Information-based monitoring platform for rational use of antibiotics at a Chinese university hospital

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ABSTRACT

Background This study aims to describe the implementation of an information-based monitoring platform for rational use of antibiotics (IMP UA) in a Chinese university hospital, and to test the effectiveness of pharmacists' interventions in the electronic prescription with the help of IMP UA.

Methods A computerised supervision system integrated with such new features as hierarchical management in terms of risks involved, limiting rights of antibiotic prescription, electronic control of drug prescribing, online acquisition of all antibiotic-related data, setting special prescriptions, and restricting the maximum dose and days of a single prescription. To test the effects of new features proposed by participating pharmacists, the number of high-risk warnings at different stages of IMP UA were statistically analysed.

Results Our preliminary study showed that IMP UA was feasible and effective for preventing or limiting irrational use of antibiotics. In particular, the number of high-risk warnings were substantially decreased after the options of 'intervention' and 'interception,' as proposed by participating pharmacists, were included in the system. There was a significant difference in percentage of level-4 (red) warnings between the non-intervention and intervention group ($p < 0.01$).

Conclusions Professional information pharmacists, via participatory development, were able to help to improve or perfect the IMP UA. With active involvement of professional pharmacists, the IMP UA can help to reduce irrational antibiotic use and minimise the risk involved.

drugs that work directly on the human body, antibiotics act on pathogens, rather than human tissues or organs. Understanding the interactions between the infected body, the antibiotics and the pathogens requires a multidisciplinary knowledge of clinical pharmacy and microbiology, among others. Moreover, infections, especially bacterial infections, are the most common conditions. As a result, antibiotics are extensively used in clinical practice, and a wide array of factors dictates their use.⁵ In treatments involving the use of antibiotics, caution should be exercised, especially with particular populations such as elderly or juvenile patients, since a seemingly small amount of negligence may lead to serious consequences, for which the doctor or patient involved might have to pay dearly. In clinical practice, doctors need to plan treatments carefully, taking factors, such as contraindications, drug interactions, results of laboratory tests, and examination findings, into consideration. Moreover, prescription screening is a highly professional job requiring knowledge in both medicine/pharmacy and law/regulations, and pharmacists are under great pressure when verifying prescriptions. Given this situation in China, efforts are urgently required to minimise medication errors and reduce the burden on medical personnel. The traditional approach to monitoring rational use of antibiotics is no longer sufficient, and the use of state-of-the-art information technology (IT)-based network management of medication-related data has become an effective means of monitoring antibiotic use.

INTRODUCTION

The status quo of antibiotic use in China

Antibacterial drugs have been in clinical use for about 70 years, with millions of lives saved. However, antibiotic misuse, especially in recent years, has resulted in bacterial resistance to antibiotics and emergence of so-called 'super bacteria' worldwide.¹

Confronted with increasingly severe bacterial resistance, the Chinese authorities have staged a national campaign against antibiotic misuse in clinical practice since 2011.² However, the status quo of antibiotic use in China remains unsatisfactory, and irrational use of antibiotics is a problem that needs to be addressed urgently.^{3,4}

In China, medication errors are not uncommon because of the relatively limited medical resources and heavy workload on medical workers, plus the rapidly increasing amounts of medical information facing medical workers. Compared with other drugs, supervision of antibiotic use is more difficult and the situation is more urgent. Unlike other

Application of IT in the supervision of antibiotic use in China

To help clinicians and pharmacists handle the rapidly increasing amount of information on the drugs available, a specialised system that provides informational support is in urgent need.^{6,7} The Chinese health authorities have recently initiated an initiative that demands that hospitals practise rational medication by using information technology.⁸ The introduction of imported or foreign software packages for monitoring the use of medicines has some problems, since Chinese hospitals, especially large general hospitals, are different from their foreign counterparts in terms of language used, number of patients involved, and organisation.

Over the past decade, medication-monitoring systems, integrated into overall hospital information systems, have been growing rapidly in China. More and more hospitals are employing IT in their clinical pharmaceutical services. With the introduction of these systems, some hospitals have made

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Figure 1 Flowchart of information-based monitoring platform for rational use of antibiotics (IMPUA).

progress in the rational use of medicines. These systems, however, still have some drawbacks.^{9 10} (1) Most domestic software systems only have one prompting feature, and they are hard to customise to particular needs. (2) Some hospitals try to intercept seemingly inappropriate electronic prescriptions, but the systems are not smart enough to identify special situations,

and do not allow communication with the doctor involved to resolve uncertainties. (3) Many hospitals are not staffed with full-time pharmacists in charge of the software system, which tends to result in frequent false alarms or erroneous prompts. Some systems have even been shut down because of complaints by doctors about regular false alarms.

