

Attitude of Physicians Towards Automatic Alerting in Computerized Physician Order Entry Systems*

A Comparative International Survey

M. Jung¹; A. Hoerbst^{1, 2}; W. O. Hackl¹; F. Kirrane³; D. Borbolla⁴, M. W. Jaspers⁵; M. Oertle⁶; V. Koutkias⁷; L. Ferret^{8, 9}; P. Massari¹⁰; K. Lawton¹¹; D. Riedmann¹; S. Darmoni¹⁰; N. Maglaveras⁷; C. Lovis¹²; E. Ammenwerth¹

¹Institute of Health Informatics, Department of Biomedical Informatics and Mechatronics, UMIT – University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria; ²Research Division for eHealth and Telemedicine, UMIT – University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria; ³Department of Medical Physics and Bioengineering, Galway University Hospital, Galway, Ireland; ⁴Health Informatics Department, Hospital Italiano de Buenos Aires, Buenos Aires City, Argentina; ⁵Centre for Human Factors Engineering of Health Interactive Technology (HIT-lab), Department of Medical Informatics, Academic Medical Center – University of Amsterdam, Amsterdam, The Netherlands; ⁶Medical Informatics and Department of Internal Medicine, Hospital of Thun, Thun, Switzerland; ⁷Lab of Medical Informatics, Medical School, Aristotle University of Thessaloniki, Greece; ⁸Pharmacy Department, Hospital of Denain, Denain, France; ⁹EA2694, University Hospital of Lille, Lille, France; ¹⁰CIS-MeF & TIBS team, LITIS EA 4108, Rouen University Hospital, Normandy, France; ¹¹IT, Medical Technology and Telephony Services of Capital Region, Copenhagen, Denmark; ¹²Division of Medical Information Sciences, University Hospitals of Geneva and University of Geneva, Geneva, Switzerland

Keywords

Medical order entry systems, clinical decision support systems, attitude, questionnaires, alerting

Summary

Objectives: To analyze the attitude of physicians towards alerting in CPOE systems in different hospitals in different countries, addressing various organizational and technical settings and the view of physicians not currently using a CPOE.

Methods: A cross-sectional quantitative and qualitative questionnaire survey. We invited

2,600 physicians in eleven hospitals from nine countries to participate. Eight of the hospitals had different CPOE systems in use, and three of the participating hospitals were not using a CPOE system.

Results: 1,018 physicians participated. The general attitude of the physicians towards CPOE alerting is positive and is found to be mostly independent of the country, the specific organizational settings in the hospitals and their personal experience with CPOE systems. Both quantitative and qualitative results show that the majority of the physicians, both CPOE-users and non-users, appreciate the

benefits of alerting in CPOE systems on medication safety. However, alerting should be better adapted to the clinical context and make use of more sophisticated ways to present alert information. The vast majority of physicians agree that additional information regarding interactions is useful on demand. Around half of the respondents see possible alert overload as a major problem; in this regard, physicians in hospitals with sophisticated alerting strategies show partly better attitude scores.

Conclusions: Our results indicate that the way alerting information is presented to the physicians may play a role in their general attitude towards alerting, and that hospitals with a sophisticated alerting strategy with less interruptive alerts tend towards more positive attitudes. This aspect needs to be further investigated in future studies.

Correspondence to:

Alexander Hoerbst, PhD
Eduard Wallnoefer Zentrum 1
6060 Hall in Tirol
Austria
E-mail: alexander.hoerbst@umit.at

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1. Introduction

Medication errors and adverse drug events (ADEs) are serious hazards for patients all over the world. Reports of the Institute of Medicine (IOM) estimate that a patient in an US-hospital faces at least one medication error per day [1, 2]. Most medi-

cation errors, and a majority of ADEs, occur during the prescription phase of the medication cycle [3–5].

Amongst other approaches, the Institute of Medicine recommends the use of information and communication technology (ICT) in order to improve medication safety [1]. Computerized Physician Order

Entry (CPOE) systems have shown the potential to reduce medication errors as well as ADEs [6]. CPOE systems may be coupled with Computerized Decision Sup-

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port (CDS) systems [7], an approach that has proven to be even more effective in reducing medication errors [6].

