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# Barriers and facilitators in using a Clinical Decision Support System for fall risk management for older people: a European survey

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## Key summary points

**Aim** The aim of our study was to assess barriers and facilitators to CDSS use reported by European physicians treating older fallers and explore differences in their perceptions.

**Findings** Our main findings were that a barrier to CDSS use is that physicians feel that complex geriatric patients need a physician's clinical judgement and not the advice of a CDSS. Regional differences in barrier and facilitator perceptions occurred across Europe.

**Message** Our main message is that when designing a CDSS for Geriatric falls patients, the patient's medical complexity must be addressed whilst maintaining the doctor's decision-making autonomy, and to increase successful CDSS implementation in Europe, regional differences in barrier perception should be overcome.

## Abstract

**Purpose** Fall-Risk Increasing Drugs (FRIDs) are an important and modifiable fall-risk factor. A Clinical Decision Support System (CDSS) could support doctors in optimal FRIDs deprescribing. Understanding barriers and facilitators is important for a successful implementation of any CDSS. We conducted a European survey to assess barriers and facilitators to CDSS use and explored differences in their perceptions.

**Methods** We examined and compared the relative importance and the occurrence of regional differences of a literature-based list of barriers and facilitators for CDSS usage among physicians treating older fallers from 11 European countries.

**Results** We surveyed 581 physicians (mean age 44.9 years, 64.5% female, 71.3% geriatricians). The main barriers were technical issues (66%) and indicating a reason before overriding an alert (58%). The main facilitators were a CDSS that is beneficial for patient care (68%) and easy-to-use (64%). We identified regional differences, e.g., expense and legal issues were barriers for significantly more Eastern-European physicians compared to other regions, while training was selected less often as a facilitator by West-European physicians. Some physicians believed that due to the medical complexity of their patients, their own clinical judgement is better than advice from the CDSS.

**Conclusion** When designing a CDSS for Geriatric Medicine, the patient's medical complexity must be addressed whilst maintaining the doctor's decision-making autonomy. For a successful CDSS implementation in Europe, regional differences in barrier perception should be overcome. Equipping a CDSS with prediction models has the potential to provide individualized recommendations for deprescribing FRIDs in older falls patients.

**Keywords** Clinical Decision Support System (CDSS) · Barriers · Facilitators · Medication review · Falls prevention

## Introduction

The use of Fall-Risk Increasing Drugs (FRIDs) such as cardiovascular and psychotropic medications [1–3] is an important and modifiable fall-risk factor [4]. FRIDs use is

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common in older adults. About 40% of community-dwelling older adults take at least one FRID. In older adults who have experienced an injurious fall, the percentage of FRIDs users is even higher (at 91%) [5]. Several studies have shown that deprescribing FRIDs in older patients decreases both fall risk and fall rate [6]. It has therefore been recommended by the European Geriatric Medicine Society (EuGMS) Task and Finish Group on FRIDs as well as by several national and international guidelines that a medication review should be performed in all older falls patients as part of a multifactorial fall-risk assessment [7]. However, despite these recommendations, the majority of clinicians struggle to routinely perform a medication review due to a lack of time, insufficient knowledge of the topic, and uncertainty about the outcome of deprescribing a FRID [7, 8].

A Clinical Decision Support System (CDSS) integrated into the Electronic Medical Record (EMR) might support clinicians in medication reviews and deprescribing decisions regarding FRIDs in older falls patients. A CDSS is “a system that links health observations with health knowledge to influence health choices by clinicians for improved health care” [9]. Previous studies have demonstrated the efficacy of a CDSS in reducing potentially inappropriate prescriptions in older adults [10], improving falls prevention in older hospitalized patients [11] and increasing the effectiveness of medication reviews [12]. However, the rate of overriding alerts was high [13] and many systems were not significantly effective in changing patient outcomes in clinical trials [14]. Assessing barriers and facilitators of new healthcare technology as experienced by users before implementation is expected to increase the likelihood of its success [15].

Previous studies have assessed barriers and facilitators for CDSS use in general [16]. Also, barriers and facilitators have been explored for CDSSs designed to improve outcomes of older patients [17]; geriatricians were studied as a subgroup of larger study population of specialists [18]. However, to the best of our knowledge, perceived barriers and facilitators for CDSS usage according to physicians who treat older fallers have not been explored. It might be expected that unique barriers and facilitators could be applicable for geriatricians. For example, because older patients are more likely to have multiple comorbidities and to be on multiple medications their clinical management may be complex. Therefore, any support in decision-making could be beneficial to physicians treating this group [19]. Taking into account the specific barriers and facilitators for Geriatric Medicine, alongside the general barriers and facilitators for CDSS, might increase successful implementation and adoption in this field.

