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Mobile applications to enhance self-management of gout

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ABSTRACT

Background: Gout is an arthritic condition that is characterised by extremely painful, debilitating acute attacks and eventual joint and organ damage if not controlled. Despite the availability of very effective therapies that, if adhered to, will prevent acute attacks and long-term damage, the disorder is increasingly prevalent. There is an urgent need to improve self-management of gout.
Objectives: Mobile health (mHealth) applications ('apps'), designed to facilitate management of chronic conditions, present novel opportunities for supporting patient self-management of gout. The aim of this review was to assess features of available gout management apps designed to assist consumers in managing their gout and their consistency with guidelines for gout management.
Methods: English-language, smart-device apps designed to assist self-management of gout were identified using search term "gout" and downloaded from Apple and Google Play app stores. To be included in the review, apps had to allow users to monitor their gout disease (e.g. serum uric acid (sUA) tracking, record acute attacks) and/or educate patients about gout. Investigators derived patient-focused recommendations for gout management from contemporary guidelines. Features of reviewed apps were independently assessed by two reviewers for their facilitation of these recommendations.
Results: The search identified 57 apps possibly relevant to gout management, of which six met the inclusion criteria. One app incorporated all recommendations for patient-focused gout management from guidelines including monitoring sUA, recording attacks and lifestyle advice. However, the majority of these elements were not functional within the app, and instead required users to manually complete printouts.
Conclusions: Currently, only one app exists that includes all recommendations to facilitate patient self-management of gout, however some features can only be actioned manually. Given the lack of progress in achieving better patient outcomes and the promise of mHealth interventions to deliver significant gains, new or updated gout management apps are required to promote successful self-management of this chronic disease.

1. Introduction

Despite the availability of very effective urate-lowering therapies (ULT), the prevalence of gout is increasing (3% of adults in the United States in 2007) and its incidence is also rising rapidly [1,2]. Authoritative guidelines for the effective management of chronic gout are available [3–6]. The core advice of these guidelines is to lower and maintain serum uric acid (sUA) to ≤6 mg/dL (0.36 mmol/L; British Guidelines recommend ≤5 mg/dL (0.30 mmol/L)) [3], and to increase the dose of allopurinol, the predominantly used ULT, slowly until this is achieved. Remarkably, if these guidelines are followed, and ULT is commenced carefully, acute gout attacks will ultimately cease and the damaging effects of monosodium-urate deposits in joints and tissues will be avoided or minimised [7].

Abbreviations: sUA, serum uric acid; ULT, urate-lowering therapy; GP, general practitioner; mHealth, mobile health; App, application.

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A study has shown that negative experiences and mistaken beliefs of patients with gout were major barriers to patients seeking information and advice about gout, and also impacted on their adherence to therapy [8]. Patients were unaware that the condition could be treated effectively, and general practitioners (GPs) were reluctant to commence ULT due to unfamiliarity with gout management guidelines and concerns regarding the risk for serious hypersensitivity to ULT drugs [9,10]. Innovative methods are required to facilitate better gout management and overcome these barriers. A study in the United Kingdom, involving 106 gout patients, showed that a nurse-delivered combination of intensive, personalised education and lifestyle advice with appropriate ULT dosing advice was successful in achieving target sUA concentrations in 9 out of 10 gout patients, thus providing evidence that self-management can be effective [11].

A systematic review of factors associated with successful chronic disease management showed evidence supporting the effectiveness of interventions to support self-management by patients [12]. These factors included educational sessions and motivational counselling with health professionals, and decision-support tools for GPs [12]. The number of adults in the United States using the internet, especially on portable devices, such as cell phones or tablets, has increased, with two-thirds of cell phone owners using the device to go online [13], and the trend continues to rise [13–15]. Over half of smartphone owners use their mobile devices to go online to find health information [16,17], with those suffering from chronic conditions more likely to do so [18]. Further, one in five smartphone owners have some form of health application (app) installed on their smartphone [19]. Electronic tools have been shown to be effective in supporting self-management, changing health behaviours such as improving medication adherence, and increasing compliance to guidelines for chronic diseases such as asthma, diabetes and juvenile idiopathic arthritis [20–23]. Additionally, a meta-analysis demonstrated the effectiveness of providing individualised feedback to patients about their progress during interventions to support behaviour change [24]. Collectively, this evidence suggests that there is a sound argument for the development of electronic health tools such as mobile health (mHealth) apps, to enhance self-management of gout and other chronic health conditions, particularly if applications can be accessed on mobile devices such as smartphones.

