Scorecards: A New Method to Prevent Adverse Drug Events? Preliminary Results from a Clinical Field Study

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Abstract. In the field of the detection and prevention of preventable ADEs, several methods have been explored to decrease the rate of ADEs due to monitoring errors. This paper describes an innovative method that aims at improving patient safety by increasing ADEs' awareness of healthcare professionals. To this end, ADE-scorecards that provide healthcare professionals with retrospective data about ADEs' causes and rates have been developed. In order to evaluate the impact of this method on the ADE rate, in-field clinical tests have been set up. Data were collected by both qualitative (semi-structured interviews) and quantitative methods (log analysis and ADE rate calculation). Preliminary results reveal that ADE-scorecards are well-accepted by most of the healthcare professionals who intend to use them as discussion supports and/or learning tools. Thus, ADE-scorecards seem to be a relevant method to improve patient safety by increasing ADE-awareness of healthcare professionals.

Keywords. Scorecards, adverse drug events, monitoring errors, in-field clinical study

Introduction

Adverse Drug Events (ADEs) are a major public health issue: they endanger patients' safety (by causing or increasing risk for comorbidity or mortality) [1] and instigate significant extra hospital costs (by lengthening patients' stay and involving extra treatments) [2, 3]. Healthcare organizations worldwide are focusing upon their reduction.

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Scientific Background

The European Union FP7 project entitled "PSIP - Patient Safety through Intelligent Procedures in medication" [4, 5] aims - amongst others - at reducing preventable ADEs characterized according to the NCCMERP taxonomy as “monitoring errors” [6]. The subset of ADEs targeted by the PSIP project includes Drug-Drug Interaction, Drug-Disease Interaction, and inadequate monitoring of clinical parameters or lab values (e.g. serum electrolytes, blood clotting parameters, blood pressure). The study in hand introduces the Human Factors’ view of an intervention, so called ADE-scorecards, aiming at reducing preventable ADEs’ rates and reports first results from a first field test with these ADE-scorecards.

In order to be able to prevent ADEs, the first necessary step is to detect them and especially to pitch on preventable events. Basically, there are two main detection methods, namely the voluntary safety reporting systems on one hand and the chart review on the other. The voluntary safety reporting systems consist in the form-based documentation of the potential ADE characteristics (including causes) by the physician, the nurse or the pharmacist who recognized the event (e.g. cf. [7]). This allows understanding how an event occurred (e.g. the patient got the wrong medication because he was not correctly identified). The information gathered with this method is mainly socio-technical and the registered ADE-causes are mainly organizational factors. Thus, the capable prevention methods following from voluntary safety reporting systems are mainly interventions aiming at consolidating and securing the medications’ use process.

The second method used, the chart review, consists in a manual or a computerized reviewing of medical charts by healthcare professionals who are especially trained to ADE detection and prevention [8]. During the manual review process, the professionals look at a large amount of charts and search for events that could be potential ADEs caused by, for instance, drug-drug interactions, contradictions or overdoses. In the computerized review process, digitalized data are used to identify in patients’ charts a signal that suggests the possible presence of an event; then, a professional goes to the chart to investigate this event further. Thus, the chart review method allows catching medical/pharmacological causes of ADEs. Consequently, the prevention measures carried out to counteract the ADEs detected with this method is to provide healthcare professionals with medical/pharmacological information about ADEs, for instance, through Clinical Decision Support Systems (CDSS).

Rationale for the Study

As well as catching only one type of causes of preventable ADEs (i.e. organizational ones for voluntary safety reporting systems and medical ones for chart review), both types of detection/prevention methods get use’s limits. Voluntary safety reporting systems underestimate the actual number of ADEs (underreporting) [9]. Chart review methods are either performed manually and therefore are very time-consuming or require computerized data what could be cumbersome to get and use. Moreover, preventing ADEs by alerting healthcare professionals through CDSS is often problematic as alerts can be too intrusive, unspecific, or even disturbing and can cause “alert fatigue” which often results in alert overriding or deactivation of the alerting system [10, 11].