Using literature to compare barriers and facilitators between countries is difficult for several reasons. Most such studies have been conducted in a single country and have used different research methods and different populations

to explore barriers and facilitators to CDSS use [17, 20, 21]. We hypothesized that differences in culture, healthcare systems, and in the implementation of Electronic Medical Record (EMR) systems could affect perception of barriers and facilitators to CDSS use among clinicians of different countries [22]. Countries can be classified into different regions based on their economic and social factors [23]. A previous survey study found differences in perception of implementation hurdles between CDSS developers from different countries [24]. Knowing regional differences in barrier perception is especially important for CDSSs that are used internationally, as it could be that a CDSS that is successful in one region fails in another due to specific barriers. For these reasons, this study aims to assess barriers and facilitators for CDSS use among physicians treating older falls patients, both community-dwelling and hospitalized, and to use a uniform questionnaire to explore international differences across Europe.

## Methods

This survey was conducted by members of the EuGMS Task & Finish Group on FRIDs. Representatives of fifteen European countries were approached and given information about the study. Eleven countries participated in the survey (see Online Resource 1). Eligible participants were physicians, nurse practitioners, and physicians' assistants who in their clinical practice (primary, secondary and tertiary care) see older adults (65 years and over) at risk of falls. A fall was defined as “an unexpected event in which the participants come to rest on the ground, floor, or lower level” [25]. All participants were asked how often they see or treat older fallers (age 65 and above) in the first question. Participants were excluded from participation if they answered that they never see older fallers or that they are not permitted to prescribe or alter medication. Written informed consent was given by all participants.

## Survey development

An initial English language draft survey was composed by two authors (KP and AL) which comprised questions on demographics, fall-risk assessments, and CDSS usage. Since no validated questionnaire was available on this topic, a new instrument was developed. A list of barriers and facilitators for medication-related CDSS use was drawn from the literature (see Online Resource 1 for specific references used) [26]. The resulting list of barriers and facilitators was cross-checked with the Technology Acceptance Model (TAM) [27] to see if all items were accounted for. Participants were asked to select the most important barriers and facilitators up to a maximum of eight per category. Participants could

add barriers and facilitators they felt were missing via an open text box. For this reason, we were not able to assess the construct validity of the questionnaire.

The final version of the draft survey was sent to all Task and Finish Group members for a review of lay-out and content after which it was linguistically checked by a native English speaker on our expert panel. All experts were involved in the preparation of the English version of the survey and agreed that the English version could be readily translated into each language. Also, the experts made sure that the terms and definitions were appropriately translated and understandable for readers of each language. The survey was piloted by five Dutch physicians outside this research project to check user-friendliness and whether it could be completed within the intended timeframe. Amendments were made, resulting in a final English language version of the survey (see Online Resource 2) which was then translated into a number of other European languages (including Czech, Danish, Dutch, Finnish, German, Italian, Polish, Spanish, and Turkish) by native speakers on our expert panel.

### Data collection

The survey was distributed in Austria, Belgium, Czech Republic, Denmark, Finland, Italy, The Netherlands, Poland, Spain, Turkey, and the United Kingdom. A nominated contact person in each country was asked to distribute the survey in their country. The distribution method was decided upon by the individual country, the contact person was instructed how to obtain a representative sample of participants. They were asked to invite physicians who treat older falls patients to participate including at least 15 geriatricians and 15 general practitioners (GPs). The survey could be filled in either on paper or digitally using LimeSurvey. The survey was conducted from December 1st 2018 to July 15th 2019. Each country was given 3 months to complete the survey.

### Barriers and facilitators

Our primary research aim was to investigate the relative importance to European physicians of the listed barriers and facilitators in CDSS use. Barriers were defined as aspects and circumstances that deter the user from using the CDSS. Facilitators were defined as aspects and circumstances that encourage use of the CDSS. A list of 17 barriers and 15 facilitators was produced. In the online survey, no questions could be skipped. To answer our second research question, which was to explore regional differences, participating countries were categorized into four European regions based on the geographical definition of the United Nations [23]. Northern Europe comprised Denmark, Finland, and the UK. Austria, Belgium, and The Netherlands were

assigned to Western Europe, Italy, and Spain to Southern Europe. Eastern Europe comprised Czech Republic, Poland, and Turkey.

