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A COMPARATIVE STUDY OF TERLIPRESSIN AND OCTREOTIDE ALLOCATION BETWEEN KING HUSSEIN MEDICAL HOSPITAL AND PRINCE RASHID BEN AL-HASAN MILITARY HOSPITAL IN THE JORDANIAN ROYAL MEDICAL SERVICES.

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ABSTRACT

Background and Rationale: Efficient and effective pharmaceutical distribution within military healthcare systems signifies a key component of the quality patient care delivery and the system resource optimization, the Jordanian Royal Medical Services (JRMS) stands as a key healthcare network serving military personnel and their families in Jordan with multiple hospitals and clinics distributed throughout the entire country that require strategic pharmaceutical resource allocation. Terlipressin and Octreotide are both critical and vital vasoactive medications with diverse therapeutic applications and can serve as important indicators of hospital capacity, clinical specialization and pharmaceutical supply chain efficiency, Terlipressin is a synthetic vasopressin analog which plays a vital role in managing hepatorenal syndrome and variceal bleeding, while Octreotide is a somatostatin analog which has applications in treating gastrointestinal bleeding, neuroendocrine tumors and various endocrine conditions and understanding the distribution of these medications within military healthcare systems will provide valuable insights and perceptions into the resource allocation strategies, the clinical practice dissimilarities and variations and the operational efficiency indicators which can inform evidence-based policy decisions.

Study Objectives: This study aims to analyze pharmaceutical distribution patterns within the JRMS by investigating the mean monthly allocation of Terlipressin 1mg vials and Octreotide 100mcg/ml ampules between two main hospitals within the network of the JRMS (King Hussein Medical Hospital and Prince Rashid Ben Al-Hasan Military Hospital) over a five year period from 2020 to 2024 with the primary objective of identifying temporal trends in monthly distribution patterns, allocation discrepancies and consumption patterns that reflect clinical practices and institutional capacities while accounting for periods of stock shortages and with secondary objectives that include evaluating the efficiency of centralized pharmaceutical distribution systems, evaluating hospital-specific utilization patterns and recognizing factors influencing medication allocation decisions. Additionally, the research will aim to provide insights into physician prescribing behaviors and clinical preferences through analysis of medication consumption trends over time.

Methodology: This research will use a retrospective quantitative analysis approach employing pharmaceutical distribution data obtained from JRMS main medical warehouses with data collection that will focus on the average distributed quantities for each medication and hospital and therefore enabling a comprehensive temporal and comparative analysis. The methodology will integrate descriptive statistical analysis and temporal trend analysis which will be conducted to identify patterns in the monthly pharmaceutical allocation over the study period and comparative analysis between hospitals which will assess the distribution patterns and potential inequalities while considering the impact of stock shortage periods on allocation decisions. Statistical measures will include year-over-year growth rates, distribution ratios and variability indices to provide comprehensive insights into pharmaceutical allocation patterns.

KEYWORDS: Pharmaceutical distribution, inventory management, hospital pharmacy, terlipressin, octreotide, healthcare supply chain

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1. INTRODUCTION:

The efficient distribution of pharmaceutical products within any healthcare systems signifies a critical component of quality patient care delivery and in military healthcare settings where capitals must be strategically assigned across multiple facilities serving diverse patient populations the pharmaceutical inventory management system becomes principally complex, the Jordanian Royal Medical Services (JRMS) functions as a comprehensive healthcare system that serves military personnel and their families and within the JRMS King Hussein Medical Hospital and Prince Rashid Ben Al-Hasan Military Hospital signifies two of the most important primary care facilities within this network [(1)].

Terlipressin and Octreotide are both vasoactive medications which function as a treatment for several critical therapeutic illnesses and they serve as an important indicator of hospital capacity and clinical practice patterns [(2)], Terlipressin is a synthetic analog of vasopressin and it is primarily used in the management and treatment of hepatorenal syndrome and variceal bleeding [(3)], while Octreotide is a synthetic somatostatin analog which has finds applications in treating gastrointestinal bleeding, neuroendocrine tumors and various other endocrine conditions [(4)]. The distribution patterns of these medications reflect not only the clinical needs of the served populations but also the operational capacity and the specialization levels of the receiving hospitals.

