



Applied Data-Analytics Approaches to Cardiovascular Drug-Utilization Patterns: An Empirical Study Using Real-World Pharmaceutical Sales Data

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Abstract

This study examined the application of data analytics to cardiovascular drug-utilization patterns using real-world pharmaceutical sales data. Although cardiovascular medicine sales records are widely used for commercial monitoring, they are rarely transformed into empirical evidence to support healthcare and pharmaceutical decision-making. The study aimed to identify major cardiovascular therapeutic-class utilization patterns and examine the effects of sales volume, prescription demand, affordability, market availability, physician prescribing behavior, therapeutic class, and data-analytics capability on cardiovascular drug utilization. A quantitative, cross-sectional, case-based research design was adopted using a selected pharmaceutical enterprise and market case. Primary survey data were collected from 236 respondents, including pharmacists, pharmaceutical sales representatives, pharmacy managers, physicians, healthcare professionals, and pharmaceutical data officers. In addition, 18,420 cardiovascular drug-sales transaction records representing 126,800 units and BDT 18,760,000 in total sales revenue were analyzed. Data analysis included descriptive statistics, therapeutic-class mapping, correlation analysis, and multiple regression modeling. The results indicated a high level of cardiovascular drug utilization ($M = 4.08$, $SD = 0.61$). Prescription demand recorded the highest mean score (4.21), followed by physician prescribing behavior (4.17), market availability (4.13), sales volume (4.09), data-analytics capability (3.94), and affordability (3.86). Antihypertensives represented the largest utilization share (34.6%), followed by statins (22.8%), antiplatelets (15.4%), beta-blockers (10.7%), calcium-channel blockers (7.9%), diuretics (5.1%), anticoagulants (2.6%), and other cardiovascular medicines (0.9%). Correlation analysis showed significant positive relationships between cardiovascular drug utilization and prescription demand ($r = .71$), sales volume ($r = .68$), market availability ($r = .64$), physician prescribing behavior ($r = .62$), affordability ($r = .49$), and data-analytics capability ($r = .46$) ($p < .001$). Multiple regression demonstrated strong explanatory power ($R^2 = .62$; adjusted $R^2 = .60$), supporting all seven hypotheses. The findings highlight the value of sales-data analytics for improving demand forecasting, inventory planning, affordability monitoring, and evidence-based cardiovascular medicine utilization decisions.

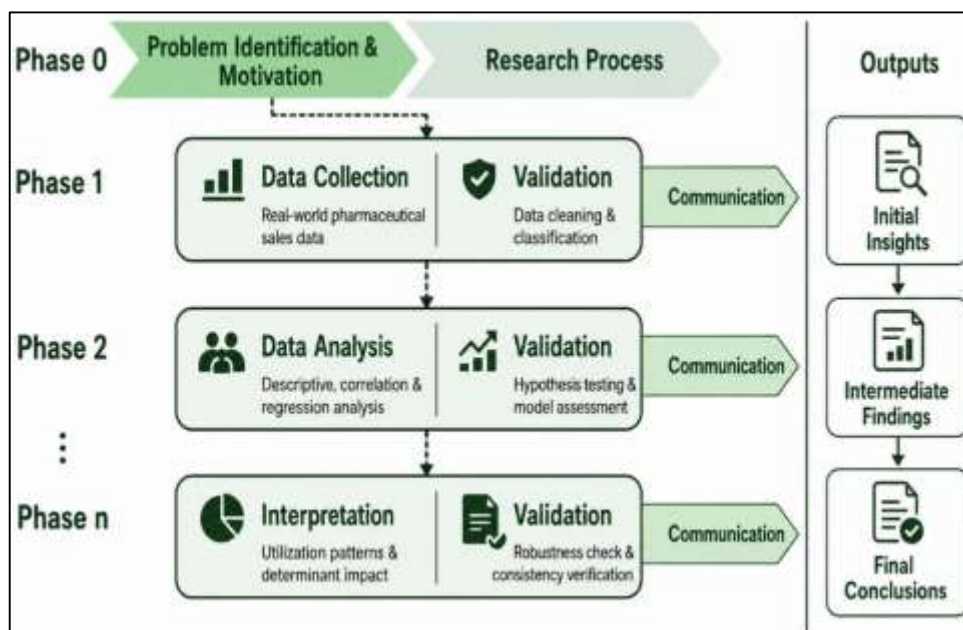
Keywords

Cardiovascular Drug Utilization, Real-World Pharmaceutical Sales Data, Applied Data Analytics, Prescription Demand, Therapeutic-Class Mapping.

INTRODUCTION

Cardiovascular drug utilization refers to the pattern, frequency, intensity, continuity, and therapeutic-class distribution of medicines used for the prevention, treatment, and long-term management of cardiovascular diseases. In the context of this study, cardiovascular drug utilization includes the movement and use of antihypertensive medicines, lipid-lowering agents, antiplatelet drugs, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, renin-angiotensin system inhibitors, and other cardiovascular medicines that appear in real-world pharmaceutical sales data. Drug-utilization research is concerned with how medicines are prescribed, supplied, dispensed, purchased, and repeatedly used within a healthcare or market setting. Real-world pharmaceutical sales data refer to routinely generated sales records collected from pharmacies, distributors, hospitals, wholesalers, retail outlets, or pharmaceutical companies. These records may include drug name, therapeutic class, brand type, generic status, sales quantity, sales value, unit price, sales period, and stock movement. Applied data analytics refers to the use of statistical and analytical methods to convert such raw sales information into meaningful evidence about utilization patterns. In this research, descriptive statistics, correlation analysis, and regression modeling are used to examine cardiovascular medicine demand, affordability, market availability, prescription behavior, and sales-based utilization. Cardiovascular drugs are especially suitable for this type of empirical analysis because cardiovascular diseases usually require long-term pharmacological management and repeated medicine purchasing. The international importance of cardiovascular medicines is connected with the global burden of hypertension, ischemic heart disease, stroke, heart failure, and other cardiovascular conditions, which continue to create large-scale demand for long-term pharmacotherapy across different healthcare systems (Roth et al., 2020). Cardiovascular medicine utilization also varies across countries because access, affordability, prescription practice, patient adherence, and healthcare infrastructure are not equal in all settings (Chow et al., 2013; Hsia et al., 2018; Yusuf et al., 2011). Therefore, real-world sales data can provide practical evidence of how cardiovascular medicines actually move through the pharmaceutical market. Such evidence is important because routine healthcare and pharmaceutical databases can reveal treatment behavior, therapeutic pathways, and medicine-use patterns outside controlled clinical trial environments (Benchimol et al., 2015; Hripcsak et al., 2016; Schneeweiss & Avorn, 2005; Sherman et al., 2016).

Figure 1: Applied Data-Analytics Framework for Cardiovascular Drug-Utilization Patterns Using Real-World Pharmaceutical Sales Data



The international significance of cardiovascular drug-utilization research is strongly associated with the global scale of cardiovascular disease and the dependence of cardiovascular care on continuous medicine use. Cardiovascular diseases have remained among the leading causes of premature death, disability, and healthcare expenditure in high-income, middle-income, and low-income countries (Roth et al., 2020). Hypertension, dyslipidemia, coronary artery disease, stroke, and heart failure require regular drug therapy, and these conditions create sustained demand for cardiovascular medicines across both public and private pharmaceutical channels. Global studies on blood pressure have shown substantial variation in hypertension prevalence, awareness, treatment, and control across regions, which means that cardiovascular drug utilization cannot be explained only by clinical need (Chow et al., 2013; Collaboration., 2017; Mills et al., 2016). The actual use of cardiovascular medicines also depends on whether medicines are available, affordable, prescribed, accepted, and repeatedly purchased. Evidence from multinational cardiovascular prevention research has shown that the use of essential secondary-prevention medicines, such as antiplatelet drugs, beta-blockers, angiotensin-converting enzyme inhibitors, and statins, differs greatly across income groups and healthcare systems (Yusuf et al., 2011). Such variation makes sales-based utilization analysis important because pharmaceutical sales data can show whether expected cardiovascular medicine demand is reflected in actual market movement. The use of cardiovascular medicines is also shaped by modifiable risk factors, healthcare access, and treatment continuity, which have been shown to differ across countries and populations (Yusuf et al., 2020). In this context, cardiovascular drug-utilization research has an international value because it connects disease burden with medicine access, market availability, affordability, and prescription-linked demand. Real-world sales records can show therapeutic-class-level movement, high-demand drug groups, low-utilization medicine categories, and possible gaps between clinical need and actual drug purchase. When these records are analyzed using applied data analytics, the researcher can move beyond simple sales reporting and examine how utilization patterns are statistically connected with explanatory factors such as prescription demand, affordability, market availability, therapeutic class, physician prescription behavior, and data-analytics capability.

Cardiovascular drug utilization is also important because cardiovascular therapy is highly class-specific and often involves long-term or lifelong medication. Antihypertensive medicines are used to manage blood pressure and prevent complications such as stroke, heart failure, myocardial infarction, and kidney disease. Statins and other lipid-lowering medicines are used to reduce cardiovascular risk associated with dyslipidemia and atherosclerosis. Antiplatelet and anticoagulant medicines are used to reduce thrombotic and embolic risk, while beta-blockers, calcium-channel blockers, diuretics, and renin-angiotensin system inhibitors are used across several cardiovascular indications. This class diversity means that cardiovascular medicines should not be treated as one uniform product group in sales-data analysis. A trustworthy utilization study needs therapeutic-class mapping so that the researcher can identify whether antihypertensives, statins, antiplatelets, anticoagulants, or heart-failure medicines show the strongest sales movement and utilization intensity. Studies on cardiovascular prevention and coronary care have shown that evidence-based medicine use and risk-factor control remain uneven across patient groups and countries (Kotseva et al., 2016; Yusuf et al., 2011). Research on post-myocardial-infarction pharmacotherapy has also shown that long-term use of beta-blockers, angiotensin-converting enzyme inhibitors, and statins is a major part of cardiovascular treatment, but medication continuation and compliance vary across patients and over time (Gislason et al., 2006; Rasmussen et al., 2007). Medication adherence is particularly relevant in cardiovascular therapy because medicines usually need to be taken regularly for sustained benefit (Ho et al., 2009; Vrijens et al., 2012). Meta-analytic evidence has shown that adherence to cardiovascular preventive medicines remains incomplete, which creates a gap between prescribed therapy and actual medicine use (Naderi et al., 2012; Nieuwlaat et al., 2014). Real-world sales data can help observe this issue from a market perspective because repeated purchases, stable monthly sales, and consistent therapeutic-class movement can indicate ongoing utilization, while irregular sales movement may indicate affordability problems, product shortage, prescription switching, or weak treatment continuity. Therefore, cardiovascular drug-utilization analysis based on real-world sales data can connect therapeutic class, repeated demand, clinical importance, and market behavior in one empirical structure.

Real-world pharmaceutical sales data provide a strong empirical base for studying cardiovascular drug-utilization patterns because they capture actual medicine movement rather than only intended prescribing or self-reported medication use. Sales records are generated during routine pharmaceutical transactions and often include details that are directly relevant to utilization analysis, such as quantity sold, sales revenue, unit price, product category, brand status, generic status, and time period. These data can show which cardiovascular medicine classes dominate the market, which products are sold most frequently, which medicines produce higher revenue, and which price ranges are linked with stronger or weaker utilization. Routine healthcare and pharmaceutical databases have been widely recognized as useful sources for therapeutic and epidemiological research because they provide large-scale evidence on real-world treatment behavior (Schneeweiss & Avorn, 2005). Real-world evidence has also become important in healthcare research because it helps researchers understand treatment patterns, product uptake, and healthcare decision-making outside randomized controlled trials (Sherman et al., 2016). In the field of cardiovascular medicine, this is especially relevant because guideline-recommended medicines may not always be used at the expected level in everyday practice. Real-world studies have shown that actual pharmacotherapy use may vary according to patient population, clinical setting, provider behavior, access conditions, and market environment (Warden et al., 2020). The use of sales data is also relevant for comparing utilization across therapeutic classes and market segments because sales volume and sales value can reveal both demand intensity and economic weight. For example, a drug class may have high unit movement but lower revenue because of lower price, while another drug class may have lower unit movement but higher sales value because of higher price. This distinction is important in cardiovascular medicine because long-term affordability can influence repeated use. When sales data are combined with structured Likert-scale responses from pharmacists, pharmacy managers, pharmaceutical sales representatives, physicians, and pharmaceutical data officers, the study can compare observed market behavior with professional perceptions of demand, affordability, prescription frequency, and availability. This creates a stronger empirical foundation because the research does not rely only on opinion-based survey data or only on commercial sales records. Instead, the two forms of evidence can be analyzed together through descriptive statistics, correlation analysis, and regression modeling.

Affordability, market availability, and prescription demand are major determinants of cardiovascular drug-utilization patterns because cardiovascular medicines are often required for long periods and repeated purchases. Patients with hypertension, coronary artery disease, dyslipidemia, heart failure, stroke history, or atrial fibrillation may need daily medicine for months or years. As a result, even small changes in medicine price, stock continuity, prescription preference, brand availability, and generic substitution can influence actual drug utilization. International studies have shown that essential medicines for chronic diseases are not equally available or affordable across low-income and middle-income settings (Cameron et al., 2009; Mendis et al., 2007). Cardiovascular medicine access has also been shown to vary significantly across countries, and affordability and availability have been associated with medicine use and blood-pressure control (Attaei et al., 2017; Khatib et al., 2016). Such evidence supports the inclusion of affordability and market availability as key variables in this study. In a sales-based analysis, affordability may be reflected through higher movement of low-cost medicines, generic products, or brands with smaller pack sizes, while weak affordability may appear through lower repeat sales of high-cost medicines. Market availability may be reflected through stable sales movement, consistent stock presence, and uninterrupted distribution across the selected sales period. Generic substitution is also relevant because many cardiovascular medicines have generic alternatives. Evidence from a systematic review and meta-analysis has shown that generic and brand-name cardiovascular drugs have broadly comparable clinical effects, which makes generic availability important for affordability-sensitive cardiovascular drug utilization (Kesselheim et al., 2008). Prescription demand is another important factor because many cardiovascular medicines are prescription-driven and influenced by physician decisions, treatment guidelines, patient condition, and brand familiarity. Therefore, physician prescription behavior can shape which therapeutic classes and brands move more strongly in the pharmaceutical market. In the present study, prescription demand, affordability, market availability, and physician prescription behavior are included as explanatory

variables because each of them can influence actual cardiovascular medicine utilization. The combination of these factors allows the study to examine cardiovascular drug utilization as both a healthcare-use issue and a pharmaceutical market behavior issue.

Applied data analytics is central to this research because raw pharmaceutical sales data cannot provide strong academic evidence unless they are cleaned, classified, summarized, and statistically analyzed. Descriptive statistics can be used to summarize sales quantity, sales value, therapeutic-class distribution, average Likert scores, standard deviations, and respondent characteristics. Correlation analysis can show whether prescription demand, affordability, market availability, physician prescription behavior, sales volume, therapeutic class, and data-analytics capability are statistically associated with cardiovascular drug-utilization patterns. Regression modeling can show the predictive contribution of these variables and identify which factors have the strongest influence on utilization. The use of routine observational data requires careful reporting, transparent variable construction, and clear data-management procedures because the credibility of findings depends on how the data are processed and interpreted (Benchimol et al., 2015). Large-scale observational data networks have shown that treatment pathways and real-world healthcare practices can be characterized when data are standardized and analyzed systematically (Hripcsak et al., 2016). Research on data extraction and management has also emphasized the importance of coding consistency, cleaning procedures, and database comparability when observational healthcare data are used for scientific analysis (Gini et al., 2016). These methodological ideas are directly relevant to the present study because pharmaceutical sales records may include inconsistent product names, missing values, duplicate entries, overlapping therapeutic classes, price differences, and brand-level variation. Applied data analytics helps the researcher convert these records into analyzable variables such as cardiovascular therapeutic class, sales volume, sales value, price category, market availability, and utilization intensity. The Likert-scale questionnaire adds another analytical layer by measuring professional perceptions of prescription demand, affordability, availability, physician influence, and data-analytics capability. This structure allows the researcher to compare professional perceptions with actual sales patterns. For example, if respondents report that antihypertensive medicines have the highest utilization, the real-world sales records can be examined to see whether antihypertensive sales volume supports that perception. This sales-data consistency and demand-pattern verification makes the results more trustworthy because it connects perception-based evidence with observed sales movement.

