DRUG INVENTORY CONTROL FOR OUTPATIENT SERVICES

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ABSTRACT

Outpatient services are medical procedures or tests that can be done in a medical center without an overnight stay. Many procedures and test can be done in a few hours. The last procedure of an outpatient service is mostly to acquire drugs from pharmacy room. In this paper, a veterans general hospital with three buildings around 16.8 hectare in south Taiwan is studied.

Shortage of drugs is normally disallowed in a hospital. Under current drug inventory control policy of this hospital, sometimes there are still shortages of some drugs. To overcome this problem, usually, the staff of dispensing division will increase safety stocks of such shortage drugs. Therefore, total inventory level of drugs stays high in this hospital.

In this study, data mining technology is applied to detect possible issues that caused drug shortage. Around 476,000 of data extracted from National Health Insurance files range from January to March, 2010, the unit is monthly and in the multi-level concepts, MIS = 0.001%, MIC = 50%, the results came out with 19 association rules. In conclusion, applying data mining technique to find out the potential relationship in a huge database allows managing staff to adjust inventory policies timely.

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1 INTRODUCTION

Outpatient services are medical procedures or tests that can be done in a medical center without an overnight stay. Many procedures and test can be done in a few hours. The last procedure of an outpatient service is mostly to acquire drugs from pharmacy room. In this paper, a veterans general hospital with three buildings around 16.8 hectare in south Taiwan is studied. There are 586 doctors, 1347 nursing attendants, 170 technical staffs, and 185 administrators in this hospital, which contains 23 medical departments, 9 administrations, and 23 research centers.

In this hospital, there is a department of supply, in charges of the inventory management, purchasing, drug distributing, quality assurance, and stock accounting, supporting drugs to clinical pharmacy division and dispensing division. The dispensing division has to plan required quantity of each drug and to retrieve them from the department of supply everyday. Therefore, a quantity of safety stock and a quantity of order for each drug have to set up in the drug inventory management system in the dispensing division. Each day at 12am, the drug inventory management system will check quantities of drugs in the department of supply and print out a distribution list and/or a shortage list to the department of supply. The department of supply can then prepare drugs for distribution and/or order shortage drugs. The dispendsing division has to accounting drug stocks in the division at the end of each month and report to the department of supply. The workflow of drug supply and accounting is illustrated in Figure 1.

Based on quantities of safety stock, quantities of shortage, quantities in monthly accounting reports, and costs of drugs, the department of supply are now apply ABC inventory control policy to manage drug inventories. ABC analysis in inventory is one of the best practices for inventory accuracy. “A” items represent 20% of the items that represent 80% of the inventory value (Pareto’s principle); “B” items are 30% of the items that represent 15% of the remaining inventory value; “C” items are the 50% of the rest items that represent 5% of the inventory value. “A” items normally are categorized as fast moving inventory, whereas “C” items are slow moving inventory.

Shortage of drugs is normally disallowed in a hospital. Under current drug inventory control policy, sometimes there are still shortages of some drugs in the dispensing division. To out come this problem, staffs of the dispensing division will increase safety stocks of such shortage drugs. As a result, total inventory level of drugs stays high in this hospital. In this study, data mining technology is applied to detect possible issues that caused drug shortage. A new association rule based on the inventory control policy is then proposed to reduce the drug inventory levels under the same outpatient service satisfactions.

