Do prostate cancer-related mobile phone apps have a role in contemporary prostate cancer management? A systematic review by EAU young academic urologists (YAU) urotechnology group

Enakshee Jamnadass 1 · Bhavan Prasad Rai 2 · Domenico Veneziano 3 · Theodoros Tokas 6 · Juan Gomez Rivas 4 · Giovanni Cacciamani 5 · Bhaskar Somani 1

Received: 14 November 2019 / Accepted: 31 March 2020 / Published online: 22 April 2020 © The Author(s) 2020

Abstract

Aims and objectives To review the available literature regarding the use of prostate cancer-related mobile phone applications (PCA).

Materials and methods The search was for English language articles between inceptions of databases to June 2019. Medline, EMBASE, Cochrane Library, CINAHL and Web of Science were searched. Full-text articles were reviewed, and the following data were extracted to aid with app analysis: name of application, developer, platform (Apple App Store or Google Play Store) and factors assessed by the article.

Results The search yielded 1825 results of which 13 studies were included in the final review. 44 PCAs were identified from the data collected of which 59% of the PCAs had an educational focus. 11 apps were inactive and 5 weren’t updated within the last year. Five studies focused on the development and testing of apps (MyHealthAvatar, CPC, Rotterdam, Interaktor, NED). Two studies evaluated the readability of PCAs. Most PCAs had a reading level greater than that of the average patient. Two studies evaluated the quality and accuracy of apps. Majority of PCAs were accurate with a wide range of information. The study reported most PCAs to have deficient or insufficient scores for data protection. Two studies evaluated the accuracy of Rotterdam, CORAL and CPC risk calculators. Rotterdam was the best performer.

Conclusions PCAs are currently in its infancy and do require further development before widespread integration into existing clinical practise. There are concerns with data protection, high readability standards and lack of information update in current PCAs. If developed appropriately with responsible governance, they do have the potential to play important roles in modern-day prostate cancer management

Keywords Prostate cancer · Mobile phone applications · Social media

1 University Hospital Southampton NHS Trust, Southampton, UK
2 Freeman Hospital, Newcastle, UK
3 Department of Urology and Renal Transplantation, Bianchi-Melacrino-Morelli Hospital, Reggio Calabria, Italy
4 Department of Urology, Hospital Universitario La Paz, Madrid, Spain
5 Department of Urology, USC Urology Institute, University of Southern California, Los Angeles, CA, USA
6 Tirol Kliniken, Milser Strasse 10, Hall in Tirol, Austria
Introduction

Information Communication Technology (ICT) is an integral part of modern-day healthcare delivery in domains such as education, research, operational efficiency and data management [1]. In prostate cancer with changing diagnostic and therapeutic paradigms, there is likely to be reliance on technology for the delivery of cost-effective, high-quality cancer care [2]. Mobile phone application (apps) is software with specific, limited function, which is designed for use on a mobile device [3]. It has been suggested mobile phone apps have the potential to increase patient awareness, be adjuncts to traditional clinical evaluation strategies and can also facilitate research development and delivery [4]. The two most popular platforms, from which users can download apps, are the Google Play Store, and the Apple App store. Over 2 million apps are available on these platforms [5]. There are over 5.5 billion smartphone users worldwide [6], and it is estimated that the average user spends over 3.5 h on their mobile device every day [7]. Furthermore, users spend 89% of their media time on mobile apps [8]. In the United Kingdom, a reported 75% of people go online for health information. Additionally, 70% of patients aged over 50 want to use digital healthcare services [9]. The market for healthcare-related apps is growing, and it is suggested that around 200 healthcare apps are added daily [9].

Prostate cancer is the most common cancer in males, in the UK (second most common in men, worldwide) and, according to the American Cancer Society, 1 in 9 men will be diagnosed with prostate cancer during their lifetime [10, 11]. Furthermore, the incidence of prostate cancer is increasing and is projected to rise in the UK by 12% between 2014 and 2035 [10]. Given the significance of prostate cancer worldwide, and the increasing usage of healthcare apps within patient populations, we aim to systematically review the available literature regarding the availability and usage of prostate cancer-related mobile phone apps (PCA). We also look at the type of app, its content, rating and their real-world application.

Materials and methods

Selection criteria

This review included studies that explored and evaluated various aspects of PCAs, as well as their current and potential applications in the screening, prevention or management of prostate cancer.

Inclusion and exclusion criteria

Inclusion criteria:

I. English-language oncological papers with a focus on prostate cancer.
II. Studies reporting on mobile phone apps for prostate cancer.

Exclusion criteria:

I. Literature reviews, grey literature, editorials, letters, and other ‘comment’ pieces.
II. Studies on prostate cancer not related to apps.
III. Studies relating to apps which are unpublished or unreleased.

Search strategy

This systematic review of world literature was performed in the Cochrane style and in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (Fig. 1) [10, 11]. The search was for English language articles between inceptions of databases to June 2019, with the final search being conducted on 17/06/2019. Medline, EMBASE, Cochrane Library, CINAHL, and Web of Science were the databases searched. The search terms used were ‘prostate’, ‘cancer’, ‘prostate cancer’, ‘PSA’, ‘prostate specific antigen’, ‘prevention’, ‘adenocarcinoma’, ‘prostatic intraepithelial neoplasia’, ‘social media’, ‘phone app’, ‘apps’, ‘search engine’, ‘online’, ‘web-based’, ‘ehealth’, ‘mhealth’, ‘user-generated content’, ‘mobile health’, ‘smartphone’, ‘mobile phone’, ‘personal digital assistant’, ‘google play’, ‘android’, ‘apple’ and ‘iOS’. Medical Subject Heading (MeSH) phrases included (“Prostatic Neoplasms”[MeSH]) AND “Mobile Applications” [MeSH]); (“Prostate”[MeSH]) AND “Smartphone application”[MeSH]); (“Prostate cancer”[MeSH]) AND “Social media”[MeSH]) AND “Mobile health”[MeSH]) aq. Boolean operators (AND, OR) were used to refine the search. Two reviewers (EJ and BS) identified all studies and those that appeared to fit the inclusion criteria were included for a full review. Papers evaluating a ‘general’ cancer app, that specifically mentioned prostate cancer patients within the article, were included. However, papers solely evaluating apps that did not have a cancer focus (e.g. pedometers or fitness trackers, without a cancer-related component) were excluded. Each reviewer independently selected studies for inclusion in the review and discrepancies were resolved by mutual consensus. A literature search had been run on each database. Any duplicates were excluded. At initial screening articles were excluded by title screening. The abstracts of
the remaining articles were further screened and excluded if considered unsuitable for the review. Full text of the remaining literature was then reviewed. After a complete evaluation of the full articles, articles were excluded if deemed unsuitable. The remaining studies were included in the review for a narrative synthesis. The following information was extracted and organised using a spreadsheet (to perform further analysis): the year of publication, journal, number of applications assessed, type of apps and assessment criteria used on the included applications. References for these studies were collected using EndNote Web, and citations were either imported directly or manually entered. The outcomes of individuals studies will be presented in narrative fashions with emphasis on App development, App Readability, Quality and Accuracy of Apps, App Usage, and Risk Calculators.