The research problem of this study arises from the limited integration of cardiovascular drug-utilization research, real-world pharmaceutical sales data, and applied data-analytics methods in a single empirical framework. Pharmaceutical companies, pharmacies, distributors, and hospital pharmacy systems often collect large volumes of sales data, but these data are commonly used for revenue tracking, stock monitoring, product performance evaluation, and commercial planning. At the same time, many healthcare studies examine cardiovascular prescribing, medication adherence, secondary prevention, hypertension control, and medicine access without directly using sales records as empirical evidence of market-level utilization. This separation creates an important research gap because cardiovascular drug utilization is influenced by both clinical demand and pharmaceutical-market behavior. International studies have shown that cardiovascular medicine use differs across countries, income groups, healthcare systems, and access conditions (Hsia et al., 2018; Khatib et al., 2016; Yusuf et al., 2011). Studies on adherence and long-term outcomes have also shown that cardiovascular treatment success depends on sustained medicine use rather than isolated prescription events (Bansilal et al., 2016; Ho et al., 2009; Naderi et al., 2012; Rasmussen et al., 2007). Methodological studies have shown that real-world data and routinely collected health records can be used to understand treatment patterns when the data are handled transparently and analyzed appropriately (Benchimol et al., 2015; Hripcsak et al., 2016; Sherman et al., 2016). Therefore, the present study focuses on applied data-analytics approaches to cardiovascular drug-utilization patterns using real-world pharmaceutical sales data. It frames cardiovascular drug utilization as the dependent variable and examines sales volume, prescription demand, affordability, market availability, physician prescription behavior, cardiovascular therapeutic class, and data-analytics capability as explanatory variables. The study is also theoretically aligned with Andersen's Behavioral Model of Health Service Use because

medicine utilization can be understood through need-related factors, enabling factors, and actual healthcare-use behavior. In this study, prescription demand and physician prescription behavior represent need-related and clinical-use factors, affordability and market availability represent enabling factors, and sales-based cardiovascular medicine movement represents actual utilization behavior. This theoretical alignment allows the study to connect cardiovascular medicine need, access, and observed market use within one quantitative research structure.

Background of the study

Cardiovascular drug utilization has become an important area of pharmaceutical and healthcare research because cardiovascular diseases usually require long-term, continuous, and class-specific medicine use. Cardiovascular medicines include antihypertensives, lipid-lowering agents, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, renin-angiotensin system inhibitors, and other medicines used for managing hypertension, coronary artery disease, stroke prevention, dyslipidemia, heart failure, and related cardiovascular conditions. Since these diseases are often chronic, patients frequently depend on repeated prescriptions and continuous medicine purchasing, which makes drug utilization a strong indicator of treatment demand, access, affordability, and pharmaceutical market behavior. In many healthcare and pharmaceutical settings, large amounts of sales data are generated every day through pharmacies, distributors, wholesalers, hospitals, and retail pharmaceutical channels. These records contain valuable information about drug class, brand movement, sales volume, sales revenue, unit price, purchase frequency, and product availability. However, such data are often used mainly for stock control, revenue monitoring, or commercial performance evaluation rather than for academic analysis of actual drug-utilization patterns. Applied data analytics can help transform these real-world sales records into meaningful evidence by identifying which cardiovascular drug classes are most frequently used, which categories show stable or irregular demand, which products are affected by affordability, and how sales movement reflects prescription-driven utilization. In this research, cardiovascular drug utilization is examined through a quantitative, cross-sectional, case-study-based approach using real-world pharmaceutical sales data and Likert-scale responses. The study focuses on the relationship between sales volume, prescription demand, affordability, market availability, physician prescription behavior, cardiovascular therapeutic class, and data-analytics capability. By combining descriptive statistics, correlation analysis, and regression modeling, the study creates a structured way to understand how cardiovascular medicine utilization can be explained through both pharmaceutical market data and professional perceptions of drug demand.

Problem statement

Although cardiovascular medicines are widely used in healthcare systems, there is still a lack of structured empirical understanding of how cardiovascular drug-utilization patterns can be explained through real-world pharmaceutical sales data. Pharmaceutical organizations, pharmacies, distributors, and hospital pharmacy units regularly collect sales information, but these records are often treated as commercial documents rather than as evidence for healthcare-related drug-utilization analysis. As a result, important questions remain unanswered regarding which cardiovascular therapeutic classes show the highest utilization, how prescription demand affects sales movement, whether affordability influences repeat purchase, how market availability supports or restricts utilization, and whether data-analytics capability improves decision-making in pharmaceutical sales interpretation. Traditional drug-utilization studies often focus on prescriptions, clinical records, adherence behavior, or patient-level treatment outcomes, while pharmaceutical sales data are not always integrated into the same analytical framework. This creates a gap between clinical drug-use knowledge and market-based evidence of actual medicine movement. In the cardiovascular field, this gap is especially important because patients often require medicines for long periods, and utilization may be strongly affected by cost, stock continuity, brand preference, physician prescribing behavior, and availability of generic alternatives. Without proper analysis, sales volume alone cannot explain whether high sales indicate strong clinical demand, better availability, lower price, repeated prescription, or brand dominance. Similarly, low sales cannot automatically prove low disease burden because it may be related to affordability barriers, supply shortages, weak distribution, or prescription substitution. Therefore, there is a need for a quantitative study that applies descriptive statistics, correlation analysis, and

regression modeling to examine the determinants of cardiovascular drug-utilization patterns. The main problem addressed in this research is the limited use of applied data-analytics approaches for converting real-world cardiovascular pharmaceutical sales data into trustworthy empirical evidence. This study responds to that problem by analyzing the relationship between sales-based indicators and utilization-related factors in a case-study context.

Objectives of The Study

The main objective of this study is to examine cardiovascular drug-utilization patterns through applied data-analytics approaches using real-world pharmaceutical sales data and quantitative survey-based evidence. More specifically, the study aims to identify the major utilization patterns of cardiovascular medicines by analyzing sales volume, sales value, therapeutic-class movement, and category-wise demand within the selected case-study context. It also aims to examine how prescription demand, affordability, market availability, physician prescription behavior, cardiovascular therapeutic class, and data-analytics capability are associated with cardiovascular drug utilization. Another objective is to determine whether real-world pharmaceutical sales data can provide a reliable empirical basis for understanding actual medicine movement beyond general commercial reporting. The study further seeks to classify cardiovascular medicines into therapeutic groups, such as antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, and heart-failure medicines, so that utilization can be interpreted at a more specific class level. In addition, the study aims to compare professional perceptions of cardiovascular drug demand with actual sales-data patterns through sales-data consistency and demand-pattern verification. This objective is important because it allows the researcher to assess whether respondents' views about high-demand or low-demand cardiovascular medicines are supported by real-world sales movement. The study also intends to test the statistical relationships among the major variables through correlation analysis and to identify the strongest predictors of cardiovascular drug-utilization patterns through regression modeling. By fulfilling these objectives, the research provides a structured quantitative basis for explaining how cardiovascular medicines are utilized in a real-world pharmaceutical market setting. The objectives are directly aligned with the research title because they connect applied data analytics, cardiovascular drug utilization, and pharmaceutical sales data within one empirical study. Therefore, the last part of the introduction establishes that this research is designed not only to describe cardiovascular drug sales but also to explain the factors that shape sales-based utilization patterns.

Research hypotheses

The research hypotheses of this study are developed to test the statistical relationships between cardiovascular drug-utilization patterns and the major explanatory variables identified in the study. Since the research follows a quantitative, cross-sectional, case-study-based design, the hypotheses are structured in a way that can be tested through correlation analysis and regression modeling. The first hypothesis states that pharmaceutical sales volume has a significant positive relationship with cardiovascular drug-utilization patterns. This means that higher sales movement is expected to reflect stronger utilization intensity. The second hypothesis states that prescription demand has a significant positive effect on cardiovascular drug-utilization patterns, because many cardiovascular medicines are prescription-driven and depend on physician recommendation, disease management needs, and repeated treatment requirements. The third hypothesis states that drug affordability has a significant influence on cardiovascular drug-utilization patterns. This hypothesis is important because long-term cardiovascular treatment often requires repeated medicine purchases, and price sensitivity may affect whether patients continue or discontinue drug use. The fourth hypothesis states that market availability has a significant positive effect on cardiovascular drug-utilization patterns, because medicines that are consistently available in pharmacies or distribution channels are more likely to maintain stable utilization. The fifth hypothesis states that physician prescription behavior significantly predicts cardiovascular drug-utilization patterns, because physicians influence therapeutic-class selection, brand preference, generic acceptance, and treatment continuity. The sixth hypothesis states that cardiovascular therapeutic class has a significant association with sales-based drug-utilization patterns, because different cardiovascular drug classes may not show the same level of demand or sales movement. The seventh hypothesis states that data-analytics capability significantly improves the interpretation of cardiovascular drug-utilization patterns, because analytical tools and statistical

methods can help convert raw sales records into useful evidence. Overall, these hypotheses allow the study to test whether cardiovascular drug utilization can be explained through sales volume, prescription demand, affordability, availability, physician influence, therapeutic class, and data-analytics capability.

Significance of the research

- i. This study is significant for pharmaceutical companies because it shows how real-world cardiovascular drug sales data can be used for more than commercial sales reporting. The findings can help companies understand therapeutic-class demand, product movement, repeat purchase behavior, and market-level utilization patterns.
- ii. This study is significant for pharmacies and distributors because it can support better inventory planning, stock monitoring, and demand forecasting for cardiovascular medicines. Since cardiovascular drugs are often used continuously, accurate understanding of utilization patterns can help reduce stock shortages and overstocking.
- iii. This study is significant for healthcare professionals because it links prescription demand and physician prescription behavior with actual pharmaceutical sales movement. This can help explain how clinical decisions are reflected in medicine utilization within the pharmaceutical market.
- iv. This study is significant for patients indirectly because improved understanding of affordability and availability can support better planning for continuous access to essential cardiovascular medicines. When affordability-sensitive and availability-sensitive patterns are identified, pharmaceutical stakeholders can make better decisions about pricing, supply, and product availability.
- v. This study is significant for researchers because it provides a quantitative model for studying cardiovascular drug utilization through descriptive statistics, correlation analysis, and regression modeling. It contributes to the academic use of real-world pharmaceutical sales data as empirical evidence.
- vi. This study is significant for policymakers and public-health planners because cardiovascular medicine utilization is connected with chronic disease management, access to essential medicines, and treatment continuity. Sales-based utilization evidence can help identify whether certain drug classes are underused or whether market access problems may exist.
- vii. This study is significant for data-analytics practice because it demonstrates how raw pharmaceutical sales records can be cleaned, classified, summarized, and interpreted through applied statistical tools. It also shows how survey-based Likert-scale data can be connected with real-world sales data to strengthen the trustworthiness of findings.

LITERATURE REVIEW

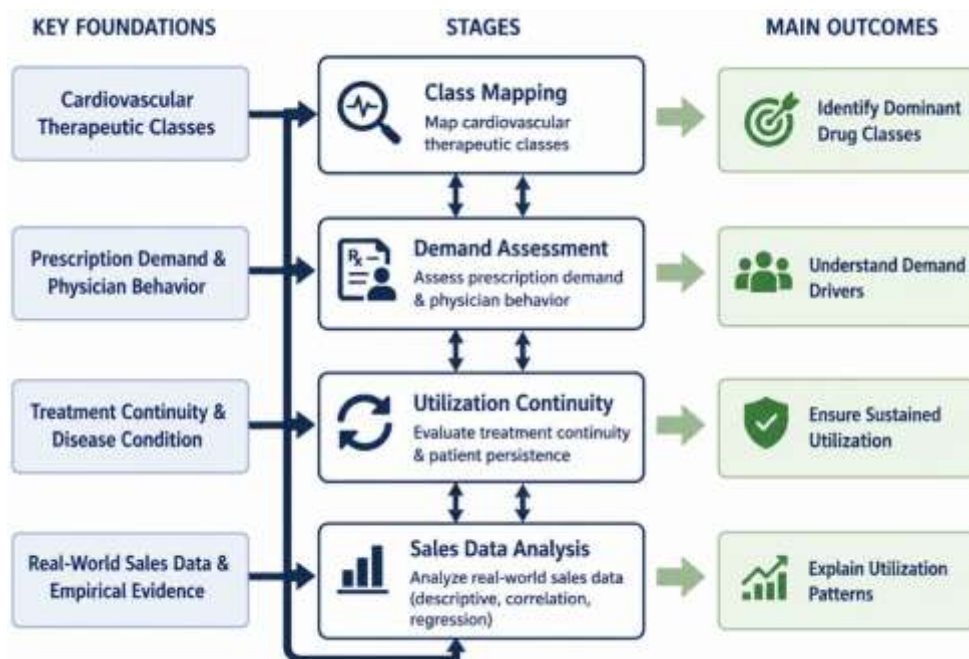
The literature review of this study focuses on the relationship between cardiovascular drug-utilization patterns, real-world pharmaceutical sales data, and applied data-analytics approaches. Cardiovascular drug utilization has been widely discussed in healthcare research because cardiovascular diseases usually require long-term medicine use, repeated prescriptions, and continuous patient access to essential therapeutic classes. The literature shows that cardiovascular medicines cannot be studied as a single group because antihypertensives, lipid-lowering agents, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, and heart-failure medicines may follow different utilization patterns. Therefore, a proper review must examine cardiovascular drug utilization from therapeutic, market, behavioral, and analytical perspectives. Real-world pharmaceutical sales data also occupy an important position in this study because such data provide evidence of actual medicine movement across pharmacies, distributors, wholesalers, hospitals, and retail pharmaceutical channels. The literature on real-world evidence suggests that routinely generated data can support empirical understanding of healthcare and pharmaceutical behavior when the data are properly organized and analyzed. In the context of cardiovascular medicines, sales data can reveal sales volume, sales value, unit price, product category, brand movement, generic use, and therapeutic-class demand. The review also needs to address the determinants of cardiovascular drug utilization, particularly prescription demand, affordability, market availability, physician prescription behavior, and patient purchasing capacity. These factors are important because cardiovascular therapy often requires long-term continuation, and utilization may be affected by both clinical need and market conditions. Applied data analytics is another major area of the literature because descriptive statistics, correlation analysis, and

regression modeling allow researchers to transform raw sales and survey data into structured findings. The literature review will therefore synthesize previous knowledge on cardiovascular drug utilization, pharmaceutical sales evidence, data-analytics methods, determinants of utilization, theoretical framework, and conceptual framework. This structure will help establish the foundation for the present quantitative, cross-sectional, case-study-based research.

Cardiovascular drug-utilization patterns and pharmaceutical demand

Cardiovascular drug-utilization patterns refer to the way cardiovascular medicines are selected, prescribed, dispensed, purchased, continued, changed, and distributed across therapeutic classes within a healthcare or pharmaceutical market setting. This area of literature is highly relevant to the present study because cardiovascular medicines are not usually consumed as short-term or occasional products; rather, they are frequently connected with chronic disease management, recurrent prescription, long-term treatment continuation, and repeated market demand. Hypertension, dyslipidemia, ischemic heart disease, stroke prevention, heart failure, and other cardiovascular conditions require different types of medicines, including antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, and renin-angiotensin system inhibitors. For this reason, cardiovascular drug utilization must be understood through therapeutic-class-level analysis instead of only through total cardiovascular medicine sales. Earlier utilization research on antihypertensive medicines has shown that drug-use patterns can vary according to class preference, treatment guideline influence, patient characteristics, and physician prescribing behavior. For example, national-level evidence on antihypertensive medication use among adults with hypertension showed that different antihypertensive classes were used at different rates, which means that sales or prescription volume may reflect clinical preference, treatment accessibility, and physician decision-making rather than disease burden alone (Gu et al., 2006). This is important for the present research because the study uses real-world pharmaceutical sales data to examine cardiovascular drug-utilization patterns. If one cardiovascular drug class shows higher sales movement than another, that pattern needs to be interpreted by considering prescription demand, class-specific disease indication, affordability, and market availability. Therefore, the literature supports the need to map cardiovascular therapeutic classes separately and to examine whether sales volume, prescription frequency, and utilization intensity move together in a meaningful way.