This study addresses the gap in understanding and comprehending pharmaceutical distribution patterns within military healthcare organizations by investigating five years of average monthly allocation data obtained from the JRMS main medical warehouses records which were taken as an average value to account for periods of stock shortages. The research aims to recognize trends, discrepancies, and efficiency indicators during both normal supply periods and shortage circumstances which may inform future pharmaceutical supply chain optimization policies and by analyzing the distribution of these two vital medications this study may contribute to the wider understanding of healthcare resource allocation in specialized medical environments.

The significance of this research is expected to extend further beyond the direct context of the JRMS as other military healthcare systems worldwide face similar challenges in optimizing pharmaceutical distribution across multiple facilities and the findings of this research may also help informing policy decisions concerning inventory management policies and approaches, hospital capacity planning and clinical practice standardization within integrated healthcare networks.

2. LITERATURE REVIEW:

2.1 Pharmaceutical Inventory Management in Healthcare Systems: Healthcare inventory management has progressed significantly over the past era in which it was driven by technological developments and the increasing pressure to reduce costs while preserving quality care. The factors affecting inventory management in healthcare include the demand and the supply of inventory items, the nature of those healthcare inventory items, the type of inventory item and their storage facility, the nature of the inventory distribution system itself, the used replenishment policy, the intended service level growth, patient medical conditions, physician prescribing habits and preferences and the criticalness of inventory items [(5)].

Modern hospital inventory management softwires and systems have become more and more sophisticated, incorporating real-time tracking, automated reordering processes and facilitating predictive analytics in order to optimize stock levels and minimize any possible waste. Hospital inventory management could be defined as a systematic approach which functions to supervision and controlling the whole life cycle of pharmaceuticals and other medical supplies from the stage of procurement to disposal [(5)]. And that's why the complexity of managing pharmaceutical inventories in hospital settings necessitates careful consideration of numerous factors including drug stability, expiration dates, storage requirements and demand inconsistency.

2.2 Centralized Pharmaceutical Distribution Systems: The drift toward centralized pharmaceutical distribution systems has acquired momentum in healthcare systems which are looking for to upgrade their efficiency and reduce their systems operations costs since a centralized pharmaceutical supply chain allows a health system to centralize and standardize the distribution in pharmacy, purchasing, services and inventory

management within a solo location which then serves individual hospitals [5]. This approach allows for better coordination and management of the system pharmaceutical resources, specially across many multiple facilities while it also helped in maintaining the standardized quality and the safety procedures, the advantages of centralized distribution stretch beyond just cost savings to include better inventory turnover, reduced stockouts and improved regulatory compliance. However, the adaptation of such systems must involve careful thought of individual hospital needs, clinical specializations and patient population type and characteristics in order to ensure an appropriate and efficient allocation of resources.

2.3 Clinical Applications and Therapeutic Significance:

2.3.1 Terlipressin in Clinical Practice: Terlipressin has proved itself as a vital vasoactive medication used in the management of numerous life-threatening conditions since vasoactive drugs can reduce portal venous pressure and limit variceal bleeding [4] and recent clinical trials have confirmed the efficacy of terlipressin in various therapeutic applications particularly in patients with liver disease and portal hypertension.

Terlipressin plus albumin is significantly more effective than midodrine and octreotide plus albumin in enhancing renal function in patients with hepatorenal syndrome [3]. This finding underscores the importance and the need of ensuring adequate terlipressin inventory in hospitals which treats patients with advanced liver disease and other related complications.

2.3.2 Octreotide Therapeutic Applications: Octreotide denotes another critical vasoactive medication with various therapeutic applications. Variceal bleeding is a major complication and the leading cause of death in patients with cirrhosis and portal hypertension [4] and this medication's role in managing gastrointestinal bleeding and neuroendocrine disorders makes it an essential component of any hospital pharmaceutical inventories. The efficacy of terlipressin was not inferior to octreotide when judging it as an adjuvant therapy for the control of esophageal variceal bleeding and in-hospital survival [3,4] and this comparative effectiveness research highlights the importance of having both medications available in the hospital settings in order to provide an optimal patient care.

