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An e-learning programme about the risk and management of QTc-prolongation in community pharmacies significantly improves pharmacists' (long-term) knowledge

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Abstract

Objective: To develop an e-learning programme about the risk of QTc-prolongation and to evaluate its impact on knowledge.

Methods: An e-learning programme, covering all aspects of QTc-prolongation, was developed and implemented in a Flemish pharmacy network. Pre-post knowledge tests and a satisfaction questionnaire were used to evaluate the impact.

Results: Overall, 166 pharmacists completed the e-learning, pre-post knowledge tests and satisfaction questionnaire. The median score on the knowledge test before the e-learning was 9/19 (IQR 6-11); this increased to 16/19 (IQR 15-18; $p<0.001$) immediately after the e-learning, and 12/19 (IQR 10-14) ten months later. The median satisfaction score was 9/10 (IQR 8-10). Most pharmacists indicated that they were more confident about their knowledge after following the training, and that this knowledge can be used in practice.

Conclusions: An e-learning about the risk of QTc-prolongation yielded high satisfaction scores among pharmacists. The training led to a significant increase in (long-term) knowledge.

Keywords: *Community Pharmacies, e-Learning, QTc-Prolongation, Risk Management*

Introduction

A lot of drugs are linked with a risk of QTc-prolongation (*e.g.* antibiotics, psychotropic drugs) (CredibleMeds, 2016). Drug-induced QTc-prolongation can, in rare cases, lead to Torsade de Pointes (TdP) and sudden cardiac death, especially in patients with other risk factors (*e.g.* older age, female gender, cardiovascular and other comorbidities, electrolyte disturbances) (Roden 2004; Drew *et al.*, 2010; van Noord *et al*., 2010).

Several guidelines to deal with the risk of QTc-prolongation are available for healthcare professionals (Ames *et al.*, 2002; Drew *et al*., 2010; Fanoe *et al*., 2014; Marzuillo *et al*., 2014). However, in general hospitals as well as in psychiatry, the adherence to the guidelines is considered to be low (van der Sijs *et al*., 2009; Tay *et al.*, 2014; Vandael *et al*., 2014; Warnier *et al*., 2014; Vandael *et al*., 2016), which might be due to a limited awareness and knowledge of this risk among healthcare professionals and limited feasibility of the guidelines in clinical practice (Al-Khatib *et al*., 2005; van der Sijs 2009; Fongemie *et al*., 2013; Choo *et al*., 2014).

In primary care, pharmacists can play an important role in the detection of drug-drug interactions (DDI) with risk of QTc-prolongation. However, no specific guidelines for primary care in general, or for community pharmacies in specific, exist. As a consequence, in an epidemiological study in Belgian community pharmacies, it was found that DDI with QTc-prolonging antibiotics are very frequent, but that the current risk management of these DDI is limited. Moreover, pharmacists were not confident about their knowledge on QTc-prolongation (Vandael *et al*., unpublished data, May 2014).

Education about this topic is therefore highly needed, both for community pharmacies and other healthcare professionals (Drew *et al*. 2010; Choo *et al*., 2014). One of the training methods that has become popular in pharmacy education is online training or e-learning (Cain & Fox 2009; Salter *et al.*, 2014). A main advantage of e-learning is that learners can choose where or when to follow the training, and on which topics they want to focus (Ruiz *et al*., 2006; Salter *et al*., 2014). In the systematic review of Salter *et al*., no evidence was found for the long-term effectiveness of e-learning programmes for pharmacists. It was emphasised that long-term follow-up studies are needed to investigate this retention of knowledge (Salter *et al*., 2014).

The objective of this study was to develop an innovative e-learning programme about the risk of QTc-prolongation for community pharmacists, and to evaluate its impact on pharmacists' (long-term) knowledge.

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Methods

This study consisted of different phases: interviews with pharmacists to explore their needs, the development and optimisation phase, and the implementation of the e-learning in a large Flemish pharmacy network.

This project was performed in cooperation with the Flemish pharmacy chain Surplus and with the Scientific Information Centre of Escapo C.V. The first version of the e-learning was specifically developed for pharmacists working in this network. In these community pharmacies (N=104), the pharmacy software 'Vianova' is used and DDI alerts are based on the 'Health Base' database (Healthbase, 2015/2016). Regarding QTc-prolongation, alerts are available for pharmacodynamic interactions between QTc-prolonging drugs of list 1 of CredibleMeds and for pharmacokinetic interactions with these list 1 drugs (CredibleMeds, 2016). Pharmacists can decide themselves if they want to activate these alerts.

Needs evaluation

To understand the needs and expectations of pharmacists for an e-learning about QTc-prolongation, face-to-face semi-structured interviews were performed. Based on a list provided by the Scientific Information Centre of Escapo C.V., containing both Surplus pharmacies in which DDI alerts with risk of QTc-prolongation were activated and deactivated, pharmacists were invited by telephone to participate in these interviews. The following topics were addressed in the interviews: current experience with the DDI alert system and DDI with risk of QTc-prolongation, current risk management, cooperation with the general practitioners, needs and expectations regarding training about QTc-prolongation, experience with e-learning and the time that they were willing to spend in this training. Furthermore, a preliminary table of contents of the e-learning was shown, as to ask feedback from participating pharmacists. All interviews were audio-recorded and a *verbatim* transcription was performed.

Development of the e-learning

Between September-December 2015, the e-learning was developed on the platform 'Sofia', provided by Acco (Acco, 2016). 'Sofia' is an easy to use platform for authors and learners. A help-desk and learning analytics are provided.

The content of the e-learning was both based on scientific literature and the consultation of experts (cardiologists, psychiatrist, general practitioner) and pharmacists. The e-learning was divided into nine modules, including general information about an electrocardiogram and the QTc-interval, the importance of pharmacovigilance, QTc-prolonging drugs and the QT-drug lists of CredibleMeds (CredibleMeds, 2016)), risk factors and a risk score, an algorithm to handle DDI with risk of QTc-prolongation, communication with the general practitioner and the patient, and a guideline to plan a local concertation about this theme. More details about the content are presented in the Results section. In each module, different learning strategies were used (narrative PowerPoints, interviews with experts, text documents, movies). Each module ends with several exercises to practice the obtained knowledge (including real-life cases, multiple choice questions, flashcards, matching words and poll questions). To develop this material, the software 'Microsoft Word', 'Microsoft PowerPoint', 'Adobe Reader', 'Adobe Premiere Elements' and 'Camtasia studios' was used.

