The role of kiosks on health services: a systematic review

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***Abstract*—Introduction**: Emergency department visits have increased substantially, leading to a significant rise in waiting time for patients. Several kiosk-based solutions have been introduced to reduce waiting times in healthcare facilities and to increase efficacy and user satisfaction. **Purpose of the Study**: This systematic review aims to identify the most effective self-service kiosk features for collecting patients' health information and to evaluate their acceptability among elderly and less educated populations, despite not being the focus, there is pontencial in the development of the system interface to facilitate the perception and understanding of those with less digital literacy. **Methods**: We conducted a systematic review of studies on diagnosis, replacement of face-to-face consultation, and triage kiosks published between January 2009 and March 2023 in the databases PubMed, IEEE Xplore, Web of Science, Cochrane Library, ScienceDirect, and Scopus. **Results**: The eight analyzed studies included 2,298 participants in total, with participants aged between 16 and 94 years. Most studies provided kiosk assistance. Elderly patients demonstrated the capability and willingness to participate in technological interventions. **Conclusion**: User interface elements were the most critical features in health kiosk design, followed by clear communication and patients' understanding of the benefits associated with kiosk use. The high levels of kiosk acceptance and satisfaction observed indicate a significant opportunity for the introduction of self-service kiosks in various healthcare contexts.

Keywords— Health Kiosk; Self-Service Kiosk; Emergency Departments; Primary Health Care; Effectiveness; Systematic Review

I. INTRODUCTION (*HEADING 1*)

Self-service kiosks have been used in a variety of healthcare areas and for different purposes, noteworthy for administrative processes, screening, triage, health diagnoses and replacement of face-to-face consultations [6]. The triage kiosks in particular serve as a pre-consultation tool, allowing healthcare professionals to assess a higher number of patients in less time [5]. One study demonstrated that placing kiosks in the waiting room allowed patients to use their waiting time more productively by providing relevant information to be used later in the health delivery process [7]. Concerning diagnostic systems, they facilitate the diagnosis of common diseases by performing a set of pre-established physiologic and mental tests. Data obtained are then compared with the information available in the kiosk workstation [8, 9].

Public places have been used for health kiosks, particularly for population screening or control, as a form of health surveillance of elderly communities [5]. This approach has been increasingly sought after in places with poor access to electricity, transportation, communication and shortage of doctors, medicines and other resources, replacing face-to-face consultation [10]. Despite the potential reported in the literature for using self-service kiosks to improve several healthcare processes, there is no systematic review on the subject. Here, we undertake a literature review aiming to identify and characterise self-service kiosk's efficacy features that improve health information collection to reduce health professionals' workload and patient's waiting times. Moreover, we also assess kiosks acceptability by the elderly and less educated population as these are well-known population with increase technology resistance [11,12]. The results of this study identifies relationships between studies, offering a more concrete interpretation of the efficacy features of kiosks in health services. A 2023 study focused on e-triage interventions and their impact on triage efficiency using Kiosks in Emergency Departments [24].

II. METHODS

A. *Search strategy*

This systematic review was conducted using the PubMed, IEEE Xplore, Web of Science, Cochrane Library, ScienceDirect, and Scopus databases, considering only articles published between January 2009 and October 2019. The search terms included "hospital kiosks," "public health kiosk," "health kiosk," "healthcare kiosk," "systematic review kiosk," "hospital kiosk and medication," and "urgency kiosk." Boolean operators were used among the terms to obtain more accurate search results. The chosen keywords were related to kiosks in the health sector. Newspapers and books were also considered for analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed [13], but the protocol was not registered on the PROSPERO repository.

B. Inclusion and exclusion criteria

Studies of self-service kiosks were included from the fields of clinical diagnosis, triage, and replacement of face-to-face consultation. Only English-language articles were considered. Review articles and studies without abstracts were not included. Studies related to management, information, prevention, and telemedicine were excluded during the selection process as they do not focus on collecting patient health information. Pediatric care was not considered because it is exclusively intended for an underage population. Articles addressing specific pathologies or those that did not provide full text or relevant results for the study were excluded during the screening process.

C. Study selection

Two reviewers (JS and PP) collected data and analyzed it independently. Articles that met the criteria were then reviewed by two more reviewers. Each reviewer classified the articles based on the main aspects of this research to obtain the relevant articles for the final review. Any differences of opinion were resolved through discussion and consensus meetings.