The PSIP project is interested in the medical causes of the ADEs; it falls in the second type of methods. It aims to:

- Innovatively produce knowledge on ADEs by performing automatic screening (by data- and semantic-mining methods) on patients' medical records. This method allows identifying within hospitals, their number, their type, their consequences and their causes.
- Investigate innovative possibilities for reducing ADEs' rates by developing systems using Human Factors engineering: the information gathered from the screening are not used only to provide healthcare professionals with ADEs' alerts. Other ways of prevention are explored.

One of the innovative ways explored to reduce ADEs' rates is a yet unexplored (at least, not reported in the literature) method. It consists in delivering to healthcare professionals monthly statistics about a particular set of ADEs in their own department, in the form of ADE-scorecards.

Scorecards are long-used in economics sciences and in various areas of industry and healthcare to support strategic management decisions [12]. In the context of ADE-prevention, scorecards could allow raising the awareness of the professionals about the ADEs' issue amongst their patients and acquainting them with their characteristics (causes, epidemiology etc.). As a result, scorecards could support identifying and undertaking strategies for reducing ADEs' occurrence.

Objectives of the Study

The objective of this paper is to investigate the impact of ADE-scorecards on healthcare teams' awareness of ADEs' issues in their own department and ultimately on the actual ADE rate. A clinical field study was set up to answer the following study questions:

- Q1: Do the clinicians, nurses and pharmacists use the scorecards (how often, why/why not, in which occasions and settings)?
- Q2: Do the users expect a benefit for patient safety due to ADE-scorecards? How? Do they intend to use them?
- Q3: Does the usage of ADE-scorecards in a clinical department lead to a change of ADE rates in this department?

1. Study Context

1.1. The ADE-scorecards

The ADE-scorecards' aim is to provide healthcare professionals (e.g. physicians, head nurses, nurses, pharmacists and may be quality management) with detailed information about the ADE cases (type and cause of ADEs, statistics) that occurred previously in their department in order to help them learn about how to avoid such ADEs in the future. Automatic Data Mining procedures [13] are applied to the hospital's Electronic Health Record (EHR) data gathered into a common data model [14] on a regular basis in order to determine the key figures on ADEs per hospital units (e.g. conditions leading the ADEs appearance). Thus, the ADE-scorecard website grants access to the

scorecards with statistics on occurrences of 65 different classes of ADEs[2] (for a technical description [15]).

1.2. Interface Design and Development

The design of the scorecards results from a collaborative and iterative user-centered design process [16] involving healthcare professionals, epidemiologists, computer specialists, website developers and ergonomists. From the beginning of this work, an ergonomist was integrated in the designers-developers team to support cooperative design. Moreover, a sample of end users (4 physicians, 2 pharmacists, 3 head nurses, 6 nurses, 1 health care quality manager), were involved at different steps in the design by commenting on the mock-ups and the prototype, choosing features among parallel versions, and proposing new features and/or facilities. This design process aimed at ensuring that main users' needs were matched by the scorecards and that the developed interface was as usable as possible.

1.3. "Synthesis and Edition of detailed statistics" Page

By logging in, users are identified and thus, the interface's language is automatically adapted and only the user's department data are displayed. The first page the users meet is the "Synthesis and Edition of detailed statistics" page that contains (see Figure 1):

- A table/chart displaying the number of each detected ADEs' kind per month.
- A drop-down menu allowing to choose the displayed period of ADE statistics. A change in this menu immediately changes the data displayed in the previous table/chart.
- Next to every adverse effect's name, check boxes allow selecting the effects for which detailed ADE-scorecards pages will be generated.

1.4. "Detailed statistics" Page

For each selected ADE, an ADE-scorecard is generated which presents (see Figure 2):

- The characteristics of identified stays that describe the sample of stays presenting the adverse effect, including: number of patients concerned, average age, gender proportions, proportions of diseases that might have impact on ADEs (e.g. alcoholism, cancers, renal insufficiency) and the death rate (these deaths are not necessarily due to the adverse effect).
- The conditions (patients' conditions, administered drugs) potentially leading to an ADE with the confidence of association (percentage of stays for which the event occurs among the stays meeting the conditions), the median appearance delay (from the moment when all conditions of the rule are met, the period from which over 50% of events appeared) and the number of stays targeted.

