Development of EirV3: A Computer-Based Tool for Patient-Reported Outcome Measures in Cancer

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INTRODUCTION

Systematic use of patient-reported outcome measures (PROMs) in clinical practice is essential for optimal patient care. The recognition of PROMs as independent outcomes in cancer is consolidated by the CONSORT Patient-Reported Outcomes Extension Statement developed to improve the reporting of PROMs on patients' evaluation of symptoms, functioning, and quality of life. Benefits of routine PROM registrations have been reported, such as improved patient-physician communication and better patient well-being. Regular PROM assessment during treatment with immediate feedback to clinicians has proven to be efficient in informing clinicians about symptoms and problems and guiding treatment decisions. A recent review reported improved symptom management and higher patient satisfaction when using PROMs in the clinical consultation, because this made physicians aware of symptoms that had not been discussed before.

Despite these findings, systematic collection and use of PROMs in clinical oncology remain uncommon. The most common barriers are logistical problems, cumbersome administration, and time constraints. These barriers may be overcome by health information technology and Web-based communication now widely available. Indeed, electronic data collection permits dynamic symptom assessment (ie, tailored questions for individual patients based on the

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patients’ previous responses). This results in fewer repetitive questions and reduces patient burden by avoiding long and cumbersome questionnaires. In addition, Web-based technology permits immediate transfer of patients’ responses to the attending physician’s desktop. When used alongside clinical data, the follow-up of patients may be more comprehensive, especially for patients who are not hospitalized.

Our research group in the European Association of Palliative Care (EAPC) Research Network and the European Palliative Care Research Centre (PRC) has developed several electronic symptom assessment tools over the past decade (Appendix). Our experiences led to the Eir Project in 2013. The long-term aim is to integrate PROMs and clinical data in a user-friendly software available on all platforms for use in treatment of adult patients with cancer across disease stages and settings.

This article describes the stepwise development process toward the current Eir version, version 3 (EirV3), which has the following two modules: Eir-Patient and Eir-Doctor. More specifically, qualitative and quantitative results from iterative test rounds are presented, focusing on the rationale behind the requirements, contents, adaptation of technical specifications, usability, patient preferences, and preference for using paper or electronic versions.

METHODS

Eir has been designed following expert-driven and user-driven approaches. The first step, selection of content, is based on literature searches, expert opinions, clinical experience, and evidence-based guidelines for symptom management, guided by iterative formative tests of preferences, needs, and skills of the end-users—patients and health care providers (HCPs). Throughout development, regular meetings and discussions were carried out in the following two main working groups: an international palliative care (PC) expert panel, consisting of 26 PC experts from Italy, Norway, the United Kingdom, Denmark, Spain, and Germany experienced in clinical oncology/PC, symptom assessment/classification, questionnaire development, and PC research and recruited from the European Palliative Care Research Centre and EAPC Research Network, and a Norwegian core working group (n = 9 to 15) consisting of experienced oncologists, PC physicians, researchers, interaction designers, graphic designers, and software developers. Altogether, results from the international meetings and local workshops (Appendix) led to the recommendations guiding the subsequent Eir development (Table 1) and to the final decisions on the content, based on reviews, guidelines, and evidence at the time (Table 2).

Formative Usability Testing

The second step in Eir development was formative usability testing, an iterative design process conducted to detect weaknesses in the structure and content and software bugs and to problem solve issues based on end-users’ input. The aim of the usability tests was to obtain the opinion of patients and HCPs regarding ease of navigation, clarity of instructions, and content relevance in Eir-Patient and Eir-Doctor (Table 3; Appendix).

Equivalence Between Electronic and Paper PROM Assessments

In 2016, a comparative study was carried out among 114 patients with cancer at six Norwegian hospitals to examine agreement between PROM assessments on tablets and paper and to assess patients’ preference for either method. Patients rated the intensity of 19 symptoms in EirV3. The order of assessment, either paper or tablet first, was randomly assigned, with 30 minutes between assessments. Intraclass correlation coefficients (ICCs) based on a two-way mixed effect analysis of variance, single measure and absolute agreement, were used to examine agreement of tablet and paper scores. According to interpretation guidelines, an ICC > 0.75 indicates excellent agreement.