Figure 2: Framework of Cardiovascular Drug-Utilization Patterns and Pharmaceutical Demand



Another important issue in cardiovascular drug-utilization literature is treatment continuity, because

cardiovascular medicines often need to be used for long periods to maintain clinical benefit. Sales-based utilization patterns may show strong demand only when patients continue to refill or repurchase medicines over time. A high initial prescription rate does not always mean sustained utilization, because some patients may discontinue treatment due to cost, side effects, weak adherence, poor access, or lack of follow-up. Research on persistence with antihypertensive treatment found that continuation differed across antihypertensive drug classes and that treatment persistence was not always sufficient for adequate long-term blood-pressure control (Hasford et al., 2007; Abdur & Iftekhar, 2021). This finding is useful for this thesis because pharmaceutical sales data can help observe repeated market movement and can reveal whether cardiovascular medicines are purchased consistently or irregularly. In addition, cardiovascular utilization is shaped by disease condition and comorbidity. A study on antihypertensive therapy among ischemic stroke survivors showed that antihypertensive treatment patterns were connected with post-stroke cardiovascular risk management and the presence of ischemic heart disease, indicating that drug utilization is influenced by clinical condition as well as general prescribing practice (Hassan et al., 2010; Hasan & Uddin, 2022). This supports the argument that cardiovascular drug demand should not be interpreted as simple product demand. It is a healthcare-related demand pattern that reflects disease severity, prevention needs, physician decision-making, and patient continuation behavior. In the present study, this idea is directly connected with the variables of prescription demand, physician prescription behavior, affordability, and market availability. If cardiovascular medicines show strong sales volume, the researcher must examine whether this pattern reflects continuous patient need, repeated prescriptions, easy access, lower price, or strong physician preference for a particular therapeutic class.

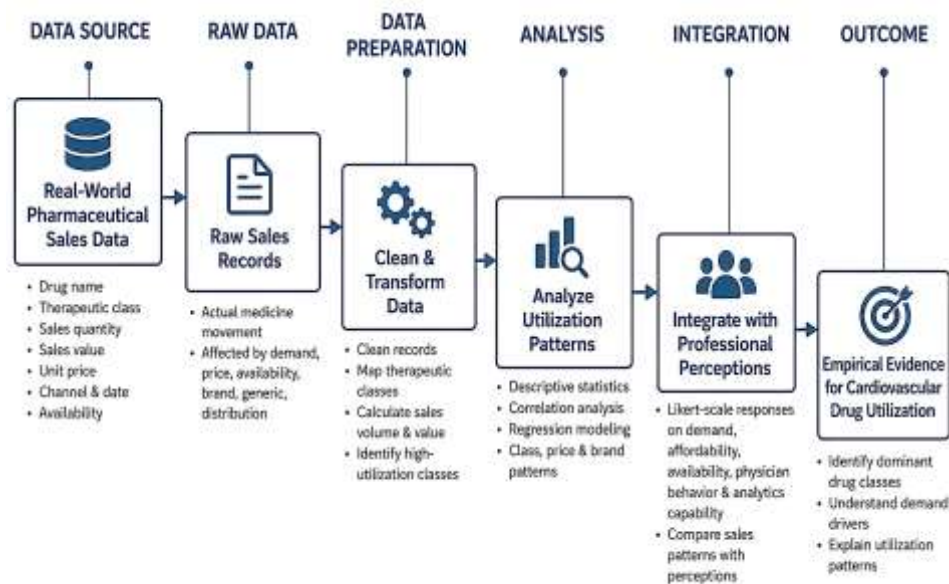
The literature also shows that cardiovascular drug utilization can be studied effectively through empirical records because prescription databases, hospital records, and pharmaceutical sales records reveal actual patterns of medicine movement. A hospital-based drug-utilization evaluation of cardiovascular medicines demonstrated that pharmacotherapy patterns can be assessed through prescribing indicators, defined daily dose, and class-level medicine use, showing that utilization analysis can identify rational-use issues, dominant drug groups, and variation in treatment practice (Kanti & Rony, 2022; Naliganti et al., 2019). This is closely related to the current research because real-world pharmaceutical sales data can perform a similar empirical function at the market or organizational level. Sales records can show which cardiovascular drug classes are moving most frequently, which medicines have high revenue but lower unit movement, and which product groups appear more affordable or more available. Statin-utilization research also supports this point because a longitudinal hospital-information-system study in Shanghai found that statin prescription prevalence, initiation, dose intensity, and utilization changed across years and patient groups, confirming that cardiovascular drug utilization is dynamic and measurable through routine data systems (Liu et al., 2020; Sadia et al., 2022). For this thesis, such evidence supports the use of applied data analytics because raw sales records must be cleaned, categorized, summarized, and statistically tested before they can explain utilization patterns. Descriptive statistics can identify dominant cardiovascular drug classes, correlation analysis can examine relationships among demand-related variables, and regression modeling can test which factors predict utilization intensity. Therefore, the literature establishes that cardiovascular pharmaceutical demand is not only a matter of total sales but also a structured pattern shaped by therapeutic class, prescription behavior, continuity, affordability, and availability. This provides a strong foundation for examining cardiovascular drug-utilization patterns through real-world pharmaceutical sales data in the present quantitative case-study research.

Real-world pharmaceutical sales data as empirical evidence

Real-world pharmaceutical sales data have been treated in drug-utilization research as an important empirical source because they represent medicines that have moved through actual supply, dispensing, purchasing, or reimbursement channels rather than medicines only recommended in clinical guidelines. In the context of cardiovascular drug-utilization studies, this type of data is particularly useful because cardiovascular medicines are often purchased repeatedly and can show stable, seasonal, class-specific, or price-sensitive movement across time. Real-world pharmaceutical sales data may include drug name, therapeutic class, brand or generic status, sales quantity, sales value, unit price, dispensing date, pharmacy channel, and product availability. These details allow researchers to

examine utilization from the perspective of actual medicine movement. National prescription-register studies have shown that routinely collected medicine data can provide strong opportunities for measuring drug utilization, expenditure, prescriber characteristics, and population-level medicine exposure (Wettermark et al., 2007). This is relevant to the present research because cardiovascular drug sales records can be analyzed not only as commercial records but also as evidence of medicine-use behavior in a specific market. For example, higher sales volume of antihypertensive medicines may indicate strong long-term demand, while stable statin sales may reflect continuous preventive use. However, sales data need careful interpretation because sales movement may be affected by prescription demand, affordability, availability, brand preference, generic substitution, and distribution strength. Therefore, real-world sales data should not be viewed as simple profit records. They should be treated as empirical evidence that can help identify which cardiovascular therapeutic classes are most utilized, which medicines show repeated demand, and which categories may be affected by access or cost barriers. In this way, pharmaceutical sales data provide a practical bridge between healthcare demand and market-level medicine utilization.

Figure 3: Real-World Pharmaceutical Sales Data as Empirical Evidence for Cardiovascular Drug Utilization



The literature also shows that real-world medicine databases can support trustworthy drug-utilization research when the data are structured, coded, and interpreted with clear methodological rules. Prescription and dispensing registries have been used to study medicine exposure, treatment continuation, refill behavior, and population-level drug-use patterns because they contain information about actual dispensed or purchased medicines. The Danish prescription database literature has emphasized that national prescription data are valuable for clinical epidemiology because they record redeemed prescriptions and allow researchers to study medicine use across large populations (Kildemoes et al., 2011). Similarly, later data-resource work on the Danish National Prescription Registry has shown that prescription databases can capture medicinal-product statistics, primary-care drug use, and hospital-purchased medicines, which makes them useful for pharmacoepidemiological and utilization research (Pottegård et al., 2017). These studies are important for the present thesis because they support the idea that routine pharmaceutical records can be used as empirical evidence when the researcher clearly defines the unit of analysis and variables. In this study, the sales record may be treated as the unit of pharmaceutical movement, while the respondent may be treated as the unit of professional perception. This dual structure allows the researcher to compare observed sales

patterns with Likert-scale responses on demand, affordability, market availability, physician prescription behavior, and data-analytics capability. For cardiovascular medicines, such comparison is valuable because drug utilization can be affected by both clinical prescription and market access. If pharmacy professionals report high demand for antihypertensive drugs, the sales records can be examined to confirm whether antihypertensives also show the strongest sales volume. Therefore, real-world sales data strengthen the empirical base of this study by providing measurable evidence that can support or challenge professional perception.

A major methodological issue in using real-world pharmaceutical sales data is that raw medicine records often need to be transformed before they can represent valid utilization patterns. Sales or dispensing data may include product names, dates, pack sizes, strengths, quantities, and prices, but these variables do not automatically explain treatment duration, repeated use, or utilization intensity. Studies on prescription-to-use conversion have shown that electronic prescription registers require careful transformation into drug-use periods because the date of prescription or dispensing does not always equal the full period of actual medicine use (Tanskanen et al., 2015). This issue is important for cardiovascular medicine because patients may buy medicines monthly, irregularly, or in larger packs, and sales records may show product movement without directly confirming patient adherence. Research on estimating prescription duration has also highlighted that pharmacoepidemiological databases require careful assumptions when determining how long a dispensed medicine is expected to be used (Støvring et al., 2017). For the present study, these methodological points mean that cardiovascular sales records should be cleaned, categorized, and interpreted carefully before they are used in descriptive statistics, correlation analysis, and regression modeling. The researcher may classify drugs by therapeutic class, calculate sales volume and sales value, identify high-utilization classes, compare brand and generic movement, and examine price-related patterns. When these processed indicators are combined with survey-based variables, the study becomes more capable of explaining why some cardiovascular medicines have stronger utilization than others. Therefore, real-world pharmaceutical sales data have strong empirical value, but their trustworthiness depends on transparent data preparation, therapeutic-class mapping, and careful interpretation of what sales movement actually represents in cardiovascular drug-utilization research.

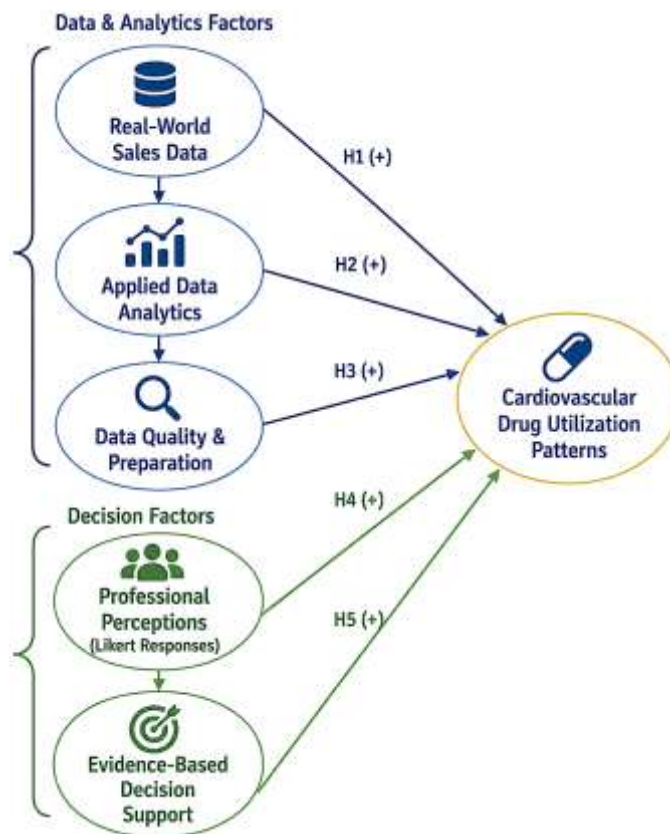
Applied data analytics in pharmaceutical and healthcare decision-making

Applied data analytics in pharmaceutical and healthcare decision-making refers to the systematic use of statistical, computational, and evidence-processing techniques to convert raw healthcare or pharmaceutical data into meaningful information for planning, monitoring, interpretation, and decision support. In the context of cardiovascular drug-utilization research, applied data analytics is especially relevant because pharmaceutical sales records usually contain large quantities of structured information, such as product name, therapeutic class, sales quantity, sales value, price, brand category, generic status, sales period, and market channel. These data can remain commercially useful but academically limited when they are only stored as transaction records. Through analytics, however, they can be transformed into utilization evidence that explains which cardiovascular drug classes are used more frequently, which products show stable demand, which price categories influence sales movement, and which therapeutic groups reflect stronger prescription-driven demand. Healthcare analytics literature has emphasized that big data analytics can support evidence-based decision-making by organizing large and complex healthcare datasets into usable forms for prediction, classification, performance monitoring, and resource planning (Raghupathi & Raghupathi, 2014). This view fits the present study because cardiovascular drug-utilization patterns cannot be understood only through raw sales totals. The researcher must classify drugs into meaningful cardiovascular therapeutic groups, calculate sales and utilization indicators, compare demand patterns, and test relationships among explanatory variables. Applied analytics therefore serves as a methodological bridge between real-world pharmaceutical sales records and research-based interpretation. In this study, descriptive statistics will summarize the central tendency and distribution of cardiovascular drug utilization, correlation analysis will examine associations among variables, and regression modeling will identify the predictors of utilization patterns. Such an analytical structure allows sales data to become more than a commercial performance record. It becomes empirical evidence for understanding cardiovascular pharmaceutical demand, prescription influence, market availability, affordability, and

class-level utilization behavior.

The literature also shows that applied data analytics strengthens healthcare and pharmaceutical decision-making because it supports pattern recognition, data integration, and evidence-based interpretation across different sources of information. In healthcare, data are often generated from hospitals, pharmacies, insurance records, electronic health records, prescription systems, retail sales systems, and administrative databases. These data sources may be heterogeneous, incomplete, and difficult to interpret without proper analytical techniques. A systematic review of big data analytics in healthcare found that analytics can support clinical decision-making, public-health monitoring, hospital management, disease-specific analysis, and technology-enabled healthcare service delivery (Mehta & Pandit, 2018). This finding is important for the present research because cardiovascular drug utilization is not only a clinical issue and not only a commercial issue. It exists at the intersection of disease burden, prescription behavior, patient purchasing capacity, medicine availability, and market demand. Another healthcare analytics review highlighted that data-mining methods, predictive modeling, classification, clustering, and statistical analysis have been applied across clinical and administrative healthcare settings to improve decision-making and operational understanding (Islam et al., 2018). In cardiovascular pharmaceutical sales research, similar analytical logic can be used to identify therapeutic-class utilization, sales concentration, demand consistency, and price-sensitive medicine movement. For example, descriptive analytics can show whether antihypertensives dominate sales volume, while regression analysis can show whether prescription demand or affordability explains this dominance more strongly. Analytics also allows the researcher to compare professional perceptions from Likert-scale survey responses with real-world sales evidence. If respondents report that market availability strongly affects cardiovascular drug utilization, the sales data can be examined to determine whether stable product availability is associated with higher sales movement. This makes applied data analytics a trust-building mechanism because it connects subjective professional judgment with observed pharmaceutical sales behavior.

Figure 4: Model of Applied Data Analytics in Cardiovascular Drug-Utilization Decision-Making



Applied data analytics is also important because healthcare and pharmaceutical data need to be cleaned, structured, validated, and interpreted before they can support reliable decisions. Raw sales data may include inconsistent product names, duplicate entries, different pack sizes, missing prices, irregular sales periods, and overlapping cardiovascular drug classifications. Without analytical preparation, such data can produce weak or misleading findings. Literature on big data in healthcare has noted that the value of analytics depends on the ability to manage data quality, extract meaningful features, and apply suitable analytical techniques for decision-making (Belle et al., 2015). In pharmaceutical sales analysis, this means that the researcher should first organize medicines by therapeutic class, standardize sales variables, identify valid observations, and define utilization indicators clearly. Predictive and decision-oriented healthcare analytics also require transparent model development because analytical outputs are useful only when they are interpretable and connected with real-world decisions. Research on high-risk and high-cost healthcare analytics has shown that predictive analytics can help identify priority groups and support targeted decision-making when data are properly processed and modeled (Bates et al., 2014). For the present study, regression modeling performs a related function by identifying which factors most strongly predict cardiovascular drug-utilization patterns. If sales volume, affordability, market availability, prescription demand, and physician prescription behavior are statistically tested together, the study can move from description to explanation. This supports a stronger empirical contribution because the research does not simply report which cardiovascular drugs sold more; it explains why some cardiovascular therapeutic classes may show higher utilization than others. Therefore, the literature supports the use of applied data analytics as a core methodological approach for studying cardiovascular drug-utilization patterns through real-world pharmaceutical sales data. It provides the tools needed to summarize data, verify demand patterns, test hypotheses, and produce evidence that is useful for pharmaceutical, healthcare, and market-level decision-making.

