



# Unequal Loads: An ANOVA-Based Assessment of Primary Health Center Distribution and Essential Drug Supply Chains in Madhya Pradesh

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## KEYWORDS

Primary Health Centers (PHCs), Essential Drug Supply Chain Management, ANOVA-based Statistical Analysis, Public Health Infrastructure, Resource Distribution and Efficiency, Madhya Pradesh Health Services

## ABSTRACT:

The Primary health centers are critical component of the This study evaluates the efficiency of supply chain management for essential drugs in Madhya Pradesh, India, by analysing the distribution of Primary Health Centers (PHCs) across districts. Utilizing a one-way ANOVA, the study compares the population per PHC in the top 5 and bottom 5 districts with the highest and lowest number of PHCs, respectively. The findings reveal significant disparities in the distribution of PHCs relative to the rural population, suggesting inefficiencies in healthcare delivery that warrant targeted interventions.

## 1. Introduction

The availability of essential drugs in rural healthcare settings is crucial for effective healthcare delivery. In India, Primary Health Centers (PHCs) serve as the first point of contact for rural populations, making their efficient distribution vital for public health. This study examines the supply chain management of essential drugs in Madhya Pradesh by analyzing the distribution of PHCs in relation to the rural population across districts.

### 1.1. Background of the Study

India's healthcare system has evolved over decades with a focus on ensuring access to basic healthcare services, particularly for rural populations. Inspired by the recommendations of the Health Survey and Development Committee Report (Sir Joseph Bhore Committee, 1946) of 1946, the Indian Government prioritized rural healthcare. The establishment of Primary Health Centers (PHCs) was intended to make healthcare accessible, especially to underserved populations (Sir Joseph Bhore Committee, 1946). Landmark initiatives like the National Family Planning Program (1952) and the policy of appointing one community health worker per 1,000 people in the 1970s reflected India's commitment to the principles later

echoed in the Declaration of Alma Ata (1978). (WHO, 1978)

Despite this commitment, the rural healthcare system has struggled with operational inefficiencies, particularly in the distribution of essential drugs. Nearly three-fourths of the country's health budget is allocated to strengthening primary healthcare, largely driven by the National Rural Health Mission (NRHM). In 2012-13 alone, the country spent approximately Rs 21,000 crore on PHCs. (Mala Rao, 2012) However, inefficiencies in supply chain management, logistical barriers, and uneven resource distribution have continued to undermine the effectiveness of these efforts.

Madhya Pradesh (MP), one of India's larger and more socio-economically challenged states, presents a critical case for examining these issues. With a population of approximately 60.4 million across 48 districts, 73% of which resides in rural areas and 37.4% living below the poverty line (Ayesha De Costa, Vinod Diwan, 2007), the state faces significant healthcare challenges. While health indicators have shown gradual improvement over the past 25 years, disparities in healthcare access remain a pressing concern.



## 1.2. Literature Review

Existing research identifies multiple challenges in drug distribution in rural healthcare settings, including:

**Logistical inefficiencies:** Studies highlight poor transportation infrastructure and suboptimal routing of drug deliveries (Arya Kharche, Sanskar Badholia, Ram Krishna Upadhyay, 2024)

**Inadequate storage facilities:** Research points to inadequate cold chain management and limited storage capacity at PHCs, affecting the availability and efficacy of drugs (Shrikala Baliga, 2012).

**Resource misallocation:** Uneven distribution of resources, including essential drugs, leads to supply shortages in high-demand areas while overstocking in others (J.Suresh Kumar, 2024).

The literature on healthcare systems in India reveals critical insights into public-private dynamics (Maiti R, Bhatia V, Padhy BM, 2015), policy gaps, supply chain performance, and systemic reforms. (Ayesha De Costa, Vinod Diwan, 2007) examined the growing dominance of private healthcare in Madhya Pradesh, questioning the role and capacity of the public sector. This is echoed in broader evaluations by (Basu, 2012) and (Patouillard E, Goodman CA, Hanson KG, 2007), which show that while private systems may offer more responsiveness, they often lead to inequities, variable quality, and increased financial burden on patients. The Bhore Committee (Sir Joseph Bhore Committee, 1946) and the Alma Ata Declaration (1978) laid the foundational vision for universal primary healthcare, yet implementation challenges remain. Studies on healthcare expenditures (Bhat, 2006) (Sundararaman, 2015) highlight that high out-of-pocket spending remains a major barrier to equitable access.

