

# Quick response code applications in medical and cardiology settings: a systematic scoping review

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## Aims

To review published literature on the use of quick response (QR) codes within medical and cardiology settings.

## Methods and Results

Medline, Scopus Search, and Cochrane Library were used to conduct the research. Title and abstract review of 376 publications were performed. Papers that discussed the application of QR codes in medical setting were included. A total of 151 articles were reviewed and thematic analysis conducted to understand how QR codes are currently used in the medical setting, the medical areas in which they are mostly used, their applications in the cardiovascular area. The analysis of 151 articles revealed that QR code technology is mainly used in the medical field to: (i) collect data via survey, (ii) educate medical staff or students, and (iii) provide information about therapies or surgery. The medical area in which QR codes are most used is the clinical one, but only 3.3% of publications concern cardiovascular settings. A third of the QR code-related articles of 2020 is about Covid-19.

## Conclusions

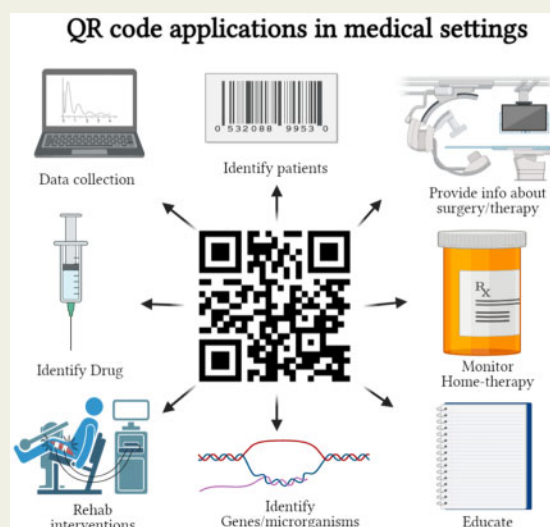
Different uses of QR codes in a medical setting are increasing. Quick response codes might represent an easy and convenient digital tool to collect data and implement telemedicine programs on a large scale involving also the cardiovascular setting.

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## Graphical Abstract



## Keywords

QR code • Telemedicine • Survey • COVID-19 • Scoping review

Quick response (QR) code is a two-dimensional barcode that can be read by the camera of smartphones or tablets to connect instantly to simple texts or websites, including surveys and multimedia contents. Quick response codes can be easily and instantly created online from a range of free websites. The increased availability of smartphones with cameras has led to QR codes being applied to a wide range of commercial applications including logistics, marketing, ticket management, and social media.<sup>1</sup>

Even if it might prove very useful in clinical practice, QR code technology is not yet widespread in the medical world. Nevertheless, it is gaining attention and several uses and applications have been proposed. Consequently, we decided to conduct a systematic review with the aim of addressing three questions: (i) How are QR codes currently being used in the medical field?; (ii) Which are the medical areas where they are used the most?; (iii) What are their applications in the cardiovascular area?

This systematic review was conducted following the PRISMA extension for scoping reviews checklist and explanation.<sup>2</sup> Databases used for the search were MEDLINE, Scopus Search, and Cochrane Library. The research took into consideration studies published in English since January 2011 until 15th of December 2020. The decision to focus on the articles published in the last decade was justified by the fact that QR code technology, despite being developed in 1994, has spread in medical settings only in recent years. The following keywords were used: 'QR code' OR 'QR codes' OR ['Quick Response' AND ('code' OR 'codes')]. A total of 462 records were obtained and 87 duplicates were identified and removed using the software Mendeley Desktop (Mendeley Ltd., London, UK). The PRISMA flowchart used to show the search strategy and subsequent study selection process is illustrated in [Figure 1](#).