Furthermore, pre-post knowledge tests (post: immediately and ten months after following the e-learning) and a satisfaction questionnaire were developed (Appendix 1 & 2). The knowledge test consisted of 19 fixed response questions (questions for each module) and a closing question to estimate the respondent's own knowledge level. The order of the questions differed between the pre- and post-tests. The satisfaction questionnaire was developed based on the Kirkpatrick model, including questions about the format and content of the training and the impact that it will have on clinical practice (Kirkpatrick, 1996). Both instruments were incorporated in a web survey on the platform of KU Leuven.

Finally, accreditation points for this training were obtained with 'Samenwerkingsverband APB-OPHACO' (Samenwerkingsverband APB-OPHACO, 2016). To earn six points, pharmacists have to follow all modules (except Module 2 about pharmacovigilance) and have to fill in both the pre-post knowledge tests (post: only immediately after following the e-learning required) and the satisfaction questionnaire.

Optimisation of the e-learning

The e-learning was optimised in January-February 2016. For this purpose, the Scientific Information Centre of Escapo C.V. launched a call to invite pharmacists of Surplus who were willing to test the e-learning. Firstly, these pharmacists had to fill in the pre-knowledge test. Subsequently, they received access to the e-learning and feedback was collected with a structured feedback form. Finally, they were requested to complete the first post-knowledge test (immediately after following the e-learning) and satisfaction questionnaire. Based on the comments of these pharmacists and from members of the Scientific Information Centre, adaptations were made to the e-learning.

Implementation of the e-learning

In March 2016, the e-learning was opened to all other pharmacists of the Surplus network (N=187). On 7 March 2016, the pre-knowledge test was spread among these pharmacists. Only when they completed this test, the login code of the e-learning was provided. The pharmacists were encouraged by the respective management board to complete the e-learning, the first

post-knowledge test and the satisfaction questionnaire within one month (final deadline: 7 May 2016). Furthermore, after the training, it was recommended to activate the DDI signals for QTc-prolongation in the software Vianova (starting with the alerts for DDI with QTc-prolonging antibiotics). Ten months after following the e-learning (24 January 2017 – 28 February 2017), the post-knowledge test was repeated. Additionally, two questions were added to investigate the extra consultation of the e-learning in the months after the training and the use of the offered tools (risk score and algorithm) in clinical practice. The results from the knowledge tests and satisfaction questionnaire were automatically extracted from the web surveys.

Data analysis

Data analysis was performed using Microsoft Excel and SPSS v.23 for Windows. Data are presented as mean±standard deviation (SD) or median+interquartile range (IQR) when appropriate. Wilcoxon Signed Rank Tests was used to investigate the difference in the number of positive answers in the pre- and post-knowledge tests (significance level≤0.05). The difference in the number of positive answers in the second post-knowledge test was tested in several subgroups (based on the confidence about their own knowledge, the extra consultation of the e-learning and the use of the tools in practice) with a Mann-Whitney test (significance level≤0.05).

Ethical approval

The study protocol was approved by the Ethics Committee of the University Hospitals Leuven (09/2015). For all performed interviews, informed consent was obtained.

Results

Explorative interviews

Eleven community pharmacists were contacted for the interviews of whom four agreed to participate. In three of the four pharmacies, DDI alerts with risk of QTc-prolongation were already activated. The results of the interviews showed that there is a clear need for training about QTc-prolongation. The interviewed pharmacists emphasised that the current knowledge about this topic is low among healthcare professionals. Especially information about risk factors was requested, making patient-specific risk estimation possible. Communication towards general practitioners and patients was also a topic of interest. Furthermore, pharmacists expected that the training should focus on clinical practice with real-life examples. The pharmacists were positive about the concept of e-learning, but did not agree on the maximum length of the training. One pharmacist recommended not exceeding a length of one hour, while other pharmacists accepted a duration of three-four hours if the e-learning was divided in different modules.

Development and optimisation of the e-learning

A detailed overview of the content and the different modules of the e-learning is shown in Table I. Respectively in Module 4 and 5, a risk score and algorithm are provided to help pharmacists in the risk management of QTc-prolonging DDI; these instruments are presented in Table II and Figure 1. Both instruments are developed based on previous research about QTc-prolongation (Vandael *et al*., 2017).

Eight pharmacists participated in the optimisation phase (75% females; mean age=38 years, SD=13 years). In general, these pharmacists were positive about the e-learning. The following strengths were mentioned: covers all important aspects, focus on clinical practice, clear structure of the e-learning, the availability of exercises, narrative PowerPoint and printable documents, and the involvement of experts. Moreover, based on the knowledge tests, the knowledge of the pharmacists increased (median number of positive answers in the pre-test=10/19, IQR=6-13; in the post-test=17/19, IQR 15-17) and they were more confident about their own knowledge (number of pharmacists that agreed that their knowledge was sufficient, in the pre-test=1/8; in the post-test=8/8). They also expressed that all questions in the knowledge tests and satisfaction questionnaire were sufficiently clear.

On the other hand, a few comments were given. The second Module about pharmacovigilance received the lowest satisfaction scores; some pharmacists expressed that there was no need for this information. Further, repetition of the information in different learning materials (*e.g.* the PowerPoint and interviews) was mentioned as a weakness. The pharmacists also asked if Module 5 about the management of QTc-prolonging DDI could be more elaborated. Finally, it was suggested to make a library module where all documents are grouped together.

