Review of Digitalized Patient Education in Cardiology: A Future Ahead?

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Abstract

Introduction: An increased focus on shared decision-making and patient empowerment in cardiology and on patient outcomes such as quality of life (QoL), depression, and anxiety underline the importance of high-quality patient education. Studies focusing on digital means of patient education performed in other disciplines of medicine demonstrated its positive effect in these areas. Therefore, a review of the current literature was performed to (i) evaluate the status of innovative, digitalized means of patient education in cardiology and (ii) assess the impact of digital patient education on outcome parameters (i.e., patient knowledge (or health literacy), QoL, depression, anxiety, and patient satisfaction). ***Method:*** A review of the current literature was performed to evaluate the effect of digitalized patient education for any purpose in the field of cardiology. Medline and EMBASE were searched for articles reporting any digital educational platform used for patient education up to May 2020. The articles were compared on their effect on patient knowledge or health literacy, QoL, depression or anxiety, and patient satisfaction. ***Results:*** The initial search yielded 279 articles, 34 of which were retained after applying in, and exclusion criteria. After full-text analysis, the total number of articles remaining was 16. Of these, 6 articles discussed the use of smartphone or tablet applications as a means of patient education, whereas 3 reviewed web-based content, and 7 evaluated the use of video (2 three-dimensional videos, from which one on a virtual reality headset). ***Conclusion:*** This review demonstrates that digital patient education increases patient knowledge. Overall, digital education increases QoL and lowers feelings of depression and anxiety. The majority of patients express satisfaction with digital platforms. It remains important that developers of digital patient education platforms remain focused on clear, structured, and comprehensible information presentation.

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Introduction

Patient education is gaining importance due to an increased focus on shared decision-making and patient empowerment in cardiology. Patient outcome metrics such as quality of life (QoL), therapy adherence, depression, or

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anxiety are influenced by patient education [1]. Previous research demonstrates potential improvements in patient education based on "demand-matched" education, that is, the individualization of content, the use of combined media, and more patient-centered information [1–3]. Although the importance of adequate patient education is known and several methods to improve education have been explored, the current approach remains insufficient to fulfill the expectations and demands of patients and cardiologists [4]. Whereas a mere 16% of patients were able to explain the benefits of a procedure after a standard care preprocedural consultation, 40% could do so after watching an informative video [5]. This hiatus in patient knowledge could cause anxiety and depression, with subsequent loss of QoL.

The involvement of digitalized education modalities such as smartphone applications, videos (three-dimensional [3D]), web-based content, or virtual reality (VR) is increasingly embraced in patient education in many disciplines of medicine [6–8]. These modalities include the latest innovations in the field of digital media such as 3D videos or VR, which may provide new dimensions for patient education. The use of immersive patient education formats that align with the patient's situational and environmental expectations in a preoperative setting appears to be an effective tool to alleviate anxiety [9]. Furthermore, the availability of useful and well-presented preprocedural information in printed, video, and/or VR may contribute to additional anxiety reduction [10–13].

Limited research has been performed to evaluate the technology readiness and effectiveness of these innovative means of patient education in cardiology. The field of cardiology could leverage these technologies to increase patient empowerment and QoL, therapy adherence, and decrease patient depression or anxiety [1–3]. Therefore, the aims of this review are 2-fold: (i) evaluating the status of digital patient education in cardiology and (ii) assessing the impact of digital patient education on outcome measures like patient knowledge or health literacy, QoL, anxiety or depression, and patient satisfaction.

Methods

Literature Search
Both Medline and EMBASE were used to search the published literature for studies up to May 6, 2020. The search was developed iteratively for synonyms of "cardiology" and "patient education," which could be combined with "animation," "augmented reality," "brochures," "digital," "digitalized," "educational video," "infor-mation," "immersive," "serious game," "telerehabilitation," "video," "virtual reality," or "website," in both controlled vocabulary (i.e., MeSH) and free text words. Nonhuman studies, reviews, studies not focused on cardiology, studies not focused on digital platforms of patient education, or non-English articles were excluded. The reference list and cited articles were checked for additional articles.

