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Regulating the Rational Use of Antimicrobial Drugs and Improving the Quality of Healthcare Big Data: A Development and Usability Study as A Prelude to AI Assisted Healthcare

Abstract: - Background: Healthcare big data has become an important strategic resource, and the study of applying it to the rational application of antimicrobial drugs is of great significance in improving and optimizing the various tasks of medicine and health and promoting the development of social health. Based on its own characteristics, the issue of data quality has important research value in promoting data output and application.

Objective: To optimize the status quo of antimicrobial drug use in medical institutions, to explore the value of healthcare big data, and to explore the data governance methods in the era of digital intelligence in order to build a good ecosystem for the application of healthcare big data.

Methods: This paper constructs a set of intelligent full-closed-loop antimicrobial rational application management platform integrated with data quality, adopts PDCA cycle management mode, analyzes the problems in the process of applying healthcare big data and gives the corresponding solutions, authorizes according to the personnel's duties, and guarantees the data security.

Results: Since the platform went online in January 2021, the antimicrobial drug use intensity indicator of a hospital has decreased year by year from 38 to 34.4 as of June 2023, effectively standardizing the use of antimicrobial drugs. The time consumed for the statistics of antimicrobial use intensity related data has decreased from an average of 30min to 2min, which has significantly improved the work efficiency.Healthcare professionals are able to monitor indicator data in real time, with or without abnormal cases, and fully grasp the trend of indicators. At the same time, the patient's medication can be viewed at any time, and the condition can be grasped in a timely manner.

Conclusions: The platform not only effectively solves the problem of information barriers, but also accurately determines the data source and statistical logic of indicator collection, reflecting the actual clinical diagnosis and treatment, and at the same time greatly reduces labor costs and optimizes the workflow.The practical experience of platform construction has important reference significance for the governance and application of healthcare big data, which provides data support and technical guarantee for the scientific, standardized and refined management of hospitals.

Keywords: Data quality; Intensity of antimicrobial drug use; Big data; Quality of care

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Introduction

Background

The rational use and clinical application management of antimicrobial drugs is a common problem faced by all medical institutions, and there are still some non-negligible problems in the management of antimicrobial drugs due to abuse and misuse, etc.[1,2].PRC National Healthcare Commission (NHSC) has put forward a series of requirements and action plans on antimicrobial drug management, and due to the lack of systematic measures and scientific management tools, most healthcare organizations have not achieved the expected results. In recent years, there has been an increasing trend of ultra-broad-spectrum antimicrobial drug use structure [3,4], which has led to an urgent need for effective solutions for antimicrobial drug use, management, and monitoring.With the vigorous development of medical information system centered on HIS system (Hospital Information System) and the rapid penetration of emerging technologies such as big data, artificial intelligence, and "Internet+" into all aspects of the medical field [5-8], the use of informatization technology to manage massive amounts of medical data has become an effective means to address the rational application of antimicrobial drugs.

HIS system is the core component of hospital information construction, which realizes information sharing and collaborative work within the hospital by integrating various hospital departments and business processes, and is the source of healthcare big data [9].When using big data technology to manage and monitor the use of antimicrobial drugs, data quality is crucial, and "high-quality" data (meaning highly accurate and complete data) is a prerequisite for the effective analysis and application of medical big data, however, there are many factors affecting the quality of the data in reality [10-13], such as the level of knowledge and skills of healthcare personnel, the process of data collection and entry, and the methods of data statistics, analysis, and application. Healthcare big data data in the whole life cycle of creation, storage, application, maintenance, migration, and end-of-life will produce different degrees of quality problems, resulting in the quality of the data can not meet the requirements of accurate analysis, which is an embarrassment faced by many hospitals in the utilization of data.

Good data quality is the basis for ensuring that medical big data plays its role. At present, there is a relative lack of research on the evaluation of healthcare big data quality in China, and most of the existing research focuses only on the application of data quality and ignores the causes of data quality problems.Healthcare big data in the whole life cycle of creation, storage, application, maintenance, migration, and end-of-life will produce different degrees of quality problems, resulting in the quality of the data can not meet the requirements of accurate analysis, which is an embarrassment faced by many hospitals in the utilization of data [14-16].Therefore, this paper takes improving the data quality of antibacterial drug use intensity indicators as an example, analyzes data problems from data governance, statistics, analysis, application and visualization, explores methods and techniques to improve data quality, improves institutional norms, clarifies the division of authority and responsibility, institutionalizes and standardizes data quality management, and realizes the whole process of quality control, daily monitoring and improvement of data generation, sharing, use, statistics, and so on. The system will be standardized to achieve quality control, daily monitoring and improvement of the whole process of data generation, sharing, use and statistics. Summarize the problems and experiences in practice, and provide

reference for the governance and application of healthcare big data.

Objective

The intensity of antimicrobial use is by far the most comprehensive indicator reflecting the rational use of clinical antimicrobials [17], and has become an important indicator in the accreditation of ranked hospitals and the assessment of national tertiary public hospitals. This paper takes improving the data quality of antimicrobial drug use intensity indicators as an example, analyzes the data problems from data governance, statistics, analysis, application and visualization, and explores the methods and techniques to improve the data quality. Therefore, based on the above analysis to carry out the following necessary research issues:

1. Coordinate data resources, integrate and share and develop and utilize them, and establish data centers.

2. Clarify the definition, statistical caliber and logic of antimicrobial use intensity indicators.

3. Research and development of BI intelligent management platform, data visualization, tracking the whole life cycle process of data, to provide effective tools for standardizing the rational use of antimicrobial drugs.

4. Improve institutional norms, clarify the division of authority and responsibility, and use the PDCA cycle to improve data quality, so as to institutionalize and standardize data quality management.