Technical Specifications and Data Safety

EirV3 is a Web site using standard HTML5, CSS3, and Javascript and designed for ease of use and touch-based navigation. This allows the system to run on any hardware with a modern Web browser, including tablets, cell phones, laptops, workstations, and public terminals. It is designed for Windows Server using IIS, but also Windows Azure. The default database for storage is Microsoft SQL Server, but Azure Blob storage and document databases also work well.

Ethical Considerations

Confidentiality issues and adherence to all regulations regarding the registration, transfer, handling, and storage of data were major issues during the development process. Data communication between the device used for data entry and the storage server is secured using HTTPS over SSL. Verification of the patient’s identity is ensured
using token-based authentication, with support for authentication protocols (eg, OAuth, OpenId, and SAML2.0). Patient data are stored on secure servers hosted by each clinic. Data are encrypted using Advanced Encryption Standard requiring an encryption key to access the database. Access to patients’ PROMs in Eir-Doctor is password protected.

The Regional Committee for Medical and Health Research Ethics Central Norway approved the comparative study, confirming that formal approval was not required for the usability tests (REK-2014/212, REK-2015/185).

RESULTS

Eir-PatientV3

Eir-Patient addresses all 12 symptoms in the EAPC Basic Dataset (ie, pain, tiredness, drowsiness, nausea, reduced appetite, breathlessness, depression, anxiety, well-being, sleep, constipation, vomiting), supplemented by four items particularly related to chemotherapy (ie, numbness in hands or feet, diarrhea, mouth sores, dry mouth) and another four items adjusted from the Patient-Generated Subjective Global Assessment for assessment of nutritional status (ie, altered sense of taste, altered sense of smell, problems swallowing, early satiety) and physical activity.

Dynamic Symptom Assessment

For Eir to be dynamic and patient tailored (Table 1), a symptom assessment hierarchy was developed as per requirements in the working groups. The opening question mimics a common start of a clinical consultation with a general question about the patient’s well-being today (Fig 1). Then there is a symptom screening section (Level 0) followed by intensity ratings of all endorsed symptoms (Level 1) and specific questions on symptom characteristics (Level 2; Table 2).

To keep the number of questions to a minimum, it was decided to add follow-up questions only if the international expert panel considered this to be of clinical relevance. In the last section, questions on height, current weight, food intake, and current level of physical functioning are for all patients.

Eir-DoctorV3

PROMs reported on the tablet by the patient are immediately available in Eir-Doctor to focus the patient-physician communication on symptoms that need attention and treatment. The Eir-Doctor opening screen displays symptom scores in descending order of intensity from high to low, with scores \( > 3 \) in red, indicating clinical severity.

<table>
<thead>
<tr>
<th>Table 1. Requirements and Methods That Guided the Eir Development Process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Requirements</strong></td>
</tr>
<tr>
<td>Mimic a clinical consultation regarding content</td>
</tr>
<tr>
<td>Cover the most common cancer-related symptoms</td>
</tr>
<tr>
<td>Minimize ad hoc formulations and questions</td>
</tr>
<tr>
<td>Dynamic, flexible, and tailored to the individual patient</td>
</tr>
<tr>
<td>Applicable in multiple settings (hospital, ambulatory, home care)</td>
</tr>
<tr>
<td>User-friendly</td>
</tr>
<tr>
<td>Feasible</td>
</tr>
<tr>
<td>Immediate transfer of all PROMs from Eir-Patient to Eir-Doctor</td>
</tr>
<tr>
<td>Longitudinal presentation of patient data</td>
</tr>
<tr>
<td>Safe transfer and storage of data</td>
</tr>
<tr>
<td>Applicable across cultures</td>
</tr>
<tr>
<td>Output reports on patient and group level</td>
</tr>
<tr>
<td>Compatibility with existing databases</td>
</tr>
</tbody>
</table>

Abbreviation: IT, information technology; PROM, patient-related outcome measure.

*Consensus on these requirements was reached based on literature searches, expert opinions, clinical experience, and evidence-based guidelines for symptom management, as well as workshops, international expert meetings, and usability testing.
significance (Fig 2). A graph on the right shows symptom intensity over time, if available. Well-being, physical activity, nutritional intake, and weight are shown on top, because these are considered key factors in patient-centered treatment.