Selection of Studies
Studies were included if they applied a digital format for patients to learn more about their disease or an upcoming procedure (i.e., smartphone or tablet application, video, web-based content, or VR). Screening, eligibility, and inclusion were performed in full by 2 authors (M.O.P. and J.H.). Disagreements concerning eligibility were resolved by discussion.

Extraction of Data
The extracted data from each article were author, publication year, study design, used modality, patient population, protocol, outcome, result on health literacy or patient knowledge, QoL, depression or anxiety, patient satisfaction, the number of patients, and if applicable, the amount of patients in the intervention and control groups. The studies were categorized into 3 outcome categories: patient knowledge (also known as health literacy), QoL, depression or anxiety, and patient satisfaction.

Results

Search Result
During screening, 268 articles were selected based on title and abstract. Figure 1 shows the flowchart for the article selection. 234 articles were excluded because they (i) did not provide a digital way of patient education, (ii) were not based on cardiology, (iii) were review articles or case-reports, (iv) focused on healthcare professionals instead of patients, or (v) were not written in the English language. Thirty-four articles were read in full, after which another 18 articles were excluded; 5 focused on training nurses in patient communication, 2 focused on telemonitoring, another 2 focused on exercise training, and 9 were merely descriptive and did not include patient evaluation. The final analysis consisted of 15 articles and 1 abstract (Fig. 1). Figure 2 shows a heatmap of the found articles by digital platform and evaluated outcome metrics. The bigger the circle, the more articles were found on the platform with corresponding outcome measure. A green circle indicates a positive effect, while a grey circle indicates no significant change. The light blue background color indicates sparse research in the domain, while dark blue indicates dense research in the domain.
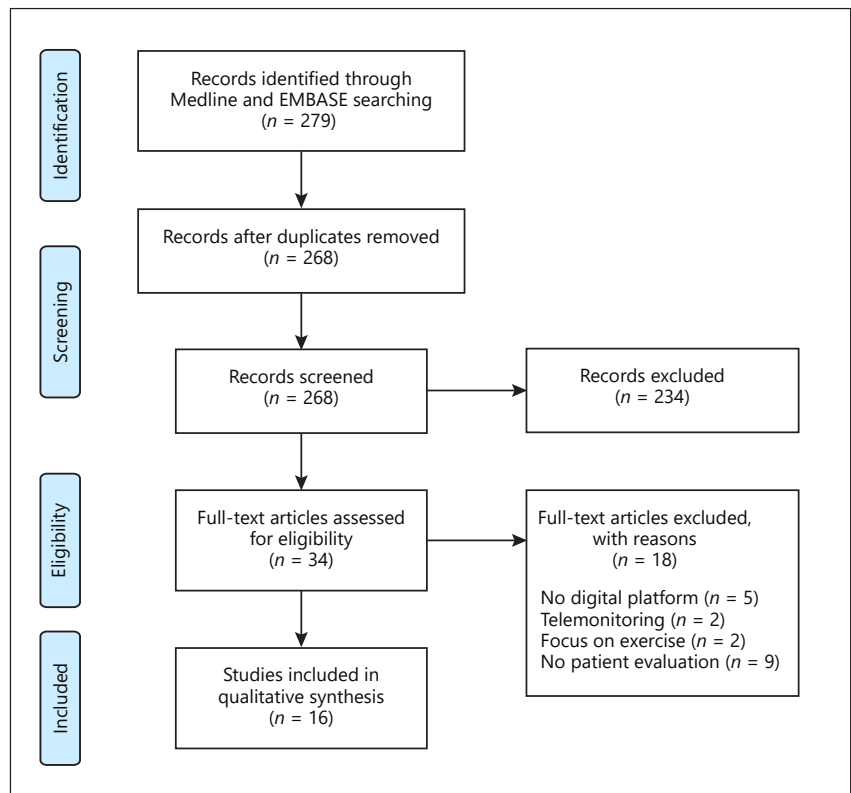
Fig. 1. Flow diagram of search query.