D. Data extraction

Two reviewers (JS and PP) independently extracted a set of information from the studies, using the CASP (Critical Appraisal Skills Programme) [14] checklist to support extraction. Throughout this process, both reviewers verified the methodological quality of the studies by assessing the limitations referenced by them to identify possible risks of bias.

E. Data items

The extraction variables taken from each study were: (1) Domain (the process that the kiosk will perform), (2) Area (location of the kiosk), (3) Country (the country where the kiosk was tested), (4) Study period (length of the kiosk test period), (5) System Objective (purpose of the kiosk), (6) Architecture (characteristics of the system architecture), (7) Population (characteristics of the population that used the kiosk), (8) Study parameters (metrics used to evaluate the kiosk), and (9) Results (effects of the application of the kiosk).

System architecture refers to the type of system implemented, the description of the biosensors and their connectivity, and the use and presence of a touchscreen. The population variable contains the number of participants who used the kiosk and their average age or age range. It also includes the presence of assistance in the use of the kiosk or patient referral.

III. RESULTS

A. Study Selection

According to the defined search strategy, we identified a total of 1438 studies from the database search and 11 studies from other sources (newspapers and books). After removing duplicates (n = 820) and rejecting studies after abstract review (n = 499), we obtained 130 studies on healthcare kiosks. Applying exclusion criteria (n = 97), we obtained 33 studies. After reviewing the full articles, more studies were rejected due to a lack of relevant results for the study (n = 25). In the final analysis, we considered a total of 8 studies for the systematic review. A summary of this selection is shown in Figure 1.

B. Study characteristics

In all 8 studies, 4 were considered from the triage domain and 4 from face-to-face consultation replacement. Of all the associated countries, 4 belonged to America, 2 to Asia, 2 to Europe, and 1 to Oceania. Regarding the intervention area, 5 studies were conducted in healthcare facilities (Hospital, Polyclinic, Clinic), and the remaining outside this context (Community room, Rest Homes, Private Apartments, University, Villages). The study period varied between 8 weeks and 12 months. The total number of participants was 2298, with a mean age ranging from 12 to 94 years. Most kiosks provided usage assistance. The main objective of the system in the various studies was to measure vital signs and extract health information from patients according to the applied domain. The system's type of architecture varied between Web App and Software. Most of the studies addressed the presence of biosensors (height, weight, blood pressure, pulse oximeter, pulse rate, glucometer, and heart rate) and their type of connectivity at kiosks. The use of touchscreen was predominant in most studies. The characteristics of the studies based on the above variables are summarized in tables 1 and 2.

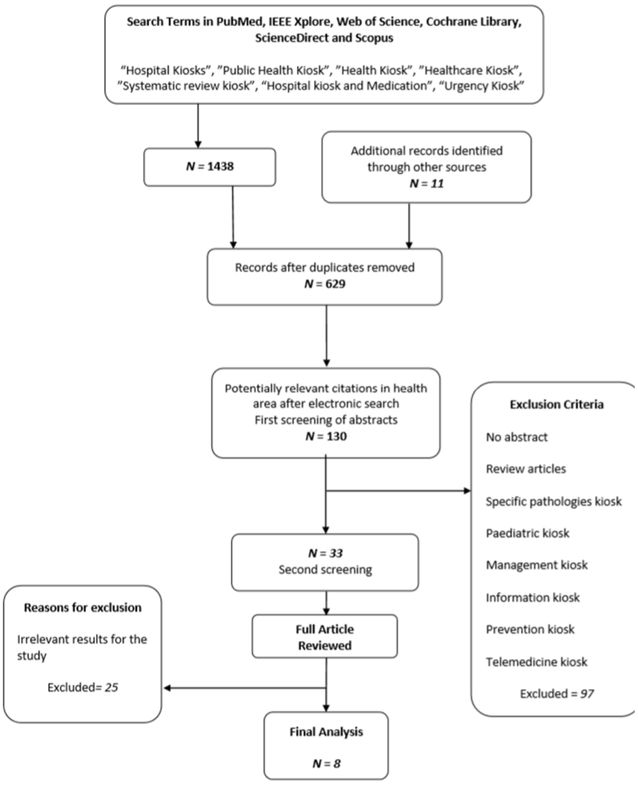

Figure 1-Flow of studies in systematic review

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The authors of the studies were contacted to obtain missing information or confirmation of data extracted for the systematic review. In [15], the age range was clarified by contacting the author since it was not mentioned in the article.