Furthermore, participants were asked to fill in their specialty using the following answer options: GP, Geriatrician—Hospital-based, Geriatrician—Community-based, Specialist General Internal Medicine, Trainee in Geriatric Medicine, or General Internal Medicine or GP Trainee. Hospital- and Community-based Geriatricians were recoded to “Geriatricians”. Specialist Internal Medicine was recoded to “Other Hospital Specialist”. We created a new category, namely “Other Geriatrics clinician” comprising doctors in speciality training, Nurse Practitioners, Physician Assistants, or Physician Assistants in training. Participants could also check answer option “Other Specialty” after which they were asked to define their specialty using an open text box. Filled in answers were translated to English and recoded into the existing categories by two researchers (KP and NvdV). If this was not possible, the specialty was classified as “Other Specialty”.

Answers that were given in the open text boxes were translated into English using an automated translation program. If translations were unclear, translators from the expert panel were contacted. Two researchers (KP and SM) independently open-coded the data (see Online Resource 3). An individual text entry could be labelled with several codes. If there was any disagreement between the researchers, a third reviewer (AL) was consulted and a resolution was agreed through discussion.

### Analysis

We calculated frequencies for categorical variables and means with Standard Deviations (SD) for continuous variables. To analyse differences between regions, we used Multivariate Analysis of Variance (MANOVA) [28]. Our results were adjusted for age, gender, years of experience, specialty, and use of a digital EMR and digital prescribing. A *p* value of 0.05 or lower was considered statistically significant. All data were entered into SPSS for Windows version 26.0.0.1 (IBM Corp., New York).

### Ethical approval

The Medical Ethical Committee of the Academic Medical Centre of the University of Amsterdam reviewed this study and ruled that no ethical approval was required (W18\_285#18.331); this study was approved by the Ethical Committees of the Jagiellonian University in Poland and the Ghent University in Belgium.

## Results

### Demographics

A total of 616 participants filled in the questionnaire of whom 35 participants were excluded from analysis, because data on barriers and facilitators were missing. The 581 remaining participants had a mean age of 44.9 (SD = 11.0) years and 64.5% of them were female (Table 1). The majority of the participants were Geriatricians (71.3%) with on average 18.2 years of work experience (SD = 11.1). Compared to the rest of Europe, routine use of a digital EMR was significantly more common in Western Europe, where also more non-Geriatrician hospital specialists filled in the questionnaire ( $p < 0.05$ ). In Eastern Europe, significantly more GPs filled in the questionnaire, whereas in the South significantly fewer GPs participated.

### Barriers for CDSS usage

An overview of all barriers, the number of participants selecting a barrier and significant regional differences is shown in Table 2. Barriers were ranked according to the European average based on the number of participants who selected a barrier.

Technical issues (66%) having to indicate a reason why the physician wants to override an alert (58%) and unclear advice (51%) were selected by more than half of all physicians. Technical issues were more often perceived as barriers by Northern and Eastern-European physicians than the other regions (Table 2, row 1). Significantly more Eastern-European physicians considered unclear advice given by the CDSS as a barrier, compared to Western and Southern European physicians (Table 2, row 3). No clinically relevant alerts and having to add patient data into the CDSS were considered barriers by significantly more Western European physicians than other regions (Table 2, row 4 and 5, respectively). In Eastern Europe, expensive CDSS and legal issues were considered barriers by significantly more physicians than in other regions (Table 2, row 6 and 9, respectively). A high frequency of alerts was seen as barrier by significantly more Northern and Western European physicians, compared to Southern and Eastern-European physicians (Table 2, row 10). For the following barriers, no significant regional differences were found: a CDSS that interrupts workflow (Table 2, row 7), affects decision-making autonomy (Table 2, row 12), does not allow the user to adopt advice with one mouse click (Table 2, row 14), and is only available online (Table 2, row 15).

**Table 1** Demographics of participants

	Total (n = 581)	Northern (n = 140)	Western (n = 123)	Southern (n = 197)	Eastern (n = 121)
Age (years), mean (SD)	44.9 (11.0)	47.5 (10.7) <sup>S,E</sup>	45.0 (11.0)	43.5 (11.2) <sup>N</sup>	43.9 (10.7) <sup>N</sup>
Gender (F), %	64.5%	65.7%	74.0%	62.4%	57.0%
Experience, years	18.2 (11.1)	21.6 (11.3) <sup>W,S</sup>	16.3 (10.8) <sup>N</sup>	17.0 (11.1) <sup>N</sup>	18.3 (10.8)
Specialty, %					
GP	9.3%	14.3%	8.9%	1.0%*	17.4%*
Geriatrician	71.3%	72.9%	66.7%	82.2%*	56.2%*
Other hospital specialist	3.6%	0.7%	11.4%*	2.5%	0.8%
Other Geriatrics clinician	13.3%	11.4%	10.6%	12.2%	19.8%
Other	2.6%	0.7%	2.4%	2.0%	5.8%
Seeing older fallers in clinical practice, %					
Daily	51.0%	58.1%	49.6%	47.7%	49.6%
Weekly	35.9%	30.9%	37.4%	41.1%	31.4%
Monthly	9.5%	8.8%	10.6%	7.1%	13.2%
Once every 3 months	2.8%	0.7%	2.4%	3.6%	4.1%
Few times per year	0.9%	1.5%	0%	0.5%	1.7%
Routinely using a digital EMR, %	80.4%	72.9%	92.7%*	78.7%	79.3%
Routinely prescribing digitally, %	80.2%	77.1%	87.8%	74.6%	85.1%