Patient Population

In total, 2,481 adult patients (59.5% male; mean age 64.8 ± 7.6 years) were analyzed. In 106 patients, the gender was not described, nor was the exact age in 536 patients (all over 18 years old). Nine articles divided their population into a control group (845 patients, 34% of the total patient population) and an intervention group (815 patients, 33% of the total patient population).

Patient Education Methods

Six papers focused on the use of smartphone or tablet applications on patients with coronary artery disease (1), heart failure (3), diagnostic catheterization (1), or heart patients in general (1). Three papers evaluated the use of a web-based environment on patients with congenital heart disease (1), coronary angiography (1), and heart failure (1). Another 7 papers focused on (3D) video education in preprocedural setting for coronary angiography (3), electrophysiology (1), or catheterization (2). Last, 1 paper evaluated the use of a 3D video in a VR headset on patients suffering from atrial fibrillation. An overview of the selected articles, their used modality, protocol, outcome, effect on patient knowledge, QoL, depression or
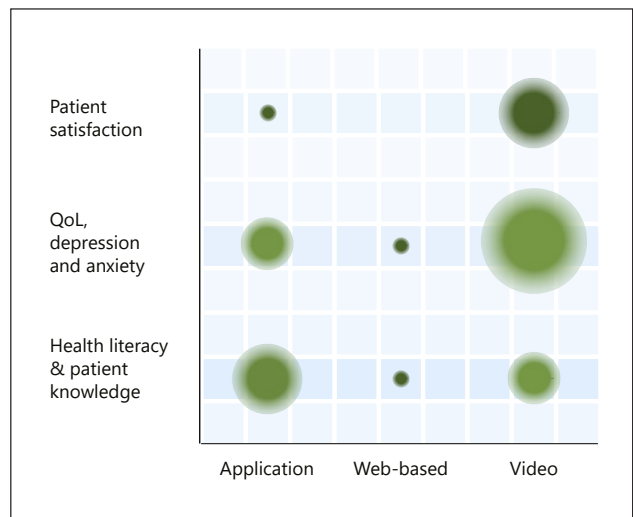
Fig. 2. Heatmap of the found articles by digital platform and evaluated outcome metrics. The bigger the circle, the more articles were found on the platform with corresponding outcome measure. A green circle indicates a positive effect, while a grey circle indicates no significant change. The light blue background color indicates sparse research in the domain, while dark blue indicates dense research in the domain.

anxiety, patient satisfaction, and the division in control and intervention group is shown in Table 1.

The majority of papers focused either on a smartphone or tablet application or on video (6 papers about smartphone or tablet application and 7 about video). Three of the 6 papers focusing on smartphone applications used a control group to test their application. Hägglund et al. [14] compared their tablet software with standard care on patients suffering from heart failure. Melin et al. [15] focused exclusively on patients with heart failure and divided their population into a control group receiving standard care, and an intervention group receiving a tablet computer with connection to a weighing scale and information on how to improve life with heart failure. Tait et al. [16] divided their population into either standard care or an intervention with an interactive tablet computer-based information program on which they received information about their heart, condition, and procedure. In the video education, all 6 papers compared patients watching the video to standard care. Goldberger et al. [17] and Gökçe and Arslan [18] performed divided patients into groups receiving written, oral, or video information with the exact same content in each group. Lattuca et al. [19], Herrmann and Kreuzer [10], and Gökçe and Arslan [18] focused on coronary angiography, Ruffinengo et al. [20] and Torrano et al. [5] applied their video for catheterization, and Goldberger et al. [17] evaluated the video on diagnostic electrophysiology. Only Doll et al. [21] compared their web-based education about coronary angiography on a control group. The remaining 6 studies did not compare the effects of visualized patient information to a control group but measured the effect of their modality on heart patients.