[2] 65 ADE classes were defined, but up to now "only" 27 classes have been detected and, 21 classes have been detected during the time of this study in the test departments (cf. Table 2 for a list of those classes).

- A chart representing the distribution of the number of ADEs per month during the current year and a histogram displaying the median delay of appearance of the ADEs.
- Description of the conditions, which may contain a longer description of the rules, scientific explanations and references, and advice.
- Access to a synthetic view of the patients' record using an EHR visualization tool named "Expert Explorer" [17].This tool allows displaying closed stays' data in a visual, comprehensive and anonymized way through 8 tabs: stay (e.g. the age, the gender), steps (the medical units the patient went through), procedures, diagnoses, lab results (in tabular and charts forms), the administered drugs (in tabular and charts forms), a parallel view of lab results' and administered drugs' charts and the documents enclosed to the record.

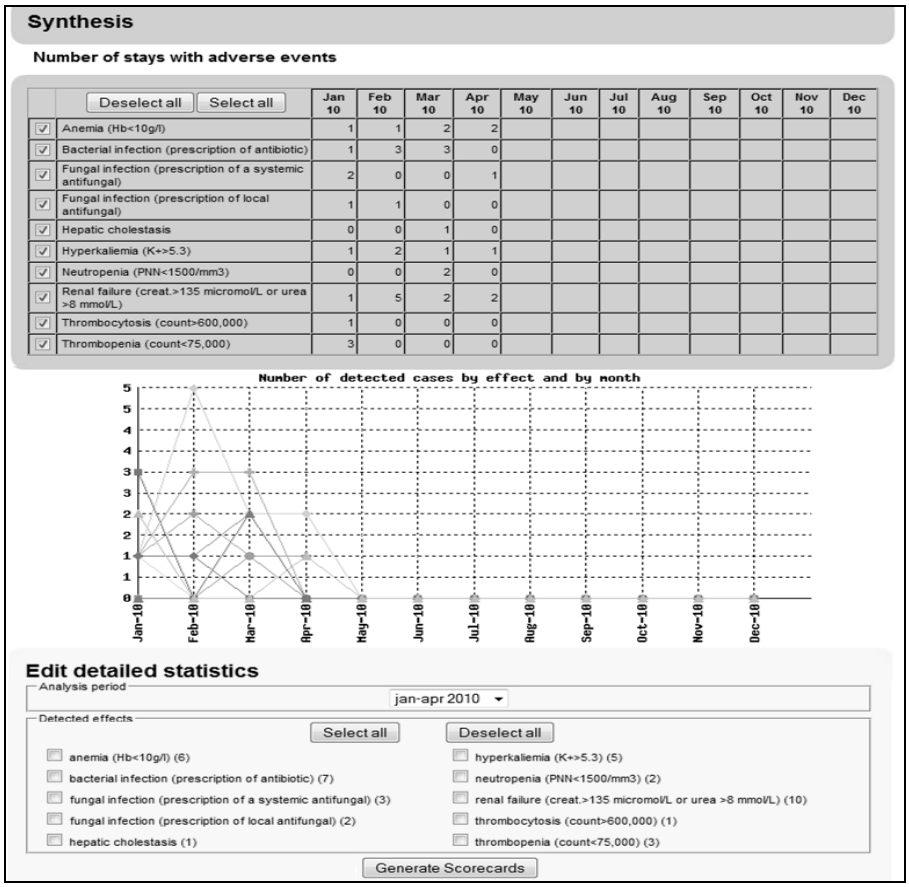

Figure 1. Screenshot of "Synthesis and Edition of detailed statistics" page.

2. Methodology

The in-field clinical test runs in a northern France 413-bed hospital and involves five wards (3 test wards and 2 control wards) and the hospital's central pharmacy.