Letters in superscript indicate a significant difference between regions. For example, N<sup>S,E</sup> means that the Northern region is significantly different from Southern and Eastern Europe. Northern Europe: Denmark, Finland, and the United Kingdom. Western Europe: Austria, Belgium, and The Netherlands. Southern Europe: Italy and Spain. Eastern Europe: Czech Republic, Poland, and Turkey

SD, standard deviation; F, female; GP, general practitioner; EMR, electronic medical record

\* $p \leq 0.05$

## Facilitators for CDSS usage

Table 3 presents facilitators for using a CDSS which are ranked from most often selected to least often selected according to the European average. Also, the number of participants selecting a facilitator and significant regional differences can be found in Table 3. Facilitators selected by more than half of all European physicians were as follows: a CDSS that is perceived to be beneficial to patient care (67%), easy-to-use (64%), contributing to increased work efficiency (57%), fitting into physician's workflow (57%), easily accessible (55%), and supportive in the decision-making process (53%). We identified regional differences in perception of facilitators. An easy-to-learn CDSS was selected as facilitator by significantly more Northern physicians (52%) compared to Southern physicians (Table 3, row 8). In the Western region, "Receiving training in how to use the CDSS" was selected significantly less often and "Fits with the workflow" significantly more often by physicians compared to other regions (Table 3, row 10 and 4, respectively). A CDSS customized to physicians'

wishes was significantly more often selected as facilitator by Eastern-European physicians and selected significantly less times by Northern European physicians compared to the other regions (Table 3, row 11). In the South, the possibility of personalizing alerts was significantly more frequently seen as facilitator than in the North and East (Table 3, row 12). Having support from the hospital board (or management team) to use a CDSS was also selected more frequently as facilitator by Eastern-European physicians than by the other regions (Table 3, row 13). For facilitators, receiving technical support (Table 3, row 9) and "I am more inclined to use a CDSS that is used by my colleagues" (Table 3, row 15), no significant regional differences were found.

## Additional barriers and facilitators

A total of 107 entries were listed in the open text box, 78 under barriers and 29 under facilitators, from which 27 distinct barriers and facilitators were derived (Table 4).