In many cases, professional pharmacists are not involved at all in IT-based pharmacy management. Without involvement of pharmacists, over-dependence on the software system causes problems: in many cases, either the system fails to intercept inappropriate prescriptions or the intervention is inappropriate.

In order to solve this problem and to better monitor and control the use of antibiotics, our hospital introduced a new mode of monitoring antibiotic use, which integrated the computerised monitoring system and notions proposed by participating professional pharmacists, named an information-based monitoring platform for rational use of antibiotics (IMPUA). This paper aims to describe implementation of IMPUA and to test the effectiveness of pharmacists' interventions in electronic prescriptions with the help of IMPUA. This work will be useful for both strengthening the professional status of pharmacists in medication management and providing a theoretical basis for the development and application of new IT in hospital pharmacy management.

METHODS

Development of IMPUA

To develop the new mode of IMPUA, we took a step-by-step approach in the expansion or improvement of the system.

Figure 2 Interface of dialogue boxes for medication intervention. As the system reminds the doctor about medication risks, the doctor is required to provide justifications in a dialogue box. ① Warning lights; ② details of drug formula; ③ dialogue box for medication intervention. The dialogue boxes have two levels: a, the first level contains four categories; b, the second level contains 5–7 items; ④ prompt of whether to continue; ⑤ button of 'Print'; ⑥ button of 'Check'; ⑦ explanatory text of warning lights of five colours.

2013. 09. 26 | 2013. 09. 26 | 门诊号码: | 刷新(R) | 关闭(C) | 记录数 361

代码	用药理由分类 Justif	行号	门诊号码	处方号码	病人姓名	开处方时间	科室
1	药物相互作用 Interaction	1.	212263985	211842080		2013-9-26 02:04:42	急诊科
2	药物配伍禁忌 Incompatibi	2.	210858595	211843436		2013-9-26 09:06:13	消化门诊
3	药物用法用量 Dosage and	3.	212616046	211843361		2013-9-26 09:02:59	消化门诊
4		4.	212618435	211842072		2013-9-26 01:35:32	急诊科
5		5.	212615338	211842568		2013-9-26 08:25:09	消化门诊
6		6.	212618251	211852525		2013-9-26 21:16:47	急诊科
7		7.	212611678	211849959		2013-9-26 15:27:32	神内科门诊
8		8.	212582062	211843182		2013-9-26 08:54:50	普外门诊

代码 用药详细理由 Justificati

1	已调整给药剂量 I have adju
2	已密切监测血药浓度 I hav
3	已交代护士或患者, 药品
4	有足够证据证明联用后可

查询结果

处方详细信息 Details of Prescription

处方类型	药品名称	药品规格	药品产地	数量	单位	单价	用药原因 Justification
西药方	氟氯西林钠粉针(伊芬)	1.0g	1185	6.00	支	110.8000	PASS:1-1:已调整给药剂量 I hav
西药方	活血止痛软胶囊	0.65g*24#	1740	4.00	瓶	43.7000	
西药方	头孢克洛缓释胶囊(曼)	0.125g*12	117	4.00	盒	26.5000	
西药方	0.9%氯化钠注射液(青)	0.9%*250ml	1135	3.00	袋	5.7000	

合计 962.70

Figure 3 Interface of retrieving records of medication justifications. The records can serve as evidence of reconfirmation of the prescription. (Note: The patients' name had been obscured.) ① The highlighted blue fields indicate the target prescription (No 212582062), which has been found by inputting the prescribing time. ② The dialogue box of the target prescription (No 212582062). The highlighted blue fields show that a justification for the medication has been given by the physician. ③ Details of the target prescription, such as the prescribing physician, drug formula, drug cost, etc.

IMPUA was put into a test operation in July 2012 and functionally included only a few features, such as automatic prompting of inappropriate prescriptions, provision of relevant information about use of a medicine, and so on, without any pharmacists' interventions. About half a year later, on the basis of preliminary research, pharmacists began to participate in IMPUA and proposed adding more features, including 'intervention' and 'interception', to IMPUA, and in May 2013, a multiple-featured system was officially put into practice.