However, recent research found that the introduction of a CPOE system can also have a negative impact in patient safety [8] and lead to unintended and unanticipated negative effects such as an increase in the risk of medication errors [9], or worse, in mortality [10]. Campbell et al. identified nine types of these unintended adverse consequences after CPOE introduction, such as workflow issues or emotional aspects [11]. In a related study, Sittig et al. focussed on those emotional responses to the CPOE system and reported that negative emotions, for example anger or annoyance, “were by far the most prevalent”. They concluded that if those aspects were not addressed properly, system implementations could fail or CPOE systems would not be routinely used [12].

The design and usability of the system seem to play a decisive role in the physicians’ attitude towards CPOE. In their systematic review, Khajouei and Jaspers identified nine CPOE specific design aspects that influence the ease of use and workflow. In particular, the design of alerts has a significant impact on the physicians’ attitudes, as for example too many false-

positive alerts or non-patient-tailored alerts may annoy the clinicians [13]. Furthermore, recent research [13–21] underlines the importance of accounting for socio-technical issues and claim that a successful CPOE implementation “often is more influenced by the organizational setting than the specificities of the CPOE system itself” [11].

Various studies have tried to measure the attitude of physicians towards CPOE systems in general and towards alerting in particular [22–31]. These studies have mostly been conducted in single hospitals, or in hospital groups using the same CPOE systems. However, the organizational settings surrounding CPOE implementations usually differ between hospitals. Hence, one could assume that the attitude of the physicians towards CPOE, and especially towards alerting, would be different when comparing different hospitals with different CPOE systems from different countries. Furthermore, we assume that this attitude may depend on the personal experience with CPOE. However, these points have not to date been systematically investigated in a multi-centric international study.

Hospital(s)	Type of Hospital	Beds
AMC Amsterdam (Netherlands)	University hospital	1,002
HIBA Buenos Aires (Argentina)	University hospital	750
Copenhagen hospitals (Denmark) (Glostrup, Herlev, Hillerød)	General hospitals	1,407
CH Denain (France)	General hospital	600
LKH Feldkirch (Austria)	General hospital	606
UHG Galway (Ireland)	University hospital	885
HUG Geneva (Italy)	University hospital	1,915
CHU Rouen (France)	University hospital	2,303
USHATE Sofia (Bulgaria)	Specialized university hospital for endocrinology	109
Thessaloniki hospitals (Greece) (AHEPA, Ippokrateio, Panageia)	1 general hospital, 2 university hospitals	2,148
Spital STS AG Thun (Switzerland)	General hospital	300

Table 1

Key data of the participating eleven hospitals

2. Study Question

What is the attitude of physicians towards alerting in CPOE systems in different hospitals from different countries, taking into account the different organizational and technical settings and also addressing the view of physicians not currently using a CPOE?

3. Methods

3.1 Study Context

This international study was conducted in ten European and – to provide a comparison outside of Europe – one South-American hospital. We directed the survey towards both university hospitals and general hospitals (► Table 1).

Three hospitals had not implemented CPOE systems (Feldkirch, Rouen, Thessaloniki). Eight hospitals were using a CPOE system from different vendors with varying levels of CDS. ► Table 2 shows more details on the CDS levels. In the following paragraphs, we describe the CPOE systems in use in more detail. For this description, we make the following definitions:

- **Automatic** alerts are those that are triggered and presented automatically to the user.
- **Optional** alerts require a specific user action to trigger the alert, for example by clicking a specific button (such as ‘check prescription’).
- **Interruptive** alerts define those alerts that in some way intercept or interrupt the prescription workflow process, and force a user action to proceed (e.g. to change a certain prescription item before a user can finalize this prescription).
- **Non-interruptive** alerts do not intercept or interrupt the prescription workflow process. The alert content is presented only for information purposes (e.g. the system indicates/informs that there are possible drug-drug interactions, but does not require the user to change prescription items or to acknowledge the alert explicitly).

Table 2 Categorization of the CDS features of the CPOE systems in use according to the classification of Kuperman et al. [32]. ✓ = CPOE offers the described functionality. CDS features labeled with a * are not consistently offered (e.g. only in some departments).