Authors	Domain	Area	Country	Study Duration	System Objective	Architecture Type - Biosensors - Sensor Connectivity - Touchscreen	Population Sample Size - Age - Assistance Presence
Coyle, T., et al (2019)[22]	Triage	Hospital	Canada	10 weeks	Self-identify and capture the arrival times of patients. Alert triage nurses arrival patients and primary complaint before triage	Web App, BP, height, scale, NA	898, 53 (21.0) avg.age, Yes
Ng, G., et al (2018)[14]	FCR	Polyclinic	Malaysia	12 months	Measure patients' physiological parameters and combines this and their recent laboratory results to classify patients. Furthermore, also produces a result slip for the patient	—, —, —, Yes	120, 21-75y, Yes
Silva, J., et al (2017)[11]	Triage	University	Portugal	—	Measure vital signs for screening or continued monitoring	Web App, Scale, BP, PO, Bluetooth	74, —, Yes
Soares, E., et al (2016)[20]	Triage	University Villages	Portugal and Brazil	21 days	Measure vital data prior to a consultation, in the scope of a population screening, or for routinely monitoring	Web App, Scale, BP, PO, Bluetooth	833, 12-89y, No
Bahadin, J., et al (2016)[21]	FCR	Clinic	Malaysia	2 months	Automates the management of stable patients with chronic conditions to complement face-to-face PCP visits	—, BP, —, —	95, 61.4 (6.7) avg.age, —
Chung, C. F., et al (2016)[23]	FCR	Clinic	USA	9 months	Used to measure BP	Web App, BP, —, —	152, —, Yes
Ahn, H. S., et al (2014)[24]	FCR	Hospital Rest Homes Private Apartments	New Zealand	12 weeks	Gives helpful information to older people. Stores health information of older people for managing their health conditions	Software, BP, Cable, Yes	99, —, Yes
Demiris, G., et al (2013)[25]	Triage	Community room	USA	8 weeks	Provides users secure access to their patient profile with the ability to capture relevant vital sign data into their personal health record, and to view pertinent nutritional or educational content	Software, BP, HR, Glucometer, PO, scale, Bluetooth	27, 78-94 y, Yes

TABLE1 - STUDIES EXTRACTED CHARACTERISTICS

INFORMATION NOT PROVIDED BY THE STUDY IS REPRESENTED BY A DASH; FCR = FACE-TO-FACE CONSULTATION REPLACEMENT; PCP = PRIMARY CARE PHYSICIAN; BP = BLOOD PRESSURE; PO = PULSE OXIMETER; HR = HEART RATE; MA = MEDICAL ASSISTANT; USA= UNITED STATES OF AMERICA

D. Risk of bias within studies

The limitations of each study were analyzed to assess the risk of bias. The use of assistance was a limitation in most studies, except for studies [5, 18]. The help provided on-site by assistants when a patient encountered a question or problem using the kiosk significantly influenced usability results.

Authors	Study Parameters	Results
Coyle, T., et al (2019)[22]	Prove that ED patients can use a self-check-in kiosk upon arrival and compare time-to-first-identification with the current triage system	Time-to-first-identification was 13.6 minutes (time-to-first identification was 4 for intervention patients and 9 for control patients) faster for patients who used the kiosk. Kiosk usability was 97%
Ng, G., et al (2018)[14]	Evaluate visit duration, patient satisfaction with the management process, health-related quality of life, and the occurrence of any adverse	Patients and physicians expressed high levels of acceptance and satisfaction. Kiosk allowed more physician time to be allocated to the management of patients
Silva, J., et al (2017)[11]	Assess kiosk usability, the tools developed, the results of the evaluation, the identified problems, and how to solve those problems	The oximeter is portable. The scale needs calibration. The BP monitor generates difficulties and is the device that takes longer to collect.

