REVIEW

The Recent Advances of Mobile Healthcare in Cardiology Practice

Shynar Kulbayeva[1], Karlygash Tazhibayeva[2], Laura Seiduanova[3], Indira Smagulova[4], Aiman Mussina[1], Shynar Tanabayeva[3], Ildar Fakhradiyev[3], Timur Saliev[3]

[1]NJSC "Astana Medical University", Nur-Sultan, Kazakhstan

[2]Al Farabi Kazakh National University, Almaty, Kazakhstan

[3]S.D. Asfendiyarov Kazakh National Medical University, Almaty, Kazakhstan

[4]"National Research Cardiac Surgery Center", Nur-Sultan, Kazakhstan

Corresponding author: Laura Seiduanova. Address: S.D. Asfendiyarov Kazakh National Medical University, Tole-bi str. 94, Almaty, 050020, Republic of Kazakhstan. Phone: + 7 707 949 20 70; E-mail: ildariko@mail.ru. ORCID ID: http//www.orcid.org/0000-0003-0205-2421.

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ABSTRACT

Background: Digitalization of healthcare led to the optimization of monitoring, diagnostics, and treatment of the range of disorders. Taking into account recent situation with COVID-19 pandemics, digital technologies allowed to improve management of viral infections via remote monitoring and diagnostics of infected patients. Up to date, various mobile health applications (apps) have been proposed, including apps for the patients diagnosed with cardiovascular pathologies. **Objective:** The presented review aimed at the analyses of a range of mHealth solutions used to improve primary cardiac care. In addition, we studied the factors driving and hindering the wide introduction of mHealth services in the clinics. **Methods:** The work was based on the guidelines of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement. The publication search was carried out using PubMed, Web of Science, Cochrane Library, Scopus, and Google Scholar databases. Studies published during the period from 2014 until January 2022 were selected for the analysis. The evaluation of risk of bias for the included studies was conducted using the Cochrane Collaboration Risk of Bias tool. **Results and Discussion:** An overall 5513 studies were assessed for eligibility after which 39 studies were included.. The main trend in the mobile health for cardiological applications is the use of different types of wearable devices and Artificial Intelligence-platforms. In fact, mobile technology allows remotely to monitor, interpret, and analyze biomedical data collected from the patient. **Conclusion:** The results of this literature search demonstrated that patients diagnosed with cardiovascular disorders can potentially benefit from the application of mHealth in cardiology. However, despite the proven advantages of mHealth for cardiology, there are many challenges and concerns regarding effectiveness, safety, reliability and the lack of official regulation and guidelines from official organizations. Such issues require solutions and further work towards a wide implementation of mHealth technologies in cardiac practice.

Keywords: mobile applications, telemedicine, cardiology, mobile app.

1. BACKGROUND

The term 'Mobile Healthcare' (mHealth) refers to the use of mobile computers and wireless technologies in healthcare to expand and improve the delivery of healthcare services outside hospitals (1, 2). The introduction of m-health dates back to 1924, when the article "The Radio Doctor-Maybe!" was published in Radio News Magazine, where a doctor assists a patient through a video call.

The recent rapid spread of coronavirus infection (COVID-19) sparked the interest in the use of m-Health platforms in healthcare (3-5). In fact, telemedicine has been proven as an optimal way to provide medical services due to the possibility to avoid a close contact with infected patients and reduce overall mortality (6-11). In addition, mobile health has been shown to lower the cost of health care and improve an access to healthcare in undeveloped nations (12, 13).

In turn, technological progress and the use of mobile phones (e.g. smartphones, tablet computers, etc.) have led to the widespread applications of so-called 'mobile applications' ('apps'). Mobile devices have become commonplace in healthcare settings, leading to a rapid increase in the development of medical software applications for these platforms (14-19).

Despite the rapid development of the digital healthcare systems and technological progress, this concept of medical care is facing various challenges. The main problems for the widespread implementation of digital health are limited digitalization and financial issues (2). Apart from that, there are concerns regarding the reliability and safety of smart devices, availability and free access to the equipment and health data (2). Another issue is a low digital literacy of some groups of patients and physicians. In addition, many other factors play a pivotal role in the effective implementation of digital platforms in healthcare and cardiology, including ethical, social, mental, political and financial factors (2). Mobile health has also been criticized for the lack of clinical quality and safety of this type of healthcare (20).

Thus, mobile applications are becoming an increasingly important platform for the provision of medical services, and their capabilities can reduce overall mortality. To date, according to the WHO, cardiovascular diseases still occupy the first position in the list of causes of death (21). The use of mobile health in these patients can improve cardiac rehabilitation (22), increase adherence to treatment , exercise tolerance (23), reduce cardiovascular symptoms (24), improve the psychosocial status, and thereby, reduce overall mortality.

The growing interest of professional organizations such as the European Society of Cardiology and the American Heart Association in using mHealth technologies indicates a need in a new systematic analysis with focus on non-invasive mHealth interventions for patients with heart failure is warranted.

2. OBJECTIVE

In this review, we intended to highlight and analyze the available mobile applications used in the primary cardiac care service. In addition, we studied the factors driving and hindering the wide introduction of mHealth services.

3. MATERIAL AND METHODS

The study was performed in compliance with the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0 (25, 26). The work was based on the guidelines of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement (26).

3.1. Data Sources and Search Strategy

The following databases were searched: PubMed, Web of Science,Cochrane Library, Scopus and Google Scholar (period covering from 2014 up to January 15, 2022). Search strategies were performed by using a combination of free text and MeSH terms, as well as Boolean operators. Search strategy was presented in Appendix 1. The articles were selected using a two-step approach. First, the titles and abstracts identified by the above searches were screened for relevant studies. Second, the full texts of these shortlisted articles were downloaded and assessed for eligibility based on the inclusion criteria.

All citations were downloaded and adjusted into EndNote version X6 (Clarivate Analytics, New York, USA). The duplicates were removed using EndNote software, and manually too. We also employed the Rayan online screening tool for searching the articles (27).

3.2. Procedure of the Data Extraction

Two reviewers (co-authors) independently extracted the data on participant characteristics, intervention details and outcomes measures. Disagreements were resolved either by oral discussion or resolved by a third author. Data were collected using a data extraction spreadsheet developed specifically for this study.

3.3. Criteria for considering studies for this review

The inclusion criteria were as the follows: all clinical trials or randomized controlled trails of mobile applications (aimed at improving the primary cardiac care or rehabilitation), reported original data, and research conducted on human participants. The publications written only in English were considered for the analysis.

The interventions were considered only for the cases of the use of medical mobile applications. Such applications (apps) were based on a well-defined function to measure risk factor for cardiovascular diseases (CVD), changes and the intention to change health behavior in outpatients diagnosed with CVD or treated.

3.4. Exclusion criteria

The studies conducted before 2008 were excluded from the analysis (the first Apple smartphones with the iOS operating system was released on June 29, 2007 (28)). From the analysis were excluded the following publications: review articles, systematic reviews, editorials, books and book chapters, conference materials, study design description (or study protocols), pilot studies without indication preliminary data, articles directly related to telemedicine without use of mobile applications (videoconferencing, sending a message, usage only web platforms, computers, phone calls). Apart from that, the usage of additional smart or medical devices in combination with telemedicine tools without smartphone apps was also excluded from the study.

