DEMOGRAPHIC AND REGIONAL INFLUENCES ON CONDOM SALES TREND IN INDIA: A TEMPORAL ANALYSIS

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***Abstract –*** Sample.

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1. INTRODUCTION

Policymakers, healthcare professionals, and companies face difficulties as a result of the uneven distribution and demand for condoms in India across various areas and demographic groups. Although access to contraceptives is important for family planning and public health, little study has been done to thoroughly examine the factors influencing condom sales and how these patterns change over time. Promoting sexual health awareness, maximizing marketing strategies, and ensuring accessibility across a range of demographic groups all depend on the understanding of these impacts.

In order to overcome this difficulty, this research utilizes statistical analysis and machine learning to identify significant trends in a large dataset on condom sales in India. This research provides practical information that may guide targeted marketing campaigns, improve supply chain effectiveness, and assist public health programs by identifying important demographic and regional factors. By using refined analytics, this study can go beyond conventional survey-based research and provide data-driven findings that may help stakeholders make wise choices.

This study is more broadly relevant to the domains of retail strategy and public health. Sales of condoms, which are essential for preventing STDs and assisting family planning initiatives, are a key indication of sexual health knowledge and the availability of contraceptives. This research helps groups and politicians create evidence-based plans to raise awareness and increase accessibility by offering insights about sales patterns, which would eventually enhance reproductive health outcomes in India.

The study's conclusions are relevant to a variety of stakeholders. Healthcare providers may optimize the delivery of contraceptives depending on area demand, and policymakers can use the information to create successful public health programs. Non-governmental organizations (NGOs) may utilize the data for advocacy and awareness campaigns, while marketers and merchants can use it to customize their plans for various customer categories.

Public health organizations looking to efficiently allocate resources, manufacturers and retailers trying to comprehend consumer demand, academic researchers studying socioeconomic trends, and tech companies creating market trend prediction models are some potential users of this research. This research has applications in retail marketing, healthcare planning, policymaking, and data-driven decision-making in a variety of fields.

1. REVIEW OF RELATED LITERATURE

This section presents related literature on condom sales and use in India, highlighting a number of demographic and regional factors that have influenced patterns over time.

1. **Overview of Key Concepts and Background Information**
   * **Economic Status:** Access to contraception and buying power are influenced by income levels. Condom sales are often higher in areas with higher per capita incomes (Tandon, K., 2023).
   * **Cultural Attitudes:** The use of condoms might be encouraged or hindered by social norms and taboos around sexual health. In certain areas, progressive views on family planning have resulted in a rise in condom acceptability and usage (TechSci Research, n.d.).
   * **Public Health Initiatives:** Promoting the use of condoms for family planning and disease prevention is mostly accomplished via government-led initiatives and awareness campaigns. During campaign seasons, these approaches often result in observable increases in sales (Research and Markets, 2025).
   * **Historical Development:** Over the years, there has been a notable shift in the condom use scenario in India. Condom usage and acceptance have historically been restricted due to cultural taboos around sexual health and contraception. However, a paradigm change occurred in the late 20th century with the emergence of HIV/AIDS. Large-scale awareness efforts highlighting the value of condom usage as a family planning tool and in avoiding STIs were started by the government and non-governmental groups. These initiatives have played a significant role in progressively altering public opinion and raising the frequency of condom usage across different populations (Morisky, D. E., 2006).
2. **Review of Other Relevant Research Papers**
   * [India Condom Market Size & Share | Industry Report, 2030](https://www.grandviewresearch.com/industry-analysis/india-condom-market-report): This study offers a thorough examination of the Indian condom industry, emphasizing market growth drivers such the large proportion of middle-aged people, the incidence of HIV, and growing awareness of sexual health issues.
   * [India Condom Market Outlook to 2028](https://www.kenresearch.com/industry-reports/india-condom-market): This perspective addresses the condom market's dominance in big cities like Bangalore, Delhi, and Mumbai, attributing it to higher awareness and dense populations.
   * [Condom Market Size, Share & Growth Analysis Report, 2030](https://www.grandviewresearch.com/industry-analysis/condom-market): Given that 50% of Indians are under 24 and 65% are under 35, as well as the country's high rate of HIV infection and other sexually transmitted diseases, this research highlights the country's potential for development in the condom industry.
   * The research cited above provide important light on the geographical and demographic variables affecting condom sales in India. Together, they highlight how market dynamics are impacted by urbanization, a young population, and public health consciousness. Nonetheless, there is a noticeable lack of research on the use of sophisticated analytical techniques, such machine learning, to analyze and forecast these sales patterns across time. By using advanced statistical and machine learning methods to provide a more detailed and predictive knowledge of condom sales trends, the new study seeks to close this gap and build on the results of earlier research.
3. **Prior Attempts to Solve the Same Problem**
   * [Social Marketing of Condoms](https://catalog.nlm.nih.gov/discovery/fulldisplay?adaptor=Local%20Search%20Engine&context=L&docid=alma9910301983406676&lang=en&mode=advanced&offset=330&query=lds56,contains,Achievement,AND&search_scope=MyInstitution&tab=LibraryCatalog&vid=01NLM_INST:01NLM_INST): The 'Nirodh' condom brand was introduced by the Indian government in 1968 as a social marketing campaign to encourage condom usage. This program used interpersonal contact and mass media efforts to lower obstacles and promote habit change.
   * [Avahan Initiative](https://docs.gatesfoundation.org/documents/avahan_factsheet.pdf): The Bill & Melinda Gates Foundation started the Avahan Initiative in 2003 with the goal of preventing HIV in India. It used tactics including community mobilization, condom distribution, and peer education to lower HIV transmission among high-risk groups.
   * [Condom Bindaas Bol Campaign](https://press.un.org/en/2007/note6096.doc.htm): Eight northern Indian states, which made up 45% of the country's condom market, saw a decline in condom sales and usage, which prompted the creation of this campaign. It sought to promote candid conversations about sexual health and mainstream the use of condoms.
   * [Delhi Metro Campaign](https://naco.gov.in/sites/default/files/April%202012.pdf): A three-and-a-half-month campaign that covers all four Delhi Metro lines was started on World AIDS Day. This program sought to increase commuters' knowledge about HIV/AIDS and encourage the use of condoms.
   * [Durex's Focus on Women and Rural Consumers](https://www.reuters.com/business/retail-consumer/durex-makes-india-condom-push-women-rural-consumers-2024-09-12/): Durex changed its emphasis to target women and rural customers after realizing that the usage of contraceptives in India was low, especially among males. Marketing initiatives and product reformulation focused on women's sexual wellbeing are part of this approach.
   * [Engagement of Transgender Sex Workers in HIV Education](https://www.theguardian.com/global-development/2025/feb/03/diesel-oil-condoms-indian-transgender-sex-workers-teach-truckers-about-aids): Transgender sex workers and organizations like the Apollo Tyres Foundation work together to teach truck drivers, who are at high risk for HIV, about condom usage and AIDS prevention. This peer-led strategy has been successful in reaching underserved populations.
4. METHODOLOGY

