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DESIGNING AN E-KANBAN SYSTEM TO IMPROVE DRUG AVAILABILITY AND MINIMISE INVENTORY WASTE AT THE HOSPITAL PHARMACY INSTALLATION

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Abstract

In an effort to provide a high level of service to hospitals, pharmaceutical installations are often faced with problems in monitoring and determining adequate drug supply levels to respond to demand, both from outpatient and inpatient units. Inventory control by hospital pharmacies is often carried out without being supported by accurate information systems or control methods, resulting in excess inventory levels which leads to higher inventory costs. This study aims to identify and develop an e-kanban system suitable for the scope of hospital pharmacy. E-kanban as a method of controlling inventory through a simple reliable information system is expected to minimize inventory waste that occurs. The e-kanban system coupled with the use of barcodes and portable scanners is expected to provide more accurate information on drug availability. Inventory monitoring and control is expected to be much easier, both at the time of replenishment and during periodic stock-taking. The implementation of the e-kanban system is also able to eliminate waste, card use and manual recording activities, replaced by the use of simpler two-bin containers. The e-kanban system can also be integrated into the existing Hospital Information System, without disrupting the running system.

Keywords*: e-kanban; inventory waste; two-bin; hospital pharmacy*

1. Introduction

One of the main activities of the Hospital Pharmacy Installation unit is inventory management, where supplies must be made available in sufficient quantities when needed. The inventory control method that has been commonly used in hospitals is based on estimated needs, namely the par level or min-max method, although in practice it often does not work well. One of the causes is the lack of discipline in recording inventory due to the large number of inventory items and the limited time available. The impact of management based on estimates like this is the excess of unnecessary inventory, lack of the required amount of inventory, expired drugs to medication errors.

Kanban is one of the tools introduced by Taichi Ohno in the Toyota Production System, where kanban acts as a signal to manage inventory based on demand (Ohno, 1988). Kanban is a closed-loop system that uses replenishment based on consumption instead of replenishment based on forecasts. Inventory control is achieved by using a bin system. When a bin becomes empty, it triggers a request to the source of supply.

Kanban is traditionally a card-based method that sends information between workstations, regarding what to produce, when to produce it and in what quantity. With a pull system, the kanban system is proven to be able to significantly reduce the amount of inventory. However, there are also some disadvantages of the kanban system, such as loss, mishandling and misplacement of kanban, delays between information and material flow, tracking and monitoring limitations, and others (Sapry, et al. 2020).

Along with the development of communication and information technology, what is called e-kanban or electronic kanban has emerged, where the kanban system is no longer in the form of manual cards but in the form of applications or other supporting technologies. For example, Mayilsamy and Pawan (2014) implemented an e-kanban system design in inventory management, likewise Menanno, et al. (2019) have used the help of communication and information technology in the form of web to upgrade conventional kanban to web-based e-kanban which allows information exchange between the company's assembly line and supermarket.

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According to Landry and Philippe in Lanza-León P et al (2021), kanban began to be developed and adopted by health services around the 1980s for inventory management as an alternative to traditional methods such as par levels. In several case studies, the implementation and utilisation of kanban techniques originating from the manufacturing industry sector have proven successful in the healthcare sector, especially in cutting inventory levels (Persona et al. 2008, Papalexi et al. 2015, Yuniar et al. 2023).

On the other hand, the application of electronic kanban in health services is still very limited, especially in hospitals. Some related research that has been conducted includes the development of e-kanban applications in pharmaceutical warehouses (Razafuad, et al. 2018), the use of RFID technology in the process of replenishing medical supplies in hospitals (Bendavid, et al. 2010), combining the two-bin kanban filling system with RFID technology (Landry & Beaulieu 2010, Rosales, et al. 2015). However, until now the application of RFID technology in developing countries is still very limited and the high cost makes the adoption of RFID not going well (Sahshank, 2021). For this reason, this research aims to design a more affordable e-ban system that can be implemented easily and can also be integrated with existing Hospital Information Systems.

2. Research Methods

The research method used in designing the e-kanban system in this study is the prototyping method. A prototype is basically made with the aim of providing the same perception and initial understanding of the basic processes/functions of the system to be built (Susanto & Meiryani, 2017). There are three approaches that can be used in prototyping, namely exploratory, experimental and evolutionary (Nacheva, 2017). Each has its own characteristics as can be seen in **Table 1**.

In this research, the approach used is experimental prototyping, where the design results can already be applied through the functions built. A recent study on prototyping, by Bjarnason et al. (2023) introduced an empirical model in software prototyping, the Prototyping Aspects Model (PAM) that allows better discussion between practitioners. PAM includes five aspects of prototyping, namely purpose, prototype scope, prototype media, prototype usage, and exploration strategy.