Formative Usability Tests of Eir-Patient and Eir-Doctor

Patients were recruited from the cancer outpatient clinic (Table 3) and were heterogeneous with respect to age, sex, cancer diagnosis, and treatment intent (curative, adjuvant, or palliative). Overall, they had few problems using Eir-Patient and appreciated that the physician received updated information about their clinical condition.

The questions per se posed few difficulties for patients, although some patients with related symptoms (eg, tiredness, lack of appetite, and depression) found some of the follow-up questions to be overlapping. Most of the outpatients had a limited number of symptoms and thus relatively few questions to which to respond. As expected, using EirV3 was perceived as more demanding for PC patients with a high symptom burden compared with patients who were in a better physical condition.

Observations of patients using Eir revealed that they did not notice all elements on the screen at a time; they focused mainly on the middle and inadvertently skipped items on the left and right sides. Even when they skipped the instructions on the screen, patients found it easy to navigate in Eir (eg, moving forward or backward, finding the right answer, and having the answer registered). However, the latter posed some difficulties for patients who either did not position the tablet in the right angle or who had fingers that were too dry or too cold to obtain sufficient pressure on their...
<table>
<thead>
<tr>
<th>Time</th>
<th>Type of Test</th>
<th>Participants</th>
<th>Procedures</th>
<th>Main Findings and Subsequent Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>September-October 2013</td>
<td>Test of a computerized pain body map</td>
<td>Outpatients with cancer (n = 10)</td>
<td>Observations of patients using different way of marking pain on a tablet Subsequent debriefing interviews Field notes</td>
<td>Finding: Shading on the pain area of the body map did not seem intuitive to patients. They preferred to tap or press the relevant area Change: Tapping or pressing the area of the pain location was sufficient for the area to be marked in red.</td>
</tr>
<tr>
<td>November 2013</td>
<td>Test of Eir-PatientV1</td>
<td>Outpatients with cancer (n = 7)</td>
<td>Observations of patient completing Eir-PatientV1 Think-aloud strategy Subsequent debriefing interviews Field notes</td>
<td>Finding: When patients did not find a relevant response alternative, they tended to choose another. Change: The alternative “None of these” was added. Finding: Some patients did not manage to get their taps registered. Change: Short and long clicks or taps, as well as swipes, are registered. Finding: The zooming function of the body map and too many navigation buttons on the same screen image were confusing. Change: The layout was improved, and the number of navigation buttons was reduced. Finding: Most patients did not read the instructions regarding completion. Change: Instructions were available by clicking on a Help button.</td>
</tr>
<tr>
<td>January-May 2014</td>
<td>Changes made in content, functionality, and layout; development of EirV2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May 2014</td>
<td>Pilot test of Eir-PatientV2</td>
<td>Outpatients with cancer (n = 7)</td>
<td>Observations of patient completing Eir-PatientV2 Think-aloud method Subsequent debriefing interviews Field notes</td>
<td>Finding: Patients had trouble understanding that they could not mark more than 1 painful area on the body map at the time. Change: An information page was added before the pain section. Finding: If patients had trembling hands, they accidentally double-clicked on the Next button and skipped a page. Change: Rapid double-clicks are registered as 1 tap (1 registration).</td>
</tr>
<tr>
<td>June-December 2014</td>
<td>Clinical test of Eir-PatientV2 and Eir-DoctorV2*</td>
<td>Outpatients with cancer (n = 42); physicians in cancer department (n = 8)</td>
<td>Observations of patient completing Eir-PatientV2 Think-aloud strategy Subsequent debriefing interviews Observations of physicians using Eir-DoctorV2 in consultation Regular group discussions with physicians during the test period Field notes</td>
<td>Findings for Eir-Patient Finding: Some elements on the screen went unnoticed; some elements were misunderstood; the elements in the middle of the screen were read first. Change: The number of elements on each screen was reduced. Question and response alternatives were placed in the middle. Finding: Taps were not registered as a result of cold/dry fingers or long nails. Change: Optional use of stylus. Finding: Patients accidentally quit Eir and had to start all over. Change: The tablets were locked to Eir.</td>
</tr>
</tbody>
</table>