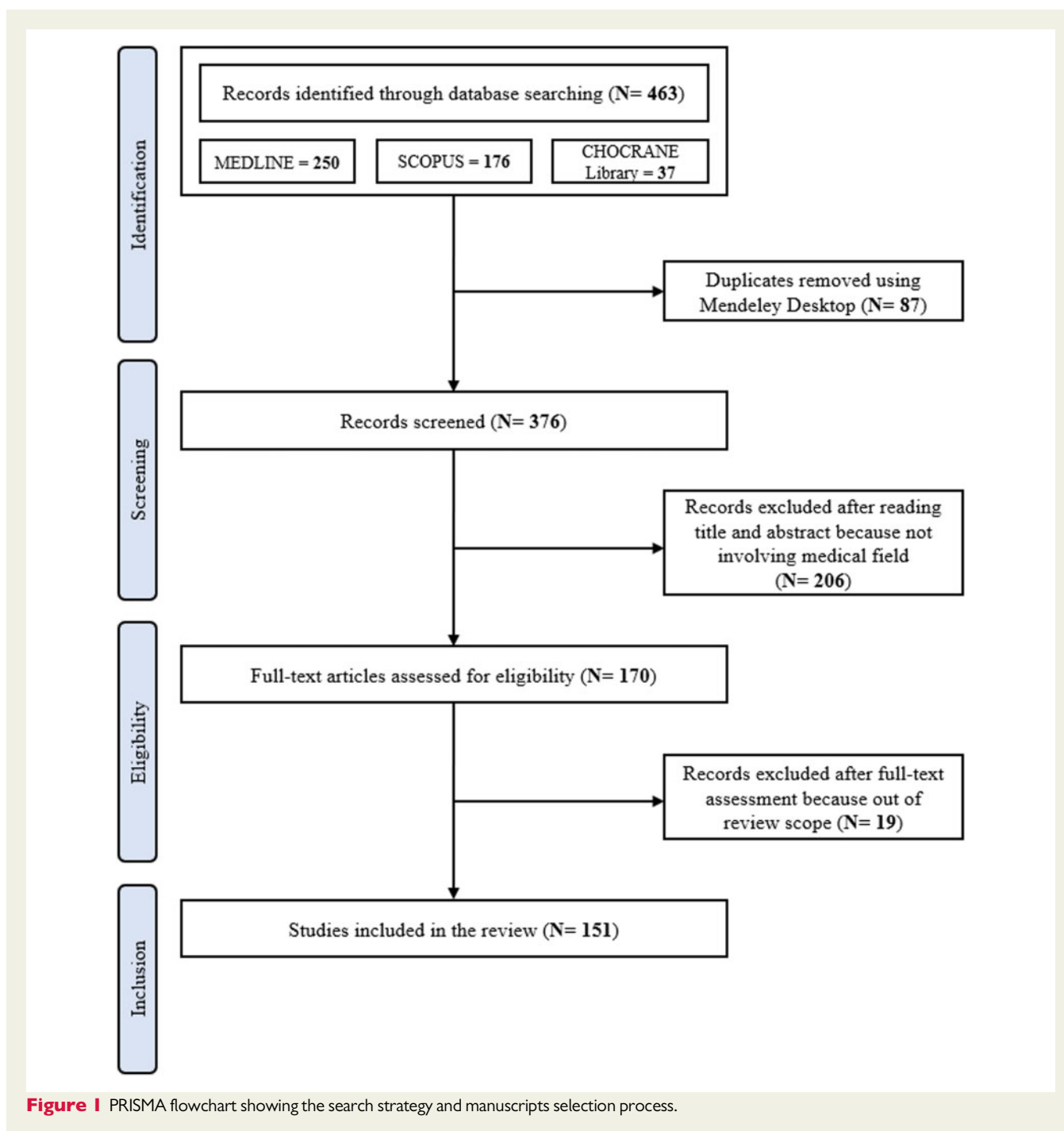
Consequently, a total of 151 articles published between 2011 and 2020 were included in this review. Article types included research articles, reviews/editorials, clinical trials, and reports/communications. A summary of the articles' characteristics is shown in [Table 1](#).

In about one-third of the included studies, QR codes were used to deliver electronic surveys for data collection. Interestingly, in the last years, QR codes have been frequently used to conduct clinical trials and 19 of these trials are currently on-going. The main applications of QR codes in the medical field are illustrated in [Figure 2A](#). The medical areas in which QR codes are used are shown in [Figure 2B](#).

