWs exposed during routine triage according to study participants' educational status.

Moreover, the TET in the SKT was significantly higher for primary school graduates as compared to university graduates (5 min [IQR 25–75: 3–6] vs 3 min [IQR 25–75: 2–3], p=0.024). Conversely, TET for the RT procedure was lower for university graduates compared to high school graduates (8 min [IQR 25–75: 5–10] vs 9.5 min [IQR 25–75: 7–12], p=0.042) as shown in Table 3, and post hoc comparisons in Figure 2A and B. The number of HCWs exposed was similar among primary, high-school, and university graduates (p=0.489), in Table 3, and post-hoc comparisons in Figure 3A. On the other hand, we observed that the number of HCWs exposed during RT procedures was significantly higher in primary school and university graduates than the high school graduates (3 [IQR 25–75: 2–4] vs 2 [IQR 25–75: 2–3], p=0.011; 3 [IQR 25–75: 2–4] vs 2 [IQR 25–75: 2–2.75], p=0.023, respectively), Figure 3B (overall p=0.002).

We performed multivariable analyses to understand better whether level of education was a significant determinant of total exposure time and the number of HCWs exposed during procedures (Table 4). After adjusting factors such as age, sex, body temperature, peripheral oxygen saturation, and PCR status, we found that individuals with higher education spent less time in the SKT, with university graduates spending 1.45 minutes (95% CI: −2.22 – −0.69) less and high school graduates spending 1.67 minutes (95% CI: −2.43 – −0.94) less. Additionally, we observed that a positive PCR test was associated with an increase in exposure time by 0.85 minutes (95% CI: 0.47–1.23). On the other hand, we found that, only the body temperature —a 1°C increase caused a 2.35-minute increase in exposure duration (95% CI: 2.24–49.65) — significantly impacted the overall exposure duration in the routine triage operations (p=0.003). Educational status, PCR status, and peripheral oxygen saturation had no bearing (Table 5).

Table 5 Study Participants' Feedback on the SKT Procedure. Responses Were Scored From 1 to 4; 1: Strongly Disagree, 2: Disagree, 3: Agree, 4: Strongly Agree

	Total Scores Mean ± SD	Agrees or Strongly Agrees %
Instructions were clear	3.35 ± 1.16	82.9
The system was user -friendly	3.40 ± 1.08	81.5
Pulse oximeter use was easy	3.12 ±1.29	72.8
Thermometer use was easy	3.31 ± 1.16	79
Time spent was not long	3.37 ± 1.23	82.3

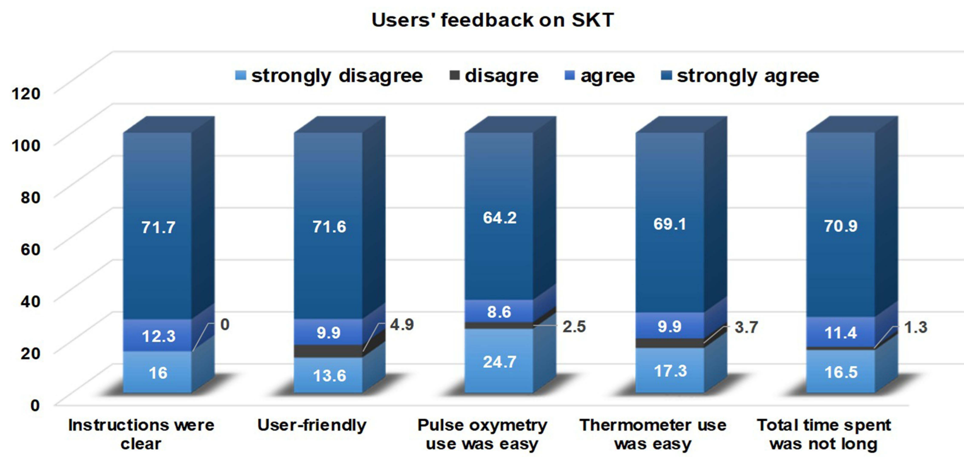

Figure 4 Users' feedbacks on SKT.