**Table 2** Overview of barriers selected in Europe and per region

Barrier	Total ( <i>n</i> = 581) Mean (SD)	Northern (N) ( <i>n</i> = 140) Mean (SD)	Western (W) ( <i>n</i> = 123) Mean (SD)	Southern (S) ( <i>n</i> = 197) Mean (SD)	Eastern (E) ( <i>n</i> = 121) Mean (SD)
Technical issues	0.66 (0.48)	<b>0.85 (0.36)</b> <sup>W,S,E</sup>	0.61 (0.49) <sup>N,E</sup>	<b>0.51 (0.50)</b> <sup>N,E</sup>	0.72 (0.45) <sup>N,W,S</sup>
Having to indicate a reason to override alert	0.58 (0.49)	0.61 (0.49) <sup>W,S</sup>	<b>0.76 (0.43)</b> <sup>N,S,E</sup>	<b>0.45 (0.50)</b> <sup>N,W,E</sup>	0.59 (0.49) <sup>W,S</sup>
Advice not clear	0.51 (0.50)	0.57 (0.50) <sup>S</sup>	0.47 (0.50) <sup>E</sup>	0.42 (0.50) <sup>N,E</sup>	<b>0.63 (0.49)</b> <sup>W,S</sup>
No relevant alerts	0.47 (0.50)	0.51 (0.50) <sup>S</sup>	<b>0.63 (0.48)</b> <sup>S</sup>	<b>0.29 (0.46)</b> <sup>N,W,E</sup>	0.53 (0.50) <sup>S</sup>
Add patient data	0.46 (0.50)	0.41 (0.49) <sup>W</sup>	<b>0.64 (0.48)</b> <sup>N,S,E</sup>	<b>0.35 (0.48)</b> <sup>W,E</sup>	0.53 (0.50) <sup>W,S</sup>
Costly	0.46 (0.50)	0.49 (0.50) <sup>E</sup>	0.42 (0.50) <sup>E</sup>	0.39 (0.49) <sup>E</sup>	<b>0.59 (0.49)</b> <sup>N,W,S</sup>
Interrupts workflow	0.42 (0.50)	0.44 (0.50)	0.43 (0.50)	0.37 (0.48)	0.48 (0.50)
Privacy issues	0.40 (0.49)	0.46 (0.50) <sup>S</sup>	0.41 (0.50)	0.34 (0.48) <sup>N</sup>	0.41 (0.49)
Legal issues	0.37 (0.48)	0.35 (0.48) <sup>E</sup>	0.30 (0.46) <sup>E</sup>	0.32 (0.47) <sup>E</sup>	<b>0.56 (0.50)</b> <sup>N,W,S</sup>
High frequency alerts	0.36 (0.48)	0.41 (0.49) <sup>S,E</sup>	<b>0.52 (0.50)</b> <sup>S,E</sup>	0.29 (0.46) <sup>N,W</sup>	0.27 (0.45) <sup>N,W</sup>
No additional information available	0.31 (0.46)	0.38 (0.49) <sup>S</sup>	0.30 (0.46)	0.27 (0.45) <sup>N</sup>	0.30 (0.46)
Affects autonomy	0.30 (0.46)	0.31 (0.47)	0.30 (0.46)	0.27 (0.45)	0.34 (0.48)
Repeats same alerts	0.28 (0.45)	0.32 (0.47) <sup>S</sup>	0.33 (0.47) <sup>S</sup>	0.22 (0.41) <sup>N,W</sup>	0.27 (0.45)
Advice not adoptable with one mouse click	0.16 (0.37)	0.12 (0.33)	0.18 (0.39)	0.19 (0.39)	0.16 (0.37)
Only online	0.15 (0.36)	0.13 (0.34)	0.11 (0.32)	0.18 (0.39)	0.17 (0.37)
My lack of motivation	0.04 (0.19)	0.03 (0.17)	0.02 (0.13) <sup>E</sup>	0.04 (0.19)	0.07 (0.26) <sup>W</sup>
My resistance to change	0.02 (0.14)	0.01 (0.09) <sup>S</sup>	0.01 (0.09) <sup>S</sup>	0.05 (0.21) <sup>N,W,E</sup>	0.00 (0.00) <sup>S</sup>

To increase readability, all means are presented as percentages in the text

Data are adjusted for age, gender, experience, specialty of the participants and routine use of a digital electronic medical record and a digital prescription system. Bold numbers indicate  $\geq 10\%$  difference between a region's mean and the European mean. Letters in superscript indicate a significant difference between regions ( $p < 0.05$ ). For example, N<sup>S,E</sup> means that the Northern region is significantly different from Southern and Eastern Europe. Northern Europe: Denmark, Finland, and the United Kingdom. Western Europe: Austria, Belgium, and The Netherlands. Southern Europe: Italy and Spain. Eastern Europe: Czech Republic, Poland, and Turkey

SD: Standard Deviation

**Table 3** Overview of selected facilitators in Europe and per region . To increase readability, all means are presented as percentages in the text