Based on this feedback, a few adaptations were made. Some documents were replaced in another module and as suggested, a library was added. Module 5 was reconsidered; more examples were incorporated and stepwise discussed. Furthermore, Module 2 was made optional and did not need to be completed to receive accreditation. Additionally, in the introduction, it was emphasised that pharmacists can choose their own learning materials (what works best for them) and that not all materials need be used.

Implementation of the e-learning and satisfaction of the pharmacists

During the implementation, 174 pharmacists opened the e-learning resulting in 3051 sessions (most sessions with Module 5: N=503). Of those 174 pharmacists, 166 completed the e-learning, pre- and first post-knowledge tests and the satisfaction questionnaire (response rate: 89%). Most pharmacists were female (80%) with a mean age of 41 years (SD=11 years), with the function of principal pharmacist: 48%, adjunct pharmacist: 26% and replacing pharmacist: 26% and a mean experience time in a community pharmacy of 17 years (SD=11 years).

Table I: Overview of the different modules in the e-learning

Modules	Learning material	Aims	Evaluation	Expected time	References
Introduction	Narrative PPT	- To explain the aims of the e-learning - To motivate the pharmacists to follow this training	NA	10 min.	NA
Module 1: Basic concepts about ECG and QTc-prolongation	- Narrative PPT - Filmed interview with a cardiologist - Movie: how to perform an ECG	- To obtain basic knowledge about QTc-prolongation, possible outcomes and symptoms - To obtain awareness about the role of a pharmacist in the risk management of QTc-prolongation - To have an idea how an ECG is performed	Multiple choice questions	30 min.	(Drew *et al*., 2010; Roden, 2004; van Noord *et al*., 2010; Beach *et al.,* 2013; Isbister *et al*., 2013; Morita *et al.,* 2008; Nachimuthu *et al*., 2012; Pickham, 2013; Sarganas *et al*., 2014)
Module 2: Pharmacoviglance	- Narrative PPT - Filmed interview with famhp - Text document: how to report ADRs to famhp	- To obtain awareness about the importance of pharmacovigilance - To have an idea how pharmacovigilance is handled at famhp - To be able to report ADRs to famhp	Poll	20 min.	(International Conference on Harmonisation, 2005; Famph, 2016; U.S. Department of Health and Human Services, 2005)
Modules	**Learning material**	**Aims**	**Evaluation**	**Expected time**	**References**
Module 3: QTc-prolonging drugs	- Narrative PPT - Filmed interview with a psychiatrist - Text document: QT-drug lists of CredibleMeds	- To be able to use the QT-drug lists of CredibleMeds To recognise QTc-prolonging drugs, especially of list 1 of CredibleMeds To be able to find an alternative for a QTc-prolonging drug	Flash cards Matching words game	30 min.	(CredibleMeds, 2016)
Module 4: Risk factors	- Narrative PPT - Text document: risk score	- To obtain knowledge about other risk factors for QTc-prolongation To be able to work with the risk score	Matching words game Real-life cases	20 min.	(Vandael *et al*., 2017; Haugaa *et al*., 2013; Tisdale *et al*., 2013)
Module 5: Risk management of QTc-prolonging DDI	- 3 Narrative PPTs - Filmed interview with a general practitioner - Text document: DDI alerts in Vianova - Text document: Finding an alternative for QTc-prolonging antibiotics, based on the Belgian antibiotic guidelines (BAPCOC)	- To be aware of the current risk management (previous epidemiological study) To be able to handle the current DDI alerts for QTc-prolongation in Vianova - To be able to work with the proposed algorithm - To be able to find an alternative for a QTc-prolonging antibiotic	Real-life cases	45 min.	(BAPCOC, 2016)
Modules	**Learning material**	**Aims**	**Evaluation**	**Expected time**	**References**
Module 6: Communication with physicians and patients	Movies: 4 real-life cases in the pharmacy (bad and good examples)	To train a good communication about the risk of QTc-prolongation, both towards physicians and towards patients	Poll	30 min.	NA
Module 7: Local concertation about the risk of QTc-prolongation	- PPT that can be used with a local concertation - Text document: how to organise a local concertation	To be able to organise a local concertation about the theme 'QTc-prolongation'	NA	10 min.	(UPB-AVB, 2013; NIHDI, 2016)
Module 8: Library	- Printable versions of all documents of the previous modules - Extra scientific articles	Overview of all documents	NA	NA	
Module 9: Evaluation	Post-knowledge test and satisfaction questionnaire (link to websurvey)	To evaluate the obtained knowledge and the satisfaction about the e-learning	NA	15 min.	NA

PPT = PowerPoint; NA = not applicable; min. = minutes; famhp = Federal Agency of Medicines and Health Products, ADR = adverse drug reaction; DDI = drug-drug interactions; BAPCOC = Belgian Antibiotic Policy Coordination Committee; ECG = electrocardiogra