Methods

Problem Analysis

Data quality is a key factor in whether new generation technologies and applications such as big data and artificial intelligence can be effectively implemented. Without high-quality data, all data-based applications can't be talked about [18].Medical institutions, which are the main storage and use institutions of healthcare big data, can utilize relevant big data analytics to improve service quality and efficiency; researchers can utilize healthcare big data to provide clinical decision support for clinicians and better treatment solutions for diseases.All of this is predicated on good data quality, and low data quality not only reduces the quality of a healthcare organization's decision-making, but also brings about incalculable losses.Therefore, evaluating the quality of healthcare big data of medical institutions is of great significance for medical institutions. Currently, there is a relative lack of research on the assessment and governance of big data quality in medical organizations in China, and the data quality of medical organizations needs to be improved.The author analyzes the problems in medical quality indicators by referring to the recognized big data quality evaluation indicators [19-23], combining data characteristics of the medical industry, the purpose of the application, the use of information systems technology and other aspects related to the influence of factors, and taking the intensity of antimicrobial drug use indicators as an example.

Problem 1: Accuracy, raw data quality varies. Insufficient auditing of medical information systems, non-standardized operations of medical staff, lack of familiarity with the business, and weak sense of responsibility can all result in errors, omissions, and inaccuracies in raw data. Antimicrobial drugs come in various forms and drug specifications, such as the compound drug "Linezolid Dextrose Injection" (Swo), which

has a drug specification of 0.6g:300ml with more than one unit. However, when calculating Antimicrobial Drug Consumption (DDDs) values in the system program, only one of the units can be used. According to the official definition, the main drug unit should be used to participate in the calculation, which is 0.6g in this case (referred to as the statistical specification). Therefore, the dosage should be taken as a unit of "g" in medical prescriptions.

In a hospital's Electronic Medical Record System (HIS), doctors can enter the unit of drug dosage in their prescriptions manually. However, if the operation is not standardized or there is a manual error in the unit entered, it can lead to incorrect calculations.

Medical prescriptions for the use of antimicrobial drugs for patients attending TCH in 2022 for four antimicrobial drugs are listed in Table 1.For example, in Table 1, a doctor entered the dosage as 300 ml, resulting in a DDDs value of 1,000, which is incorrect. According to equation 1, the correct DDDs value for this medical order should be 4, which is 250 times lower. Table 1 also lists several other compounded drug scenarios that can have outliers. As shown in the table, Samples 1 and 4 will result in large DDDs values, while Samples 2 and 3 will result in small DDDs values. It is difficult to identify outliers by just looking at the overall antimicrobial drug intensity of use in a certain period of time. These data quality issues are insidious but can significantly impact the accuracy of the indicator.

Equation 1：

$$DDDs = \sum\{dose/drug\ specification \times daily\ frequency \times days\ of\ duration/hotkey\}$$

Table 1. Examples of data with incorrect drug dosage units in 4 medical orders using antimicrobials in 2022

	Sample 1	Sample 2	Sample 3	Sample 4
Drug code	1230070	A0140022	12200862	12300704
Drug name	(Swo)Linezolid Dextrose Injection	(Dafu Kang) Fluconazole Sodium Chloride Injection	(Bag) Moxifloxacin Sodium Chloride Injection 250ml:0.4gX1	(Elidel) Linezolid Dextrose Injection
Dosages	300ml	0.2g	0.4g	300ml
Drug specifications	0.6g:300ml	100ml:0.2g	250ml:0.4g	0.2g:100ml
Statistical specifications	0.6	100	250	0.2
Daily frequency	1	1	8	2
Days of duration	5	4	7	13
hotkey	2	1	1	6
DDDs	1250	0.008	0.089	7500

Correct value（DDDs）	4	4	56	4.33
Inaccuracy	Increase of about 312 times	500-fold decline	Decrease of approximately 629 times	Increase of about 1732 times

Problem 2: Completeness, lack of data granularity. Currently, China's medical information system is still in the development stage, and the collection of clinical medical data is not meticulous. Some medical personnel do not pay enough attention to medical process data and fail to fill in the data in a timely manner, resulting in a serious lack of refinement of medical data. From a horizontal perspective, it is crucial to ensure that the data covers all aspects of the diagnosis and treatment process and all the contents of the medical record. From a vertical perspective, the data must run through the patient's visits and extend to out-of-hospital follow-up. From a holistic perspective, the data must integrate fragmented patient-centered medical information and fragmented financial-centered human, financial, and material information.

For example, patient transfers to other departments occur frequently during treatment, but corresponding flags are not set up in the database of hospitals to record them. In statistical data, interdisciplinary patients are usually counted according to the department from which they are discharged. For instance, the ICU department often needs to accept transferred patients. However, when calculating antimicrobial drug use intensity indicators by department, the system does not take into account the department where the patient received the antimicrobial drugs before being transferred to the ICU. As a result, these patients are eventually counted in the ICU department's discharge statistics, which is unfair to the discharge department. The lack of persuasive data undermines the formation of a perfect assessment system.

When monitoring the indicators of the intensity of antimicrobial use, the criteria for children and adults are different, and here there is an issue of age calculation, with differences in the accuracy of the algorithms of different information systems.However, the calculation of age can be challenging due to variations in the accuracy of different information systems' algorithms. For instance, in the medical field, a child is typically defined as being under the age of 14. However, when calculating a patient's age in a hospital's HIS system, differences in algorithm accuracy can result in discrepancies. For example, a patient born on June 1, 2008, would be considered an adult on May 30, 2023, in some systems that calculate age by the number of years between the date of birth and the current date, resulting in an age of 15. In contrast, other systems calculate age based on the number of days between the date of birth and the current date, resulting in an age of 14, accurate to the day and thus considered a child.

Moreover, the lack of a unified algorithmic standard for essential public information, such as holiday schedules, department divisions, bed attributes, and employee work numbers, can lead to inaccurate assessment results and affect medical staff's decision-making.

Problem 3: Consistency, lack of standardization of statistical caliber and unclear logic of taking numbers. Data

can only be valuable in the right application. During the application process, data rules need to be defined, business needs and data quality requirements need to be translated into executable Structured Query Language (SQL), and SQL code needs to be completed by engineers with database-related skills. In domestic hospitals, most of the medical statistical reports are made by the medical staff to request data from the information center engineers, and there is no platform directly for the medical staff to access and view the data by themselves. On the one hand, engineers lack relevant specialized medical knowledge and do not have a thorough understanding of the requirements, which may easily lead to errors in taking statistics. On the other hand, different medical personnel or unclear expression of each demand, or different engineers involved in the statistics may lead to inconsistency in the caliber of statistics.