Facilitator	Europe ( <i>n</i> = 581)	Northern (N) ( <i>n</i> = 140)	Western (W) ( <i>n</i> = 123)	Southern (S) ( <i>n</i> = 197)	Eastern (E) ( <i>n</i> = 121)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Benefit patient care	0.67 (0.47)	0.71 (0.46) <sup>S</sup>	0.76 (0.43) <sup>S</sup>	<b>0.57 (0.50)<sup>N,W,E</sup></b>	0.69 (0.47) <sup>E</sup>
Easy to use	0.64 (0.48)	<b>0.75 (0.44)<sup>S</sup></b>	0.67 (0.47) <sup>S</sup>	<b>0.51 (0.50)<sup>N,W,E</sup></b>	0.69 (0.47) <sup>S</sup>
Work more efficiently	0.57 (0.50)	0.61 (0.49) <sup>S</sup>	<b>0.67 (0.47)<sup>S</sup></b>	0.50 (0.50) <sup>N,W</sup>	0.53 (0.50)
Fits workflow	0.57 (0.50)	0.62 (0.49) <sup>W,S</sup>	<b>0.77 (0.42)<sup>N,S,E</sup></b>	<b>0.44 (0.50)<sup>N,W</sup></b>	0.53 (0.50) <sup>W</sup>
Easily accessible	0.55 (0.50)	<b>0.68 (0.47)<sup>W,S</sup></b>	0.50 (0.50) <sup>N,E</sup>	<b>0.44 (0.50)<sup>N,E</sup></b>	0.64 (0.48) <sup>W,S</sup>
Feeling supported in clinical decision-making	0.53 (0.50)	<b>0.63 (0.49)<sup>S,E</sup></b>	<b>0.75 (0.44)<sup>S,E</sup></b>	<b>0.37 (0.48)<sup>N,W</sup></b>	0.45 (0.50) <sup>N,W</sup>
Fall risk estimation accurate	0.43 (0.50)	0.42 (0.50)	0.52 (0.50) <sup>S</sup>	0.39 (0.49) <sup>W</sup>	0.42 (0.50)
Easy to learn	0.40 (0.49)	<b>0.52 (0.50)<sup>S</sup></b>	0.42 (0.50)	0.31 (0.46) <sup>N</sup>	0.40 (0.49)
Technical support	0.34 (0.48)	0.31 (0.47)	0.27 (0.45)	0.38 (0.49)	0.40 (0.49)
Receiving training	0.31 (0.46)	0.37 (0.49) <sup>W</sup>	<b>0.11 (0.32)<sup>N,S,E</sup></b>	0.37 (0.48) <sup>W</sup>	0.35 (0.48) <sup>W</sup>
Customized CDSS	0.27 (0.44)	<b>0.16 (0.37)<sup>W,E</sup></b>	0.29 (0.46) <sup>W,E</sup>	0.25 (0.44) <sup>E</sup>	<b>0.40 (0.49)<sup>N,W,S</sup></b>
Personalize alerts	0.26 (0.44)	0.19 (0.40) <sup>S</sup>	0.24 (0.43)	0.35 (0.48) <sup>N,E</sup>	0.21 (0.41) <sup>S</sup>
Support of hospital board	0.20 (0.40)	0.24 (0.43) <sup>E</sup>	0.11 (0.31) <sup>E</sup>	0.17 (0.37) <sup>E</sup>	<b>0.32 (0.47)<sup>N,W,S</sup></b>
Recommended by colleagues	0.09 (0.29)	0.15 (0.36) <sup>W,S</sup>	0.07 (0.26) <sup>N</sup>	0.06 (0.24) <sup>N</sup>	0.10 (0.30)
Used by colleagues	0.09 (0.29)	0.10 (0.30)	0.12 (0.33)	0.06 (0.24)	0.09 (0.29)

Data are adjusted for age, gender, experience, specialty of the participants and routine use of a digital electronic medical record and a digital prescription system. Bold numbers indicate  $\geq 10\%$  difference between a region's mean and the European mean. Letters in superscript indicate a significant difference between regions ( $p < 0.05$ ). For example, N<sup>S,E</sup> means that the Northern region is significantly different from Southern and Eastern Europe. Northern Europe: Denmark, Finland, and the United Kingdom. Western Europe: Austria, Belgium, and The Netherlands. Southern Europe: Italy and Spain. Eastern Europe: Czech Republic, Poland, and Turkey

SD: Standard Deviation

Coding of all entries is provided in Supplement 4. A number of entries were clarifications of barriers and facilitators that were already in the survey or were other comments ( $n = 36$ , data not shown). Most frequently added barriers were a CDSS that takes too much time to work with ( $n = 15$ ) or if the time investment required is greater than the benefits ( $n = 4$ ). Some participants stated that they thought the doctor's judgement was better than a CDSS ( $n = 7$ ). Furthermore, because geriatric patients are complex, the CDSS does not take into account all the patient's variables in the same way as their doctor does, and does not take account of the patient's goals and values ( $n = 7$ ). A CDSS integrated into currently used digital systems ( $n = 16$ ) and a quick-responding CDSS ( $n = 7$ ) were perceived as facilitating factors.

## Discussion

In this study, we surveyed European clinicians who treat older fallers to learn which barriers and facilitators are most relevant for them, if they anticipate additional barriers or facilitators, and to look for regional differences. We asked our participants to indicate which of the known barriers and

facilitators to CDSS use are most relevant for them. The most important barriers were technical issues, having to indicate a reason for overriding an alert and unclear advice. The most important facilitators were a CDSS that is beneficial to patient care, easy-to-use, contributed to increased work efficiency, fits into the physician's workflow, was easily accessible and supportive to the decision-making process. We also identified new barriers and facilitators (including those of particular concern in treating older patients) which were the time-expenditure to work with a CDSS, an integrated CDSS in current digit systems and concerns if a CDSS could give accurate advice for medically complex patients.

Finally, we looked for regional differences.