Three full-time information pharmacists handle and maintain the platform, examining prescription-screening results from the system and checking with doctors when a prescription is called into question. Professional pharmacists use, improve and update the system on a constant basis. In this way, potential risks of irrational medication are further reduced and better management strategies are identified. The information-based monitoring platform, to some extent, met our expectation of controlling antibiotic misuse. It features some useful functions, such as hierarchical management in terms of the risks involved, limiting the right to prescribe antibiotics, electronic control of drug prescribing, online acquisition of all antibiotic-related data, restricting the maximum dose and days of a single prescription, and providing special access to certain drugs under emergency conditions.

Hierarchical management

Figure 1 shows the flowchart of the hierarchical management. According to the classification of medication hazards, we used

different measures to control the risk, including 'prompting, intervention and interception'. Before printing out a prescription, the system, according to its risk level, will remind doctors of possible risks. The warning lights have five colours—black, red, orange, yellow and blue—corresponding to different (from high to low) risk levels. Some prescriptions are directly intercepted or rejected by the system when they contain definite incompatible combinations or overdoses of some medicines. If there is a trade-off between the benefit and the risk associated with a prescription, a special intervention is used (a warning box pops up). If a doctor deems that a medication is necessary for a given patient, he or she is required to provide justifications in a dialogue box before the prescription is printed out. Moreover, all records are saved automatically and can be retrieved if necessary.

At the doctor workstation, there are two buttons, 'Check' and 'Print', on the screen. If a doctor wants to know if his or her prescription satisfies the criteria of rational use of medicines, he or she can click the 'Check' button. If he or she is sure of the correctness of the prescription, he or she can directly click the 'Print' button. Then, immediately after the 'Print' button is clicked, the system will send the prescription to the IMPUA for processing. The system will invoke the functions 'wf_pass(1)' and 'ii_nwarn_ts' to assign a risk level to some medicines of the prescription, with a warning box popping up. The entire process takes place within a time period of 3 s. The function 'ii_nwarn_ts' involves five risk levels. For instance, 'ii_nwarn_ts=5' indicates that the risk level is the highest. The data

table 'PASS_YYLY' contains all the justifications for using a specific drug, including such fields as 'TYPE (NUMERIC)', 'CODE (NUMERIC)', 'NAME (VARCHAR)', 'YSMD (VARCHAR)' and 'CZRQ (DATETIME)'. Among them, the field 'TYPE (NUMERIC)' contains four classification codes (1, 2, 3, 4) of justification, each having 5–7 subcodes. When a doctor clicks one of the justifications, it will be saved as a code (eg, 1–2), which is available for later retrieval (figure 3).

The participating pharmacists designed a set of items for the dialogue boxes concerning antibiotic use (box 1). To optimise the contents or items of dialogue boxes, we studied over 60 000 prescriptions involving irrational drug use and consulted more than 100 practising doctors. The dialogue boxes have two levels. The first level contains four categories: interaction, incompatibility, dosage and usage, and special populations. The second level contains 5–7 items. When a doctor clicks the first-level menu, the non-relevant items automatically disappear, which saves time and facilitates use. Figure 2 shows the interface of the dialogue boxes for medication intervention, which currently apply only in the outpatient department.

The data are retrievable in terms of prescribing time, registration number, name of the doctor involved, etc. Figure 3 shows the interface for searching medication justifications.

All retrievable records can serve as evidence of reconfirmation of the prescription by the doctor and intervention by the pharmacists.

Measures to limit overuse of antibiotics

In the system, antibiotic overuse was monitored by setting the maximum dose and the longest time (days) for a single prescription. Any information on the antibiotic is input into IMPUA by pharmacists, including defined daily dose, categories, the smallest package dispensed to patients, and professional titles of doctors entitled to prescribe antibiotics.

To ensure data accuracy, the data are updated and verified on a regular basis. Antibiotics are divided into three categories: special, restricted and non-restricted. Entitlement to use the drugs in the different categories varies with the professional title. Figure 4 shows the prompting interface of IMPUA: 'The drug is a special or restricted antibiotic. You are not entitled to prescribe it!'. In IMPUA, antibiotics in the 'special' category, such as itraconazole injection, aztreonam and imipenem/cilastatin, can be found under the heading 'Inpatient department'. This means that only doctors with a higher professional title working in inpatient areas are entitled to prescribe this kind of antibacterial drug. In some emergency scenarios, if the doctor on duty does not have the professional title required to prescribe a drug in the 'special' category, he or she can obtain the right by asking for permission from his or her supervisor, but the right lasts for no more than 1 day. If a doctor fails to observe a rule, his or her right to prescribe antibiotics will be suspended by the system. The system also strictly controls the amount and time of antibiotic injection used in emergency rooms and outpatient departments: the time is <1 day in emergency rooms and <3 days in outpatient departments.