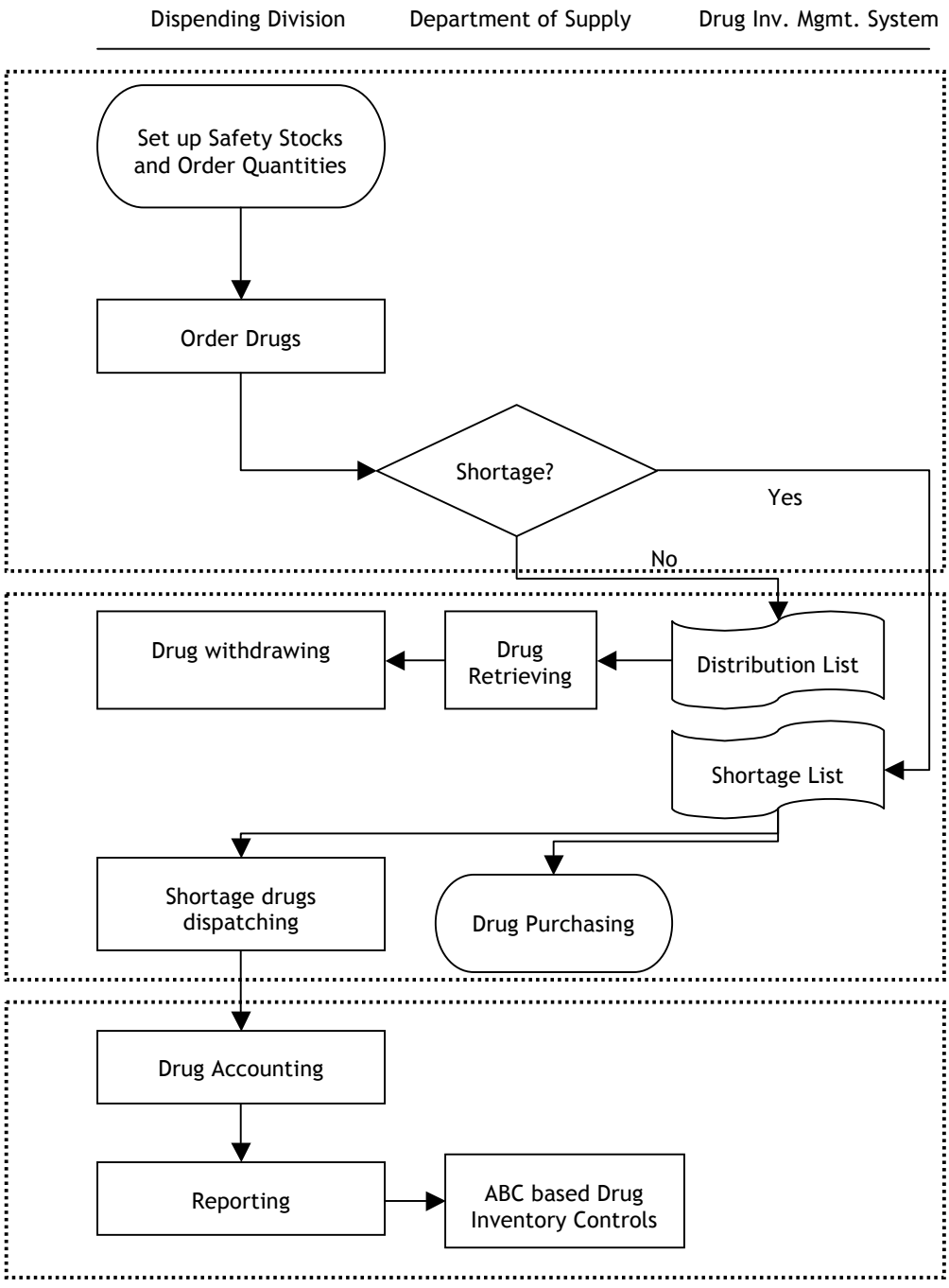

Figure 1: Workflow of Drug Supply and Accounting

2 THE IMPROVEMENT CONCEPTS

In this section, we will discuss the rationale behind our discovery for improving drug inventory control to this hospital.