Gout is a chronic disease in which patients have long-term challenges to maintain good control of their gout. Taking medication regularly, often for life, and having regular sUA tests are critical behaviours required. The change in behaviour of many gout patients needed to meet this standard is extremely challenging as evidenced by the low medication adherence rates and poor control of gout revealed in many studies [25–27]. Hence, the development of an mHealth app to support the required behaviour changes would be a significant advance in gout management. Gout is a strong candidate condition for self-management given the presence of an indicator, sUA, which correlates closely with the risk of gout attacks and can be monitored by patients. With an improved understanding of their condition, along with reminders and individual feedback, it is anticipated that gout sufferers will more likely reach and maintain target sUA concentrations through better treatment adherence. This review assessed mobile apps currently available to patients for the management of gout. To do so, a thorough examination of the apps was conducted which included comparison of the apps' content and features against internationally accepted gout management guidelines, important for successful outcomes in individual patients.

2. Methods

2.1. Search strategy for mobile apps for gout patients

A search was performed in the Apple App Store℠ for iPhone and iPad compatible mobile apps for gout management. The search in the Apple App Store using the term "gout" (in May 2015) retrieved 57 apps. The inclusion criteria for the apps to be included in the review were that the app had to be in English, primarily related to the disease gout, designed for patient use and incorporate elements of disease monitoring and/or patient education. The App Store description of each app was then read and assessed against these inclusion criteria. Following this, 51 apps were excluded (Table 1), with only six apps (11%) meeting the above conditions. The Android™ mobile app store, Google Play™, was also searched for gout management apps designed to assist consumers to better manage their gout using Android devices, and no additional apps were found.

2.2. Identification of self-management recommendations from existing gout management guidelines

Of the available gout guidelines, four were selected for this review. These four guidelines [3–6] were selected because they are the most recently developed and under the auspices of the leading, international associations in the field of rheumatology. These guidelines [3–6] are directed primarily towards healthcare providers to manage their patients, and hence, not all recommendations are applicable to patient self-management. Two investigators (AN, DK) independently reviewed the gout management guidelines and reached a consensus on the recommendations that were relevant to individual patient self-management (Table 2) i.e. those recommendations that could be actionable by a patient.

2.3. Presence of patient-focused recommendations for management of chronic gout in gout apps

Two investigators (AN, DK) independently assessed the six apps that met the inclusion criteria, separately, against each of the recommendations from Table 2. For a recommendation to be considered present, the app needed to include a function or educational material (e.g. an informational statement or section) for that specific recommendation. Once again, the investigators met to compare results and came to a consensus after discussion.

Table 1
Reasons for apps being excluded from further study.

Exclusion criteria	# of mobile applications
Not related to gout (e.g. many were French where goût refers to taste of food)	28
Related to gout (disease), but only provided information on purine content of foods that might contribute to gout	12
Related to gout (disease), but only provided homeopathic advice	2
Related to gout (disease), but not for patient use (targeted to healthcare providers)	7
Overall health management app not primarily focused on gout e.g. provided tracking facility for several blood concentration pathology results, one of which was urate, but included no other information about gout	2
Not in English	18

Note: Categories not mutually exclusive.