Figure 1: Algorithm to handle QTc-prolonging DDI in a community pharmacy

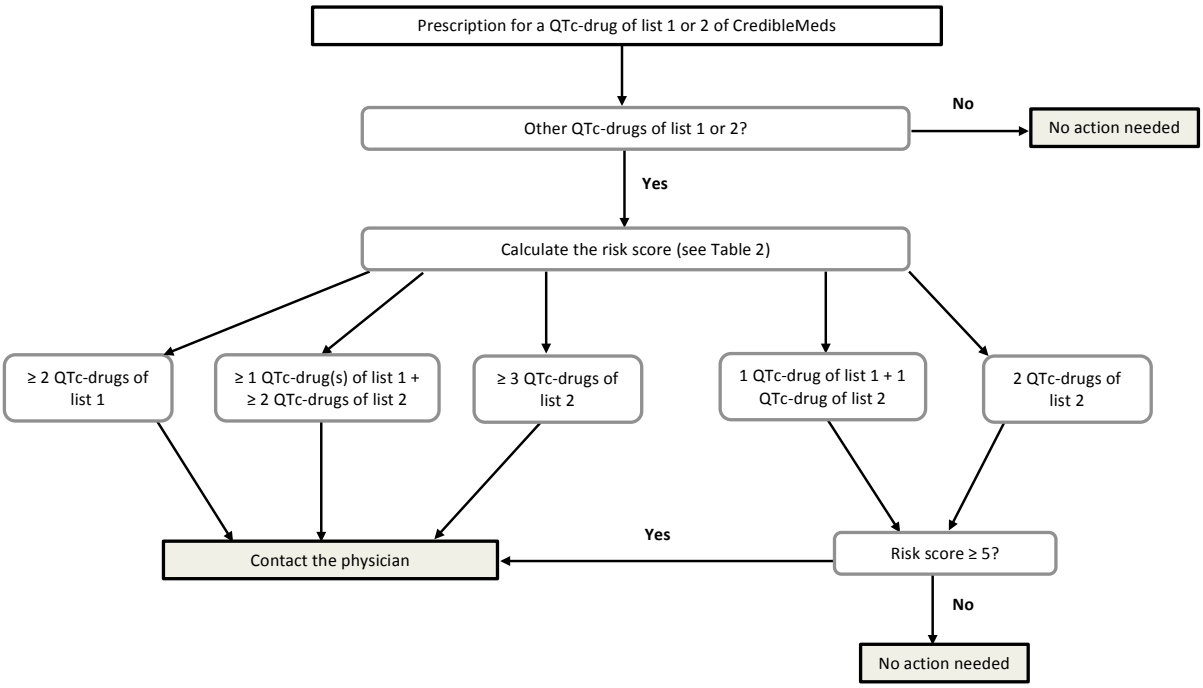


Table II: Risk score for QTc-prolongation, score ≥ 5 defined as high risk

Risk factors for QTc-prolongation	Points
• Use of ≥1 potassium-lowering diuretic [+]	3 points
• Use of ≥1 anti-arrhythmic drug	3 points
• Age ≥65 years	2 points
• Female gender	2 points
• Thyroid disturbances	2 points
• Cardiovascular comorbidities/drugs[*]	1 point
• Diabetes mellitus	1 point
TOTAL RISK SCORE	**Maximum 14 points**

[+] No points if used in combination with potassium-sparing diuretics

[*] Including antihypertensive drugs, beta-blocking agents, nitrates, calcium-channel blockers, agents acting on the renin-angiotensin system and lipid-modifying agents

Table III: Results of the satisfaction questionnaire - general score and scores per Module (1=extremely dissatisfied, 10=extremely satisfied)

	Median (IQR)
General satisfaction score	9 (8-10)
Satisfaction score Module 1	9 (8-10)
Satisfaction score Module 2	7 (5-8)
Satisfaction score Module 3	9 (9-10)
Satisfaction score Module 4	9 (9-10)
Satisfaction score Module 5	9 (8-10)
Satisfaction score Module 6	8 (7-9)
Satisfaction score Module 7	6 (5-8)
Satisfaction score Module 8	8 (7-9)

The results of the satisfaction questionnaire are presented in Table III and Figure 2. In general, the median satisfaction score for the e-learning was 9/10 (IQR=8-10). Most pharmacists (93%) indicated that the e-learning platform was easy to use. Furthermore, they found that the obtained knowledge can be used in clinical practice (99%) and that they are more confident to handle DDI with risk of QTc-prolongation after completing the e-learning (96%). Most pharmacists (respectively 98%, 94% and 92%) stated that they will use the Crediblemeds lists, the risk score and the algorithm in daily practice. Moreover, the majority (96%) will recommend the e-learning to other healthcare professionals.

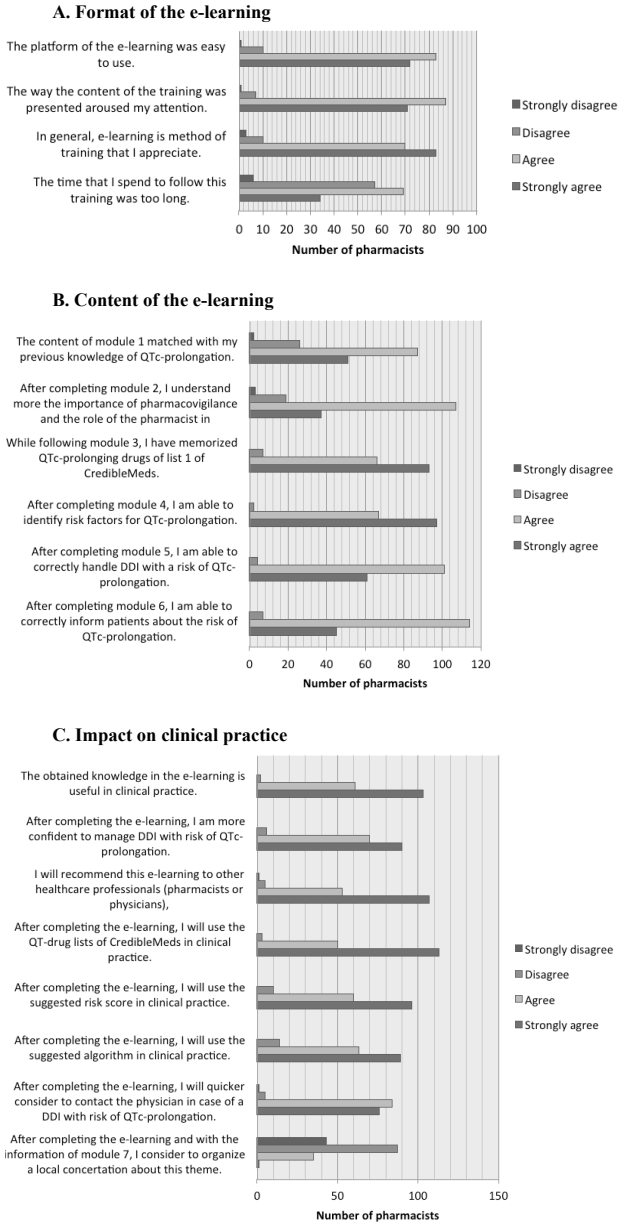
Impact on knowledge

The pre- and first post-knowledge tests were completed by 166 pharmacists. The median number of positive answers was 9/19 (IQR=6-11) in the pre-test and 16/19 (IQR=15-18) in the first post-test which is a significant difference ($p<0.001$). The median individual difference in right answers pre and post was 7 (IQR=5-10).