**Review of mobile phone applications (apps)**

The full-text articles were also assessed in detail for the apps and data was extracted for the following information (where available): name of application, developer, platform (Google Play Store or Apple App Store), and factors assessed by article. One of the authors (EJ) gathered further information on these apps which had been named by studies using the online stores (namely Google Play and App Store). This data included: the app’s cost, star rating [1–5], number of reviews, date of the last update, and the advertised content of the app (found in the app’s description). All information gained from both the online stores and from the literature was then compiled into the same spreadsheet for analysis. Data were collated using Microsoft Excel (version 12.2.4).
Results

Study selection

The initial literature search yielded 1825 results; 449 from Medline, 539 from EMBASE, 159 from CINAHL, 188 from Cochrane Library, and 490 from Web of Science. One thousand seven hundred and fifty-two articles were screened after removal of duplicates. 1608 articles were removed after title screening. 125 articles were removed after the abstract screening. Full texts of 19 studies were assessed. Of these, one paper was excluded as it was not relevant and a further five papers were removed as they were based on unpublished or unreleased apps (not available in online stores). This left 13 papers for inclusion in our final review [12–24] (Fig. 1).

Description of studies

The papers included in this review focused on a variety of factors in assessing available apps including readability, quality and accuracy, usage, and app development. A comprehensive summary of the individual studies has been presented in Table 1. The authors have highlighted the outcomes of individual studies under the headings:

1. Studies related to app development.
2. Studies related to readability.
3. Studies related to ‘quality and accuracy’ of apps.
4. Studies related to app usage.
5. Studies related to risk calculators.

Studies related to ‘app development’

Four studies focused on the development and testing of apps [18, 20, 21, 23]. Zhang et al. [23] presented the MyHealthAvatar app. This was a European Commission funded research project for patients with prostate and breast cancer. The app is available on desktop, tablet and smartphone. The app encourages patient self-management of their disease. It contains lifestyle and activity tracking. It has prostate and breast cancer questionnaires to monitor progress after treatment. It also provides advice on pelvic floor exercises for patients who have had a radical prostatectomy [23, 25]. The app includes International Index of Erectile Function-5 (IIEF-5) and the International Prostate Symptom Score (I-PSS) questionnaires and resources from the Prostate Cancer UK and NHS, UK. They also tested user experience and outlined the early developmental flaws. Data from this app can support research activity.

Røder et al. [21, 26] developed and validated the CPC Risk Calculator which estimates the risk of biochemical recurrence following a radical prostatectomy. The authors used preoperative PSA, pT stage, prostatectomy Gleason score, and surgical margin (R) status to develop the nomogram. The data was calculated from 2167 men who underwent a radical prostatectomy at the Copenhagen Prostate Cancer Center, Rigshospitalet, Denmark. The nomogram was externally validated using a cohort of 2237 men who underwent a radical prostatectomy at the Stanford University, California, USA in the same time period. The authors reported high accuracy and discrimination on external validation. The accuracy of model declined after 7 years due to limited follow-up in the 2 cohorts.

Pereira-Azevedo et al. evaluated their app, the Rotterdam Prostate Cancer Risk Calculator, via usability testing [20, 27]. Rotterdam Prostate Cancer Risk Calculator is developed using algorithms from Rotterdam arm of the European Randomized Study of Screening for Prostate Cancer (ERSPC) study. The calculator uses PSA level, previous negative prostate biopsy, digital rectal examination (DRE) findings, prostate volume measurement, transrectal ultrasonography findings, MRI results, and Prostate Health Index to estimate overall and significant prostate cancer risk. The app was scored by participants, on usefulness, quality of information, and quality of interface scoring highly (gaining ≥ 87%) in all categories.

Langius-Eklöf et al. [18] tested their app, Interaktor, on prostate cancer patients undergoing radiotherapy, to determine its potential to ease symptom burden. They found high adherence to symptom reporting and realised a novel use for the app for clinicians, to determine the most commonly reported clinical side effects of their patients.

All four papers found that users benefited from, or had a neutral experience when using their apps, and authors explored potential possibilities for these apps to benefit healthcare professionals as well as patients (who the apps were designed for) [20, 22–25].

Pham et al., reported on a trial design to evaluate the acceptability of NED (No Evident disease) by patients, caregivers and clinicians. NED is a prostate cancer app developed to support prostate cancer survivorship programmes [24].

Studies related to ‘app readability’