For example, one of the statistics for the intensity indicator for antimicrobial use is the calculation of the number of days of duration, and an engineer would reasonably assume that the time difference between the end time of the medical prescription and the start time of the medical prescription should be used, see equation 2.

Equation 2：

days of duration = end time of the medical prescription - start time of the medical prescription

However, sometimes the total amount of medication actually dispensed by the doctor's order and the number of days calculated from the daily dosage are not equal to the number of days calculated by the above method. For example, in Table 2, taking one medical prescription for a certain patient as an example, the difference between the start time and the end time of the prescription was 8 days, but the total amount of medication issued by the medical prescription was enough to take 8.5 days. According to the understanding of the definition of the indicator, the duration should be 8.5 days. On the other hand, clinicians and pharmacists, who are professionals, do not have direct access to the detailed data, which in turn makes it difficult to verify the accuracy of the data.

Table 2. Example of doctor's order information for antimicrobial drug use where the total amount of medication actually dispensed is inconsistent with the number of days after the daily dosage has been calculated

Contents of medical advice	Drug Specifications	Each dose	Daily Dose	Start time of medical advice	End time of medical advice	Total amount of dispensing	precession dose
Doxycycline injection 0.1gX1	0.1g	0.1g	2	2022-04-04 10:17:00.000	2022-04-12 9:50:10.753	17	0

Problem 4: Timeliness, frequent changes in policies and norms, hospital statisticians and analysis systems cannot keep up with the changes. Due to the busy daily business of hospitals and irregular management processes, hospital statisticians are not up-to-date with new policies and norms, which is not conducive to their accurate statistics. In addition, most of the hospital HIS systems are purchased from foreign companies, with cumbersome updating processes, poor maintenance services, and inability to respond to changes in business

specifications in a timely manner, which directly affects the quality of source data. For example, in order to strengthen the rational use of drugs, in 2019, the National Health Commission issued the Notice on Continuously Improving the Management of Clinical Application of Antimicrobial Drugs, which proposes to adjust the antimicrobial drug classification catalog every 2 years, and the related types of drugs, levels, and target values will be updated. If these are not updated in a timely manner in the HIS system and the drug system, the statistical data will not correctly reflect the real situation of the relevant indicators, and may even mislead decision-making.

For the indicator of the intensity of antimicrobial use in hospitalized patients, in order to ensure the accuracy of the data, the hospitalized patients in the first page of the case are selected as the denominator in the calculation. In China, the first page of the case is a summary of the diagnosis and treatment of the patient after discharge from the hospital, and it is also the original information of disease classification and medical statistics. The first page of the case includes the basic information of the patient, information of the hospitalization process, diagnosis and treatment information, and cost information, so it can be said that the first page of the case is the essence of the condensed part of the case.The information on the first page of the case can be collected from the hospital medical department, outpatient department, finance department and other departments, and there is also a large amount of information that needs to be filled in by clinicians according to the patient's condition. After filling out, the department of the case home page quality control officer or relevant personnel to carry out the first level of quality control.Case managers and coders prepare disease classification and surgical operation codes, and perform hospital-level quality control of the front page information according to the case content. After the completion of the first page of the case, information managers upload data in a timely manner in accordance with the data transmission interface standards to ensure that the first page of the case data is complete and accurate [24-26].Because the data on the case home page is scrutinized, but with a time delay, the patient of the month in the case home page will not be able to view his/her data until after the 15th of the following month. Although this statistical method ensures the accuracy of the data, the feedback of the problem is relatively lagging behind, and this delay will make the processing effect greatly reduced. In order to assist management in making informed decisions, real-time monitoring and early warning are essential to maximize the value of the data.

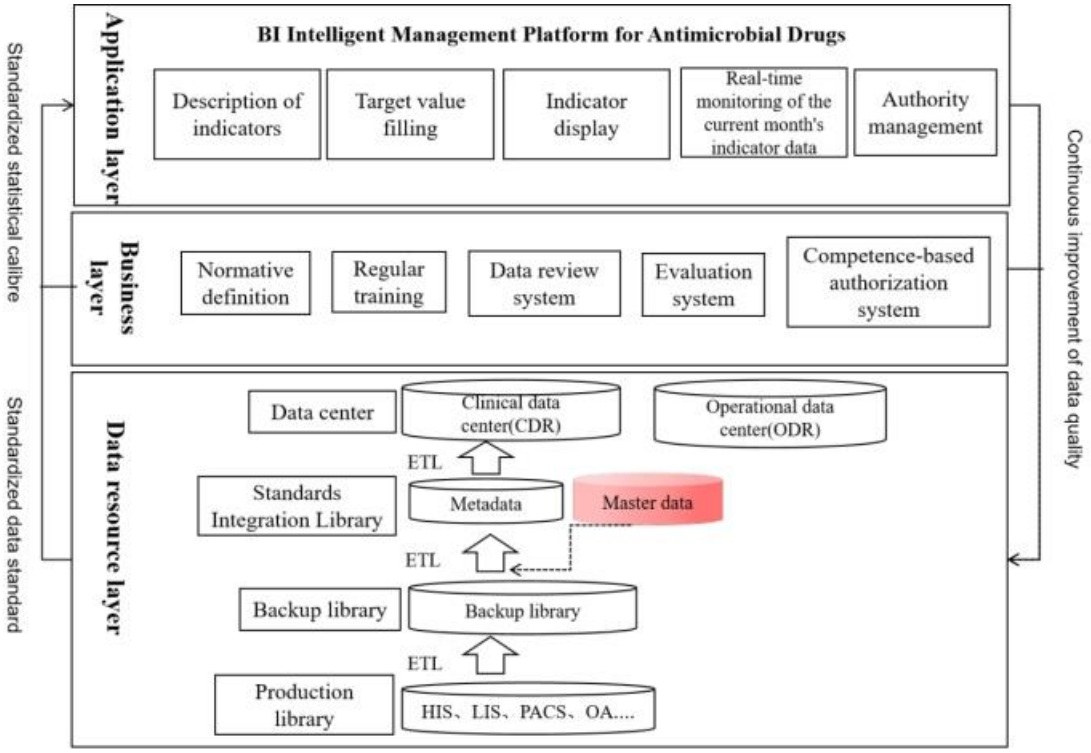
Problem 5: Normative, data standards are not harmonized. There are many business systems in hospitals, with different construction companies and different implementation standards, leading to the phenomenon of data silos. Unstandardized, inconsistent and redundant data cannot be shared with other information systems, making data integration, merging and correlation difficult to process efficiently. Medical quality indicators usually need to get data from various systems such as HIS, EMR, LIS, OA, etc. For example, a certain hospital needs to get the basic information of patients from the case home system to get the number of patient days in the same period of time for the statistics of inpatient antimicrobial drug intensity indicators, and the data are stored in the Oracle database; to get the patient's medical prescription from the inpatient doctor's station system, and the data are stored in the SQL The data source is stored in SQL Server database; the data source is stored in SQL Server database; the data source is stored in MySQL database; the data source is stored in MySQL database; the data source is stored in MySQL database; the data source is stored in MySQL database; the data source is stored in