Result of Used Modality on Patient Knowledge, QoL, Depression, Anxiety, or Patient Satisfaction
Smartphone or Tablet Application
Six articles evaluated the use of a smartphone or tablet application, from which 4 measured the possible increase of patient knowledge, 2 measured the QoL, depression, or anxiety, and 3 evaluated patient satisfaction. Hägglund et al. [14] showed a statistically nonsignificant improvement in patient knowledge, as their control and intervention groups did not differ significantly enough. Melin et al. [15], Strömberg et al. [22], and Tait et al. [16] used an application on either a smartphone or tablet to increase patient knowledge. Melin et al.'s [15] study found that after 6-month follow-up patients displayed better self-care and better engagement during consulta-

tion sessions. Tait et al.'s [16] study found that patients using the tablet computer had significantly better recall of the information compared to the group receiving written and verbal information. Strömberg et al.'s [22] study found that using a web-based content helped patients understand their own disease better. In terms of QoL, Melin et al. [15] found that after 6-month follow-up patients scored higher on the Kansas City Cardiomyopathy Questionnaire (72.7 in the intervention group vs. 51.8 in the control group) using a tablet application. Hägglund et al. [14] found a significant increase in QoL measured by means of the SF-36 questionnaire (65.1 vs. 52.1). Cho et al. [23] and Jain et al. [24] both evaluated an application and found that patients found the smartphone application useful. Strömberg et al. [22] found that patients were either satisfied or very satisfied using the web-based environment for gaining information about their disease.

Web-Based Education
Three papers discussed the use of web-based education, 2 measured patient knowledge, and 1 evaluated the QoL. Valente et al. [25] and Doll et al. [21] all used web-based content to increase patient knowledge. These authors found that using a web-based content helped patients understand their own disease better. Delgado et al. [26] showed an increase in QoL based on the Minnesota Living with Heart Failure Questionnaire after 3 months, but this effect was not statistically significant.

Video-Based Education
Seven articles evaluated the use of video-based content, from which 4 measured the possible increase of patient knowledge, 5 measured the QoL, depression, or anxiety, and 3 evaluated patient satisfaction. Torrano et al. [5] and Lattuca et al. [19] demonstrated that questions on planned procedures were better answered by the intervention group, compared to the control group (Torrano et al. [5]: 75 ± 17 vs. 32 ± 19; Lattuca et al. [19]: 12 ± 3 vs. 10 ± 3). Goldberger et al. [17] evaluated a short questionnaire to patients after their oral, written, or video information about their understanding of diagnostic electrophysiology but did not find a significant difference in patient knowledge between formats (patient scores 6 ± 2, 4 ± 2, and 5 ± 2, respectively). Their work was the sole publication that did not find an effect on QoL, depression or anxiety, and patient satisfaction before and after either of the 3 consent formats. Herrmann and Kreuzer [10], Ruffinengo et al. [20], and Gökçe and Arslan [18] all found a decrease in anxiety when showing a video to pa-

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Table 1. Overview of patient education modalities found in reviewed literature

