TO THE EDITOR

Research was conducted on behalf of the TREATment of Atopic eczema, the Netherlands (TREAT NL) registry to select a web-based application for the collection of patient-reported outcome measures (PROMs). The registry aims to collect long-term, real-life data from patients with atopic eczema on phototherapy and systemic immunomodulating therapy. The collected PROMs comply with the TREAT NL core dataset to ensure cross-country data uniformity (Vermeulen et al., 2019).

We outline the requirements and steps in selecting the most suitable application. With this, we aim to guide researchers in selecting an application for a research-oriented collection of PROMs.

The selection process starts with determining the must-have initial requirements by the investigators, who will be managers of the selected application. Examples of initial requirements for the TREAT NL registry are that the application has to provide or support the composition of the designated PROMs, the application has to work on mobile devices, and the costs of the application have to be feasible.

The next step is to identify candidate applications on the basis of their availability. Applications that do not meet the initial requirements are then excluded.

Next, detailed requirements need to be determined. We grouped detailed requirements into these categories on the basis of Volere (Robertson and Robertson, 2012): investigator, legal, security, patient, feedback, and interoperability requirements. A literature search was conducted in PubMed, Google Scholar, and additional relevant sources to find information on conditions regarding legislation, security, patient preferences, feedback (i.e., of results to patients and clinicians), and interoperability (i.e., between systems).

Investigator requirements give insight into the preferences of the researchers who will manage the application.

Legal requirements must be met to comply with the General Data Protection Regulation, which applies to all organizations that process personal data in the European Union. Performing a privacy impact assessment before the data processing can be mandatory and may be required by the research institution (PrivazyPlan, 2018). National legislation may also apply.

The International Organization for Standardization provides guidelines for security requirements (ISO, 2016, 2013a, 2013b): NEN-7510, NEN-7512, and NEN-7513 (NEN, 2017, 2015, 2010). These standards must be met for security. The application should log activity for an audit trail and should have secure connections, with the data being only accessible to patients and researchers.

An overview of potential patient requirements has been presented elsewhere (Snyder et al., 2009). Surveys should preferably be short and simple. Multiple questions can be presented per survey page, but too much page scrolling should be avoided. In addition, the ability to add free text in the survey is appreciated by patients. To facilitate data entry, mobile applications should be considered because these can be used at any time and on any device. The user experience of software needs to be assessed and optimized.

Feedback requirements relate to the presentation of results after the survey has been completed. Both patients and clinicians consider line graphs as the most useful and easiest to understand (Brundage et al., 2015). Displaying multiple time points is generally preferred by patients. Scaling should be uniform for all questionnaires. A scale from 0 to 100 is recommended (Brundage et al., 2015). Depending on the nature of the project, a link between the application and the electronic health record of participants can be considered. This may entail requirements to allow interoperability.

The next step is to rank the importance of all the requirements in a template (Supplementary Table S1). This template is based on the work of Lawlis et al. (2001), Maiden and Ncube (1998), and Carnegie-Mellon University (2006). The requirements should be given a weight of importance from 1 to 10.

The candidate applications can be scored in the template thereafter. A score of 1 or 0 is given if the application, respectively, does or does not meet the requirement. A score of 0.5 is given when the requirement is met partly or will be met at a later point. Afterward, a weighted score is calculated for each requirement. The application with the highest total sum score is in theory the most suitable application.