The research highlighted how the medical setting in which QR codes are adopted with the highest frequency is the non-cardiological clinical area (42.4%). [Figure 3](#) illustrates precisely which are the clinical area disciplines in which the QR code is adopted. As can be seen from [Figure 3](#), 60% of applications in the clinical setting are equally divided between three disciplines: community medicine, internal medicine, and infectiology. A possible explanation of why rural (community) medicine is so 'virtuous' in using QR codes is because it can exploit them to carry out an easy and cheap monitoring of home therapy. Instead, the main purpose for which QR code technology is used in internal medicine is to provide information about diseases and possible therapies/treatments. Finally, we hypothesize that such frequent use of QR codes in infectious diseases can be attributable to the wide use that is being made of them during the Covid-19 Era (see below in the manuscript).

The use of QR codes in medicine could represent an important digital-health innovation that might change both clinical research and daily clinical practice.

Currently, physicians take advantage of several digital tools to collect data and provide information, advice, or communication to



patients. Even if several digital apps are available to download for tablets or smartphones to support clinical activities; this requires people to remember the name of the app and to be familiar with using the app store and digital technologies. Anyway, these limitations can be overcome by machine-readable codes. Although different machine-readable codes exist (e.g. barcodes), QR codes seem to be more appropriate for health care settings as people can use them without having to download specific scanning apps or having to purchase a barcode scanner. Therefore, QR codes represent a novel, easy-to-use, free, and widely applicable technology but more data are needed to demonstrate their superiority over other digital tools.

The results of our literature search show that the most frequent medical use of QR codes is for data collection. This is achieved by creating electronic surveys, i.e., online questionnaires associated with a link convertible into a QR code. Quick access to the online survey is granted to the user by scanning the QR code with a smart device, and the answers are automatically and real-time collected in a dataset, thus limiting the human compilation error. Implementing QR code access to electronic surveys maximizes the scalability, reliability, and speed of data collection while reducing costs.

Another interesting QR code technology application is to provide useful and always-available information to patients regarding

**Table 1** Summary of article characteristics

	N (total = 151)	%
Publication year		
2011	2	1.3
2012	4	2.6
2013	9	6.0
2014	5	3.3
2015	8	5.3
2016	19	12.6
2017	10	6.6
2018	17	11.3
2019	22	14.6
2020	55	36.4
Articles type		
Research articles	75	49.7
Reviews/Editorials	25	16.6
Clinical Trials	28	18.5
Reports/Communications	23	15.2
QR code surveys		
Yes	47	31.1
No	104	68.9
Covid 19-related articles		
Yes	18	11.9
No	133	88.1
Cardiovascular articles		
Yes	5	3.3
No	146	96.7

therapies or surgeries. For example, Gough *et al.*<sup>3</sup> explored the use of QR codes in orthopaedics by designing and applying a waterproof information sticker (containing a QR code linked to multimedia info) to all synthetic casts fitted in their fracture clinic. Similarly, QR codes are used to identify patients in clinical practice. Indeed, a surgical prospective study of Dixon *et al.*<sup>4</sup> showed that the use of QR codes in the operating rooms reliably provides patient information during the procedure improving accuracy, compliance to surgery protocols, and outcomes. Additionally, as it improves the learning experience and students' intrinsic motivation, QR code technology is widely used to educate medical staff and students.<sup>1</sup>

Quick response code might also be a solution to improve medication adherence in complex patients, such as cardiovascular ones. An Italian study (published after the date of our literature search) evaluated the feasibility of an adherence home-monitoring system in elderly patients with heart diseases. This system allowed to send immediate digital feedback regarding medication intake just by reading a QR code attached on the pills box. The investigators found that this QR code-based tool is highly feasible for this category of patients, suggesting its potential large-scale clinical application.<sup>5</sup>

Furthermore, QR code technology might be implemented for cardiovascular screening strategies in patients with risk factors. For example, in the 'AF SELF SMART study',<sup>6</sup> a QR code tool will be used to screen the population and identify silent atrial fibrillation. This self-

screening will involve performing a lead-1 electrocardiogram (ECG) in the general practitioner waiting room, creating an individualized QR code linked to the ECG trace, and sending it directly into the patients' electronic medical record.