Online acquisition of antibiotic-related quality control data

Currently, in China, most medical quality-control data associated with the use of antibiotics are still collected on paper. Manually obtaining these data is time-consuming and tends to cause errors. In IMPUA, all formulas for calculating measures of antibiotic use such as antibiotic use density (AUD), antibiotic use rate (AUR) of prophylactic antibiotics for type I incision

Box 1 Contents or items of dialogue boxes concerning antibiotic use

1. Drug interactions
 - ▶ I have adjusted the dose.
 - ▶ I have been monitoring the plasma concentration of the drug.
 - ▶ I have informed the nurse or the patient that these drugs should be taken at a certain time interval.
 - ▶ There is sufficient evidence to prove that the combined use of these drugs can enhance efficacy.
 - ▶ There is sufficient evidence to prove that the combined use of these drugs can reduce or offset side effects.
 - ▶ There is sufficient evidence to prove that the combined use of these drugs will not harm this patient.
 - ▶ Others, please specify.
2. Drug incompatibility
 - ▶ I have informed the nurse that these drugs should be infused separately using different bottles or tubes.
 - ▶ The administration routes of these drugs are different.
 - ▶ I have informed the nurse or the patient that these drugs should be taken at a certain time interval.
 - ▶ There is sufficient evidence to prove that these drugs are compatible.
 - ▶ Others. Please specify.
3. Drug dosage and usage
 - ▶ There is sufficient evidence to prove that this dosage is beneficial to the patient (the dose exceeds maximal dosage).
 - ▶ There is sufficient evidence that this dosage is beneficial to the patient (the dose exceeds the routine dosage, but not the maximum dosage)
 - ▶ There is no dosage form suitable for the special patient, prescribing is limited.
 - ▶ There is no suitable administration route or frequency in the hospital information systems, prescribing is limited
 - ▶ Others. Please specify.
4. Special populations
 - ▶ For children, the benefits outweigh the risks.
 - ▶ For the elderly, the benefits outweigh the risks.
 - ▶ For pregnant women, the benefits outweigh the risks.
 - ▶ There is sufficient evidence to prove that the drug is beneficial to this patient.
 - ▶ Others. Please specify.

surgery, submission rate of microorganism specimens in prescriptions, and AUR of outpatients, emergency patients and inpatients are stored in the system in the form of computer programmes, and the result can be automatically obtained when relevant variables are input. This feature helps managing departments to dynamically track the actual status of antibiotic use in the hospital in a real-time fashion and effectively control the amount of antibiotics against the mandatory state standards or requirements. A doctor can also monitor his or her use of antibiotics, which can serve as a reminder for their rational use.

Figure 4 Information-based monitoring platform for rational use of antibiotics (IMPUA) interface that limits use of antibiotics.

Closed-loop management mode

By integrating human management experience and information technology, we proposed a 'closed-loop management mode for rational drug use in medical institutions'. In this management mode, the database is the core. The closed-loop management mode starts from 'early warning' mode to 'looking-back' mode and then back to the 'early-warning' mode. With this closed-loop mode, we bring the management check points backwards (to drug prescribing by doctors) and give warnings about possible irrational use of drugs and, by gleaning and retrospectively analysing a myriad of drug-using information, especially early-warning data, trace the problems that have already occurred. Moreover, by using computerised management, we can control irrational use of drugs and help administrators adjust their management strategies. The results of the controlling process will be sent back to be incorporated into the early-warning system to further minimise irrational use of drugs.

Assessment of IMPUA

To evaluate the effectiveness of the new features proposed by participating pharmacists, we statistically analysed the differences between numbers of warning lights before (13 March 2013 to 13 May 2013) and after (13 May 2013 to 13 July 2013) introduction of the new features into IMPUA. The SPSS V.19.0 software package was used. The χ^2 test was used for enumeration data. A $p < 0.05$ was considered to be significant. The number of electronic medical orders, the proportion of warning lights in the past 3 years, and the antibiotic use tendency were also analysed.