Author	Year	Study design	Used modality	Patient population	Protocol	Outcome	Health literacy and patient knowledge	QoL, depression, and anxiety	Patient satisfaction	N	Inter-vention	Control
Cho et al. [23]	2014	Single group assignment, interventional study	Application	Coronary artery disease	An educational app was developed and provided to patients with coronary artery disease. Questionnaires were completed and assessed to score patient satisfaction with the provided app	Patients were satisfied with the usefulness of the app	na	na	↑	30	30	na
Hägglund et al. [14]	2015	Randomized controlled trial	Application	Heart failure	Intervention group patients received a tablet with specialized software in combination with a wireless connected weight scale. In the perspective of the provided patient education, health-related QoL and knowledge about heart failure were assessed. The control group only received conventional information	No significant difference was found for patient knowledge. On the other hand, health-related QoL was improved significantly within the intervention group in comparison with the control group	–	↑	na	82	41	41
Melin et al. [15]	2018	Randomized controlled trial	Application	Heart failure	Intervention group patients received a tablet as telemedicine tool providing them with information and advice. Control group patients were subjected to standard care. Within the context of patient education, health-related QoL scores were measured, and knowledge scales, days in the hospital, and adherence were analyzed	Significant improvement in health-related QoL was observed within the intervention group, even as a significant difference in knowledge in favor of the intervention group, and a significant reduction in hospital days	↑	↑	na	72	32	40
Stormberg et al. [22]	2006	Randomized controlled trial	Application	Heart failure	Computer-based interactive patient education program was evaluated for effects on knowledge, compliance, and QoL. Patients were randomized to either receiving solely conventional education or conventional education in combination with information provided with the computer-based program	Knowledge was significantly increased within the intervention group. Patients were either satisfied or very satisfied using the web-based environment for gaining information about their disease	↑	na	↑	42	42	na
Tait et al. [16]	2014	Randomized controlled trial	Application	Diagnostic catheterization	Patients were randomized to receive information about their procedure via standard modalities (verbal and written) or information provided with an interactive iPad-based informational program. Patient knowledge was assessed in both groups before and after the procedure	Patient knowledge was significantly higher within the intervention group	↑	na	na	164	83	81
Jain et al. [24]	2019	Single group assignment, interventional study	Application	Heart patients in general	A smartphone-based educational mobile application for heart patients was developed and assessed for user experience and satisfaction	The modality was found user-friendly, and patients were satisfied with the functionality	na	na	↑	35	35	na
Valente et al. [25]	2013	Prospective multicenter study	Web-based	GUCH	Patients were provided with information deriving from web-based resources. Evaluation was done with multiple surveys	The provided information modality resulted in significant improvement of patient knowledge	↑	na	na	520	520	na
Doll et al. [21]	2019	Randomized study	Web-based	Diagnostic coronary angiography	In this cluster-randomized study, the effects of a web-based decision-aid tool were assessed in terms of patient knowledge, attitudes, and preferences. Cardiologists were assigned to receive vs. not receive patient preferences, with subsequent assessment of treatment decision	Decision aid was associated with increased patient knowledge and greater interest in shared decision-making. No difference was found for change in patient preferences and concordance between preference and treatment	↑	na	na	203	103	100
Delgado et al. [26]*	2003	Single group assignment, interventional study	Web-based	Heart failure	Pilot study on the efficacy of an informational website. QoL scores (Minnesota Living with Heart Failure) were obtained at baseline and 3-month follow-up	Patients reported high levels of satisfaction with the concerned website. Furthermore, multiple QoL score domains related to social and personal activities (of the used MLHFQ-questionnaire) improved significantly	na	↑	na	16	16	na

Table 1 (continued)

Author	Year	Study design	Used modality	Patient population	Protocol	Health literacy and patient knowledge	QoL, depression, and anxiety	Patient satisfaction	N	Intervention	Control
Lattuca et al. [19]	2018	Prospective, randomized study	Video	Coronary angiography	Evaluation of a 3D information video in comparison with standard information provided to patients who were admitted to scheduled coronary angiography. Patients were asked to complete information questionnaire, and satisfaction and anxiety scale afterward	↑	–	↑	821	406	415
Goldberger et al. [17]	2011	Randomized study	Video	Diagnostic cardiac electrophysiology study	Patients undergoing initial diagnostic cardiac electrophysiology study were randomly assigned to oral, written, or video informed consent	–	–	–	63 (20 oral, 22 written, 21 video)		
Ruffinengo et al. [20]	2009	Randomized controlled trial	Video	Coronary angiography	Evaluation of an informative video on anxiety levels and patient satisfaction	na	↑	↑	93	48	45
Herrmann and Kreuzer [10]	1989	Randomized controlled trial	Video	Heart catheterization	Both intervention and control groups received conventional information via personal interview with the doctor and printed information on a leaflet. Intervention group patients were additionally provided with an educational video. Anxiety scores were obtained in both groups with an anxiety questionnaire (State–Trait Anxiety Inventory)	na	↑	na	65	33	32
Gökçe and Arslan [18]	2019	Randomized controlled trial	Video	Coronary angiography	Trials were designed to investigate possible effects of video and written education on procedure-related anxiety. Patients were assigned to written, oral, or video patient education. In all patients, physiological variables were measured and anxiety scores (State–Trait Anxiety Inventory) were obtained before education, before the procedure, and after the procedure	na	↑	na	90 (30 oral, 30 written, and 30 video)		
Torrano et al. [5]	2011	Cross-sectional study	Video	Diagnostic catheterization	Patients undergoing their first diagnostic catheterization procedure were provided with a video concerning information of and guidance on the intervention. The intervention group watched the information video before completing the questionnaire; the control group first completed the questionnaire and then watched the video. The questionnaire was used to assess the effects of the information video on patient knowledge and health literacy	↑	na	na	94	45	49
Balsam et al. [27]	2019	Single group assignment, interventional study	VR	Atrial fibrillation patients	This study assessed the effectiveness of a 3D VR video to provide patients with information about the risks of stroke in atrial fibrillation and pharmacological stroke prevention. The VR video was provided with oculus glasses and a smartphone. Patients were asked to complete a questionnaire before, 1 week after, and 1 year after the projection	↑	na	na	100	100	na

