Rasch Measurement Model of Inventory Administration Practiced By Public Hospitals in Malaysia

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Abstract *— This paper discussed on the major concern relating to inventory management practices of pharmacy department in hospitals which is facing difficulty in managing the drugs after investing in them. inventory and highlight areas that can be improve for lower ability hospitals to become more efficient. The Rasch Measurement Model (RMM) with Winsteps Version 3.92.1 software was applied for data analysis due to its ability in interpreting and analyzing the ability of respondents in performing difficult items. Online questionnaires were distributed to selected public hospitals and out of 103 online questionnaires, 81 were returned with a response rate of 78.64%. However, only questionnaires from 80 respondents are useable. The typology standard result shows that the mean person of 3.01 and logit value of 2.02 differentiate the lower and higher ability hospitals into 51% and 49%.. Easiest items (A1.4, A1.6 & A1.10) and difficult items (A2.5 & A2.6) have also been highlighted in the discussion. Public hospitals of S23 having the most ability while public hospitals of S51 resulted as having the minimal ability in implementing inventory administration practices. In addition, Rasch analysis points out that existing items need to be reviewed by adding more difficult items, in order to develop further future research. Finally, this study is perhaps the first attempt in investigating the typology standard of inventory administration to be practised by public hospitals in Malaysia using RMM.*

Keywords— *Inventory Administration Practices, Public Hospitals, Rasch Measurement Model, Item Response Theory*

1. Introduction

Inventory is kept by an organization for the aim of internal or external customer demands, and is also known as the largest item in the category of current assets and therefore must be properly managed. Inventory items have to be recorded if changes occur in the stock. The objective of properly managing the inventory is to control the total number of inventory to stock, the ordering number, when to replace, and to order [1]. Inventory management practices in the healthcare segment is more difficult if compared to the rest of the industries due to the patients' needs for accurate service, particularly on having sufficient medical supply [2]. In addition, inventory levels have been seen as one of the more interesting areas for improvement in the healthcare materials management and academics have also given attention to replenishment processes in healthcare organizations [3]. The hospital management has to ensure the availability of various drugs as these are essential and vital for patient care. The pharmaceutical department is one of the important departments to supply medicine to patients. The pharmacy management team should focus on developing effective strategies to maximize the leverage of drugs and human resource costs [4]. The medicine or drugs which are not properly controlled may lead to an excess or surplus in stock. Furthermore, this excess or surplus will lead to the reduction in the number of drugs ready to be provided to the patients and due to that, the quality of healthcare would be negatively affected [5].

The study by [4] revealed that inventories should be allocated without incurring any waste. However, it was later shown that the pharmacy department faced difficulty in managing the inventory after investing in it [6]. Report from [7] stated among the reasons that have led to waste and economic inefficiency as highlighted are (1) inadequate and incompetent workforce, (2) poor supply chain and the presence of mismatched services, (3) underutilized and unused high-end equipment when skilled specialists resigned from the public sector, (4) some hospitals in the public sector had low bed

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occupancy ratio and (5) the lack of clinical quality. Drugs are very important in health facility which can save lives of many if used properly, on time, right quantities, and qualities and at affordable cost. Unfortunately, studied shows that there is a problem in maintaining inventory of drugs at the required level [5]. In viewing that, the healthcare sector must transform to be an extra effective and efficient healthcare providing system in ensuring that the healthcare services are widely utilised and must speedily react to the changes in products and services in order to be at the forefront of advanced technologies and in applying innovative processes while substituting past processes [7].

Inventory Administration: Inventory administration as one of the practices refers to those activities which consist of precise record-keeping on shipment and acceptance of items at the right time. Recent developments in the field of inventory administration have led to a renewed interest where the trade-off between customer service levels and inventory investment is addressed in practice by formal quantitative inventory management solutions [8]. The research study [9] indicated that proper management of inventory can enhance an organization's supply chain to run efficiently. Drug administration from the point of view of the healthcare sector is referring to the ability of healthcare and pharmaceutical organizations to optimize the pharmaceuticals being used [10].

Since drug expenditure is the main component of the hospital's spending, drug inventory management practices would be an interesting area to investigate [11]. Furthermore, [10] discovered that very limited study has been circulated on the major concerns towards the administration of drugs in public hospitals. Due to that, it is recommended that organizations should adopt inventory keeping method that best suit their operations [12]. Thus, the study on inventory management practices focusing on inventory administration is highly needed and will be the scope of this research to ensure a better administration of drugs among the public hospitals in Malaysia.