Soares, E., et al (2016)[20]	Analyze the difficulties of building a simplified Health Kiosk capable of measuring BP, weight, and PO using PHDs	An average of 26.1 seconds to the process of identification and average of 31.3 seconds for manually entered data. The average time for a complete kiosk session is 283 seconds. Global acceptance was very positive. Incorrect or difficult placement of the BP cuff. Patients the poor and less educated completed the session without help. The kiosk freed up human resources. A full session took around 5 min
Bahadin, J., et al (2016)[21]	Show that the kiosk could be a feasible means of delivering care for stable patients with chronic conditions and could generate cost savings for the management of patients with stable chronic dis-ease	Kiosk was easy to use, and 96% agreed that they could use the kiosk instead of a physician. BP reading was higher than that of the nurse. Reduction of 128 physician visits, saved of $5335. Patients need to spend only about 7 min at the kiosk
Chung, C. F., et al (2016)[23]	Evaluate BP kiosk acceptability and usability, as well as its effects on the workflow of patient BP self-measurement	Some older patients seemed to take longer to use the new technology, whereas others felt the self-service technologies were impersonal. 80% of the patients thought kiosk BPs were as accurate as those taken by clinic staff. MA reported that the time saved (1.5 minutes) allowed them to spend more time in clinical stuff.
Ahn, H. S., et al (2014)[24]	Assess feasibility and acceptability in robot system for older people in private and public places	Kiosk can help older people. The participants in the private apartments were satisfied with the BP measurements service. A kiosk may be more acceptable in rest-homes and hospital lounges than in private homes
Demiris, G., et al (2013)[25]	Demonstrate how informatics applications can support the assessment and visualization of older adult's wellness. Assess the acceptability and feasibility of the kiosk	Older adults are willing to participate in technology-enhanced interventions. Kiosk is "convenient," "easy and fast," and participants can "repeat the test" and "do it myself." The duration of each session corresponds to 20 minutes (more 5 min, once a week) and is held 3 times a week. The model of a community is cost-effective

TABLE 2 – STUDIES EXTRACTED CHARACTERISTICS

In [20], the kiosk was tested only during peak hours, when the authors believed ED stressors would be most pronounced, highlighting the kiosk's success or failure. The single-center design and modest sample size were the primary factors increasing the risk of bias in study [7]. In [5], the usability tests were conducted at a Science Faculty where many participants had some technical background and had interacted with medical devices or a touchscreen interface before, resulting in higher usability rates. The most significant limitations in [18] were the modest sample size and the kiosks' limited accessibility. The study period reported in [15] was 21 days, which may lead to unreliable results due to the short test period. Other limitations could be attributed to the lack of information on illiteracy and the population's educational level in most studies.

E. *Study results*

Studies [5, 15, 16, 17] took place in community rooms, villages, universities, rest homes, and private apartments, in addition to diverse hospital settings. Biosensors that use batteries as an energy source were used in studies [5, 15, 16]. Bluetooth was used to transmit data in [5, 15, 17]. Studies [7, 5, 15, 18, 19, 16, 17] used kiosks with Blood Pressure (BP) sensors, and some providers and clinic staff were concerned about the accuracy of measurements. Some patients showed concern about hygiene and measuring their BP in public, particularly those with prehypertension [19]. Touchscreen interfaces were used in [7, 5, 15, 16]. Elderly patients showed the capacity and willingness to participate in technological interventions [18, 19, 16, 17]. Older adults with specific health issues (e.g., tremors, use of hearing aids) require customized training and assistance [17]. Poor and less educated patients were able to use the kiosks [15].