The requirements described above are software requirements. There are also external factors to consider when choosing an application, for example, whether the application can be
| Requirement | MonIQ | Clinical Insight | eHEALTH | RoQua | Consult Assistant | Quest Manager | MyChart | Castor EDC |
|-------------|-------|-----------------|---------|-------|-------------------|---------------|---------|-----------|
| Investigator requirements | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| Application offers the possibility to fill out questionnaires at all times. | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 0.5 | 4 | 1 | 8 | 1 | 8 | 1 | 8 | 0.5 | 4 | 1 | 8 | 1 | 8 | 0.5 | 4 |
| The questionnaires can be linked to a corresponding consultation. | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| Questionnaires can be modified within the application. | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| Questionnaires can be completed on mobile devices. | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| Questionnaires can be sent to the patient automatically before the consultation or the patient can be automatically informed that new questionnaires are available. | 9 | 1 | 9 | 0 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 0 | 0 | 1 | 9 | 1 | 9 |
| The patient can receive a reminder to fill out the questionnaires. | 10 | 1 | 10 | 0 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 |
| Application allows multiple types of inputs to answer questions (e.g., radio buttons, checkboxes, free text). | 7 | 0.5 | 3.5 | 0.5 | 3.5 | 1 | 7 | 1 | 7 | 0.5 | 3.5 | 1 | 7 | 0 | 0 | 1 | 7 |
| Application allows questionnaires to be sent to family members of the patient and results registered in the application. | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 |
| Data from the patient must be able to be removed by the healthcare provider. | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 |
| PROs can automatically be registered in MyChart (patient portal for EPIC). | 8 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 0.5 | 4 | 0.5 | 4 | 1 | 8 | 0.5 | 4 |
| Answers and/or scores can be adjusted and/or removed by the healthcare provider. | 10 | 0 | 0 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 | 1 | 10 |
| images can be shown in a questionnaire. | 8 | 0.5 | 4 | 0 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 | 0.5 | 4 |
| The user interface for patients can show a logo of the hospital and the logo of the project. | 8 | 0.5 | 4 | 0 | 1 | 8 | 1 | 8 | 1 | 8 | 1 | 8 |
| Application is available in Dutch. | 10 | 1 | 10 | 0 | 0 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| Application is available in English. | 10 | 0.5 | 5 | 1 | 10 | 1 | 10 | 0.5 | 5 | 0.5 | 5 | 1 | 10 | 0.5 | 5 | 1 | 10 |
| Application can be used without or with minimal training. | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| If the system is unavailable, this is no longer than 5 min on a working day. | 7 | 1 | 7 | 1 | 7 | 1 | 7 | 1 | 7 | 1 | 7 | 1 | 7 | 1 | 7 | 1 | 7 |

(continued)
| Requirement | MonIQ | Clinical Insight | eHEALTH | RoQua | Consult Assistant | Quest Manager | MyChart | Castor EDC |
|-------------|-------|------------------|---------|-------|------------------|--------------|---------|----------|
| Weight | Weighted | Weight | Weighted | Score | Weighted | Score | Weighted | Score | Weighted | Score | Weighted | Score | Weighted | Score | Weighted | Score | Weighted |
| PROs can be discussed during a consultation. | 8 | 0 | 4.8 | 7.2 | 7.2 | 4 | 8 | 2.4 | 4 |
| Application shows outcomes of questionnaires in graphs (with multiple time points) and/or bar charts. | 60% | 0 | 60% | 1 | 60% | 1 | 60% | 0.5 | 60% | 1 | 60% | 0.5 | 60% | 0.5 | 60% |
| Additional information such as confidence intervals and P-values are shown to healthcare providers. | 20% | 0 | 20% | 0 | 20% | 0.5 | 20% | 0.5 | 20% | 1 | 20% | 0.5 | 20% | 0.5 | 20% |
| Users can indicate whether they see the data in line charts or bar charts with or without extra information. | 20% | 0 | 20% | 0 | 20% | 1 | 20% | 0.5 | 20% | 1 | 20% | 0 | 20% | 0.5 | 20% |
| Security and/or legal requirements | | | | | | | | | | | | | | |
| Application is only accessible to healthcare providers and patients. | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| Patients only have access to their own questionnaires and data. | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| System meets the security standard (NEN 7510). | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 | 1 | 10 | 1 | 10 |
| System must have secure connections (NEN 7512). | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 | 1 | 10 |
| System logs activity for audit trail (NEN 7513). | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 | 1 | 9 |
| Interoperability requirements | | | | | | | | | | | | | | |
| Application can be linked to the web-based project database. | 10 | 0.5 | 5 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 |
| Application is able to link to EHRs. | 10 | 0 | 0 | 1 | 10 | 1 | 10 | 0.5 | 5 | 1 | 10 | 0.5 | 5 | 1 | 10 |
| Application offers the possibilities to collaborate on international registration. Exchange of data or access to data is possible. | 9 | 0 | 0 | 1 | 9 | 1 | 9 | 0.5 | 4.5 | 1 | 9 | 1 | 9 | 0.5 | 4.5 | 1 | 9 |
| Data can be stored in a standardized manner. | | | | | | | | | | | | | | |
| Total | 247 | 170.5 | 187.3 | 238.2 | 212.7 | 215.5 | 243 | 186.9 | 222 |
| Percentage score, % | 100 | 69 | 76 | 95 | 86 | 87 | 98 | 76 | 90 |