	Amsterdam	Buenos Aires	Copenhagen	Denain	Galway	Geneva	Sofia	Thun
Basic CDS functionalities								
Drug-allergy checking			✓		✓	✓		✓
Basic dosing guidance	✓			✓	✓	✓	✓	✓*
Formulary decision support					✓	✓		✓
Duplicate therapy checking	✓	✓	✓		✓	✓		✓
Drug-drug interaction checking	✓	✓	✓	✓		✓		✓
Advanced CDS functionalities								
Advanced dosing guidance					✓	✓*		✓*
Guidance for medication-related laboratory testing						✓*		✓*
Drug-disease contraindication checking						✓*		
Drug-pregnancy checking						✓*		

3.1.1 Amsterdam

The commercial CPOE system Medicator/ESV (iSoft) has been used across all clinical departments since 2004, except for the ICU, which uses a different system. It is connected to the pharmacy drug database and the national drug database and offers links to drug formularies, handbooks, protocols, and intra- and internet applications. It also support order sets. All alerts are automatic and interruptive. The alerts only present the most important information; detailed information is available on demand.

3.1.2 Buenos Aires

The CPOE module of the homegrown clinical information system Italice was implemented in 1999 in the outpatient setting. It is based on a self-developed drug-drug interaction knowledge database. High severity alerts and duplicate drug alerts are automatic and interruptive. All other alerts are indicated in a non-interruptive way by a red flag next to the order and can be accessed optionally. In addition, a drug compendium for drug related information can be accessed directly from the prescription screen.

3.1.3 Copenhagen

The commercial CPOE system EPM (Acure/IBM) was introduced in the participating study hospitals between 2006 and 2009. The system is integrated with the regional pharmacy database and drug formularies and allows for regional and local customized clinical pathways with pre-configured drug protocols. All alert are automatic and interruptive. Additional information on a particular drug is available on demand.

3.1.4 Denain

The CPOE module of the commercial clinical information system DxCare (Medasys) has been in use since 2003 and is connected to the commercial drug database of Vidal. All alerts are optional and interruptive. Furthermore, the user can access comments on the prescriptions made by the pharmacist.

3.1.5 Galway

The CPOE module of the commercial clinical information system Metavision (iMDSOFT) has been in use since 2005. All alerts are automatic, but only interruptive for the most important issues. All other alerts are non-interruptive and shown as information notices. The system also sup-

ports locally customized clinical pathways with pre-configured drug protocols. In addition, further information on all drugs, including policies and procedures, are available via a link to an intranet site managed by the clinical pharmacists.

3.1.6 Geneva

The homegrown CPOE system Presco has been in use since 2002. It is used across the eight HUG hospitals, except for the intensive care units (ICU), which uses a different CPOE system. The system is linked to the official Swiss drug database. It is highly adapted and customized to different aspects; there is general decision support for the entire organization as well as specialized decision support for single divisions, diseases and procedures. Depending on the individual type of CDS, different triggering and presentation strategies are used. Furthermore, the CPOE system supports clinical pathways and guidelines. Appropriate committees define all functionalities and parameters.

3.1.7 Sofia

The CPOE system Medica was developed with a company (Macrosoft) in 2010. It offers automatic and interruptive alerts for dosage support across the entire hospital.

Table 3 Sampling details of the participating study hospitals

Hospital	Type of Questionnaire	Contacted Departments	Physician Sample	Contacted Physicians	Valid Return n (%)
Amsterdam	Electronic	All departments using CPOE	Full sample	217	78 (35.9%)
Buenos Aires	Electronic	Family medicine	Full sample	110	47 (42.7%)
Copenhagen	Paper-based	Anesthesia, gastro-surgery, internal medicine	Convenience sample	207	94 (45.4%)
Denain	Paper-based	All departments	Full sample	60	26 (43.3%)
Feldkirch	Paper-based	Internal medicine, psychiatry, surgery, urology	Convenience sample	30	18 (60%)
Galway	Electronic	Anaesthesia, cardiothoracic surgery, critical care	Full sample	22	22 (100%)
Geneva	Electronic	All departments using CPOE	Full sample	1,585	552 (34.8%)
Rouen	Electronic	All departments	Convenience sample	100	41 (41%)
Sofia	Paper-based	All departments	Full sample	53	31 (58.5%)
Thessaloniki	Electronic	All departments (mostly pediatrics)	Convenience sample	110	72 (65.5%)
Thun	Electronic	Gynecology, internal medicine, obstetrics, orthopedics, surgery	Full sample	106	37 (37%)

All available alert information is presented at once.

