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ORIGINAL RESEARCH CONTRIBUTION

A Randomized Trial of Computer Kiosk–expedited Management of Cystitis in the Emergency Department

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Abstract

Objectives: The objective was to assess the efficiency and safety of an interactive computer kiosk module for the management of uncomplicated urinary tract infections (UTI) in emergency departments (EDs).

Methods: This was a prospective unblinded randomized trial. Women age 18 to 64 years seeking care for suspected UTI in three urban EDs were referred to a computer kiosk after triage. The kiosk evaluated women for uncomplicated UTI (based on patient report of at least one irritable voiding symptom within 7 days and absence of complicating features), and eligible patients were randomized to expedited management or usual ED care. Expedited management consisted of a brief clinician encounter to confirm computer kiosk responses and selection of one of four standard antibiotic regimens. Study outcomes included urine culture results, duration of ED visit, time to illness resolution, return visits, and satisfaction with care.

Results: Seventeen percent (n = 103) of 624 participants with suspected UTI fulfilled uncomplicated criteria and were randomized. Sixty-nine percent of these women had a positive urine culture. Compared with the control group, the computer-expedited management group had lower median visit duration (89 minutes, interquartile range [IQR] = 65 to 150 minutes vs. 146 minutes, IQR = 105 to 216 minutes) for a decrease of 57 minutes (95% confidence interval [CI] = 27 to 87, p = 0.004). They had similar time to illness resolution, number of return visits, and satisfaction with care.

Conclusions: An interactive computer kiosk accurately, efficiently, and safely expedited the management of women with uncomplicated UTI in a busy, urban ED. Expanding the use of this technology to other conditions could help to improve ED patient flow.

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Emergency department (ED) visit rates have increased steadily over the past 10 years, particularly among adults with ambulatory care–sensitive conditions such as urinary tract infections (UTIs).[1] Crowded EDs need new strategies to improve patient flow.[2,3] One approach to reduce crowding has been to reroute patients with low-acuity illnesses to primary care clinics.[4] However, this approach has not had a significant effect on the problem for a variety of reasons—one being limited access to primary care for underserved patient populations, such as those seeking care at safety net EDs.[5]

A computer kiosk module for expedited management of UTIs was found to be accurate, acceptable, and safe in an urgent care clinic setting.[6] However, it is unclear whether the technology is suitable for the ED or whether these findings can be generalized to the ED, an often chaotic environment where care is more complicated and the patient population is particularly diverse. If successful in the ED, computer kiosk–expedited management of low-acuity illnesses could be an important tool in efforts to improve efficiency of care, reduce ED wait times, and ease crowding.

Our aim was to assess the efficiency and safety of kiosk management for women presenting to the ED with symptoms of UTI compared with usual (traditional)

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care. We hypothesized that the kiosk module would identify patients with a high proportion of positive urine cultures, and that compared with usual care (control group), patients randomized to kiosk management would have a reduced length of stay in the ED and similar time to illness resolution, return visits to the ED, and patient satisfaction.

METHODS

Study Design

We conducted a nonblinded randomized controlled trial to compare computer kiosk–expedited management to usual ED care (control) for women with suspected UTI. Prior to initiating patient recruitment, the trial was registered with ClinicalTrials.gov (NCT00731315) and approved by each hospital's institutional review board.

Study Setting and Population

The study was performed at three EDs in northern California: 1) University of California, San Francisco, an urban tertiary care university hospital with an annual ED census of approximately 40,000; 2) Alameda County Medical Center, an urban county hospital with an annual ED census of approximately 85,000; and 3) Community Regional Medical Center ED in Fresno, an urban county hospital with an annual ED census of approximately 110,000.

At each participating ED, nurse triage staff, after their initial assessment, referred consecutive patients with one or more irritable voiding symptoms or suspected UTI to the kiosk module. Enrollment took place between November 2008 and June 2010.