***Item Response Theory (IRT)*:** This study uses the IRT models because it has the ability to estimate each item's difficulty as well as each person's ability on the same metric, allowing for meaningful comparisons of the two [13]. IRT measurement models also permit the analysis of test development at the dimension and item level for self-report survey instruments [14]. Therefore, this study is underpinned by the IRT Theory in identifying the level of implementation of inventory administration practiced among Malaysian public hospitals.

Within the scope of this paper, the objective is to conduct an exercise to check the reliability of the instruments using the Rasch Model, due to the Rasch Model being able to provide methods in checking the reliability and quality of the instrument [15]. Another objective of this study is to measure the Rasch Measurement Model (RMM) of inventory administration practices among the public hospitals in Malaysia, focusing on drugs management and to offers some concluding remarks. This paper attempts to gain a better understanding of this under the scrutinised issue.

2. Research Methodology

Study Design and Settings: The study was designed as a quantitative approach study which involved the collection of data using questionnaire and the analysis setting was based to Rasch Measurement Model. 143 public hospitals in Malaysia, a combination of Hospital Kuala Lumpur and state hospitals, major specialist hospitals, minor specialist hospitals, special hospitals/institutions and non-specialist hospitals were approached for data collection. The population frame is derived from the Health Ministry of Malaysia directory according to the number of specialists and quantity of beds available and currently providing services to the community [7].

Ethical Approval: In Malaysia, an ethical requirement is compulsory for conducting clinical and non-clinical observational studies. Permission and approval to conduct this study were obtained from the Medical Research & Ethics Committee (MREC), Ministry of Health Malaysia through the National Medical Research Register (NMRR). In addition, written consent was also obtained from the Directors of the selected public hospitals prior to data collection. Then, The Heads of Pharmacy were informed about the research initiatives and confidentiality of their responses.

Data Collection: The unit for analysis that was chosen was the Logistics Pharmacy Unit of public hospitals in Malaysia. The target respondents were those directly involved in implementing and maintaining the inventory management practices at the drug stores. In this context, data will be collected from the Heads of Pharmacy Officers who are directly related in implementing inventory management practices and their direct role in the inventory management (drug management) activities of the department. This study is proportionately stratified and random sampling based. The samplings were based on the 103 public hospitals, with a combination of Hospital Kuala Lumpur and state hospitals (14), major specialists hospitals (26), minor specialist hospitals (27),

special hospitals/institutions (11) and non-specialist hospitals (66) located in Malaysia. Then, on-line questionnaires were email personally to the respondent which is Head of Pharmacists Officers at the Pharmacy Store within the 103 public hospitals. Finally, the number of return feedback were 81 responses which represented a valid respond rate of 78.64%. Thus, 80 responses were deemed usable, subsequently coded and were used for further analysis. Based on G*Power analysis, the actual sample size of 80 had yielded a statistical power of 0.87%>0.80%. Therefore, the sample size in this study was considered sufficient to reach an acceptable level of statistical power [16]-[17].

Instrumentation: The survey method used questionnaires for obtaining the information. The inventory administration measurement are made up of two sections. Section A seeks demographic information of respondents and the organisations. Section B had 27 items comprising managing planning with 14 items, managing employees having 8 items while managing suppliers were with 5 items. The measurements are adopted from a previous study [9], [18], [19], [20], [21]. This study employed a six-point scale to measure the ability of the public hospitals to implement the items under inventory adminstration, which were as follows, (1) extremely low; (2) very low; (3) low; (4) high; (5) very high and (6) extremely high. The Likert scale of 6 points was used because prior studies showed that compared to other points, six points were the most reliable [22]. Besides, the use of six scales is relevant for evaluation because the statistical analysis of this studies indicated that participants expressed the optimal level of confidence in their extreme judgements when these scales were applied [23]. Online questionnaires were emailed personally to the respondents, being the Heads of Pharmacists Officers at the Pharmacy Store within the public hospitals.

Previous research has shown that missing data cannot be avoided in survey [24]. Due to that, online questionnaires were chosen for data collection to overcome the problem. If there were missing answers in the questions, it will be displayed again until all data have been filled in. Respondents are only allowed to re-submit if all the data have been completed. In addition, online questionnaires can minimize errors when the researchers manually enter the data, because this data can be transferred directly to the analysis software [25].