3.1.8 Thun

The CPOE module of the commercial clinical information system Phoenix (CompuGroup) was introduced in 2003, followed by extensive in-house development. It is used across the hospital, except for the ICU, which uses another CPOE system. The system is linked to the official Swiss drug database. Drug interaction checks are triggered automatically, but can also be triggered optionally. Drug interaction alerts for higher severities are interruptive. Alerts for lower severity are suppressed and only presented on demand (optional alert). The amount of information presented to the user depends on the severity of the alert. Drug interaction alerts for oral anticoagulants are automatic, but non-interruptive. Drug-allergy alerts are automatic and interruptive. Dosing guidance alerts are automatic, but non-interruptive.

3.1.9 Feldkirch, Rouen and Thessaloniki

Medication ordering is still paper-based in these hospitals. We included them in the survey to measure the attitudes of CPOE 'non-users'.

4. Study Design and Participants

We performed a cross-sectional quantitative and qualitative questionnaire survey. The study design was presented to the ethics committee at UMIT. The committee did not consider a formal approval of the design necessary. Further approval was obtained from the local hospital management as required.

For the Denain and Sofia sites, we contacted all physicians in all clinical departments. In Amsterdam, Galway, Geneva and Thun, we contacted all physicians who were identified as current users of the CPOE system. For Buenos Aires, as the CDS functionality of the CPOE system was solely used in the outpatient clinics, we only contacted the physicians in the family medicine department, as this was the sole outpatients-only department. In Copen-

hagen, Feldkirch, Rouen and Thessaloniki, we contacted a convenience sample of physicians. For the number of contacted physicians, see ► Table 3.

5. Survey Instrument

The survey was conducted in either paper-based or web-based format (using LimeSurvey), and each hospital was free to choose their preferred format. The survey content was the same for all participating hospitals, and provided in three parts:

5.1 Part 1: Attitudes of the Physicians

We selected eleven survey items from existing surveys in the prevailing literature that measured the attitudes of physicians towards CPOE systems and alerting [22–24]. By a group discussion, survey items that matched to the objectives of the current survey were selected. We adapted the wording of the items to fit the organizational context in each hospital (e.g. adding the name of the local CPOE system). Furthermore, we formulated four additional statements regarding the scope of alert overload, alert filtering, alert presentation

and expenditure of time. The order of the statements was randomized to avoid an unintentional 'serial position effect'. All 15 items were scaled with a 4-point Likert scale. A list of the questions can be seen in ►Figure 1 and in ►Supplementary Online File 1.

5.2 Part 2: Benefits and Problems of Automatic Alerting

In two free-text questions, we asked the physicians to detail what they considered the largest benefits and the biggest problems of an automatic alerting functionality in CPOE systems.

5.3 Part 3: Personal Details

We asked the physicians to provide demographic data about their age, sex, professional role, years of work experience, and years of experience with CPOE systems.

The questionnaire was pre-tested with seven doctors from different specialties. It was then translated into Bulgarian, Danish, Dutch, French, German, Greek and Spanish. The questionnaires were then again pre-tested in each hospital with two or three doctors. The study was conducted between the second quarter of 2010 and the first quarter of 2012.

6. Methods for Data Analysis

We calculated the frequencies and presented the data using condensed bar charts.

To validate the 15 items and to elicit single latent variables that would allow for calculating certain attitude scores, we then performed a factor analysis on all answers from all hospitals (using Principal Component Analysis PCA and Varimax rotation techniques). For each identified factor, we performed a reliability analysis and then calculated an additive score using the following scoring scheme: Disagreement = 1 point; partial disagreement = 2 points; partial agreement = 3 points; agreement = 4 points. Missing values (e.g. 'no statement' answers) were replaced by the factor's median score of the corresponding physician. For every physician, we summed up

the points and compared them between the hospitals using box plots. The statistical analysis was performed with the software tool SPSS™ Statistics 20 (IBM).