2.4 Inventory Management Challenges in Healthcare: Hospital pharmacy inventory management is faced with unique challenges that differentiate it from other industries mainly running out of products results in loss of sales and profitability for most businesses however the outcome for shortages of vital medications can be prolonged sickness and hospital stay, loss of life and malpractice lawsuits [6] and that's why this critical nature of pharmaceutical inventory necessitates sophisticated management approaches which balance cost efficiency with patient safety and care [7].

An effective hospital pharmacy inventory management system helps control costs and addresses the financial needs of your hospital and it also identifies opportunities to minimize carrying costs, enhance bid compliance, minimize stock outs, reduce shrinkage and decrease obsolete inventory [6] and that's why the complexity of managing these competing priorities requires data-driven approaches and tactics to inventory optimization.

2.5 Technology Integration in Pharmaceutical Distribution: The use of technology in inventory management has transformed how hospitals track and manage and optimize their drug supplies and a healthcare app for the hospital pharmacy inventory management can also provide critical and vital insights and perspectives into the stock levels and can also predict demand and facilitate an automated reordering processes and practices [6,7] and these technological developments and technologies can enable more precise and accurate inventory management and eventually can lead to better resource allocation across multiple facilities inside the healthcare network.

The finest pharmacy inventory management systems must include automated restocking, expiration tracking and electronic health record (EHR) integration [5,6] and such systems are particularly valuable in multi-facility environments and settings where coordination and standardization are essential and vital for effective pharmaceutical distribution.

3. METHODOLOGY:

3.1 Study Design and Data Collection: This study employed a retrospective quantitative analysis method in order to examine and investigate

pharmaceutical distribution patterns within the JRMS network from 2020 to 2024 and this research focused on two critical vasoactive medications: Terlipressin 1mg vials and Octreotide 100mcg/ml ampules and used data which were obtained from the JRMS main medical warehouses distribution records which represents the average monthly allocation from the central pharmaceutical stores of the JRMS to two primary hospitals within the system (King Hussein Medical Hospital and Prince Rashid Ben Al-Hasan Military Hospital). The data accounts for periods of stock shortages and by doing so it was capable of providing a realistic assessment of pharmaceutical distribution during both normal and constrained or limited supply situations.

3.2 Study Population and Setting: The study examined pharmaceutical distribution to two major healthcare facilities within the Jordanian Royal Medical Services (JRMS), King Hussein Medical Hospital functions as a comprehensive tertiary care center and functions as the primary medical facility within the JRMS network. In contrast Prince Rashid Ben Al-Hasan Military Hospital provides specialized medical services which are tailored to military personnel and their families, and both institutions run under the JRMS umbrella and receive their pharmaceutical supplies from its centralized warehouses through standardized and well-well-known distribution protocols.

3.3 Data Parameters and Variables: The study analyzed several key parameters in order to assess and evaluate pharmaceutical distribution patterns and it included a temporal variable and examining the average monthly distribution data over a five-year period from 2020 to 2024 and the medication variables focused on the average monthly distribution of Terlipressin 1 mg vials and Octreotide 100 mcg/ml ampules and the institutional variables which were also considered specifically the average monthly allocations to King Hussein Medical Hospital and Prince Rashid Ben Al-Hasan Military Hospital. Additionally, the analysis also accounted for supply chain factors including any periods of stock shortages which may have impacted of effected the resulted distribution patterns.

3.4 Statistical Analysis: Descriptive statistics were calculated for all variables including mean monthly distribution, standard deviation, range and percentage distribution and temporal trend analysis was also performed to identify patterns in pharmaceutical allocation over the study period while considering the impact of stock shortage periods on distribution patterns also comparative analysis between the two hospitals was conducted to assess and evaluate distribution patterns and to identify potential disparities or differences in both normal and constrained supply situations.

The study employed and used several statistical measures and tactics to analyze distribution patterns which included the calculation of the average monthly distribution totals for each medication and hospital, the percentage share of distribution between the two hospitals under study and both month-over-month and year-over-year variation rates and also the coefficient of variation was used to assess and evaluate the distribution stability particularly during periods of supply shortages and stockouts. However, our analysis was limited to the data which was obtained from JRMS and it did not include information on patient outcomes, clinical utilization rates, medication wastage or expiration, physician prescribing patterns or patient demographic data which if was available may have provided much more insights and perspectives into these medications use and their demand drivers.