When we analyzed parameters that affected the number of HCWs exposed; every 1% increase in peripheral oxygen saturation caused a 0.10 (95% CI: 0.02–0.18) increase and 0.11 (95% CI: −0.19 – −0.03) decrease in the number of HCWs exposed during SKT and RT procedures, respectively (p=0.017 and p=0.008). We also observed, that the number of HCWs exposed in the self-triage kiosk decreased by 0.68 (95% CI: −1.18 – −0.19) and 0.95 (95% CI: −1.43 – −0.46) in university graduates and high-school graduates as compared to primary-school graduates, after adjusting for age, sex, body temperature, peripheral oxygen saturation, and PCR status, respectively (p=0.007 and p<0.001). A confirmed case by PCR testing was linked to a decrease by 0.25 (95% CI: −0.50 - −0.002, p=0.048) in the number of HCWs exposed during RT, see Table 4.

Study Participants' Feedback on the SKT Procedure

The average patient assessment scores ranged from 3.12 ± 1.29 to 3.40 ± 1.08 (Table 5). More than 80% of the study participants found the kiosk user-friendly and the instructions clear (Figure 4). Using a pulse oximeter and thermometer was easy for 73% and 79% of the population, respectively. Most study participants stated that the overall procedure duration was not long. Eighty percent of the participants could finish the self-triage on their own.

Discussion

Our study shows that self-kiosk triage in the emergency department can reduce the number of healthcare workers needed and shorten the time spent with patients who may transmit COVID-19 without compromising patient satisfaction. Our data demonstrates that patient education status and PCR status affect the overall amount of time spent during SKT, whereas vital signs such as body temperature affect the amount of time spent during routine triage. On the other hand, the total number of HCWs exposed during RT is influenced by the patient's education level and oxygen saturation. However, oxygen saturation is the only factor that affects the number of HCWs exposed during SKT.

The coronavirus disease 2019 presented an enormous challenge to healthcare systems globally. Optimizing access to healthcare while minimizing face-to-face patient encounters is critical for limiting exposures, conserving resources, and maintaining health.[13,18] Interactive kiosks have traditionally been utilized to deliver specialized patient education and information.[13,19–22] Additionally, they have been shown to be well-tolerated by patients who have socioeconomic and linguistic challenges.[23,24] The use of a self-service kiosk during emergency service triage offers several advantages.[5] Such facilities are considered as "patient-centered" options, because they increase user satisfaction, reduce paperwork, and improve staff productivity.[16] Accordingly, health systems have begun to adopt self-service medical kiosks to facilitate patient registration, information delivery, health promotion, appointment scheduling, and payment processing.[13,16,21,23,25,26] A recent study by Joseph et al explored the effectiveness of kiosks in improving triage efficiency in EDs.[5] The review of nine studies found that e-triage interventions, such as kiosks, were successful in reducing pre-triage waiting times and improving triage process. While some studies reported challenges, such as low uptake, the overall evidence supports the use of kiosks to complement conventional nurse-led triage, potentially enhancing patient outcomes.[5] EDs considering kiosks may benefit from reduced overcrowding and better resource management. Nevertheless, the efficacy and safety of the relatively new concept of digital check-in and triage kiosk in emergency departments is considered a novel area of research pending more scientific data.[27]