The functioning of rural health systems has also been evaluated, as seen in (J.Suresh Kumar, 2024), who assesses government schemes and their impact. At the supply chain level, (Prabal Vikram Singh, Anand Tatambhotla, Rohini Kalvakuntla, Maulik Chokshi, 2013) and (Vijaya Chebolu-Subramanian, Rangaraja P. Sundarraj, 2021) underscore inefficiencies in drug procurement, while (Maiti, 2015) emphasize the need for prioritizing essential medicines in public policy. The (WHO, 2004) framework on equitable access remains relevant in this context. Studies on cold chain

infrastructure in Delhi (Gaurav Kumar, Sanjay Gupta, 2020) and the potential of ICT interventions (Kumar Gupta, 2018) illustrate that technological integration can improve logistics and service delivery.

(Mondal S, 2018) adds a supply chain management perspective, showing that human capital significantly influences healthcare agility and performance. (Kotwani A, 2011) provide critical evidence on irrational antibiotic use in outpatient settings, raising concerns about prescription practices. In terms of quality of care, (Rao, 2006) proposed a scale to capture patient perceptions, while (Das, 2007) highlighted significant issues with clinical conduct in Delhi. Additionally, the Journal of Business & Industrial Marketing and Social Science & Medicine contributions underline how supplier responses and system agility impact overall healthcare delivery. The inclusion of landmark policy instruments like the Patient Protection and Affordable Care Act (2010) (Sara Rosenbaum, 2010) also enables comparative learning from global health systems. Together, these studies point to the urgent need for structural reform, capacity building, and greater public investment to ensure equitable and high-quality healthcare access in India.

However, most studies focus on national or regional-level analysis, offering limited insights into district-level disparities, particularly within Madhya Pradesh.

## 1.3. Identified Gap

While extensive research exists on healthcare infrastructure and resource distribution, there is a notable gap in empirical evidence addressing the effectiveness of essential drug supply chains at the PHC level in Madhya Pradesh. The current literature primarily explores infrastructure deficits and human resource shortages, but few studies rigorously evaluate supply chain performance - from procurement to last-mile delivery - within the state's rural healthcare network.

## 1.4. Research Question

This study aims to bridge this gap by addressing the following research question:

How effective is the supply chain management system in ensuring equitable distribution of essential drugs across PHCs in Madhya Pradesh?



The study will assess:

The spatial distribution of PHCs relative to rural populations.

The efficiency of drug delivery mechanisms.

The extent of supply shortages or surpluses at PHCs.

By exploring these dimensions, this research seeks to provide actionable insights into improving essential drug availability at the grassroots level, contributing to the broader goal of strengthening rural healthcare delivery in Madhya Pradesh.

## 1.5. Identified Problem

Despite the critical role of PHCs in rural healthcare, there is growing concern that the current supply chain management for essential drugs may not be efficient. This inefficiency could lead to uneven access to essential drugs across different districts, particularly in areas with fewer PHCs. This study seeks to assess whether the existing distribution of PHCs meets the needs of the rural population in Madhya Pradesh.

## 2. Research Objectives

To assess the efficiency of supply chain management for essential drugs at PHCs in Madhya Pradesh.

To determine whether there is a significant difference in the population per PHC between districts with more and fewer PHCs.

To identify the need for interventions in the existing drug distribution schemes.

## 3. Research Hypotheses

**H01:** There is no efficient supply chain management for essential drugs at PHCs in Madhya Pradesh.

**H02:** There is no requirement for interventions in the existing drug distribution schemes of the government.

## Research Method

### A. Methodology

This study employs a quantitative, cross-sectional research design. The focus is on district-level disparities in Madhya Pradesh regarding the distribution of PHCs and their effectiveness in drug supply chain management.

**Study Area:** Madhya Pradesh, covering 10 selected districts (top 5 with the highest number of PHCs and bottom 5 with the lowest number).

**Study Period:** Data collected for the year 2023.

**Data Sources:** Government health reports, district health records, and National Health Mission (NHM) data.

### Inclusion Criteria

Districts with available data on the number of PHCs and rural population statistics.

### Exclusion Criteria

Districts with incomplete or outdated health data.

### Sample Size

10 districts (top 5 and bottom 5 based on the number of PHCs).

### Data Collection

Data was collected from official state health reports, NHM datasets, and verified district-level statistics.

### Data Analysis Techniques

A one-way ANOVA was conducted to compare the population per PHC across the selected districts.

The analysis measured efficiency by population served per PHC, testing whether significant differences existed between districts with more and fewer PHCs.

#### a. ANOVA Test Setup:

**Null Hypothesis (H0):** There is no significant difference in the population per PHC across the districts (i.e., the efficiency of supply chain management is consistent).