3.5 Ethical Considerations: The study used aggregate distribution data which was obtained without access to any patient-specific information and by that ensuring privacy and confidentiality and the research itself focused solely on institutional inventory allocation patterns within the JRMS system.

4. RESULTS AND DISCUSSION:

4.1 Overall Distribution Patterns: We can learn a lot about how Terlipressin and Octreotide are distributed in the JRMS just by looking at pharmaceutical distribution data from 2020 to 2024. Over the course of five years 1,960 total units were distributed, King Hussein Medical Hospital got 1,725 units (88.0%) and Prince Rashid Ben Al-Hasan Military Hospital got 235 units (12.0%). This big difference in distribution shows that between the two hospitals the JRMS's main drug distribution center is King Hussein Medical Hospital. Average monthly allocations show that the hospital always gets resources first. The 88:12 ratio shows that there is a clear preference in which the pharmaceutical resources are given out and which suggests that King Hussein Medical Hospital is the

main medical center within the JRMS that needs to have a lot more supplies on hand each month to give patients a good care all the time, even when there aren't enough supplies (table 1)

Table 1: The frequency of distribution of medications by year and hospital

Year	Medication Name	King Hussein Medical Hospital	Prince Rashid Ben Al-Hasan Military Hospital
2020	Terlipressin 1mg Vials	91	2
2020	Octreotide 100mcg/ml Ampules	212	38
2021	Terlipressin 1mg Vials	78	2
2021	Octreotide 100mcg/ml Ampules	284	26
2022	Terlipressin 1mg Vials	75	6
2022	Octreotide 100mcg/ml Ampules	197	49
2023	Terlipressin 1mg Vials	92	5
2023	Octreotide 100mcg/ml Ampules	249	19
2024	Terlipressin 1mg Vials	89	13
2024	Octreotide 100mcg/ml Ampules	358	75

4.2 Temporal Trends Analysis:

4.2.1 Overall Inventory Trends: The five-year period shows that monthly pharmaceutical allocation patterns can change a lot, which may be due to both changes in clinical demand and problems in the supply chain. The average monthly allocation data gives us a lot of information about how the JRMS handles drug distribution when there aren't enough of them. The data shows big changes from the baseline monthly averages in 2020. These changes are probably due to changes in clinical demand and problems in the supply chain that affect how monthly allocations are made (figure 1).

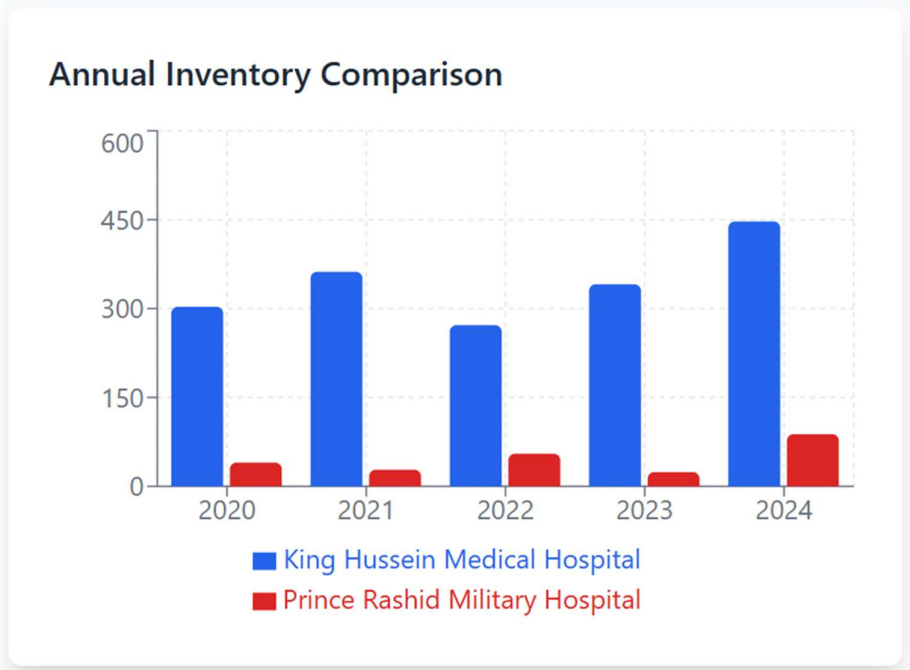

Figure 1: Annual inventory comparison by hospital

The year-by-year analysis of average monthly allocations reveals an interesting pattern which in turn reflects both clinical demand and supply chain management (table 2):