(Continued on following page)
touch for registration. The pain body map with zoom functions and related follow-up questions turned out to be the most challenging part of Eir-Patient. Difficulties were related to marking of the painful area, primarily because patients tried to mark multiple areas at a time, even if instructions told them not to. They also found some of the follow-up pain questions confusing, particularly those related to pain descriptors (e.g., “burning” and “pins and needles”), whereas some patients missed an option for marking radiating pain. The technologic features and explanations were revised accordingly in EirV3. All follow-up questions applied to each pain site, and the number of elements on each screen was reduced (e.g., by skipping some of the instructions for navigation or answers, dropping a progress bar, and consistently centering the relevant items on the screen). Increasing the user-friendliness was also pursued by adding a “Help” function; adding the response alternative “None of these,” as appropriate; and accepting different types of taps, swipes, and drags for registration.

When testing Eir-Doctor, physicians defined the graphical presentation of symptom trajectories as a key factor to monitor effect of treatments. They also mentioned that the current display in EirV3, which resulted from iterative rounds of feedback from clinical testing, made them aware of symptoms they had not known troubled the patient. Physicians found it useful to start the consultations with the list of symptoms and intensity scores. Because the patient’s symptoms are ordered by intensity, the list and order of

### Table 3. Iterative Usability Testing of Eir (Continued)

<table>
<thead>
<tr>
<th>Time</th>
<th>Type of Test</th>
<th>Participants</th>
<th>Procedures</th>
<th>Main Findings and Subsequent Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-May 2015</td>
<td>Changes made in content, functionality, and layout; development of EirV3</td>
<td></td>
<td>Findings for Eir-Doctor</td>
<td>Findings: Physicians misunderstood the summarized information of well-being, nutrition, and physical functioning on the opening screen and did not intuitively understand (or remember) what questions the patient had answered. Change: Extra information was added to clarify what information had been given by the patient. Finding: Detailed information on well-being, nutrition, and physical functioning was left out of Eir-Doctor. Change: All these variables were presented in 1 click. Finding: The list of symptoms could be difficult to follow if the patient has registered several symptoms. Change: More sorting functions for symptoms added (e.g., high to low on intensity and development of intensity since last registration).</td>
</tr>
<tr>
<td>May-June 2015</td>
<td>Pilot test of Eir-PatientV3</td>
<td>Outpatients with cancer (n = 9)</td>
<td>Observations of patients using Eir-PatientV3 Think-aloud method Subsequent debriefing interviews Field notes</td>
<td>Findings: If the patient had more than 1 painful area, the second pain section was initiated with a confusing question. Change: New question added. Finding: Patients found the question about physical function confusing, because this item had too many response alternatives that were not mutually exclusive. Changes: Question was changed to a validated question on physical function with fewer response options</td>
</tr>
</tbody>
</table>

*Changes in Eir-Patient-versions led to immediate changes in the corresponding Eir-Doctor-versions, thus numbering of versions is identical.*
symptoms vary from one patient to the other. Some physicians preferred a fixed order, whereas others preferred high intensity as the default. All physicians regretted the fact that EirV3 is not yet integrated into the electronic patient records, because this would enhance the clinical decision making by combining individual patient data from different sources.34

**Equivalence Between Electronic- and Paper-Based Assessment**

Of the 114 patients included in the paper and pencil versus electronic assessments comparative study, 110 patients (97%) completed both versions, 59 patients (54%) on tablets first and 51 patients (46%) on paper first. Mean age was 64.5 years (range, 27 to 86 years), and median Karnofsky performance score was 90 (range, 50 to 100). GI cancer was most common (47%), followed by prostate cancer (10%), breast cancer (9%), and malignant melanoma (9%). Eighty-nine percent of patients had metastatic disease. Overall, the median ICC was high (0.81; Table 4), with excellent values (> 0.75) for 15 of the 19 items (range, 0.64 [vomiting] to 0.92 [tiredness]). Overall, 41% of the patients preferred assessment on tablets, 19% preferred paper, and 40% had no preference. Preference for electronic assessment was more frequent among patients with higher education and patients with previous digital experience.