This section provides the general information of the dataset, algorithms, tools, and techniques used to generate substantial amount of information necessary to manifest results.

1. **Data Collection**
   * The dataset used for this study is about the condom market size in India, which has over fifty-thousand (50,000) rows with nineteen (19) features, namely: Year, Market Size (USD Million), CAGR (%), Material Type, Product Type, Distribution Channel, Event Name, Event Date, Company Involved, Event Details, Region, Market Penetration, Growth Rate (%), Brand Name, Market Share (%), Revenue Contribution, Innovation Index, Regulatory Impact, Awareness Campaign Impact.
   * The dataset is sourced by five Data Companies and one e-commerce company and compiled by Ankush Panday (Product Manager).
   * The dataset was released under the MIT license and started collection on January 1, 2018, with the expected end date of January 1, 2040.
2. **Data Pre-Processing**
   * The implementation of data cleaning by handling missing values through imputing numerical features with the median and categorical features with the most frequent value.
   * For the transformation of data, a standardized numerical feature is implemented to have a mean of 0 and a standard deviation of 1, ensuring uniform contribution to the clustering algorithm.
   * One-hot encoding is implemented to convert categorical variables into a numerical format suitable for clustering.
3. **Experimental Setup**
   * Tools and Frameworks Used

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| --- | --- | --- |
| **Tool/Library** | **Version** | **Purpose** |
| Python | 3.10+ | Programming language |
| Google Colab | Latest | Cloud-based Jupyter Notebook for execution |
| NumPy | 1.24+ | Numerical computing |
| Pandas | 1.5+ | Data manipulation |
| Matplotlib | 3.7+ | Data visualization |
| Seaborn | 0.12+ | Statistical visualization |
| Scikit-learn | 1.2+ | Machine learning (clustering, preprocessing, evaluation) |