Table 2: The year-by-year analysis of average monthly allocations

Year	Total Monthly Average (Units)	Change from Previous Year	Percentage Change
2020	343	–	Baseline
2021	390	+47 units	+13.7%
2022	327	–63 units	–16.2%
2023	365	+38 units	+11.6%
2024	535	+170 units	+46.6%

The drop in 2022 could be due to some problems in the supply chain or due to changes in how resources are allocated during times of shortage and the large rise in 2024 could also be due to either a more stable supply chain or a higher clinical demand that requires more resources each month.

4.2.2 Medication-Specific Trends:

Terlipressin Monthly Distribution Patterns: At King Hussein Medical Hospital the average monthly allocation of Terlipressin stayed pretty stable with monthly averages between 6.3 and 7.7 units and the coefficient of variation for King Hussein Medical Hospital's Terlipressin distribution was 8.2% which means that the patterns of use stayed the same over the course of the study and is suggestive of that the monthly allocation stayed pretty stable even though there may have been problems with the supply chain.

The monthly allocation of Terlipressin at Prince Rashid Military Hospital however showed more variation with a monthly average that changed from 0.17 units in 2020–2021 to 1.08 units in 2024. This is a six-fold increase which could mean that either more clinical services became available or that allocation policies have changed during some times of shortage.

Octreotide Monthly Distribution Patterns: The average monthly allocation of octreotide showed more variation especially at King Hussein Medical Hospital, over the course of two years the monthly average went from 16.4 units in 2022 to 29.8 units in 2024 establishing an increase of 82%, this big difference in monthly allocation suggests that Octreotide distribution is more likely to be affected by changes in the supply chain or changes in clinical demand.

The monthly allocation of Octreotide at Prince Rashid Military Hospital also changed a lot since the monthly average went from 1.6 units in 2023 to 6.25 units in 2024 which is a 290% increase. This big change in the monthly allocation shows that either the clinical services or the allocation policies have changed a lot during times when supplies were more readily available (figure 2).

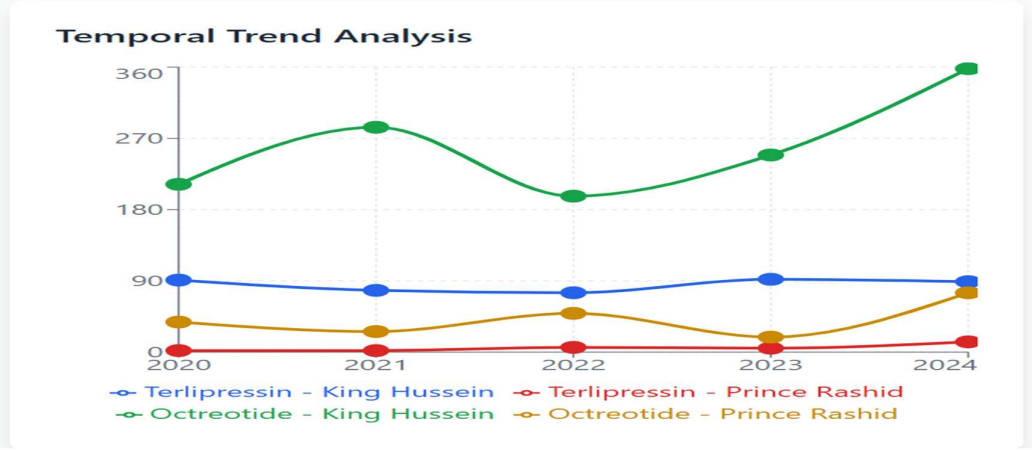

Figure 2: Temporal trend analysis

4.3 Comparative Hospital Analysis:

4.3.1 Distribution Ratios:

The distribution ratios between the two hospitals give us an idea of their relative capacities and areas of expertise (table 3):

Table 3: Comparative Hospital Analysis

Hospital	Mean Monthly Allocation (Units)	Standard Deviation (Units)	Range (Units)	Coefficient of Variation (%)
King Hussein Medical Hospital	28.8	5.5	22.7 – 37.3	19.0%
Prince Rashid Military Hospital	3.9	2.1	2.0 – 7.3	54.7%

The higher coefficient of variation for Prince Rashid Military Hospital means that the monthly distribution of those drugs is less stable. This could mean that this hospital is more affected when there aren't enough supplies or when clinical demand changes.