Improved communication during patient-clinician visits is associated with increased patient satisfaction, treatment adherence, and better health outcomes.[28] Establishing a provider-patient relationship with the essential components of trust is more challenging without a face-to-face interview.[29–31] On the other hand, healthcare providers are faced with the need to minimize face-to-face in situations such as pandemics.[30] In our study, we found that most participants were satisfied with the self-kiosk triage; the majority were able to use SKT independently, found it user-friendly, and thought the instructions were clear. More than 70% of the participants found using the thermometer and pulse oximeter to be simple. Table 2 demonstrates that the mean body temperature and oxygen saturation recorded in the kiosk were lower than those recorded during RT. The RT group had more patients with fever than the SKT group. Additionally, the SKT group had significantly more patients with hypoxia, suggesting the measurements taken during SKT are subject to improvement. We evaluated the measurement accuracy of the thermometry and oximetry used in the kiosk prior to full integration, confirming their accuracy and comparability to clinical-grade devices (Table S4). However, in the study results, body temperature and peripheral oxygen saturation were measured significantly higher during the RT procedure than the self-measurement procedures in SKT. There are several explanations for the differences observed in body temperature and oxygen saturation measurements between SKT and RT. Firstly, Piccini et al have shown that for contactless infrared thermometers, the working distance and angle of inclination can lead to a large discrepancy between body temperature readings in their comprehensive study analyzing the reliability of body temperature measurements obtained with infrared thermometers commonly used during the COVID-19 pandemic.[32] The placement point and angle of the infrared thermometer in the kiosk we used in our study and the lack of instruction specifying the optimal working distance and angle of inclination for measurement might have caused an under-estimation of body temperature during medical kiosk procedures. Moreover, patients using the SKT system may have initially struggled to adhere to operational instructions, such as maintaining the correct distance for temperature measurement or keeping their hands steady for SpO2 readings causing a motion artefact.[33] This learning curve may introduce variability, particularly during initial usage. Secondly, changes in environmental conditions such as lighting, and ambient radiation may have influenced the thermometry measurements up to 0.5°C as shown recently.[32] The lighting conditions might be different in the RT room and the point kiosk was placed in our study and may have influenced the results between two measurement points. Third, patients may have experienced anxiety when interacting with the kiosk independently. Conversely, interaction with healthcare providers in RT may induce a calming effect causing a more stable measurement. Moreover, measurements taken by trained healthcare professionals during RT procedures are more precise due to consistent handling and proper device positioning. In contrast, self-measurements at the SKT kiosk may introduce variability due to patient errors, such as improper alignment or inconsistent use. Fourth, the timing of the measurements might be a modifier. Measurements in RT are often performed sequentially and after a brief rest period, allowing for stabilization of physiological parameters. In contrast, kiosk measurements may occur immediately after patient activity, such as walking to the kiosk, which was located at the entrance of the ED in our study, might have potentially affect readings. Last of all, non-contact infrared thermometers, like the one used in the SKT, have been reported to exhibit slightly broader measurement tolerances compared to clinical-grade thermometers. Thermometers have variable diagnostic accuracy across age groups.[34] Therefore, we acknowledge that further independent validation studies with larger sample sizes could strengthen these conclusions.

In our research, we found that self-interview facilities, like SKT tested in this experiment, may offer potential benefits such as increased patient privacy compared to face-to-face patient visits in a traditional triage setting. Although privacy was not directly measured in this study, the significantly higher rates of reported respiratory symptoms, recent travel history, and recent contact with an index COVID-19 case during SKT compared to routine triage (Table 1) suggest that patients may feel more comfortable disclosing sensitive information in this format. These findings align with previous research comparing computer-assisted self-interviews to face-to-face interviews, which indicated that the computer-assisted self-interviews improved participants' privacy perception.[35] However, it is important to note that in some cases, patients were hesitant to share detailed personal health information when using symptom checker applications, as seen in the 135 patients who were excluded from the analysis due to mismatched responses between their symptom checker input and the physician's diagnosis.[12] This discrepancy may reflect hesitancy to share detailed personal medical information in some cases, potentially driven by varying patient motivations when engaging with self-triage systems.[12] Further research is needed to explore the factors influencing patient behavior and to improve the design and effectiveness of self-triage systems.

While face-to-face visits may be necessary for individuals with serious illnesses who have difficulty using technology, such as those who are visually or audibly impaired.[36,37] Contrary to what we had anticipated, increasing age did not affect the time was spent during either SKT or routine triage procedures.

Previous research shows that only patients who are familiar with and literate in the delivery modality can receive telehealth services.[38] In our study, we observed that the total amount of exposure time needed for the SKT was significantly reduced compared to standard triage protocols, leading to fewer HCWs being exposed. Emergency departments often face overcrowding and long registration and triage wait times. Self-service technologies can ease this burden, allowing triage nurses to focus on complex tasks.[39] While recent studies show that smartphones might be more user-friendly than kiosks, offering multiple self-registration options is recommended to meet diverse patient needs.[39] Our findings demonstrated that participants' education level was a significant determinant in the time needed for SKT, whereas it had no impact on the time spent during routine triage procedures. University and high school graduates completed the SKT more quickly than primary school graduates. High-school graduates were more rapid than university graduates. Our findings indicated that, in addition to educational status, a positive PCR status is another factor that increased the overall duration that SKT required (by 0.85 minutes). In contrast, during RT, the body temperature was the only factor that changed the total exposure duration; a 1°C rise in body temperature caused a 2.35-minute increase in exposure time, indicating that those patients needed a more thorough evaluation. Peripheral oxygen saturation, PCR status, and educational level were irrelevant in this context (Table 5).