2.1 Why ABC Inventory Control

Today, in Taiwan, hospitals, which mainly depend on the national health insurance (NHI) as their major financial source, have been facing great difficulties posed by the government. Analysed the expense configuration of hospitals, around 43% to 54% is on human resources, 20% to 22% is on drugs, 5% to 10% is on assets, 6% to 11% is on medical supplies, and others,

which included administration, research and development, etc. Human resource expense is always the top expense of a hospital, and drug expense is around 40% of the rest expenses. Based on a case study of a general hospital in Taiwan at 2001, the average expense is over 70 million US dollars per hospital and the drug expense is around 20%. The records from NHI show a great increase of drug expense at around 13 billion US dollars in 1995 to around 34 billion US dollars in 2008 in Taiwan. Although hospitals are classified as non-profit organizations [13], because of the trends of aging population and new developed healthcare technologies, there have been concerns about the abuse of medical resources. This caused deficits of NHI and has pushed the government to reallocate risks and transfer part of risks to hospitals. A lot of new policies, such as up-bounds of drug expensing, are applied to hospitals. With so many policies to follow, hospitals are facing great changes in the industry. From business perspective, a general hospital, which belongs to a medical university, has also to play many roles, such as serve the function of teaching, research, provide healthcare services, and upgrade its healthcare quality. In order to survive with limited financial supports from NHI plus the great demand of patients, hospitals have become more careful in keeping their costs and expenses under control. Since ABC analysis in inventory is one of the best practices for inventory accuracy and cost control, most hospitals will utilize it as their drug inventory control policy. ABC analysis is normally also a module included in an Enterprise Resource Planning (ERP) system. This is another reason why a hospital applies ABC drug inventory controls if it has a healthcare ERP system.

2.2 The Shortage Of ABC Inventory Control In The Hospital

An ABC compile process (for example, as shown in Figure 2) can be executed for an inventory management department. It usually supports multiple compile criterions [7], such as current on-hand quantity, current on-hand value, historical usage value, forecasted usage value, etc. The result can be used to drive the cycle counts, where one might count items of high value (“A” items) very frequently, items of lower value less frequently (“B” items), and items of lowest value very infrequently (“C” items). Typically ABC Analysis is reviewed by gathering, as a minimum (1) a list of part numbers from the ERP system, (2) obtaining the cost data for each part, (3) obtaining its consumption volume over a specific period, and (4) calculating the consumption value for each part [8].

