



Use of QR and EAN-13 codes by older patients taking multiple medications for a safer use of medication

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ABSTRACT

Background: Older persons following a prolonged complex drug regimen often make mistakes when taking their medication. Currently, the widespread use of tablets and smartphones has encouraged the development of applications to support self-management of medication.

Objective: The aim of this study was to design, develop and assess an app that transforms medication-associated ean-13 (barcodes) and Quick Response codes (QR) into verbal instructions, to enable safer use of medication by the elderly patients taking multiple medications.

Methods: Meetings were held in which participated a total of 61 patients.

Results: The results showed that patients appreciated the application and found it useful for safer use of medicines.

Conclusions: The study results support the use of such technology to increase patient safety taking multiple medications safety.

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1. Introduction

Older persons following a prolonged complex drug regimen often make mistakes when taking their medication [1–4]. These mistakes usually involve confusions in the drugs themselves or their correct dose or else forgetting to take a drug, any of which may sometimes have severe consequences [5]. These

patients usually have tricks to help them with the correct use of their medication; for example, using pill boxes, associating a drug with their meals, or making a note on the drug box of the dose and therapeutic indication in order to avoid these omissions or confusions [4,6,7].

The growth in the sales of tablet computers and smartphones has favoured the development of applications to help people remember to take their medication [8–15]. These

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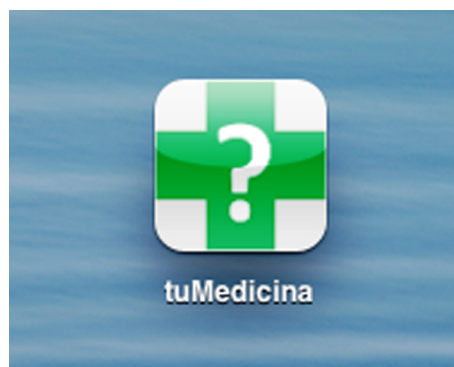


Fig. 1 – TUMEDICINA app.

pill-box like applications can be adapted to the individual preferences, therapeutic regimen, dosage and lifestyle of the patient. They help with the self-medication of drugs regularly taken by independently living patients. An alternative method involves ean-13 (barcodes) and more recently QR (Quick Response codes), which are now also becoming more common in the healthcare setting, though with more applications available for the professional as opposed to the patient [16,17], with the latter mainly aimed at improving patient safety [18].

We here report on the development and evaluation of an application that transforms medication-associated ean-13 and QR codes into verbal instructions, to enable safer use of medication by the patient.

2. Methods

2.1. The description of the app

The application, named in Spanish TUMEDICINA (YourMedicine) (Fig. 1), has been developed for smartphones and tablet computers using both Android and iOS considering the chronically ill patients information collected in previously study [15] for a safety medication use.

TUMEDICINA captures the ean-13 or the QR from the packaging of the medication and converts it into spoken instructions. These instructions include the therapeutic aim of the drug, the dosage, expiry date, information about possible interactions with other drugs, as well as other useful information such as the instruction of the physician or method of storage. The information can be personalized according to the needs of the particular patient. The application was designed bearing mind any of the following three situations (Fig. 2):

a. The safe use of prescription drugs that need to be taken regularly and that are not individually packaged. This is a common situation in countries like Spain, where the drugs are provided in containers containing a set number (for example, 7 or 30), rather than the number needed by the patient. This therefore poses a risk for patient safety as after a few weeks or months confusion may arise about the aim or dosage of a drug;

b. The administration of drugs by caregivers, who often change depending on the time of day or over short periods of time, as for example an older person cared for by two relatives (son or daughter);

c. The safe use of drugs for patients with memory problems who might forget or confuse the drugs to be taken or some other aspect of their treatment.

The app TUMEDICINA was designed to be capable of storing information about a certain medicine (e.g. purpose of the medicine, daily dose, possible adverse effects, main cautions, expiration, etc.). The users should be able to access such data just by showing the medicine box to their smartphones or tablets, and the app should give the information via voice. Other requirements include:

- There must be two different app areas: the caretaker area where the information about the medicines is introduced; and the patient area, where patients access such data.
- The app must have a friendly user interface, particularly for the patient area (elderly patients will be the most common users).
- The access from patient area to caretaker area must be hidden (or password protected), so that patients never leave their area accidentally.