Study Protocol

The UTI kiosk management module was developed using Macromedia design software. It was housed in a touchscreen computer kiosk with audio handset and printer (Kiosk Information Systems [KIS], Inc., Louisville, CO [http://www.kis-kiosk.com/standard-thinman.html]) located in the ED waiting room at two of the hospitals and right next to triage rooms at the third hospital. Neither the kiosk manufacturer nor the software company had any role in the sponsorship, design, implementation, or evaluation of the study. The UTI kiosk module content was adapted from a previous trial, where its accuracy, safety, and acceptability were validated in an urgent care clinic.[6] Informed consent and patient information were obtained by the kiosk using audiovisual formats in English and Spanish. The UTI kiosk management module requires each patient to answer 29 simply phrased questions to determine whether or not she is eligible for expedited treatment of a UTI (Data Supplement S1, available as supporting information in the online version of this paper). These questions were peer-reviewed for understanding and appropriateness of reading level. Criteria for expedited treatment are based on a systematic review of predictors of uncomplicated UTI and from several UTI telephone management algorithms.[7–9] The computer kiosk module itself has only been tested once previously in an urgent care setting.[6] To be eligible for kiosk-expedited management, an 18- to 64-year-old woman must report the following: 1) history of prior UTI; 2) irritable voiding symptoms (dysuria, urgency, or frequency); and 3) absence of complicating factors (Figure 1). The module takes about 5 minutes to complete.

After completing the UTI kiosk module, eligible participants were randomized by the computer to expedited treatment or usual care. A simple (unrestricted) randomization algorithm was used.[10] The module asked participants to provide a telephone number for a follow-up interview approximately 2 to 4 weeks after the visit. Participants were informed that they would be mailed a $10 gift card upon completion of the follow-up telephone interview. Both groups were instructed to provide a urine specimen to triage staff for microbiologic testing.

Women randomized to kiosk management were provided a printout of their responses to the UTI module, including current symptoms, review of systems, past medical history, presence of allergies, and medication use. The printout included clinician instructions recommending one of four antimicrobial regimens commonly used for uncomplicated UTI, and based on our institutional antibiograms (trimethoprim-sulfamethoxazole, one double-strength tablet twice daily for 3 days; ciprofloxacin, one 500-mg tablet twice daily for 3 days; nitrofurantoin, one 100-mg tablet two times daily for 5 days; or cephalexin, one 500-mg tablet four times daily for 7 days). Patients were given instructions to return for additional medical evaluation if symptoms did not resolve after 3 days of antibiotic therapy. The next available clinician reviewed the printout, performed a medical screening examination (often in the triage area), selected a recommended antibiotic regimen after confirming medications and allergies, and wrote a brief note for the medical record based on the patient's responses on the printout. Patients in the kiosk intervention group were generally discharged home without any additional testing (e.g., urinalysis, urine pregnancy testing, blood tests), although further testing could be ordered at the discretion of the treating clinician. Women randomized to the control group were instructed to return to the waiting area after completing the module and were evaluated and treated in the ED in the usual manner.

Measurements

Urine culture and antimicrobial susceptibility testing were performed by each hospital's microbiology laboratory, and results were accessed by study personnel from the clinical laboratory database. Medical records were independently reviewed by two research assistants who used a data abstraction spreadsheet to verify patient age, sex, and chief complaint and to determine the duration of visit and final diagnosis of control group participants. There was a data dictionary available to the research assistants that stated the operational definition for all key variables. Missing data were also recorded. Any ambiguous data were reviewed by both reviewers and consensus was obtained. A third blinded reviewer (JS or BF) resolved any persistent differences in reviewer findings. JCS, BF, and RG met frequently with research assistants to assure that definitions remained consistent. Reviewers were