Our findings are consistent with the previous research, reporting that a CDSS that is beneficial to patient care [29] and that can be integrated into current digital medical systems thus avoiding the need to switch between programs [30] are important facilitators. On the other hand, a time-consuming CDSS would decrease physicians' work efficiency, and it was also deemed important that CDSS alerts should provide useful and new information, so that the time spent on using the CDSS is balanced by the benefits gained to patient care [16].

**Table 4** Overview of additionally identified barriers and facilitators entered in open text boxes

Additional barrier/facilitator	Example	<i>N</i>
Integration with digital systems	Integrated with the electronic medical records (EMR) system (using without leaving the open visit)	16
Takes too much time to work with the CDSS	If it takes a long time, it is a barrier	15
Doctor's judgement is better	I think that I can make enough decisions myself and that I can always apply it better to the situation of the individual patient than an algorithm	7
Personalized to patient's complex current medical situation	If insufficient consideration is given to the individual patient and the circumstances. Each patient remains individual and sometimes there is a higher goal than risk of falling (e.g., comfort)	7
System must respond quickly	Response speed. It has to be agile	7
Make CDSS available to other health care providers	We do not just want a system for falls clinics and geriatricians, we need this to be used by GPs, trainees and non-geriatricians	5
Cannot say anything about barriers and facilitators without seeing CDSS	I have not seen the support system so cannot give a meaningful answer	4
Evidence of added value in clinical practice	I want to be absolutely sure that the clinical decision support system is fully tested and evidence-based	4
Lack of time	No time	4
Time investment is greater than the benefit of the result/advice	When the support costs extra work, while no advice comes out that I did not come up with myself	4
Environmental constraints	Lack of network signal	3
Wanted to select all items in the provided list	I think all the factors mentioned play a role	2
Data quality	The one currently in use cannot find the diagnoses in the medical record where they are always marked. The diagnosis must be specifically structured so that the system can find it	2
External factors	I'm not sure the IT system in Wales is up to it	2
No blocking pop-ups	The system generates information that can be ignored or ignored as the situation requires, without having to click warning windows out of the way	2
Reliability	I want the information to be useful and reliable	2
Shared decision-making with patient	It is a support in the discussion with family members aimed at reducing the use of antipsychotic drugs	2
Suggestions for a different system	I think it would be nice if, at an outpatient clinic, you were asked whether you were ready to perform a review once a year and with a hospitalized patient at least once a week, provided that medication changes were made and before discharge	2
Too much text	Already in our current electronic medication system there is a warning system, since there is a lot of unnecessary comments and moreover sometimes a full screen of information I do not bother to read this	2
Based on latest scientific evidence	CDSS based on the latest meta-analyses in the area of side effects in people with FS (abbreviation of participant without further explanation), because Beers and START STOP are no longer valid and we cite them	1
Customized to a specific knowledge source	Being able to adapt the system to my pharmaceutical handbook [e.g., RSA (abbreviation of participant without further explanation)]	1
If the patient wants me to use the system	When patients ask for it	1
Information available for patients	Patient's perspective	1
Information communication to patient	A patient letter or med overview is also rolled out with an explanation, what the patient can take and can also be sent to the doctor	1
Problem lies elsewhere	My problem is not so much in which medication I have to prescribe, but especially in who then has to do it (Me? GP? Follow up?) This tool does not help with that	1
Uncertainty of advice is not clear	Lack of clarity in the uncertainty of the advice and too high predictive capacity for the individual patient, with lack of evidence of added value in practice	1

**Table 4** (continued)

Additional barrier/facilitator	Example	<i>N</i>
Wants to participate in the design	I would like input into the design	1

Previous studies identified that the accuracy of CDSS advice is important to users [31, 32]. This study identified additional concerns of physicians treating older patients. In particular that it is challenging to provide accurate computerized advice for older patients, because they are both medically complex and also vary greatly in their goals and values.

Geriatric patients are a heterogeneous group when it comes to their medical, psychological, and social functioning [33]. They require a personalized treatment approach in which a CDSS could aid decision-making. However, it is not certain that a CDSS would be perceived as helpful in this population. CDSS recommendations are often based on clinical guidelines in which treatment advice is given based on clinical trials. Older adults are often underrepresented in these clinical trials because of their multimorbidity and medical complexity [34]. Furthermore, outcome measures that are important to older adults are often not taken into account in clinical trials [33]. Therefore, it is possible that guideline-based CDSS advice may not be perceived as applicable to this population due to the lack of evidence to use as a basis for CDSS advice. Although challenging, it is important to design a CDSS for Geriatric Medicine to aid decision-making in older patients.