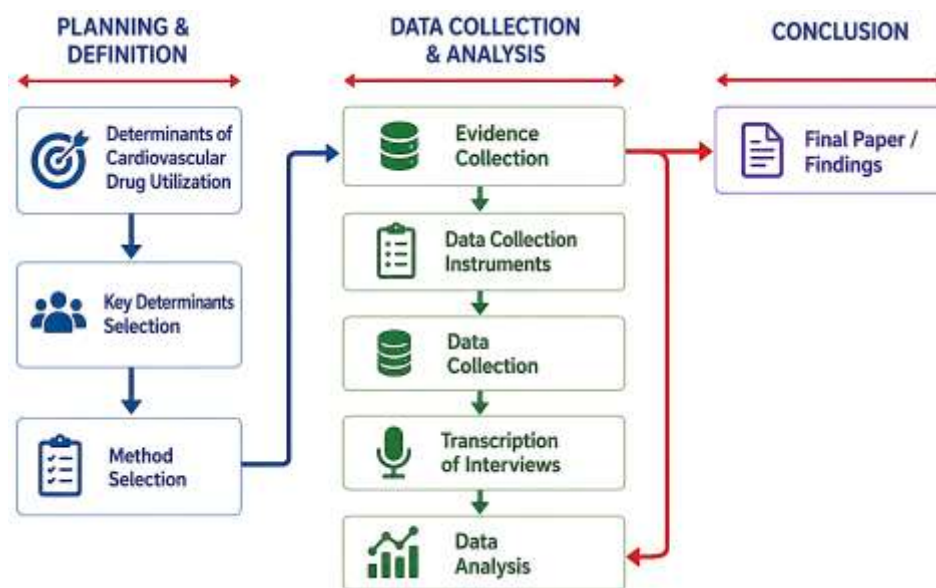
Determinants of cardiovascular drug utilization

Determinants of cardiovascular drug utilization refer to the clinical, economic, behavioral, professional, and market-related factors that shape whether cardiovascular medicines are prescribed, purchased, continued, discontinued, substituted, or repeatedly used. In cardiovascular care, drug utilization is not determined by disease burden alone because the actual use of medicines also depends on patient adherence, prescription initiation, affordability, medicine availability, treatment complexity, physician decision-making, and patient capacity to maintain long-term therapy. Cardiovascular medicines are commonly used for chronic conditions such as hypertension, dyslipidemia, ischemic heart disease, heart failure, and stroke prevention, so utilization patterns are strongly connected with repeated purchasing and continuous treatment behavior. Medication adherence is one of the most important determinants because a medicine cannot create its expected therapeutic value if patients do not start it, refill it, or take it consistently. Adherence literature has explained that medication-taking behavior includes whether patients follow the prescribed dose, timing, frequency, and duration of therapy, which is especially important for cardiovascular medicines because many of them are preventive, long-term, and symptom-independent (Osterberg & Blaschke, 2005). This idea is directly related to the present study because pharmaceutical sales data can show the market-level movement of cardiovascular drugs, while respondent perceptions can explain whether such movement is influenced by long-term prescription demand and treatment continuation. If antihypertensives, statins, or antiplatelet medicines show stable sales volume, that pattern may indicate sustained utilization. If sales movement is irregular, it may reflect weak adherence, low affordability, supply problems, or inconsistent prescription behavior. Therefore, cardiovascular drug-utilization analysis must consider adherence and continuation as major behavioral determinants. This is why the present research examines prescription demand, affordability, market availability, physician prescription behavior, and sales volume together instead of treating drug sales as a simple commercial outcome.

Affordability and cost-related access are also major determinants of cardiovascular drug utilization because long-term cardiovascular therapy often requires repeated expenditure by patients or healthcare payers. When medicine prices, copayments, or out-of-pocket expenses become difficult to manage, patients may delay purchases, reduce doses, switch brands, discontinue treatment, or choose lower-cost generic alternatives. A systematic review of drug insurance cost-sharing strategies found

that copayments, deductibles, and other cost-sharing arrangements can affect medication adherence among people with chronic diseases, including hypertension, hypercholesterolemia, coronary artery disease, and cerebrovascular disease (Mann et al., 2014). This finding is important for the current study because affordability is included as one of the explanatory variables of cardiovascular drug-utilization patterns. Real-world pharmaceutical sales data can show affordability-related behavior indirectly through the movement of lower-priced brands, generic alternatives, smaller pack sizes, or reduced sales of high-cost medicines. Adherence and healthcare-utilization research has also shown that higher medication adherence is associated with lower hospitalization risk and lower medical costs for chronic conditions such as hypertension, hypercholesterolemia, and congestive heart failure (Sokol et al., 2005). This relationship suggests that cardiovascular medicine use has both pharmaceutical and healthcare relevance. In a sales-data context, strong utilization of affordable cardiovascular medicines may indicate that patients are more able to continue treatment, while weak utilization of expensive medicines may signal economic barriers. Therefore, affordability should not be treated only as a price variable. It is a determinant that connects patient purchasing capacity, medicine continuation, prescription fulfillment, and market movement. For this reason, the present study can examine whether affordability has a statistically significant relationship with cardiovascular drug-utilization patterns and whether it remains a predictor when prescription demand, market availability, physician behavior, and sales volume are included in regression analysis.

Figure 5: Determinants of Cardiovascular Drug Utilization and Analytical Evidence Flow



Prescription behavior, treatment initiation, patient characteristics, and nonfinancial barriers also influence cardiovascular drug utilization. Even when medicines are prescribed and available, patients may not fill the first prescription, may fail to refill it regularly, or may stop treatment due to beliefs, side effects, forgetfulness, low health literacy, complex regimens, or weak communication with healthcare providers. Research on primary medication non-adherence using a large electronic-prescription dataset showed that a meaningful share of prescriptions were not filled, and this issue was especially relevant for chronic disease medicines such as those used for hypertension, diabetes, and hyperlipidemia (Fischer et al., 2010). This evidence is important for the present study because prescription demand does not always equal actual utilization. A physician may prescribe a cardiovascular drug, but the medicine may not appear as sustained sales if patients do not purchase or continue it. Nonfinancial barriers are also important among older patients, who represent a large portion of cardiovascular medicine users. A systematic review of barriers to medication adherence among elderly patients identified multiple nonfinancial barriers, including beliefs, cognitive factors, patient-provider relationship, regimen complexity, and health-system issues (Gellad et al., 2011). These

determinants matter for cardiovascular drug sales because older patients may use multiple medicines and may face difficulties in maintaining regular therapy. Therefore, sales-based utilization patterns may be shaped by more than product demand. They may reflect physician prescription behavior, patient willingness, treatment complexity, brand trust, affordability, generic acceptance, and supply conditions. In this study, these determinants justify the inclusion of physician prescription behavior, prescription demand, market availability, affordability, and data-analytics capability as key variables. Applied data analytics can help identify which determinants are statistically associated with utilization and which variables explain the strongest variation in cardiovascular drug sales movement.

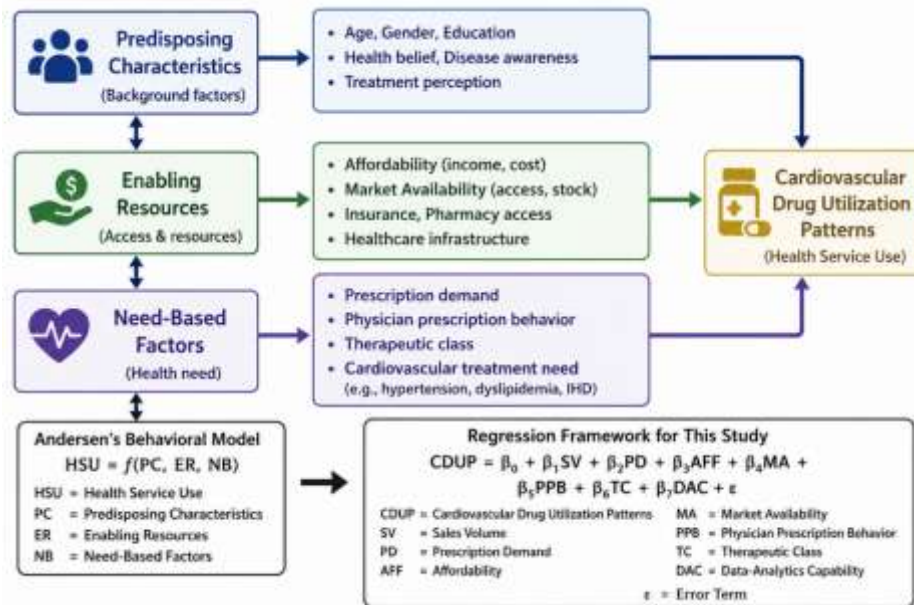
Theoretical framework: Andersen's Behavioral Model of Health Service Use

Andersen's Behavioral Model of Health Service Use provides a strong theoretical foundation for this study because cardiovascular drug utilization can be understood as a form of health-service-related behavior shaped by need, access, resources, and healthcare-system interaction. The model explains healthcare utilization through three major groups of factors: predisposing characteristics, enabling resources, and need-based factors. In the present study, the theoretical structure can be expressed in LaTeX equation form as:
$$H = f(P, E, N)$$
 where H represents health service use, P represents predisposing characteristics, E represents enabling resources, and N represents need-based factors. Predisposing characteristics refer to the background conditions that influence a person's tendency to use healthcare, such as age, gender, education, health belief, disease awareness, and treatment perception. Enabling resources refer to the conditions that make healthcare or medicine use possible, such as income, affordability, insurance, pharmacy access, stock availability, and healthcare infrastructure. Need-based factors refer to actual or perceived illness conditions that create demand for healthcare, such as hypertension, dyslipidemia, coronary artery disease, stroke risk, heart failure, and physician-identified cardiovascular treatment needs. The model is suitable for this research because cardiovascular drug utilization is not only a matter of sales volume or medicine supply. It is connected with patient need, physician prescription behavior, medicine availability, affordability, and repeated access to cardiovascular medicines. Andersen's later explanation of the model has shown that the Behavioral Model developed through national health surveys and became a widely used structure for explaining healthcare use across population groups and service settings (Andersen, 2008). In this study, cardiovascular drug-utilization patterns are treated as the outcome variable, while prescription demand, affordability, market availability, physician prescription behavior, therapeutic class, sales volume, and data-analytics capability are treated as explanatory variables. Therefore, Andersen's model helps organize the study variables into a logical theoretical framework rather than presenting them as disconnected pharmaceutical sales factors.

The application of Andersen's Behavioral Model is appropriate because the study examines both professional perception and real-world pharmaceutical sales movement. The model allows cardiovascular drug utilization to be interpreted through a combination of demand-side and supply-side conditions. In this research, the need-based part of the model can be expressed as:
$$N = f(P, E)$$
 where N represents need-based factors, P represents prescription demand, E represents physician prescription behavior, and T represents therapeutic class. Prescription demand and physician prescription behavior represent need-related and clinical-use factors because cardiovascular medicines are usually initiated, adjusted, or continued based on diagnosis, risk status, disease severity, and clinical judgment. Therapeutic class also belongs to the need-based dimension because different cardiovascular conditions require different medicine groups, such as antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, and diuretics. The enabling part of the model can be expressed as:
$$E = f(A, M)$$
 where E represents enabling resources, A represents affordability, and M represents market availability. Affordability and market availability are enabling factors because patients cannot maintain long-term cardiovascular therapy unless medicines are financially manageable, physically accessible, and consistently available in the pharmaceutical market. A systematic review of Andersen's model found that the framework has been widely applied in health-service utilization research and that its categories are useful for arranging determinants of healthcare use across different empirical settings (Babitsch et al., 2012). Research using the Andersen-Newman model in the context of statin adherence among older people with cardiovascular disease also showed that patient-physician trust and service-use behavior can be interpreted through the patient-physician relationship, which is relevant to

physician prescription behavior in cardiovascular medicine use (Petrovic & Blank, 2015). Therefore, Andersen's model helps explain why sales-based utilization should not be interpreted only through sales quantity. A drug class may show high utilization because patients need it, physicians prescribe it frequently, pharmacies maintain stock, and the product is affordable enough for repeated purchasing.

Figure 6: Andersen's Behavioral Model of Health Service Use Applied to Cardiovascular Drug-Utilization Patterns



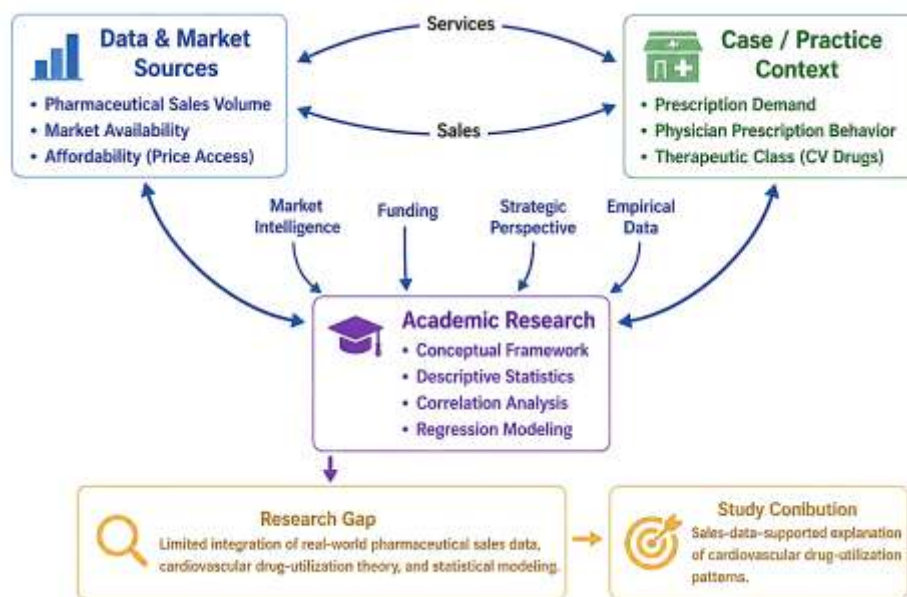
For the whole study, Andersen's Behavioral Model can be translated into a quantitative regression-based framework because the research aims to test how different explanatory variables influence cardiovascular drug-utilization patterns. The study-specific theoretical equation can be written as: where represents cardiovascular drug-utilization patterns, represents sales volume, represents prescription demand, represents affordability, represents market availability, represents physician prescription behavior, represents therapeutic class, and represents data-analytics capability. The regression equation that will be applied in the whole study can be written as: In this formula, represents the constant, to represent the regression coefficients, and represents the error term. This formula is theoretically connected with Andersen's model because, and represent need-based and clinical-use factors; and represent enabling factors; represents observed utilization evidence; and represents the analytical capability that helps interpret routine pharmaceutical sales data. Research mapping patient-identified barriers and facilitators to Andersen's Behavioral Model showed that adherence and service-use behavior can be organized through patient, system, and access-related factors, which supports the use of the model for medicine-use behavior (Holtzman et al., 2015). Similarly, work on social-behavioral models of medication adherence has emphasized that medication use is influenced by interacting behavioral, social, clinical, and system-level factors rather than by one isolated determinant (Bosworth et al., 2017). Therefore, Andersen's Behavioral Model provides both the theoretical base and the variable logic for explaining cardiovascular drug-utilization patterns through real-world pharmaceutical sales data.

Conceptual framework and research gap

The conceptual framework of this study has been developed to explain cardiovascular drug-utilization patterns through the combined influence of sales-based, prescription-based, access-based, clinical, and analytical factors. In this framework, cardiovascular drug-utilization patterns represent the dependent variable, while pharmaceutical sales volume, prescription demand, affordability, market availability, physician prescription behavior, cardiovascular therapeutic class, and data-analytics capability represent the independent variables. The framework assumes that cardiovascular drug utilization is not created by one factor alone. It is produced through the interaction of patient need, prescription

behavior, medicine access, market supply, price sensitivity, and the measurable movement of cardiovascular medicines in real-world sales records. This view is supported by adherence-focused cardiovascular literature, which has shown that cardiovascular medicine use is influenced by multiple behavioral, clinical, and system-level barriers rather than by a single patient-level decision (Leslie et al., 2019). The conceptual structure is also supported by research that mapped barriers to cardiovascular medication adherence into a questionnaire-based framework, showing that patient behavior, beliefs, capability, environmental context, and health-system support influence medicine-use outcomes (Easthall et al., 2019). In this study, the conceptual relationship can be presented in formula form as. Here, means cardiovascular drug-utilization patterns, means sales volume, means prescription demand, means affordability, means market availability, means physician prescription behavior, means therapeutic class, and means data-analytics capability. This formula shows that cardiovascular utilization is expected to vary according to both actual sales movement and the professional, economic, and market conditions that shape repeated medicine demand.