**DISCUSSION**

This study presents the requirements behind, the methods used, and the results achieved during the stepwise iterative development process of EirV3, an electronic symptom assessment system for cancer care. The main objective was to improve clinical consultations by focusing on the patient’s perspective, through immediate transfer of PROMs to the HCP’s computer. Thus, EirV3 represents something beyond a direct electronic version of paper PROMs, as is frequently done.47-49 The real-time visual presentation of individually tailored PROMs supplemented with graphs for symptom development cannot be achieved by the paper-and-pencil format.
between electronic and paper patient-reported outcome measures. We regard the continuous involvement of end-users to improve the usability of any tool, be it digital or on paper. This was also the benefit of developing and testing Eir-Patient and Eir-Doctor in parallel, as feedback from physicians could be used for amendments of Eir-Patient, and vice versa.

Most patients regarded Eir as intuitively easy to use and appreciated its relevance and that results reached the physicians immediately. However, this was true on the group level. It may be that the perceptions varied among subgroups of patients (eg, fit vs frail patients, patients with few symptoms vs those with many). As a result of a generally higher symptom burden, completion was more demanding for patients in the palliative outpatient unit than in the oncology unit, potentially supporting the issue about subgroup differences, corresponding with results from other studies using computerized assessment.21,53-56

The most negative comments were that Eir is not yet automatically incorporated into the electronic medical records and that it should be opened in an Internet browser, not connected with the regular hospital network.

Patients judged to be cognitively impaired were not included in the studies. However, it could be that some patients with mild cognitive impairment may find it easier to use an electronic tool, but this

### Table 4. Results From the Study Examining Equivalence Between Electronic and Paper Patient-Reported Outcome Measures

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>ICC</th>
<th>95% CI</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-being</td>
<td>0.73</td>
<td>0.63 to 0.81</td>
<td>3.12</td>
</tr>
<tr>
<td>Pain</td>
<td>0.89</td>
<td>0.84 to 0.92</td>
<td>2.43</td>
</tr>
<tr>
<td>Numbness</td>
<td>0.87</td>
<td>0.82 to 0.91</td>
<td>2.06</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>0.83</td>
<td>0.76 to 0.88</td>
<td>2.40</td>
</tr>
<tr>
<td>Drowsiness</td>
<td>0.89</td>
<td>0.85 to 0.93</td>
<td>3.20</td>
</tr>
<tr>
<td>Tiredness</td>
<td>0.92</td>
<td>0.88 to 0.94</td>
<td>3.92</td>
</tr>
<tr>
<td>Insomnia</td>
<td>0.75</td>
<td>0.65 to 0.82</td>
<td>2.39</td>
</tr>
<tr>
<td>Anxiety</td>
<td>0.81</td>
<td>0.73 to 0.87</td>
<td>2.68</td>
</tr>
<tr>
<td>Depression</td>
<td>0.80</td>
<td>0.72 to 0.86</td>
<td>2.04</td>
</tr>
<tr>
<td>Nausea</td>
<td>0.76</td>
<td>0.67 to 0.83</td>
<td>1.06</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0.65</td>
<td>0.53 to 0.75</td>
<td>0.37</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>0.88</td>
<td>0.83 to 0.91</td>
<td>1.02</td>
</tr>
<tr>
<td>Constipation</td>
<td>0.90</td>
<td>0.86 to 0.93</td>
<td>1.81</td>
</tr>
<tr>
<td>Lack of appetite</td>
<td>0.91</td>
<td>0.87 to 0.93</td>
<td>2.05</td>
</tr>
<tr>
<td>Mouth sores</td>
<td>0.88</td>
<td>0.83 to 0.92</td>
<td>0.49</td>
</tr>
<tr>
<td>Dry mouth</td>
<td>0.82</td>
<td>0.75 to 0.88</td>
<td>2.50</td>
</tr>
<tr>
<td>Altered sense of taste</td>
<td>0.74</td>
<td>0.64 to 0.81</td>
<td>1.92</td>
</tr>
<tr>
<td>Altered sense of smell</td>
<td>0.77</td>
<td>0.69 to 0.84</td>
<td>1.29</td>
</tr>
<tr>
<td>Problems swallowing</td>
<td>0.72</td>
<td>0.61 to 0.80</td>
<td>0.69</td>
</tr>
</tbody>
</table>

NOTE. Median ICC for all items was 0.81 (25th-75th quartile, 0.75 to 0.89).