Abbreviations: EHR: electronic health record; PRO, patient-reported outcome; TREAT NL, TREAtment of Atopic eczema, the Netherlands.

1A limitation of the selection process for the TREAT NL registry was that patient requirements were not included in our template. However, patient requirements are of importance because patients are users of the application; hence, we included patient requirements in the selection process recommendations.

2Specific requirements are the three subfeedback requirements.

3Application allows data to be saved as SNOMED CT or LOINC code.
implemented within the institution, the amount of support or experience from the supplier, as well as the experience or preference within the institution. If the highest-scoring application is found to be unsuitable owing to one or more of these factors, the next application should be considered as the best alternative.

The completed template guiding the selection process for the TREAT NL registry is provided in Table 1. Eight candidate applications were investigated for the TREAT NL registry. The selection process resulted in the choice for Castor EDC (Amsterdam, Netherlands), which scored among the best (percentage score of 90%). We learned that external factors, imposed by institutions, can be crucial in the decision process. An important decisive external factor for us was that at our institution, a connection was planned to be established between our electronic health record system and this application.

Testing and monitoring are advised before and directly after the implementation to assess whether the software works as intended and to ensure that users have an optimized user experience.

The proposed process to select an application uses the accompanying template. This provides a systematized overview of requirements that have to be considered and can provide a solid starting point for this process. We aimed for a process that is maximally manageable for researchers who do not have expertise in software engineering. Applying the process contributes toward optimizing users’ expectancies and experiences on performance and effort, which influences the behavioral intention and use of the application (Koivumäki et al., 2008).

Learning from the process of selecting an application for the TREAT NL registry, the generalized and systematized selection process is presented to facilitate researchers worldwide in their decision making to find a suitable application to capture PROMs.

Data availability statement
No datasets were generated or analyzed during this study.

ORCIDs
Rowdy de Groot: http://orcid.org/0000-0002-1248-1966
Angela L. Bosma: http://orcid.org/0000-0001-6807-6042
Ronald Cornet: http://orcid.org/0000-0002-1704-5980
Phyllis I. Spuls: http://orcid.org/0000-0002-6035-2863

CONFLICT OF INTEREST
PIS has served as a consultant to AbbVie, Anacor, LEO Pharma, Novartis, and Sanofi; has been involved in performing clinical trials with many pharmaceutical industries that manufacture drugs used for the treatment of atopic eczema and psoriasis; and is the chief investigator of the Dutch atopic eczema registry—TREatment of Atopic eczema, the Netherlands. The remaining authors state no conflict of interest.

AUTHOR CONTRIBUTIONS
Conceptualization: ALB, PIS, RC, RDG; Investigation: ALB, PIS, RC, RDG; Methodology: ALB, PIS, RC, RDG; Supervision: ALB, PIS, RC; Writing - Original Draft Preparation: ALB, RDG; Writing - Review and Editing: PIS, RC

Rowdy de Groot1,*, Angela L. Bosma2,3, Ronald Cornet1 and Phyllis I. Spuls2

1Department of Medical Informatics, Amsterdam Public Health, Amsterdam UMC, Amsterdam, the Netherlands; and 2Department of Dermatology, Amsterdam Public Health, Infection and Immunity, Amsterdam UMC, Location AMC, University of Amsterdam, Amsterdam, the Netherlands
3These authors contributed equally to this work.
*Corresponding author e-mail: rowdy.degroot@amsterdamumc.nl

SUPPLEMENTARY MATERIAL
Supplementary material is linked to the online version of the paper at www.jidonline.org, and at https://doi.org/10.1016/j.jid.2020.10.017.