The articles discussing the mobile applications in a different context were also excluded from the analysis: for example, research on the biological effects of radiation from mobile phones.

3.5. Quality assessment

The quality assessment tool is based on the Cochrane Risk Of Bias tool (29). Specifically, this assessed the risk of bias in random sequence generation; allocation concealment; blinding of participants, personnel, and outcome assessors; incomplete outcome data; selective outcome reporting, and overall; Each question is answered as “yes” (low risk of bias), “no” (high risk of bias), or “unknown” (unknown/unclear risk of bias).

The risk of bias assessment was conducted by one reviewer and validated by the second reviewer, and disagreements were resolved by discussion.

4. RESULTS

4.1. Study selection and study characteristics

The characteristics and main features of the analyzed studies are provided in Table 1. Figure 1 illustrates a systematic procedure for searching and selecting articles. The initial query yielded 25258 potentially relevant records. 19745 articles were excluded for duplicate records. An overall 5513

				Method	Participants				
?	Author Year	Name of app	Reason for use	Study design Duration Total participants	Mean age+ SD/ Age range	Gender (Male/ Female)	In each group	Interventions	Outcomes
1	Berglund et al. (37), 2018	Smartphone application system for alerting out-of-hospital cardiac arrest (OHCA).	Dispatch of lay volunteers trained in cardiopulmonary resuscitation	Prospective observational run-in study; Follow-up: 6 months; N=198 patients;	Information not provided	Information not provided	Information not provided	Information not provided	In the n = 198 OHCAs, lay responders arrived at the scene in 116 cases (58%), and prior to EMSs in 51 cases (26%). An AED was attached in 17 cases (9%) and 4 (2%) were defibrillated. Lay responders performed CPR in 54 cases (27%).
2	Chandler et al.(31), 2020	Tension Tamer (TT); (Android or iOS)	For reducing SBP levels among adults with stage 1 systolic hypertension	Two-arm, small-scale efficacy RCT (NCT03168789) ; Follow-up:12 months; N=30 out or 80 patients; were included.	TT group: 46.5 ± 13.0; SPCTL group: 43.4 ± 14.2;	TT group: 48.7% /51.3%; SPCTL group: 49.3%/50.7%;	TT group:16; Lifestyle education program delivered via Smartphone (SPCTL)group: 14;	TT group: assessed continuous real-time heart rate (HR) from a user's fingertip placed over a video camera lens during sessions. Users receive immediate feedback graphs after each session, showing their HR changes. SPCTL group: twice-daily dosage schedule for engagement in a walking or running program using the RunkeeperTM app (month 1: 15 min sessions; months 2 and 3: 10 min sessions; months 4–12: 5 min sessions).	The TT group showed greater SBP reductions at months 3 (−8.0 vs. −1.9), 6 (−10.0 vs. −0.7), and 12: (−11.6 vs. −0.4 mmHg; all p-values <0.04).
3	Coppetti et al.(44),2017	For contact PPG: "Instant Heart Rate"(IHR); "Heart Fitness" (HF); For non-contact PPG: "Whats My Heart Rate" (WMH) ; "Cardiio" (CAR) (iPhone 4, iPhone 5).	To check an accuracy of heart rate monitoring	N=108 randomly selected patients	68 (52-76);	73/35	Information not provided	Contact photoplethysmography (PPG): contact of fingertip to built-in camera was performed.	The accuracy of app-measured heart rate as compared to electrocardiogram: mean absolute error (in bpm standard error) was 2 ±0.35 (pulse oximetry), 4.5± 1.1 (IHR), 2 0.5 (HF), 7.1 1.4 (WMH) and 8.1 1.4 (CAR). IHR and HF had higher feasibility and better accuracy for heart rate measurement than WMH and CAR.
4	Guo et al.(46), 2019	King OPTO-Electronic (version for patient and for physician (Android or iOS)	Hierarchical management in patients with chronic heart failure (CHF)	A single-arm prospective study; N=66 out of 70; Follow-up: 4 months;	69.35±11.15;	34/32	Information not provided	Telehealth program incorporating remote monitoring service platforms, mobile apps, and smart health tracking devices; Mobile app: data uploading, remote consultations, electronic medical record viewing, and medical appointments;	The program showed a positive effect on self-management for patients (healthy diet: P=.046, more fruit and vegetable intake: P=.02, weight monitoring: P=.002, blood pressure: P<.001, correct time: P=.049, and daily dosages of medicine taken: P=.006).
5	Guo et al.(47), 2020	mobile Atrial Fibrillation App (mAFA)	To report adherence/persistence and long term (≥1 year) clinical outcomes of the mAFA-II trial	A cluster randomised trial; N=1261 subjects; Follow-up: 12 months;	Mean age: 67 years	Information not provided	Information not provided	Control group: usual care; Intervention group: usage of mAFA;	Intervention group, had a lower risk of the composite outcome of 'ischaemic stroke/ systemic thromboembolism, death, and rehospitalization' (hazard ratio, HR 0.18, 95% confidence interval, CI: 0.13–0.25, P < 0.001), compared to usual care. Of 842 patients using their smart devices for 'Better symptom management', 70.8% had good management adherence, with the persistence of use of 91.7%. Amongst AF patients with long term use (≥1 year) of mHealth technology for optimising stroke prevention, symptom control and comorbidity management, adherence/persistence was good
6	Johnston et al.(38), 2016	Web-based smartphone application	To evaluate effectiveness of improving treatment adherence and cardiovascular lifestyle in MI patients	Multicenter, randomized trial (NCT01874262); N=166 out of 174; Follow-up: two visits during 6 months;	Control group: 58.4±8.6; Active group: 56.8±8.0;	Control group: 63/17; Active group: 71/15;	Control group: 80; Active group: 86;	Control group: received a simplified tool containing only a simplified drug adherence e-diary; Active group: used a complete smartphone app with an extended drug adherence e-diary and secondary prevention educational modules;	At 6 months, greater patient-registered drug adherence was achieved in the active versus the control group (16.6 vs. 22.8[p=0.025]). Patient satisfaction was higher in the active versus the control group (87.3 vs. 78.1[p=0.001]). Use of app improved patient drug adherence and cardiovascular lifestyle changes and quality of life.
7	Ni et al.(48), 2018	Two mobile applications were used: WeChat and BB Reminder (iPhone 5; used only for research purposes).	To develop a mobile technology (mHealth) intervention to improve medication adherence among patients with coronary heart disease (CHD).	N=36 out of 50; Two phases: Phase 1 lasted for three months; Phase 2 lasted for two months; Follow-up: 1 month;	Information not provided	Control group: 15/3; Experimental group: 14/4;	Control group: 18; Experimental group: 18;	Control group: received educational materials via WeChat; Experimental group: received the same educational materials via WeChat. received a reminder from BB Reminder for every dose of their medications. In Phase 2 educational materials were sent every five days rather than every two days, and medication-taking reminders were sent daily.	At the 30-day follow-up, the mean of the decrease in medication non-adherence score in the experimental group (M =-1.35, SD = 2.18, n =36) was more than the decrease in control group (M =- 0.69, SD = 1.58, n = 36), which means the medication adherence improved more in the experimental group
8	Sakakibara et al.(70), 2017	Healing Circles program (iPhone/ iPad with at least iOS 7.0)	To explore the use of technology to facilitate peer support in women with CVD.	N=35 out of 127; Follow-up: 10 weeks;	Information not provided	Information not provided	Information not provided	Participants' use of the program was completely voluntary and driven by when they wanted to or felt a need to connect with others. Six to nine consecutive participants were assigned to the same ''Circle-of-Friends''.	After 10 weeks of using the Healing Circles program, improvements were observed in the participants' health behaviors (p = 0.04), self-monitoring (p = 0.04), social support (p = 0.01), and social integration (p = 0.002).