This app is capable of scanning the code of the medicine boxes, using the tablet or smartphone camera. The information about the medicine is structured in the following fields:

- What is it for?
- When should I take it?
- How should I take it?
- Cautions.
- Next physician visit.
- Expiration.

Such information is stored as audio recordings. There must be a caretaker responsible of carrying out the recordings (e.g. a relative of the patient, a physician, etc.).

A novel, more user friendly, approach for codes scanning has been adopted in the app:

- The standard procedure, found in most apps, must be used with the rear camera of a smartphone or tablet. The user holds the device with one hand and points at the code present in the medicine box (which the user must hold with his/her other hand). Such procedure is not easy to accomplish for elderly users, particularly if their device is a tablet, which is difficult to hold with only one hand.
- Our procedure, valid for tablets and smartphones with front camera, is easier to use. The phone or tablet is placed over a table, and the user just has to pass the medicine box over it; pretty much like cashiers in supermarkets do.

Fig. 3 shows both approaches in action.

Under certain circumstances, it has been necessary to add stickers with our own printed QR to the medicine boxes. First, when the medicines were bought through the Spanish Social

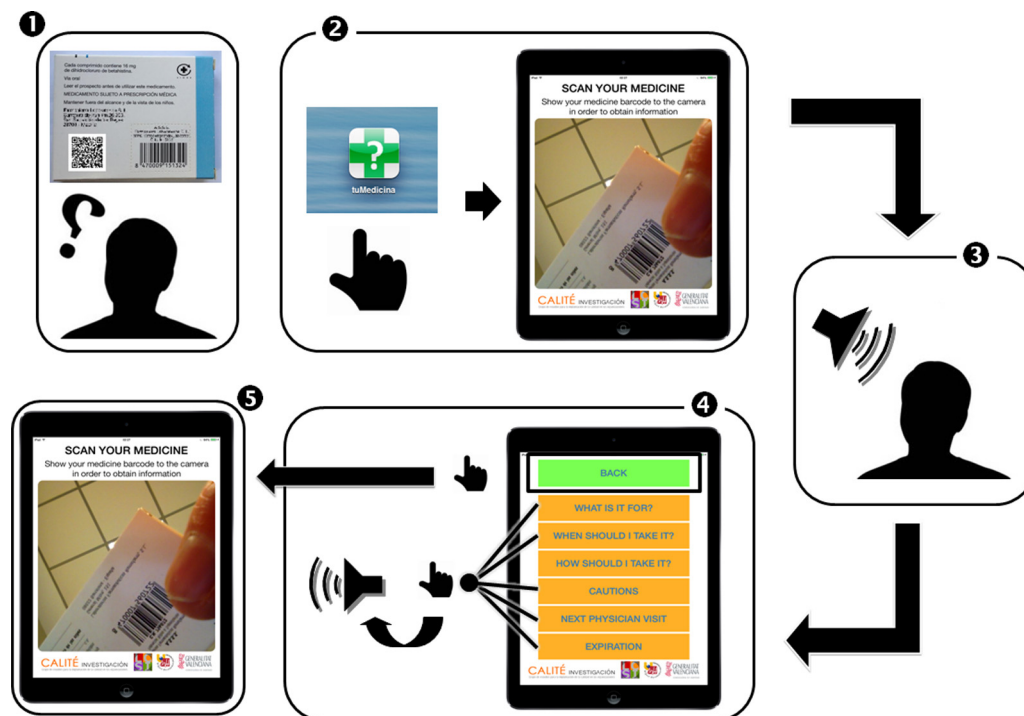


Fig. 2 – TUMEDICINA sequence using.

Security Service; because the barcodes are removed when medicines are acquired. Second, when the camera resolution of the device (smartphone or tablet) is low, because small QR codes may be difficult to identify.

