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# **Rapid sequence induction traceability in an ICU dedicated patient data management system: a multicentric retrospective study**

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# **Abstract**

## **Purpose**

Patient data management systems (PDMS) are widely used in intensive care units (ICUs) to improve care traceability. Verbal orders are still used for prescriptions requiring immediate execution but should be subsequently recorded in the system. We assessed the rapid sequence induction (RSI) traceability for endotracheal intubation in an ICU dedicated PDMS.

## **Materials and Methods**

A retrospective study was conducted on anonymous databases in 21 ICUs. Endotracheal tube insertions performed during one year were compared to the number of RSI registered in the PDMS.

## **Results**

We listed 5516 endotracheal tube insertions. A suxamethonium injection was registered in 829 cases and a rocuronium administration in 909 cases. The RSI traceability rate in the overall cohort was 31.5% and was greater in the units where nurses were allowed to record a drug administration before the computerized physician order entry.

## **Conclusions**

PDMS are supposed to improve prescription completeness and traceability, but our study suggests an opposite result. **A co-responsibility policy between physicians and nurses should be promoted to improve care traceability. PDMS ergonomic improvements and enhanced integration in clinical workflow might also result in better compliance with documentation requirements.** In each centre, indicators of PDMS correct use should be defined and periodically monitored.

## **Keywords**

Intensive care unit; Traceability; Patient data management system; Computerized critical care information system; Computerized physician order entry

## **Declaration of interest**

On behalf of all the authors, the corresponding author states that there is no conflict of interest.

## **Financial Disclosure statement**

None

## **Introduction**

In critical care environment, caregivers deal with growing amount of varied information, including clinical observations, data from vital signs monitors, ventilators

and other medical devices, biological and bacteriological results, medical imaging. Dedicated patient data management systems (PDMS) are therefore widely used to compile these data and are considered as key components of clinical care quality improvement and medical practice modernization [1].

These computerized critical care information systems may contribute to increasing prescription safety and to reduce medication errors, even if it did not demonstrate any improvement in patients' outcome yet [2]. Compared to handwritten orders, computerized physician order entry (CPOE) improves prescription legibility and completeness due to standardized expression of route, dose, time to be given, and approved drug names [3]. CPOE provides dose checking support including lower and upper limits [4]. It can also include clinical decision-support capabilities, helping prescriber to adapt drug doses to renal or hepatic function, detecting drug interaction, or providing alerts in case of allergies. Finally, CPOE ensures prescription and administration traceability, because each action on the system is timestamped and can be assigned to the person logged in.

Despite CPOE potential benefits, verbal orders are still used for prescriptions requiring immediate execution. Endotracheal intubation is a frequent and challenging situation in intensive care units (ICU), sometimes realized in an emergency context, and which can induce life-threatening complications [5]. The implementation of an intubation management bundle, including rapid sequence induction (RSI) with rapid-onset hypnotic and neuromuscular-blocking drug administration, has been demonstrated effective to reduce these immediate severe complications [6]. In such context, verbal orders are more convenient for global crew management, providing that orders are accurately communicated, correctly understood, and subsequently

transcribed into the medical record [7]. This study aimed to assess the RSI traceability for endotracheal intubation in an ICU dedicated PDMS.

## Materials and Methods

A retrospective multicentric study was performed on ICU anonymous databases, concerning the whole year 2016. French ICUs using the same ICU dedicated PDMS for more than a year (Centricity Critical Care™ ICU dedicated solution, General Electric Healthcare) were asked to participate in the study. This system is an integrated PDMS supporting medical devices documentation, data acquisition from bedside monitors and life support equipment, biological test results and bedside observations among others. It enables drug prescriptions by physicians, which may be backdated, then drug administration traceability by nurses. If allowed by the staff, the PDMS enables nurses to record a drug administration by themselves before the computerized physician order entry. This functionality is supposed to facilitate verbal orders traceability; nurses can transcribe an order and must report the prescriber's name, then the system requires a subsequent physician validation (figure 1).