Evaluation of IMPUA

In order to serve the clinic and patients better, we handed out questionnaires to medical personnel and patients in our hospital (figure 5).

Anyone could contact us for further information at any time if they had any problems with using IMPUA. Once the problems had been solved, the completed tables were collected and summarised.

RESULTS

Number of electronic medical orders checked by IMPUA

Over the past 3 years, the number of electronic medical orders checked by IMPUA has continually risen (figure 6). With electronic medical records (EMRs) covering ever more hospital units, many handwritten orders have been changed into electronic orders, which can be checked by the prescription-reviewing system. From figure 6, we can see that IMPUA reviewed about 5.7 million electronic orders within the first half of 2015, which is double the number in the second half of 2014. IMPUA is playing an increasingly important role in rational drug use.

Warning light tendency

Data comparison before and after integration of new features into IMPUA

Table 1 gives the original data and the results 2 months before and after the integration of new features. It shows that, with the intervention and interception features, the number of high-risk warning (black and red) lights noticeably decreased. The

Inquirer	Staff type	Sort of counseling problems	Level of prescription's risk
Name	☐ Pharmacist	☐ Special populations	1-Absolute taboo Errors or fatal harm
Sex	☐ Doctor	☐ Administration route	2-Relative contraindication Not recommended or serious harm
☐ Male	☐ Nurse	☐ Drug incompatibility	3-Caution
☐ Female	☐ Administrator	☐ Drug contraindications	4-Proper attention
	☐ Graduate student	☐ Drug interactions	
	☐ Intern	☐ Drug Dosage	
	☐ Patient	☐ Policies and information	
	☐ Families	☐ Software usage	
	☐ Other	☐ Other	
Tel	Communication Means		Time
	☐ Tel ☐ E-mail ☐ Web ☐ Interview ☐ Other		YYYY MM DD
Counseling problems			References
			☐ China Pharmaceutical Reference
			☐ <Chinese pharmacopoeia-Clinical application guidelines>
			☐ <Chinese National Formulary>
			☐ <Martindale-The complete Drug Reference>
			☐ <Pharmacology>
			☐ <Clinical Pharmacotherapy>
			☐ Profession medicine manual
			☐ Drug instructions
			☐ The latest national policy
			☐ Journals or databases
			☐ Other
Answer			Signature
			Time
			YYYY MM DD
Follow-up results			Signature
			Time
			YYYY MM DD
Evaluation			Signature
			Time
			YYYY MM DD

Figure 5 Information-based monitoring platform for rational use of antibiotics (IMPUA) consultation and evaluation form.

difference in the number of red lights (level 4) before and after incorporation of the new features was significant ($p < 0.01$). Our study demonstrates that the new features proposed by participating pharmacists are feasible and effective for preventing irrational use of drugs before they are prescribed.

Monitoring results over a longer period of time (3 years)

The proportion of warning lights was kept low over the past 3 years by integrating the new features of intervention and interception (figure 7): the proportion of black and red lights did not exceed 0.053% and 1.52%, respectively. Incidences of irrational drug use are far fewer than the value (2.08–6.81%) reported in the literature.^{11 12} In those studies, medication orders were monitored using PASS (prescription automatic screening system). Compared with PASS, IMPUA embodies

many new features of intervention and interception, which may be more effective at promoting rational use of medicines.

Antibiotic use tendency

Several quality indicators of antimicrobial stewardship were also evaluated in this study. Figures 8 and 9 show evidence that from 2011 to 2014, after special renovation and IT-based intervention, AUD and AUR were both in decline. The specific data are as follows: AUD fell by almost half (50 DDDS), AUR for inpatients decreased from 69.88% to 51.27%, AUR for outpatients decreased from 56.18% to 38.98%, and AUR in the emergency department decreased from 24.96% to 18.18%. Meanwhile, all AURs began to level off from 2013. The changes in AUD and AUR demonstrate that pharmacists' interventions with the help of IMPUA can significantly improve irrational antibiotic use.

Figure 6 Amount of electronic orders checked by information-based monitoring platform for rational use of antibiotics (IMP UA) in 2013–2015.