The using app is simple. As soon as the app is started, it begins a code search. Once a correct code is detected, the app enters the patient area and allows the patient to hear the different data fields associated with the medicine. A secret gesture (in our case, a diagonal swipe across the tablet's touch-screen) allows us to leave the patient area and enter the caretaker area, where all data associated with a medicine can be introduced or modified. The caretaker can also check the current recordings.

Whenever the return button is tapped (within the patient area or within the caretaker area), the app starts searching for barcodes or QR codes again.

This behaviour can be represented by the flowchart shown in Fig. 4; where patient and caretaker areas can be clearly identified. Figs. 5 and 6 show screenshots of the patient area and the caretaker area respectively.

2.2. App patient assessment

We undertook an observational study to evaluate the suitability, relevance and effectiveness in the opinion of older patients taking multiple medications of a computerized application



Fig. 3 – Two different scanning approaches (rear camera versus front camera).

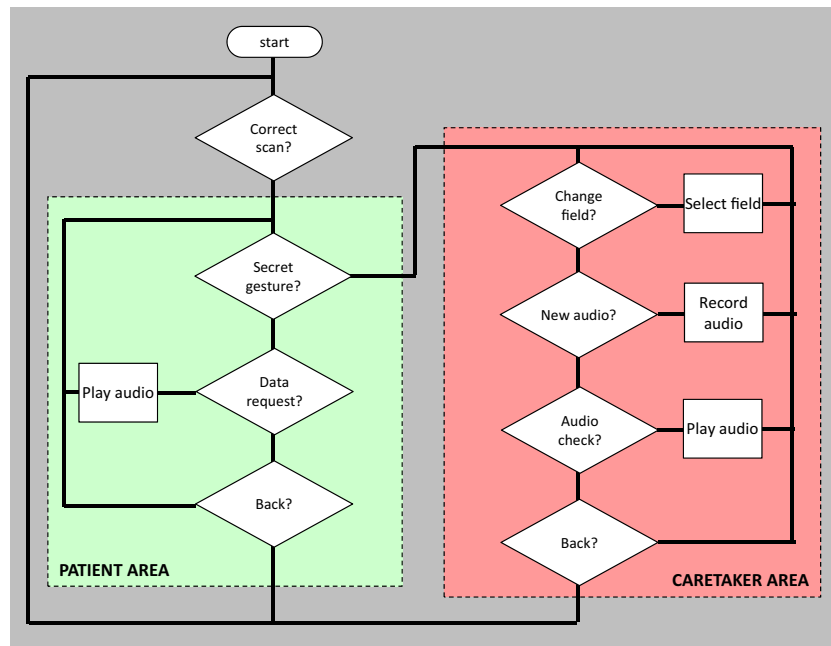


Fig. 4 – Application flowchart.

that converted ean-13 codes and QR into verbal instructions for the safe use of medicines.

A total of 7 group visits with older patients taking multiple medications were conducted. For this evaluation study a convenience sample of patients was recruited from 2 health centres and associations of diabetic patients from Alicante, Elche and Elda. All the patients participated voluntarily. Exclusion criteria were: patients who had made an official complaint or filed a civil responsibility claim during the previous 3 months; and patients who had neurological or psychiatric disorders that prevented them from answering the

questions. Also excluded were patients who lived in health-care centres or old-age homes. No information was coded that could lead to patient identification. The study was approved by the Ethics Committee of Miguel Hernández University (reference DPS-JJM-01-13).