As shown in *Table 1*, a significative increase in the use of QR codes in clinical setting occurred in 2020, the year interested in the COVID-19 outbreak. In fact, our review showed that approximately 33% of QR codes-articles published in 2020 adopted this technology for COVID-19 purposes. Possible roles and interesting applications of QR codes electronic surveys in COVID-19 era have been recently proposed.<sup>7</sup> In a period when it is essential to enhance telemedicine and remote-reporting services, QR codes could represent an innovative and safe technological tool, suitable for remote management of different patients categories, including cardiological ones.

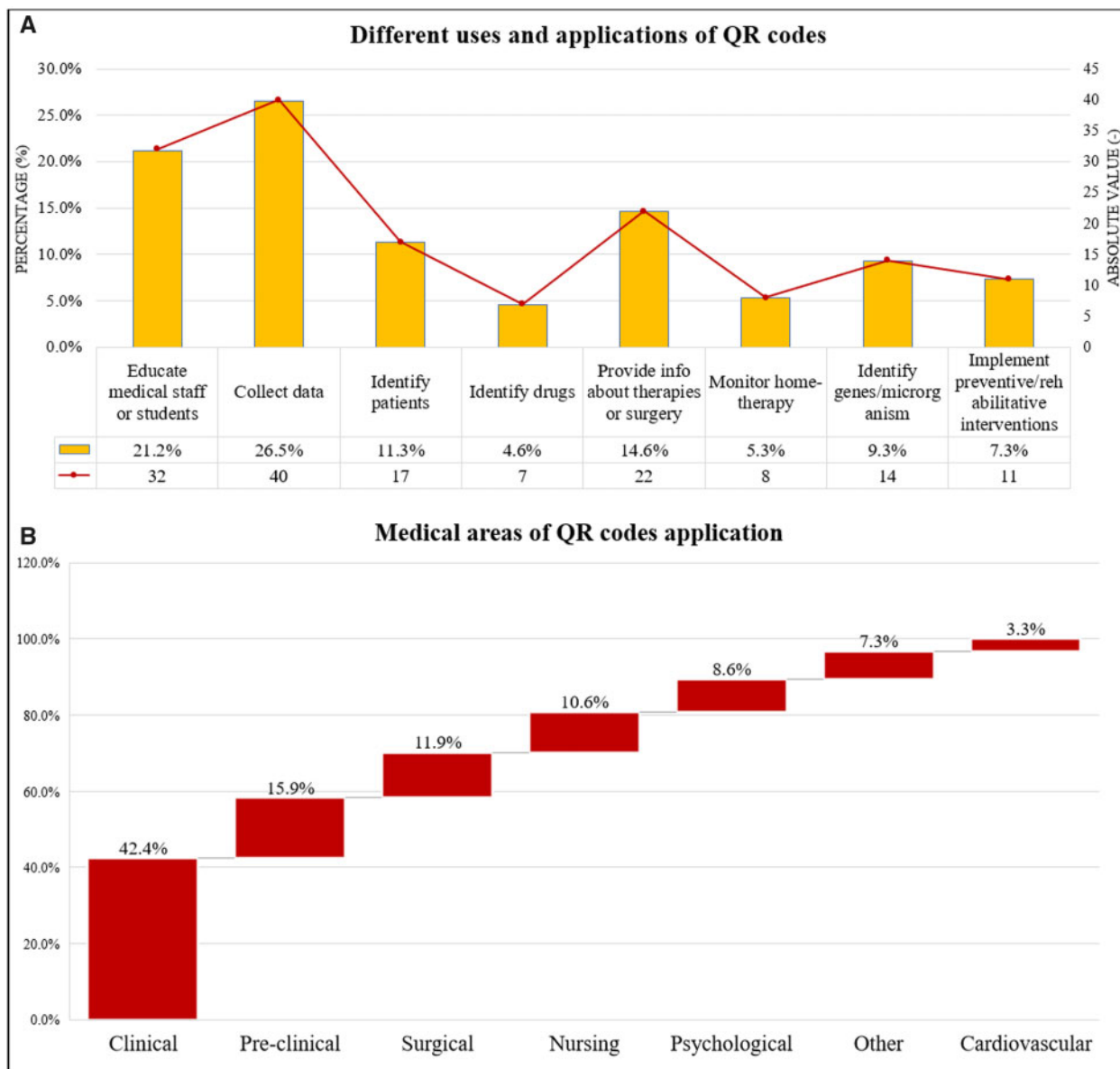
As regard to cardiovascular diseases setting, currently, only five scientific articles are present in the literature (after our search two other studies, mentioned above, have been published<sup>5,6</sup>). In this setting, two randomized clinical trials used QR codes.<sup>8,9</sup>