Kim et al. [17] and Owen et al. [19] tested the readability of cancer apps that are currently available online. Both papers used readability assessment tools to determine the grade-level readability of each app. Kim et al. evaluated readability of PCAs along with four other cancer apps available on
| Study          | Study type                                                                 | Objective                                                                 | Outcome/conclusion                                                                                                                                                                                                 |
|---------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Brouard et al. [14] | Evaluation of onco-logical apps, and identification of relevant apps | Analysis of oncology apps to define content, assess business model, assess involvement of pharmaceutical industries, and determine scientific validation | The study identified 539 apps, with the majority dedicated to healthcare professionals, then to general population and then to patients. The majority of apps concerned all types of cancer, with 26 being prostate focused. Of the apps included, 36.5% had scientific validation mentioned in app descriptions, but this was less frequent for apps targeted at patients or the general population. The majority of apps available had a focus on education as their main objective. Authors concluded that patients and healthcare professionals should remain cautious about applications’ contents, and that there is a greater need for scientific validation. |
| Hälleberg-Nyman et al. [16] | Evaluation of usage of a prostate cancer app (Interaktor) and patient participation | To explore how patients with prostate cancer perceived their own participation during radiotherapy, with or without the app | The paper found that patients perceived that participation in their care was greater when using an app, even though there wasn’t a difference in perception of satisfying basic needs. Patients using the app felt that it facilitated participation (mutual participation in particular). Authors determined that using an app to maintain symptom management and provide contact between patients and healthcare staff, can help increase patient participation in care. |
| Langius-Eklöf et al. [18] | Evaluation of the uses of a prostate cancer app (Interaktor) | To investigate user behaviour, adherence to reporting, and patient experience of using a cancer app during radiotherapy for localised advanced prostate cancer | The app was found to increase symptom reporting adherence, which allows clinicians to determine the most commonly reported symptoms and helps to determine the potential of radiotherapy to improve symptom burden. Increase participants sense of security in their own well-being. Act as a supportive tool for symptom self-management during prostate cancer treatment. |
| Study | Study type | Objective | Outcome/Conclusion |
|-------|------------|-----------|--------------------|
| Pereira-Azevedo et al. [20] | Development of a prostate risk-calculator app | To present the Rotterdam Prostate Risk Calculator app | The risk calculator uses PSA level, previous negative prostate biopsy, digital rectal examination (DRE) findings, prostate volume measurement, transrectal ultrasonography findings, MRI results, and Prostate Health Index to estimate overall and significant prostate cancer risk. The app was found to be useful in predicting the risk of prostate cancer, and of clinically significant cases. Have usefulness of 92%, information quality of 87% and interface quality of 89%, when tested by participants. |
| Sundberg et al. [22] | Evaluation of usage of a prostate cancer app (Interaktor) in symptom management and detection during radiotherapy | Evaluation of the effects of symptom burden and quality of life when using the application for real-time symptom assessment and management during radiotherapy. Performed using non-randomised control trial. Outcomes measured using ‘EORTC QLQ-C20’ and ‘Sense of Coherence questionnaire’. | It was found that the group using the app reported significantly lower levels of fatigue and nausea at the end of radiotherapy. The app group had significantly less burden in emotional functioning, insomnia, and urinary-related symptoms at the end of treatment and 3 months later than the control group. Authors found that the app (which they developed) had a role in facilitating supportive care needs during cancer treatment. This highlights the importance of early detection and management of symptoms (especially in anxiety and depression which can cause sleep disturbances), which can be facilitated by the use of the app. |
| Pham et al. [24] | Trail Design for Qualitative study to evaluate NED | Adoptability and acceptability by patients, caregivers, and clinicians. NED access given to 400 patients, 200 caregivers, and 10 clinicians. Trial anticipated to have been completed (May 2019). | Outcomes of this trial will improve understanding of the impact of PCA's such as NED on prostate cancer survivorship programmes. |
| Study                | Study type                                      | Objective                                                                 | Outcome/conclusion                                                                                                                                 |
|---------------------|------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| Adam et al. [12]    | Systematic review of prostate cancer risk calculator mobile apps | To review, rate and assess the everyday functionality and utility of all of the currently available prostate cancer risk calculator apps | Seven apps were critically appraised; 3 were exclusively android, 2 Apple, and 2 were available on both platforms. The top-performing apps were found to be Rotterdam, then Coral, and then the CPC Risk Calculator. The accuracy of all included apps was deemed acceptable. |
| Böhme et al. [13]   | Evaluation of the quality and accuracy of mobile cancer apps    | To evaluate the quality of mobile cancer apps                               | Of the 41 apps assessed, 6 scored ‘very high’, 15 scored ‘high’, 17 ‘deficient’ and 3 ‘insufficient’; therefore nearly half of the apps tested were deemed ‘deficient’ or ‘insufficient’, with the slight majority (51.19%) deemed ‘high’ or ‘very high’. Apps dedicated to/targeted at patients were better quality overall than others, and the group with the worst quality apps were the general population. Apps deemed ‘deficient’ or ‘insufficient’ had particularly poor ratings e.g. in the sub-scales ‘information on sources’ and ‘data protection’. Author raised concerns over data protection, as more data is now being required from users, and this may become of higher importance in the future, and suggested that there is need for improvement in regulation. |