MySQL database; the data source is stored in MySQL database; the data source is stored in SQL Server database. These data are heterogeneous, multi-sourced and stored on different servers, and cannot be directly counted.

Prescription

In order to solve the data quality problem of the intensity of antimicrobial use in a certain hospital, the hospital's quality control office took the lead, and joined hands with the information center and the pharmacy department to discuss and develop a solution. By unifying the data storage mode, integrating the data resources, standardizing the statistical caliber, formulating the assessment system, and improving the management process, the BI intelligent management platform for the intensity of antimicrobial drug use was finally designed and realized, as shown in Figure 1.

Figure 1. Antimicrobial Drugs BI Intelligent Management Platform Overall Architecture Diagram



Unify data storage models and integrate data resources

The platform extracts data from each business system and formats the data from multiple heterogeneous sources before storing it in a unified PostgreSQL database as a backup repository. Data fusion is then performed to generate complete master data information, which is subsequently distributed to each business system to ensure the accuracy and completeness of such information in each system. Establish rules for data normalization, extraction, and conversion in conjunction with master data formats. During the ETL process, data needs to be cleaned, validated, such as character legitimacy, date data format, numeric value legitimacy, etc., and converted correctly. The error dataset is also created, where isolated information that cannot be matched and data that fails to be converted are added and manually processed. The data that are processed successfully are entered into the standard integration library. On the basis of the standard integration library, data sources are analyzed according

to the requirements, standardized standard models are used to govern the data, and the data center of the healthcare organization is finally established. Take antimicrobial drug use intensity indicators as an example, in response to the data normalization issues (Problem 5) in the "Problem Analysis" subsection, according to the official documents to standardize the definition of indicators and statistical caliber, establish a view, screen out the data required for antimicrobial drug use intensity indicators from each information system of the hospital, remove duplicated data, replenish the missing values, and mark the abnormal values, so as to ensure the accuracy and completeness of the data. Heterogeneous multi-source data is transformed into a unified format and stored in a postgreSQL database in the data center, which facilitates data integration and analysis at a later stage.

Standardize the caliber of statistics and clarify the logic of taking numbers

First, all departments of the hospital interpreted the definition of the indicator of the intensity of antimicrobial drug use based on the national document on quality control indicators for medical institutions, and at the same time determined the location of the data involved in the calculation of the indicator in the HIS system.Second, the implementation department (e.g., information center) determines the corresponding database fields and specifies the logic and statistical methods for each item. Finally, the supervisory department (e.g., QAO) supervises whether the implementation process is standardized, verifies the statistical results, and displays the definitions of the indicators and the statistical methods on the platform, which is accessible to every legitimate user, and provides timely feedback to the supervisory department if there are any problems.

For the problem of statistical specification of compound drugs (Problem 1) in "Problem Analysis" subsection, adoption of a unit conversion scheme at the data governance level, on the one hand. The dosage data field in the medical prescription is first judged, and if it is not the unit of the main drug, it is converted accordingly. For example, the drug specification of Sample 4 (Elidel) Linezolid Glucose Injection in Table 1 is 0.2g:100ml, the main drug is 0.2g, and the value of the dosage data field in the doctor's order is 300ml, which is inconsistent with the unit of the main drug, which will be converted to equivalence and then participate in the calculation, i.e. 300/100×0.2=0.6.On the other hand, at the level of data generation, the HIS system has been improved to restrict user input, with drug units changing from user-editable input to drop-down box selections, while the range of selections in the drop-down box is linked to the type of drug, so that data problems caused by manual misinputs can be avoided, and regular training has been provided to medical staff to improve their digital literacy.

As for the algorithm of the number of days (Problem 3) in "Problem Analysis" subsection, the actual amount of medication dispensed and the daily dosage were selected as more accurate and reasonable due to the lack of precision in filling in the end time and the start time in the doctor's order. In this process, it is necessary to consider the consultation process and the actual situation of the patient, the total amount of medication dispensed in the doctor's orders, but it is necessary to further determine whether the patient has already paid, and whether there is any pre-returned dose. The final equation 3 for calculating the number of days is as follows:

Equation 3：

Duration days = (total paid dispensing － pre-returned dose) / daily dosage

In response to the problem of interdisciplinary patient data processing (Problem 2) in "Problem Analysis" subsection, under the premise that there is no corresponding field marking in the database, it is possible to decide the department to which a patient belongs by checking the use of his bed within the statistical time period according to the bed table in the HIS system, so as to realize that patients' inpatient hospitalization is based on the statistics of the corresponding data of the actual department, and that the index data are more precise, so as to realize the assessment of each department in a reasonable and fair manner.

In response to the problem of inconsistent algorithms of various systems for public basic information (Problem 2) in "Problem Analysis" subsection, based on the data center, the algorithm standard is unified, and a new table is built to store the results as a unified export, so as to solidify the foundation for the application of medical and health big data.