9	Liu et al.(49),2020	"WeChat"	To reduce the time taken for diagnosis and treatment of ST-elevation myocardial infarction (STEMI)	N=140 patients;	Control group: 58.3 ±11.6; Intervention group: 60.6± 11.8;	Control group: 56/14; Intervention group: 58/12;	Control group: 70; Intervention group: 70;	Control group: did not transfer pre-hospital ECG; Intervention group: with pre-hospital ECG transmission via WeChat;	In the WeChat group versus the control group, the median first medical contact to wire, door to wire and first medical contact to catheterization laboratory activity were shorter (132 vs 171 minutes, p < 0.001; 60 vs 95 minutes, p < 0.001; 29 vs 74 minutes, p < 0.001). Pre-hospital ECG transfer via a WeChat group is an innovative approach to accelerate the diagnosis and treatment of STEMI patients.
10	Mendelson et al.(56), 2014	Smartphone based application	To evaluate the effects of a combination of continuous positive airway pressure (CPAP) and telemedicine support on blood pressure (BP) reduction in high cardiovascular risk obstructive sleep apnea (OSA) patients	A multi-center RCT (NCT01226641); N=82 out of 107adults with a high cardiovascular risk;	Standard care group: 63 ± 9; Telemedicine group: 62 ± 9;	Standard care group: 75.5%/ 24.5%; Telemedicine group: 90.7%/ 9/3%;	Standard care group: 42; Telemedicine group: 40;	Standard care group: CPAP; Telemedicine group: CPAP and telemedicine. There BP measurements, CPAP adherence, sleepiness, and quality of life data; in return, they received pictograms containing health-related messages.	CPAP treatment supported by telemedicine alone did not improve blood pressure and cardiovascular risk in high cardiovascular risk OSA patients.
11	Mertens et al.(64), 2016	Medication Plan (Apple iPad)	To assess the mobile app on a tablet aimed at supporting drug intake and vital sign parameter documentation affects adherence in elderly patients	N=24 patients; Follow-up: 28 days;	73.8±.5.	Information not provided	Information not provided	A crossover design with 3 sequences: -an initial phase without assistive systems (between 3 and 6 months in line with standard rehabilitation treatment; -after an inpatient hospital stay) -an interventional phase (28 days of using the app system), and a comparative phase (28 days of using a paper diary)	Stronger adherence for the medication app than the paper system for both blood pressure recordings (P<0.001) and medication intake (P=0.033). A mobile app for medication adherence increased objectively and subjectively measured adherence in elderly users undergoing rehabilitation.
12	Nan et al.(50), 2020	The Tiantanzhixin app	To compare outcomes in patients with STEMI who had percutaneous coronary intervention (PCI) and the use of a telemedicine app.	A single-center observational retrospective study; N=243 patients;	Patients before pandemic: -App user group: 68 (51–73.5) ; -Non-App user group: 66.5 (57–76); Patients after pandemic: -App user group: 67.5 (53.25–81.25); -Non-App user group: 71.5 (56.75–77.75);	Patients before pandemic: -App user group: 13/12 ; -Non-App user group: 100/58; Patients after pandemic: -App user group: 5/3; -Non-App user group: 32/20;	Patients before pandemic (n=183): -App user group (n=25); -Non-App user group (n=158); Patients after pandemic (n=60): -App user group (n=8); -Non-App user group (n=25);	Usual care for Non-App user group and Telemedicine via the Tiantanzhixin app in App user group;	The time from symptom onset to calling an ambulance (SCT), door to balloon time (DTB), and total ischemia time were significantly prolonged in patients after the pandemic Telemedicine reduced the delay time of STEMI patients during the COVID-19 pandemic.
13	Shcherbina et al.(32), 2019	MyHeart Counts app (Apple, version 5S or newer).	To assess the effect of four different physical activity coaching interventions on daily step count via mobile app.	Randomised, controlled cross-over trial;	Participants who completed baseline and at least one intervention: 43.04±15.28; Participants who completed baseline and all four interventions: 50.59±15.45;	Participants who completed baseline and at least one intervention: 715/271; Participants who completed baseline and all four interventions: 360/131;	Participants who completed baseline and at least one intervention: 1075; Participants who completed baseline and all four interventions: 493;	Participants were randomly assigned to receive four combinations of four 7 day interventions via the app. Interventions consisted: daily 10 000 steps, hourly prompts to stand following 1 h of sitting.	Four smartphone-based physical activity coaching interventions significantly increased daily physical activity. MyHeart Counts app can increase shortterm physical activity levels in a free-living cohort.
14	Tian et al.(67), 2015	Android-powered "app"	To evaluate a simplified cardiovascular management program (Sim-Card) delivered by community health workers (CHWs)	Cluster-randomized controlled trial; Participants: 1828 out of 2,000 high-risk individuals in 40 clusters; Follow-up: 1 year;	Information not provided	Information not provided	Control group: 20 villages; Intervention group: 20 villages;	Intervention group: were managed by CHWs through an Android-powered "app" on a monthly basis focusing on two medication use and two lifestyle modifications (prescription of drugs and providing lifestyle recommendations.)	Compared with the control group, the intervention group had a 25.5% (P<0.001) higher net increase in the primary outcome of the proportion of patient-reported anti-hypertensive medication use pre-and-post intervention. There were also significant differences in certain secondary outcomes: aspirin use (net difference 17.1%, P<0.001) and systolic blood pressure (−2.7 mmHg, P=0.04). However, no significant changes were observed in the lifestyle factors.
15	Vuorinen et al.(24), 2014	Mobile app	To evaluate the effect of smartphone- based app to decreasing HF-related hospitalization	A two-arm RCT (NCT01759368); Participants: 1 part: 59 patients; 2 part: 35 patients; Follow-up: 6 months;	Control group: 57.9 ± 11.9; Intervention group: 58.3±11.6;	Control group: 39/8; Intervention group: 39/8;	1 part Control group:29; Intervention group:30; 2 part Control group:18; Intervention group: 17;	Control group: usual care; Intervention group: the patients were given a home-care package including a weight scale, a blood pressure meter, a mobile phone, and self-care instructions; A pre-installed software app on the mobile phone supported the uploading of measurements and the self-assessment of symptoms.	Home telemonitoring did not reduce the number of patients' HF-related hospital days and did not improve the patients' clinical condition.
16	Wackel et al.(33), 2014	Two apps: Instant Heart Rate (California) and Heart Beat Rate (France) (iPhone 5)	To measure heart rates during supraventricular tachycardia (SVT) in pediatric patients	N=26 patients;	Information not provided	Information not provided	Information not provided	Both apps function by placing the patients' finger over the video camera while being illuminated by the flash and then recording color changes in the skin produced by blood flow via PPG to generate a measurement of heart rate.	During tachycardia, neither of the 2 apps consistently determined an accurate heart rate at rates >200 bpm. The apps tested should not be considered an accurate tool for assessment of heart rates during SVT in pediatric patients
17	Eyles et al.(57), 2017	SaltSwitch smartphone app	To determine the effectiveness of app to support people with cardiovascular disease to make lower salt food choices	Two-arm, parallel, randomised controlled trial (ACTRN12614000206628); N=66 patients; Follow-up: 6 weeks (2 weeks baseline and 4 weeks intervention);	Control group: 65±8; Intervention group: 64±7;	Control group:25/8; Intervention group: 30/3;	Control group:33; Intervention group: 33;	Control group: usual care; Intervention group: used app for 4 weeks. App enables users to make lower salt food choices by scanning the barcode of a packaged food using their smartphone camera to receive an immediate interpretive, traffic light nutrition label on screen, along with a list of lower salt alternatives.	App is effective in supporting people with cardiovascular disease to make lower salt food purchases.
18	Hamaya et al.(34), 2021	Kencom (iOS and Android)	To assess the effects of kencom on physical activity levels and CVD risk factors	N=12602 users;	44,1±10,2;	6584/6018	N=12602 users for Step analysis; N=5473 users for CVD risk analysis;	Daily step count, annual health check-up data, and insurance claim data of the kencom users were analysed.	The use of the app was significantly associated with enhanced physical activity, which might lead to weight loss and improvement in lipid profile.