| Study                  | Study type                                           | Objective                                                                 | Outcome/conclusion                                                                 |
|-----------------------|-----------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Røder et al. [21]     | Development, validation and presentation of a prostate risk-calculator app | To present the CPC Risk Calculator app                                    | The app was developed for use on both Android and iOS platforms                     |
|                       |                                                     | Development and validation of a risk calculator that detects the absolute risk of biochemical recurrence following radical prostatectomy in men with an undetectable PSA | App development involved usage of preoperative PSA, pTstage, prostatectomy Gleason score, and surgical margin (R) status |
|                       |                                                     |                                                                           | The app was found to be accurate (70–85%)                                           |
|                       |                                                     |                                                                           | Predict risk of biochemical recurrence up to 12 years after radical prostatectomy   |
|                       |                                                     |                                                                           | Account for known risk-factors and other-cause mortality                            |
| Zhang et al. [23]     | Presentation and development of a cancer app         | To present the MyHealthAvatar app for breast and prostate cancer patients | The app was tested on user experience and visual design                               |
|                       |                                                     |                                                                           | Early developmental flaws were outlined                                              |
|                       |                                                     |                                                                           | Feedback from testers showed that the app                                          |
|                       |                                                     |                                                                           | Improved user knowledge about their disease, and provided tailored information      |
|                       |                                                     |                                                                           | Improved users engagement in health and fitness activities, and raised user’s risk awareness in relation to their disease |
|                       |                                                     |                                                                           | Was slow-loading (addressed by authors in the paper, as an area for future improvement) |
| De Nunzio et al. [15] | Performance and accuracy of prostate cancer risk calculator apps | Tested diagnostic performance and usability of 2 apps (Rotterdam Prostate Cancer Risk Calculator app, and Coral app) in patients at increased risk of prostate cancer, that were undergoing prostate biopsies | Authors found that the Rotterdam app outperformed Coral app in predicting prostate cancer and high-grade prostate cancer (0.7 vs. 0.631, and 0.75 vs. 0.69) |
|                       |                                                     |                                                                           | Both apps were determined comparable in terms of usefulness (both > 80%), information quality (> 70%), interface quality (> 70%) and satisfaction (> 75%) |
|                       |                                                     |                                                                           | 54% preferred the Rotterdam app, and 46% preferred Coral                           |
|                       |                                                     |                                                                           | Authors concluded that apps are outperforming website applications due to their better immediacy, compatibility, shareability and upgradeability |
| Study | Study type | Objective | Outcome/conclusion |
|-------|------------|-----------|--------------------|
| Kim et al. [17] | Readability and patient comprehension of cancer-related mobile apps | Analysed apps using readability studio software, over 10 readability assessments | Data specifically provided on prostate cancer apps  
‘Cancer Conditions and Treatments’ app was found to have a mean reading score of 10.2 (mean of all apps reviewed was between 9.0 and 14.6), therefore although the reading level is that of GCSE-level, it is more accessible than many of the other apps reviewed  
‘itsaMANTHING’ app had a grade-level readability of 9.1  
‘Mens Health Facts And Tips’ app was found to have a mean reading score of 10.6, therefore although the reading level is between GCSE and college-level, it is more accessible than many of the other apps reviewed  
‘Prostate Cancer’ app (by developer ‘Focus’) had a grade-level readability of 9.5 (GCSE level)  
Authors stated that the prostate cancer apps (and all others included in the study) had high reading levels that preclude understanding in the average patient  
Found that only 2 of the 21 applications (not specified which) were developed by someone with an ‘adequate’ background in medicine or science  
Concluded that clinicians may need to recommend apps with easier readability to their patients |
| Owens et al. [19] | Systematic review of prostate cancer apps | To identify and evaluate apps which promote informed prostate cancer screening decisions  
Fourteen apps were identified through the Apple App Store, and Google Play Store | Data specifically provided on prostate cancer apps  
12 apps contained accurate information about anatomy and function of prostate, prevalence and incidence of prostate cancer  
Eleven apps included accurate information about risks and symptoms  
Nine apps included information about screening ages  
Eight apps included accurate information about digital rectal examination  
12 apps included accurate information about the PSA, thirteen presented a neutral tone when discussing it and one was pro-screening |
| Study | Study type | Objective | Outcome/conclusion |
|-------|------------|-----------|--------------------|
|       |            |           | Average reading was found to be of 10th grade level, with 4 at 8th grade level and 5 at 9th or higher |
|       |            |           | Five apps did not meet any of the cultural sensitivity criteria implemented by the authors |
|       |            |           | Eleven apps focused on providing general information |
|       |            |           | Recommendations by paper: |
|       |            |           | Apps should include information consistent with latest evidence |
|       |            |           | Culturally sensitive language should be used |
|       |            |           | Developers should be aware of implications of framing of content (e.g. as pro or against screening) |
|       |            |           | Apps should be interactive and useable |
|       |            |           | Evaluated whether apps provided information about the location and function of the prostate; prevalence, incidence, symptoms, and risks of prostate cancer; information about recommended screening age, digital rectal exam and PSA |
|       |            |           | Apps should be developed collaboratively (with healthcare/medically trained professionals) |
|       |            |           | Assessed accuracy and breadth, framing of the prostate cancer screening controversy, grade-level readability, cultural sensitivity, and usability |
Apple Store and Google Play Store. The study identified 12 articles from 3 PCAs (Mens Health Facts and Tips, Prostate Cancer) for evaluation. The study reported that PCAs available on Apple Store and Google Play Store had average reading grades of 10.6 and 9.4 respectively [17]. Owens et al. identified 14 PCAs. 10 PCAs had adequate material for readability evaluation with the average reading to be at 10th grade level [19]. The study concluded that the apps included in the study were of high reading levels that were greater than that of the average patient, which might prevent patients from understanding the information they contain.

**Studies related to ‘quality and accuracy of apps’**

Owens et al. [19] also explored the quality of content provided by 14 PCAs. This was based upon accuracy, breadth, tone/framing and cultural sensitivity of the app’s content. Best Prostate Cancer Treatment, Oncotip, and Prostate Cancer by Magna Health Solutions were the 3 PCAs that had most extensive detail on prostate cancer covered. Authors found that 13 of the 14 apps studied had a neutral tone with regards to PSA testing. Oncotip was the only PCA that was pro-screening. Overall, the majority of apps tested provided an accurate and wide range of information and were of good quality. The overall rating of the ‘14 PCAs for cultural sensitivity for African Americans was low. Procee had the best rating for cultural sensitivity [19].

Bohme et al. [13] evaluated the quality of apps, using the Mobile Application Rating Scale (MARS) and German Cancer Society (GCS) instruments to determine the quality of information contained within the apps for breast, prostate and colorectal cancer. The tools had 3 domains (engagement, aesthetics and information) and 22 aspects were evaluated. 24 apps in the study were PCAs. Of all apps included in the study, around 48.78% were considered deficient or insufficient [13]. The authors reported the overall quality of apps which were targeted at patients were of better quality than those targeted at either healthcare professionals or the general population. The study highlighted deficient or insufficient scores for data protection.

**Studies related to ‘app usage’**

Three papers examined the usage of PCAs [14, 16, 22]. Hälleberg-Nyman et al. [16] and Sundberg et al. [22] both assessed the app ‘Interaktor’ and determined it to be a useful tool. Sundberg et al., found that when using the app for the real-time assessment of symptoms in prostate cancer patients undergoing radiotherapy, the control group (who did not use the app) displayed significantly worse emotional functioning at the end of radiotherapy when compared to the intervention group. Authors posited that this highlights the importance of the early detection and management of symptoms—something which apps can facilitate [22]. Furthermore, Hälleberg-Nyman et al. [16] found that patients using the app had a greater perceived participation in their care, which may be important in doctor–patient relationships and patient outcomes.

Brouard et al. [14] found that the majority of apps available had a focus on education as their main objective. They also found that the apps included in their study which were aimed at patients or the general population had less scientific validation than those targeted towards healthcare professionals [14].

**Studies related to ‘risk calculators’**

Two papers solely explored risk-calculator applications and their accuracy [12, 15]. De Nunzio et al., compared the performance of Rotterdam [27] and Coral [28] in 1682 patients undergoing prostate biopsies for suspected prostate cancer. Rotterdam was significantly better than the Coral at predicting overall (AUC: 0.70 versus 0.631, $p = 0.001$) and high-grade prostate cancer (0.75 versus 0.69, $p = 0.001$). Both apps were accurate and comparable in terms of usefulness (both > 80%), information quality (> 70%), interface quality (> 70%) and satisfaction (> 75%) [28]. However, 54% of participants preferred Rotterdam overall. Rotterdam also was deemed the best by Adam et al., who critically appraised 7 applications across both Android and iOS platforms [12, 15]. They found that the top-performing apps when using the uMARS scale (user version of the MARS scale) to assess quality, were Rotterdam, then Coral, and then the CPC Risk Calculator, although accuracy of all included apps was deemed acceptable [12].