The patients participated in a session showing how the application worked, both for the recording of verbal instructions and the reading of the ean-13 or QR code using a smartphone or tablet and the automatic transformation into spoken instructions, held between November and December 2013. A person who did not participate in the app design

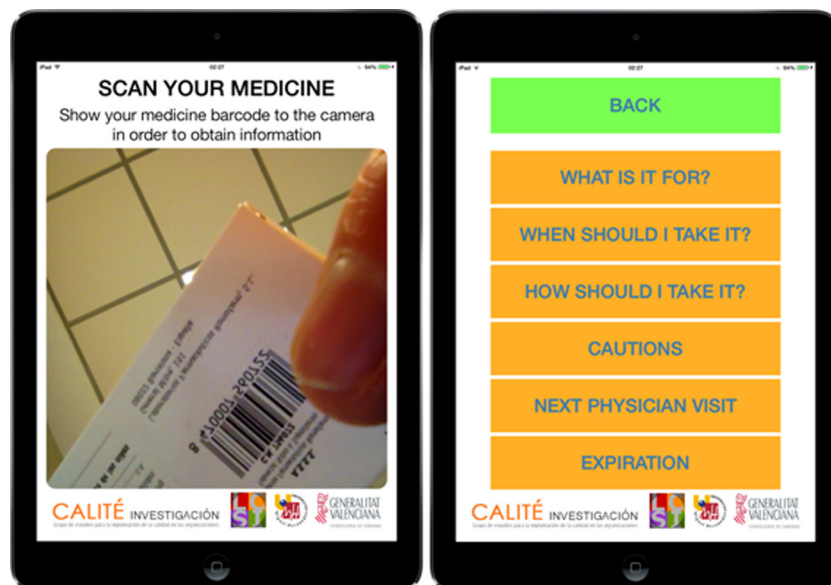


Fig. 5 – Screenshots of the patient area.

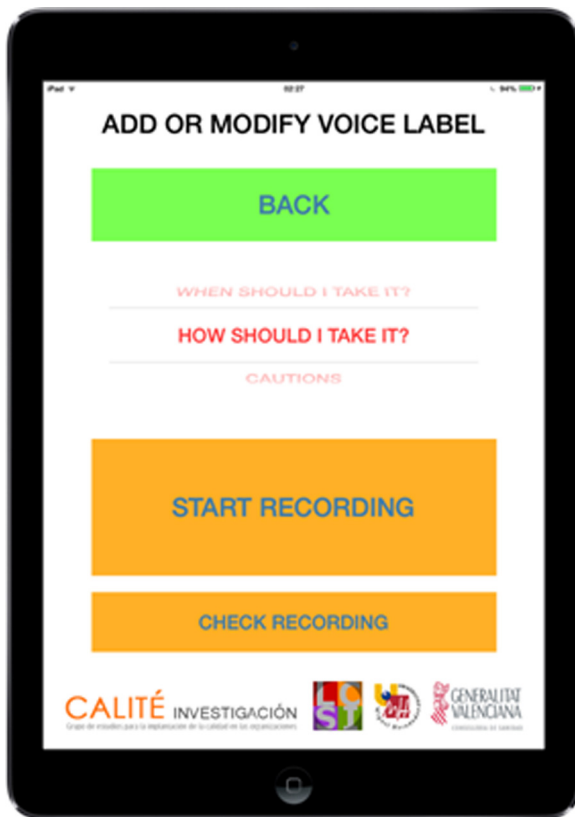


Fig. 6 – Screenshot of the caretaker area.

conducted this presentation. The patients were then able to use TUMEDICINA individually, using each of its characteristics. They were able to give their opinion individually at first and then in a group session about the features and functioning of the application. Prior to starting the study the participants answered a questionnaire about errors using medication in their homes [19]. This questionnaire is provided as supplementary material (Appendix 1). A second questionnaire was used to obtain the patients' perceptions using the App. This questionnaire is provided as supplementary material (Appendix 2).

The following variables were recorded: having an adverse event during the previous year related with medication, medication errors in the previous year, and therapeutic compliance; evaluation of the efficacy and usefulness of the tool: advantages and disadvantages; perception of the degree of autonomy and self-efficacy provided by its use; ease of use, reliability and overall satisfaction with the tool. Strengths and weaknesses of the tool were considered in order to adapt it to make it more convenient and reliable. Other independent variables considered were: gender, age, who the patient lived with, number of disorders the patient has, medication errors (during the previous year, in an attempt to increase the reliability), number of drugs taken and whether they were prescribed by one or more physicians, plan currently used to prevent mistakes, e.g., pill boxes or notes on the packaging. Statistical analyses included descriptive tests, Chi-Square to compare assessments between patients with or without experience with cell phones, smartphones or surfing on the Net,

and stepwise linear regression analyses, considering the overall satisfaction with TUMEDICINA as the dependent variable and the above-mentioned factors as independent variables (patients using pillboxes; writing on the packaging and number of drug taken every day).