2.1. Study Design

In order to answer the 3 study questions a combination of qualitative and quantitative study modules was designed. To study the impact of the ADE-scorecards on ADE rates (Q3) a quasi experimental field study with controlled intervention (=introduction of ADE-scorecards) on the variables monthly ADE rates (detected by the PSIP approach) investigated before and after the implementation of the ADE scorecards was chosen.

Log file analyses and qualitative, semi-structured interviews are conducted to answer study questions Q1, Q2.

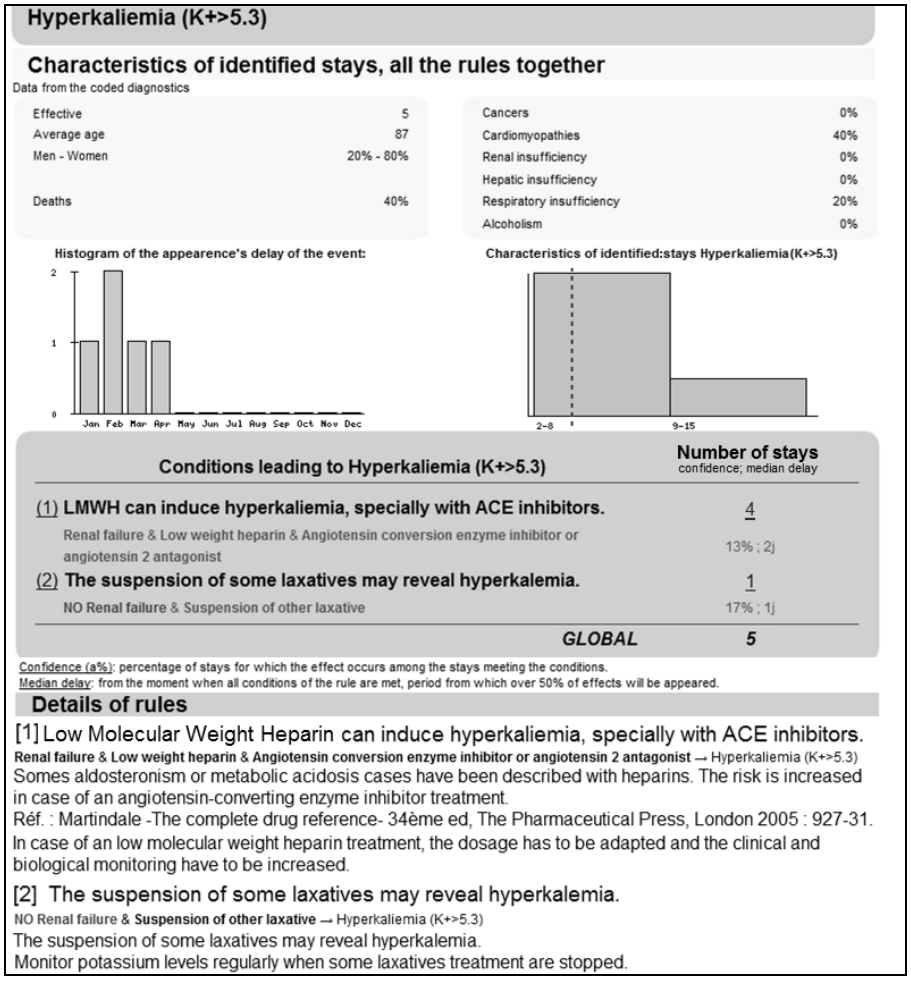

Figure 2. Screenshot excerpts of the "Detailed statistics" page.

2.2. Participants and Study Flow

In the test wards, scorecards were accessible to physicians but also (head) nurses and pharmacists as they are also fully involved in the drugs' management process. In each department, the same volunteers as in the design phase of the ADE-scorecards (except

the quality manager) were involved (cf. Table 1). The scorecards give them access to the ADEs information concerning their own department; pharmacists get access to all three test departments' scorecards as they are involved in the drugs' management process of all medical wards.