The answers to the free-text question were analyzed by quantitative content analysis with inductive category development according to Mayring [33] by two researchers using the software tool MaxQDA 10™ (Verbi GmbH). The frequencies of each category were normalized according to the sample size of each hospital, summed up and visualized by tag clouds using the web tool Wordle™ (Jonathan Feinberg).

7. Results

7.1 Participants

We distributed 2,600 questionnaires, of which 1,018 were returned complete. Due to different sampling strategies, the return rate differed from 34.8% in Geneva to 100% in Galway (►Table 3). Across all hospitals, a balanced number of male and female physicians responded. In almost all hospitals, the median age category was 30–39 years (40–49 years in Denain and Rouen). In Denain, Galway and Rouen, the physicians' positions on an average were on a high level in the hierarchy; in Feldkirch and Thessaloniki, on a low level; and in all other hospitals, on a medium level. In most of the hospitals, the average time the physicians had worked was 10–15 years; in Rouen it was 17 years; and in Feldkirch and Thessaloniki, it was 3 and 5 years, respectively. In the hospitals with a CPOE system, the physicians had worked, on average, between 3–7 years with the CPOE system.

7.2 Study Findings

7.2.1 General Attitudes towards Alerting

►Figure 1 illustrates the answers to the 15 questions. Detailed frequency values for each question and hospital are provided in ►Supplementary Online File .

For all hospitals surveyed, a large majority of the physicians replied that automatic alerts would be a useful tool in prescribing (question 1), that their CPOE systems had the capacity to improve prescribing quality

(question 2) and may help to reduce prescribing errors (question 7). In addition, for most of the hospitals, a majority stated that their initial prescribing decision may be influenced by the alerts (question 15), without, however, limiting their freedom of taking prescribing decision (question 13).

Conversely, for half of the hospitals, a majority of the physicians thought that CPOE systems with automatic alerting would trigger too many irrelevant alerts (question 14). However, except for two hospitals, the physicians, in most part, did not think that reacting to alerts would cost them too much time (question 4). In almost all hospitals, the majority of the physicians disagreed with the statement that automatic alerts would only provide the physicians with information they already knew (question 9). The majority also disagreed that automatic alerts would be essentially meaningless and a waste of time (question 3).

A large majority of the hospitals surveyed thought that it would be useful if the CPOE system provided more information on a drug-drug-interaction if the user demanded it (question 10) and that it should be more difficult to override lethal drug-drug interactions (question 6). However, they were rather undecided, whether or not to be obliged to enter a reason for overriding serious drug-interaction alerts (question 8).

With regard to the presentation of the alerts, for all hospitals, a majority of the physicians strongly agreed that there should be a greater distinction between important and less important drug-drug interactions (question 11) and that the alerts should be filtered according to the clinical context (question 5). Furthermore, in most hospitals, a majority of the physicians wished that automatic alerts should be solely presented in an informative and non-interruptive way (question 12).

7.2.2 Results of the Factor Analysis

To test whether our data was suitable for a factor analysis, we performed a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy as well as Bartlett's test of sphericity. The KMO coefficient was 0.78 and the significance of Bartlett's test was



Figure 1 Relative frequencies of the answers to the 15 items from all hospitals. The hospitals without a CPOE system are indicated with grey letters. ‘No statement’ answers are not illustrated. Detailed frequency values are supplied in ► Supplementary Online File.