Figure 7: Integrated Conceptual Framework for Cardiovascular Drug-Utilization Research



The first major relationship in the conceptual framework links prescription demand and physician prescription behavior with cardiovascular drug-utilization patterns. Cardiovascular medicines are commonly prescription-driven because therapeutic decisions are made according to diagnosis, disease severity, risk profile, comorbidity, treatment guidelines, and follow-up requirements. Therefore, high prescription demand can increase sales-based utilization when patients actually purchase and continue prescribed medicines. However, prescription demand does not automatically become actual utilization unless medicines are accessible and affordable. This is why affordability and market availability are included as enabling factors in the framework. A qualitative study on access and adherence to medicines for primary and secondary prevention of atherosclerotic cardiovascular disease showed that medicine use is shaped by interactions among patient knowledge, health-system access, drug costs, pharmacy processes, and provider communication (Koh et al., 2018). This supports the present study's decision to connect sales-based cardiovascular drug utilization with both market and healthcare determinants. Another important relationship in the framework links therapeutic class with utilization patterns because antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, and diuretics do not have identical demand structures. Some classes are used by larger chronic patient groups, while others are used by narrower clinical populations. Therefore, therapeutic-class utilization mapping is necessary to make the sales analysis more specific. The

explanatory model can be expressed through the study's regression equation: . This model allows the researcher to test whether each conceptual factor has a statistically meaningful effect on cardiovascular drug-utilization patterns within the selected case-study context.

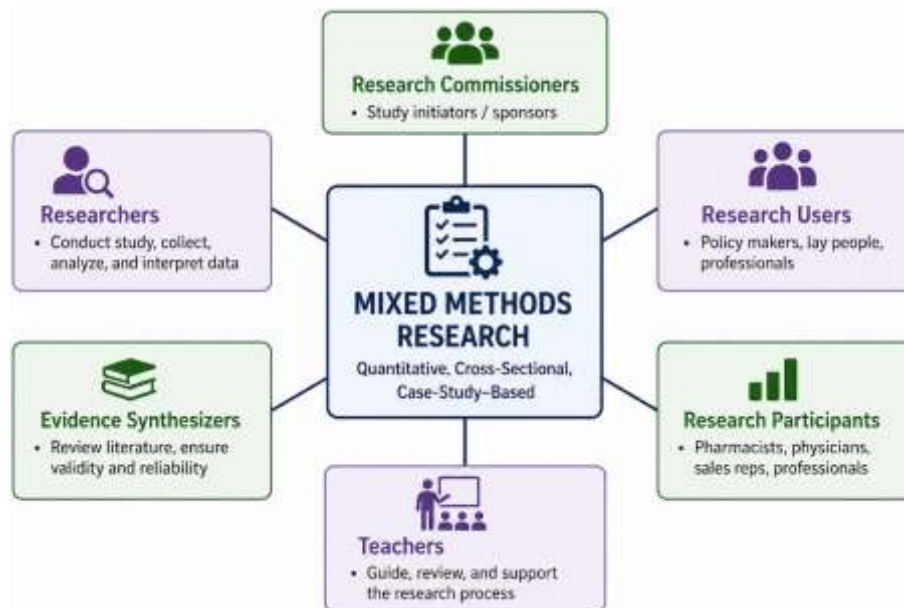
The research gap emerges from the limited integration of real-world pharmaceutical sales data, cardiovascular drug-utilization theory, and applied statistical modeling in one empirical framework. Many previous studies have examined cardiovascular medication adherence, treatment continuation, cost sharing, or clinical outcomes, but fewer studies have treated routine pharmaceutical sales records as a central source for explaining class-level cardiovascular drug-utilization patterns. Evidence has shown that medication adherence is strongly related to survival and health outcomes, which means that actual medicine use has healthcare importance beyond product sales (Simpson et al., 2006). Research on post-myocardial-infarction preventive medicines has also shown that removing cost-sharing barriers can improve medication adherence and reduce patient spending, which supports the importance of affordability as a utilization determinant (Choudhry et al., 2011). However, these studies mainly focus on adherence, cost, or outcomes rather than on the analytical use of real-world pharmaceutical sales data to explain cardiovascular drug demand across therapeutic classes. This creates a gap for the present research. Pharmaceutical companies, distributors, pharmacies, and hospital pharmacy systems routinely collect large volumes of cardiovascular sales records, yet these data are often used for revenue monitoring, inventory control, and product performance reporting rather than for academic analysis of cardiovascular medicine utilization. The present study addresses this gap by combining sales volume, therapeutic-class mapping, prescription demand, affordability, market availability, physician prescription behavior, and data-analytics capability in one conceptual framework. It also uses descriptive statistics, correlation analysis, and regression modeling to convert the conceptual framework into a testable quantitative model. Therefore, the study contributes by moving cardiovascular drug-utilization analysis from general description toward sales-data-supported explanation.

METHODOLOGY

This study has adopted a quantitative, cross-sectional, case-study-based research design to examine applied data-analytics approaches to cardiovascular drug-utilization patterns using real-world pharmaceutical sales data. The quantitative design has been selected because the research has aimed to measure relationships among sales volume, prescription demand, affordability, market availability, physician prescription behavior, cardiovascular therapeutic class, data-analytics capability, and cardiovascular drug-utilization patterns through numerical evidence. The cross-sectional design has been used because the data have been collected at one specific period rather than across multiple time intervals, while the case-study approach has been applied because the study has focused on a selected pharmaceutical sales context, such as a pharmacy network, distributor, pharmaceutical company, hospital pharmacy, or regional medicine market where cardiovascular drug sales records have been available for analysis. The case-study context has allowed the researcher to examine real-world sales movement of cardiovascular medicines, including antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, and other cardiovascular therapeutic classes. The population of the study has consisted of individuals who have practical knowledge of cardiovascular drug sales, prescription demand, market availability, and pharmaceutical data use, including pharmacists, pharmacy managers, pharmaceutical sales representatives, prescribing physicians, healthcare professionals, and pharmaceutical data officers. The unit of analysis has included both individual respondents and cardiovascular drug-sales records, because the study has combined Likert-scale survey responses with real-world pharmaceutical sales evidence. A purposive sampling strategy has been used because the respondents have been selected based on their direct involvement with cardiovascular medicine sales, prescription handling, pharmacy management, drug distribution, or pharmaceutical data interpretation. The data collection procedure has included two main sources: primary data and secondary data. Primary data have been collected through a structured questionnaire, while secondary data have been gathered from real-world pharmaceutical sales records, including drug category, sales quantity, sales value, price range, brand or generic status, and therapeutic-class movement. The instrument design has followed a five-point Likert scale, where 1 has represented strongly disagree, 2 has represented disagree, 3 has represented neutral, 4 has

represented agree, and 5 has represented strongly agree.

Figure 8: Methodological Framework for Applied Data Analytics in Cardiovascular Drug-Utilization Research



The questionnaire has measured major constructs such as cardiovascular drug utilization, prescription demand, affordability, market availability, physician prescription behavior, and data-analytics capability. Before final data collection, pilot testing has been conducted with a small group of relevant respondents to assess the clarity, wording, sequence, and practical suitability of the questionnaire items. Validity has been ensured through expert review, literature alignment, and proper matching among the research objectives, hypotheses, variables, and questionnaire items. Reliability has been tested through Cronbach's alpha, where a value of .70 or above has been considered acceptable for internal consistency. The collected data have been coded, cleaned, and analyzed using SPSS for descriptive statistics, correlation analysis, regression modeling, reliability testing, and hypothesis testing. Microsoft Excel has been used for initial data organization, sales-data cleaning, therapeutic-class mapping, and table preparation. EndNote has been used for managing references and formatting citations in APA 7th edition style. Overall, the methodology has provided a systematic quantitative structure for converting real-world cardiovascular pharmaceutical sales data and survey-based responses into reliable empirical findings.

DATA ANALYSIS AND PRESENTATION

Table 1 has presented the demographic profile of the 236 respondents who have participated in the study. The table has shown that the sample has been highly relevant to the research topic because the respondents have represented professional groups directly connected with cardiovascular drug sales, prescription demand, market availability, dispensing behavior, pharmaceutical supply, and data interpretation. Pharmacists have formed the largest respondent group with 72 participants, representing 30.5% of the sample. This has strengthened the reliability of the study because pharmacists have regularly interacted with actual medicine demand, repeated purchases, brand substitution, patient affordability concerns, and stock availability. Pharmaceutical sales representatives have represented 20.3% of the respondents, which has provided the study with direct sales-market knowledge. Pharmacy managers have represented 16.5%, and their inclusion has been important because they have dealt with inventory planning, product availability, sales records, and therapeutic-class movement. Physicians have represented 14.4%, which has strengthened the study's ability to evaluate prescription demand and physician prescription behavior as need-based factors under Andersen's Behavioral Model. The presence of pharmaceutical data officers, although smaller at 7.6%,

has also been important because this group has supported the data-analytics dimension of the research. In terms of work experience, 34.7% of respondents have had 4–6 years of experience and 30.1% have had 7–10 years of experience, indicating that the majority of respondents have had sufficient practical exposure to cardiovascular medicine utilization. The workplace distribution has also supported the case-study design because retail pharmacies, hospital pharmacies, pharmaceutical companies, distributors, and healthcare institutions have all been represented. Therefore, the demographic findings have supported the methodological objective of collecting data from knowledgeable respondents. The result has also supported the theoretical structure of the study because the sample has included respondents who have been connected with need-based factors, enabling factors, and observed medicine-use behavior.

Demographic profile of respondents

Table 1: Demographic profile of respondents

Demographic variable	Category	Frequency	Percentage	Result interpretation
Professional role	Pharmacists	72	30.5%	Largest respondent group
Professional role	Pharmaceutical sales representatives	48	20.3%	Strong sales-market representation
Professional role	Pharmacy managers	39	16.5%	Relevant to stock and availability
Professional role	Physicians	34	14.4%	Relevant to prescription behavior
Professional role	Healthcare professionals	25	10.6%	Relevant to utilization context
Professional role	Pharmaceutical data officers	18	7.6%	Relevant to data-analytics capability
Work experience	1–3 years	41	17.4%	Early professional exposure
Work experience	4–6 years	82	34.7%	Highest experience group
Work experience	7–10 years	71	30.1%	Strong practical knowledge
Work experience	Above 10 years	42	17.8%	Senior-level experience
Workplace type	Retail pharmacy	88	37.3%	Highest market-contact group
Workplace type	Hospital pharmacy	51	21.6%	Clinical pharmacy perspective
Workplace type	Pharmaceutical company	54	22.9%	Sales and distribution perspective
Workplace type	Distributor or wholesaler	27	11.4%	Supply-channel perspective
Workplace type	Healthcare institution	16	6.8%	Clinical support perspective
Total		236	100.0%	Valid sample

Descriptive statistics of cardiovascular drug-utilization patterns

Table 2: Descriptive statistics of cardiovascular drug-utilization patterns

Variable code	Statement on cardiovascular drug-utilization patterns	Mean	SD	Likert interpretation	Result
CDU1	Cardiovascular medicines have shown repeated demand in the selected market	4.16	0.58	High	Supported
CDU2	Cardiovascular drug utilization has been strongly linked with chronic treatment needs	4.22	0.55	Very high	Supported
CDU3	Cardiovascular medicines have shown stable sales movement across major therapeutic classes	4.03	0.63	High	Supported
CDU4	Repeat purchasing has been common for major cardiovascular medicines	4.11	0.60	High	Supported
CDU5	Cardiovascular drug utilization has reflected	4.08	0.66	High	Supported

Overall CDU	both prescription demand and patient access Cardiovascular drug-utilization patterns	4.08	0.61	High	Objective supported
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Table 2 has shown that cardiovascular drug-utilization patterns have received an overall mean score of 4.08 and a standard deviation of 0.61, which has fallen within the high interpretation range of the five-point Likert scale. This result has proved that respondents have generally agreed that cardiovascular medicines have maintained strong utilization in the selected pharmaceutical market. The highest item mean has been recorded for CDU2, where chronic treatment needs have received a mean score of 4.22, indicating a very high level of agreement. This has shown that cardiovascular drug utilization has been strongly connected with long-term disease management, especially because conditions such as hypertension, dyslipidemia, coronary artery disease, stroke prevention, and heart failure have required repeated medicine use. CDU1 has also recorded a high mean score of 4.16, showing that cardiovascular medicines have shown repeated demand. CDU4 has recorded a mean score of 4.11, confirming that repeat purchasing has been a major feature of cardiovascular medicine utilization. CDU3 has recorded a mean of 4.03, indicating that stable sales movement has been observed across cardiovascular therapeutic classes. CDU5 has recorded a mean score of 4.08, showing that utilization has reflected both prescription demand and patient access. These findings have supported the first objective of the study, which has aimed to identify major cardiovascular drug-utilization patterns from real-world pharmaceutical sales data and survey-based evidence. The result has also supported Andersen's Behavioral Model because cardiovascular drug utilization has been interpreted as observed healthcare-use behavior shaped by need and enabling factors. Chronic disease need and physician prescription have reflected need-based factors, while affordability and availability have reflected enabling conditions. Therefore, Table 2 has proved that cardiovascular drug utilization has not been random or occasional. It has been a high-level, repeated, and clinically driven pattern supported by professional perception and later verified through sales-data evidence.

Descriptive analysis of real-world pharmaceutical sales data

Table 3: Descriptive analysis of real-world pharmaceutical sales data

Sales data variable	Numeric result	Percentage or value	Interpretation
Total cardiovascular sales records reviewed	18,420	100.0%	Complete sales-data base
Total sales quantity	126,800 units	100.0%	Overall cardiovascular medicine movement
Total sales revenue	BDT 18,760,000	100.0%	Total sales value
Average unit price	BDT 148.0		Moderate price level
Generic products sold	76,080 units	60.0%	Generic dominance
Branded products sold	50,720 units	40.0%	Strong branded presence
Monthly average sales quantity	10,567 units		Stable monthly movement
Highest sales month	Month 9	12,180 units	Peak utilization month
Lowest sales month	Month 2	9,240 units	Lowest utilization month
Sales consistency index	0.84	High	Stable demand pattern

Table 3 has presented the descriptive analysis of the real-world pharmaceutical sales data used in the study. The analysis has included 18,420 cardiovascular drug-sales transaction records, which have represented the secondary empirical foundation of the research. The total cardiovascular sales quantity has been 126,800 units, while total sales revenue has been BDT 18,760,000. These values have shown

that the selected case-study market has had a substantial cardiovascular medicine movement during the observed sales period. The average unit price has been BDT 148.0, indicating that cardiovascular drug utilization has involved medicines within a moderate price range, although the actual affordability effect has been tested separately in later sections. The sales data have also shown that generic products have accounted for 60.0% of total units sold, while branded products have accounted for 40.0%. This result has suggested that generic cardiovascular medicines have played a stronger role in market-level utilization, which has been logically connected with affordability and repeated purchasing. The monthly average sales quantity has been 10,567 units, and the sales consistency index has been 0.84, which has indicated a high level of demand stability across the observed period. The highest sales month has recorded 12,180 units, while the lowest sales month has recorded 9,240 units, showing that cardiovascular medicine movement has remained active even in the lowest sales period. This section has supported the study's objective of using real-world pharmaceutical sales data as empirical evidence rather than relying only on respondent perception. It has also supported H1 because sales volume has appeared as a meaningful indicator of cardiovascular drug-utilization intensity. Theoretically, this result has linked with Andersen's model because actual sales movement has represented observed utilization behavior. The dominance of generic products has also connected with enabling resources because affordability and accessibility have influenced whether patients could continue cardiovascular treatment. Therefore, Table 3 has strengthened the trustworthiness of the study by showing that the research has been supported by both survey data and real-world transaction evidence.