Every user gets unlimited access to the ADE-scorecards. Additionally, the users are encouraged to consult at least a set of ADEs defined by the head physician of their department (cf. Table 1). At the beginning of the study in late June 2010, scorecards contained ADEs information for the four firsts months of 2010 and for all 2009, 2008 and 2007. Then, about every two months, users get informed of the upload of new ADEs' information in the scorecards.

Table 1. Description of the departments and practitioners participating.

Departments	**Involved healthcare professionals**	**Number of beds (approx. number of patients/year)**	**Effects of special interest (self defined)**
Department A	2 physicians, 1 head-nurse, 3 nurses	13 (out of 25) (1,340)	Hyperkaliemia Renal failure VKA overdose
Department B	1 physician, 1 head-nurse, 2 nurses	25 (800)	All
Department C	1 physician, 1 head-nurse, 1 nurse	10 (390)	All (especially interested in renal failure)
Control Department A	none	30 (880)	Ø
Control Department B	none	56 (1,500)	Ø
Pharmacy	2 pharmacists	n.a. (5,000)	All

Furthermore, to ensure that users will look at the new information at least once, two kinds of meetings of "scorecards' presentation" are organized at the beginning of the study and then after each upload:

- Physicians/pharmacists meetings animated by ergonomists and a physician (from another hospital) involved in the PSIP project.
- Head-nurses/nurses meetings animated by ergonomists.

These meetings have been negotiated three months before the beginning of the field test with physicians, pharmacists and (head) nurses. It was an occasion for them to look at examples of scorecards data and at PSIP information.

2.3. Data Collection and Analysis

Qualitative and quantitative data have been collected. During the meetings with the users semi-structured interviews were conducted and recorded using an audio recorder. The semi-structured interviews dealt with different topics: participants' current need of information about the ADEs occurring in the medical units, their consideration of the ADE-scorecards (how to use it), their feeling about the opportunity of using this tool to prevent/manage ADEs and their intention to use it.

Meetings with physicians and pharmacists permitted observing discussions between them and the "PSIP physician" about the information displayed and the details of the stays where patients encountered ADEs. From the second round of meetings information about the scorecards' use (Q1) were also documented.

Log files were recorded to know who was using the Web-based ADE-scorecards (e.g. physicians, nurses, pharmacists), when and more precisely which ADEs' page was accessed. Only the connections followed by an action on the ADE-scorecards website (e.g. change of page or of analysis period) were considered. Amongst them, we counted only logs separated by 60 minutes to avoid considering connections following technical disconnections.

Finally, to observe whether scorecards' implementation impacts on ADEs' rates, these rates were calculated as described in [13]. They allow two comparisons: (i) numbers of ADEs in the involved wards before against after the implementation of the ADE-scorecards and (ii) the evolution of the numbers of ADE in the involved wards against control ones.

3. Results

The introduction of the ADE-scorecards in three study wards started in late June 2010. The in-field clinical study being running since 5 months only, it is too soon to perform an interrupted time-series analysis on the evolution of the ADE rates and to get concrete answers to study question Q3 by now. Thus, only results related to the users' considerations about the ADE-scorecards and their use of this tool (study questions Q1, Q2) are presented hereinafter.

3.1. Usage of the Scorecards

From the start of the introduction of ADE-Scorecards on the 24th of June 2010 to the 8th of December 2010, a total of 69 connections shared out between the different medical units and groups of professionals. Nurses and head nurses in the study wards connected to the scorecards 31 times, physicians 8 times and the pharmacists consulted the scorecards in 30 cases. Pharmacists are looking at the ADE-scorecards more than the other professionals. Moreover, they looked at each and every ADE-scorecard available (23 out of the 23 that appeared in 2010) even if they looked more often at some effects (too high INR, renal failure, hyperkaliemia, bacterial infection and hyponatremia) than at others as depicted in Table 2.