Visualization of data for real-time monitoring and early warning

Since the human brain processes visual information 10 times faster than textual information, summarizing complex data in charts and graphs ensures that it can be understood, and accepted, much faster than a confusing report or spreadsheet. Big data visualization can use rich and meaningful graphical means to represent the various indicators, decision makers can easily understand the various data through these charts, find patterns and problems, so as to make scientific and accurate decisions. The platform utilizes a combination of data analysis technology and graphic technology, utilizing FineBI's various visual data presentation formats, including but not limited to dot line charts, bar charts, dashboards, pie charts, and tables. The B/S architecture serves as the foundation for data analysis and visualization. According to the definition of indicators, data can be statistically analyzed, drilled down and drilled through, screened and filtered, pivoted, geographically analyzed, advanced calculations and other operations to achieve a three-dimensional presentation of data. Year-on-year and year-on-year comparisons of historical antimicrobial drug data and analysis of indicator trends help users see multiple attributes of indicator data. At the same time, multiple dimensions of statistical analysis of indicators, all-round to meet the needs of fine-tuned management of medical institutions. The time dimension supports annual, monthly, quarterly, days, and the scope dimension supports to departments, medical groups, and individual doctors, as well as the detailed data query of each index. A module is set up in the platform to fill in the target values of the indicators, and the target values are scientifically formulated according to the requirements of official documents and the disease spectrum of each department for monitoring and comparison, as a basis for performance assessment.

In response to the problem of delayed antimicrobial use intensity data for hospitalized patients raised (Problem 4) in "Problem Analysis" subsection, increase the display of real-time antimicrobial use intensity data for the current month, and obtain patient information for the current month from the HIS system. Risk warning is set for abnormal data to notify the staff to take measures in time, so that the problem can be solved during the patient's stay in the hospital to optimize the operation mechanism of the medical institution.

Independent research and development, efficient and high-quality services for doctors and patients

Hospitals to improve their own information systems research and development capabilities, able to match the work of the hospital to design and develop the appropriate software platform to support, can respond to various changes in a timely manner, to avoid outsourcing of a variety of issues. Technically solving the pain points and slots in the work of medical staff can improve the operational efficiency of hospitals and enhance the patient experience.

For example, regarding the intensity of antibacterial drug use indicator, the platform has increased data analysis from different perspectives, such as statistical analysis by drug type, department, and medical group, to fully leverage the advantages of independent research and development and the value of data, better meeting various needs. With regard to the timeliness issue mentioned (Problem 4) in "Problem Analysis" subsection, the independent research and development team can respond to policy changes promptly.

The platform customizes the permission management module so that only users who meet the conditions and complete the application process can become legitimate users of the platform. At the same time, it sets roles and assigns permissions according to users' responsibilities, clarifies the scope of data that can be used, and does a good job of data security management.

Iterate the development process to ensure data quality

The PDCA cycle management model [27] is used throughout the construction of the BI intelligent management platform for the rational application of antimicrobial drugs, and testing is conducted after development is completed, with a focus on checking data quality. Mobilizing clinicians, nurses, pharmacy, medical department, quality control office are all involved in the trial run of the platform, submit problems and suggestions to the Zendo system management in a timely manner, the development engineers to confirm and fix the problem, the author to verify the fix results and close the problem. This is repeated over many rounds of iterations to gradually improve the quality of the data and continuously improve the functionality of the platform.

Ethical Considerations

When using hospital data for scientific research, firstly, we are conducting the research jointly with the hospital and have already communicated with the hospital to obtain the permission to use the data without conflict of interest. Secondly, we strictly comply with relevant laws and regulations and ethical guidelines when using the data. At the same time, permission control is adopted to ensure that patient data privacy and confidentiality are fully protected, including secure data storage, encryption technology and access control measures.

Results

Since the rational application of antimicrobial drugs BI intelligent management platform was put on line in January 2021 in a certain hospital, the data related to the intensity of antimicrobial drug use have been effectively governed, the quality of the data has been unanimously recognized by the whole hospital, and the value of clinical DDD has significantly decreased, with remarkable effects, as follows:

Improving data quality and enhancing the value of data use

In the process of data cycle governance, we take a variety of measures to govern the data to improve data quality, pay attention to the problems in each link and different dimensions, and give effective countermeasures, as well as verifying the effectiveness of countermeasures in practice and solving problems practically, so as to lay a solid foundation for the application of healthcare big data in the fields of clinical assisted decision-making, scientific research, patient health monitoring, and drug R&D.Taking the data problem caused by wrong input of antimicrobial drug dosage unit mentioned in the “Problem Analysis” subsection as an example, this paper takes corresponding countermeasures for such problems.A comparison of the monthly 2022 DDDs values for the 2 typical error-prone drugs in Table 1 before and after data governance is presented in Table 3.From the data in Table 3, it can be seen that before data governance, Sample 1 and Sample 4 medicines would have large DDDs due to the unit problem, and after the governance, they generally decreased, which is consistent with the situation analyzed in Table 1.

Table 3. Comparison of DDDs values before and after unit error-prone drug data governance

Drug code	**01230070(Sample1)**		**012300704(Sample4)**	
Unit conversion	**Before**	**After**	**Before**	**After**
2022-01	6391.75	139	106	40.67
2022-02	16273	112	32.5	15.5
2022-03	6709	122.5	22109	30.83
2022-04	6778.67	52.5	42544	22.5
2022-05	358	73	102.5	38
2022-06	169	59	16	6
2022-07	120.5	61	-	-
2022-08	102.5	35.5	35.5	14.67
2022-09	18884	83.5	-	-
2022-10	116	42	36.5	16
2022-11	258.5	86	-	-
2022-12	8366	33.5	-	-

“-” indicates that there is no utilization data for the drug in the current month.