Interestingly, we identified regional differences in perceptions of barriers and facilitators across Europe. Both Northern and Western European physicians considered a high frequency of alerts an important barrier to CDSS usage, while for Western European physicians, the need to input patient data into the CDSS and alerts lacking clinical relevance were important barriers. Physicians in Northern Europe preferred an easy-to-work-with system and physicians in the West favoured a CDSS that fitted their workflow and demanded little extra work to operate. Receiving training was selected significantly less frequently as a facilitator by Western European physicians. These reported differences might be explained by regional cultural differences, in particular, whether the culture is “individualistic” or “collectivist”. For example, most countries of Northern and Western Europe are thought to have a more individualistic culture than Southern and Eastern-European countries, which except for Italy, have a more collectivist culture [35]. Individualists find it more important to work efficiently than collectivists [35]. Additionally, receiving training is considered to be less important for individualists compared to collectivists [35]. In Eastern Europe, high implementation costs and legal issues were considered significantly more often barriers than in other regions. Also, support from hospital

board or management team was considered a facilitator to CDSS use in this region. This might be explained by differences in the regions’ “power-distance” index. Eastern-European countries scored higher on the Power-distance index, meaning that inequality within a society is more accepted in these regions. For example, people living in a high power-distance-culture rather have their superior tell them what to do, whereas people living in a low power-distance culture rather consult with their superior on decision-making [35].

Moreover, not only different cultures but as differences and developmental level in health care systems (and geriatric medicine services in particular) between different countries could also explain the results. In two of the Eastern-European countries, geriatric medicine is not a recognized independent specialty but rather a subspecialty [36]. The duration of the postgraduate training in geriatric medicine varies widely across Europe, from 60 months in Northern Europe to 24–48 months in Eastern Europe [36], as does the number of chairs in geriatric medicine [37]. Due to a shorter duration of postgraduate geriatric medicine training and the lack of a recognized specialism, the need for decision support could be greater in these regions, whereas a more clinically experienced physicians in geriatric medicine might be less inclined to use clinical decision support. As previous experience with digital health care systems might influence the barrier and facilitator perceptions towards new CDSSs, we corrected for the use of electronic health records and digital prescription systems.

In summary, this survey of European CDSS use had several strengths. To the best of our knowledge, this is the first study investigating barriers and facilitators in CDSS use by physicians who treat older falls patients and assessing differences between different European countries. There was widespread uptake of our survey across European regions. We identified regional differences in perceived barriers and facilitators across Europe.

On the other hand, our study also had several limitations. We could not use formally validated instruments to compose our survey, because none have been developed for this purpose, nor did we validate or assess the reliability of this survey. Nevertheless, the list of barriers and facilitators in our survey was based on a thorough search of the literature.

Although all national questionnaires were translated by native speakers on our research team, none of the translators were official translators nor were backward translations performed. This might have affected the accuracy of the translations. Although most countries followed the suggestion to distribute the survey via their national Physicians’ professional

bodies so as to reach a broad audience, a couple of countries were only able to distribute the survey in local hospitals through physician colleagues. Because most of our surveys were distributed online, e.g., via email or newsletters, we were unable to calculate the response rate nor were we able to collect data on non-responders. We analysed the data by clustering countries into European regions. Although many classifications exist to categorize European countries, we used the classification of the United Nations [23], which grouped the European countries into regions based on their homogeneity in economic or social factors. The use of a different classification could yield different results. It would be interesting for future studies to explore if differences in barriers and facilitators can be found between individual countries and in subcategories of specialists, for example hospital-based and community-based geriatricians.

## Conclusion

In this survey of a CDSS for older falls patients, technical issues and having to indicate a reason for overriding an alert were the most important barriers. The most important facilitators were a CDSS perceived to be beneficial to patient care and easy-to-use. Our results suggested regional differences in the perception of barriers and facilitators across Europe. This study suggested that when developing a CDSS for Geriatric Medicine, the medical complexity of the older patient should be taken into account and that there should be scope for physicians to use their clinical judgement in the decision-making process. Involving the clinicians treating older patients in the development of CDSS will likely help to ensure that barriers are adequately addressed and that the CDSS facilitates clinicians in caring for their patients.

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**Availability of data and materials** Data are available on request.

## Declarations

**Conflict of interest** Sirpa Hartikainen has received lecture fee from Astellas Pharma.

**Ethical approval** The Medical Ethical Committee of the Academic Medical Centre of the University of Amsterdam reviewed this study and ruled that no ethical approval was required (W18\_285#18.331); this study was approved by the Ethical Committees of the Jagiellonian University in Poland and the Ghent University in Belgium.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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