4.3.2 Clinical Implications: The patterns of distribution suggest that each hospital in the JRMS has its own unique clinical role: King Hussein Medical Hospital seems to be the main tertiary care center because it has a steady high volume of pharmaceutical needs and stable Terlipressin use patterns that follow established treatment protocols and the big rise in Octreotide use which suggests that the hospital is expanding its clinical services, Prince Rashid Military Hospital, on the other hand, has the characteristics of a more specialized facility. Its baseline pharmaceutical needs are lower, its medication use is more variable, and its allocations for Terlipressin and Octreotide grew significantly in 2024, which suggests that services have recently expanded.4.4 Patterns of doctor prescribing and clinical preferences.

4.4.1 Terlipressin Utilization Patterns: The fact that the Terlipressin distribution at King Hussein Medical Hospital is fairly stable (CV=8.2%) suggests that there are clear clinical guidelines for how to use this medication and this stability shows that doctors have established consistent ways of prescribing Terlipressin for conditions and diseases that require it such as managing hepatorenal syndrome and variceal bleeding. however the big rise in the amount of Terlipressin given to Prince Rashid Military Hospital in 2024 (550% more than in 2023) could mean that the hospital is expanding its hepatology services, that patients are getting more complicated conditions and need vasoactive support or that the hospital is using better clinical protocols that include Terlipressin therapy.

4.4.2 Octreotide Prescribing Trends: The way octreotide is distributed suggests that it is used more in clinical settings: The 82% rise at King Hussein Medical Hospital from 2022 to 2024 could mean that this drug is being used in more ways than just the usual ones, that more patients need treatment for neuroendocrine tumors or that the protocols for managing gastrointestinal bleeding in this hospital have been improved also the 295% increase at Prince Rashid Military Hospital in 2024 suggests that clinical services have grown significantly, specialized treatment protocols have been created or specialists who prefer Octreotide therapy may have been hired.

4.5 Consumption Pattern Analysis:

4.5.1 Seasonal and Temporal Variations: The data shows some interesting patterns in how each hospital use the two medications which could be due to differences in how doctors and healthcare providers behave: The monthly allocation went down in 2022 (327 units on average compared to 390 in 2021) this is probably because of problems with the supply chain or changes in policy during times of shortage and this drop suggests that the JRMS used strategic allocation policies to control the flow of pharmaceutical resources when supply was limited. The rise in monthly allocation in 2024 (535 units on average) could mean that the supply chain became more stable or that there is more clinical demand which led to the monthly allocation levels to be higher, and this pattern suggests that the JRMS was able to successfully adapt to problems in the supply chain and manage its resources strategically during recovery periods.

4.5.2 Medication-Specific Consumption Insights: The amount of Octreotide and Terlipressin used gives us an idea of what doctors prefer: From 2020 to 2023 3.2:1 (Octreotide:Terlipressin) is the average ratio. 4.2:1 (Octreotide:Terlipressin) in

2024and this rising ratio suggests that Octreotide is being used more often in clinical practice, that doctors may prefer it over other treatments or that more patients may need Octreotide therapy.

5. CONCLUSIONS:

This study which examined how Terlipressin and Octreotide were distributed from 2020 to 2024 in two main hospitals of the Jordanian Royal Medical Services (JRMS) shows that the JRMS had a centralized and strategic way of distributing drugs, King Hussein Medical Hospital got 88% of the total inventory which strengthens its position as the main tertiary care center and from 2020 to 2024 the total distribution rose by 47.5% with a big jump of 46.6% in 2024 which could mean that services were expanded or treatment protocols were improved. Terlipressin use stayed the same at King Hussein but Octreotide use changed and grew showing that clinical uses are changing and the ratio of Octreotide to Terlipressin went from 3.2:1 to 4.2:1 in 2024 suggesting that it is being used more widely in patients treatment and that the JRMS centralized system worked well in handling the increase in demand well and it also showed that the healthcare network was mature and getting better at what it did.

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