Outcome (column):
- Lattuca et al. [19]: Information score and satisfaction were higher in the video information group; anxiety did not differ
- Goldberger et al. [17]: All formats have similar effects on anxiety and patient comprehension. The oral informed consent requires more physician time
- Ruffinengo et al. [20]: The use of an informative video has significant effects on anxiety reduction and patient satisfaction improvement
- Herrmann and Kreuzer [10]: While anxiety scores within the control group remained unchanged, anxiety score within the intervention group improved significantly
- Gökçe and Arslan [18]: Written and video education both led to significantly lower anxiety scores prior to the procedure in comparison with conventional oral information
- Torrano et al. [5]: Intervention group patients scored significantly higher on the procedure-related knowledge questionnaire. The guidance video was found effective in improving patient knowledge and health literacy
- Balsam et al. [27]: Significantly more patients were aware of the risk of stroke as a consequence of AF directly after watching the VR video (22% vs. 83%; $p < 0.0001$). This awareness-effect remained during the 1-year-follow-up (71.1%)

QoL, quality of life; VR, virtual reality; 3D, three dimensional. * Only abstract available.

tients about their procedure. Lattuca et al. [19] found a statistically insignificant ($p = 0.07$) trend toward decrease in anxiety. In terms of patient satisfaction, the authors found that the self-reported satisfaction with the video format was higher than the standard care (8.4 ± 1.9 vs. 7.7 ± 2.3 on a dedicated 16-point questionnaire). Ruffinengo et al. [20] found that the satisfaction level was significantly higher in patients receiving the video format compared to standard care on the visual analogue scale ($p = 0.00001$). Balsam et al. [27] was the only article to describe a VR video to educate patients. The education was focused on the disease itself, as well as on therapy and possible complications. They found that significantly more patients in the intervention group were aware of the risk of stroke as a consequence of atrial fibrillation, compared to the control group (83 vs. 22%; $p < 0.0001$). This effect remained during the 1-year-follow-up period (71 vs. 23%; $p < 0.0001$).

Discussion

This review compares 3 digital patient educational platforms for patient knowledge, QoL, depression or anxiety, and patient satisfaction, within the field of cardiology. We found that 3 main platforms were used in this search, namely education video, smartphone or tablet application, and web-based information. One article is based on a 3D video on a VR headset, possibly due to the novelty of the platform. Overall, the authors demonstrated a positive effect on the primary outcomes of patient knowledge, QoL or anxiety, and patient satisfaction. Most articles evaluate at least one or more of these outcome measurements, which enables a direct comparison between papers.

Previous studies on digital patient education in other fields of medicine demonstrated that digital patient education improves patient knowledge, QoL, decreases depression and anxiety, and increase satisfaction. In orthopedics, a smartphone application was developed to educate patients in the first 4 weeks after total knee replacement. The application had a positive effect on QoL, self-care, and patient satisfaction [28]. In oncology, White et al. [29] found an increased QoL in women with breast cancer when evaluating an information-based website. In dermatology, Migden et al. [30] evaluated that the use of video increased patient knowledge on how to properly perform wound care. Especially, information retention seemed to be drastically improved by digital patient education. We expected these positive results to hold similarly true for cardiology patient education.