Furthermore, regarding the mechanism of the kanban system used in this study is the two bin system, where this system has been widely used to manage supplies in hospitals since the 1980s (Moons, et al. 2018). Kanet and Well (2020) have also identified two bins with the same quantity as the most appropriate in the healthcare context. In this research, the two bin system will be combined with barcode technology. In this system, similar items will be stored in two bins of the same size, and the system is implemented in a single container with a divider between the bins in the centre of the container. As the first bin or primary bin is the front of the container, while the second bin or secondary bin is the back of the container. When the first bin is empty, the container can be turned around so that the barcode marker is visible and the secondary bin is positioned at the front.

3. Results and Discussion

The results of the initial identification of the needs of the e-kanban system to be developed can be seen from the use case diagram shown in **Figure 1**. This system will be built using client-server architecture, where there are two main actors of system users, namely warehouse staff and hospital pharmacy staff.

Furthermore, the development of the e-kanban system prototype is carried out using the prototyping method, which will produce an initial interface design that already contains the main functions of the system. In the next stage, iterative adjustments are made to the interface based on input from users, in this case pharmacy staff, warehouse staff and the Head of the Pharmacy Installation as the person in charge of the pharmaceutical installation.

After the initial prototype was obtained, a formal analysis was carried out based on the identification of information needs. System

Table 1. Comparison of prototyping approaches (Nacheva, 2017)

	Exploratory	***Experimental***	***Evolutionary***
Tujuan	Studi: Klasifikasi kebutuhan sistem	Evaluasi: *User testing*, menilai apakah solusi memenuhi kebutuhan sistem	Adaptasi perubahan: Sistem terus beradaptasi atas perubahan lingkungan
Objek penelitian	Kebutuhan sistem	Solusi terealisasi sebagian	Kebutuhan sistem secara rinci
Fidelity	Rendah	Sedang	Tinggi
Hasil	*Rapid prototype*	*Rapid* atau fungsional *prototype*	Sistem final atau pilot

Figure 1. Use Case Diagram eKanban System

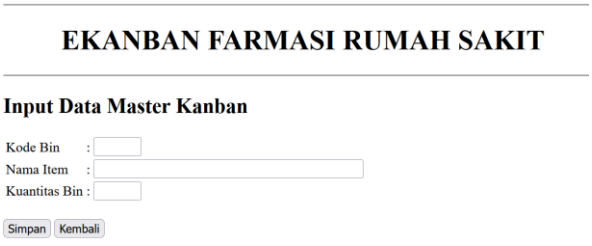
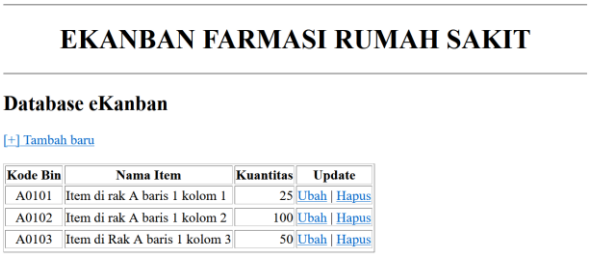


Figure 2. Hospital Ekanban Main Page



EKANBAN FARMASI RUMAH SAKIT

Database eKanban

[+] Tambah baru

Kode Bin	Nama Item	Kuantitas	Update
A0101	Item di rak A baris 1 kolom 1	25	Ubah | Hapus
A0102	Item di rak A baris 1 kolom 2	100	Ubah | Hapus
A0103	Item di Rak A baris 1 kolom 3	50	Ubah | Hapus

Figure 3. Kanban Master Input Page

EKANBAN FARMASI RUMAH SAKIT

Input Order Ke Gudang

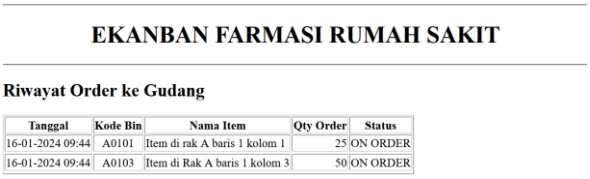
Scan Bincode :

Kode Bin	Nama Item	Qty Order
A0101	Item di rak A baris 1 kolom 1	25
A0103	Item di Rak A baris 1 kolom 3	50

Total: 2

Scan Reset Transfer

Figure 4. Kanban Master Data Page



EKANBAN FARMASI RUMAH SAKIT

Riwayat Order ke Gudang

Tanggal	Kode Bin	Nama Item	Qty Order	Status
16-01-2024 09:44	A0101	Item di rak A baris 1 kolom 1	25	ON ORDER
16-01-2024 09:44	A0103	Item di Rak A baris 1 kolom 3	50	ON ORDER