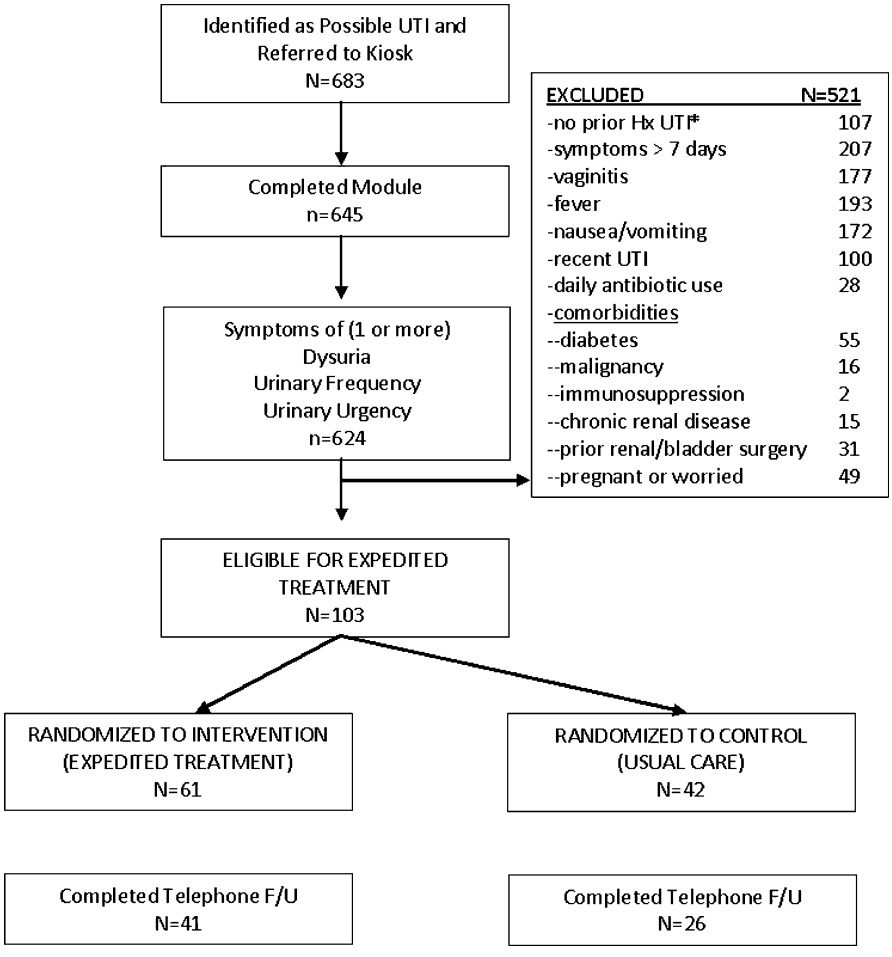

Figure 1. Consort patient flow diagram. *Does not include 194 subjects in whom this question was not asked. F/U = follow-up; Hx = history; UTI = urinary tract infections.

blinded to intervention group during the medical record review.

Telephone follow-up interviews were performed by study personnel in English and Spanish and included domains on satisfaction with the episode of care (adapted from previous studies of acute illness outcomes among ED populations),[11] illness resolution, adverse events, and subsequent UTI-related visits. Follow-up interviews were conducted beginning 14 days after the index visit, and attempts to establish contact continued for 40 weeks before terminating. When available, each hospital's clinical information database was also accessed to determine whether participants who could not be reached by telephone had any additional ED visits or hospitalizations during the 30 days following their initial presentation.

Outcome Variables

The accuracy of the kiosk module was determined by the proportion of kiosk-eligible patients who had positive urine cultures and by the proportion of control group patients who receive final diagnoses of uncomplicated UTI by the ED providers. Positive urine cultures were defined as exhibiting at least 100 colony-forming units/mL of a known uropathogen.[12] Predetermined comparisons between kiosk and control groups included the mean/median visit duration, the proportion with symptoms over 3 days, and measures of satisfaction. Duration of ED visit was calculated based on the electronically recorded time of presentation and time of discharge as entered in the health information system at each ED. For this primary outcome, we calculated a sample size based on historical average duration of ED visit for women with UTI. To find a difference of at least 30 minutes between groups with a power of 80%, based on mean (± standard deviation [SD]) visit of 180 (±48) minutes, we calculated that we would need at least 41 patients in each group.