Abbreviation: ICC, intraclass correlation coefficient.
needs to be thoroughly examined using a cognitive screening tool and a simpler electronic tool, which was beyond the scope of this work.

The comparative study examining equivalence between electronic and paper-based PROMs showed excellent agreement between the two methods. However, it should be noticed that the mean symptom intensity scores were low (Table 4). This may indicate that more patients were fit than frail and calls for purposeful, maybe even stratified, sampling in forthcoming Eir studies to examine use in frailer patients. The issue regarding subgroups relates to generalizability and even stratified, sampling in forthcoming Eir studies to examine use in frailer patients. The issue regarding subgroups relates to generalizability and cannot be examined by formative testing. However, this is not related to electronic PROMs tools per se, but applies to most formative testing.

A recent randomized controlled trial concluded that this was attributed to the systematic monitoring that led to immediate symptom management in patients with a high symptom burden. However, it is interesting that better satisfaction with patient-HCP communication is still the most prominent effect of systematic PROM registrations, 15 1 years after the first publication by Velikova et al. Two take-home messages apply. First, even if newer studies do not show statistically significant effects of PROMs, the work toward patient-centered, electronic tools should continue to promote clinical uptake. Second, no tools are intended to replace the face-to-face interaction between patients and HCPs; instead, they should be regarded an asset for putting the patient's perspective in the center of the communication.

In conclusion, overall, technologic advances have led to an abundance of electronic PROM tools. In contrast to many others, EirV3 is not a direct electronic version of a paper-based questionnaire, but a dynamic tool adapted to the individual patient. EirV3 resembles a clinical consultation, and patient-HCP communication is still the most prominent effect of systematic PROM registrations, 61 15 years after the first publication by Velikova et al.

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Manuscript writing: All authors

Final approval of manuscript: All authors

Agree to be accountable for all aspects of the work: All authors
AUTHORS’ DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST
The following represents disclosure information provided by authors of this manuscript. All relationships are considered compensated. Relationships are self-held unless noted. I = Immediate Family Member, Inst = My Institution. Relationships may not relate to the subject matter of this manuscript. For more information about ASCO’s conflict of interest policy, please refer to www.asco.org/rwc or ascopubs.org/jco/site/ifc.

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APPENDIX

Former Development of Electronic Symptom Assessment Tools From Our Group

The Patient Assessment Tool-Computerized study (2007). In this descriptive study, patients with advanced cancer responded to 59 questions and a pain body map on touchscreen computers.\(^6\) The selection of items was based on systematic reviews\(^{20,63}\) and surveys among patients with cancer and expert groups. Most patients (93%) were able to report symptoms directly on the computer.

The European Palliative Care Research Collaborative Computerized Symptom Assessment study (2008 to 2009). This international, multicenter study used a more sophisticated tablet version in 1,017 patients with advanced cancer. Patients were recruited from 17 centers and eight countries (Norway, the United Kingdom, Austria, Germany, Switzerland, Italy, Canada, and Australia). They responded to questions on symptoms, nutritional intake, and physical and emotional functions. The software was programmed in four languages (English, German, Italian, and Norwegian) and contained several skip sessions to reduce patient burden, if the patient had no pain, the rest of the pain section was omitted.\(^25\) In agreement with results from other computerized assessment studies,\(^{21,53-56}\) the completion rate was high (95%), with more missing information and need for assistance associated with higher age and lower performance status, similar to results when using paper-and-pencil assessments.\(^{23}\)

Continuous software improvements and small-scale tests were performed based on feedback from patients and health care providers in the European Palliative Care Research Collaborative Computerized Symptom Assessment study. In 2012, a tablet version that included treatment recommendations for pain and depression was used in a Norwegian clinical trial of 143 outpatients with cancer.\(^24\) Two studies comparing different versions of a computerized pain body map in randomized order and testing different ways of marking pain were also conducted and demonstrated the need to optimize the user-friendliness by simplifying the design for the frailest patients.\(^{25,26}\)

Expert Meetings and Workshops to Decide the Content and Development of Eir

Between 2013 and 2015, regular meetings were held by the international expert panel and the core working group, in addition to two workshops.