Effectively promote the rational use of antimicrobial drugs

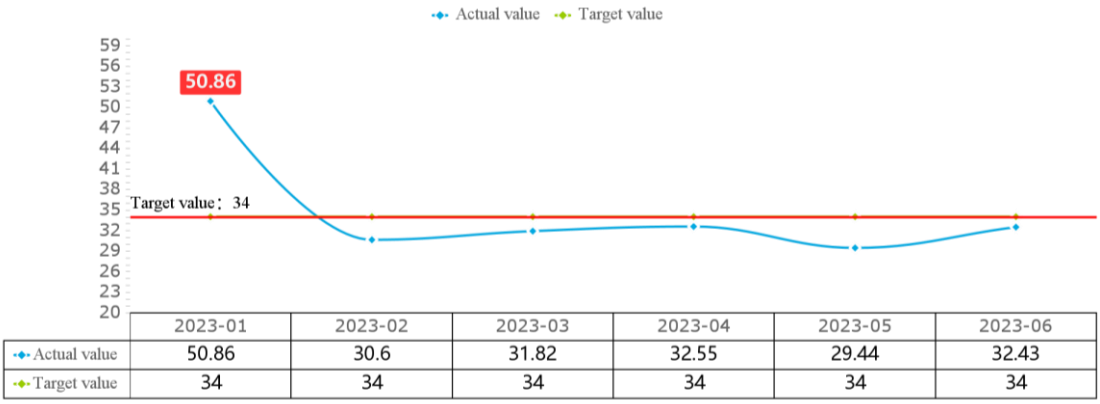
Before the platform went live, the hospital-wide antimicrobial use intensity value was 38 in 2021, and after the platform went live, it decreased to 35.13 in 2022 and 34.4 in 2023 as of the end of June. On the other hand the target value for the intensity of antimicrobial use was also adjusted from 38.5 in 2021 to 34 in 2023.Specifically, as shown in Table 4, it can be seen that the use of antimicrobial drugs is under continuous optimization after the platform goes live.In response to the temporary non-attainment of the indicator by the end of June 2023, the platform can be accessed to view the specific monthly data (see Figure 2), which shows that the indicator value

of the intensity of antimicrobial use in January 2023 reached 50.86, which exceeded the target value and was marked in white on a red background as a warning, while the other months were all below the target value.Functional supervisory section receives the warning and then promptly understands the situation, the high data for this indicator is due to the January 2023 New Crown outbreak and the winter flu, which led to a large number of people contracting pneumonia and the need to use antimicrobial drugs. By using the platform to view the DDDs summarized by drug type in January 2023, Table 5 lists the use of selected drugs in ascending order of total consumption, and it can be found that the top 10 are drugs commonly used for the treatment of pneumonia [28-30], which is in line with the actual situation of the hospital survey, which also proves the accuracy of the platform's data.

Table 4. The actual value of the intensity of antimicrobial use in the hospital as a whole and the target value set by the hospital in the last 3 years

	2021	**2022**	**2023（As of the end of June）**
Actual value	38	35.13	34.4
Target value	38.5	37.5	34

Figure 2. Monthly Hospital-Wide Antimicrobial Use Intensity Data, 2023



	2023-01	2023-02	2023-03	2023-04	2023-05	2023-06
Actual value	50.86	30.6	31.82	32.55	29.44	32.43
Target value	34	34	34	34	34	34

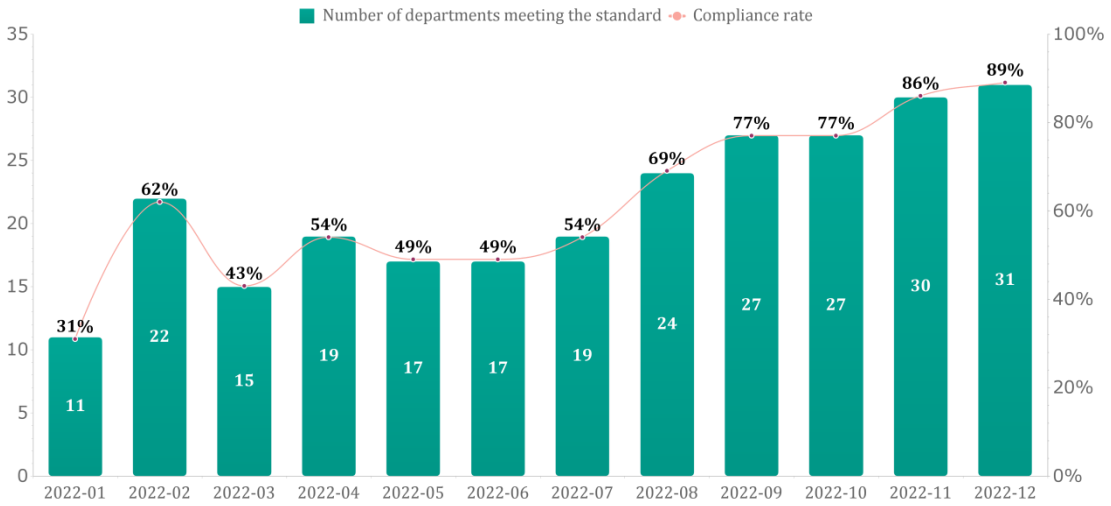
Table 5. 2023-01 Statistics on the use of various classes of antimicrobial drugs in descending order of total consumption, based on drug class

Drug code	**Drug name**	**Norm**	**hotkey**	**Total usage**	**DDDs**
011102115	(Percocet)Piperacillin	2.25g(8:1)	7	28917.61	4131.09

	tazobactam injection				
012200801	0.2g levofloxacin injection (Zocor)	0.2g:2ml	2.5	7180.08	2872.03
011200712	(1g Sulpusan) Cefoperazone Sulbactam Injection	1.0g(1:1)	8	19186.80	2398.35
011200214	(Likensong)Ceftriaxone sodium injection	1g	2	2406.85	1203.43
011200213	Ceftriaxone sodium injection (China)	1g	2	1368.02	684.01
01170051	Imipenem Cilastatin Injection (Tylenol)	500mg:500mg	4	2576.02	644.01
011700853	(Ronan)Meropenem injection	0.5g	6	2677.50	446.25
011201322	(Kefauzou)Cefazolin sodium needle	1g	3	884.40	294.80
011700852	(Shurok)Meropenem injection	0.5g	6	1676.00	279.33
A0140022	(Dafu Kang) Fluconazole Sodium Chloride Injection	100ml:0.2g	1	254.50	254.50
011601036	(Zithromax)Azithromycin injection	0.5g	1	241.67	241.67
01110055	0.3g Amoxicillin sodium clavulanate injection	0.3g(5:1)	12	2750.48	229.21