The first one was a prospective controlled clinical trial including 335 patients undergoing coronary angiography.<sup>8</sup> The aim of the study was to investigate the effect of a QR code-based video education program on anxiety, instructions adherence, and patient satisfaction. In particular, the day before coronary angiography, patients in the experimental group had free and unlimited access to an educational video on their smartphones by scanning a QR code, while patients in the control group watched the same video on a tablet once only. The results showed that anxiety significantly improved in the experimental group, both pre- and post-procedure. Furthermore, individuals in the experimental group showed better adherence to instructions on removing dentures/jewellery, and better compliance in taking medicines, water consumption, and diet before and after the procedure.

WECHAT study is an on-going multicentre, single-blind, randomized controlled trial, which aims to explore the effect of social media on dual antiplatelet therapy (DAPT) adherence following drug-eluting stent (DES) implantation.<sup>9</sup> It is recruiting 760 patients with DES requiring 12 months of DAPT. Whereas the intervention group is receiving a QR code-personalized intervention (educational messages, interactive responses, medication, and follow-up reminders), the control group will only receive usual care and general educational messages provided by cardiologist. The primary endpoint will be the discontinuation rate of any dual antiplatelet drug within 1 year of DES implantation, while the secondary endpoint will include medication adherence and MACEs.

Considering the positive results obtained using QR codes in different medical areas, it could be useful to apply this tool on a larger scale, including cardiovascular diseases. In fact, cardiological patients are frequently affected by multiple chronic diseases and need a poly-pharmacological therapy; therefore, adherence is essential in the management of these complicated patients. In this context, QR codes can represent an easy digital way to increase patient's compliance, to encourage the monitoring of vital parameters and also to improve patient's follow-up, ensuring a strengthening of telemedicine programs and a facilitation to access healthcare services.

**Conflict of interest:** none declared.



**Figure 2** (A) The main uses and applications of quick response codes in medical field are shown. (B) The medical areas in which quick response codes are used are illustrated.

## Lead author biography



Andrea Faggiano was born in Brescia, Italy on 23 December 1995. He studied Medicine and Surgery at ‘Statale’ University of Milan where he completed his Master’s degree in 2020. Since January 2021, he is a Cardiology fellow at Fondazione IRCCS Ca’ Granda Ospedale Maggiore Policlinico, Milan (Italy), in the Cardiology Department led by Professor Stefano Carugo. His main

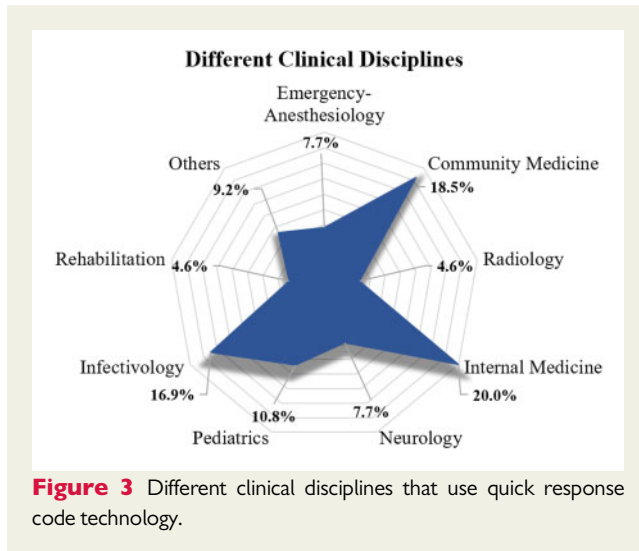
fields of interest are heart failure, echocardiography, and cardiovascular prevention.

### Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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