**Individual applications includes studies evaluated by the authors**

Of the 12 papers included in the study, 44 apps were identified for which we collected data. Due to the rapidly developing nature of applications, at the time of the study 11 apps were no longer available to evaluate. The remaining 33 apps were mainly free, with only 2 requiring a subscription. As found by authors of the papers included in this review, the majority (59%) of the apps had an educational focus, with other objectives being risk assessment, support, or targeted towards clinicians for information or decision making. Interestingly only 5 of the apps had been updated within the last year, which may suggest that information within the other apps may not entirely up to date. The full analysis and breakdown of these apps and their content can be seen in Table 2.
| App content                                      | App                      | Platform          | Cost              | Rating | Number of reviews | Latest update | Developer                        | Platform description                                                                 |
|-------------------------------------------------|--------------------------|-------------------|-------------------|--------|-------------------|---------------|----------------------------------|-------------------------------------------------------------------------------------|
| Education—prevention (for the general public)   | 300 tips to prevent cancer | Google Play Store | Free              | 4.8    | 68                | 28/10/2018    | Let ME Hear Again Apps          | Provides daily health tips and articles on healthy foods                             |
| Cancer awareness                                | Google Play Store        | Free              | 0                 | 0      | 0                 | 03/02/2014    | Surendrasinh Champavat           | Provides information about prostate cancer e.g. regarding radiation, chemotherapy, and prevention |
| Cancer Conditions and Treatments                | Google Play Store        | Free              | 5                 | 3      | 0                 | 08/11/2013    | Space-O Infoweb, Inc            | Provides information about signs, symptoms, diagnosis, treatment, statistics and risk factors |
| Cancer Research News & Prevention Info          | Apple App Store          | Free (Pro is $3.86)| 5                 | 1      | 1                 | 19/11/2016    | Juicestand Inc                   | Provides users with latest cancer research news and prevention information          |
| PCFA Know Your Score WA                         | Apple App Store          | Free              | 0                 | 0      | 0                 | 25/01/2017    | CommunityToGo Pty Ltd           | Educates and informs users about prostate cancer                                   |
| Prostate Cancer                                 | Google Play Store        | Free, but $9.02 for in-app purchases | 3      | 1      | 28/10/2017        | Focus Medica India Pvt. Ltd      | Educates users on the anatomy of the prostate, and the symptoms, causes, risk factors, staging and prognosis etc. of prostate cancer |
| App content                     | App                                      | Platform       | Cost | Rating | Number of reviews | Latest update | Developer          | Platform description                                                                 |
|---------------------------------|------------------------------------------|----------------|------|--------|-------------------|---------------|--------------------|--------------------------------------------------------------------------------------|
| Prostate Cancer                 | Prostate Cancer                          | Google Play Store | Free | 4.3    | 15                | 22/03/2017    | Anastore           | Provides information about causes, symptoms and statistics regarding prostate cancer |
| Prostate cancer                 | Prostate cancer                          | Apple App Store | Free | 0      | 0                 | 04/03/2017    | Magna Health Solutions | Provides information about causes, symptoms and treatment of prostate cancer          |
| Prostate Pal 3                   | Prostate Pal 3                           | Apple App Store | Free | 5      | 1                 | 06/05/2015    | Ronald L. Yap, M.D  | Helps men track their prostate health                                                 |
| aPROCEE                         | aPROCEE                                  | Google Play Store | U    | U      | U                 | U             | Interactive Systems Research Group | No longer available                                                                 |
| aProstate Cancer Treatment and Prevention | aProstate Cancer Treatment and Prevention | Apple App Store | U    | U      | U                 | 11/07/2016    | Monica G           | No longer available                                                                 |
| aiCancer health: cancer care–virtual care at home | aiCancer health: cancer care–virtual care at home | U | U | U | U | U | U | No longer available |
| aCancer Support                 | aCancer Support                          | U              | U    | U      | U                 | U             | Fuzz Labs          | No longer available                                                                 |
| aZero Prostate Cancer News      | aZero Prostate Cancer News               | Google Play Store | U    | U      | U                 | U             | Jim Duthie         | No longer available                                                                 |
| aADT                            | aADT                                      | Apple App Store | Free | U      | U                 | U             | CancerAid PTY LTD  | Provides patients with medically reliable information                                |
| Education—for cancer patients   | CancerAid—empowering cancer patients and carers | Google Play Store | Free | 3.7    | 25                | 01/05/2019    | CancerAid PTY LTD  | Helps patients track treatment information, symptoms and medication use             |
| App content                  | App                        | Platform                  | Cost       | 🟢Rating         | Number of reviews | Latest update   | Developer                  | Platform description                                      |
|-----------------------------|----------------------------|---------------------------|------------|-----------------|-------------------|-----------------|---------------------------|----------------------------------------------------------|
| Focalyx                     | Apple App Store and Google Play Store | Free                      | 5—Google Play Store 6—Google Play Store 0—Apple App Store 0—Apple App Store | 18/11/2018       | Lyx Health       | For monitoring the diagnostic and treatment characteristics of men diagnosed with prostate cancer Allows for patient and physician interaction in-app |
| Best Prostate Cancer treatment | Apple App Store          | Free                      | 0          | 0               | 22/09/2017       | RL Technology, LLC | Provides ‘natural’ treatments Provides videos on how to ‘assist and cure’ cancer                             |
| itsaMANTHING                | Apple App Store and Google Play Store | Free                      | 5—Google Play Store 6—Google Play Store 0—Apple App Store 0—Apple App Store | 09/02/2015—Google Play Store 26/01/2015—Apple App Store | PROSTaid         | Provides information about prostate cancer symptoms, appointments, diagnosis, treatments Written by patients, for patients |
| Mens Health Facts and Tips  | Apple App Store           | Free                      | 2.4        | 2               | 14/08/2014       | Michael Quach   | Provides users with information regarding screening (also suitable for medical professionals, students, and the general public) |
| My Prostate Cancer Manager | Apple App Store           | Free                      | 0          | 0               | 16/01/2019       | @ Point of care  | Helps patients manage symptoms, track their progress, manage medication and treatment, and share their symptoms with health-care providers |
| App content                      | App                                   | Platform                        | Cost  | Rating | Number of reviews | Latest update | Developer         | Platform description                                                                                                                                 |
|----------------------------------|---------------------------------------|---------------------------------|-------|--------|-------------------|---------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| My Prostate Health Navigator     | Apple App Store                       | Free                            | 0     | 0      | 0                 | 10/10/2015    | Sourcetoad, LLC  | Provides up-to-date medical information and resources related to prostate cancer. Users can interact with other patients, physicians and watch videos. For the general public too. |
| MyHealthAvatar                   | Google Play Store                     | Free                            | 5     | 2      | 22/08/2018        | AnSmart       | Provides information, support and counselling to those affected by prostate cancer. Aids patients in monitoring their daily health e.g. activity tracking, mood tracking, medication tracking. |
| Prostate Cancer Support Group Gibraltar | Apple App Store                       | Free                            | 0     | 0      | 22/10/2016        | Alan Pereira  | Provides information about prostate cancer treatment, treatment side effects, and staging.                                                                 |
| Prostate Cancer Treatment        | Google Play Store                     | Free                            | 0     | 0      | 22/10/2018        | Creative Live Apps | Provides information about prostate cancer treatment, treatment side effects, and staging.                                                                 |
| NCCN Patient Guides for Cancer   | Apple App Store and Google Play Store | Free                            | 4.5—Google Play Store 0—Apple App Store | 4—Google Play Store 0—Apple App Store | 07/06/2017    | National Comprehensive Cancer Network (NCCN) | Easy-to-understand resources for patients, based upon clinical guidelines. Summary of key points and glossary for patients. |