19	Nahid et al.(58), 2020	Mobile app "My Smart Heart" (Android)	To determine the effect of using smartphone applications on self-care behaviors in patients with heart failure	Randomized controlled clinical trial; N=120 patients; Follow-up: Each week, the patients were reminded of using the application for 6 weeks and then every month for about two more months;	Control group: 60.71±12.62; Intervention group: 55.95±14.41;	Control group: 31/25; Intervention group: 35/29;	Control group: 60; Intervention group: 60;	The main features of the application are profile, reminder, educational content, educational videos, daily messages, medication guide, Q/A, FAQ, registration of physical and mental symptoms and vital signs with the ability to record symptoms and alerts in abnormal cases daily.	App can improve self-care in patients with heart failure
20	Manigault et al.(60), 2020	Pharmacist-designed app (Android)	To determine the effectiveness of using a app in improving BP and promoting adherence to anti-hypertensive medication regimens in patients with hypertension	Prospective, multicenter, randomized, controlled trial (NCT04066010); N=78 patients; Follow-up: during 3 months before, during study, and 3 months after study completion;	Information not provided	Control group: 16/13; Intervention group: 14/19;	Control group: 39; Intervention group: 39;	Control group: usual care; Intervention group: received features of full version of app such as calendar reminder, "Call your pharmacy" button, Bp log to enter BP value, educational part;	App did not result in improved medication adherence or BP control, but may be beneficial in patients with hypertension who want to improve medication adherence.
21	Márquez Contreras et al.(61), 2019	"ALERHTA" app	To evaluate the effectiveness of app in pharmacological therapeutic adherence of the mild-moderate arterial hypertension	Prospective, randomized controlled trial; N=148 patients; Follow-up:12 months;	Control group: 57.08±10; Intervention group: 57.7±9;	Control group: 48%/52%; Intervention group: 47.9%/52.1%;	Control group: 75; Intervention group: 73;	Control group: usual care; Intervention group: to record personal data, recommended BP levels as objectives, record the doctor's advice about the prescribed treatment, the posology, set reminder alarms, set a calendar of appointments or events, and record the results of the BP measurement	App favors the pharmacological therapeutic adherence and improves the percentage of hypertensive patient control.
22	Wolf et al.(39), 2016	Mobile-based eHealth tool	To investigate the effect of an eHealth diary and symptom-tracking tool in combination with person-centered care (PCC) for patients with acute coronary syndrome (ACS).	Randomized intervention study (Swedish registry, Researchweb.org, ID NR 65 791); N=199 patients; Follow-up:6 months;	60±10;	Information not provided	Control group: 105; PCC intervention group:94;	Control group: usual care; PCC intervention group: patients in the intervention group could choose to use a Web-based or mobile-based eHealth tool, or both, for at least 2 months after hospital discharge.	There were a significant effect on improvement of the general self-efficacy and the composite score for patients using an eHealth diary and symptom-tracking tool in combination with PCC compared with traditional care
23	Lunde et al.(42), 2020	Mobile app (Android or iOS)	To examine the effect of individualized follow-up with an app for one year on peak oxygen uptake (VO2peak) in patients completing cardiac rehabilitation (CR)	Single-blinded multicentre randomized controlled trial (NCT03174106); N=113 patients; Follow-up:12 months;	Control group: 58.4±8.2; Intervention group: 59.5±9.1;	Control group: 40/16; Intervention group:48/9;	Control group: 56; Intervention group:57;	Control group: usual follow-up; Intervention group: individualized follow-up enabled with an app;	VO2peak, exercise performance and exercise habits, as well as self-perceived goal achievement were improved, compared with a CG in patients post-CR
24	Lunde et al.(43), 2019	Mobile app (Android or iOS)	To assess feasibility of usage of app for promoting and monitoring patients' adherence to a heart-healthy lifestyle after CR	Experimental, pre-post single-arm trial; N=14 out of 24 patients; Follow-up:12 weeks;	60.1±8.5;	10/4	N=14	During the study period, patients received weekly, individualized monitoring through the app	All patients used the app for preventive activities and found the app both useful and motivating
25	Abu-El-Noor et al.(63), 2020	Mobile app	To assess the impact of using a mobile app on the level of adherence to treatment regimens among hypertensive patients	Randomized clinical trial; N=191 patients; Follow-up:3 months;	Control group: 57.5±11.9; Intervention group: 55.4±10.9;	Control group: 40/54; Intervention group:35/62;	Control group: 94; Intervention group:97;	Control group: usual care; Intervention group: received daily reminding alarms and a monthly (or less) message to remind them about the next appointment for follow-up.	The use of a mobile phone app resulted in improvements in adherence to hypertension treatment.
26	Yu et al.(51), 2020	Heart Health Application	To evaluate the effectiveness and feasibility of using a smartphone-based application to improve medication adherence in patients after coronary artery bypass grafting (CABG).	A large scale, multicenter, open -label, randomized controlled trial (NCT02432469); N=1000 patients; Follow-up:6 months;	Control group: 56.8±8.0; Intervention group: 58.4±8.6;	Control group: 63/17; Intervention group:71/15;	Control group: 499; Intervention group:501;	Control group: received usual care; Intervention group: receive medication reminders and cardiac health education	A smartphone -based application supporting secondary prevention among patients after CABG did not lead to a greater adherence to secondary preventive medications
27	Bozorgi et al.(59), 2021	Mobile app	To assess the effect of a self-management application on patient adherence to hypertension treatment	Randomized, controlled clinical trial (IRCT2015111712211N2); N=118 out of 120 patients; Follow-up: intervention for 8 weeks and followed up until the 24th week;	Control group: 51.6 ± 9.4; Intervention group: 52.0 ± 8.1;	Control group: 36/24; Intervention group:35/25;	Control group: 60; Intervention group:58;	Control group: received usual care; Intervention group: received educational-supportive intervention, along with the routine treatment	The treatment adherence score increased by an average of 5.9 (95% CI 5.0-6.7) in the intervention group compared to the control group. App can be effective in self-management and better patient adherence
28	Chan et al.(52), 2016	Cardiio Rhythm app	To assess the diagnostic performance of a standalone smartphone photoplethysmographic (PPG) application	Prospective screening study; N=1013 out of 1098 patients;	68.4± 12.2	474/539;	N=1013	PPG measurements were performed by using the Cardiio Rhythm smartphone application.	App provides an accurate and reliable means to detect AF in patients at risk of developing AF
29	Gonzalez-Sanchez et al.(62), 2019	Mobile app	To assess the effect on cardiovascular risk factors (CVRFs) , of adding the use of a smartphone app to an intervention consisting of standard counseling on physical activity and the Mediterranean diet	Multicenter, randomized and controlled clinical trial (NCT02016014); N=833 patients; Follow-up: 12months;	Control group: 52.3 ± 11.9; Intervention group: 51.4 ± 12.1;	Control group: 150/268; Intervention group:166/249;	Control group: 418; Intervention group:415;	Control group: received counseling ; Intervention group: were assigned to the counseling + app;	The use of an app for three months to standard counseling on diet and physical activity, does not provide additional benefits for improving CVRFs or the estimated CVR in the long term.
30	Eckardt et al.(65), 2021	Smartphone guided secondary prevention (SGSP) app	To assess lifestyle changes for patients with CAD after usage of app	N=17 out of 43 patients met the criterion for 28-day adherence; Follow-up: 4weeks;	Adherence group: 62.4 ±8.8; Non-adherence group:59.3 ±9.2;	Adherence group: 14/3; Non-adherence group:19/7;	Adherence assessment group: 17; Non-adherence group:26;	The app provided a daily 15-minute program that included video-guided exercises, video sessions with background information about CAD, and a tool to record blood pressure and heart rate once a day	The regular use of a SGSP app appears to support lifestyle changes in patients with CAD