Rasch Measurement Model (RMM): RMM is a parameter model within the IRT Models [14] and is a probabilistic model, which is commonly used to measure the latent traits, such as the ability and stance. Initially RMM is used widely in educational-related studies [26]. Nevertheless, RMM has now been applied in many other disciplines including medical and health [27]. RMM works in a way where, it measures the interaction between the person and item at the same time, using the same scale simultaneously and known as conjoint measurement [28]. Response from a person will be used to develop the scale and it works continuously and at an equal interval with a measurement unit named as Logit [27]. Its unit of measure is based on the log odds (called logits) of respondents' agreeing with the items.

The items are ordered along the zero calibrated scale from the easiest to agree with to the hardest to agree with. There are two fundamental theorems in RMM: (1) a high ability person will most likely able to accomplish any given task and (2) an easy task can be accomplished without difficulty by any person with any level of ability [29]. This study used RMM because it is relevant to the analysis of quantitative data, related to medical and health as well as it can measure the ability of each respondent in the implementation of the items difficulty level [26], [30]. However, to relate it with this study, the fundamental theorems can be interpreted as;

- A successful inventory administration implementer will most likely able to overcome any mismanagement in inventory administration practices
- A prominent inventory administration practice will be experienced by any inventory administration implementer with any level of ability

3. Findings and Discussion

i) Descriptive Analysis

The profiling of respondents' and organizations' demographics information is important to academic research since this study represents pioneering work in the survey of the Rasch Measurement Model (RMM) of inventory administration practices focusing on drugs management among Malaysian public hospitals. It can be concluded that the majority (36.3%) of the Heads of Pharmacy have more than 16 years of experience in the field of pharmacy, 32.1% between 11-15 years, 24.7% between 6-10 years and only 5% have the experience between 1-5 years. Further analysis on the years of the Main Medical Store has been in operations shows that the majority (78.8%) have been operating for more than 16 years, 9.9% between 11-15 years and 11.1% between 6-10 years. The majority (68.8%) of the Main Medical Store have between 1 to 2 pharmacists, while 23.8% have between 3 to 4 pharmacists, 23.8% between 5-6 pharmacists and only 5% have 7

pharmacists and above depending on the category of the hospital.

In terms of the number of administrative staff involved in medical store management, the majority (85%) are managed by 1 to 10 staff, 12.5% by 11-20 staff and 2.5% by 21-30 staff. Lastly, a majority (45.7%) of the hospital category are from the non-special hospitals, 21% are from major hospitals, 16% are from minor hospitals, 14.8% are from HKL/state hospitals and 2.5% from special hospitals involved in this study, representing the different categories of public hospitals in Malaysia.

ii) Goodness of Fit

The test was analysed by using the Winstep Version 3.92.1 software in order to analyse the data as well as to test the validity and reliability of the instrument. The Rasch model also considers the ability of the respondents or Heads of Pharmacy Officers who answered the questionnaires and the difficulty of each item [31]. Rasch moves the concept of reliability from establishing "best fit line" of the data into producing a reliable repeatable measurement instrument [32]. In addition, a better tool can provide a much more accurate and valid measurement for the constructs [33].

Dimensionality Analysis: Table 1 shows the dimensionality indices of inventory administration. Within the Rasch Measurement Analysis (RMA), the raw variance explained by measures is 56.4%>40.0% which is considered strong measurement dimension [34]. Meanwhile, the unexplained variance in 1st contrast is calculated as 4.7% which is acceptable and has a very good percentage because it was in the range of 3 to 5% [15].

Table 1.Dimensionality Indices of Inventory Administration

Variance	%
Raw variance explained by measures	56.4
Raw variance explained by persons	26.2
Raw variance explained by items	30.2
Unexplained variance in 1st contrast	4.7

Item Fit Analysis: In order for the data collected to be considered as fit to the Rasch Model it must meet the following criteria which are Point Measure Correlation (PMC); 0.4<PMC<.0.80, Outfit Mean Square; 0.5<MNSQ value <1.5 and Outfit Z-Standard; -2<ZSTD<+2 [29], [35], [36], [37]. Due to that, the investigation and decision has to be made if any data did not meet any one of the criteria [29]. 4 items (standard of procedure, skills & knowledge, numbers of personnel and categories of personnel) have been diagnosed as minor misfits because outfit MNSQ and outfit ZSTD radius fall outside the range of 0.5<MNSQ value<1.5 and -2<ZSTD value<+2 [25]. However, the researcher choose not to remove the minor misfit items because they still contributed to the discussion of this study, even if the 4 items are outfit of 95% confidential interval between data [25], [27]. Thus, 27 items of inventory administration are retained for further analysis.