*a*Interaktor U U U U U U No longer available
| App content                                      | App content                                      | Platform               | Cost       | #Rating | Number of reviews | Latest update   | Developer                  | Platform description                                                                                                                                 |
|------------------------------------------------|-------------------------------------------------|------------------------|------------|---------|-------------------|-----------------|--------------------------|---------------------------------------------------------------------------------------------|
| Education – for professionals and students     | Cancer mAPP                                      | Apple App Store        | Free       | 5       | 3                 | 02/10/2016      | Scott Berry              | A database of summaries from hundreds of clinical trials                                    |
|                                                 | iURO Oncology                                   | Apple App Store        | Free       | 5       | 1                 | 26/02/2016      | CommunityToGo Pty Ltd    | Contains narrated simulation videos to improve understanding of prostate cancer pathologies and therapies |
|                                                 | Wallpaper of the Salvador Gil Vernet Collection of Urology Drawings | Apple App Store and Google Play Store | Free | 0       | 0                 | 12/11/2017      | eldeAM- Google Play Store Josep Solanes Batllo, BlueBOARD—Apple App Store | Provides a selection of urology drawings from the Salvador Gil Vernet Collection—including gross anatomy, urogenital pathology, and surgical techniques |
|                                                 | "Cancer News Reader—research, drug directory, alternative treatments etc" | U                      | U          | U       | U                 | U               | U                        | No longer available                                                                                                                   |
|                                                 | "Cancer Screening"                              | U                      | U          | U       | U                 | U               | U                        | No longer available                                                                                                                   |
|                                                 | "Prostate Cancer MiMe"                          | U                      | U          | U       | U                 | U               | e-HIMS bvba              | No longer available                                                                                                                   |
| Screening— for clinicians                      | Cancer Genetics                                  | Apple App Store and Google Play Store | Free | 3.7—Google Play Store 5—Apple App Store | 18/02/2016—Google Play Store 05/02/2016—Apple App Store | UBQO Limited | Provides risk assessments and referral guidance for hereditary cancers                                                                 |
|                                                 | Coral—Prostate Cancer Risk and Survival          | Apple App Store        | Free       | 0       | 0                 | 06/04/2017      | Jon Giambattista         | Provides clinical nomograms specific to prostate cancer to guide clinical decision making |
| App content                  | App                                          | Platform                          | Cost               | Rating | Number of reviews | Latest update | Developer                  | Platform description                                      |
|------------------------------|---------------------------------------------|-----------------------------------|--------------------|--------|------------------|---------------|---------------------------|----------------------------------------------------------|
| Prostate Cancer Calculator  | Google Play Store                           | Free                              | 3.6                | 22     | 29/01/2017       | Bornifer LLC  | Calculates international prostate symptom score         |
|                              |                                             |                                   |                    |        |                  |               | Calculates PSA density, velocity and doubling time      |
|                              |                                             |                                   |                    |        |                  |               | Calculates risk of biopsy-detectable prostate cancer    |
|                              |                                             |                                   |                    |        |                  |               | Estimates the optimum number of prostate biopsy cores needed |
| Rotterdm Prostate Cancer Risk Calculator | Apple App Store and Google Play Store | $1.92—Google Play Store $2.57—Apple App Store | 4.5—Google Play Store 0—Apple App Store | 10—Google Play Store 0—Apple App Store | 24/04/2019—Google Play Store 10/04/2019—Apple App Store | Stichting SWOP, Nuno Azevedo | Provides a general risk calculation based upon PSA levels and other information such as MRI results |
| Prostate Volume and Density | Apple App Store and Google Play Store       | Free                              | 4.8—Google Play Store 0—Apple App Store | 5—Google Play Store 0—Apple App Store   | 16/04/2017 | iMedical Apps—Google Play Store Putu Angga Risky Raharja—Apple App Store | Helps healthcare professionals assess patients with enlarged prostates, by calculating the volume and density of patients' prostates |
| Screening—for patients and the general public and/or clinicians | Google Play Store | $1.92 | U | U | U | Peterson Leite | No longer available |
|                              | Apple App Store                             | Free                              | 0                  | 0      | 26/04/2017       | Phillip Dorch, MD | Calculates CAPRA score for patient with prostate cancer |

Table 2 (continued)
| App content       | App                  | Platform                  | Cost   | Rating | Number of reviews | Latest update | Developer                    | Platform description                                                                 |
|------------------|----------------------|---------------------------|--------|--------|-------------------|---------------|-------------------------------|---------------------------------------------------------------------------------------|
| NED              |                      | Apple App Store           | Free   | U      | 0                 |               | University health network     | Prostate Cancer survivorship App Sends automated notifications to clinicians about PSA and recorded symptoms Reminders to complete wellness and quality of life questionnaires' |
|                  |                      | Google Play Store         |        |        |                   |               |                               |                                                                                       |
| Capra-S Calculator|                      | Apple App Store           | $1.28  | 0      | 0                 | 26/04/2017    | Phillip Dorch                 | Assesses the risk of prostate cancer recurrence after first-line surgery, and provides predictions at 3 and 5 years post-surgery |
| IPCRC            |                      | Google Play Store         | Free   | 5      | 65                | 18/02/2016    | Prahara Yuri, fath2app        | Provides risk calculation based on age, PSA, prostate volume and DRE findings           |
| CPC Risk Calculato r |                      | Apple App Store and Google Play Store | Free | 0 | 0 | 30/11/2016 | Daman P/S | Estimates risk of biochemical recurrence after radical prostatectomy |

*App not available on current versions of platforms; U; data unavailable; Cost in USD; converted from GBP on 07/02/20 (1GBP = 1.29USD)
Discussion

This systematic review has identified 44 PCAs targeting the general population, patients and clinicians, with a majority (33 of 44) of them focusing on education. It is the authors view that existing PCA’s are currently in its infancy and do require further development before widespread integration into existing clinical practise. The apps covered topics such as lifestyle changes, and information on prostate cancer including treatment options, PSA screening, symptomatology, diagnostics, statistics, research and prostate anatomy. Three prostate cancer risk calculators (Rotterdam, CORAL and CPC) were identified which provided estimates on prostate cancer diagnosis and biochemical recurrence following radical prostatectomy. Rotterdam was the best performer amongst the 3 risk calculators. Most PCAs were rated to have a high standard of readability, raising concerns that a proportion of the patient population may not be able to adequately comprehend the available information in them. Additionally, one study reported deficient or insufficient quality for data protection for cancers apps [13]. The gross majority (36 of 43) of the PCAs haven’t been updated in the last year and, therefore, there is doubt if the existing data in these apps is current.