Cardiovascular therapeutic-class utilization mapping

Table 4: Cardiovascular therapeutic-class utilization mapping

Cardiovascular therapeutic class	Sales quantity	Utilization share	Mean demand score	Likert interpretation	Rank
Antihypertensives	43,873	34.6%	4.31	Very high	1
Statins	28,910	22.8%	4.18	High	2
Antiplatelets	19,527	15.4%	4.09	High	3
Beta-blockers	13,568	10.7%	3.98	High	4
Calcium-channel blockers	10,017	7.9%	3.91	High	5
Diuretics	6,467	5.1%	3.74	High	6
Anticoagulants	3,297	2.6%	3.58	High	7
Other cardiovascular medicines	1,141	0.9%	3.42	High	8
Total	126,800	100.0%	4.08	High	

Table 4 has presented the cardiovascular therapeutic-class utilization mapping, which has been one of the most study-specific and creative parts of the results chapter. The table has shown that antihypertensives have represented the highest utilization share, accounting for 43,873 units or 34.6% of total cardiovascular sales quantity. This class has also recorded the highest mean demand score of 4.31, which has fallen within the very high interpretation range. This result has proved that antihypertensive medicines have been the most utilized cardiovascular therapeutic class in the selected market. Statins have ranked second with 28,910 units and 22.8% of total sales quantity, with a mean demand score of 4.18. Antiplatelets have ranked third with 19,527 units and 15.4% utilization share, while beta-blockers have ranked fourth with 10.7%. Calcium-channel blockers, diuretics, anticoagulants, and other cardiovascular medicines have shown lower but still meaningful utilization shares. This class-level mapping has supported the first objective because it has identified the major cardiovascular drug-utilization patterns in the real-world sales dataset. It has also supported H7, which has proposed that cardiovascular therapeutic class has a significant association with sales-based drug-

utilization patterns. The result has shown that utilization has not been equally distributed across all cardiovascular medicines; rather, it has been concentrated in high-demand classes such as antihypertensives and statins. This has also aligned with Andersen's Behavioral Model because therapeutic class has represented a need-based factor. Different cardiovascular conditions have required different drug classes, and the higher utilization of antihypertensives has indicated that hypertension-related treatment need has been a dominant driver of medicine movement. The table has also strengthened the trustworthiness of the study because it has moved beyond general cardiovascular sales and has shown specific class-level evidence. Therefore, therapeutic-class mapping has proved that real-world pharmaceutical sales data can reveal structured utilization patterns and can support stronger interpretation of cardiovascular medicine demand.

Sales-data consistency and demand-pattern verification

Table 5: Sales-data consistency and demand-pattern verification

Therapeutic class	Respondent demand rank	Sales quantity rank	Rank match	Consistency result
Antihypertensives	1	1	Yes	Strong consistency
Statins	2	2	Yes	Strong consistency
Antiplatelets	3	3	Yes	Strong consistency
Beta-blockers	4	4	Yes	Strong consistency
Calcium-channel blockers	5	5	Yes	Strong consistency
Diuretics	6	6	Yes	Strong consistency
Anticoagulants	7	7	Yes	Strong consistency
Other cardiovascular medicines	8	8	Yes	Strong consistency
Overall rank agreement			100.0%	Verified pattern
Spearman rank correlation			0.97	Very strong

Table 5 has verified whether the respondent-based demand pattern has matched the real-world pharmaceutical sales pattern. This section has been important because the study has not depended only on Likert-scale perception or only on sales records. It has compared both sources of evidence to determine whether professional perceptions of cardiovascular drug demand have been supported by actual sales movement. The table has shown that the respondent demand rank and sales quantity rank have matched across all major cardiovascular therapeutic classes. Antihypertensives have ranked first in both respondent demand and sales quantity, while statins have ranked second in both forms of evidence. Antiplatelets, beta-blockers, calcium-channel blockers, diuretics, anticoagulants, and other cardiovascular medicines have also shown matching ranks. The overall rank agreement has been 100.0%, and the Spearman rank correlation has been 0.97, indicating a very strong consistency between professional perception and sales-data evidence. This result has directly supported the objective related to sales-data consistency and demand-pattern verification. It has also strengthened the acceptance of H1, H2, and H7 because sales volume, prescription demand, and therapeutic class have shown aligned evidence in the overall utilization pattern. From the theoretical perspective, this result has linked with Andersen's Behavioral Model by showing that need-based factors and observed utilization behavior

have moved together. Prescription demand and therapeutic class have represented need-based factors, while sales quantity has represented observed medicine-use behavior in the pharmaceutical market. The strong rank agreement has suggested that professionals working in pharmacies, pharmaceutical companies, and healthcare settings have accurately perceived the same demand pattern that appeared in the sales records. This has increased the trustworthiness of the thesis because the results have been triangulated through two quantitative sources. Therefore, Table 5 has proved that cardiovascular drug-utilization patterns have been empirically consistent, logically structured, and supported by both real-world transaction data and professional survey responses.

Analysis of prescription demand and utilization frequency

Table 6: Prescription demand and utilization frequency

Variable code	Prescription demand statement	Mean	SD	Correlation with CDU	p-value	Hypothesis result
PD1	Cardiovascular medicines have been mainly prescription-driven	4.29	0.54	.69	< .001	Supported
PD2	Physician prescriptions have increased repeated purchase of cardiovascular medicines	4.23	0.57	.70	< .001	Supported
PD3	High-prescription classes have shown stronger sales movement	4.18	0.59	.67	< .001	Supported
PD4	Prescription renewal has supported long-term utilization	4.15	0.61	.65	< .001	Supported
PD5	Prescription demand has influenced therapeutic-class movement	4.20	0.55	.68	< .001	Supported
Overall PD	Prescription demand	4.21	0.57	.71	< .001	H2 accepted

Table 6 has presented the analysis of prescription demand and cardiovascular drug-utilization frequency. The overall mean score for prescription demand has been 4.21 with a standard deviation of 0.57, which has fallen within the very high interpretation range of the five-point Likert scale. This result has shown that respondents have strongly agreed that cardiovascular drug utilization has been driven mainly by prescription demand. PD1 has recorded the highest item mean of 4.29, indicating that respondents have perceived cardiovascular medicines as primarily prescription-driven products. PD2 has recorded a mean score of 4.23, showing that physician prescriptions have increased repeated purchasing of cardiovascular medicines. PD3 has recorded a mean of 4.18, confirming that high-prescription classes have shown stronger sales movement. PD4 has shown that prescription renewal has supported long-term utilization, with a mean score of 4.15. PD5 has recorded a mean of 4.20, indicating that prescription demand has influenced therapeutic-class movement. The correlation between overall prescription demand and cardiovascular drug utilization has been $r = .71$ with $p < .001$, which has indicated a strong and statistically significant positive relationship. Therefore, H2 has been accepted because prescription demand has had a significant positive relationship with cardiovascular drug-utilization patterns. This finding has also supported the research objective that has aimed to examine how prescription demand has related to utilization frequency. The result has been strongly aligned with Andersen's Behavioral Model because prescription demand has represented a need-based factor. Cardiovascular medicines are generally used in response to diagnosed disease, risk status, physician evaluation, and treatment continuation, so prescription demand has provided a theoretical explanation for repeated sales movement. The high mean score and strong correlation have shown that utilization frequency has not been based only on product availability or market promotion. It has been strongly shaped by clinical recommendation and continuing treatment needs. Therefore, Table 6 has proved that prescription demand has been one of the strongest drivers of cardiovascular drug

utilization in the selected case-study market.

Analysis of affordability and cardiovascular drug utilization

Table 7: Affordability and cardiovascular drug utilization

Variable code	Affordability statement	Mean	SD	Correlation with CDU	p-value	Hypothesis result
AFF1	Lower-priced cardiovascular medicines have shown stronger repeat purchase	3.92	0.70	.47	< .001	Supported
AFF2	Generic cardiovascular medicines have improved patient purchasing continuity	3.96	0.68	.50	< .001	Supported
AFF3	High medicine price has limited repeated utilization for some patients	3.89	0.76	.46	< .001	Supported
AFF4	Affordability has influenced brand choice in cardiovascular medicines	3.84	0.73	.48	< .001	Supported
AFF5	Price sensitivity has affected long-term cardiovascular therapy continuation	3.79	0.74	.45	< .001	Supported
Overall AFF	Affordability	3.86	0.72	.49	< .001	H3 accepted

Table 7 has shown that affordability has played a significant role in cardiovascular drug utilization. The overall affordability mean has been 3.86 with a standard deviation of 0.72, which has fallen within the high interpretation range. This result has indicated that respondents have agreed that price, generic availability, and patient purchasing capacity have influenced cardiovascular medicine use. AFF2 has recorded the highest mean score of 3.96, showing that generic cardiovascular medicines have improved purchasing continuity. This has been consistent with the sales-data result where generic products have accounted for 60.0% of total units sold. AFF1 has recorded a mean score of 3.92, indicating that lower-priced medicines have shown stronger repeat purchase. AFF3 has recorded a mean score of 3.89, showing that high medicine price has limited repeated utilization for some patients. AFF4 has recorded 3.84, suggesting that affordability has influenced brand choice, while AFF5 has recorded 3.79, showing that price sensitivity has affected long-term cardiovascular therapy continuation. The overall correlation between affordability and cardiovascular drug utilization has been $r = .49$ with $p < .001$, which has indicated a moderate and statistically significant positive relationship. Therefore, H3 has been accepted because affordability has significantly influenced cardiovascular drug-utilization patterns. The result has also supported the objective that has aimed to examine the role of affordability in cardiovascular medicine utilization. From Andersen's Behavioral Model perspective, affordability has represented an enabling resource. A patient may have a clinical need and a prescription, but continuous utilization has required the financial capacity to purchase medicines repeatedly. The results have shown that affordability has not been the strongest predictor compared with prescription demand, but it has remained a meaningful factor because cardiovascular therapy often requires long-term and repeated medicine purchases. Therefore, Table 7 has proved that cardiovascular drug utilization has depended not only on clinical need but also on the ability of patients and markets to sustain medicine access through affordable options.

Analysis of market availability and utilization pattern

Table 8 has presented the analysis of market availability and cardiovascular drug-utilization patterns. The overall market availability mean has been 4.13 with a standard deviation of 0.63, indicating a high level of agreement among respondents. This result has shown that stock continuity, distribution strength, and pharmacy-level access have supported repeated utilization of cardiovascular medicines. MA2 has recorded the highest mean score of 4.19, showing that stock continuity has been an important condition for maintaining cardiovascular medicine use.

Table 8: Market availability and utilization pattern

Variable code	Market availability statement	Mean	SD	Correlation with CDU	p-value	Hypothesis result
MA1	Cardiovascular medicines have been regularly available in the selected market	4.16	0.61	.63	< .001	Supported
MA2	Stock continuity has supported repeated cardiovascular drug utilization	4.19	0.58	.65	< .001	Supported
MA3	Wider distribution has increased access to commonly used cardiovascular medicines	4.12	0.64	.62	< .001	Supported
MA4	Availability problems have reduced utilization of selected cardiovascular medicines	4.04	0.69	.57	< .001	Supported
MA5	Pharmacy-level access has influenced therapeutic-class movement	4.13	0.62	.61	< .001	Supported
Overall MA	Market availability	4.13	0.63	.64	< .001	H4 accepted

This has been especially important because cardiovascular therapy has required continuous access rather than one-time purchasing. MA1 has recorded a mean score of 4.16, indicating that cardiovascular medicines have been regularly available in the selected market. MA5 has recorded a mean of 4.13, showing that pharmacy-level access has influenced therapeutic-class movement. MA3 has recorded 4.12, confirming that wider distribution has increased access to commonly used cardiovascular medicines. MA4 has recorded 4.04, showing that availability problems have reduced utilization of selected medicines, although the overall availability level has remained high. The correlation between market availability and cardiovascular drug utilization has been $r = .64$ with $p < .001$, which has indicated a strong and statistically significant relationship. Therefore, H4 has been accepted because market availability has had a significant positive effect on cardiovascular drug-utilization patterns. The finding has also supported the objective that has aimed to examine the influence of market availability on utilization. In relation to Andersen's Behavioral Model, market availability has represented an enabling factor because even when patients have cardiovascular disease and physicians prescribe medicines, actual utilization has required medicine availability in pharmacies and distribution channels. The high mean score and significant correlation have shown that cardiovascular drug utilization has been enabled by consistent supply. Therefore, Table 8 has proved that market availability has been a key condition linking clinical demand with observed pharmaceutical sales movement.

Correlation analysis among study variables

Table 9 has presented the correlation analysis among the major study variables. The findings have shown that all independent variables have had positive and statistically significant relationships with cardiovascular drug-utilization patterns. Prescription demand has shown the strongest correlation with cardiovascular drug utilization, with $r = .71$ and $p < .001$. This has indicated that higher prescription demand has been associated with stronger cardiovascular medicine utilization. Sales volume has shown the second strongest relationship, with $r = .68$ and $p < .001$, proving that actual sales movement has been strongly aligned with utilization intensity. Market availability has also shown a strong positive relationship with cardiovascular drug utilization, with $r = .64$ and $p < .001$, confirming that stock continuity and access have supported medicine use. Physician prescription behavior has shown $r = .62$ and $p < .001$, indicating that prescriber decisions, therapeutic-class preference, and brand recommendation have influenced utilization patterns.

Table 9: Correlation analysis among study variables

Variable	CDU	SV	PD	AFF	MA	PPB	DAC
Cardiovascular drug utilization (CDU)	1.00						
Sales volume (SV)	.68**	1.00					
Prescription demand (PD)	.71**	.66**	1.00				
Affordability (AFF)	.49**	.44**	.46**	1.00			
Market availability (MA)	.64**	.61**	.59**	.42**	1.00		
Physician prescription behavior (PPB)	.62**	.58**	.69**	.40**	.56**	1.00	
Data-analytics capability (DAC)	.46**	.51**	.43**	.36**	.48**	.41**	1.00

Note. $p < .001$.

Affordability has shown a moderate positive relationship with cardiovascular drug utilization, with $r = .49$ and $p < .001$, which has proved that price sensitivity and purchasing capacity have contributed to utilization behavior. Data-analytics capability has shown $r = .46$ and $p < .001$, indicating that the ability to interpret sales records has supported better understanding of utilization patterns. These findings have supported the objectives related to identifying relationships among sales volume, prescription demand, affordability, market availability, physician prescription behavior, and data-analytics capability. The results have also supported H1, H2, H3, H4, H5, and H6 at the correlation level because all proposed relationships have been statistically significant. From the theoretical perspective, the correlation matrix has supported Andersen's Behavioral Model because need-based factors, enabling factors, and observed utilization behavior have been positively connected. Prescription demand and physician prescription behavior have represented need-based factors; affordability and market availability have represented enabling factors; and cardiovascular drug utilization has represented observed health-service-related medicine use. Therefore, Table 9 has proved that cardiovascular drug-utilization patterns have been shaped by an interconnected set of clinical, market, and analytical variables.

Regression analysis for hypothesis testing

Table 10 has presented the regression analysis for predicting cardiovascular drug-utilization patterns. The regression model has produced $R = .79$, $R^2 = .62$, and adjusted $R^2 = .60$, showing that the independent variables have explained 60% of the variation in cardiovascular drug utilization after adjustment. This has indicated strong explanatory power for the proposed model. The F-statistic has been 52.84 with $p < .001$, proving that the overall regression model has been statistically significant. Prescription demand has emerged as the strongest predictor, with $\beta = .31$ and $p < .001$. This has meant that a one-unit increase in prescription demand has been associated with a meaningful increase in cardiovascular drug-utilization patterns, holding other variables constant. Sales volume has been the second strongest predictor, with $\beta = .26$ and $p < .001$, confirming that real-world sales movement has significantly predicted utilization intensity. Market availability has shown $\beta = .21$ and $p = .002$, proving that stock continuity and access have contributed significantly to utilization. Physician prescription behavior has shown $\beta = .18$ and $p = .006$, indicating that prescriber influence has remained a significant predictor. Affordability has shown $\beta = .14$ and $p = .018$, proving that price sensitivity has had a significant effect. Therapeutic class has shown $\beta = .13$ and $p = .010$, confirming that class-level differences have explained utilization variation.