3. Results

A total of 61 patients answered all the questions. Their mean age was 68.8 years (SD 8.3) and 24 (39.3%) were older than 70 years; 38 (62.3%) were men. The proportion of men older than 70 years of age was similar to that of women ($p=0.98$). Only 6 (9.8%) patients lived alone; 55 (90.2%) lived with a partner or other relative. In all, 53 (86.9%) patients stated that they were responsible for organizing and taking their medication at home. The participants reported a mean of 3.0 (SD 2.0) disorders; 50 (82.0%) had diabetes, 24 (48.0% of the diabetic patients) were insulin-dependent; 42 (68.9%) had hypertension; 12 (19.7%) had other cardiovascular diseases; 9 (14.8%) COPD; and 9 (14.8%) digestive disorders. The group aged 70 years or over reported a similar number of disorders ($p=0.31$). The mean number of drugs taken daily was 6 (SD 3.2). The men took a similar mean number of drugs every day as the women ($p=0.33$). The oldest took a mean of 6.3 drugs versus the 5.3 in those younger than 70 years ($p=0.55$). The patients were being looked after by a mean of 2.0 (SD 0.9) physicians. Both the oldest and the older groups ($>$ or <70 years) consulted their physicians a similar mean number of times per year; $p=0.84$.

3.1. Medication errors

A total of 13 (21.3%) patients reported having made at least one medication error during the previous year (3 [4.9%] had made 2 medication errors). In 6 (9.8%) cases the error concerned confusion about the drug to be taken, 1 (1.6%) concerned drug interaction after mixing drugs that should not have been mixed, 8 (13.1%) patients took their medication at the wrong time, and 1 (1.6%) took more than stipulated.

3.2. Tricks to prevent errors

To attempt to prevent mistakes, 16 (26.2%) patients wrote the purpose and dose of the drug on its packaging and 23 (37.7%) used pillboxes to organize their daily medication. The use of pillboxes was slightly more usual among the older patients though not significantly so ($p=0.16$).

3.3. Use of Internet and smartphones

Over half the patients (31; 56.4%) did not use nor were accustomed to using smartphone-like cell phones, a personal computer or navigating on the Internet. A smartphone was used by 13 (21.3%) participants, a home computer by 29 (47.5%) with 27 (44.3%) having an ADSL Internet connection. E-mail, Skype or Facebook was used by 18 (29.5%) patients; 16 (26.2%) navigated the Internet in search of information; 9 (15.3%) read the press on the computer; 8 (13.1%) watched films downloaded from the Internet; and 15 (24.6%) used the Internet to make an appointment with their physician. The older patients

Table 1 – Valuations of the characteristics of TUMEDICINA.

EAN-13 or QR code attribute	Satisfied patients, N (%)	Patients had previous experience ^a , N (%)	Patient had not previous experience, N (%)	Chi-Square P Sig
EAN-13 or QR codes easy to scan	55 (90.2)	27 (87.1)	22 (91.7)	0.59
No failures reading the EAN-13 or the QR codes	44 (72.1)	21 (67.7)	17 (70.8)	0.12
Easy to hear	51 (83.6)	26 (83.9)	19 (79.2)	0.66
Language easy to understand	59 (96.6)	31 (100)	22 (91.7)	0.10
Useful information for safe use of the medication	57 (93.4)	29 (93.5)	22 (91.7)	0.79
Full and varied Information	58 (95.1)	29 (93.5)	23 (95.8)	0.71
I like it to organize my medication	51 (83.6)	24 (77.4)	22 (91.7)	0.16
Overall satisfaction	56 (91.5)	8.3 ^b	8.4 ^b	0.88
Patients saying affirmatively to questions.				
^a Six patients were not included because did not fulfilment criteria of any of this two groups.				
^b Mean score. Each questions saying yes is 1 point.				

reported a similar use of the Internet and smartphones as those younger than 70 years ($p=0.57$).