Among our safety outcomes, we defined prolonged illness resolution as lasting longer than 3 days, because irritable voiding symptoms are expected to resolve within 3 days of initiating effective antimicrobial treatment for uncomplicated UTI.[13] A repeat visit to any ED for any reason was counted as a return visit, as were return visits to ambulatory care if they were related to persistent urinary symptoms or related to adverse events from treatment. Our overall satisfaction questions used standard five-level response options (excellent, very good, good, fair, poor) derived from a validated instrument for assessing satisfaction with an episode of ambulatory care.[14]

Data Analysis

Variance estimates for our univariate results include 95% confidence intervals (CIs) for proportions, SDs for means, and interquartile ranges (IQRs) for medians. Comparisons of proportions were performed using Fisher's exact test, means were compared with exact t-test, and medians with Wilcoxon rank sum test. Comparison of visit satisfaction was performed using Proc GEN MOD for ordinal data. All analyses were performed using intention-to-treat methodology with SAS statistical application software (version 9.2, SAS Institute, Cary, NC).

RESULTS

Among 645 women with suspected UTI who were referred to and completed the computer kiosk module, 103 (17%) were eligible for the trial (Figure 1). The most common reasons for ineligibility were patient report of new flank pain (64%), illness duration > 7 days (40%), history of fever (37%), recent change in vaginal discharge (34%), and nausea/vomiting (32%). The most common exclusion comorbidity was diabetes (11%). Among the 103 eligible participants, 78 had a urine culture performed, and 54 (69%) with a urine culture performed had a confirmed UTI. The most common organism isolated was *Escherichia coli* (87% of isolates). Other organisms isolated included ''enteric Gram-negative rods'' ($n = 3$), *Staphylococcus saprophyticus* ($n = 2$), and group B streptococcus ($n = 2$).

Among the 103 women in our study sample, 61 were randomized to the kiosk group and 42 to usual care. Twenty-nine (69%) of usual-care patients received a final diagnosis of UTI. The two groups had similar distributions of age, race, ethnicity, Spanish language, study site, culture-confirmed infection, and, among culture positive cases, similar concordance between the antibiotic prescribed and susceptibility of the uropathogen (Table 1). There was no significant difference between rates of positive urine cultures between groups (p = 0.49). Seventy-two percent of patients' cultures in the kiosk group were positive for UTI, compared with 64% in the control group. Among participants with positive urine cultures, 100% in the kiosk group and 15 of 16 (94%) in the control group were treated with antibiotics. Among participants with negative urine cultures, 14 of 15 (93%) received antibiotics in the kiosk group compared with six of nine (66.7%) in the control group (p = 0.13).

Participants randomized to the kiosk group had a lower median duration of ED visit compared with the control group (89 [IQR = 65 to 150] minutes vs. 146 [IQR = 105 to 216] minutes, difference 57 [95% CI = 27 to 87] minutes, p = 0.004). There was no difference between groups in the proportion reporting symptoms longer than 3 days following the ED visit, return visits for UTI-associated illness or adverse reactions, or overall satisfaction with care (Table 2). There were four participants in the control group who left without being seen, compared with none in the kiosk group. Among participants who did not complete follow-up telephone interviews, only one control group patient had a subsequent ED visit at the study site within 3 weeks for UTI-related conditions. There were no hospitalizations. No patient in either group had a return visit for a condition requiring emergent management, such as pelvic inflammatory disease or appendicitis.