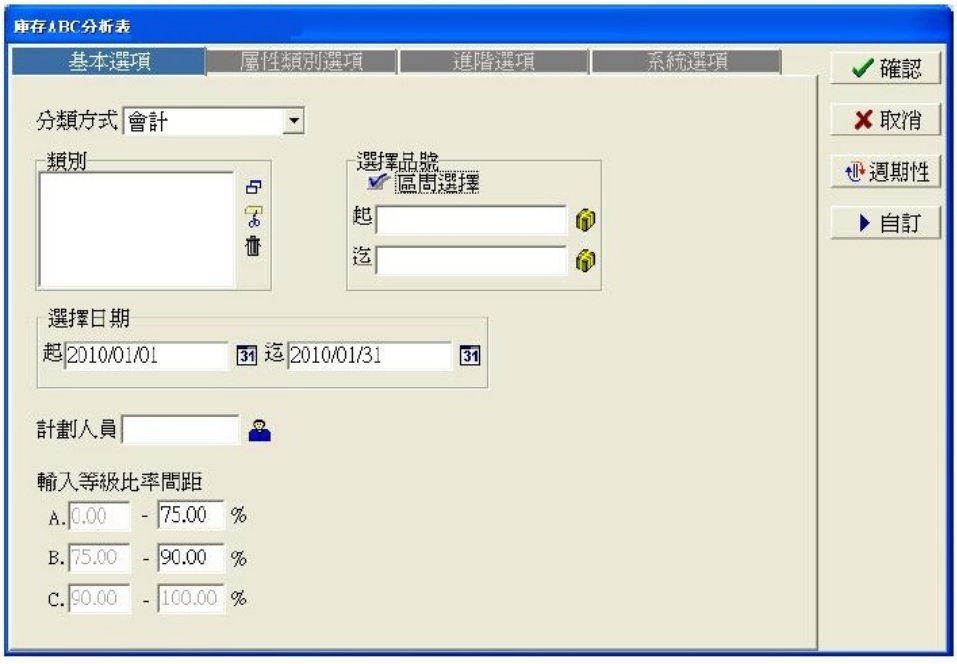

Figure 2: ABC Analysis Module

Recall the drug requirement planning and purchasing procedures in the veterans general hospital. The drug requirement planning and purchasing is simplified as setting up safety stocks in the dispensing division, and setting up another safety stocks in the department of supply. In another word, drug consumption levels of the department of supply are coming from the drug levels, which are always below their safety stock levels set by the dispensing division. Based on the converted drug consumption volumes and drug costs, the department of supply further has classified drugs and populated the classification data against the drug in the drugs master record. They can use this data to drive key drugs management activity. For example co-ordinating their perpetual inventory management activity – they may routinely verify their Category A drugs on a monthly basis but only review their category C drugs several times a year. They may use scheduled orders for their Category C drugs but may require detailed purchase orders and negotiation for their Category A drugs.

However, the converted drug consumption volumes might be the reason that caused the shortage of some drugs occasionally. Therefore, the drug associations from NHI data are further evaluated [1] [2] [5] [6] [12] and compared.

2.3 The Drug Association Mining From NHI Data

In Taiwan, every citizen has an IC health insurance card. Whenever one goes to a hospital or a clinic, he or she needs to present his or her IC health insurance card. An IC card device will read data from his or her IC card and connect to the NHI to check if the IC card is valid. Two electronic files, Ambulatory Care Expenditures by Visits (also called CD file in this hospital) and Details of Ambulatory Care Orders (also called OO file in this hospital), have to submit to NHI for clinic diagnosis and drug expending reimbursements. These two files present detail treatment transactions of every patient with his/her diseases and acquiring drugs. In this case study, we first classified the drugs in OO file with Anatomical Therapeutic Category (ATC), which is a category system provided by WHO Collaborating Centre for Drug Statistics Methodology. There are 1732 different drug categories concluded in this hospital. By combining CD, OO, and ATC, we obtained 476,177 patient treatment transactions (as shown in Figure 3) during January to March, 2010.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	SEQ_NO	A0004802	A0006391	A0010011	A0010852	A0010852	A0010852	A0010852	A0010862	A0026572	A0028012	A0028631	A0033181	A0033651	A0033881
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0
4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	4	0	0	1	0	1	0	0	0	0	0	0	0	0	1
6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9	8	0	0	0	0	0	1	0	0	0	0	0	0	0	0
10	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	11	0	0	0	0	0	0	0	0	0	0	0	1	0	0
13	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	17	0	0	0	0	0	0	0	0	0	0	0	0	1	0
19	18	0	0	0	0	0	0	0	0	0	0	1	0	0	0
20	19	0	0	1	0	0	0	0	0	0	0	0	0	0	0
21	20	0	0	0	0	0	0	0	0	0	0	0	0	1	0

Figure 3: Patient Treatment Transactions

By several experiment tests, we set up the minimum support (MIS) [9] [11] as 0.001% and the minimum confidence (MIC) as 50% in PolyAnalyst 6.0 software, and mined 19 drug association rules (as shown in Table 1).