3.4. Perception of experience with the QR application for a safe use of medication

The degree of satisfaction with TUMEDICINA was 8.3 (SD 1.6) points, out of a maximum of 10. The best-valued attributes of the application were: simplicity and clarity of the verbal messages (59, 96.7%), clarity of the information provided (58, 95.1%), and usefulness of the verbal messages for the safe use of their medication (57, 93.4%) (Table 1). There was a not difference in the satisfaction assessment between patients with or without experience using cell phones or surfing on the Internet (Table 1). The best valuations of TUMEDICINA were made by those patients who used pill boxes to organize their medication (β 1.1, 95% CI 0.1–2.1, $\pi=0.033$) those who made notes on the packaging as a trick (β 1.3, 95% CI 0.1–2.5, $\pi=0.040$), and those patients who took 5 drugs every day as compared with those who took 6 or more (β –0.2, 95% CI –0.3, –0.1, $\pi=0.007$).

4. Discussion

The study patients valued the TUMEDICINA application positively and considered it useful for a safer use of their drugs. The use of TUMEDICINA was equally easy for the patients who already had experience with cell phones, tablets or computers as for those who were using this technology for the first time. TUMEDICINA was particularly well valued by the patients who normally used pillboxes or who made notes on the packaging to help them recall the purpose of the medicine. This indicates that there exists a patient profile that is particularly well predisposed to using this tool as an aid to avoiding errors. This outcome is complementary of the suggestions of previously studies showing that elderly can use smartphones and tablets and the app designed for them [9,15,20].

TUMEDICINA was also very well evaluated by those patients who took 5 drugs daily. Those who took more than 5 gave slightly less positive evaluations, though still around 8 out of 10. These results are similar to those obtained with other

smartphones applications [10] though our study was undertaken in a different environment and with older persons, who are considered to be less skilled with these technologies.

TUMEDICINA is a first attempt to apply ean-13 codes and QR technology to an application attempting to prevent medication errors among older persons taking 5 or more drugs daily. TUMEDICINA may be especially useful for older patients being looked after by different persons who do not always accompany the patient to the physician and therefore do not receive any direct instructions about the adequate use and dosage of the medication to be taken. It is also useful for those patients when there exist several different forms of presentation of the same active ingredient, with the public health system (as in Spain) financing the cheapest. In this case the patient may have doubts about the indication and dosage of a new tablet, capsule, pill or drops, using TUMEDICINA to find a rapid solution. Finally, when using drugs that are already in the house and that are repeated prescriptions there is greater safety as the QR contains information to ensure that a medication is not used when it is not indicated or has expired.

Consideration should be given to the fact that older persons tend to give positive assessments of the healthcare they receive, which may have influenced the positive opinions given about TUMEDICINA. Although the app assessment was conducted regardless of the design phase, the patients could have given more positive assessments than expected knowing that they are participating in an evaluation study. Further studies are therefore needed to verify the usefulness of this application involving samples of patients with different types of diseases as well as to assess its usefulness in persons with a partially worsening cognitive function.

Author contributions

All the authors have contributed substantially to the material and/or intellectual content, data analysis, if applicable, and the writing of the manuscript, sufficiently to accept public accountability for it.

Summary points

What was already known on the topic:

- Older persons following a prolonged complex drug regimen often make mistakes when taking their medication (confusions and omissions). These patients usually have tricks to help them with the correct use of their medication.
- The growth in the sales of tablet computers and smartphones has encouraged the development of applications to help people remember to take their medication.

What this study added to our knowledge:

- It seems that the helper applications to self-management of medication, as TUMEDICINA are well accepted among the elderly with taking multiple medications.
- This finding is of significance for the design and marketing of technological tools that contribute to the safe use of medicines by elderly patients.

Conflict of interest

The authors declare they have no conflict of interest for this study.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.ijmedinf.2015.02.001>.

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