Evaluation of medical personnel

Up until now, we have collected about 60 questionnaires submitted by physicians, administrative personnel, pharmacists, graduate students and patients. The problems include software usage, drug interactions, drug contraindications, administration route, and special populations. We answered the questions in detail, and obtained a good evaluation of IMPUA from medical personnel. From the perspective of doctors, the new features were smarter and fewer false alarms were reported. Administrators

believed the new features were helpful for collecting information on appropriate use of medicines. Pharmacists felt that the features helped them to better fulfil their responsibilities in reviewing prescriptions. Table 2 shows the results of the clinical questionnaires containing 'staff type' and 'sort of problems'.

DISCUSSION

In China, clinical pharmacy is a new profession that appeared less than a decade ago and physicians have little faith in

Table 1 Results of warning lights before and after integration of the new features into the information-based monitoring platform for rational use of antibiotics (IMP UA)

Group	Time period	Before integration					After integration				
		Number	Average	Total	Average	Rate (%)	Number	Average	Total	Average	Rate (%)
Black lights (level 5)	1st month	148	146	8962	8766	1.67	95	100.5	6586	6147	1.63
	2nd month	144		8570			106		5708		
Red lights (level 4)	1st month	5790	5600.5	8962	8766	63.89	3561	3216.5	6586	6147	52.33*
	2nd month	5411		8570			2872		5708		

* $p < 0.01$ compared with number before integration of the new features into IMPUA.

Figure 7 Proportion of warning light tendency, 2013–2015.

Figure 8 AUD (antibiotic use density) tendency, 2011–2014.

pharmacists' ability to provide appropriate suggestions about medication. An IT-based prescription-reviewing system is a good tool for pharmacists to identify inappropriate prescriptions and its improvement relies on the active participation of pharmacists. Although we all know that in this kind of system, 'intervention' and 'interception' work better than 'prompting' in reducing serious medication errors, most hospitals refrain from using these features for fear that the system may not be 'smart' enough. In this study, on the basis of a comprehensive and thorough investigation of clinical medication protocols by professional pharmacists, we integrated several features—designed to identify, question and intercept possibly inappropriate prescriptions—into IMPUA. Over the past 3 years, the new features have been well received by physicians, administrative personnel and pharmacists in our hospital.

This study had some limitations: (1) although IMPUA is applied in the whole hospital, the new features of intervention and interception are only used in the outpatient department because the EMR system has only recently been introduced into our inpatient departments; (2) owing to the large number of outpatients and the few pharmacists available, the intervention was achieved through dialogue boxes, without real-time one-on-one interaction between pharmacist and doctor.

Figure 9 AUR (antibiotic use rate) tendency, 2011–2014.

Table 2 Results of clinical questionnaires

Staff type	Total ratio (%)	Sort of problems	Total ratio (%)
Pharmacist	10.00	Special populations	6.67
Doctor	46.67	Administration route	3.33
Nurse	5.00	Drug incompatibility	10.00
Administrator	8.33	Drug contraindications	5.00
Graduate student	11.67	Drug interactions	13.33
Intern	3.33	Drug dosage and usage	26.67
Patient	3.33	Policies and information	5.00
Families	5.00	Software usage	26.67
Other	6.67	Other	3.33

What this paper adds

What is already known on this subject

- The irrational use of antibiotics is a problem that needs to be addressed urgently. The traditional approach for monitoring rational use of antibiotics is no longer sufficient, and the use of state-of-the-art information technology (IT)-based network management of medication-related data has become an effective means of monitoring antibiotic use. Over the past decade, medication-monitoring systems, integrated into overall hospital information systems, have been growing rapidly in China. However, in many cases, professional pharmacists are not involved in IT-based pharmacy management at all. Without involvement of pharmacists, over-dependence on the software system will cause problems.

What this study adds

- In this study, we introduced a computerised monitoring system that integrated the ideas for rational use of antibiotics proposed by participating professional pharmacists. It demonstrates that the new features of 'intervention' and 'interception' are feasible and effective for preventing irrational use of drugs before they are prescribed.

CONCLUSION

In this study, we introduced a computerised monitoring system, which integrated the notions of rational use of antibiotics proposed by the participating professional pharmacists. The study demonstrates that the new features of intervention and interception are feasible and effective for preventing irrational use of drugs before they are prescribed. IMPUA is smarter than other similar prescription-reviewing systems reported in the literature. It was well received by medical personnel and patients in our hospital. In future, we will further deploy the new features and real-time one-on-one interaction in the IMPUA of our inpatient sector and evaluate their effectiveness.

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