Table 1: Drug Association Rules

Rule	Association Rule X⇨Y
1	Drug A10BB09 ⇨Drug A10BA02
2	Drug C03DA01⇨Drug C03CA01
3	Drug A10AB01 or Drug B05DB⇨Drug A10AC01
4	Drug D04AX91⇨Drug D07XA01
5	Drug D01AC09⇨Drug D01AE20
6	Drug A10AE04⇨Drug A10AB05
7	Drug D05AX02⇨Drug D07AC06
8	Drug C10AD06⇨Drug C10AB05 or Drug C10AB02
9	Drug A04AA01 and Drug A03FA03⇨Drug A02AB or Drug A02AD01
10	Drug A04AA01 and Drug A02AB or Drug A02AD01⇨Drug A03FA03
11	Drug B01AC11⇨Drug C02KX01
12	Drug G02AB01 and Drug A02AX⇨Drug G02AB03
13	Drug G02AB03 and Drug A02AX⇨Drug G02AB01
14	Drug G02AB03 and Drug G02AB01⇨Drug A02AX
15	Drug G03DB01⇨Drug G03CA03
16	Drug B01AB01⇨Drug B01AD04
17	Drug A07EC02 and Drug A02AG⇨Drug A07BC05
18	Drug A07EC02 and Drug A07BC05⇨Drug A02AG
19	Drug A16AA06⇨Drug B03BA03

We further compared the drugs discovered in Table 1 with their ABC categories (as shown in Table 2) set in the drug inventory management system in this hospital. Something interesting is discovered. Some associated drugs (for example, drug A10AB01 and A10AC01 in rule 3) were categorized into different category based on current inventory control policy. This could cause drug shortages since different category of drug items are managed by different purchasing strategy.

Table 2: ABC Category in Drug Inventory for Outpatient Services

Rule	Association Rule X→Y	ABC Category
1	Drug A10BB09→Drug A10BA02	B→B
2	Drug C03DA01→Drug C03CA01	C→C
3	Drug A10AB01 or Drug B05DB→Drug A10AC01	C or A→B
4	Drug D04AX91→Drug D07XA01	C→B
5	Drug D01AC09→Drug D01AE20	C→C
6	Drug A10AE04→Drug A10AB05	B→A
7	Drug D05AX02→Drug D07AC06	B→C
8	Drug C10AD06→Drug C10AB05 or Drug C10AB02	C→B or C
9	Drug A04AA01 and Drug A03FA03→Drug A02AB or Drug A02AD01	C and C→C or B
10	Drug A04AA01 and Drug A02AB or Drug A02AD01→ Drug A03FA03	C and C or B→C
11	Drug B01AC11→Drug C02KX01	A→A
12	Drug G02AB01 and Drug A02AX→Drug G02AB03	C and C→C
13	Drug G02AB03 and Drug A02AX→Drug G02AB01	C and C→C
14	Drug G02AB03 and Drug G02AB01→Drug A02AX	C and C→C
15	Drug G03DB01→Drug G03CA03	C→C
16	Drug B01AB01→Drug B01AD04	C→B
17	Drug A07EC02 and Drug A02AG→Drug A07BC05	C and C→C
18	Drug A07EC02 and Drug A07BC05→Drug A02AG	C and C→C
19	Drug A16AA06→Drug B03BA03	C→C

2.4 The new association rule based ABC inventory control policy

An association rule based ABC inventory control policy is thus suggested to this hospital. A new ABC analysis module, which integrated data mining technique with CD, OO, and ATC files, is recommended to further develop. The new drug categories should be classified not only based on the inventory costs but also the drug associations from outpatient treatments. A new workflow of drug supply and accounting is also designed as illustrated in Figure 4.