Table 2
Patient-focused recommendations for management of chronic gout extrapolated from the four main gout management guidelines [3–6].

a Take ULT to reach and maintain sUA below a target concentration to prevent crystal formation and to promote crystal dissolution
• Take colchicine/nonsteroidal anti-inflammatory drug (NSAID) during first months of ULT as prophylaxis against acute attacks
• Monitor/track sUA regularly during upward titration of ULT and after target is reached
• Record number and severity of acute attacks
• Treat associated comorbidities and risk factors of gout e.g. comorbidities: hyperlipidaemia, hypertension, hyperglycaemia, obesity; risk factors: alcohol intake, purine intake, fructose intake
• Follow non-pharmacological advice e.g. lifestyle advice regarding weight loss if overweight, diet (limit purine-rich food, reduce alcohol (especially beer))

Abbreviations: ULT, urate-lowering therapy; sUA, serum uric acid; NSAID, nonsteroidal anti-inflammatory drug.

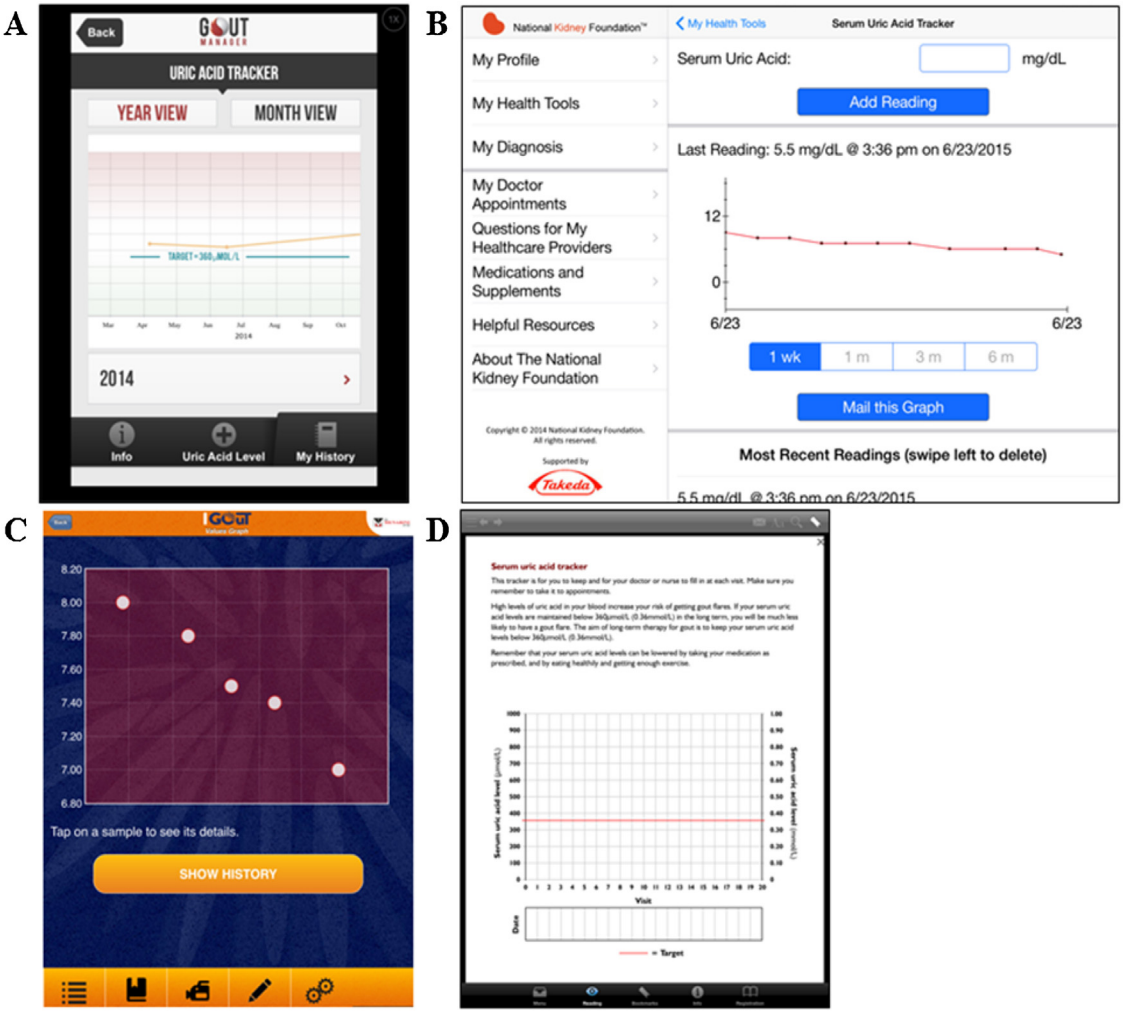

Fig. 1. Graphing functions within apps for patients to monitor serum uric acid (sUA) concentrations.