Not only that, the management has formulated a performance appraisal system with clear rewards and punishments, set target values for each department and conduct monthly appraisals, which effectively promotes the rational use of antimicrobial drugs in the clinic. As shown in Figure 3, since the platform went online in 2021, 35 departments in the hospital, the number of departments meeting the standard has gradually increased each month, and the rate of meeting the standard has steadily increased. It can be seen that after the platform went online, it standardized the use of clinical antimicrobial drugs and improved the level of rational use of antimicrobial drugs in clinical departments.

Figure 3. Hospital-wide compliance for 35 departments in 2022



Significantly improve the efficiency of medical staff

Before the platform went live, staff who needed data related to the intensity of antimicrobial use needed to communicate their needs to the information center engineers each time, which took about 10min.Engineers according to the demand, each time you need to re-code the query data in the database, about 15min ~ 20min, the whole process takes about 25min ~ 35min. so repeat the cycle, the process is cumbersome and inefficient. At the same time, as there is no breakdown data to track, the data is not convincing and there is no timely and effective monitoring intervention if there is any abnormality. After the platform is online, the staff only need to log in to view the platform, the average time consumed is 2min, which greatly improves the work efficiency, reduces the manual statistical work, and reduces the cost of data management. At the same time there is relevant detailed data can be tracked, common supervision.

Highly customized to help hospitals grow in all directions

Before the platform went online, due to the lack of an overall level management mechanism in hospitals, data standards were managed by multiple departments, there was a lack of coordination mechanism, the focus of staff in each department on the indicators of intensity of antimicrobial drug use varied, and there were multiple sets of standards in implementation, which made it easy to confuse and make mistakes in statistics. After the platform was launched, it was comprehensively considered and different versions were customized for each department to meet their daily needs. All departments can obtain the data they need through the platform, which solves the problem of a multitude of opinions.

Continuous improvement of the quality of medical services

Through the platform monitoring function real-time check indicator data, found exceeding the standard or can be deactivated cases, directly to the doctor's feedback, the platform on-line before can only be checked through the clinical department after the submission of medical records, after the on-line during the hospital can be timely intervention, significantly improve the quality of medical services. At the same time, clinicians are regularly trained and examined, which is included in the performance appraisal, to improve their operational quality and standardization of operation.

Conscientiously safeguard data security

Prior to the launch of the platform, there was no uniform path to obtain data, so medical staff had to ask the information center engineers for data when they needed to use it.At the same time, due to the lack of clear data management rules and regulations, information center engineers can not accurately determine whether the person who raises the demand has the authority to use the data, and for the sake of colleagues, it is difficult to refuse, and most of the time they will provide the data according to their requirements, so it can be seen that there is a hidden data security problem in this way.After the platform was put on line, a data management system was formulated to provide a path to access the data, requiring users to apply for permissions according to the process by themselves with reference to the system, and then to access the data by becoming a legitimate user of the platform after passing the approval process, which has perfectly solved the above problems.

Discussion

Principal Findings

Through the research of this paper, it is found that the establishment of a data center and the development of a BI intelligence platform can make data visualization and transparency, on the one hand, provide managers with auxiliary decision-making, improve the quality of medical services, and improve the operational efficiency of hospitals.On the other hand, it indirectly mobilizes all staff to look at the data holistically from different perspectives, as they are both users and producers of data. This makes it easier to identify problems and solve them.The focus of data governance should not only be on the data itself, but also on business processes, statistical calibers, and the mutual collaboration of multiple organizations and institutions. The technology-driven basis requires the joint participation of personnel from all departments of the institution, especially data-using and supervisory departments, as well as the enhancement of digital literacy of the entire staff, whose main issues and experiences are summarized below:

1. It is important to standardize the statistical caliber of data in data applications.Although the definition of the indicators for assessing the quality of healthcare is unique in the policy document, the different information systems of each healthcare organization lead to the same data item in the definition of the indicator being distributed in different parts of the system. On the other hand, the different understanding of the indicators in each healthcare organization also leads to inconsistent statistical methodology, e.g., the method of calculating the age of the child in the analysis of the problem, the interdisciplinary problem, and the method of calculating the number of days of duration in the indicator of the intensity of antimicrobial drug use.Therefore, when using statistical data indicators, it is necessary to determine the logic and statistical methodology based on a full understanding of the definition of the indicators and in accordance with the construction of the respective information systems, while accepting the testing of the statistical results by the entire staff, so as to correctly utilize the value of the data and provide scientific and accurate decision-making for the administrators.

2.Heavy on applications, light on data quality. On China policy, the state requires healthcare organizations to report data on various healthcare quality indicators on a regular basis, but all of them only provide a generalized result and do not require breakdown data. In the electronic medical record rating and evaluation process, the

requirements of various application function points are relatively detailed, but only the data of the last three months are required to meet the standard, so medical institutions only require data that can be delivered for these indicators, and the quality of the data is not sufficiently emphasized. In addition, improving data quality is a long-term project [31,32], many medical institutions in the construction of information systems pay more attention to the number of applications, the presence or absence of functionality, while ignoring the role of data, the lack of relevant technical and institutional support, and the inability to form a regular data governance work. To address this type of problem, this paper integrates the data resources of the whole hospital, unifies the planning, establishes the data center, designs and implements the BI intelligent management platform, provides a unified path to support the viewing of multi-dimensional data related to the indexes, and the whole hospital participates in and supervises the quality of the data together. Strictly control every step of the process, including data source, indicator definition, statistical method, data calibration, data maintenance, and regularly adopt the PDCA cycle model for its closed-loop management to provide strong evidence for the improvement of the performance appraisal system.