The factors affecting the amount of HCWs exposed during standard triage procedures were educational level, oxygen saturation, and a positive PCR status (Table 4). The number of HCWs exposed during RT decreased by 0.25 if the case was confirmed by PCR testing; every 1% increase in peripheral oxygen saturation resulted in a 0.11-person reduction in the number of HCWs exposed; and the number of HCWs exposed during RT decreased by 0.68 and 0.95 person in university and high school graduates as compared to primary-school graduates. More HCW involvement in the standard triage procedures may have been necessary due to compromised vital signs, such as declining oxygen saturation and a more dramatic clinical presentation that resulted in a positive PCR status at the end. Higher compliance with routine evaluation procedures as well as higher educational status among high school and university graduates can be used to explain why there were less HCWs exposed in RT among these groups of graduates. On the other hand, during SKT, the only variable that affected the number of HCWs exposed was oxygen saturation; a 1% reduction in oxygen saturation resulted in a 0.10-person reduction in contacts, which may indicate that the HCWs had a higher level of suspicion for COVID-19 as the oxygen saturation decreased.

Under COVID-19, regular medical care has transitioned into a virtual environment depending on telemedicine. Whether this forced transition to telemedicine will facilitate a safer and more effective method of providing healthcare is seeking answer yet. Our work adds to the body of knowledge about a telemedicine program performed by an in-house self-kiosk for COVID-19 triage in an emergency department scenario. There are limitations to this study. A larger and more diverse sample size would enhance the generalizability of the findings. While this study represents a pilot effort, future research will aim to include a broader population across multiple healthcare settings to validate and strengthen the results. Additionally, the kiosk used in our study operated in a monolingual format due to characteristics of the target population, which limits the applicability of our findings to populations with diverse language needs. The study's design excludes gathering participant input on RT procedures because the researchers avoided taking any additional steps that would have prolonged the face-to-face contact period between patients suspected of having COVID-19 and HCWs. Furthermore, both thermometry and pulse oximetry measurements performed during SKT are prone to improvement. Differences observed in body temperature and oxygen saturation measurements between SKT and RT may result from operational conditions. Future research will address these discrepancies to enhance the reliability of SKT data. We will further investigate and address these discrepancies in future studies to improve the reliability of SKT data. Educational level significantly influenced the time required for SKT, highlighting the need for an improved kiosk interface and

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instructions tailored to users with varying educational backgrounds. While this study focused on immediate outcomes, such as HCW exposure and patient satisfaction, long-term effects, including patient health outcomes, ED efficiency, healthcare worker safety, and cost-effectiveness, remain unexplored. Subsequent studies covering these dimensions will provide a more comprehensive evaluation of the self-kiosk triage procedures.

Conclusion

The use of self-kiosk in this pilot study demonstrated the potential of self-kiosk triage to efficiently collect basic medical data in an ED setting, reducing healthcare worker exposure and offering a feasible alternative for patient self-triage during a high pressure scenario, such as pandemics. While these findings highlight the feasibility and user satisfaction of self-kiosk triage, it is impact on the overall ED throughput remains to be determined. This study highlights the acceptability and ease of use of SKT among participants, with notable reductions in healthcare worker contact time compared to routine triage procedures. This study contributes to the limited body of research on self-kiosk triage in emergency settings. However, the current findings should be interpreted with the following considerations. The observed discrepancies in body temperature and oxygen saturation readings between SKT and routine triage emphasize the need for improved operational conditions of the kiosk device. We acknowledge the potential bias arising from the involvement of the kiosk developer and emphasize the need for independent validation of our findings in future research. Further investigations are required to validate its effectiveness across broader populations and healthcare settings, assess its impact on ED efficiency, and explore long-term outcomes such as healthcare worker safety, patient outcomes and cost-effectiveness.

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Disclosure

This work is conducted solely to meet public health and medical needs during the COVID-19 pandemic following the principles outlined in Good Publication Practice Guidelines for Company-Sponsored Biomedical Research.[40] This manuscript is written for the scientific exchange focusing on the needs of healthcare providers'.[40] EK, GK, and AS are employees of CITS, IT R&D Center, Coskunoz Holding. They ensured that all study data classified in the medical kiosk is shared with publication working group members transparently on a timely basis. EK, GK, and AS, or any other department of the CITS, Coskunoz Holding did not get involved in the acquisition, analysis and interpretation of the data, drafting the work, and journal choice for submission. EK, GK, and AS made substantial contributions to the conception and design of the research kiosk, reviewed the final manuscript draft for intellectual content, and approved the final version for publication. Pandemic Mobile Intelligent Kiosk has a pending utility model application, a form of protection that is not recognized globally. The inventors listed on this application are GK, EK, TK, EBB, SGT, AGD, and DE.

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