31	Kang et al.(40), 2021	HEART4U (Android or iOS)	To evaluate the impact of the mHealth tool in real-world practice for atherosclerotic cardiovascular disease (ASCVD) patient care	Prospective randomized, single-center, open-label trial (NCT03392259); N=640 out of 666 patients; Follow-up: 6 months;	Control group: 59.2 ± 7.6; Intervention group: 57.4 ± 7.7;	Control group: 271/62; Intervention group:279/54;	Control group: 321 completed; Intervention group:322 completed;	Control group: received usual care; Intervention group: received via app self-engagement by providing relevant information and user-device interactions	No significant benefits associated with the use of the mHealth tool in terms of the predefined study endpoints in stable patients with ASCVD. A post-hoc subgroup analysis showed the benefit was greater if a participant in the intervention group accessed the application more frequently.
32	Morawski et al.(35), 2018	Medisafe app	To assess ability of app to improve self-reported adherence to antihypertensive medications and blood pressure control	2-arm, randomized clinical trial (NCT02727543); N=411 patients; Follow-up: 12 weeks;	Control group: 52.4 ± 10.1; Intervention group: 51.7 ± 10.5;	Control group: 75/127; Intervention group:89/120;	Control group: 202; Intervention group:209;	Control group: received usual care; Intervention group: received via app reminder alerts, adherence reports, and optional peer support.	After usage of app a small improvement in self-reported medication adherence but no change in systolic blood pressure compared with controls
33	Sankaran et al.(45), 2019	HeartHab	To assess the impact of app on patients' overall motivation, increasing physical activities, reaching exercise targets, quality of life, and modifiable risk factors in patients with CAD during telerehabilitation	Randomized crossover study with a crossover point at 2 months (NCT03102671); N=28 out of 50 patients; Follow-up: 4 months;	60.8 ± 8.2;	24/4	Group1: 14; Group 2: 14;	Group1: used HeartHab in the 1st phase and received usual care in the 2nd phase; Group 2: received usual care in the 1st phase and HeartHab in the 2nd phase;	The usage of app demonstrated significant effects on glucose and HDL cholesterol and positive carryover effects on weight, HDL cholesterol, and VO2 max
34	Schmidt et al.(66), 2020	App (Android, versions 5.0 and higher)	To monitor the functionality, acceptance and usability of this app in left ventricular assist device (LVAD) patients.	Prospective single-center study; N=13 patients after 1027±653 days after LVAD implantation; Follow-up: 4 weeks;	60.0 ± 7.0;	12/1	N=13	The patients were requested to use the application (e.g. daily measurement of weight, INR, etc.)at least once a day.	App can definitely be used to improve aftercare in LVAD therapy in selected patients
35	Senoo et al.(55), 2022	the Smart AF	To assess degree of improving of medication adherence in elderly patients with AF	Prospective observational study; N=136; Follow-up:1 month; 3 months; 6 months;	64.3 ± 9.6;	108/28	N=136	Participants used app, which integrates education, automatic reminder, and patient engagement strategies with a simple user interface	App improved medication adherence among elderly patients with AF.
36	Yadav et al.(68), 2021	HealthRADAR app	To assess the acceptability of app for patient follow-up and its comparison to routine practice among patients with ACS who have undergone a PCI	Randomized controlled trial; N=228 out of 231; Follow-up: 4 weeks; ;	Control group: 54.2 ± 10.2; Intervention group: 54.3 ± 11.3;	Control group: 102/17; Intervention group:88/21;	Control group: 119; Intervention group:109;	Control group: received usual care; Intervention group: received via app reminder alerts, adherence reports, and optional peer support.	App based system shows higher satisfaction rate and comparable clinical outcome.
37	Volpi et al.(41), 2021	mHealth app	To assess the influence of using an mHealth app on patients' adherence to hypertension treatment	Non-randomized, controlled, open-label trial; N=49 out of 84; Follow-up: 12 weeks;	Control group: 60.4 ± 10.4; Intervention group: 57.2 ± 7.1 y;	Control group: 8/16; Intervention group:15/10;	Control group: 24; Intervention group:25;	Control group: received usual care; Intervention group: used app includes the recording of blood pressure, weight, waist circumference, height, sleep, mood, and engagement in physical activities, also alerts, and reminders.	App can empower patients to manage their own health and increase adherence to hypertension treatment.
38	Harzand et al. (36), 2018	CR program delivered via a commercially available smartphone platform (Moving Analytics, Los Angeles, California) (Android or iOS)	To evaluated the feasibility and acceptability of a smartphone-enabled, home-based cardiac rehabilitation among veterans Single-arm, non-randomized study (NCT02791685); N=13 out of 21; Follow-up: 12 weeks; with CHD	Single-arm, non-randomized study (NCT02791685); N=13 out of 21; Follow-up: 12 weeks;	62.0 ± 7.0;	Information not provided	N=13;	Participants received a 12-week home-based CR program that included app and an integrated hospital-facing online dashboard for remote patient monitoring and care coordination by a trained coach.	Smartphone-enabled home-based CR intervention may be an acceptable alternative for veterans who cannot enroll in center-based CR.
39	Liu et al.(53), 2019	HeartGuardian app (Android)	To assess the short-term effectiveness of app in supporting people with CVD on lipid control and medication adherence.	Two-armed, parallel, randomised control Trial; N=57; Follow-up: 12 weeks;	59.05 ± 7.23;	Information not provided	Control group: 28; Intervention group:29;	Control group: receive weekly text messages on health education; Intervention group: receive weekly text messages on health education + use of HeartGuardian app on smartphones;	App could help patients with CVD better manage their dyslipidemia and improve medication adherence, reduce the rate of major adverse cardiac events and greater improvement in medication adherence (82.14% vs 37.93%, P=0.001)

studies were assessed for eligibility after which 39 studies were included. Studies published during the period from 2014 until January 2022 were selected for the analysis.