3. Results

The six apps that met our inclusion criteria for review were *ArthritisID*, *Gout by AZoMedical*, *Gout Channel*, *Gout Manager*, *iGoutapp* and *Managing Gout*. The patient focused self-management features of these apps are summarised in Table 3.

Of the six mobile applications reviewed, two provided only educational material, namely *ArthritisID* and *Gout by AZoMedical*. *ArthritisID* provided users with information about the pathophysiology of gout, its diagnosis and treatment, whereas *Gout by AZoMedical* was a periodically updated summative collection of news articles and latest developments in gout management. The remaining four apps contained both patient education and some functions that allowed disease monitoring. It should be noted that during subsequent analysis, the educational material of *iGoutapp* was not available for further review due to a technical issue. *iGoutapp* still displayed the sections on educational material, however they displayed no further information when clicked. We did not systematically evaluate the quality, patient acceptability or other attributes of the educational material of these apps, instead only indicating whether they were present or not. Evaluating the

Table 3
Summary of features of mobile applications satisfying self-management inclusion criteria.

Application name	Developer	Current status	Features
ArthritisID	Arthritis Consumer Experts *(national Canadian organisation providing science-based information, education and support programs to arthritis patients)*	• Functional • Released: 23 August, 2011 • Last updated: 9 August, 2014	• Educational information on gout (pathogenesis of disease, importance of using ULT to reach a sUA target and taking prophylaxis during ULT initiation; included videos of experts discussing gout) –*Recommendations 1, 2* • Dietary and lifestyle advice (reduce purine and alcohol consumption, increase physical activity) - *Recommendation 6* • Arthritis screening tool (quiz; interactive picture of body with bones and joints) • Sharing function (can share information and articles found in app via email) • Links to websites for further information and social media accounts of developers
Gout by AZoMedical	AZoNetwork *(team of specialist medical news editors and scientists providing online information for healthcare consumers and professionals)*	• Functional • Released: 11 March, 2014 • Last updated: 12 February, 2015	• Up-to-date medical news and information related to gout • Search function for retrieval of information on app • Ability to bookmark pages of information ('Favorites') • Sharing capabilities (can send information and articles found in app via email)
Gout Channel	FBCommunication *(publishing and communications company)* & Menarini Group *(pharmaceutical company)*	• Functional • Released: 5 June, 2012 • Last updated: nil	• Educational information on gout (pathogenesis of disease, importance of using ULT to reach a sUA target, taking prophylaxis during ULT initiation, monitoring sUA and treating comorbidities; included animations) –*Recommendations 1, 2, 5* • sUA concentration monitoring (printable blank graphs) allowing patient to print the forms and then graph their data –*Recommendation 3* • Ability to record acute attacks (printable 'Symptom Tracker') –*Recommendation 4* • Dietary and lifestyle advice (reduce purine and alcohol consumption, increase physical activity, avoid triggers for acute attacks, remember to take medication) –*Recommendation 6* • Action plan (printable blank plan to discuss with healthcare provider) • Ability to bookmark pages of information
Gout Manager	Life Healthcare Communications *(communications company)* & Menarini Group *(pharmaceutical company)*	• Functional • Released: 26 February, 2014 • Last updated: nil	• Educational information on gout (pathogenesis of disease, importance of using ULT to reach a sUA target and monitoring sUA) –*Recommendation 1* • sUA concentration monitoring (interactive electronic graph) allowing patients to enter and keep record of sUA data –*Recommendation 3* • Ability to enter and keep record of occurrence of acute attacks ('Gout Attack Diary') - *Recommendation 4* • Dietary and lifestyle advice (reduce purine and alcohol consumption, increase physical activity, remember to take medication) –*Recommendation 6* • Ability to set reminders (record acute attacks, record urate concentrations, make doctors' appointment, go to doctors' appointment) • Links to websites for further information
iGoutapp	Menarini Farmaceutica Internazionale *(pharmaceutical company associated with Menarini Group)*	• Semi-functional: sUA graph can be used, but 'Publications' contained no content besides the message "error retrieving files", and 'Medical Information' has headings for subject matter, however when clicked only showed a 'loading' message, but no content appeared • Released: 26 June, 2013 • Last updated: nil	• sUA concentration monitoring (interactive electronic graph) allowing patients to enter and keep record of sUA data –*Recommendation 3* • Educational information on gout (tabs for 'Medical Information' (contained headings for pathogenesis of disease and treatments, but no content) and 'Publications' (contained no content); included video for the website 'stamp out gout' (UK government initiative to improve and increase awareness of gout))