The second post-test, ten months after the training, was completed by 97 pharmacists (76.3% females; mean age 41±11 years). This subset did not differ from the initial group of 166 pharmacists. Their median score on the second post-test was 12/19 (IQR 10-14). This is a significantly higher score ($p<0.001$) than in the pre-test for this subgroup (median=8/19, IQR=6-11), but

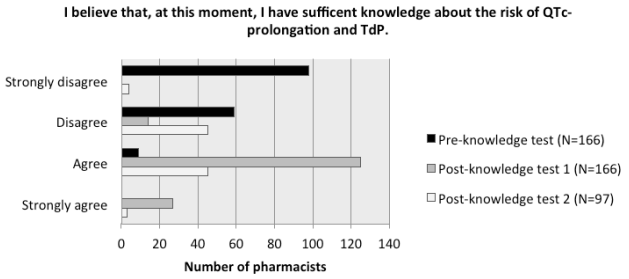
significantly lower (p<0.001) than in the first post-test (median=16/19, IQR=15-18). The median individual decrease in right answers between the first and second post-test was -4 (IQR=-6 – -2).

Figure 2: Results of the satisfaction questionnaire - Answers to the statements



The majority of pharmacists (95%) were not confident about their own knowledge before following the e-learning. This confidence shifted with 92% of the pharmacists who indicated that they were confident about their knowledge in the first post-test. However, this number decreased to 49.5% in the second post-test. These results are presented in Figure 3.

Figure 3: Results of the knowledge test - Answers to the statement about self perception of their knowledge of the risk of QTc-prolongation and TdP



Ten months after following the e-learning, half of the pharmacists (55.7%) indicated that they consulted the e-learning again after completing the training of whom 18.6% in the last month. Only a minority of the pharmacists (3%) had not yet used the risk score and/or algorithm in clinical practice (frequency of use: multiple times per week: 9.3%, one time per week: 12.4%, multiple times per month: 26.8%, one time per month: 23.7%, only a few times in the last ten months: 24.7%).

Pharmacists who were confident about their knowledge ten months after following the e-learning (median score=14/19, IQR 11-15) and who consulted the e-learning again after completing the training (median score=13/19, IQR 11-15), had a significant higher score on the second post-test (respectively p=0.003 and p=0.002) than colleagues who did not. Frequent use of the tools in practice (at least multiple times per month; median score=13/19, IQR 11-14) was not significantly correlated with higher scores (p=0.081).

Discussion

An innovative e-learning about the risk of QTc-prolongation, developed based on co-design and consultation with experts, including various learning materials, was implemented in a large Flemish pharmacy network. During the implementation phase, 166 pharmacists (response rate=89%) completed the e-learning, knowledge tests and satisfaction questionnaire. The pharmacists were very satisfied with this training with a median satisfaction score of 9/10. Furthermore, they had a significant higher score on the knowledge test immediately after completing the e-learning and ten months later.

Novel approach in pharmacy education

Although ‘e-learning’ is frequently used as a training method in pharmacy education (Salter *et al*., 2014), only a limited number of e-learning studies are published about risk management (Legris *et al*., 2011, American

Society of Health-System Pharmacists, 2013). This is the first e-learning for community pharmacists that focuses on the risk management of QTc-prolongation. Most pharmacists indicated that e-learning is a method of training that they appreciate and that they were satisfied with the format of this e-learning in specific.

This e-learning was developed and optimised in cooperation with community pharmacists and experts (co-design). By exploring the needs of community pharmacists beforehand, and by involving them in the development process, the training was maximally fit to the target population. Consequently, high satisfaction scores with a median of 9/10 were obtained.

The pharmacists expressed that the information in the e-learning was very complete and well-structured in the different modules. Further, the practice-based approach of the e-learning and the availability of a lot of exercises and cases were highly appreciated by the target population. Moreover, they appreciated the tools for clinical practice (a risk score and algorithm) that are offered in the e-learning (Module 4 and 5). These tools were developed based on a systematic review which summarised and assessed the evidence of different risk factors for QTc-prolongation (Vandael *et al*., 2017). As far as the authors' know, no other guidelines about the risk management of QTc-prolongation that specifically focus on the role of community pharmacists are available. The majority of the pharmacists indicated that they will use these tools in clinical practice. At the occasion of the second post-knowledge test, half of the pharmacists (48.5%) confirmed that they frequently used the risk score and/or algorithm in the ten-months interval after completing the e-learning (at least multiple times per month).

The content of the e-learning was generally in line with the whole-task approach of the Four Component Instructional Design (4C/ID) model which is often used in medical education. This model consists of four main components: learning tasks, supportive material, procedural information, and part-task practice. In the learning tasks, all parts of a complex task should be tackled to comply with the whole-task approach (van Merriënboer *et al*., 2012; Maggio *et al*., 2015). In this e-learning, different aspects of the risk of QTc-prolongation were covered in the different modules in a structured and integrated way. The information was offered in several learning materials with the concept of different learning strategies. Secondly, supportive information was available in the library section. Thirdly, procedure information was elaborated in the many real-life examples, especially in Module 5 where concrete tools were offered and explained in a step-by-step approach. Finally, part-task practice was integrated in the exercises at the end of each module.

Impact on knowledge

A significant higher score in the knowledge test was found directly after completing the e-learning (before: median score=9/19; after: median score=16/19). Further, in contrast with baseline, the majority of pharmacists (92%) were confident about their own knowledge after the training.

As recommended in the review of Salter *et al.*, we also tested the retention of knowledge at a later time point (ten months after following the e-learning) (Salter *et al.*, 2014). As expected, the median score (12/19) decreased in comparison with the first post-test, but still remained significantly better than in the pre-test. Half of the pharmacists were still confident about their own knowledge. Pharmacists who consulted the e-learning again after completing the training had significantly higher scores, indicating that repeated training is needed to obtain a more optimal knowledge level.