No major differences were observed across the departments as for the nurses. Indeed, the differences of numbers of consultations are easily explained by the size of the units and the number of professionals involved (cf. Table 1). Moreover, even if they did not look at each and every ADEs' information available, they consulted a rather wide range of them. Finally, in the three departments, nurses expressed that ADE-scorecards could be useful to improve medications' management if it allows discussing with physicians.

On the contrary, as for the physicians, behaviors of use of the ADE-scorecards vary across the medical departments according to:

- **The actual consultation of the scorecards by the physicians**: outside any "scorecards presentation" meeting, while one physician consulted four times the ADE-scorecards (C), another one consulted them only once (B). The

number of consultations is not related to the size of the department nor to the number of physicians involved. It seems rather that this difference comes from the physicians' interest in this tool: indeed, the physician who consulted the more the ADE-scorecards expressed a lot of interest in the scorecards (in terms of information about potential causes) while the one who consulted them once expressed that "retrospective data are not useful" to prevent ADEs.

Table 2. Prevalence of ADEs detected between January and June 2010 and number of consultations of the ADE-scorecards' pages related to the 21 classes of ADEs detected during the test time (as of 12-08/2010), according to the departments and the kind of healthcare professionals.

Effects	**Department A**			**Department B**			**Department C**			**Pharmacy**	
		nb of cons.			**nb of cons.**			**nb of cons.**			**nb of cons.**
	Prevalence	Nurses & Head Nurse	Physicians	Prevalence	Nurses & Head Nurse	Physicians	Prevalence	Nurses & Head Nurse	Physicians	Overall prevalence	Pharmacists
Anemia	4	3	4	3	5	0	1	3	7	8	12
Bacterial infection	8	1	1	14	0	0	1	0	4	23	16
Fungal infection (presc. of systemic antifungal)	2	0	0	4	0	0	3	0	1	9	5
Fungal infection (presc. of local antifungal)	0	0	0	1	0	0	2	0	3	3	4
Hemorrhage (presc. of hemostatic)	1	1	1	8	1	0	1	1	1	10	8
Heparin overdose	0	0	0	1	1	0	0	2	0	1	1
Hepatic cholestasis	0	0	2	9	1	0	2	2	4	11	5
Hepatic cytolysis	2	0	0	4	0	0	0	0	0	6	5
High a CPK rate	2	3	3	2	1	0	0	0	0	4	1
Hypereosinophilia	0	0	0	2	1	0	0	0	0	2	4
Hyperkalemia	22	8	11	11	8	0	9	4	13	42	21
Hypocalcemia	1	1	2	2	1	0	0	0	0	3	1
Hypokalemia	1	1	3	0	0	0	1	1	3	2	1
Hyponatremia	3	0	0	0	0	0	1	2	3	4	29
Increase of pancreatic enzymes	2	0	0	0	0	0	0	0	0	2	1
Neutropenia	0	0	0	1	4	0	0	0	0	1	1
Renal failure	26	1	1	18	4	1	9	1	5	53	25
Thrombocytosis	2	0	0	7	0	0	1	0	1	10	5
Thrombopenia	7	0	1	6	1	0	3	1	1	16	10
VKA overdose (presc. of vit K)	1	0	0	8	0	0	1	1	3	10	6
VKA overdose (INR>4.9)	11	5	6	10	1	0	1	0	2	22	27
Sum	95	24	35	111	29	1	36	18	51	242	188

- **The discussion about the information contained in the scorecards between nurses and physicians**: such discussions took place in only one department (C) even if nurses in other departments expressed their interest in discussing ADE information with physicians.

3.2. Users' Considerations about the Scorecards

Almost all (except one) physicians and pharmacists expressed that the display of information about the ADEs' statistics is useful for them to get a global and actual representation of the ADEs' prevalence in their respective units.

The detailed information was also appreciated by them and also by (head) nurses because some of the ADEs' causes were either known but not in mind ("it allows to have in mind some adverse effects of medications"), or unknown (e.g. nurses ignored that antibiotics increased the effect of vitamin K antagonists (VKA) on INR (international normalized ratio), and a physician ignored low-molecular-weight heparin could cause hyperkaliemia). In this way, professionals considered the scorecards as a learning-supporting/knowledge refreshment tool that could be also used to teach ADEs to medical and nursing trainees.