The results of this review show 3 major digital platforms, namely smartphone or tablet application, web-based, and video content. Teaching patients via web-based content seems achievable since patients increasingly possess their own computers and smartphones [31]. Interactive media's such as an application or web-based content allow patients to choose their own areas of interest and can go over the material at their own pace, increasing interest in health literacy [22, 31]. The biggest disadvantage to online videos is retaining attention when learners can only passively watch the videos. Creating interactivity expands the attention span, making patients adhere more to the information given [21, 22, 32]. Dror et al. [33] found that adding interactive elements such as questions prolong the students' attention span and increase the amount of information retained by the student. As with the video format, patients with low literacy skills seem to benefit greatly from web-based education. A possible explanation could be that learning from a computer is less stressful than in the hospital environment from a doctor or nurse. Patients may be embarrassed to ask questions they feel may expose a lack of knowledge on their part, which is not a problem in a web-based environment [22].

Goldberger et al. [17] did not find a statistically significant difference in anxiety or patient comprehension between oral, written, and video informed consent before their informational platform, immediately after consent, and after the intervention. They did find a difference in baseline scores between the 3 groups, meaning a suboptimal randomization. Anxiety scores before and directly after the consent procedure are comparable, which could be due to the short time between the questionnaires. Although they did not find a significant difference between the 3 consent procedures, they did show that written or video consent is just as effective as oral informed consent.

One article discussed the use of VR to educate patients with atrial fibrillation. By informing patients about their disease, patients showed to adhere more to their treatment [27]. Cleeren et al. [34] showed that 3D animations result in a higher patient knowledge when comparing to a drawn explanation of the same procedure. The use of 3D images or VR environment is similar to a video, but it may make the message even more explanatory due to increased interactivity. Pandrangi et al. [9] used VR as an active tool to teach patients preoperatively about abdominal aortic aneurysm. Patients felt better informed and

more engaged because of the use of VR. Bekelis et al. [35] divided patients undergoing cranial and spinal operations in VR or standard care. Patients watching VR experienced less preoperative stress and were more satisfied. Jimenez et al. [36] also divided patients into the VR education or standard care and found that patients educated by VR had a higher knowledge about radiotherapy in breast cancer. VR seems to be a good way to educate patients before their procedure to reduce stress and gains a higher patient satisfaction. It also increases patient knowledge about their disease or therapy.

In this review, positive results were found in all outcome parameters. Digital education on any platform seems to especially help patients with low levels of education [16, 37–40]. The use of applications by patients enhances understanding and recall of the given information when compared to standard care (written or oral) [16]. Possible explanations could be that patients can go through the information at their own pace, applications ask for active participation, and applications can visualize the heart or the procedure, making it comprehensible for patients [16, 37–39]. However, attention to an application is scarce due to an information-overloaded world [32]. Information should be given in a clear, and comprehensible way for patients to increase the amount of information to be recalled [17, 19, 20].

Torrano et al.'s [5] study showed that only 16% of patients at baseline receiving standard care were able to explain the benefits of the procedure they were about to undergo. A changing world with increasingly available digital platforms should also change the manner in which doctors educate their patients. Smartphone or tablet application, web-based, and video education could contribute in the way patient education is performed and may enhance patient knowledge, reduce anxiety, and seem to increase patient satisfaction.

Conclusion

Digital platforms show great potential in educating patients at their own pace, providing additional (visual) information, and are capable of describing the disease or procedure in a clear manner. Digital platforms are shown to increase patient knowledge and satisfaction. Overall, these platforms enhance QoL and decrease anxiety. It remains important for developers of digital information platform to focus on how to present their information in a clear, structured, and comprehensible way.

Conflict of Interest Statement

The funders had no role in the study design, data collection and analysis, decision to publish, or the preparation of the manuscript. The authors have no conflicts of interest.

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Author Contributions

All authors contributed to researching data, discussion of content, and reviewing and editing the manuscript before submission.

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