DISCUSSION

The use of an interactive computer kiosk module designed to expedite the management of female ED patients with simple UTI was associated with decreased visit duration. Our findings that culture results, illness

Table 1
Comparison of Experimental and Control Groups for Simple Cystitis

	Kiosk-expedited Management Group ($n = 61$)	Control Group ($n = 42$)	p-value
Age (yr), mean (SD)	31.4 (10.2)	34.4 (11.3)	0.17
Race/ethnicity, % (95% CI)			
White	31 (21–46)	21 (10–37)	0.76
Black or African American	8 (4–20)	12 (4–26)	
Hispanic	10 (4–20)	7 (2–20)	
Other	16 (9–30)	21 (10–37)	
Missing or refused	35 (23–48)	39 (26–57)	
Spanish language, % (95% CI)	5 (1.0–14)	2 (0.1–13)	0.64
Study site, % (95% CI)			
ED 1	66 (54–79)	57 (41–72)	0.11
ED 2	25 (16–39)	41 (28–59)	
ED 3	10 (4–20)	2 (1–16)	
Culture-confirmed UTI (%) (95% CI)	38/53 (72%) (60–85)	16/25 (64%) (42.5–82.0)	0.49
Antibiotic treatment of culture confirmed UTI (%) (95% CI)	38/38 (100%) (91–100.0)	15/16 (94%) (72–99)	0.12
Antibiotic treatment of culture-negative UTI (%) (95% CI)	14/15 (93%) (70–99)	6/9 (67%) (36–88)	0.13
Antibiotic concordance,* % (95% CI)	94 (81–98)	100 (76–100)	1.0

UTI = urinary tract infection.
*Treatment with an antibiotic to which the patient's bacterial culture result is resistant.

Table 2
Comparison of Outcomes Between Groups

	Kiosk-expedited Management Group	Control Group	p-value
Time spent in ED, minutes (median, IQR)*	89 (65–159) (n = 61)	146 (105–216) (n = 39)	0.004
Symptoms > 3 days, % (95% CI)†	44 (29–60)	33 (16–55)	0.4012
Return visits for UTI illness,† % (95% CI)	10 (4–26)	4 (1–27)	0.6438
Overall satisfaction with care,† % (95% CI)			
Excellent	29 (18–48)	27 (12–48)	0.8660
Very good	29 (18–48)	27 (12–48)	
Good	29 (18–48)	22 (12–48)	
Fair	10 (4–26)	12 (3–30)	
Poor	2 (0.1–13)	12 (3–30)	

IQR = interquartile range; UTI = urinary tract infection.
*Based on 61 participants in computer-assisted group and 39 in the control group who completed their visit. Four participants in the control group left without treatment.
†Based on 41 participants in computer-assisted group and 26 in the control group completing telephone follow-up surveys.

resolution, return visits, and patient satisfaction did not differ between intervention and control groups supports the safety and effectiveness of this algorithm in identifying and successfully treating women at high likelihood of having a culture-confirmed UTI. We believe this is the first study to demonstrate improved throughput efficiency with the use of kiosk technology in the ED.

Crowding in the ED has been recognized as a significant problem for over two decades.[3] Although the causes are complex, there is a growing awareness that crowding can lead to suboptimal patient outcomes.[2,15–18] Solutions to the overall crowding problem have been elusive, but it is generally agreed that maximizing efficiency of care while maintaining safety of care is the ideal.[3] To this end, there have been many ''front-end'' strategies that have been developed (bedside registration, advanced triage protocols, practitioner in triage, fast-track, electronic tracking boards) to improve the initial processing of ED patients, but few have been rigorously tested.[19]

Computer kiosks in the waiting room have been suggested as another strategy to improve front-end efficiency. Despite some information in the lay press, reports in the medical literature describing use of kiosks in the ED have been limited to collecting past medical history from pediatric asthma patients, disseminating pediatric safety education, and screening for domestic violence.[20–22] No studies to date have assessed the effect of kiosks on throughput metrics.[19] Our study is among the first to assess the efficiency as well as effectiveness and acceptance of kiosk technology implementation in the ED setting. It is also among the first to investigate complete illness management using front-end kiosk technology.