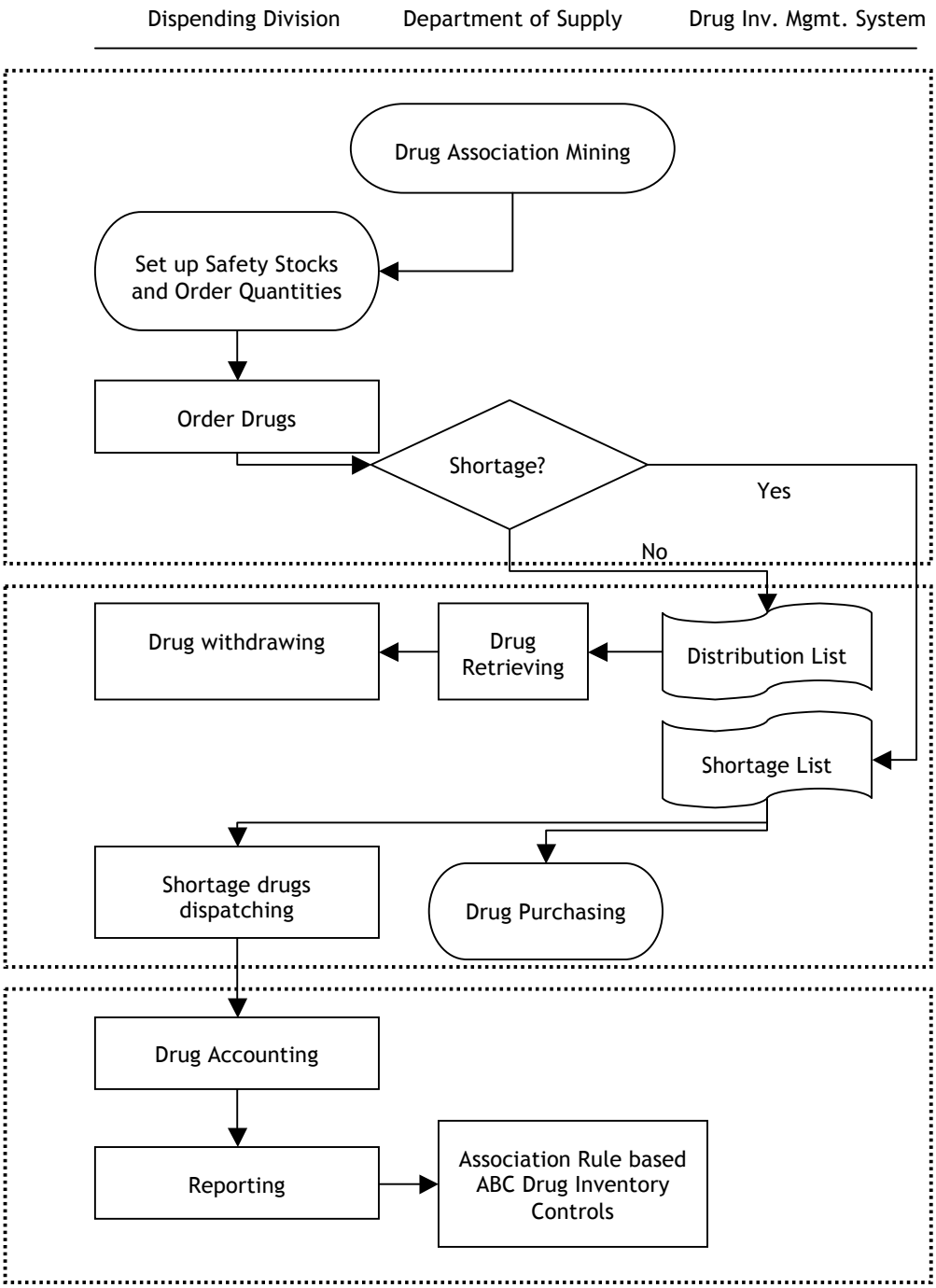

Figure 4: Association Rule Based ABC Inventory Control Workflow

3 CONCLUSION

In the past, there have been many researches focusing on the association rules. Most of them applied the association rule mining to find out the relationships between diseases and drugs [3] [4] [10], few studies have discussed about the application on drug inventory management. In this study, patient treatment data were generated from Ambulatory Care Expenditures by Visits file and Details of Ambulatory Care Orders file that submitted to NHI. The drug associations during those patient treatments were mined in period. By doing so, we are able to forecast which drugs will be frequently prescribed in company with another drug as it is being prescribed. Those frequent used drugs are thus utilized to repopulate the drug classification data against the drug in the cost based ABC analysed drugs master record. A

new association rule based ABC inventory control module is also suggested to develop for this hospital. In hope, they can successfully lower the frequency of the drug supply shortage and improve the quality of their outpatient services.

4 ACKNOWLEDGEMENTS

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