The analysis showed that studies on the use of mobile applications were conducted in the USA (n=7) (30-36), Sweden (n=3) (37-39), Republic of Korea (n=1) (40), Brazil (n=1) (41), Norway (n=2) (42, 43), Switzerland (n=1) (44), Belgium (n=1) (45), China (n=9) (22, 46-53), Romania (n=1) (54), Japan (n=1) (55), Finland (n=1) (24), France (n=1) (56), New Zealand (n=1) (57), Iran (n=2) (58, 59), Georgia (n=1) (60), Spain (n=2) (61, 62), Palestine (n=1) (63) and Germany (n=3) (64-66). Two studies were conducted simultaneously in India (n=2) (67, 68).

By category, the research was focused on the following areas: mobile applications for diagnostic purposes (for example, ECG recording (30), assessment of heart rate (31, 33, 44, 65). Some studies were carried out to validate the system for urgent care alarm (37), lifestyle changes (43, 45, 53, 62, 65), adherence to treatment (35, 38, 41, 47, 48, 51, 53, 55, 59, 60, 63, 64, 67, 68), and physical activity of the patients (22, 32, 34, 41, 45, 62).

In terms of application, mobile applications were designed for patients with diagnoses such as heart failure (24, 46, 58), supraventricular tachycardia (30, 33), cardiac arrest (37), acute coronary syndrome (39, 68), hypertension (31, 35, 41, 59-61, 63), ischemic heart disease (36, 48, 69), coronary ar-

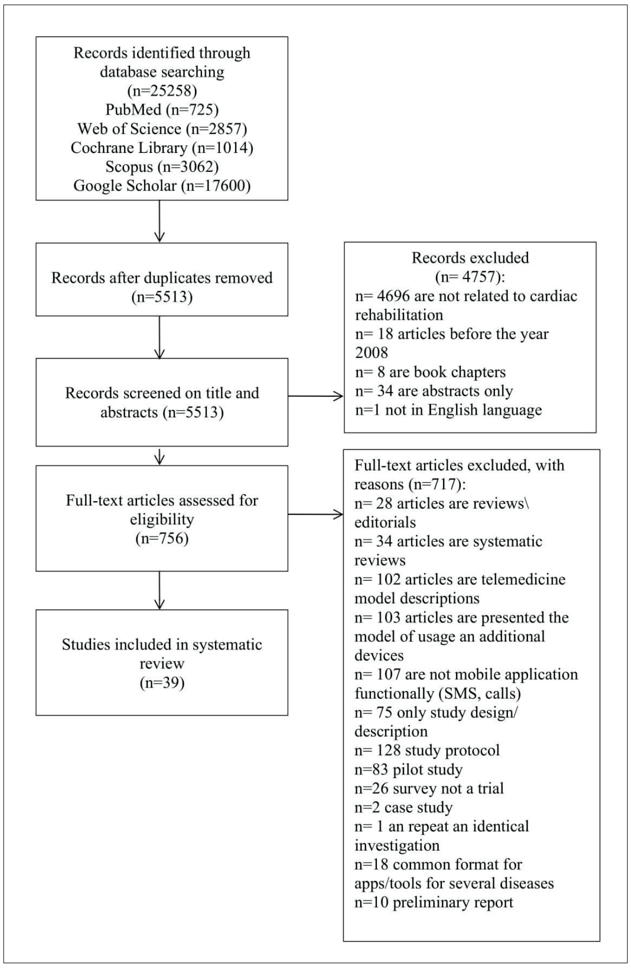

Figure 1. PRISMA flow diagram for study selection process

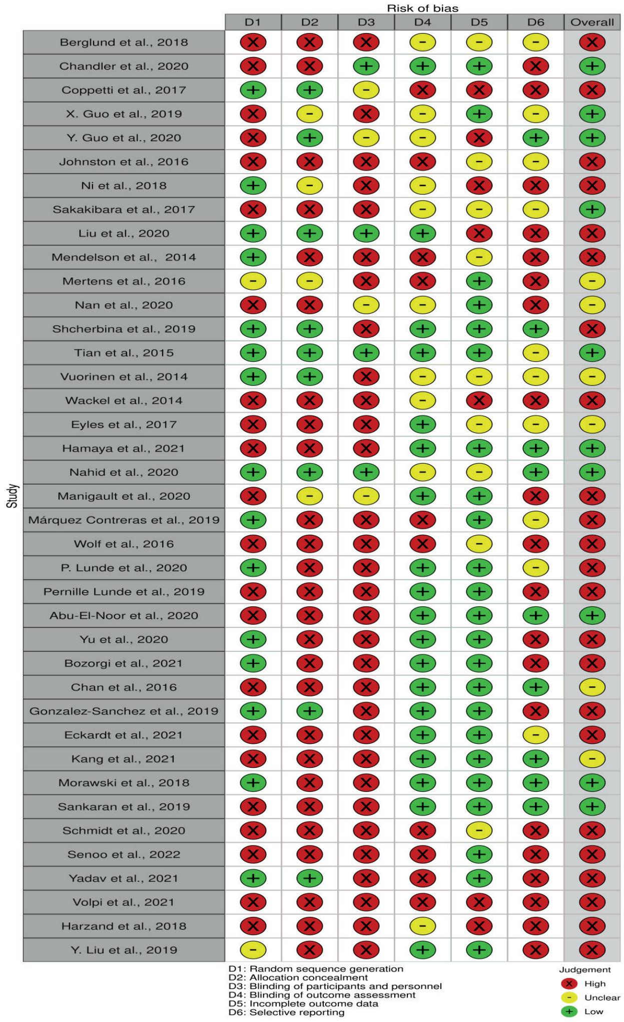

Figure 2. Risk of bias summary

tery disease (45, 65) or after coronary artery bypass grafting (51), myocardial infarction (38, 49, 50), atrial fibrillation (52, 55), obstructive coronary artery disease (70), (47) and general CVD (32, 40, 53, 54, 62, 64).

There were prospective (22, 46, 55, 60, 66), retrospective (40, 49, 50, 61), RCTs (22, 24, 32, 35, 39, 40, 42, 51, 53, 56-63, 67, 68).

Some mobile applications have been designed for use in pediatric cardiac patients (30, 33).

Apart from that, it should be noted that many mobile applications, were employed as an additional tool for medical personnel to monitor the condition of patients (22, 24, 31, 35, 36, 46, 52).

In addition to the analysis of mobile application, we also studies text messages (31, 36, 38, 46, 56, 58), educational materials (38, 51, 55, 58, 59, 64), video instructions for using the application and monitoring the health status (31, 46, 65, 70), reminder functions (35, 36, 41, 46, 48, 51, 55, 61, 63, 68) and as a symptom-tracking tool (39, 41).

Despite the progress in the use of mobile applications, there is a range of challenges caused by various factors, including the lack of RCTs and a small sample size (31, 33, 36, 46, 49, 67, 70). A relatively heterogeneous ratio of different age categories of patients (47) and a short follow-up period (22, 64) dictate the research in this direction and optimization of the study design. Moreover, statistically significant effectiveness of mobile applications was not found out and requires further intensive studies (50, 56).