The original module content for UTI kiosk management was based on a systematic review of predictors of uncomplicated UTI and on validated telephone management algorithms.[7–9] The UTI kiosk management was first implemented in an urgent care center, where its accuracy, safety, and acceptability were validated.[6] An important goal in bringing this module into the ED environment, where there is a high prevalence of occult serious disease, was for our diagnostic algorithm to be as specific as possible, so that only patients with a high probability of having a culture-positive UTI, and with mild disease, would be eligible for computerized treatment. As hoped, the rate of positive cultures was high, and similar to that achieved by previous reports and by the physicians in the control arm of the study.[7] However, a corollary of this high specificity was that only 17% of patients referred to the kiosk were found eligible. We hope that with refinement of the algorithm, the UTI kiosk protocol can include a higher proportion of ED patients, without losing specificity.

For our primary outcome, patients randomized to the kiosk group had a shorter length of stay in the ED by nearly an hour, compared with the control group. This demonstrates that kiosk technology has the potential to improve ED throughput. It also illustrates the barriers to truly rapid care inherent in our systems. Why did it take 89 minutes for patients to go to triage, then to the kiosk, give a urine sample, and be briefly screened by a provider and receive a prescription? First, there is a relatively fixed amount of time required up front for registration and nurse triage that likely accounted for 20 to 30 minutes. Second, the kiosk could not easily be integrated into the electronic health record in any of the sites. Thus, a clinical record had to be generated separately from the kiosk printout to comply with standard operating procedures in these hospitals. Finally, additional time was likely spent waiting for an emergency physician or physician's assistant to perform the mandatory Emergency Medical Treatment and Active Labor Act medical screening exam and provide an antibiotic prescription. Kiosk modules might prove more efficient at institutions where nursing staff are allowed to perform the medical screening examination.

We have also demonstrated that kiosk-delivered health care was highly acceptable to women seeking care for UTI in these EDs. Only 12% of patients randomized to kiosk management felt that the quality of care they had received in the ED was fair or poor, compared

with 23% in the control group. It is possible that satisfaction was similar because less interaction with a doctor in kiosk management was counterbalanced by shorter throughput time. It is also possible that women appreciated the autonomy afforded by the kiosk and that it takes advantage of their own familiarity with this illness.

It is generally accepted that antibiotic treatment of uncomplicated cystitis leads to symptom resolution within 3 days. Thus, we were surprised to see that symptoms persisted for over 3 days in at least a third of patients. While there was no significant difference in this outcome between groups, our confidence estimates for these important outcomes are quite wide due to the small number of events, and this issue deserves further study in larger trials.

LIMITATIONS

Our final sample size was small, partly because a smaller than expected proportion of women with suspected UTI met eligibility criteria. Our study population therefore may not fully reflect the larger population of women with UTIs (selection bias), limiting the generalizability of our results. In addition, because of the small sample size, we could not compare uncommon outcomes such as hospitalizations or perform subgroup analyses.

Our safety outcomes depended in part on culture results, as was assessment of the accuracy of the computer kiosk diagnostic algorithm. Cultures were unfortunately not obtained in a significant proportion of patients and less often in the control group than in the kiosk management group. The kiosk module instructed all eligible patients to obtain a urine sample, which, by protocol, was supposed to be sent for culture by the triage nurse. However, patients sometimes failed to submit urine at triage, and in the usual-care group, nurses sometimes sent the specimen for urinalysis only, since this reflects usual care for cystitis. While unlikely, it is possible that patients who did and did not have a culture systematically differed, representing a source of unmeasured bias that affected our primary safety outcome.

A significant proportion of patients in both groups could not be reached by phone for the follow-up survey, which provided our symptom duration and satisfaction data. This is another potential source of unmeasured bias. Our loss-to-follow-up rate is similar, however, to that in another study in which ED patients were enrolled in a follow-up telephone survey at the time of their visit.[11] Moreover, we did not find any significant difference between subjects who did and did not follow-up with regard to sociodemographic, illness characteristics, or microbiologic results.

CONCLUSIONS

The use of a computer kiosk to assess and treat adult women presenting to the ED with urinary tract infection symptoms demonstrated improved efficiency for patients while maintaining safety. Expanding the use of this technology to other medical conditions has the potential to help improve ED patient flow.

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Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. UTI Module Questions.

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