Rating Scales: Figure 1 shows the probability curves for rating scales. In this study, 6 rating scales are used to measure the items and each of the rating categories should have a distinct peak in the probability curve graph [25]. Further investigation is needed and collapsing action may need to be implemented if the rating scales observed are flat. Interestingly, all the rating scales have distinct peak as shown in Figure 1. It indicated that the responses are fairly distributed among the categories. Therefore, no collapsing is required.

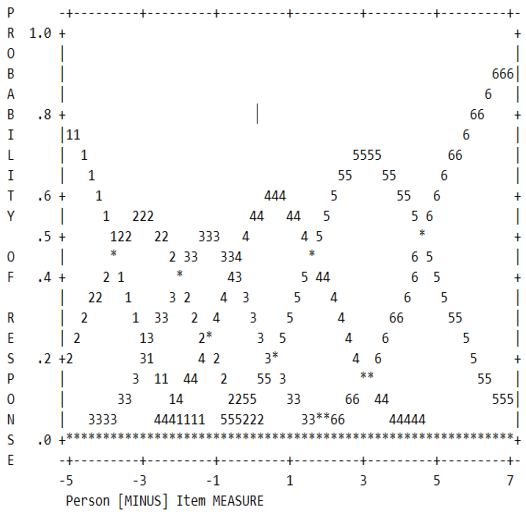

Figure 1.Rating Categories

Reliability Analysis: Table 2 shows the summary statistics of inventory administration. Reliability indices of >0.5 and a separation index >2 is regarded as adequate in RMA [25]. The reliability of the items was 0.97, while the reliability of the person was 0.93. Item separation was 5.80>2.00 and classified as being adequate and the reliability of the person 0.93 is classified as being very good [15]. Data indicated that the value is in the trusted level of reliability, fit to model data and can be used for analysis.

Table 2. Summary Statistics of Inventory Administration

ITEM Parameters	Index
Reliability	0.97
Separation	5.80
PERSON Parameters	**Index**
Reliability	0.93
Separation	3.55
Maximum	6.90
Minimum	-1.25
Cronbach alpha	0.95
Person raw score to measure correlation	0.99

iii) **Rasch Measurement Model (RMM) of Inventory Administration Practices**

Rasch Model examines the latent trait synchronously by using a map called Variable Map [27], Person-Item Map [30] or Person-Item Distribution Map [33], all of which referring to the same map. Meanwhile, this study will use a map called Rasch Measurement Model (RMM) to indicate the ability of public hospitals in performing the item difficulties in inventory administration. Other than that, RMM allows both the person and item to be mapped together on the same logit scale (logit value) that makes findings easier to read and having a clearer view to understand on how the person's behaviour correlates to each respective items [33].

RMM is divided into person ability (left-hand side) and item difficulty (right hand-side) of the map by one vertical dashed line (like a ruler) represented by one established unit, called "Log of odd units" or "Logit". Logit is a unit of intangible measurement, has equal intervals and the unit used is logit value [27], [30]. Letter M represents mean for item and person, S denote for one standard deviation and T for two standard deviations away from the mean. Item mean is always at zero (0) because it has been calibrated (zero-set) by the Winstep software while for the person mean, there is a 50:50 chance since it depends on the respondents having agreed to the question asked [27].

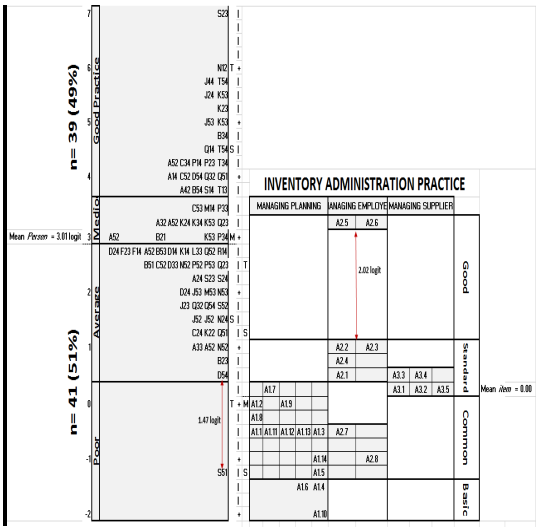

Figure 2. The Rasch Measurement Model (RMM) of Inventory Administration Practices

The Rasch Measurement Model (RMM) of Inventory Administration Practices is shown in Figure 2. The RMM indicates that, along the line on the left side are the respondents which are represented by public hospitals as the unit of analysis and are ranked according to their ability towards inventory administrations practices. The public hospitals that have the highest ability are at the top, whilst the public hospitals that have the lowest ability are at the bottom. On the right of the map, items are arranged from easy to difficult which would reflect the ability of the respondents. Based on the index of person separation 3.55 (which is rounded into 4) in Table 2, public hospitals fall into 4 level of competency: poor, average, moderate and good practice, as appears in Figure 2. RMM shows that the mean for person is located at 3.01 logit which is above the mean item 0.00 logit. The maximum logit for person is 6.90 logit which is represented by S23, and the minimum logit for person is -1.25 logit as represented by S51. The person ability was arranged in descending order from the highest to the lowest ability in performing the items.