Table 3 (*Continued*)

Application name	Developer	Current status	Features
Managing Gout	National Kidney Foundation *(organisation dedicated to awareness, prevention and treatment of kidney disease for healthcare professionals and patients)* & Takeda *(pharmaceutical company)*	• Functional • Released: 6 November, 2014 • Last updated: 13 January, 2015	• Educational information on gout (pathogenesis of disease, importance of using ULT to reach a sUA target, monitoring sUA and treating comorbidities) –*Recommendation 1* • sUA concentration monitoring (interactive electronic graph) allowing patients to enter and keep record of sUA data –*Recommendation 3* • Provided feedback when above normal sUA value was entered – 'Values above safe ranges' –*Recommendation 3* • Ability to enter and keep record of occurrence of acute attacks –*Recommendation 4* • Ability to enter and keep record of parameters of gout comorbidities (albumin-to-creatinine ratio, glomerular filtration rate, body weight) –*Recommendation 5* • Dietary and lifestyle advice (reduce purine and alcohol consumption, reduce obesity, increase physical activity) –*Recommendation 6* • Ability to set reminders for doctors' appointments, which become events in device's native calendar • Sharing capabilities (can send recorded data found in app via email) • Links to websites for further information

quality of the educational material will be an important step in developing improved apps.

Four apps (*Gout Channel*, *Gout Manager*, *iGoutapp*, *Managing Gout*) provided functions to monitor the patients' sUA concentrations, thus allowing patients to visualise the effectiveness of their ULT (Fig. 1). Three of these apps had a function that tracked sUA concentrations over time in a graph and/or table format (Fig. 1A-C). The remaining app, *Gout Channel*, provided users with an empty graph that the patient could print out and manually plot their sUA concentrations over time (Fig. 1D). Two of these four apps provided a 'target' sUA concentration on the graphs for the patient to compare their own sUA concentrations (Fig. 1A, D). Importantly, the use of ULT to reach these target concentrations was stressed in the majority of the apps (four of six). However, no app mapped ULT use against sUA on the same graph, demonstrating a potential feature for future app development.

Interactive electronic graphing functions were available in (A) *Gout Manager* (B) *Managing Gout* and (C) *iGoutapp*. In these apps, patients entered their serum uric acid and these values were plotted on a graph. A printable graph template was available in (D) *Gout Channel*, in which patients could plot their serum uric acid values manually.

Recurrent acute attacks are of most relevance to patients and recording the length and severity of acute attacks was recommended for effective gout management by the American College of Rheumatology gout guidelines. Three apps included functions for the user to enter the date, duration and pain levels of acute attacks (Fig. 2). Two apps refined this with diagrams of the body so patients could select the areas affected. *Gout Manager* had a movable and color-coded pain scale for the patient to not only locate the attack site but also select the level of pain of their attacks (Fig. 2A). In *Managing Gout*, users could select the pain intensity (1–5) from a scale using cartoon faces depicting escalating levels of pain and distress (Fig. 2B).

Facility to record details of patients' acute gout attacks was available in (A) *Gout Manager* and (B) *Managing Gout*. A printable 'Symptom tracker' was available in (C) *Gout Channel*, in which patients could complete information about their gout attacks by hand.