4.2. Risk of Bias Assessment

The evaluation of risk of bias for all 39 studies was conducted using the Cochrane Collaboration Risk of Bias tool (Figure 2).

As for random sequence generation, only 2 studies identified the unclear risk of bias (53,64), and 15 studies identified the low risk of bias (24, 32, 35, 42, 44, 48, 49, 51, 56, 58, 59, 61, 62, 67, 68). Results of allocation concealment bias (selection bias) showed that, only 9 studies revealed low risk of bias (24, 32, 44, 47, 49, 58, 62, 67, 68) and 4 studies was assessed as having a unclear risk of bias (46, 48, 60, 64). According to the binding of participants and personnel, in general, high risk of bias was detected in many studies, and only 4 studies revealed low risk of bias (31, 49, 67, 58) and 4 studies demonstrated unclear risk of bias (44, 47, 50, 60). In terms of blinding of outcome assessment, in total, in the 19 papers included in this review was identified with low risk of bias (31, 32, 34, 35, 40, 42, 43, 45, 49, 53, 57, 60, 63, 51, 52, 59, 62, 65, 67) and in 10 studies was detected unclear risk of bias (24, 33, 36, 37, 46, 47, 48, 50, 58, 70). According to the indicator of incomplete outcome data, low risk of bias was detected in 23 studies (31, 32, 34, 35, 40, 42, 43, 45, 46, 50, 51, 52, 53, 55, 59, 60, 61, 62, 63, 64, 65, 67, 68) and in 9 studies was determined unclear risk of bias (24, 37, 38, 39, 56, 57, 58, 66, 70).

According to the indicator of selective reporting , 10 studies

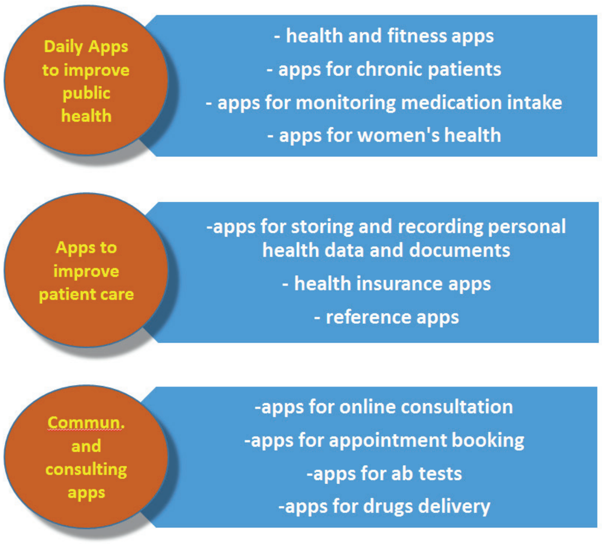

Figure 3. Mobile applications for healthcare system

were with the characteristics of the unclear risk of bias (24, 37, 38, 39, 46, 57, 58, 66, 67, 70) and only 9 works had low risk of bias (32, 34, 35, 40, 45, 47, 52, 58, 63).

In general, it should be noted that most of the studies included in the analysis (37 out of 39 studies) on many points of assessment were found to be of poor quality, and only 2 studies (58, 67) were assessed as satisfactory.

5. DISCUSSION

It has been shown that health digital platforms can help to improve physical activity, healthy eating, and socialization (71-74). Moreover, mHealth applications demonstrated an effectiveness to treat various behavioral outcomes such as an adherence to the treatment (75-79). However, health apps were not able to effectively reduce harmful behavioral factors, including smoking, alcohol consumption, unhealthy diet, and improve clinical indicators (BMI, level of triglycerides, diastolic and systolic blood pressure, and HbA 1c).

The main trend in the mobile health for cardiological applications is the use of different types of wearable devices and Artificial Intelligence-platforms (AI) (80-86). In fact, mobile technology allows remotely to monitor, interpret, and analyze biomedical data collected from the patient (87). Up to date, the classical approach for the diagnostics and prevention of heart pathology is based on the thorough analysis of patient's medical history, physical examination, laboratory and imaging data (87). The recent advances in digital health provides an opportunity to fasten and optimize heart diagnostics via effective analysis of massive data obtained from electrocardiography, echocardiography, patients' electronic health record data, and laboratory tests. It encompasses the use of AI-platforms to monitor and analyze cardiac activity in real-time manner (88).

Apart from AI technologies, there is a number of studies on the application of different wearable devices and smart clothes in cardiology. Such technologies allow to monitor the vital parameters of cardiovascular system such as blood pressure, heart rate and ECG (89-91). In this regard, mobile applications can be classified into several categories, such as daily applications for improving public health, applications for improving patient care, and applications for communication and counseling (Figure 3).

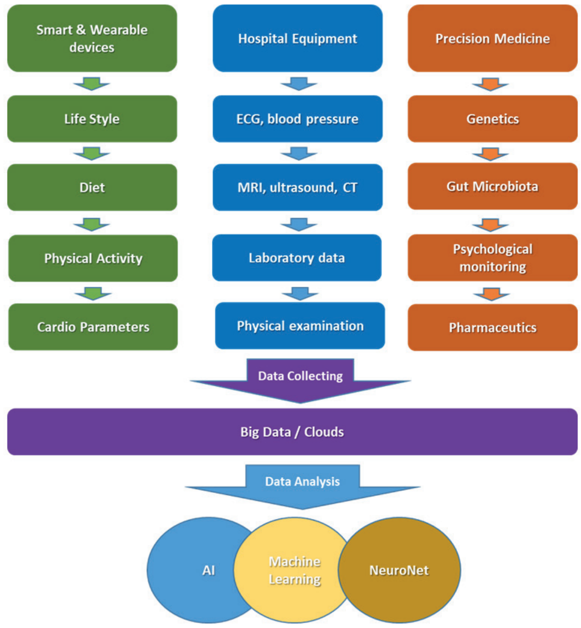

Figure 4. Stages of the development of a mobile application in healthcare system

Daily apps for improving public health can be divided into health and fitness apps, apps for chronic patients, apps for monitoring medication intake, and apps for women's health. Applications for improving patient care include: applications for storing and recording personal medical data and documents, applications for health insurance, and reference applications. Communicating and consulting apps consist on apps for online consultation, apps for appointment booking, apps for appointment booking, apps for ab tests and apps for drugs delivery.

Over the past decade, several studies have been published on mHealth treatment for heart failure (83, 92-97). Most of published systematic reviews have mainly been focused on the effects of telephone support and traditional telehealth interventions using fixed-line technologies such as home tele-monitoring and video conferencing. Other systematic reviews highlighted findings of studies on the mHealth based on other types of remote patient monitoring interventions or invasive technologies to distort the true impact of digital platforms.

One of main public concerns and barriers for a wide implementation of mHealth in monitoring patients is the safety and data protection (87). In fact, many medical apps possess some security vulnerabilities or a weak encryption (98-101). In this regard, the employing of block-chain technology can help to protect the sensitive information via decentralized storage of patients' data (102-104). This problem has been aggravated by the absence of universal and standard ethical regulations of health data protection (2).