Heads of ICU were interviewed by phone to know if this functionality was allowed in their unit. They were also asked about ICU's features, as the number of critical care beds and the number of physicians during day work and night or weekend shifts. According to the French law, the ratio of beds per nurse is 2.5. The number of admissions during the study period was collected, as well as the mean simplified acute physiology score and the mortality rate. Concerning ICU practices, we asked each centre if RSI was usually realized for endotracheal intubation.

Endotracheal tube insertion, daily care and removal were documented by nurses in the PDMS. All and consecutive endotracheal tube insertions performed in ICU

between the 1<sup>st</sup> of January 2016 and the 31<sup>st</sup> of December 2016 were included. To exclude endotracheal intubation realized prior to ICU admission (e.g. in operating room or prehospital setting), only endotracheal tubes registered in the PDMS more than 20 minutes after ICU admission were considered (*n intubations*). The number of RSI was evaluated by the count of distinct administrations of an induction dose of rapid onset neuromuscular-blocking agents (rocuronium or suxamethonium) registered in the PDMS (*n inductions*). Rocuronium continuous perfusions were not considered. The RSI traceability rate was then calculated as the ratio between the number of RSI and the number of endotracheal tube insertions (*traceability rate = n inductions/n intubations x 100*).

After each head of ICU agreement, database request was performed using a secure remote access. Data extraction and treatment were realized with Crystal Reports Software, SAP<sup>TM</sup>. Statistical analysis was realized with pvalue.io<sup>TM</sup> software. Continuous variables concerning the different centres are presented as median with interquartile range (IQR). Correlations between RSI traceability rate and quantitative variables were assessed by Pearson coefficient. For qualitative variables, traceability rate differences between groups were compared by Mann-Whitney test.

This anonymous and retrospective database analysis was declared to the French National Commission on Informatics and Liberty (CNIL) under the number 2213322v0 and was realized according to its requirements (reference methodology MR-004).

## **Results**

Twenty-two ICUs answered the survey, among which one was excluded because usually realizing endotracheal intubation without RSI. The data from the 21 remaining ICUs were analysed (table 1).

Eleven ICUs were in university hospitals, and ten in non-university hospitals. The median number of beds was 14 (IQR 10–16). The median number of senior physicians was 3 (IQR 2–4) during day work and 1 (IQR 1–1) during night or weekend shifts. The median number of residents was 3 (IQR 2–4) during day work and 1 (IQR 1–1) during night or weekend shifts. The ratio of beds per physician was 2 (IQR 2–2.4) during day work and 8 (IQR 6–9) during night or weekend shifts. In 8 ICUs, nurses were allowed to record drug administration in the PDMS prior to physician order entry.

During the study, 19736 ICU admissions occurred. The median of mean admission age between the different ICU was 61.1 years old (IQR 58.7–63.3), the median of mean simplified acute physiology score was 40.9 (IQR 34.2–44.7), and the median of the average length of stay was 6.5 days (IQR 5.3–7.9). The overall mortality rate was 12.8%.

A total of 5516 endotracheal tube insertions were identified. A suxamethonium injection was registered in 829 cases (15%), and a single bolus rocuronium administration in 909 cases (16.5%). The RSI traceability rate in the overall cohort was 31.5%. It widely varied between the different ICUs, from 0.33% to 83.10% (Table 2). The median RSI rate between the different centres was 28.1% (IQR 8.1–52.8).

No correlation was found between the RSI traceability rate and the number of beds in the unit, the number of physicians, the number of ICU admissions per year, or the ratio of beds per physician during day work or during night or weekend shifts. The traceability rate was more important in the units where nurses were allowed to report by themselves a drug prescription in the PDMS (46.8% (IQR 32.1–66.7) vs 10.5% (IQR 7.11–34.2),  $p = 0.037$ , figure 2).