A recommendation from all the gout guidelines was for healthcare providers to provide lifestyle and dietary advice to gout patients. Four of the apps included educational material on diet and lifestyle, with two of these apps only providing information about gout and its treatment.

3.1. Additional features

Several apps included additional features that could potentially enhance communication and management of comorbidities such as obesity, diabetes and hypertension. One app, *Managing Gout*, provided functions to monitor these comorbidities by, for example, allowing patients to record and graph their blood pressure, urinary albumin-to-creatinine ratio, glomerular filtration rate and body weight. In three of the apps, dietary and lifestyle advice for comorbidities commonly seen with gout was available.

In *Managing Gout*, patients could send reports of their results via email to their healthcare providers. There was also a free-text box called 'Questions for My Healthcare Providers' where patients could note questions to raise with their doctors in future appointments. *iGoutapp* allowed healthcare providers to register for an account so that they could access educational material, but did not allow for direct interaction with their gout patients. The two educational apps, *ArthritisID* and *Gout by AZoMedical*, had sharing capabilities, allowing the user to share educational information and news articles through email. Three of the six apps contained links to external websites for further information on gout and gout support groups, with *ArthritisID* also providing users with the social media accounts of its developers.

Of the six apps, only three apps had version updates needed to rectify operational failures (e.g. compatibility with updated operating systems). *ArthritisID* was the only app that indicated that features might be updated in response to user requests. The lack of version updates in the majority of these gout management apps perhaps indicate limited uptake and use by gout patients.

4. Discussion

For effective management of gout, patients need not only knowledge of their disease and its treatment, but also support and a clear rationale to adhere to treatment. The use of mobile applications to support self-management of chronic conditions presents much potential. The extent to which such apps contain content consistent with treatment guidelines and are user-friendly is central to their likely adoption and effectiveness. This review assessed features of gout management apps that were designed to assist consumers to manage their gout better and identified significant limitations of the apps. Of the six gout apps found, only one app incorporated all recommendations for patient-focused gout management. This