**Alternative Hypothesis (H1):** There is a significant difference in the population per PHC across the districts (i.e., the efficiency of supply chain management varies significantly).

#### b. Tools Used:

Data analysis was performed using SPSS and Microsoft Excel for statistical calculations and visualization.

This methodology ensures a structured approach to evaluating the supply chain management system and identifies actionable insights for improving drug distribution at PHCs in Madhya Pradesh.



## B. Data Recap

A comparative analysis was conducted between the top 5 districts with the highest number of Primary Health Centers (PHCs) and the bottom 5 districts with the lowest number of PHCs in Madhya Pradesh. This comparison aimed to evaluate disparities in population coverage per PHC and assess whether districts with fewer PHCs face significantly higher service burdens.

The following tables summarize the data collected:

**Table 1.** Top 5 Districts with Highest Number of PHCs

| District   | Rural Population | Number of PHCs | Population per PHC |
|------------|------------------|----------------|--------------------|
| Chhindwara | 1,841,041        | 64             | 28,766             |
| Khargone   | 1,869,494        | 58             | 32,224             |
| Dhar       | 2,124,422        | 49             | 43,354             |
| Satna      | 2,047,315        | 45             | 45,496             |
| Mandsaur   | 1,256,762        | 40             | 31,419             |

**Table 2.** Bottom 5 Districts with Lowest Number of PHCs

| District   | Rural Population | Number of PHCs | Population per PHC |
|------------|------------------|----------------|--------------------|
| Harda      | 520,703          | 7              | 74,386             |
| Sheopur    | 797,568          | 7              | 113,938            |
| Agar       | 522,216          | 6              | 87,036             |
| Ashoknagar | 832,615          | 6              | 138,769            |
| Guna       | 1,132,484        | 5              | 226,497            |

## 4. Results

### Results

The one-way ANOVA revealed a significant difference in the population per PHC between the top 5 and bottom 5 districts. The F-statistic was 34.27, with a p-value of 0.0005, indicating that the efficiency of supply chain management varies significantly across districts.

### Interpretation

**F-statistic:** 34.27

**p-value:** 0.0005

Since the p-value (0.0005) is less than the significance level (typically 0.05), you would reject the null hypothesis (H0). This suggests that there is a significant difference in the population per PHC between the top 5 and bottom 5 districts, indicating varying levels of efficiency in supply chain management across districts.

### Key Observations

**Extreme Burden in Guna and Ashoknagar:** Guna, with a population-per-PHC ratio of 226,497, faces the highest service burden among all districts, followed by Ashoknagar (138,769). This stark difference highlights a severe gap in healthcare accessibility.

**Better Coverage in Chhindwara and Mandsaur:** Chhindwara, with 28,766 people per PHC, has the most favorable ratio among the top districts, suggesting more equitable service distribution.

**Implications for Supply Chain Efficiency:** Districts with fewer PHCs are likely to experience delayed drug deliveries, stockouts, and overburdened staff, which can directly impact the effectiveness of essential drug distribution.

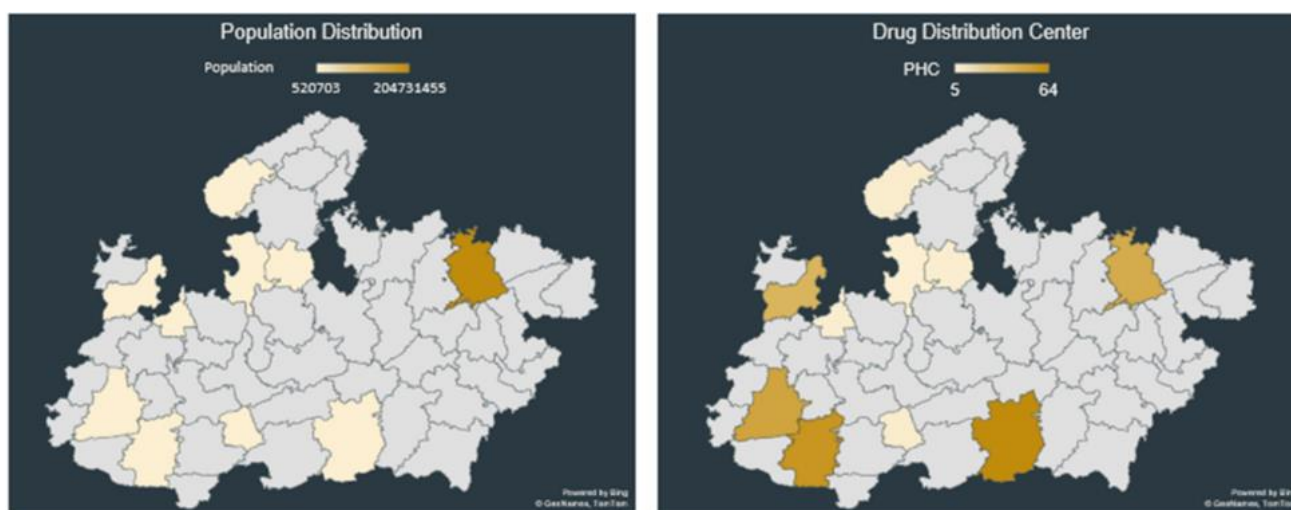
This data-driven comparison lays the groundwork for further statistical analysis (e.g., ANOVA) to determine whether these disparities are statistically significant, supporting the study's hypothesis and guiding potential interventions.