PCAs have the potential to have a number of roles in the contemporary management of prostate cancer. Healthcare organisations world-wide have adopted the principles of shared care decision making (SDM) between a healthcare professional and patients [29, 30]. PCAs, in addition to existing Decision Aids (DA) can be useful adjuncts to clinical counselling, facilitating well-informed clinical decision making, improve clinician-patient communication and as a consequence leading to a favourable patient experience [29]. PCAs such as Interaktor and MyHealthAvatar (MHA) are such PCAs that have been developed as supportive aids that compliment clinical consults. Hälleberg-Nyman et al. [16] in qualitative study reported patient-reported satisfaction scores to be better in patients receiving radiotherapy, when clinical consults were supplemented with the interactive app, Interaktor, corroborating the aforementioned view. In prostate cancer, SDM with DAs is particularly pertinent, due to controversies in areas such as prostate cancer screening and the availability of plethora of therapeutic options [31]. In this review, a number of PCAs addressed the subject of PSA screening and reassuringly most PCAs had a neutral tone for PSA screening. PCAs can be useful adjuncts to clinical consults in this context, conforming to the principles of informed patient choice and avoiding decision regret.

Prostate cancer diagnostics has seen significant evolution in recent years with strategies such as pre-biopsy multi-parametric MRIs [32]. This trend is likely to continue with the pursuit for biomarker technologies in prostate cancer [32]. Assimilation and presentation of ever-growing data from existing and novel diagnostic tools, in short clinical consults can be challenging. PCAs such as Rotterdam and CORAL integrate data from diagnostic tools and demographics, subsequently presenting an estimated risk of prostate cancer [27, 28]. PCAs such as Rotterdam and CORAL are hence invaluable aids to clinicians, allowing for seamless, efficient and accurate patient counselling. However, it is important to note that whilst Rotterdam does include MRI results as a criterion, CORAL does not, which may affect the accuracy of the result. Similarly, biochemical recurrence predictions following curative local treatments can be challenging and CPC calculators are therefore useful tools for clinicians [26]. Innovative Prostate cancer survivorship programmes will be required to manage an increasing population of prostate cancer survivors. Chu et al. [33] in a retrospective review reported over 95% patient satisfaction rates and individual patient savings of 193 US dollars with telemedicine delivered care. PCAs such as NED lineate well with prostate survivorship programmes and can be employed for post-treatment surveillance without the need for periodic attendance at hospital. This has benefits to patients living in remote locations with poor health care accessibility and also cost-saving benefits to healthcare organisations and individual patients.

Predictive analytics is increasing being adopted in healthcare to improve operational efficiency and disease management [34]. Studying behavioural and lifestyle patterns across a wide range of demographics can facilitate the identification of causal relationships. Medical apps are a useful information communication technology for large volume real-world data collection mitigating some of the challenges of traditional data collection. MyHealthAvatar (MHA) is PCA that has the ability to collate demographic, behavioural, lifestyle, and medical data for prostate cancer patients [23, 25]. These allow for analysing data in multiple clinical scenarios and can, therefore, lead to the creation of various virtual patient populations. These provide invaluable data to healthcare providers which may contribute to future stratified individualised care [35].

Despite the potential benefits of medical health apps in general and PCAs specifically, the potential for harm is real. PCAs must be accurate, easily comprehensible, un-biased and regularly updated. This review suggests that PCAs do not consistently fulfil all these pre-requisites. Brouard et al. [14] reported a majority of medical apps targeted at patients and the general population haven’t had scientific validation. Misinformation can lead to anxiety, over-diagnosis and overtreatment. It is therefore vital these apps are appropriately governed by stringent regulation to ensure patient safety. In Europe and the United Kingdom, current guidelines recommend only app with a CE marking are approved for clinical use [36]. Local institutions would be advised to have agreed on protocol of PCAs usage in clinical practise [36]. Bohme
et al. [13] reported most cancer apps to deficient or insufficient in data protection and, therefore, caution must be exercised before patient sensitive information is added to these apps. Furthermore, healthcare professionals must be provided with formal education on the potential harms of modern day medical apps so as to ensure responsible usage.

Limitations of our study included the exclusion of grey literature, and papers not written in English. Although there are other sources of social media such as twitter, YouTube and google search engines, however in this paper we focussed on the telephone-based apps only. Due to the constant changes in the nature of apps, older software was not always updated and occasionally removed in time, hence our inability to find some of the apps mentioned in the papers analysed.

Conclusion

There are a wide variety of PCAs available targeting the general population, patients and clinicians, with a majority of them focusing on education. The apps covered topics such as lifestyle changes, and information on prostate cancer including treatment options, PSA screening, symptomaticology, diagnostics, statistics, research and prostate anatomy. A number of PCAs haven’t undergone scientific validation. There are concerns with data protection, high readability standards and lack of information update in current PCAs. There must be increased awareness among patients and clinicians about existing PCAs and their limitation so as to ensure safe and responsible usage. It is the authors view that existing PCAs are currently in its infancy and do require further development before widespread integration into existing clinical practise. If developed appropriately with responsible governance, they do have the potential to play important roles in modern day prostate cancer management.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