IV. DISCUSSION

The studies [5, 16, 18, 7] showed very positive kiosk acceptability and satisfaction, indicating that people are willing to use this kind of technological intervention to replace standard procedures. In [17, 15], the autonomy of participants during the use of these systems showed that the kiosks can be used practically without assistance. Studies [5, 15] presented kiosks for screening or continued monitoring that allow streamlining procedures in healthcare facilities, expanding healthcare access to populations that otherwise would not have it, and performing large scale population screenings at low marginal costs. This shows that kiosks could help more isolated people lacking some essential health services. Almost all studies use biosensors, but only some transmitted the data via Bluetooth [5, 15, 17]. This communication brings benefits in terms of interoperability and accessibility. However, most studies reported problems with Bluetooth that could not be solved in a reasonable time and prevented kiosk usage, as mentioned in [15]. Studies [5, 15, 16] present biosensors that use batteries as an energy source, and [5,15] reported that the use of batteries could create the need for their replacement, which may indirectly interfere with the usability of the system. Biosensors with Bluetooth Low Energy (LE) technology are a possible alternative for battery replacement reduction since it is intended to provide considerably reduced power consumption. The quality of the measurements performed by the sensors compared to those performed by health professionals was another evaluation performed in [7, 18, 19]. Most patient respondents in [19] thought kiosk blood pressure (BP) were accurate, even though some reported higher values of BP. The physicians explained that this happened because patients did not have the chance to sit and wait in the reception area before measuring their BP. These instructions regarding the BP sensor should be considered at any kiosk or may be provided by clinical staff in an initial process to reduce unrealistic measurements. A discrepancy described in [18] between the values of measurements taken by the kiosk and those taken by clinical professionals affected confidence in the system. This difference in BP readings may be caused by BP measurements changing from minute to minute and can be affected by various factors. A possible factor is that the kiosk's BP takes single measurements rather than repeated measurements by a nurse clinician. The patient's level of anxiety about the new measurement protocol in contrast to the familiar face of the nurse clinician may also account for the observed differences. The BP monitor is the device whose result takes longer to collect due to the cuff not being rigid. In the choice of this device, one must take into account the type of cuff to avoid the need for manual adjustment to the user's arm [5]. The incorrect or difficult placement of the cuff hints that a cuff-less blood pressure device would be preferable [15]. The users with several layers of clothing have difficulty performing the blood pressure procedure since it involves clearing the left arm of anything that might block the circulation. The choice of a BP wrist monitor is a solution to this problem since the measurement will be taken at the wrist, and there is no need to collect clothing. Blood pressure measurement is a procedure that requires a set of several instructions, making it difficult for the user. Instructions with more compact information to be presented simultaneously with the measurement will make the procedure more supportive and avoid forgetting instructions [5]. The concern of the providers, patients, and clinic staff and the need to obtain accurate measurements require that accuracy must be taken into account in the choice of BP or another type of sensor. Good accuracy or certification of the sensors provides confidence to the healthcare professionals and patients in the results obtained from the measurements [19].

In [19], hygiene concerns prevented patients from using the kiosk. Hospital institutions must provide solutions to ensure the kiosk's hygiene and transmit a secure kiosk usage environment to the patients. The kiosk used by different patients requires constant hygienic cleaning of the sensors, which is not always possible. Thus, sensors that are easy to clean or without body contact should be considered. The oximeter is a small and extremely portable device, but at the same time, some restrictions have to be made to make it theft-proof in public locations [5]. The need for the calibration step reported in [5] led to users spending an excessive amount of time performing this procedure. Therefore, the choice of sensors that require calibration should be avoided. Some patients were confused and concerned by the prehypertension notations on the kiosk paper printout in [19]. Results classification can make patients more anxious and worried, affecting their state of health, and should be avoided after each measurement. Some patients had concerns about measuring their BP in public because of having to sleeve up an arm or others seeing their BP readings [19]. The location of the kiosks in a private area, outside the field of view of other patients, makes the user more comfortable interacting with the system. The kiosks should also be placed in places that do not affect the workflow of hospital institutions. The use of touchscreen was mentioned in [7, 5, 15, 16] to offer direct and easy-to-use interfaces. This interaction modality has reached ubiquitous status, making touch-based kiosks very easy to operate, even for the elderly. It also saves space by eliminating the need for keyboards and mice. Studies [18, 19, 16, 17] were successfully applied to participants with a more advanced age group, showing that elderly patients demonstrate the capacity and are willing to participate in technological interventions. Still with an initial need for care, the elderly show good learning capacity in the use of kiosks, showing that independent use of kiosks to routinely and unobtrusively assess and identify patterns of elder wellness is possible, without the need to go to hospital environments. The measurement of vital signs in private homes is more comfortable than in hospitals, public spaces, or rest homes. For the development of these types of kiosks, it is necessary to consider their size because probably smaller kiosks will be more acceptable in terms of portability and comfort in private homes, which essentially contain small partitions [16]. Older adults with specific health issues (e.g., tremor, use of hearing aids) may experience considerable difficulties when using this equipment, which may be overcome by designing new devices and interaction techniques and user interfaces that can facilitate this type of users. The kiosk tools should be adapted to the user's preferences to allow comfortable and familiarised use [17]. Another issue regarding the acceptability by the elderly population is that some still prefer face-to-face visits rather than the kiosks' use [18,19] as these self-service technologies can be impersonal, causing a lack of confidence with the equipment, which can be another variable to consider when designing these systems. A pre-setting of the system with assistance and health professionals could help avoiding this unfamiliarity adapting the interface for a specific user. For example, we could add the photo of the patient and some language that could me more adapted to that patient. Study [15] provides evidence that even poor and less educated patients were able to use the kiosk. The use of instructions containing text (which is also spoken), images, audio, and video and the use of images for interaction with the kiosk can help patients with reading difficulties to understand how to perform each of the measurements on the kiosk. The use of color to discriminate between good and bad results will also help patients understand their health status. A smart card for authentication also facilitates the patient identification process by reducing patient interaction with the system [15].