## 5. Discussion

### A. Comparative Analysis

**Top 5 Districts:** The average population served per PHC among the top 5 districts is approximately 36,652. These districts benefit from a more balanced distribution of PHCs relative to their rural population, ensuring better accessibility to essential drugs and healthcare services.

**Bottom 5 Districts:** The average population served per PHC among the bottom 5 districts is 128,525, nearly 3.5 times higher than that of the top districts. This indicates a significant disparity in access to primary healthcare services, potentially leading to service bottlenecks and reduced drug availability.



**Figure 1:** The ANOVA Analysis Reveals A Significant Disparity In The Population Per PHC Across Districts

## B. Discussion

### a. Interpretation of Results

The one-way ANOVA revealed a significant difference in the population per PHC between the top 5 and bottom 5 districts. The F-statistic was 34.27, with a p-value of 0.0005, indicating that the efficiency of supply chain management varies significantly across districts. Since the p-value (0.0005) is less than the significance level (0.05), the null hypothesis ( $H_0$ ) is rejected. This suggests that there are notable disparities in the population served per PHC between districts, implying uneven healthcare access.

### b. Comparison with Previous Research

The present study's findings align with existing literature that highlights disparities in healthcare infrastructure and supply chain management across Indian states. (Ayesha De Costa, Vinod Diwan, 2007) reported significant variability between public and private sector healthcare provision in Madhya Pradesh, suggesting systemic imbalances that mirror the population disparities per PHC observed in this study. Similarly, (Mondal S, 2018) emphasized the role of human capital in influencing healthcare agility and supply chain performance, reinforcing the importance of district-level management capacity in ensuring equitable service delivery.

Further, (Kumar Gupta, 2018) discussed how the integration of information and communication technologies could strengthen pharmaceutical supply chains, potentially mitigating the kinds of inefficiencies

identified here. (Prabal Vikram Singh, Anand Tatambhotla, Rohini Kalvakuntla, Maulik Chokshi, 2013) and (Vijaya Chebolu-Subramanian, Rangaraja P. Sundarraj, 2021) also highlighted procurement process challenges and essential medicine shortages across Indian states, which are critical factors contributing to district-wise disparities.

This study extends prior work by offering a quantitative measure of the gap between districts with better and poorer PHC availability in Madhya Pradesh, thereby providing a focused, data-driven contribution to the broader understanding of healthcare delivery inequalities in India.

### c. Limitations and Potential Implications

Key limitations include reliance on secondary data sources, which may introduce reporting biases or inaccuracies. Additionally, the analysis focuses on PHC distribution but does not account for other healthcare infrastructure, such as community health centers or sub-centers, which may influence service delivery. The findings emphasize the need for targeted interventions, particularly in districts like Guna and Ashoknagar, to ensure equitable drug distribution and reduce healthcare access disparities.

## 6. Conclusions

### Summary of Main Findings

The study demonstrates significant disparities in PHC distribution across Madhya Pradesh, with bottom-



performing districts serving up to 3.5 times the population per PHC compared to top-performing districts. The ANOVA results confirm statistically significant differences, highlighting inefficiencies in the essential drug supply chain.

### Future Research Directions

Future studies could explore additional factors affecting drug distribution, such as transportation networks, storage conditions, and staff availability. Longitudinal studies tracking changes over time would provide deeper insights into the sustainability of interventions.

### Practical and Theoretical Implications

Practically, the findings support policy recommendations for redistributing PHCs to underserved districts and optimizing supply chain logistics. Theoretically, the study contributes to supply chain management literature by linking distribution efficiency to healthcare outcomes in resource-constrained settings.

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