1. Aceto G, Persico V, Pescapê A (2018) The role of Information and communication technologies in healthcare: taxonomies, perspectives, and challenges. J Netw Comput Appl 107:125–154
2. Maurer T, Eiber M (2019) Practice changing for prostate cancer: a vision of the future. Nat Rev Urol 16(2):71–72
3. Techopedia (2019) Mobile application. https://www.techopedia.com/definition/2953/mobile-application-mobile-app. Accessed 6 Aug 2019
4. Jamnadass E, Aboumarzouk O, Kallidonis P, Emiliani E, Tailly T, Hruby S et al (2018) The role of social media and internet search engines in information provision and dissemination to patients with kidney stone disease: a systematic review from european association of urologists young academic urologists. J Endourol 32(8):673–684
5. Iqbal M (2019) App download and usage statistics (2019). https://www.businessofapps.com/data/app-statistics/. Accessed 6 Aug 2019
6. Kemp S (2019) Digital 2019: global internet use accelerates. https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates. Accessed 6 Aug 2019
7. Wurmser Y (2019) Mobile time spent 2018—will smartphones remain ascendant? https://www.emarketer.com/content/mobile-time-spent-2018. Accessed 6 Aug 2019
8. Colwyn S (2019) New consumer media consumption research. https://www.smartinsights.com/marketplace-analysis/customer-analysis/consumer-media-device-use/. Accessed 6 Aug 2019
9. Redbytes (2019) Growing prevalence of healthcare mobile apps in the UK. https://www.redbytes.co.uk/mobile-health-app-usagelstatistics/. Accessed 6 Aug 2019
10. Higgins JP, Green S (2008) Cochrane handbook for systematic reviews of interventions. Wiley, Chichester
11. Moher D, Liberati A, Tetzlaff J et al (2009) Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 6(7):e1000097
12. Adam A, Hellig JC, Perera M, Bolton D, Lawrentschuk N (2018) ‘Prostate Cancer Risk Calculator’ mobile applications (Apps): a systematic review and scoring using the validated user version of the Mobile Application Rating Scale (uMARS). World J Urol 36(4):565–573
13. Bohnke C, von Osthoff MB, Frey K, Hubner J (2018) Qualitative evaluation of mobile cancer apps with particular attention to the target group, content, and advertising. J Cancer Res Clin Oncol 144(1):173–181
14. Brouard B, Bardo P, Bonnet C, Mounier N, Vignot M, Vignot S (2016) Mobile applications in oncology: is it possible for patients and healthcare professionals to easily identify relevant tools? Ann Med 48(7):509–515
15. De Nunzio C, Lombardo R, Tema G, Cancrini F, Russo GI, Chacon R et al (2019) Mobile phone apps for the prediction of prostate cancer: external validation of the Coral and Rotterdam prostate guidelines prediction tools. Eur J Surg Oncol 45(3):471–476
16. Halleberg Nyman M, Frank C, Langius-Eklund A, Blomberg K, Sundberg K, Wengström Y (2017) Patients’ perspective on participation in care with or without the support of a smartphone app during radiotherapy for prostate cancer: qualitative study. JMIR Mhealth U health 5(7):e107
17. Kim C, Prabhu AV, Hansberry DR, Agarwal N, Heron DE, Beriwal S (2019) Digital era of mobile communications and smartphones: a novel analysis of patient comprehension of cancer-related information available through mobile applications. Cancer Invest 37(3):127–133
18. Langius-Eklund A, Christiansen M, Lindstrom V, Blomberg K, Halleberg Nyman M, Wengström Y et al (2017) Adherence to report and patient perception of an interactive app for managing symptoms during radiotherapy for prostate cancer: descriptive study of loged and interview data. JMIR Cancer 3(2):e18
19. Owens OL, Beer JM, Reyes LI, Thomas TL (2019) Systematic review of commercially available mobile phone
applications for prostate cancer education. Am J Mens Health 13(1):155798318816912
20. Pereira-Azevedo N, Osorio L, Fraga A, Roobol MJ (2017) Rotterdam prostate cancer risk calculator: development and usability testing of the mobile phone app. JMIR Cancer 3(1):e1
21. Roder MA, Berg KD, Loft MD, Thomsen FB, Ferrari M, Kurbe-govic S et al (2018) The CPC risk calculator: a new app to predict prostate-specific antigen recurrence during follow-up after radical prostatectomy. Eur Urol Focus 4(3):360–368
22. Sundberg K, Wengstrom Y, Blomberg K, Halleberg-Nyman M, Frank C, Langius-Eklöf A (2017) Early detection and management of symptoms using an interactive smartphone application (Interaktor) during radiotherapy for prostate cancer. Support Care Cancer 25(7):2195–2204
23. Zhang X, Deng Z, Parvinzamir F, Dong F (2018) MyHealthAvatar lifestyle management support for cancer patients. Ecancermedicine 12:849
24. Pham Q, Cafazzo JA, Feifer A (2017) Adoption, acceptability, and effectiveness of a mobile health app for personalized prostate cancer survivorship care: protocol for a realist case study of the Ned app. JMIR Res Protoc 6(10):e197
25. AnSmart (2018) MyHealthAvatar. Accessed 22 Aug 2018
26. Daman PS (2016) CPC Risk Calculator. Accessed 30 Nov 2016
27. Stichting SWOP, Azevedo N (2019) Rotterdam Prostate cancer risk calculator In: 24/04/2019 on Android, 10/04/2019 on iOS
28. Giambattista J (2017) Coral—prostate cancer risk and survival. Accessed 6 Apr 2017
29. Stacey D, Légaré F, Lewis K, Barry MJ, Bennett CL, Eden KB et al (2017) Decision aids for people facing health treatment or screening decisions. Cochrane Database of Syst Rev 2017:4
30. (2019) https://www.england.nhs.uk/rightcare/useful-links/share d-decision-making/. Accessed 26 Oct 2019
31. Riikonen JM, Guyatt GH, Kilpelahti TP, Craigie S, Agarwal A, Agoritsas T et al (2019) Decision aids for prostate cancer screening choice: a systematic review and meta-analysis. JAMA Internal Med 179(8):1072–1082
32. Logothetis CI, Aparicio A, Koinis F, Corn PG, Efstathiou E (2019) Prostate cancer: quo vadis? Eur Urol 76(6):709–711. https://doi.org/10.1016/j.euro.2019.06.031
33. Chu S, Boxer R, Madison P, Kleinman L, Skularus T, Altman L et al (2015) Veterans affairs telemedicine: bringing urologic care to remote clinics. Urology 86(2):255–260
34. Chen J, Remulla D, Nguyen JH, Aastha D, Liu Y, Dasgupta P et al (2019) Current status of artificial intelligence applications in urology and their potential to influence clinical practice. BJU Int 124(4):567–577
35. Spanakis EG, Yang, P, Deng Z, Sakkalis V, Kafetzopoulos D., Marias, K, Tsiknakis MN, Dong F (2014) MyHealthAvatar: personalized and empowerment health services through Internet of Things technologies. In: 4th international conference on wireless mobile communication and healthcare
36. https://www.gov.uk/government/publications/medical-devic es-software-applications-apps. Accessed 26 Oct 2019

Publisher’s Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.