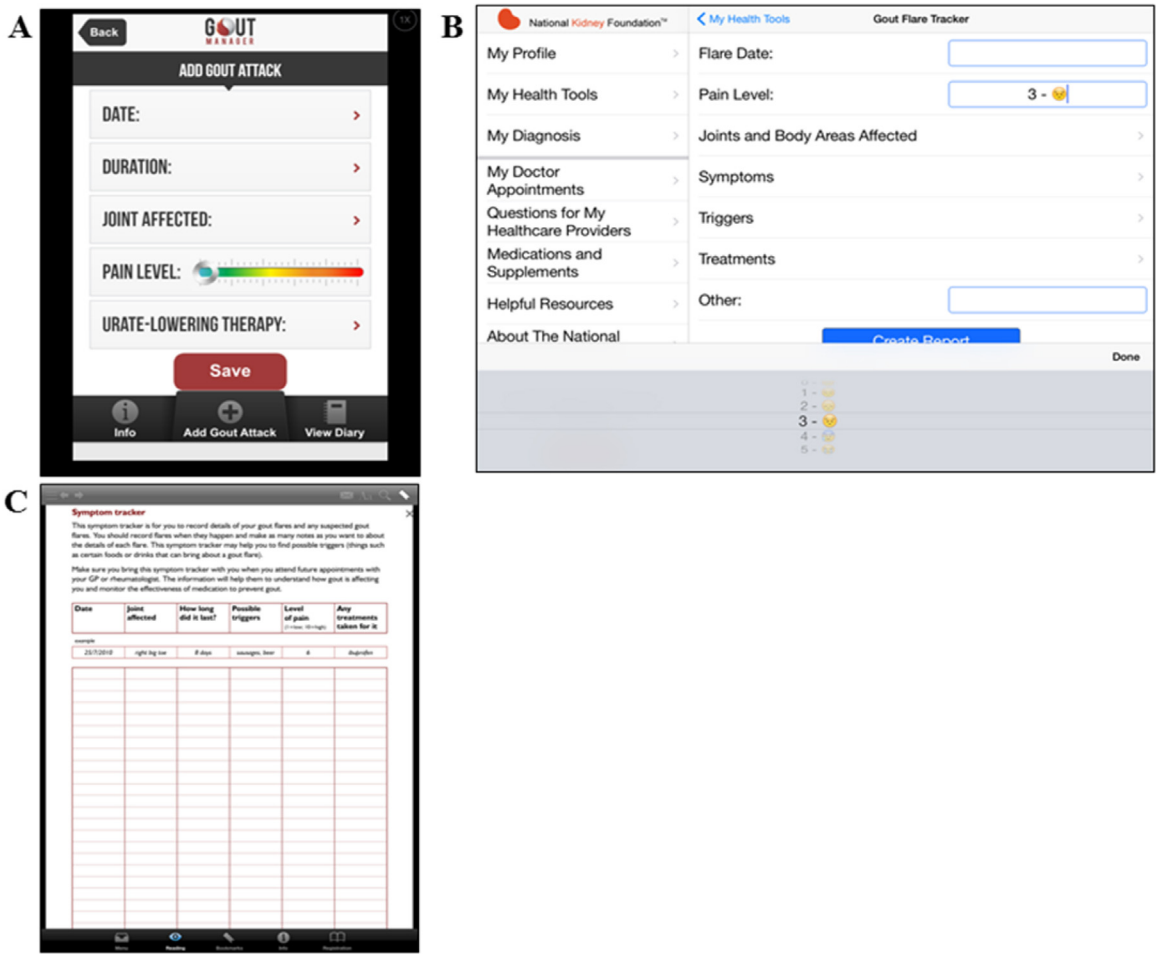

Fig. 2. Functions within apps to record acute gout attacks and their features.

result is not unique to gout apps, with reviews of apps designed for diabetes also finding similar results [28,29].

4.1. Useful features for a gout self-management app

Successful gout management is based on a single clinical indicator- getting the urate concentration below target using ULT. Once this target is reached and sustained, patients should no longer experience acute attacks, essentially being 'cured' of gout. While the majority of these apps contained adequate educational material on the disease and its treatment, facilitation of the key component of gout management, monitoring of sUA, was not possible in all apps (only four of the six), and none of these apps linked sUA values to taking ULT continuously. This is critical information to feedback to patients for them to better understand the relationship between sUA, continued adherence to ULT and risk of attacks. Building this feedback feature into a gout management app may be very effective in improving medication adherence in gout treatment. Additionally, an important function of a gout management app is to be able to record acute attacks as these are of most significance to patients [10]. This allows patients, and optimally also their healthcare providers, to identify possible triggers for acute attacks and to explore strategies and treatment options, such as lifestyle changes, to reduce the likelihood of further acute attacks. Monitoring and recording information about gout attacks is especially important during ULT initiation, when the risk of acute attacks is elevated [30]. Surprisingly, only three of the six apps reviewed had this function.

As noted, adherence to ULT is critical for effective, long-term gout management [31]. However, medication adherence is a significant problem in chronic disease management [32], especially in gout, with reports that the majority of gout patients do not consistently take their ULT [25–27]. None of the apps that were reviewed incorporated reminders for patients to take their ULT medication, although two apps stressed the importance of good compliance. The apps did, however, provide other reminder functions, with *Gout Manager* having reminders to record gout attacks and sUA concentrations. Additionally, in both *Gout Manager* and *Managing Gout*, reminders to make and attend doctors' appointments were available. Behaviour change theory and empiric observations emphasise the importance of personalised feedback to the patient about their progress and recommended actions in response, via reminders and alerts [24]. Thus, reminders and alerts should be elements of an effective gout management app for patients, with studies showing their effectiveness in self-management of individualised feedback of blood sugar results in chronic diabetes patients [24]. However, in this review, only one app, *iGoutapp*, provided feedback to the patient by displaying a short warning notice ('Values above safe ranges') when an sUA value above the 'normal range' (6 mg/dL [0.36 mmol/L]) was entered. Further, allowing inputted patient data to be shared with healthcare providers, would give an opportunity for the healthcare provider to provide patients with personalised responses that can improve medication adherence or improve gout management, for example adjusting the dose of ULT [33]. Therefore, in this review, those apps that provided feedback, for example those that required an action e.g. to regularly record

sUA and acute attacks, could be considered to be more effective than those that did not.