## Discussion

Among many potential benefits, CPOE are reputed to increase prescription completeness and traceability [3]. Although concerning a specific process, our study suggests an opposite result, showing that RSI traceability for endotracheal intubation was low in an ICU dedicated PDMS. The traceability rate widely differed between the different centres but was less than 50% in 3 out of 4 ICU.

In healthcare environment, traceability consists of identifying all the precise information related to the patient and the medications administered [8]. In emergency context, verbal orders are common to increase interoperability between nurses and physicians, but traceability must remain a concern. During ICU stays, many transfers of patient care information happen through written and verbal communication. Each time, communication failures may occur and information may be omitted [9]. Comprehensive traceability in electronic medical record ensures entire care information recovering even much later [10]. Individually, RSI traceability will allow subsequent caregivers to know that the patient already underwent such a procedure and how it went on. Collectively, traceability enables to assess ward practices, as the number of RSI and the adherence to recommendations. It can also be useful for medico economic purposes, to document medical procedures or to account drug consumption [11]. Finally, endotracheal intubation in ICU remains a high-risk procedure with potential adverse events like broken teeth, aspiration, or difficult airway management with possible life-threatening complications (hypoxaemia, hypotension, cardiac arrest) [5]. In such cases, RSI traceability can be used to ensure that all necessary precautions have been taken.

The ICU dedicated PDMS assessed in this study is supposed to facilitate care traceability even in an emergency setting, either by allowing delayed physician order entry or by allowing nurses to record drug administration prior to prescription, which requires subsequent physician countersignature. Therefore, the poor traceability rate observed in the study indicates that these functionalities **may not be sufficient to ensure comprehensive traceability**. The system 'usability', which combines ease-of-use and utility, has already been described as one of the main factors contributing to PDMS efficacy in clinical setting [1]. While poor usability leads to workflow interruptions, increases workload and can facilitate errors, systems with high usability are expected to have a positive impact on the quality of care, work efficiency, and staff satisfaction. Systems ergonomic features must be suitable for specific ICU setting. It concerns hardware specifications, including sufficient number of computer workstations located in the right places, as well as the software user interface [12]. Many limitations have already been listed in the literature, as complex login procedures or too short downtime, slow system response time, high number of mouse clicks required, suboptimal interfaces or redundant alerts [13,14]. Then entering, discontinuing, or reordering a medication is sometimes a complex and lengthy task requiring numerous steps.

**Although the same PDMS was used in all the ICUs, RSI traceability rate widely differed between the different centres. Integration into existing environments and workflows is critical to successful PDMS implementation [15].** Customizability is a decisive feature to adapt generic system to ward practices or specific tasks. Minor changes can sometimes make the system more user-friendly and increase user satisfaction and acceptance [16]. **For example, pre-filled orders and order sets can be implemented in the PDMS used in this study. Integration in workflow is so critical**

than unexpected increased mortality was reported in a regional paediatric referral centre after the implementation of a commercially sold CPOE [17]. It was associated with many difficulties including additional time needed to enter orders, delays in the administration of critical medication and altered interactions between ICU team members. The same commercial CPOE product was implemented in another centre few months later, with staff active involvement, and careful design, build, implementation, and support. A nonsignificant reduction in the risk of mortality was then observed in the postimplementation period [18].