Strengths and limitations

As mentioned above, this study has several strengths, including the stepwise practice-based approach, and the involvement of the target population and experts in the development and optimisation process of the e-learning. Furthermore, the e-learning was implemented in a large pharmacy network with a high response rate. Pre-post knowledge tests, measuring also long-term knowledge which is innovative in comparison with other studies, and a satisfaction questionnaire were completed by the pharmacists to evaluate the e-learning.

A few limitations should be addressed. Only one Flemish pharmacy chain was involved in the study; the results should still be confirmed in other Flemish pharmacies. Furthermore, only a limited number of pharmacists participated in the explorative interviews and optimisation phase. During the implementation phase, the high participation rate can partly be explained by the fact that the pharmacists were repeatedly motivated by the respective management to follow the e-learning.

Future perspectives

To study the impact on clinical practice, a before-after retrospective study will be performed. The aim of this study is to investigate the prevalence of DDI with QTc-prolonging antibiotics and how these DDI are handled by community pharmacists, before and after the implementation of the e-learning. This study will shed a light on how the obtained knowledge is translated in the risk management of QTc-prolongation.

Furthermore, the e-learning will further be adapted to other pharmacy software and implemented in other Flemish community pharmacies. In addition, the e-learning can also be offered to other healthcare professionals and settings.

Finally, the authors believe that training alone is not enough and other initiatives are needed to improve cooperation with other healthcare professionals to handle this complex risk, *e.g*. case conferences with physicians and nurses about this theme. In Module 7 of the e-learning, materials are provided to perform a case conference.

Conclusion

An innovative e-learning programme about the risk of QTc-prolongation, co-designed with pharmacists and experts and including tools for clinical practice, was successfully implemented in a large Flemish pharmacy network. The results of the satisfaction questionnaire indicated that the community pharmacists were very satisfied with this training. Moreover, the e-learning resulted in a significant increase in knowledge (including long-term knowledge) and most pharmacists were more confident about this knowledge. The impact of the e-learning on clinical practice will further be investigated in a follow-up study. The authors believe that this approach can also be offered to other healthcare professionals and settings, and can serve as a model for other trainings on risk management.

Conflicts of Interest and Source of Funding

Ph.D.-student EV was supported by funding of the Belgian government agency for Innovation by Science and Technology (IWT). The development of the e-learning was also supported by funding from Pfizer. No conflicts of interest declared.

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Appendix 1: Knowledge test (in Dutch)

Algemene informatie:

Code doorgekregen door WID: A___

Geslacht: Man □ / Vrouw □

Leeftijd: __

Jaar van afstuderen: __

Ervaring als apotheker in een openbare apotheek- uitgedrukt in jaren: _

Huidige functie: Provisor □ / Adjunct □ / Plaatsvervanger □

Aantal uren per week dat u momenteel werkt in een apotheek: __

Kennisvragen

OPMERKING: Elk van onderstaande vragen heeft slechts 1 juist antwoord.

1. Vanaf welke duur van het QTc-interval is er een significant toegenomen risico op Torsade de Pointes (polymorfe ventrikeltachycardie)?
   - □ QTc ≥ 100 msec
   - □ QTc ≥ 400 msec
   - □ **QTc ≥ 500 msec**
   - □ QTc ≥ 550 msec
   - □ Ik weet het niet

2. Een verhoogd risico op QTc-verlenging kan te wijten zijn aan een aangeboren genetisch defect.
   - □ **Juist**
   - □ Fout
   - □ Ik weet het niet
   - □ Ik denk juist maar ik ben niet zeker
   - □ Ik denk fout maar ik ben niet zeker

3. Een verlengd QTc-interval evolueert steeds tot Torsade de Pointes.
   - □ Juist
   - □ **Fout**
   - □ Ik weet het niet
   - □ Ik denk juist maar ik ben niet zeker
   - □ Ik denk fout maar ik ben niet zeker

4. Het QTc-interval is een marker voor ventriculaire depolarisatie.
   - □ Juist
   - □ **Fout**
   - □ Ik weet het niet
   - □ Ik denk juist maar ik ben niet zeker
   - □ Ik denk fout maar ik ben niet zeker

5. Welke symptomen zijn volgens u kenmerkend voor een symptomatisch verlengd QTc-interval (en een mogelijke episode van Torsade de Pointes)?
   a. Duizeligheid
   b. Paresthesieën
   c. Druk op de borst
   d. Syncope
   e. Hartkloppingen
   - □ Enkel symptoom e
   - □ Symptomen b en e
   - □ Symptomen a, c en d
   - □ **Symptomen a, d en e**
   - □ Alle hierboven vermelde symptomen kunnen bij een symptomatisch.verlengd QT-interval voorkomen.

6. Hoe veroorzaken geneesmiddelen meestal een verlenging van het QTc-interval?
   - □ Door blokkade van spanningsafhankelijke calciumkanalen.
   - □ Door activatie van spanningsafhankelijke calciumkanalen.
   - □ **Door blokkade van HERG-type kaliumkanalen.**
   - □ Door activatie van HERG-type kaliumkanalen.