International expert panel. The international expert group participated in workshops and roundtable discussions addressing symptom assessment, classification, and management in 2013 and 2014. Relevant symptom dimensions and validated symptom assessment tools for the choice of specific items were identified, aggregated, and presented to researchers and clinicians from different specialties to reach consensus regarding relevance and importance.\(^{10,31,33,64-66}\)

The first international Eir expert group meeting in 2013 was organized as part of the European Partnership for Action Against Cancer.\(^55\) Here, 26 participants discussed computerized symptom assessment and development of Eir. The meeting was organized with short introductions about the objectives of Eir and symptom assessment followed by plenary discussions and two workshops in which the participants worked in groups, addressing symptom assessment and treatment guidelines. The following decisions were made at the meeting:

- Eir’s content should be based on evidence-based or consensus-based assessment methods.
- Eir should have a hierarchical structure, with an introductory question prior to a screening section on symptoms, followed by a section on symptom intensity and yet another for characterization for endorsed symptoms (Fig 1).
- Patients’ registrations in Eir should be immediately transferred and visually presented.
- Eir should be user-friendly and relevant for heterogeneous cancer populations.
- Eir should be easy to adapt to cultural and clinical preferences.

The second international expert meeting (2013; n = 9) was arranged after the participants had tested the first tablet version of Eir-Patient (EirV1). Here, feedback regarding content and layout was collected and summarized for each of the screen images. Subsequent discussions resulted in consensus on which symptoms to include in Eir and the structure and presentation of the included items. The third international meeting (2014) consisted with experts in neuropathic and breakthrough pain (n = 5) and focused on achieving consensus on how to screen these pain types in Eir.
**Norwegian core working group.** The core working group (n = 15) consisted of oncologists, palliative care physicians, researchers, interaction designers, graphic designers, and software developers. Members of the core working group were the first to test each new feature of Eir, as part of the iterative development. Regular multiprofessional meetings were organized with group members, the software development team, and designers to discuss functionality and features and decide refinements.

**Workshops.** Prior to the development EirV1 in 2013 (Table 1), two national workshops were conducted to assess the needs and preferences of end-users. The first workshop (2013) presented the overall idea and intention of Eir to physicians, nurses, designers, and patients as participants (n = 20). Furthermore, the intended features of Eir-Patient, such as content, layout, and functionalities, were presented, and feedback suggestions from the participants were collected. The participants were positive about using an electronic tool and could foresee several advantages related to easy collection and more focus on symptom assessment, including immediate access to patients’ patient-reported outcome measure scores and perhaps also improved communication.

The second workshop in 2013 was conducted with five physicians who suggested different ways of presenting patient-reported outcome measures in Eir-Doctor, either with as much information as possible on the opening screen in Eir-Doctor or to highlight only the most relevant information (eg, symptoms with the highest intensity, those with the most pronounced increase, or a combination of these).

**Formative Usability Testing Methods**

Formative usability tests43 on separate sections (eg, general pain and breakthrough pain), as well as on more complete versions of Eir, were repeatedly performed by patients at the Cancer Clinic, St Olavs Hospital, Trondheim University Hospital, during the entire development process. Reports from these tests were presented to the core working group in weekly meetings, together with ideas for changes as drawn sketches or on a monitor. Consensus was reached regarding how to eliminate identified usability problems and to meet user preferences.

In November 2013, EirV1 was tested by outpatients with cancer for the first time (Table 3). On the basis of results from tests in end-users and feedback and discussion in all groups, major improvements from EirV1 to EirV2 were made in the first two quarters of 2014. The most important changes aimed to improve the user interface. For example, the display was radically changed to make the distinction between response options clearer, the buttons were slightly moved, and the layout on all questions in the symptom screening and follow-up sections were standardized. EirV2 included the Eir-Patient and Eir-Doctor modules, which were tested in 42 inpatients and outpatients and eight physicians at the Cancer Clinic in 2014 (Table 3). Patients completed Eir-Patient on tablets in the waiting room, and physicians used Eir-Doctor in the consultations. Usability data were collected through interviews and observations.