Items under inventory administration practices are divided into three: managing planning, managing employee and managing supplier. Based on Figure 2, out of 80 public hospitals, there are thirty nine public hospitals (49%) falls above the mean person (3.01 logit) which represent competent category of moderate and good practice. Meanwhile, forty-one public hospitals (51%) failed to fulfil the highest item A2.5 and A2.6, and therefore, are falls below the competent category average and poor. Logit value of 2.02 differentiates the category of public hospitals in performing inventory administration practices. Items A2.2 until A1.5 are standard and common practices for the Heads of Pharmacy

except for person S51. From the organization code, it shows person (S51) being at the poor category level because having low ability to implement A1.4, A1.6 and A1.10 basic practice items while person (S23), which is at the top level and being the most good practice category, shows the high ability of those public hospitals to carry out the entire items. There are twelve inventory management practice items falls into standard and good practice which is being above average (0.00 logit). Meanwhile, another fifteen items were falls into common and basic practice which is below average (0.00 logit). This finding highlights that most public hospitals in Malaysia are able to implement common and standard inventory administration practices.

The lowest item is easiest to answer (A1.4, A1.6 & A1.10) while the highest item is the most difficult to implement (A2.5 & A2.6). The easiest item A1.4 is related to what extent does drug purchase planning improves the service level, A1.6 is related to what extent does the sufficient drug supply built maximizes service performance and item A1.10 is related to the question on to what extent does rack labelling of drugs placed in the storage area important while the most difficult items which are A2.5 and A2.6 are related to the question with regards to what extent does the main medical store have sufficient numbers of personnel and to what extent does the main medical store have sufficient categories of personnel. Items A2.5 and A2.6 indicates that 41 public hospitals (51%) which categorized as poor and average must strive to have sufficient number of personnel and sufficient categories of personnel to manage drugs in the main medical store in order to move and achieve at least moderate or good practice category.

4. Conclusion, Limitation and Direction for Future Research Equations

Since the Rasch Measurement Model (RMM) was used for data analysis which can validate the construct validity of the instrument, the result of this study is different and provided the very unique strength of discussions from those conducted previously. This study is focusing on items A2.5 and A2.6 that acquire organization to focus more on how to improve the ability of lower hospitals (poor category) to achieve higher ability hospitals (moderate to good practice) with adequate and competent workforce. Therefore, present study suggest the following action to be taken to alleviated few obstacle in inventory administration implementation based to the previous discussion and studied [5], [10], [20], [39].

A few suggestions to the pharmacy department has been identified for the management of drugs: 1) 41 public hospitals (51%) that falls under lower category hospitals must have a sufficient numbers and categories of personnel to manage drugs in main medical store, 2) organizations are recommended to conduct inventory management in house well trained course to increase the inventory management skills of personnel dealing with drugs, 3) more broadly, organization are suggested to re-visit the procedure on how to manage and quantifying the drugs needed, 4) pharmacy department must be supported with other information technologies and lastly 5) invest in an efficient and effective inventory management system that can help in improving commitment and skills level of personnel involved in drugs supply in the hospitals.

Findings of this research would also be very significant for public hospitals to measure the inventory administration implementation as it provides a basis for a valid instrument construct. Other than that this paper will facilitate in adding new knowledge to existing literature relating to inventory studies. The limitations from this study which can be highlighted are; 1) some of the existing items need to be reviewed according to three types of quality controls, 2) study focuses only on the implementation of administration practices under inventory management, and 3) this logit value depends on the 80 sample size, if bigger sample size are used the mean value can be different. However, for the organizations to move forward, the instruments are propose to be refine by adding more difficult items in order to develop better tools in describing successful inventory administration implementation within Malaysian public hospitals, adding more sample size and future research also can look on the other typology area of inventory practices such as inventory control and inventory systems in public hospitals, private hospitals and industries.

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