During the interviews, 11 participants out of the 13 answered to every topic tackled. All in all, 10 out of 11 participants said that ADE-scorecards could help them to prevent ADEs' appearance. The last participant would prefer to get alerts upon ADEs through a CDSS, which is compatible with the scorecards method. Nonetheless, every participant expressed his/her intention to use the ADE-scorecards in an ADEs' prevention approach.

4. Discussion

This paper aimed at describing an innovative intervention to reduce preventable ADEs related through an innovative way of ADEs' prevention consisting in delivering to healthcare professionals monthly statistics ADEs in the form of ADE-scorecards. The impact of such an intervention (in terms of patient safety improvement and healthcare teams' awareness of ADEs') as been studied the last five months in the clinical field. During this period, data that ADE-scorecards contain have been actualized twice and two rounds of "presentations meetings" have been performed.

4.1. Answers to Study Questions

ADE-scorecards have been used by almost all involved physicians and nurses in the three test departments and by pharmacists. Scorecards are used by healthcare professionals as a punctual source of information. Indeed, they consider the ADE-scorecards as a learning-supporting/knowledge refreshment tool for trainees as well as for themselves because it displayed innovative knowledge adapted to the medical unit clinical context. Moreover, healthcare professionals consider also ADE-scorecards as a tool supporting the dialogue between the different kinds of professionals involved in the medications' use process (pharmacist-physician and nurse-physician discussions).

Overall, ADE-scorecards allow healthcare professionals to be informed and aware of the ADEs' prevalence in their wards. This has been highlighted by most of the

participants as a major benefit from the scorecards. The perceived utility of the ADE-scorecards is clearly expressed by most of the users. Consequently, all participants said that they would use the scorecards in an ADEs' prevention approach.

Due to the short duration of the study, the actual impact of ADE-scorecards' on ADEs' rate and on medical practices remains unknown for now. Indeed, changes in medical practices takes time to be implemented and cannot be observed after 5 months. In addition, the in-field clinical study method needs to take a step back to observe an actual impact over time. Thus, 5 months back is not a sufficient period to clearly assess of an impact of the scorecards neither on the medical practices, nor on the ADEs rates. More time is needed for such as study to check whether ADE-scorecards are an efficient tool to allow decreasing the rate of ADEs by improving healthcare professionals' ADEs-awareness.

4.2. Strengths and Weaknesses of the Study

One of the most important points of the study in hand is its innovative topic: it is the first time in the literature, at our knowledge, that the impact of the use of ADE-scorecards by healthcare professionals is evaluated and reported. Moreover, the study design, by combining qualitative and quantitative study modules, allows gathering different kinds of information about ADE-scorecards' use from complementary points of view (e.g. behavioral, considerations, ADEs rate). This mixed methodology allows getting a comprehensive view of the different issues related to ADE-scorecards' implementation.

However, one of these study modules (semi-structured interviews) implied to organize regular "scorecards presentation" meetings: thanks to them, we could gather feelings of the users and we ensured that they looked at the scorecards at least once. Now, these interventions surely influenced the participants as well as ADE-scorecards. They may have increased their ADEs-awareness. Thus, the respective impacts of the ADE-scorecards implementation and of the presentation meetings are closely intertwined. So, results' interpretation could not attribute potential changes in ADEs' rates and medical practices to the only ADE-scorecards. In order to observe pure impact of the ADE-scorecards another study without any intervention of PSIP physicians and ergonomists is under preparation in another hospital. Another potential bias is related to the fact that the participants were already involved in the design of the ADE-scorecards. Even if they did not see information about the ADEs' rates and causes for their own medical unit, their awareness of the ADEs issue could have been increased before the actual beginning of the study.

5. Conclusion

Even if the study in hand is still running, preliminary results show that ADE-scorecards could be a useful tool to increase the healthcare professionals' awareness of the ADEs' issue in their own department and thus to increase the safety of their own patients.