Crew management is also a cornerstone to improve PDMS acceptance and further use. Computerized information systems implementation has already been reported as responsible for staff relationship impairment, generating significant tensions among physicians, nurses, and administrators, and sometimes leading up to the system withdrawal [19]. The entire team must be engaged, informed about aims and expected benefits, and trained before such an implementation in ICU. Thus, during a PDMS implementation in a neonatal intensive care unit, physicians felt technical training was incomplete whereas nurses remained concerned that workflow may be altered; interdisciplinarity collaboration was critical to ensure PDMS implementation while maintaining efficient workflow [20]. In a national survey across critical care information systems in Germany, perceived usability was strongly influenced by the duration of training with PDMS, the satisfaction with the occupation, and the general inclination to whether PDMS is useful [1]. In our study, traceability was greater in the units where nurses were allowed to transcribe a drug prescription in the PDMS. It can be suggested that in these units, nurses had been specifically trained to this process and had been more implicated in the PDMS implementation. **Even after implementation, a long-term management strategy, including continuing education**

and appropriate support, is needed for PDMS proper use [15]. This might partly explain the variability in traceability between the different centres in our study.

Poor traceability observed in this study requires considering areas for improvement. The main result of our study is that traceability was better when nurses and physicians were co-responsible for RSI documentation in the PDMS: such policies should be promoted. Standard operating procedures based on checklists have been proposed for RSI [21]. Such tools could include reminders for induction traceability in the medical record once intubation has been performed. PDMS ergonomic improvements might also be considered for this purpose. Collaborative work with the PDMS provider already led to suggest adding in future software release a 'nurse note option' in order to facilitate the traceability of emergency drug administration under nurse login. Each time a new invasive material is recorded in the PDMS, an interactive menu could also be added to ask the user: 'did you perform an anaesthesia?'. Finally, PDMS use should also be periodically monitored in each centre by reproducing this study or using alternative indirect indicators like the difference between the drug traceability in the PDMS and the drug delivery by the hospital pharmacy.

Our study suffers several limits. Retrospective analysis suits for practices assessment to avoid any influence on real practices but can induce some collection bias. To avoid any confusion with endotracheal intubations performed prior to ICU admission, early intubations (less than 20 minutes after admission) have been excluded which may underestimate the total account of cases. Endotracheal intubation without any RSI administration, for example in case of cardiac arrest or for endotracheal tube replacement in patients who already received continuous neuromuscular blocking agents, have not been specifically considered either. These

cases led to slightly underestimate the RSI traceability rate. Conversely, punctual neuromuscular blocking with a single dose of rocuronium for another indication than RSI may sometimes occur (for example for bronchial fibroscopy or percutaneous endoscopic gastrostomy) and led to slightly overestimate the traceability rate. Finally, since we did not find any data available about the RSI traceability in other ICUs with or without PDMS, our study did not assess the specific PDMS impact on RSI traceability. A comparison before and after PDMS implementation could also have enabled to know whether the low traceability rate was only due to the computerized order process or to other factors. To explain the differences in traceability, assessment of PDMS implementation strategies in each centre (customization, initial and ongoing training, support) would have been of special interest as well.

## Conclusion

Computerized critical care information systems have been recognized as valuable tools to increase care safety, efficiency and effectiveness. In ICU setting, they provide clinical decision support and mainly allow to collect and store large amounts of health data in various formats. Such databases enable to recover individual clinical information even after a long time, to investigate and improve collective practices, and to conduct clinical research. ICU databases contain precious information that we must take care of. Above all, databases require trusted and comprehensive data. PDMS enables reliable traceability provided that those who enter data are reliable too, but our study suggests it is not always the case.

According to our results, a co-responsibility policy between physicians and nurses should be promoted to improve care traceability. PDMS ergonomic improvements and enhanced adoption by end-users might also result in better compliance with

**documentation requirements.** In each centre, indicators of PDMS correct use should be defined and periodically monitored. ICU dedicated PDMS must be perfectly integrated in clinical workflow to support caregivers and finally benefit to the patients.