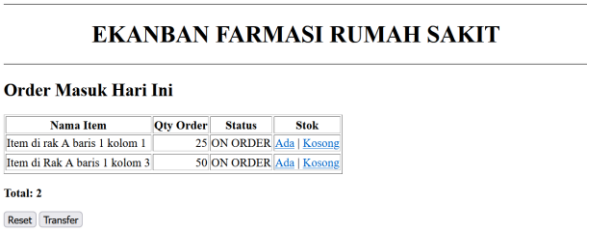
Total: 2

Figure 5. Order Input to Warehouse Page

EKANBAN GUDANG FARMASI RUMAH SAKIT

- ORDER MASUK
- RIWAYAT PENGISIAN ORDER

Figure 6. Order History Page



EKANBAN FARMASI RUMAH SAKIT

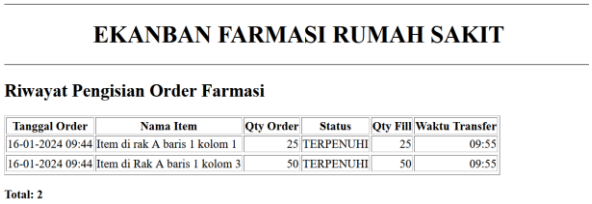
Order Masuk Hari Ini

Nama Item	Qty Order	Status	Stok
Item di rak A baris 1 kolom 1	25	ON ORDER	Ada | Kosong
Item di Rak A baris 1 kolom 3	50	ON ORDER	Ada | Kosong

Total: 2

Reset Transfer

Figure 7. Warehouse Ekanban Main Page



EKANBAN FARMASI RUMAH SAKIT

Riwayat Pengisian Order Farmasi

Tanggal Order	Nama Item	Qty Order	Status	Qty Fill	Waktu Transfer
16-01-2024 09:44	Item di rak A baris 1 kolom 1	25	TERPENUHI	25	09:55
16-01-2024 09:44	Item di Rak A baris 1 kolom 3	50	TERPENUHI	50	09:55

Total: 2

Figure 8. Warehouse Order Fulfillment Page

EKANBAN GUDANG FARMASI RUMAH SAKIT

Riwayat Pengisian Order Farmasi

Tanggal Order	Nama Item	Qty Order	Status	Qty Fill	Waktu Transfer
16-01-2024 09:44	Item di rak A baris 1 kolom 1	25	TERPENUHI	25	09:55
16-01-2024 09:64	Item di rak A baris 1 kolom 2	100	TERPENUHI	50	09:55

Total: 2

Figure 9. Order Replenisment History Page

compatibility with existing information systems is also considered, one of which is in determining the database schema and database management system used, in this case MySQL.

The resulting e-kanban system consists of two designs, one design as a client, namely the pharmacy department, and another design as a server, namely the warehouse department. The design of the main page of the e-kanban system for clients contains four functional menus, namely kanban master input, kanban master data, oder input to the warehouse and order history to the warehouse, as shown in **Figure 2**. Furthermore, **Figure 3**, **Figure 4**, **Figure 5** and **Figure 6** show the interface in the form of form pages to accommodate data or display related information from the four main menus.

The design of the main page of the e-kanban system for the server only contains two functional menus, namely incoming orders and order filling history, as shown in **Figure 7**. **Figure 8** below is an interface for order fulfillment form through the incoming order menu, while **Figure 9** shows the order replenishment history page which includes the quantity fulfilled and delivery time.

The designed e-kanban system adopts the kanban concept combined with barcode technology to trigger replenishment. The technique of replenishing supplies in bin containers must still pay attention to good drug storage rules including the application of the FEFO (*First Expire First Out*) and FIFO (*First In First Out)* systems (Satibi, 2017). where the remaining secondary bin inventory is moved to the previously empty primary bin, while the secondary bin is filled again according to the bin quantity.

Determination of kanban quantity, using inventory entitled model (Mifta, 2017):

$$Kq = \frac{Dc \times Q \times R}{H \times P}$$

Kq = Kanban quantity
Dc = Daily rate of medicine
Q = Quantity used for each drug code
R = Medicine replenishment time
H = Time available for medicine replenishment

P = Medicine package size

With the use of e-kanban, the kanban quantity is more flexible to be updated according to conditions dynamically. This can be done with the ease of monitoring drug inventory in real time and periodically.

Based on the results of the initial trial implementation of this e-kanban system in a pharmaceutical installation in a private hospital in Kendal, a significant reduction in inventory waste was obtained. This saving is obtained from the reduction of many inventory buffers with the previous method (Min Max), although some drug items require an additional amount. The potential inventory waste that can be eliminated reaches 22% of the total inventory value.

4. Conclusion

From the research that has been done, it can be concluded that the design of a simple but functional e-kanban system can be one of the innovations to minimise inventory waste in hospitals. Excess inventory as a result of conventional inventory management based on estimates will have a further impact, which is detrimental not only to the efficiency of pharmacy operations but also to the services provided to patients. The e-kanban system can be adopted and easily integrated with the Hospital Information System which usually also uses a client-server system.

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