The combining of all information about the patient's health condition from smart and wearable devices, hospital equipment (radiography, ECG, etc.) and laboratory data can help to optimize the analysis of health status and treatment strategies (Figure 4). For example, collecting information via smart and wearable devices is a way for daily monitoring of life style, diet, physical activity and cardio parameters which can facilitate control of patient's health condition. In terms of hospital equipment, as it known that, there is a possibility to gather a data such as ECG, blood pressure measurement, MRI, ultrasound, CT, laboratory data, and physical examination. As for precision medicine, it is a way to obtain the information about genetics, gut microbiota, psychological monitoring and treatment. Finally, the application of artificial intelligence, machine learning and neuro net for the analysis of health data will provide an opportunity for improving the life quality, diagnostics and treatment of various disorders.

Despite the recent progress, there are still many unresolved issues for the wide implementation of health mobile applications. One of the main problems is the age of the patients. It includes the difficulty of using a smartphone by elderly people (105). It should be noted that the age-related disparities are a temporary barrier. In fact, young cohort of patients will also become elderly after a certain period of time. So, some of youngsters will join the group of patients with chronic diseases. Aside from that, there is a problem related to the privacy and security of mHealth data (106). The situation can be improved by employing a protection system used for Internet banking, such as two-factor authentication or biometric platforms (107). Other problems related to digital health technologies include, but are not limited to, reliability, safety, productivity, and ethical issues.

At present, there is a range of mobile health applications recommended by WHO (108). For example, there are applications for detecting hearing loss "hearWHO" (109), guidelines for HIV testing (110), quit the smoking app (111), and fitness/yoga instructions (112). However, the absence of official recommendations for mobile apps given by official state institutions and WHO (for therapy adherence improvement and cardiac rehabilitation) hinders their wide implementation in the clinical environment.

6. CONCLUSION

The application of mobile technologies for health practice led to the significant improvement of early diagnostic and timely treatment of life-threating conditions such as cardiac arrest (113-118). In fact, early cardiopulmonary resuscitation and defibrillation using digital technologies could help safe many lives. Mobile health apps can fasten and optimize the medical assistance for the patients with cardiac arrest in pre-hospitalization stages (114, 119-122).

In addition, it has been shown that digital health platforms can be effectively employed to assist the patients with other cardiologic pathologies such as arrhythmias and atrial fibrillation (123-126). The results of a number of the studies demonstrated that patients diagnosed with cardiovascular disorders can potentially benefit from the application of mHealth in cardiology. It encompasses the improvement of clinical outcomes such as decreased infarct size, smaller reductions in ejection fractions, lower peak troponin and creatine-phosphokinase, and reduced mortality (127).

However, despite the proven advantages of mHealth for cardiology, there are many challenges and concerns regarding effectiveness, safety, reliability and ethical issues. Another big issue is the lack of official regulation and guidelines from official organizations. It concerns data privacy, standardization and unification of digital protocols. Such issues require solutions and further work towards a wide implementation of mHealth technologies in cardiac practice.

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Supplementary file
Appendix 1. Search strategies

For PubMed

#1	"mobile application*"[Text Word] OR "mHealth"[Text Word] OR "m-health"[Text Word] OR "mobile health"[Text Word] OR "mobile device*"[Text Word] OR "mobile app"[Text Word] OR "mobile apps"[Text Word] OR "smartphone"[Text Word] OR "mobile phone"[Text Word] OR "tablet*"[Text Word]	108,714
#2	cText Word] OR "cardiovascular diseas*"[Text Word] OR "heart failur*"[Text Word] OR "ischemic heart diseas*"[Text Word] OR "acute coronary syndrom*"[Text Word] OR "myocardial infarction"[Text Word] OR "cardiac rehabilitation"[Text Word] OR "hypertension"[Text Word]	1,237,030
#3	(#1) AND (#2)	5,030
#4	(#1) AND (#2) Filters: Clinical Study	1,442
#5	(#1) AND (#2) Filters: Clinical Study, Clinical Trial	1,442
#6	(#1) AND (#2) Filters: Clinical Study, Clinical Trial, Randomized Controlled Trial	1,442
#7	(#1) AND (#2) Filters: Clinical Study, Clinical Trial, Randomized Controlled Trial, English	1,283
#8	(#1) AND (#2) Filters: Clinical Study, Clinical Trial, Randomized Controlled Trial, English, Humans	1,274
#9	(#1) AND (#2) Filters: Clinical Study, Clinical Trial, Randomized Controlled Trial, Humans, English, from 2008 - 2022	725

For Scopus

TITLE-ABS-KEY ("Mobile application*" OR mhealth OR m-health OR "mobile health" OR "mobile device*" OR "mobile app" OR "mobile apps" OR smartphone OR "mobile phone" OR "tablet*") AND TITLE-ABS-KEY (cardiolog* OR "cardiovascular diseas*" OR "heart failur*" OR "ischemic heart diseas*" OR "acute coronary syndrom*" OR "myocardial infarction" OR "cardiac rehabilitation" OR "hypertension") AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "MEDI")) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008)) AND (LIMIT-TO (LANGUAGE , "English"))	3,062

For Web of Science

#1	TS=("Mobile application*" OR mHealth OR m-health OR "mobile health" OR "mobile device*" OR "mobile app" OR "mobile apps" OR smartphone OR "mobile phone" OR "tablet*")	214 383
#2	TS=(Cardiolog* OR "cardiovascular diseas*" OR "heart failur*" OR "ischemic heart diseas*" OR "acute coronary syndrom*" OR "myocardial infarction" OR "cardiac rehabilitation" OR "hypertension")	1 218 510
#3	#1 AND #2	4 808
#4	#1 AND #2 and 2022 or 2021 or 2020 or 2019 or 2018 or 2016 or 2017 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 (Publication Years)	3 958
#5	#1 AND #2 and 2022 or 2021 or 2020 or 2019 or 2018 or 2016 or 2017 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 (Publication Years) and Articles (Document Types)	2 927
#6	#1 AND #2 and 2022 or 2021 or 2020 or 2019 or 2018 or 2016 or 2017 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 (Publication Years) and Articles (Document Types) and English (Languages)	2 857

For Cochrane Library

#1	MeSH descriptor: [Mobile Applications] this term only	977
#2	"mHealth"	1944
#3	"m-health"	6853
#4	"mobile health"	1607
#5	"mobile device"	396
#6	"mobile app"	1032
#7	"mobile apps"	211
#8	"smartphone"	5005
#9	"mobile phone"	3206
#10	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9	15631
#11	MeSH descriptor: [Cardiology] explode all trees	128
#12	"cardiovascular disease"	24833
#13	"heart failure"	33237
#14	"ischemic heart disease"	6936
#15	"acute coronary syndrome"	6954
#16	"myocardial infarction"	33549
#17	"cardiac rehabilitation"	2730
#18	"hypertension"	69145
#19	#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18	146587
#20	#10 AND #19	2726
#21	#10 AND #19 (Filter: custom data range)	1559
#22	#10 AND #19 (Filter: custom data range; only clinical trials)	1014

For Google Scholar

"mobile application"OR "mHealth"OR "m-health"OR "mobile health"OR "mobile device"OR "mobile app" OR "mobile apps" OR "smart-phone"OR "mobile phone"OR "tablet*" AND "cardiology"OR "cardiovascular disease" OR "heart failure" OR "ischemic heart disease" OR "acute coronary syndrome" OR "myocardial infarction" OR "cardiac rehabilitation" OR "hypertension"	17600