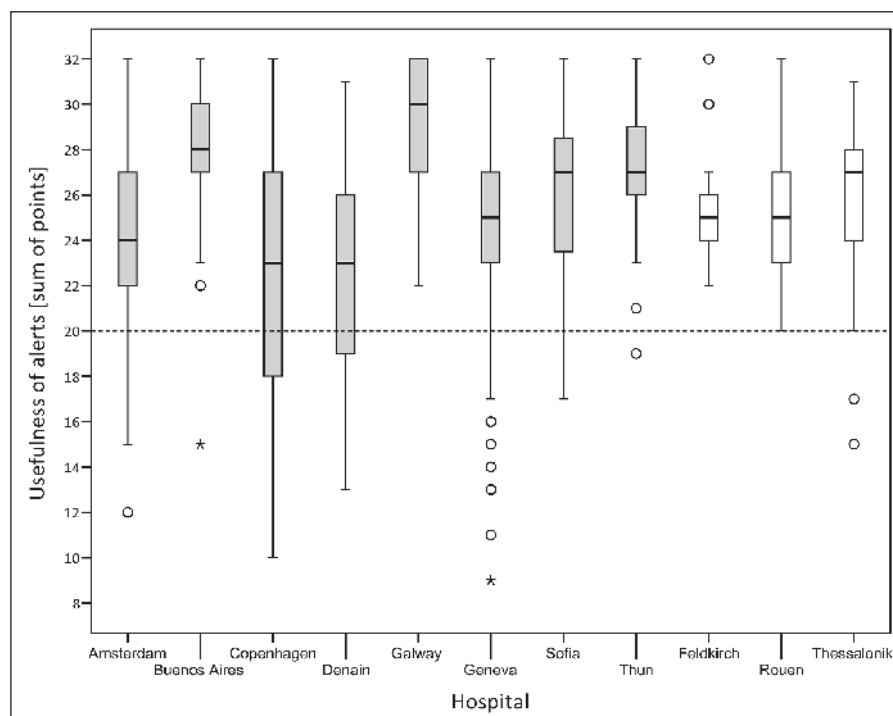


Figure 2 Box plot of the sum scores of the factor ‘usefulness of alerts’ (based on the items 1, 2, 3, 4, 7, 9, 13, 14). The hospitals without a CPOE system are indicated with white boxes. The maximum score to reach was 32 points; the minimum score was 8 points. The horizontal dotted line indicates the ‘neutral’ mean of 20 points. Scores below this line indicate negative attitudes; scores above this line indicate positive attitudes.

smaller than 0.01%, indicating that our data was suitable for performing a factor analysis. From the factor analysis, we could elicit two factors. The reliability analysis of these factors yielded Cronbach’s Alphas (internal consistency) of $\alpha_1 = 0.79$ for the first factor, and $\alpha_2 = 0.44$ for the second factor. As the internal consistency of the second factor was too low (< 0.5), we only took the first factor into account, which consists of eight items (Items number 1, 2, 3, 4, 7, 9, 13 and 14, compare ► Figure 1/ Supplementary Online File). In regard to the content of these items, we labeled these factors ‘usefulness of alerts’. The power of all items was sufficiently high; deleting one of the items would not have resulted in a higher internal consistency. We then calculated a sum score of this factor for each participant.

Regarding this identified factor, all hospitals – also those without a CPOE system – show positive tendencies on a scale from 8 (minimum score) to 32 (maximum score) and have median scores between 23 (Copenhagen and Denain) and 30 (Galway). Almost all hospitals have an inter-quartile range (IQR) settled solely in the positive area. Only three hospitals had positive or neutral scores without negative outliers (► Figure 2).

7.2.3 Qualitative Results

Overall, the physicians provided 679 free-text statements to the question of the biggest benefits and 652 statements to the question of the biggest problems of automatic alerting. The inductive categorization resulted in 38 categories of benefits and 24 categories of problems. The quantitative content analysis indicated that the prevention of serious errors, safer prescriptions and patient safety in general, were perceived as the major benefits of an automatic alerting functionality. Other frequently nominated benefits included the reminder functionality, along with the reduction of general errors, interactions and ADEs. For the perceived major problems of an automatic alerting functionality, the analysis indicated time consumption, alert overload, irrelevant alerts as well as alert fatigue. Other frequently reported problems were slower prescriptions, missing contextualization of the alerts, and perceived over-reliance on technology. A high number of physicians claimed that they would not see any problems with automatic alerts (► Figure 3).