* + Computing Environment
    - **Platform:** Google Colab
    - **Hardware:**
      1. **CPU:** Intel® Xeon® CPU @ 2.20GHz
      2. **RAM:** 12GB
    - **Cloud Storage:** Google Drive
  + Organization of Experiments
    - **Data Loading & Exploration**
      1. Load the dataset and check for inconsistencies, missing values, and distributions.
      2. Use df.info(), df.describe(), and df.isnull().sum() for initial exploration.
    - **Data Pre-Processing**
      1. Handling missing values, feature scaling, encoding categorical features.
      2. Standardization (StandardScaler) for clustering models.
    - **Clustering Model Selection**
      1. Choose and compare multiple clustering algorithms:
         1. **K-Means** (for spherical clusters)
         2. **Hierarchical Clustering** (for tree-like clustering)
         3. **DBSCAN** (for noise-resistant clustering)
    - **Hyperparameter Tuning**
      1. Optimize the number of clusters (K) using the Elbow Method and Silhouette Score.
    - **Evaluation**
      1. Assess clustering results using metrics like Davies-Bouldin Score and Inertia.
  + Hyperparameters Used in Clustering Models

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| --- | --- | --- | --- |
| **Clustering Algorithm** | **Hyperparameter** | **Description** | **Value Used** |
| K-Means | n\_clusters | Number of clusters (K) | 3, 4, 5, 6 (tested using Elbow Method) |
| init | Initialization method | “k-means++” |
| max\_iter | Maximum iterations | 300 |
| n\_init | Number of times algorithm runs with different seeds | 10 |
| Hierarchical Clustering | n\_clusters | Number of clusters | 3, 4, 5 |
| linkage | Linkage method | “ward” (minimizes intra-cluster variance) |
| DBSCAN | eps | Maximum distance between points in a cluster | 0.5, 0.7, 1.0 (tuned experimentally) |
| min\_samples | Minimum points required to form a cluster | 5, 10 |

1. **Algorithm**
   * **K-Means Clustering**
     + K-Means is a centroid-based clustering algorithm that partitions data into K clusters by minimizing intra-cluster variance (sum of squared distances).
     + It assigns each data point to the nearest centroid and iteratively updates centroids until convergence.
   * **Hierarchical Clustering (Agglomerative)**
     + Builds a hierarchy of clusters by recursively merging (or splitting) clusters based on distance metrics.
     + Uses linkage methods (e.g., Ward, Single, Complete) to decide which clusters to merge at each step.
   * **DBSCAN (Density-Based Spatial Clustering of Applications with Noise)**
     + A density-based clustering algorithm that groups points close to each other based on a minimum distance threshold (eps).
     + Points that don’t belong to any cluster are treated as outliers (noise).
   * **Justification for Algorithm Choice**

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| --- | --- | --- | --- |
| **Algorithm** | **Reason for Selection** | **Strengths** | **Limitations** |
| K-Means | Suitable for clustering when we assume spherical cluster shapes | Fast, scalable, easy to interpret | Sensitive to outliers, requires pre-defined K |
| Hierarchical Clustering | Good for hierarchical relationships and doesn’t require predefining K | No need to specify clusters beforehand, produces a dendrogram | Computationally expensive for large datasets |
| DBSCAN | Effective for arbitrarily shaped clusters and identifying outliers | Can detect noise (outliers), doesn’t require K | Struggles when clusters have varying densities |

* + **Why These Algorithms?**
    - K-Means was chosen for its simplicity, efficiency, and scalability, making it ideal for exploratory analysis.
    - Hierarchical Clustering was used for understanding data structure via a dendrogram, useful when cluster count is unknown.
    - DBSCAN was used to handle non-spherical clusters and detect anomalies in the dataset.
  + **Training Process and Optimization Techniques**
    - K-Means uses an iterative optimization process:
      1. Initialize K centroids (using "k-means++" for better convergence).
      2. Assign points to the nearest centroid.
      3. Update centroids as the mean of assigned points.
      4. Repeat until centroids stabilize or max iterations (300) is reached.
    - Hierarchical Clustering doesn’t require explicit training but iteratively merges clusters based on distance metrics (ward linkage used).
    - DBSCAN identifies core points (high-density regions) and expands clusters based on eps and min\_samples parameters.
  + **Optimization Techniques Used**

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| **Algorithm** | **Optimization Technique** | **Description** |
| K-Means | Elbow Method, Silhouette Score | Used to determine the optimal number of clusters (K) |
| DBSCAN | Grid Search for eps & min\_samples | Optimized the radius and min points to refine clustering |
| Hierarchical Clustering | Dendrogram Analysis | Used to determine the best number of clusters visually |

* + **Loss Functions Used**
    - **K-Means Loss Function (Inertia):**
      1. Measures the sum of squared distances between points and their respective centroids.
      2. Lower inertia means better clustering (but not necessarily optimal).

1. **Training Procedure**
   * Sample
2. **Evaluation Metrics**
   * Sample
3. **Comparison of Clustering Algorithms**
   * Sample
4. RESULTS AND DISCUSSION

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1. CONCLUSION

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