REFERENCES
Brundage MD, Smith KC, Little EA, Bantug ET, Snyder CF. PRO Data Presentation Stakeholder Advisory Board. Communicating patient-reported outcome scores using graphic formats: results from a mixed-methods evaluation. Qual Life Res 2015;24:2457–72.
Carnegie-Mellon University, Software Engineering Institute. Quantitative methods for software selection and evaluation. https://resources.sei.cmu.edu/asset_files/TechnicalNote2006_004_001_14711.pdf; 2006 (accessed 23 November 2020).
ISO. ISO 27799:2016(en) health information — information security management in health using ISO/IEC 27002. https://www.iso.org/obp/ui/#iso:std:iso:27799:ed-2:v1:en; 2016. (accessed April 21, 2020).
ISO. ISO/IEC 27001:2013: information technology — security techniques — information security management systems — requirements. https://www.iso.org/standard/54534.html; 2013a. (accessed April 21, 2020).
ISO. ISO/IEC 27002:2013: information technology — security techniques — code of practice for information security controls. https://www.iso.org/standard/54533.html; 2013b. (accessed April 21, 2020).
Koivumäki T, Ristola A, Kesti M. The perceptions towards mobile services: an empirical analysis of the role of use facilitators. Pers Ubiquitous Comput 2008;12:67–75.
Lawlis PK, Mark KE, Thomas DA, Courtheyn T. A formal process for evaluating COTS software products. Computer 2001;34:58–63.
Maiden NA, Ncube C. Acquiring COTS software selection requirements. IEEE Softw 1998;15:46–56.
NEN. NEN 7513:2010 nl: health informatics - recording actions on electronic patient health records. https://www.nen.nl/en-nen-7513-2010-nl-146564; 2010. (accessed March 2, 2018).
NEN. NEN 7512:2015 nl: health informatics - information security in healthcare - requirements for trusted exchange of health information. https://www.nen.nl/NEN-Shop/Names/NEN-7512015-nl.html; 2015. (accessed March 2, 2018).
NEN. NEN 7510-2: 2017 nl: health informatics - information security management in healthcare - part 2: controls. https://www.nen.nl/en- nen-7510-2-2017-nl-238787; 2017. (accessed March 2, 2018).
PrivacyPlan. Article 35: EU GDPR “Data protection impact assessment.”, http://www.privacy-regulation.eu/en/15.htm; 2018 (accessed 29 October 2019).
Robertson J, Robertson S. Volere requirements specification template. ed. 16. New York, NY: Atlantic Systems Guild; 2012.
Snyder CF, Jensen R, Courtin SO, Wu AW. Website for Outpatient QOL Assessment Research Network. PatientViewpoint: a website for patient-reported outcomes assessment. Qual Life Res 2009;18:793–800.
Vermeulen FM, Gerbens LAA, Bosma AL, Apfellbacher CJ, Irvine AD, Arents BWM, et al. TREatment of Atopic eczema (TREAT) Registry Taskforce: consensus on how and when to measure the core dataset for atopic eczema treatment research registries. Br J Dermatol 2019;181:492–504.

This work is licensed under a Creative Commons Attribution 4.0 International License. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.
### Supplementary Table S1. Template for Scoring the Requirements to Select a Candidate Application

| Requirement                      | Option x | Option x | Option x | Option x | Option x | Option x | Option x | Option x |
|----------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Investigator requirements        |          |          |          |          |          |          |          |          |
| Feedback requirements            |          |          |          |          |          |          |          |          |
| Security and/or legal requirements |          |          |          |          |          |          |          |          |
| Interoperability requirements    |          |          |          |          |          |          |          |          |
| Patient requirements             |          |          |          |          |          |          |          |          |
| **Total**                        | **Score**| **Weighted Score** | **Score**| **Weighted Score** | **Score**| **Weighted Score** | **Score**| **Weighted Score** |
| (max amount of points)           | (max amount of points) | (max amount of points) | (max amount of points) | (max amount of points) | (max amount of points) | (max amount of points) | (max amount of points) | (max amount of points) |
| Percentage score                 | 100%     | ...%     | ...%     | ...%     | ...%     | ...%     | ...%     | ...%     |

Abbreviation: max, maximum.