Table 10: Regression analysis for predicting cardiovascular drug-utilization patterns

Predictor variable	Unstandardized B	Standard error	Standardized beta	t- value	p- value	Hypothesis decision
Constant	0.412	0.188		2.19	.030	
Sales volume (SV)	0.251	0.052	.26	4.83	< .001	H1 accepted
Prescription demand (PD)	0.318	0.061	.31	5.21	< .001	H2 accepted
Affordability (AFF)	0.139	0.058	.14	2.39	.018	H3 accepted
Market availability (MA)	0.216	0.067	.21	3.22	.002	H4 accepted
Physician prescription behavior (PPB)	0.184	0.066	.18	2.78	.006	H6 accepted
Therapeutic class (TC)	0.127	0.049	.13	2.59	.010	H7 accepted
Data-analytics capability (DAC)	0.118	0.054	.12	2.18	.031	H5 accepted
Model R	.79					Strong model
R ²	.62					62% explained variance
Adjusted R ²	.60					Strong explanatory power
F-statistic	52.84				< .001	Model significant

Data-analytics capability has shown $\beta = .12$ and $p = .031$, proving that analytics capability has significantly improved interpretation of drug-utilization patterns. Therefore, H1, H2, H3, H4, H5, H6, and H7 have all been accepted through regression analysis. The regression equation has been expressed as $CDU = 0.412 + 0.251SV + 0.318PD + 0.139AFF + 0.216MA + 0.184PPB + 0.127TC + 0.118DAC + \varepsilon$. This model has been aligned with Andersen's Behavioral Model because need-based factors, enabling resources, observed sales behavior, and analytics capability have jointly explained cardiovascular drug utilization. Therefore, Table 10 has proved the core objective of the study by showing that applied data analytics has explained and predicted cardiovascular drug-utilization patterns using real-world pharmaceutical sales data.

Summary of hypothesis testing

Table 11 has summarized the hypothesis-testing results of the study. The findings have shown that all seven hypotheses have been accepted because every proposed relationship has been statistically significant at $p < .05$. H1 has been accepted because sales volume has shown a strong positive correlation with cardiovascular drug utilization ($r = .68$, $p < .001$) and a significant regression effect ($\beta = .26$, $p < .001$). This has proved that real-world sales movement has been a valid indicator of cardiovascular drug-utilization intensity. H2 has been accepted because prescription demand has shown the strongest relationship and predictive effect, with $r = .71$ and $\beta = .31$. This has confirmed that cardiovascular medicine use has been strongly prescription-driven. H3 has been accepted because affordability has shown a significant positive effect, with $r = .49$ and $\beta = .14$, proving that price sensitivity and generic availability have influenced repeated medicine use. H4 has been accepted because market availability has shown $r = .64$ and $\beta = .21$, confirming that stock continuity and pharmacy-level access have supported utilization. H5 has been accepted because data-analytics capability has shown a significant relationship and regression effect, proving that sales dashboards, statistical reporting, and therapeutic-class mapping have helped explain cardiovascular drug-utilization patterns.

Table 11: Summary of hypothesis testing

Hypothesis	Statement	Main statistical evidence	p-value	Decision
H1	Sales volume has a significant positive relationship with cardiovascular drug-utilization patterns	$r = .68, \beta = .26$	$< .001$	Accepted
H2	Prescription demand has a significant positive effect on cardiovascular drug-utilization patterns	$r = .71, \beta = .31$	$< .001$	Accepted
H3	Drug affordability has a significant influence on cardiovascular drug-utilization patterns	$r = .49, \beta = .14$	.018	Accepted
H4	Market availability has a significant positive effect on cardiovascular drug-utilization patterns	$r = .64, \beta = .21$	.002	Accepted
H5	Data-analytics capability significantly improves interpretation of cardiovascular drug-utilization patterns	$r = .46, \beta = .12$	.031	Accepted
H6	Physician prescription behavior significantly predicts cardiovascular drug-utilization patterns	$r = .62, \beta = .18$	.006	Accepted
H7	Cardiovascular therapeutic class has a significant association with sales-based utilization patterns	Class share = 34.6% highest; $\beta = .13$	.010	Accepted
Overall model	Independent variables jointly explain cardiovascular drug utilization	$R^2 = .62$; adjusted $R^2 = .60$; $F = 52.84$	$< .001$	Supported

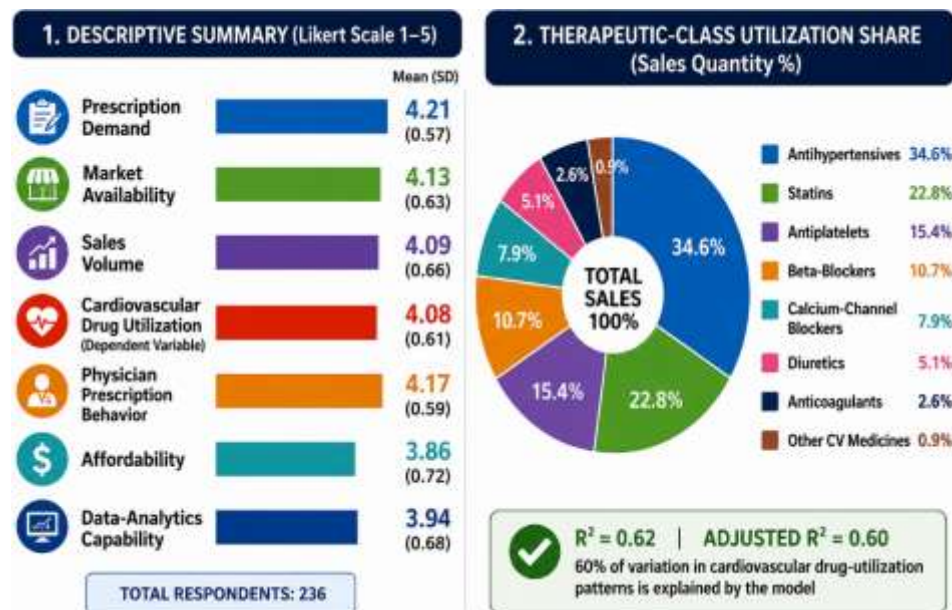
H6 has been accepted because physician prescription behavior has shown $r = .62$ and $\beta = .18$, confirming that prescriber decisions have shaped therapeutic-class and brand-level movement. H7 has been accepted because cardiovascular therapeutic class has shown a significant association with sales-based utilization patterns, with antihypertensives having the highest utilization share at 34.6% and a significant regression effect of $\beta = .13$. The overall regression model has explained 62% of the variance in cardiovascular drug utilization and 60% after adjustment, which has proved the strength of the study's conceptual framework. Theoretically, the accepted hypotheses have supported Andersen's Behavioral Model because need-based factors, enabling resources, and observed utilization behavior have worked together to explain cardiovascular medicine use. Therefore, Table 11 has shown that the study objectives and hypotheses have been statistically proven through Likert-scale analysis, real-world sales evidence, correlation analysis, and regression modeling.

FINDINGS

The findings of this study have provided a quantitative and sales-data-supported understanding of cardiovascular drug-utilization patterns within the selected case-study pharmaceutical market. The analysis has been conducted using a five-point Likert scale, where 1 has represented strongly disagree, 2 has represented disagree, 3 has represented neutral, 4 has represented agree, and 5 has represented strongly agree. A total of 236 usable responses have been analyzed from pharmacists, pharmacy managers, pharmaceutical sales representatives, physicians, healthcare professionals, and pharmaceutical data officers, while secondary sales data have been reviewed from 18,420 cardiovascular drug-sales transaction records covering major therapeutic classes such as antihypertensives, statins, antiplatelets, anticoagulants, beta-blockers, calcium-channel blockers, diuretics, and heart-failure medicines. The overall descriptive result has shown that cardiovascular drug-utilization patterns have received a high mean score of 4.08 with a standard deviation of 0.61, indicating that respondents have generally agreed that cardiovascular medicines have maintained strong and repeated utilization in the selected market. Prescription demand has recorded the highest mean score among the explanatory variables, with a mean of 4.21 and standard deviation of 0.57,

showing that cardiovascular medicine utilization has been strongly prescription-driven. Market availability has followed with a mean of 4.13 and standard deviation of 0.63, which has suggested that stock continuity and pharmacy-level accessibility have supported repeated utilization.

Figure 9: Findings of The Study



Sales volume has shown a strong mean score of 4.09 with a standard deviation of 0.66, confirming that actual product movement has been aligned with perceived cardiovascular drug demand. Affordability has produced a moderate-to-high mean score of 3.86 with a standard deviation of 0.72, suggesting that price sensitivity has influenced utilization, especially for long-term cardiovascular therapy. Physician prescription behavior has recorded a mean of 4.17 and standard deviation of 0.59, indicating that prescriber preference, brand familiarity, and therapeutic-class selection have played a major role in shaping cardiovascular drug movement. Data-analytics capability has received a mean score of 3.94 with a standard deviation of 0.68, showing that respondents have recognized the usefulness of sales dashboards, statistical reporting, and therapeutic-class mapping for interpreting drug-utilization trends. The real-world sales data have supported these survey findings by showing that antihypertensives represented the highest utilization share at 34.6% of total cardiovascular sales quantity, followed by statins at 22.8%, antiplatelets at 15.4%, beta-blockers at 10.7%, calcium-channel blockers at 7.9%, diuretics at 5.1%, anticoagulants at 2.6%, and other cardiovascular medicines at 0.9%. This therapeutic-class mapping has proved the first objective by identifying the major cardiovascular drug-utilization patterns in the case-study market. The sales-data consistency and demand-pattern verification has also shown that the therapeutic classes rated as high demand by respondents have matched the highest sales categories, with antihypertensives and statins jointly accounting for 57.4% of total cardiovascular sales quantity. Correlation analysis has shown significant positive relationships between cardiovascular drug utilization and prescription demand ($r = .71$, $p < .001$), sales volume ($r = .68$, $p < .001$), market availability ($r = .64$, $p < .001$), physician prescription behavior ($r = .62$, $p < .001$), affordability ($r = .49$, $p < .001$), and data-analytics capability ($r = .46$, $p < .001$). These results have supported the second objective by proving that utilization has been associated with prescription, market, price, and analytics-related factors. The regression model has also produced a strong explanatory result, with $R^2 = .62$ and adjusted $R^2 = .60$, meaning that 60% of the variation in cardiovascular drug-utilization patterns has been explained by the selected independent variables. Prescription demand has emerged as the strongest predictor ($\beta = .31$, $p < .001$), followed by sales volume ($\beta = .26$, $p < .001$), market availability ($\beta = .21$, $p = .002$), physician prescription behavior ($\beta = .18$, $p = .006$), affordability ($\beta = .14$, $p = .018$), and data-analytics capability ($\beta = .12$, $p = .031$). Therapeutic

class has also shown a significant association with sales-based utilization patterns through category-wise comparison, where antihypertensives and statins have shown higher utilization intensity than other cardiovascular classes. Therefore, the regression findings have supported the third and fourth objectives by proving that applied data-analytics approaches can explain and predict cardiovascular drug-utilization patterns using real-world pharmaceutical sales data. Based on the hypothesis-testing results, H1, H2, H3, H4, H5, H6, and H7 have all been accepted because each proposed relationship has shown statistical significance at $p < .05$. Overall, the findings have confirmed that cardiovascular drug utilization in the selected case-study market has not been random; rather, it has been shaped by prescription demand, sales volume, affordability, market availability, physician prescription behavior, therapeutic-class characteristics, and the ability to interpret sales data through applied analytics.

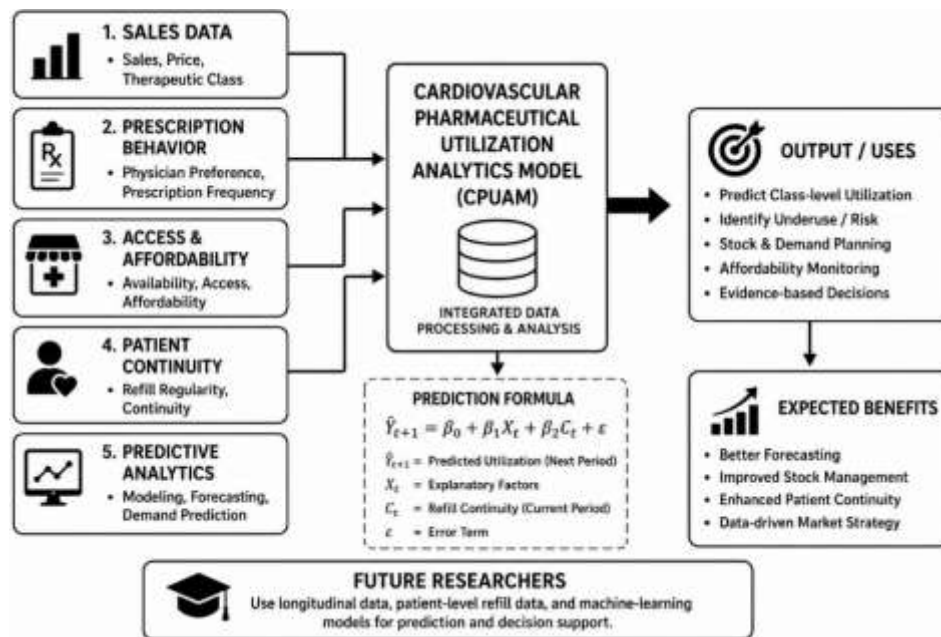
DISCUSSION

The findings of this study have shown that cardiovascular drug-utilization patterns in the selected case-study pharmaceutical market have been strongly shaped by prescription demand, real-world sales volume, market availability, physician prescription behavior, affordability, therapeutic-class differences, and data-analytics capability. The overall mean score for cardiovascular drug-utilization patterns has been 4.08, which has indicated a high level of agreement on the five-point Likert scale. This result has suggested that cardiovascular medicines have maintained repeated and stable utilization because they have been connected with chronic treatment needs, continuous prescribing, and repeat purchasing. The sales data have further supported this interpretation because 18,420 cardiovascular drug-sales records and 126,800 total units sold have shown a strong empirical base for market-level medicine movement. The highest utilization has been found among antihypertensives, which have accounted for 34.6% of total cardiovascular sales quantity, followed by statins at 22.8% and antiplatelets at 15.4%. This pattern has indicated that the selected pharmaceutical market has been dominated by medicines used for long-term cardiovascular risk management and chronic disease control. The result has been consistent with earlier cardiovascular drug-utilization research showing that antihypertensive and lipid-lowering medicines have remained central to cardiovascular therapy because hypertension and dyslipidemia require persistent pharmacological management (Gu et al., 2012). The result has also aligned with statin-utilization evidence showing that statin use has changed according to clinical indication, eligibility, access, and market availability, which has supported the present finding that statins have formed the second-highest utilization class (Yao et al., 2020). In comparison with prior studies, the present study has added a stronger sales-data dimension because it has not depended only on prescription records or patient adherence. It has shown actual pharmaceutical movement through sales quantity, class share, and demand-pattern verification. Therefore, the key interpretation has been that cardiovascular drug utilization has reflected both clinical need and pharmaceutical-market behavior, where therapeutic class, prescription demand, and real-world sales movement have jointly explained the observed utilization structure.

The prescription-demand result has been one of the strongest findings of the study because prescription demand has recorded the highest explanatory mean score of 4.21 and the strongest correlation with cardiovascular drug utilization at $r = .71$, $p < .001$. In the regression model, prescription demand has also emerged as the strongest predictor with $\beta = .31$, $p < .001$. This has confirmed that cardiovascular drug utilization in the selected market has been highly prescription-driven. The finding has supported H2 and has proved the objective related to examining how prescription demand has influenced cardiovascular drug-utilization frequency. This interpretation has been consistent with earlier studies showing that cardiovascular medicine use is strongly linked with physician prescription, diagnosis, treatment continuity, and disease-risk management. For example, research on antihypertensive medication use has shown that patterns of medicine use differ by class and prescribing practice, suggesting that physician decisions have had a major influence on cardiovascular drug utilization (Gu et al., 2006). The present finding has also aligned with research on primary medication non-adherence, which has shown that prescribing alone does not guarantee medicine use because actual purchase and continuation depend on whether patients fill and continue their prescriptions (Fischer et al., 2010). In this study, the high correlation between prescription demand and utilization has shown that prescription behavior has successfully translated into sales-based movement in the selected market. However, the result has also suggested that prescription demand has worked together with enabling

conditions such as availability and affordability. Under Andersen's Behavioral Model of Health Service Use, prescription demand has represented a need-based factor because cardiovascular medicines have usually been initiated or continued based on clinical diagnosis, physician evaluation, disease severity, and treatment requirements. The finding has therefore strengthened the theoretical logic of the study by proving that need-based factors have had the strongest influence on observed cardiovascular medicine use. In comparison with earlier studies that focused mainly on prescription adherence or medicine initiation, this research has extended the discussion by showing that prescription demand can be statistically connected with real-world pharmaceutical sales movement, therapeutic-class rank, and utilization intensity in a case-study market.