## **Glossary**

CPOE: computerized physician order entry

ICU: intensive care unit

IQR: interquartile range

PDMS: patient data management system

RSI: rapid sequence induction

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## Détails prescription

Préparation ESMERON Rocuronium 50 mg

\* Voie IVD

## Programmer

 Intervalle  Temps/quantité flexible\* Fluide et qté : Pas dilution  ml

\* Quantité : 100 mg Concentration : 10 mg/ml

Dosage : 1,2 mg/kg ( 83,3 ... kg)

Réinitialiser

Intervalle :  min

Répétitions : 1

\* Prochaine fois 12/04/2019 14:53

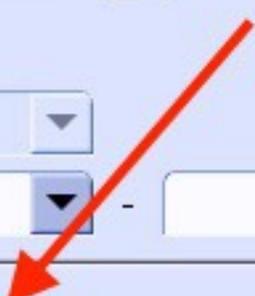
\* Valide 12/04/2019 14:53 - 

## Autres

\* Prescrit par 

Notes Induction à séquence rapide : 1.2mg/kg

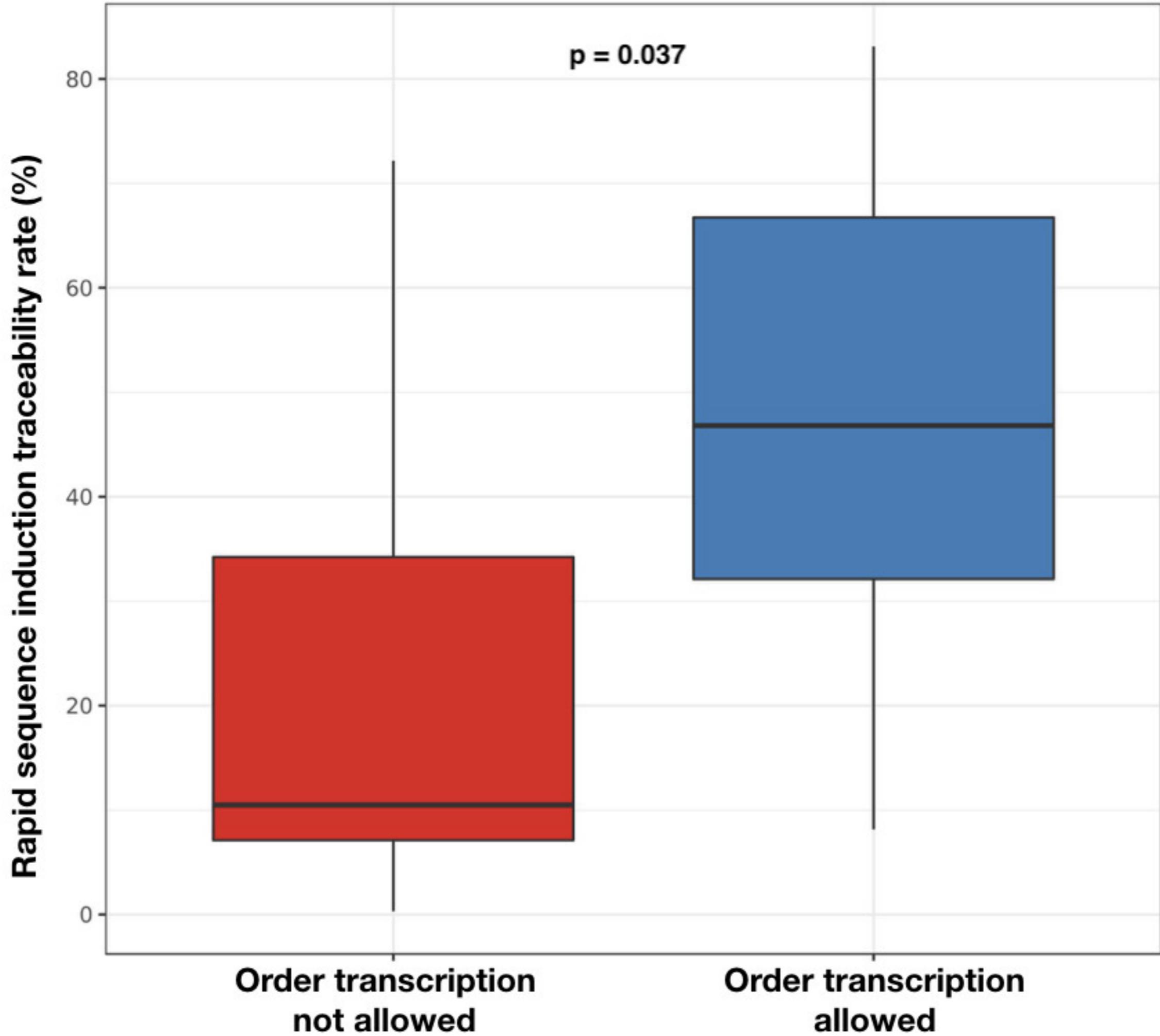
**Prescriber's name reported  
by nurses**