7. Bij nieuwe geneesmiddelen (aangeduid door een omgekeerde, zwarte driehoek in het BCFI) wordt er door het FAGG in het kader van farmacovigilantie enkel gevraagd om ernstige, onverwachte en/of verdachte bijwerkingen en bijwerkingen bij kwetsbare bevolkingsgroepen te melden.
   - □ Juist
   - □ **Fout**
   - □ Ik weet het niet
   - □ Ik denk juist maar ik ben niet zeker
   - □ Ik denk fout maar ik ben niet zeker

8. Welke van de volgende beweringen zijn juist (en duiden op het belang van farmacovigilantie na het op de markt komen van geneesmiddelen)?
   a. Het aantal testpersonen in klinische studies is te laag om zeldzame nevenwerkingen als Torsade de Pointes te detecteren.
   b. In klinische studies wordt er een geselecteerde testpopulatie gebruikt die niet helemaal representatief is voor de klinische praktijk.
   c. Klinische studies worden uitgevoerd in gestandaardiseerde omstandigheden met een nauwe opvolging van de testpersonen.
   d. Een beperking van klinische studies is de korte duur van de blootstelling aan de geneesmiddelen.
   - □ Geen enkele van bovenstaande beweringen is juist.
   - □ Beweringen b en d zijn juist.
   - □ Beweringen b, c en d zijn juist.
   - □ Beweringen a, b en c zijn juist.
   - □ **Alle bovenstaande beweringen zijn juist.**

9. Welke bronnen kan u consulteren in het kader van een interactie met risico op QTc-verlenging?
   a. De website van *CredibleMeds* (www.crediblemeds.org).
   b. De SKP's/bijsluiters van desbetreffende producten.
   c. De website van *Cybele* (www.pharm.kuleuven.be/apps/cybele).
   d. Het boek 'Commentaren medicatiebewaking'
   e. De website van Domus Medica (www.domusmedica.be)
   - □ Bronnen a en c

□ Bronnen d en e

□ **Bronnen a, b en d**

□ Enkel bron d

□ Geen enkele van deze bronnen levert voldoende informatie over het potentieel risico op QTc-verlenging.

10. Welk van volgende beweringen zijn juist?
    a. Er is evidentie dat moxifloxacine (Avelox®) een verlenging van het QTc-interval kan veroorzaken.
    b. Er is evidentie dat desloratadine (Aerius®) een verlenging van het QTc-interval kan veroorzaken.
    c. Er is evidentie dat sulpiride (Dogmatil®) een verlenging van het QTc-interval kan veroorzaken.
    d. Er is evidentie dat de combinatie van moxifloxacine en sulpiride een groter risico geeft op QTc-verlenging dan het gebruik van elk van deze geneesmiddelen afzonderlijk.
    e. Er is evidentie dat de combinatie van desloratadine en moxifloxacine een groter risico geeft op QTc-verlenging dan het gebruik van elk van deze geneesmiddelen afzonderlijk.

    □ Geen enkele van bovenstaande beweringen is juist.

    □ Alle bovenstaande beweringen zijn juist.

    □ **Beweringen a, c en d zijn juist.**

    □ Beweringen a, b en e zijn juist.

    □ Enkel bewering c is juist.

11. Voor welke van volgende geneesmiddelen is er evidentie dat ze een verlenging van het QTc-interval kunnen veroorzaken?
    a. Erythromycine (Erythroforte®, Erythrocine®)
    b. Ranitidine (Acidine®, Zantac®)
    c. Levetiracetam (Keppra®)
    d. Doxycycline (Vibratab®, Efracea®)
    e. Donepezil (Aricept®)

    □ Geneesmiddelen a, c en e

    □ Enkel geneesmiddel a

    □ Geneesmiddelen b en d

    □ **Geneesmiddelen a en e**

    □ Alle bovenstaande geneesmiddelen kunnen mogelijk het QT-interval verlengen.

12. Er is evidentie dat het geneesmiddel Sotalol (Sotalex®) een verlenging van het QTc-interval kan veroorzaken.

    □ **Juist**

    □ Fout

    □ Ik weet het niet

    □ Ik denk juist maar ik ben niet zeker

    □ Ik denk fout maar ik ben niet zeker

13. Er is evidentie dat het geneesmiddel Citalopram (Cipramil®) een verlenging van het QTc-interval kan veroorzaken.

    □ **Juist**

    □ Fout

    □ Ik weet het niet

    □ Ik denk juist maar ik ben niet zeker

    □ Ik denk fout maar ik ben niet zeker

14. Welke van volgende factoren geven volgens u allemaal een verhoogd risico op QTc-verlenging en Torsade de Pointes?

    □ Leeftijd, geslacht, Alzheimer, hyperkaliëmie

    □ **Leeftijd, geslacht, hypokaliëmie, diabetes**

    □ Leeftijd, Alzheimer, diabetes, hypercalciëmie

    □ Leeftijd, geslacht, hypocalciëmie, jicht

15. Diureticagebruik is een risicofactor voor QTc-verlenging en Torsade de Pointes.

    □ **Juist**

    □ Fout

    □ Ik weet het niet

    □ Ik denk juist maar ik ben niet zeker

    □ Ik denk fout maar ik ben niet zeker

16. Geneesmiddelen voor schildklierlijden vormen een risicofactor voor QTc-verlenging en Torsade de Pointes.

    □ **Juist**

    □ Fout

    □ Ik weet het niet

    □ Ik denk juist maar ik ben niet zeker

    □ Ik denk fout maar ik ben niet zeker

17. Welke van volgende beweringen zijn juist?
    a. Alle geneesmiddelen die gekend zijn met een mogelijke verlenging van het QTc-interval worden door de interactiesoftware van ViaNova bewaakt.
    a. De interactie tussen een QTc-verlengend geneesmiddel (met een duidelijk risico op Torsade de Pointes) en een middel dat zijn afbraak remt wordt momenteel (indien geactiveerd) bewaakt in ViaNova.
    b. De risicofactoren voor een verhoogd risico op QTc-verlenging worden momenteel weergegeven bij afhandeling van een QTc-verlengende interactie met ViaNova.
    c. Bij het afhandelen van de interactie tussen een kortstondige kuur met een QTc-verlengend antibioticum en een chronisch QTc-verlengend geneesmiddel kan je best kiezen om het interactiesignaal voor een tijdje te onderdrukken.

    □ Geen enkele van bovenstaande beweringen is juist.

    □ Beweringen c en d zijn juist.

    □ Beweringen a en b zijn juist.

    □ Beweringen a en c zijn juist.

    □ **Enkel bewering b is juist.**

18. Hanne (24 jaar) komt de apotheek binnen met een voorschrift voor Ciproxine® 250 mg (ciprofloxacine). Uit haar medicatiehistoriek leidt u af ze ook behandeld wordt voor een depressie met Sipralexa® 10 mg (escitalopram). Verder neemt ze ook nog Mercilon® en Paracetamol Teva 1 g zo nodig. Wat doet u?