Gout patients have a high likelihood of having comorbid conditions that could require them to take additional medications [34,35]. Thus it is important to address patient concerns with having to take an abundance of medications [36]. Additionally, this is particularly important as it has been reported that healthcare providers prioritise treating patient comorbidities over their gout [37]. This behaviour may also occur in patients and so, compared to their potential comorbidities such as hypertension and diabetes, patients may feel that their gout is non-life-threatening and thus only take their gout medications during acute attacks and then cease doing so after their symptoms subside. Therefore, a gout management app should provide tailored advice to address these concerns. It would also be pertinent to explain whether medications used to treat patients' specific comorbidities have contraindications or interactions with their gout medications.

4.2. Future work

It has been noted that current methods of app development may not produce the most effective apps and there is a need for more scientific and rigorous approaches to app development and evaluation [38]. Evaluations of the effectiveness of the self-management apps to actually improve patient outcomes and induce behaviour change, is an important step in identifying the role of mobile apps in effectively supporting self-management [39]. Electronic aids have been shown to provide benefits to patients in other chronic disorders [20–23] but no published evidence of the effects of mobile apps for gout patients was identified. Prior to undertaking such an evaluation however, analysis of which features of a gout management app are likely to lead to better outcomes would be an important first step. No information was available regarding the process of building the apps included in the review, or specifically whether patients with gout were involved in the process. However, one study from South Korea describing the development of a web-based gout self-management application identified features likely to be useful for patients as determined by consultations and a needs analysis with gout patients [40]. These features included providing patients with gout education divided into main topics, interaction with gout experts and a checklist tool that patients used to self-manage their gout. Input from gout patients during the process of app creation is crucial, as has also been identified in studies examining the effectiveness of apps in improving health outcomes [41–43], and the design of tools which are highly used by users [44,45] in chronic conditions other than gout. Hence, a fundamentally important step in the design of a gout management app is to identify those features that patients find useful in the management of their disease and to rigorously undertake usability testing of the app by patients in order to optimise the effectiveness of the app. Only then would conducting controlled trials to determine the effectiveness of a gout management app be appropriate.

4.3. Conclusions

In conclusion, although there were many potentially useful features in these gout management apps, the apps did not include personalised reminders to take medications, the capacity for interaction and communication with healthcare providers or the provision of real-time individualised feedback to the patient regarding their sUA concentrations. Also, the failure to update the functionality of apps to maintain compatibility with constantly updating software is problematic for potential users and could result in limited uptake and effectiveness of these apps. Thus, these apps might be considered as pilots for future, improved apps. This review provides a starting point for the development of 'next generation' gout apps that must involve patients in their design and validation. These new apps should be tested in controlled trials to assess if they can change behaviours of gout patients such that there is significantly improved adherence to ULT, essential for successful control of gout.

Summary points

- Consumers, especially those with chronic diseases, are increasingly adopting electronic tools and applications to manage their health
- A validated gout management app directed towards patient self-management could improve patient outcomes
- One gout management app incorporated elements recommended for successful patient self-management of gout, however the app was not entirely electronic
- The development of an app designed to support patients achieve better control of their gout, and which is evaluated for effectiveness at improving patient outcomes, is required.

Conflicts of interest

None.

Authors' contributions

Conception and design of study: AN, MB, JW, RD.
Acquisition of data: AN, DK, RD.
Analysis and interpretation of data: AN, MB, DK, AT, AL, JW, RD.
Drafting article: AN, MB.
Revising article critically for important intellectual content: AN, MB, DK, AT, AL, JW, RD.
Final approval of version to be submitted: AN, MB, DK, AT, AL, JW, RD.

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