3.Heavy on slogans, light on practice. Due to the heavy workload of the medical institutions' schedules, many problems have existed for a long time, and although solutions have been formulated for some of these problems and slogans have been shouted loudly, but due to the lack of substantive and effective monitoring measures, the implementation of the program has been unsatisfactory for a long period of time, and the problem has been shelved. In response to such problems, the management process should be improved, execution should be strengthened, and a scientific and reasonable appraisal system should be set up to transform appraisal results into quantifiable indicators.Regular training is carried out to ensure that the relevant personnel know what they should know and understand, the appraisal system is improved, and incentives and penalties are implemented to urge staff to be motivated, and supervisory departments are set up to strictly check the implementation of the program.

4.Heavy on outsourcing, light on independent research and development. Most of the information systems in hospitals are purchased from third-party companies, and most of the various types of information systems are introduced under the leadership of the using departments, with the systems being relatively independent and lacking the awareness and ability to plan and design the data as a whole [33-35].The problems with the outsourcing system are summarized in two ways:First, the system has broad audit conditions, lacks calibration functions, and does not have reasonable control when the data are generated, resulting in poor data quality. Secondly, due to a variety of information systems are constantly built up in recent years, at the beginning of the construction of certain fields of information is not so important, does not belong to the required items, and later with the continuous extension of the medical management business needs, this information becomes mandatory, and the hospital information systems want to keep pace with the needs of the pace of the need for third-party companies to update the maintenance of such a way of the process is cumbersome, the cycle is long, and often no end, which leads to frequent information systems design lagging behind the actual needs. With the development of Internet hospitals and smart hospitals, such problems are becoming more and more significant. Therefore, hospitals are encouraged to improve their ability to conduct independent research and development to facilitate subsequent updates and maintenance. And for the same theme of the data due to the various

departments concerned about the perspective, management differences lead to inconsistent caliber, at this time, independent research and development can be customized to meet the needs of various departments to meet the requirements of the hospital's all-round development.

Comparison with Prior Work

Good data quality is to ensure that medical big data to play its role in the foundation, at present China's health care big data quality evaluation of the relative lack of research, although the "data governance" concept has been involved in the medical field, China's policy to carry out a large number of studies [36,37], hospitals to carry out the data governance work is generally based on the big data platform or data warehouse construction, the use of big data-oriented governance model [38], such as the first hospital affiliated with Sun Yat-sen University using the "data center" technology, to the subject data as a clue to data governance, and achieved certain results[39];Guangzhou Women's and Children's Medical Center (GWCMC) uses the data governance cycle Plan-Do-Check-Action (PDCA) framework for multi-level data governance based on the construction of specialty databases to form a specialty data asset and scientific research data platform [40].On the other hand, there are fewer studies on the evaluation of big data in healthcare in China, and the main research focuses on improving data quality in healthcare organizations from a management perspective. The study [41] pointed out that the data quality problem is one of the core problems in hospitals, it cannot be solved only by the information department, and it needs the leadership to coordinate and unify all departments, strengthen the communication and collaboration between departments, establish a hospital sharing platform, reduce duplicate entries, and reduce the workload of healthcare workers.In addition, the study [42-45] pointed out that relevant review and supervision mechanisms should be established to strengthen the sense of responsibility of each health care worker, the implementation of accountability at all levels, and the relevant responsible personnel to give relevant disciplinary measures.

It can be seen that many studies have focused on the theoretical aspects of data quality, while the discovery of data quality problems lags behind and lacks real time, and there is less on how to implement these theories into quantifiable practical experience.This paper not only analyzes the problems in the process of the full life cycle of data in theory, but also verifies and visualizes them in practice. The establishment of the platform can monitor the data in real time, comprehensively grasp the trend of the indicators, and provide timely warning of abnormalities and prevent them from occurring.

Limitations

This study had some limitations. First, this paper's analysis and countermeasures for big data issues in healthcare are based on the general context of Chinese healthcare, where culture, social needs, and healthcare service environments can vary, but many issues are generic and worthy of reference. Therefore, in order to eliminate these differences as much as possible, we have a detailed analysis process and summary overview of each type of problem in the paper.Secondly, some of the factors affecting data quality in the article are data source problems, which need to improve the HIS system in order to be effectively solved. Since some of the HIS

systems are outsourced, the maintenance process is cumbersome in the later stage, and approvals are needed, and the whole process takes a period of time, the results cannot be quantitatively verified for the time being, and we can only repair the data as much as possible and improve the value of the data at the data governance level.

Conclusions

Along with the digital transformation of healthcare, more and more data is being collected. Data quality is like the foundation, which cannot be seen when it is buried in the ground, but it is the foundation of the building. If the foundation is not solid, the ground will be shaken. Without a good data quality, data utilization and development will not be able to play its value. Therefore, healthcare organizations must correctly recognize the value of data, manage data assets and strengthen data governance.The data problem of antimicrobial drug use intensity indicator in this paper is just a small microcosm of healthcare big data, and the study of its data quality improvement has guiding significance for healthcare big data governance.

Hospital data governance is neither a matter of several departments nor a purely technical issue, but involves many aspects of the overall management of the hospital, including work systems, processes, standards, mechanisms, etc., and is a long-term and complex systematic project. Therefore, hospital administrators should take multiple measures to manage data quality, identify the current status of data quality in the hospital, analyze the reasons for the problems in-depth, and put forward targeted measures to solve the problems, so as to realize scientific and refined management of the hospital and guarantee the in-depth fusion of big data, artificial intelligence and clinical decision-making.

Acknowledgements

This investigation was supported by the program of 2023 Visiting Engineer Program for Universities and Colleges "University-Enterprise Cooperation Program" (FG2023320) and the key incubation program of Taizhou Vocational College Of Science & Technology(23ZD05).

Data Availability

Data sets generated and/or analyzed during this study are not publicly available due to patient privacy concerns, but are available from the corresponding authors upon reasonable request.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Some process information of PDCA cycle management and related functions of BI intelligent management platform for antimicrobial use intensity are shown.

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