8. Discussion

8.1 Answers to the Study Question

Both quantitative and qualitative results show that the majority of the physicians appreciate the benefits of alerting in CPOE systems by providing for safer prescriptions through the reduction of errors, especially the most severe ones and, hence, a general increase in patient safety. However, alerting should be better adapted to the clinical context and make use of more sophisticated ways to present alert information. The physicians also wish for less interruptive alerts that are prioritized to avoid possible overload of irrelevant alerts that may lead to alert fatigue. Interestingly, in almost all hospitals, the majority of the physicians did not think that automatic alerts would cost them too much time, despite time consumption was the most frequently nominated problem with automatic alerts in the free-text comments. One reason may be that only a minority of physicians is af-



Figure 3 Tag clouds of the benefits (green) and problems (red) of automatic alerting as named by the physicians. Bigger letters indicate higher relative frequencies (normalized with regard to the different sample sizes). The biggest tag in the benefits cloud ‘prevention of serious errors’ was mentioned 88 times. The biggest tag in the problems cloud ‘time consumption’ was mentioned 138 times.

ected by this problem, but that for those the problem is seen as very severe.

All hospitals have a comparable, mostly positive, general attitude towards automatic alerts (► Figure 1) and a clear positive attitude towards the factor ‘usefulness of alerts’ (► Figure 2). In general, we also found that the attitudes of the CPOE users and CPOE non-users did not differ in general (► Figure 1) and specifically not regarding the factor ‘usefulness of alerts’ (► Figure 2). One explanation for this finding could be based on the similarities in the clinical work patterns and the common understanding of the physicians concerning patient safety and quality of care, irrespective of the computerization of the prescribing process.

The three hospitals with the highest scores, Buenos Aires, Galway and Thun (► Figure 2), use more sophisticated alerting strategies, which only interrupt the physicians for the more important and severe warnings [34, 35]. The CPOE-using hospitals with the lowest scores, Copenhagen and Amsterdam, only offer automatic and interruptive alerts. Sofia also makes use of such alerts. However, they only provide alerts for dosage adaptations, which are much less in number and probably perceived highly relevant due to the speciality of the hospital.

8.2 Strengths and Weaknesses

This study was not designed to identify and quantify factors that influence the CPOE attitude of physicians, or to quantify the objective impact of automatic alerts. We did neither evaluate the perceptions of other care providers, such as nurses, or of patients nor did we take patient outcome criteria into account. We focused on measuring the impact as perceived by the physicians, and on comparing the attitudes towards CPOE in various settings.

The survey reflects an international focus and includes physicians from a range of hospitals of different size and with various CPOE settings, including non-CPOE settings. We focussed mostly on European hospitals, the results may not be transferable to other areas. In general, the response rates were quite high (35%–100%) and overall, more than 1,000 physicians participated in this survey. Limitations include use of a convenience sample of hospitals and, furthermore, potential recruitment biases due the convenience sampling of physicians are possible in Copenhagen, Feldkirch, Rouen and Thessaloniki. Due to the sampling strategy and the voluntary nature of this survey, the participants cannot be seen as fully representative for all hospital physicians. Also a lower/higher rate of participating physicians in the samples with a basic more negative/posi-

tive attitude towards alerting cannot be excluded.

Non-professional translators who were familiar with the field carried out the translation of the questionnaire. A multi-stage process including back-translation was not conducted. Furthermore, it was necessary to make minor adaptations to the wording of the questions to fit the local conditions of each hospital.

The factor analysis resulted in one factor with a very high internal consistency.

8.3 Results in Relation to Other Studies

Most of our results are in-line with the findings of the evaluation studies our survey instrument is based on [22–24], as well as with other surveys results reported in the literature (see below). However, to our knowledge, this is the first broader international CPOE survey addressing physicians in various countries and also including CPOE non-users. No studies are known to us that specifically compare the physicians' attitudes towards CPOE alerting in various technical and organizational settings or which try to quantify factors that influence these attitudes.

Comparable to our results, the physicians surveyed by Magnus et al. and Hor et al. also stated that alerts could be a useful tool [24], reminder functionality as a kind of memory support, which was mentioned in the free text comment in our survey (► Figure 2) as a benefit of automatic alerting, was also noted by physicians in other surveys [13, 31]. Furthermore, we found a broad consensus by the clinicians over the issue of increased patient and medication safety through the use of CPOE/CDS in our study and also in other surveys [25–27, 30]. A few physicians in our survey mentioned technology reliance as possible negative effects. This concern was shared by Holde et al. [27]. Other surveys found that physicians felt that automatic alerting had an influence on their initial prescribing decisions [23], which would, however, not limit the professional autonomy of the prescriber [22]. Our quantitative results support these findings.