OK

Annuler

Aide...



**Table 1: ICU's features**

*ICUs are classified from the lowest RSI traceability rate to the highest.*

ICU	Number of critical care beds	Admissions during year 2016	Number of senior physicians		Number of residents		Number of beds per physician		Nurses allowed to transcribe orders	University Hospital
			Day work	Nights or weekend shifts	Day work	Nights or weekend shifts	Day work	Nights or weekend shifts		
1	12	1646	3	1	3	1	2	6	No	Yes
2	10	555	3.8	1	2	0	1.7	10	No	Yes
3	16	924	2.5	1	3	1	2.9	8	No	Yes
4	16	888	3	1	5	1	2	8	No	Yes
5	16	699	3	1	4	1	2.3	8	No	Yes
6	18	803	6	1	8	1	1.3	9	Yes	Yes
7	12	546	3	0	3	1	2	12	No	Yes
8	14	658	1.5	1	3	1	3.1	7	No	No
9	10	349	2	1	2	1	2.5	5	No	No
10	12	989	4	1	4	1	1.5	6	No	Yes
11	18	1242	4	1	5	1	2	9	Yes	Yes
12	14	683	2	1	4	1	2.3	7	Yes	No
13	18	2019	5	1	4	1	2	9	No	No
14	8	1344	2	1	2	0	2	8	Yes	No

15	9	378	2	1	2	0	2.25	9	Yes	No
16	8	220	1.5	1	2	0	2.3	8	No	Yes
17	24	1891	4	2	6	2	2.4	6	No	No
18	10	710	2	1	2	1	2.5	5	Yes	No
19	18	1610	7	2	8	1	1.2	6	No	Yes
20	10	425	1.5	1	2.5	1	2.5	5	Yes	No
21	14	1157	3	1	4	1	2	7	Yes	No

**Table 2: Rapid sequence induction (RSI) traceability rate by centre**

ICU	Admissions during year 2016	Endotracheal intubations	RSI traceability		RSI traceability rate (%)
			Rocuronium injections	Suxamethonium injections	
1	1646	307	1	0	<b>0.33</b>
2	555	76	0	1	<b>1.32</b>
3	924	470	3	22	<b>5.32</b>
4	888	211	3	12	<b>7.11</b>
5	699	320	2	21	<b>7.19</b>
6	803	393	28	4	<b>8.14</b>
7	546	165	15	0	<b>9.09</b>
8	658	439	34	12	<b>10.48</b>
9	349	74	0	8	<b>10.81</b>
10	989	217	32	0	<b>14.75</b>
11	1242	448	122	4	<b>28.13</b>
12	683	290	20	77	<b>33.45</b>
13	2019	225	8	69	<b>34.22</b>
14	1344	105	0	48	<b>45.71</b>
15	378	119	35	22	<b>47.90</b>
16	220	108	0	57	<b>52.78</b>
17	1891	475	147	135	<b>59.37</b>
18	710	209	114	15	<b>61.72</b>
19	1610	460	107	225	<b>72.17</b>
20	425	115	36	58	<b>81.74</b>
21	1157	290	202	39	<b>83.10</b>