Acknowledgments

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 216130 – the PSIP project.

The authors would like to acknowledge every healthcare professionals (physicians, nurses, head nurses and pharmacists) and technicians whose involvement made completion of this study possible.

References

[1] J.U. Schnurrer, J.C. Frölich, [Incidence and prevention of lethal undesirable drug effects], *Internist* **44** (1993), 889–95.

[2] D.W. Bates, N. Spell, D.J. Cullen, E. Burdick, N. Laird, L.A. Petersen, S.D. Small, B.J. Sweitzer, L.L. Leape, The costs of adverse drug events in hospitalized patients. Adverse Drug Events Prevention Study Group, *Journal of the American Medical Association* **277** (1997), 307–11.

[3] D.C. Classen, S.L. Pestotnik, R.S. Evans, J.F. Lloyd, J.P. Burke, Adverse drug events in hospitalized patients, Excess length of stay, extra costs, and attributable mortality, *JAMA* **277** (1997), 301–6.

[4] R. Beuscart, W. Hackl, C. Nøhr, *Detection and prevention of adverse drug events: information technologies and human factors*, IOS Press, Amsterdam, 2009.

[5] Patient Safety by Intelligent Procedures in medication, http://www.psip-project.eu/, last access on March 2011.

[6] National Coordinating Council for Medication Error Reporting and Prevention, NCC MERP: The First Ten Years "Defining the Problem and Developing Solutions". 2005. 23-5-2009.

[7] Association pour l'Assurance Qualité en Thérapeutique et l'Evaluation, http://www.adiph.asso.fr/aaqte/FormulaireREEM.pdf, last access on March 2011.

[8] A.K. Jha, G.J. Kuperman, J.M. Teich, L. Leape, B. Shea, E. Rittenberg, E. Burdick, D.L. Seger, M. Vander Vliet, D.W. Bates, Identifying adverse drug events: development of a computer-based monitor and comparison with chart review and stimulated voluntary report, *J Am Med Inform Assoc* **5** (1998), 305–14.

[9] S.A. Edlavitch, Adverse drug event reporting, Improving the low US reporting rates, *Arch Intern Med* **148** (1998), 1499–503.

[10] H. van der Sijs, J. Aarts, T. van Gelder, M. Berg, A. Vulto, Turning off frequently overridden drug alerts: limited opportunities for doing it safely, *J Am Med Inform Assoc* **15** (2008), 439–48.

[11] H. van der Sijs, A. Mulder, T. van Gelder, J. Aarts, M. Berg, A. Vulto, Drug safety alert generation and overriding in a large Dutch university medical centre, *Pharmacoepidemiol Drug Saf* **18** (2009), 941–7.

[12] R.S. Kaplan, D.P. Norton, The balanced scorecard--measures that drive performance, *Harv Bus Rev* **70** (1992), 71–9.

[13] E. Chazard, G. Ficheur, B. Merlin, M. Genin, C. Preda, R. Beuscart, Detection of Adverse Drug Events Detection : Data Agregation and Data Mining, *Stud Health Technol Inform* **148** (2009), 75–84.

[14] E. Chazard, B. Merlin, G. Ficheur, J.C. Sarfati, R. Beuscart, Detection of Adverse Drug Events: Proposal of a Data Model, *Stud Health Technol Inform* **148** (2009), 63–74.

[15] E. Chazard, A. Băceanu, G. Ficheur, R. Marcilly, R. Beuscart, Les «ADEs Scorecards», un outil de détection et de visualisation des effets indésirables liés aux médicaments, Proceedings Journées Francophones d'Informatique Médicale, Tunis, 2011.

[16] International Standards Organisation,. *Human centered design processes for interactive systems (Rep. No. ISO 13407)* (1999), International Standards Organisation, Geneva, 1999.

[17] A. Băceanu, I. Atasiei, E. Chazard, N. Leroy, The Expert Explorer: A Tool for Hospital Data Visualization and Adverse Drug Event Rules Validation, *Stud Health Technol Inform* **148** (2009), 85–94.