The danger of an annoying overload of irrelevant alerts as reported by the physi-

cians in our survey is widely discussed in the literature [13, 24, 30, 36–39]. This issue shows similarities with the prevailing research on the risks associated with the design and use of medical device alarms in hospitals, on nuisance effects and on prioritization [40, 41]. The objective of our study, however, was not to derive specific actions to overcome this issue. Regarding the question of whether or not automatic alerts would cost too much time, we found a discrepancy in the literature, as we did between our quantitative and qualitative data. On the one hand, Holden found that the clinicians' time was 'better spent in other ways' and that CPOE was perceived as a 'threat to efficiency' [27]. On the other hand, Sittig et al. found that CDS in CPOE would be 'worth the time it takes' [31] and Weingart et al. even found an increase in the physicians' perceived efficiency by e-prescription [30]. Our findings that the physicians perceived that alert content provided more than just 'known information', which would therefore not make the alerts a waste of time per se, were supported by Ko et al. [23]. Overall, the efficiency of CPOE systems can be improved when the specificity and sensitivity levels of their advice increase [42].

The physicians questioned in other surveys wished for more on-demand information on an alert [24] and thought that it would be necessary to make overrides of severe interactions more difficult [24, 28]. The latter finding is not supported by a survey by Ko et al., in which the physicians remained undecided [23]. Taken into consideration the relatively low positive predictive value of alerts, mandatory documentation of override reasons appears to potentially increase alert fatigue [39]. However, it remains unclear whether or not the physicians should be obliged to enter reasons when overriding serious drug-interaction alerts [23, 28].

The physicians in our survey stated that there should be a greater distinction between important and less important alerts. This is supported by other studies [28, 29, 37]. The physicians in our survey express a need for specific alerts adapted to the clinical context, which was suggested by other researchers as well [13, 31, 43, 44]. An approach that considers the clinical context in

order to prioritize and filter irrelevant alerts is relatively innovative and is described in more detail by Riedmann, Jung et al. [45, 46]. Further innovative approaches towards better-adapted alerting strategies are described in [13, 47–49].

9. Meaning and Generalizability of the Study

In general, the attitudes of the physicians towards CPOE and alerting were positive. Also the CPOE non-users showed positive attitudes, though their surveyed population was small ($n = 131$). We could not find obvious differences between the hospitals with or without a CPOE system, or between those with a commercial or home-grown CPOE system, and we could not see an influence of the duration of the CPOE usage or the working experience of the physicians. What we could observe is that the chosen alerting strategy (e.g. which kind of alerts are interruptive) may have an influence on the physicians' attitudes toward CPOE alerting and especially on the perception that too many irrelevant alerts are being displayed.

The problems identified in our survey center on the perceived overload of irrelevant alerts leading to alert fatigue and loss of time. Consequently, a large majority of participants in all hospitals wished for a better distinction of the alerts according to their importance in the clinical context. The three hospitals, which had the highest scores regarding the perceived 'usefulness of the alerts', have already taken preventive action precisely on this issue. Their more strategic alerting strategies sought not to patronize the physicians, but use sophisticated presentations to prevent alert fatigue. It might be that the alerting strategy and the way the information is presented to the physician play a major role in their general attitude towards alerting in CPOE. This theory is supported by a systematic review by Langemeijer et al., which revealed that the physicians preferred alert designs which distinguished between the severity levels [50].

10. Unanswered and New Questions

Our study was not designed to reveal and quantify the factors that may explain significant differences in the attitude of physicians towards CPOE and alerting. Our results indicate that basic beliefs may have a stronger influence than the practical experience with CPOE, and that hospitals with a sophisticated alerting strategy with less interruptive alerts tend towards more positive attitudes. Altogether, this should be further investigated by experiment in future studies, probably including even more hospitals.

11. Conclusions

In this survey, we tried to measure the attitude towards automatic alerting in CPOE systems in various settings. The general attitude of the physicians is positive, independently of the country, the organizational setting and the personal CPOE experience. A well-developed alerting strategy seems to positively influence the physicians' attitudes. To achieve this, highly structured drug and patient case information is needed, as well as locally customizable CPOE systems which are capable of taking into account the clinical context and of differently presenting the alert information to the user.

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