The kiosk's implementation resulted in a saving of $5335 concerning face-to-face consultations, offering a better cost-benefit option to patients [18]. Modularity allows for the health kiosk to be easily adapted for different use cases [5]. The automation of hospital procedures [15] and the application of kiosks in community environments (eliminating the need for monitoring equipment to be installed in every residence) [17] have advantages of being cost-effective. The cost-effectiveness of a healthcare kiosk in clinical care is a parameter to evaluate in a kiosk's development since this analysis can also bring cost benefits to patients derived from reduced physician visits and the flexibility of alternative health service options [7, 16]. The kiosk may be a feasible care option; however, studies [7, 18] present a low sample size, which contributes to limit the generalization of the results. In the kiosk's test phase, one should have a heterogeneous and high sample size to obtain a study that provides well-founded evidence. In [15], the Brazilian patients do not need assistance makes the results of the usability of the kiosk more reliable. The identification time at the self-service kiosk was 13.6 minutes faster, half the time of the standard procedure performed by health professionals. Nurses can prioritize triage by collecting the main complaint during the identification process, allowing them to select patients for triage quicker and more accurately [20]. The use of kiosks allowed more time for physicians to be allocated to the treatment of other patients since the system allowed performing the procedures, which would typically be performed by health professionals [7, 19]. The kiosk's usage for taking blood pressure and performing other activities allows the physician to spend more time talking with the patient [22]. In the same study, nurses gained about 1.5 minutes per patient, which was used to perform other tasks, such as preparing documents, educational materials, and handling telephone encounters and voicemails [19]. Participants who used a citizen card took 5.2 seconds less to complete the identification process than participants who manually entered the data, saving them minutes of form filling [5]. Kiosk usage time was not highly time-consuming, which is beneficial considering the possible use cases [5]. The time of use in [5] was slightly shorter than study [15] since users had a technological background. In relation to study [17], the time of use was the longest due to the cognitive evaluation data's collection performed at the kiosk. In addition, the study required patients to be enrolled for two months, which made it more conducive to withdrawals.

V. LIMITATIONS

Our study has several limitations. The number of final studies for review was reduced because we established specific inclusion and exclusion criteria. Another possible limitation of the study is the use of keywords that may not be sufficient to retrieve all articles related to self-service kiosks in the health area. The quality of the studies varied, and only half of them were randomized and controlled with usual care.

VI. CONCLUSIONS

Self-service kiosks are a promising technology in the healthcare sector in various environments. The kiosks' acceptability was positive for both healthcare professionals and patients. Elderly or less educated patients were able to complete the kiosk's session even without assistance, considering them easy to use. User interface elements were the most relevant efficacy feature, allowing the kiosks to be adapted to patients of different age groups and educational levels. The replacement of standard procedures with the use of the kiosks relieved health professionals from some simple routine tasks. Biosensor technology has reached a sufficient level of maturity in terms of accuracy and usage simplicity, making it a very important component of health kiosks. More studies are needed to investigate the long-term impact of health kiosks, particularly in emergency settings where waiting times are increased by crowding and in populations with limited access to primary care.

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REFERENCES

[1] Who.int. 2020. Primary Health Care. [online] Available at: https://www.who.int/health-topics/primary-health-care#tab=tab_1 [Accessed 3 November 2020].

[2] Pines, Jesse M., et al. "International perspectives on emergency department crowding." Academic Emergency Medicine 18.12 (2011): 1358-1370.

A. A. Tabriz, J. G. Trogdon, and B. J. Fried, "Association between adopting emergency department crowding interventions and emergency departments' core performance measures," The American journal of emergency medicine, 2019.

[3] F. George and K. Evridiki, "The effect of emergency department crowding on patient outcomes," Health Science Journal, vol. 9, no. 1, p. 1, 2015.

J. Silva, P. Brandão, and R. Prior, "Usability assessment of a health kiosk," in 2017 IEEE Symposium on Computers and Communications (ISCC), pp. 260–265, IEEE, 2017.