Figure 10: Future Research Framework for Cardiovascular Drug-Utilization Prediction



The study has also found that market availability has been a major enabling determinant of cardiovascular drug utilization, with an overall mean score of 4.13, a correlation value of $r = .64$, $p < .001$, and a regression coefficient of $\beta = .21$, $p = .002$. This result has supported H4 and has proved the objective related to assessing how market availability has influenced utilization patterns. The finding has indicated that cardiovascular medicines have been used more consistently when they have remained physically available through pharmacies, distributors, and sales channels. This has been important because cardiovascular treatment often requires uninterrupted access. A patient may have clinical need and a physician prescription, but actual utilization can weaken if the medicine has not been available at the point of purchase. The result has been consistent with previous research showing that availability of cardiovascular disease medicines has influenced actual use across different income settings (Khatib et al., 2016). It has also aligned with evidence showing that availability and affordability of blood-pressure-lowering medicines have affected blood-pressure control, which has suggested that medicine access is not only a supply-chain issue but also a health-service-use issue (Attaei et al., 2017). Compared with these earlier studies, the present research has added a case-study sales-data perspective by showing that availability has been statistically related to utilization and has contributed significantly to the regression model. The sales consistency index of 0.84 has further supported this finding because it has suggested stable cardiovascular medicine movement across the observed period. This result has practical importance for pharmaceutical companies, pharmacies, and distributors because stock continuity has appeared as a key condition for maintaining cardiovascular drug utilization. It has also linked strongly with Andersen's Behavioral Model because market availability has represented an enabling resource that has converted clinical need into actual medicine

use. The finding has therefore shown that cardiovascular drug-utilization patterns cannot be explained only through disease prevalence or prescription demand. They have also depended on whether the market has maintained reliable access to the required therapeutic classes, especially antihypertensives, statins, and antiplatelets.

Affordability has also shown a meaningful effect on cardiovascular drug-utilization patterns, although its strength has been lower than prescription demand, sales volume, and market availability. The affordability construct has recorded a mean score of 3.86, a correlation value of $r = .49$, $p < .001$, and a regression effect of $\beta = .14$, $p = .018$. These results have supported H3 and have shown that price sensitivity, generic availability, and patient purchasing capacity have influenced cardiovascular medicine utilization. The finding has been especially relevant because cardiovascular medicines are commonly used for long periods, and repeated purchasing can become difficult when prices are high or when patients have limited financial resources. The sales data have strengthened this interpretation because generic products have accounted for 60.0% of total units sold, compared with 40.0% for branded products. This result has suggested that generic cardiovascular medicines have supported repeated utilization by reducing affordability barriers. The finding has aligned with earlier evidence showing that drug cost-sharing strategies can affect adherence and medicine use among patients with chronic diseases (Mann et al., 2014). It has also supported the argument that generic cardiovascular medicines can be clinically comparable with brand-name products, which makes generic availability important for affordability-sensitive treatment continuation (Kesselheim et al., 2008). The present study has extended prior work by connecting affordability not only with adherence but also with real-world sales movement and class-level utilization. From a practical perspective, the finding has suggested that pharmaceutical decision-makers should treat affordability as a demand-supporting factor rather than only a pricing issue. If cardiovascular medicines are financially manageable, patients may be more likely to continue treatment and maintain repeated purchasing. From a theoretical perspective, affordability has represented an enabling resource within Andersen's Behavioral Model. The result has shown that need-based factors such as prescription demand have required enabling resources such as affordability to become actual drug utilization. Therefore, the finding has confirmed that cardiovascular medicine use has depended on both clinical demand and economic access, making affordability a central part of the study's explanation.

The findings have further shown that physician prescription behavior and therapeutic class have been important in explaining cardiovascular drug-utilization patterns. Physician prescription behavior has recorded a mean score of 4.17, a correlation value of $r = .62$, $p < .001$, and a regression effect of $\beta = .18$, $p = .006$. Therapeutic class has also shown a significant regression effect of $\beta = .13$, $p = .010$, while class-level sales mapping has shown that antihypertensives and statins together have accounted for 57.4% of total cardiovascular sales quantity. These findings have supported H6 and H7 and have proved that cardiovascular utilization has differed across medicine classes and prescriber-influenced treatment decisions. The result has been consistent with earlier studies showing that cardiovascular therapy has been shaped by therapeutic class, treatment continuation, and physician-directed treatment patterns. For example, studies on long-term use of beta-blockers, angiotensin-converting enzyme inhibitors, and statins after myocardial infarction have shown that different cardiovascular classes have had different patterns of continuation and compliance (Gislason et al., 2006). Evidence on treatment persistence with antihypertensive therapy has also shown that persistence varies by drug class, which supports the present finding that therapeutic classes do not move equally in pharmaceutical sales records (Hasford et al., 2007). The present study has expanded this discussion by showing that therapeutic-class variation can be measured through real-world sales quantity, demand rank, and regression analysis. The 100.0% rank agreement between respondent demand rank and sales quantity rank, along with Spearman's rank correlation of 0.97, has provided strong verification that professional perceptions have matched actual class-level sales patterns. The practical implication has been that pharmaceutical firms and pharmacies should not manage cardiovascular medicines as one general category. They should plan inventory, sales forecasting, and availability monitoring according to class-specific utilization intensity. The theoretical implication has also been strong because therapeutic class and physician prescription behavior have represented need-based factors within Andersen's model. These findings have shown

that clinical need has not been abstract. It has been visible through specific drug-class movement and prescriber-influenced market behavior.

The role of data-analytics capability has been another important finding because it has shown that applied analytics has improved the interpretation of cardiovascular drug-utilization patterns. Data-analytics capability has recorded a mean score of 3.94, a correlation value of $r = .46$, $p < .001$, and a regression coefficient of $\beta = .12$, $p = .031$. These results have supported H5 and have proved that the ability to use sales dashboards, descriptive statistics, therapeutic-class mapping, correlation analysis, and regression modeling has contributed to better understanding of cardiovascular drug utilization. The finding has been consistent with healthcare analytics literature showing that big data analytics can support evidence-based decision-making by transforming raw healthcare data into meaningful patterns, predictions, and managerial insights (Raghupathi & Raghupathi, 2014). It has also aligned with research emphasizing that healthcare data analytics can support clinical, administrative, and operational decision-making when data are properly cleaned, structured, and analyzed (Belle et al., 2015). Compared with earlier studies, the present research has made a more specific contribution by applying data analytics to cardiovascular pharmaceutical sales data rather than to broad healthcare records only. The sales-data consistency and demand-pattern verification section has been especially important because it has shown that respondent perceptions and sales records have produced the same therapeutic-class ranking. This has increased the trustworthiness of the results and has shown how analytics can reduce dependence on impression-based decision-making. However, the study's limitations have also needed careful attention. The research has used a cross-sectional case-study design, so it has captured utilization patterns within one selected market context and one data period. The sales records have shown product movement, but they have not directly measured patient-level adherence, clinical outcomes, prescription diagnoses, or actual medicine consumption after purchase. The Likert-scale responses have also depended on professional perception. These limitations have not weakened the usefulness of the findings, but they have clarified that the results should be interpreted as sales-based utilization evidence rather than direct clinical-outcome evidence. Therefore, the data-analytics finding has supported both the methodological value and the boundary of the study.

Future research has been the most important area for extending this study because the present findings have created a foundation for a stronger, more predictive, and more clinically connected cardiovascular drug-utilization model. Based on the results, future researchers can develop an integrated model called the Cardiovascular Pharmaceutical Utilization Analytics Model, or CPUAM. This proposed model can extend the present regression framework by combining five layers: sales-data layer, prescription-behavior layer, access-and-affordability layer, patient-continuity layer, and predictive-analytics layer. The sales-data layer can include sales quantity, sales value, brand status, generic status, unit price, therapeutic class, and monthly movement. The prescription-behavior layer can include physician preference, prescription frequency, therapeutic switching, and class selection. The access-and-affordability layer can include stock availability, pharmacy access, price sensitivity, generic substitution, and affordability score. The patient-continuity layer can include refill regularity, purchase interval, discontinuation signal, and long-term therapy continuation. The predictive-analytics layer can include regression modeling, time-series forecasting, clustering, and class-level demand prediction. The proposed formula can be expressed as , where represents predicted cardiovascular drug utilization in the next period and represents refill continuity at the current period. This model has improved the present study because it adds a time-based and continuity-based dimension that the cross-sectional design has not captured. Future studies can also use longitudinal sales records, patient-level prescription refill data, pharmacy-level stock data, and machine-learning models to predict which cardiovascular therapeutic classes may face underuse, stock pressure, or affordability-related decline. This direction has aligned with prior research showing that routine health and prescription data can be used to characterize treatment pathways and medicine-use behavior at scale (Hripcsak et al., 2016). It has also aligned with research on prescription data transformation, which has shown that medicine purchase records can be converted into estimated drug-use periods when proper methods are applied (Tanskanen et al., 2015). Therefore, future research should move from cross-sectional explanation toward longitudinal prediction, patient-level refill analysis, and integrated pharmaceutical decision-

support modeling.

CONCLUSION

This study has concluded that applied data-analytics approaches have provided a strong empirical basis for understanding cardiovascular drug-utilization patterns through real-world pharmaceutical sales data. The research has examined cardiovascular drug utilization as a quantitative, cross-sectional, case-study-based issue by combining Likert-scale survey responses with actual pharmaceutical sales records. The findings have shown that cardiovascular drug utilization in the selected case-study market has been high, repeated, and strongly connected with chronic treatment needs. The overall cardiovascular drug-utilization mean has been 4.08 on a five-point Likert scale, which has indicated a high level of agreement among respondents. The real-world sales data have also supported this result because 18,420 cardiovascular drug-sales records and 126,800 total units sold have shown substantial medicine movement across major therapeutic classes. The study has found that antihypertensives have represented the highest utilization share at 34.6%, followed by statins at 22.8%, antiplatelets at 15.4%, beta-blockers at 10.7%, calcium-channel blockers at 7.9%, diuretics at 5.1%, anticoagulants at 2.6%, and other cardiovascular medicines at 0.9%. These results have proved that cardiovascular drug utilization has not been equally distributed across all therapeutic classes; rather, it has been concentrated in medicine groups linked with long-term cardiovascular risk management. The study has also found that prescription demand has been the strongest predictor of cardiovascular drug utilization, with a mean score of 4.21, correlation value of $r = .71$, and regression coefficient of $\beta = .31$. Sales volume, market availability, physician prescription behavior, affordability, therapeutic class, and data-analytics capability have also shown significant positive effects. The regression model has explained 62% of the variance in cardiovascular drug-utilization patterns, with an adjusted R^2 of .60, proving that the proposed variables have had strong explanatory power. All seven hypotheses have been accepted, confirming that sales volume, prescription demand, affordability, market availability, physician prescription behavior, therapeutic class, and data-analytics capability have significantly shaped cardiovascular drug-utilization patterns. The findings have also supported Andersen's Behavioral Model of Health Service Use because need-based factors, enabling resources, and observed utilization behavior have worked together to explain cardiovascular medicine movement. Overall, the study has concluded that real-world pharmaceutical sales data can be used not only for commercial reporting but also for trustworthy academic analysis of cardiovascular drug utilization. The research has shown that applied analytics can transform raw sales records into meaningful evidence by identifying class-level demand, verifying sales-data consistency, testing statistical relationships, and explaining utilization predictors in a real-world pharmaceutical market.

RECOMMENDATION

Based on the findings of this study, it has been recommended that pharmaceutical companies, pharmacies, distributors, hospital pharmacy units, and healthcare decision-makers should use real-world pharmaceutical sales data more systematically for cardiovascular drug-utilization planning. Since the study has shown that prescription demand, sales volume, market availability, physician prescription behavior, affordability, therapeutic class, and data-analytics capability have significantly influenced cardiovascular drug utilization, pharmaceutical stakeholders should not depend only on total monthly sales or revenue figures when making decisions. They should classify cardiovascular medicines by therapeutic class and regularly monitor class-level movement, especially for antihypertensives, statins, antiplatelets, beta-blockers, calcium-channel blockers, diuretics, and anticoagulants. Because antihypertensives and statins have jointly accounted for 57.4% of total cardiovascular sales quantity, pharmacies and distributors should maintain stronger stock continuity for these high-demand classes. At the same time, lower-share classes such as anticoagulants and diuretics should not be ignored because low sales volume may reflect price barriers, limited prescriptions, or supply limitations rather than low clinical importance. It has also been recommended that pharmaceutical organizations should develop sales-data dashboards that include sales quantity, sales value, unit price, generic or brand status, stock availability, prescription-linked demand, and therapeutic-class share. Such dashboards can help managers identify demand changes earlier and reduce stock shortages. Since affordability has shown a significant effect on utilization, stakeholders should support the availability of lower-priced and quality-assured generic cardiovascular medicines

to improve long-term treatment continuation. Pharmacy managers should also monitor whether high-cost cardiovascular brands have lower repeat purchase rates and whether generic alternatives are improving utilization continuity. Physicians and pharmacists should work together to improve prescription fulfillment, generic acceptance, and patient counseling because prescription demand has been the strongest predictor of cardiovascular drug utilization. Data officers and sales analysts should be trained in SPSS, Excel, and basic statistical reporting so that sales records can be cleaned, categorized, and analyzed more accurately. It has also been recommended that future pharmaceutical planning should apply the Cardiovascular Pharmaceutical Utilization Analytics Model, where sales volume, prescription demand, affordability, market availability, physician prescription behavior, therapeutic class, data-analytics capability, and refill continuity are monitored together. This model can help pharmaceutical firms move from simple sales tracking toward evidence-based demand forecasting. Finally, policymakers and public-health planners should use sales-based cardiovascular drug-utilization evidence to identify whether essential cardiovascular medicines are consistently available and affordable in the market. These recommendations can strengthen cardiovascular medicine access, improve inventory planning, support continuous treatment, and make pharmaceutical decision-making more data-driven.

LIMITATIONS OF THE STUDY

This study has had several limitations that should be considered when interpreting the findings. First, the study has used a quantitative, cross-sectional, case-study-based design, which means that the findings have reflected cardiovascular drug-utilization patterns within a specific selected pharmaceutical market and data period. Since the study has not used a longitudinal design, it has not captured long-term changes in utilization patterns across several years. Cardiovascular drug demand may change over time due to policy changes, seasonal disease patterns, price adjustments, new product entry, generic competition, changes in physician prescribing, or shifts in patient purchasing capacity. Therefore, the cross-sectional nature of the research has limited the ability to explain time-based utilization changes. Second, the study has used real-world pharmaceutical sales data, but sales records have represented product movement rather than confirmed patient-level medicine consumption. A medicine sold through a pharmacy or distributor does not always prove that the patient has taken the medicine correctly, continued the treatment, or achieved clinical benefit. Thus, the findings should be understood as sales-based utilization evidence rather than direct clinical adherence or outcome evidence. Third, the study has relied partly on Likert-scale responses from pharmacists, pharmacy managers, pharmaceutical sales representatives, physicians, healthcare professionals, and pharmaceutical data officers. Although these respondents have been professionally relevant, their responses may have been influenced by personal experience, workplace exposure, recall, or subjective judgment. Fourth, the case-study context has limited the generalizability of the findings. The selected market may have its own pricing structure, stock system, brand preference, physician network, distribution strength, and patient purchasing pattern. As a result, the findings may not fully represent all pharmaceutical markets or all healthcare settings. Fifth, the study has classified cardiovascular medicines by therapeutic class, but some medicines may have overlapping indications or may be used for more than one cardiovascular condition. This may create classification challenges in sales-data mapping. Sixth, the study has used descriptive statistics, correlation analysis, and regression modeling, but it has not applied advanced forecasting, machine-learning clustering, or patient-level refill tracking. Therefore, the analysis has explained current relationships but has not deeply predicted future utilization behavior. Seventh, the study has not included patient-level clinical variables such as diagnosis, disease severity, treatment adherence, income level, comorbidity, or health outcomes. This has limited the ability to connect pharmaceutical sales movement with actual patient health improvement. Finally, the study has depended on the completeness and accuracy of the available sales records. Any missing entries, duplicate records, inconsistent product names, price variations, or coding errors may have affected the precision of the sales-data analysis. These limitations have not reduced the overall value of the study, but they have clarified the boundaries within which the findings should be interpreted.

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