    □ Er is geen gevaar voor QTc-verlenging, u levert Ciproxine® af.

    □ **U vermoedt een verhoogd riciso op QTc-verlenging en contacteert de arts.**

□ U vermoedt een verhoogd risico op QTc-verlenging en vervangt het antibioticum door een alternatief (zonder contact met de arts).

□ U vermoedt een verhoogd risico op QTc-verlenging. Toch besluit u om Ciproxine® af te leveren, maar u waarschuwt de patiënt echter voor de symptomen van Torsade de Pointes.

□ Ik weet het niet.

19. Dennis (35 jaar) lijdt aan een bipolaire stoornis waarvoor hij al een tiental jaar Maniprex® 500 mg (Lithium) neemt. De laatste tijd is zijn toestand echter verslechterd en heeft de psychiater beslist Nozinan® 25 mg (Levomepromazine) aan zijn behandeling toe te voegen. Voor de rest neemt Dennis geen andere medicatie. Wat doet u?

□ Er is geen gevaar voor QTc-verlenging, u levert Nozinan® af.

□ U vermoedt een verhoogd riciso op QTc-verlenging en contacteert de arts.

□ **U vermoedt een verhoogd risico op QTc-verlenging, maar u schat het risico eerder laag in en u levert Nozinan® af.**

□ Ik weet het niet.

20. Ik vind op dit moment van mezelf dat ik voldoende kennis heb over het onderwerp QTc-verlenging/Torsade de Pointes:

□ Helemaal akkoord

□ Eerder akoord

□ Eerder niet akkoord

□ Helemaal niet akkoord

Mocht u nog opmerkingen hebben over deze kennistest, dan kan u ze hier kwijt:

Appendix 2: Satisfaction questionnaire (in Dutch)

Vorm van de e-learning

Hoe tevreden bent u in het algemeen over de e-learning?

Helemaal niet tevreden — Zeer *tevreden*

1	2	3	4	5	6	7	8	9	10

Duid aan wat past.

	Helemaal niet akkoord	Eerder niet akkoord	Eerder akkoord	Helemaal akkoord
Het e-learning platform is makkelijk in gebruik.				
De manier waarop de inhoud werd voorgesteld wekte mijn interesse op.				
In het algemeen is e-learning een manier van leren die ik apprecieer.				
De tijd die ik aan de e-learning spendeerde was te lang.				

Als u akkoord ging dat de tijd die u aan de e-learning spendeerde te lang was, welke modules zou u dan inkorten of schrappen?

Inhoud van de e-learning

Hoe leerrijk vond u de verschillende modules? Specifieer met een cijfer tussen 1 en 10 (1=helemaal niet leerrijk, 10=zeer leerrijk).

Module 1: Algemene begrippen
Module 2: Farmacovigilantie
Module 3: QT-verlengende geneesmiddelen
Module 4: Risicofactoren
Module 5: Afhandeling van QT-verlengende interacties
Module 6: Communicatie
Module 7: MFO
Module 8: Bibliotheek

Duid aan wat past.

	Helemaal niet akkoord	Eerder niet akkoord	Eerder akkoord	Helemaal akkoord
Module 1 was een goede inleiding voor de e-learning.				
De informatie in Module 1 sloot aan bij mijn voorkennis over QT-verlenging.				
Na het doorlopen van Module 2 zie ik beter het belang in van farmacovigilantie en de rol van de apotheker hierin.				
De informatie over farmacovigilantie in Module 2 was herhaling voor mij. Ik heb hier niets nieuws uit geleerd.				
Na het doorlopen van Module 3 weet ik waar en hoe ik de lijsten met QT-verlengende geneesmiddelen kan raadplegen.				
Door het volgen van Module 3 heb ik de belangrijkste geneesmiddelen met risico op QT-verlenging kunnen memoriseren.				
Na het volgen van Module 4 ben ik in staat om risicofactoren omtrent QT-verlenging te detecteren.				
Na het volgen van Module 5 heb ik meer inzicht gekregen in de interactiemeldingen met risico op QT-verlenging in Vianova.				
Na het volgen van Module 5 kan ik interactiemeldingen rond QT-verlenging correct afhandelen.				

Na het volgen van Module 6 ben ik in staat om op een correcte manier patiënten in te lichten bij het afleveren van QT-verlengende medicatie/ interacties.

Invloed op de praktijk

Duid aan wat past.

	Helemaal niet akkoord	Eerder niet akkoord	Eerder akkoord	Helemaal akkoord
De kennis opgedaan in de e-learning is nuttig voor mij in de dagelijkse praktijk.				
Na het volgen van deze e-learning voel ik me zelfzekerder om interacties met risico op QT-verlenging te bewaken.				
Ik zou de e-learning aanraden aan andere zorgverleners (apothekers of artsen).				
Bij een volgend probleem rond farmacovigilantie zal ik dit rapporteren aan het FAGG.				
Ik ga de lijsten van CredibleMeds in de praktijk gebruiken.				
Na het volgen van deze e-learning zal ik de risicoscore berekenen bij patiënten die risico lopen op QT-verlenging.				
Na het volgen van deze e-learning zal ik de interactiemeldingen rond QT-verlenging opzetten (of op laten staan) in Vianova.				
Na het volgen van deze e-learning zal ik het voorgesteld algoritme toepassen in de praktijk.				
Na het volgen van deze e-learning zal ik sneller contact opnemen met artsen over deze interacties.				
Na het volgen van deze e-learning zal ik meer aandacht besteden aan de communicatie met arts en patiënt met betrekking tot QT-interacties.				
Na het volgen van deze e-learning en met behulp van de informatie uit Module 7 overweeg ik om een MFO rond dit thema te organiseren.				

Waarom overweegt u wel / niet om een MFO rond dit thema te organiseren?

Andere onderwerpen die u in de e-learning nog aan bod had willen zien komen? Onderwerpen die u liever geschrapt had? Andere opmerkingen/ suggesties?