[4] A. Joshi and K. Trout, "The role of health information kiosks in diverse settings: a systematic review," Health Information & Libraries Journal, vol. 31, no. 4, pp. 254– 273, 2014.

[5] G. Ng, S. W. Tan, and N. C. Tan, "Health outcomes of patients with chronic disease managed with a healthcare kiosk in primary care: protocol for a pilot randomised controlled trial," BMJ open, vol. 8, no. 3, p. e020265, 2018.

[6] G. Sun, S. Tao, Y. Lu, Y. Chen, Y. Shi, N. Rong, R. Wang, and X. Lu, "A low-cost community healthcare kiosk," in 2011 IEEE 13th International Conference on e-Health Networking, Applications and Services, pp. 270–273, IEEE, 2011.

[7] R. G. Maunder and J. J. Hunter, "An internet resource for self-assessment of mental health and health behavior: Development and implementation of the self-assessment kiosk," JMIR mental health, vol. 5, no. 2, p. e39, 2018.

[8] P. Mukhopadhyay, H. S. Roy, and N. Mukherjee, "E- healthcare delivery solution," 2019 11th International Conference on Communication Systems Networks (COM- SNETS), 2019.

[9] Vaportzis, Eleftheria, Maria Giatsi Clausen, and Alan J. Gow. "Older adults perceptions of technology and barriers to interacting with tablet computers: a focus group study." Frontiers in psychology 8 (2017): 1687.

[10] Czaja, Sara J., et al. "Factors predicting the use of technology: findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE)." Psychology and aging 21. (2006): 333.

[11] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: The prisma statement [accessed on 23 september 2019]." https://journals.plos. org/plosmedicine/article?id=10.1371/ journal. pmed.1000097, 2009.

[12] "Casp checklists - casp - critical appraisal skills programme [accessed on 25 september 2019]." https://casp-uk.net/casp-tools-checklists/, May 2018.

E. Soares, C. Oliveira, J. Maia, R. Almeida, M. Coimbra, P. Brandão, and R. Prior, "Modular health kiosk for health self-assessment," in 2016 IEEE Symposium on Computers and Communication (ISCC), pp. 278–280, IEEE, 2016.

[13] H. S. Ahn, I.-H. Kuo, C. Datta, R. Stafford, N. Kerse, K. Peri, E. Broadbent, and B.

[14] A. MacDonald, "Design of a kiosk type healthcare robot system for older people in private and public places," in International Conference on Simulation, Modeling, and Programming for Autonomous Robots, pp. 578–589, Springer, 2014.

[15] G. Demiris, H. J. Thompson, B. Reeder, K. Wilamowska, and O. Zaslavsky, "Using informatics to capture older adults' wellness," International journal of medical infor- matics, vol. 82, no. 11, pp. e232–e241, 2013.

[16] J. Bahadin, E. Shum, G. Ng, N. Tan, P. Sellayah, and S. W. Tan, "Follow-up consultation through a healthcare kiosk for patients with stable chronic disease in a primary care setting: a prospective study," Journal of general internal medicine, vol. 32, no. 5, pp. 534–539, 2017.

[17] C.-F. Chung, S. A. Munson, M. J. Thompson, L.-M. Bald- win, J. Kaplan, R. Cline, and B. B. Green, "Implementation of a new kiosk technology for blood pressure man- agement in a family medicine clinic: from the wwami region practice and research network," The Journal of the American Board of Family Medicine, vol. 29, no. 5, pp. 620–629, 2016.

N. Coyle, A. Kennedy, M. J. Schull, A. Kiss, D. Hefferon, P. Sinclair, and Z. Alsharafi, "The use of a self-check-in kiosk for early patient identification and queuing in the emergency department," Canadian Journal of Emergency Medicine, pp. 1–4, 2019.

[18] Usability.gov. 2020. Interaction Design Basics | Usability.Gov. [online] Available at: https://www.usability.gov/what-and-why/interaction-design.html [Accessed 3 November 2020].

[19] Gladia, R. Annes, and G. Kavya. "Design and Development of Non-Invasive Kiosk for Self-Care Health Management." Glob. J. Pure Appl. Math 13 (2017): 4787-4794.

[20] Joseph, M.J., Summerscales, M., Yogesan, S. *et al.* The use of kiosks to improve triage efficiency in the emergency department. *npj Digit. Med.* 6, 19 (2023). https://doi.org/10.1038/s41746-023-00758-2