TOWARDS SUSTAINABLE TRANSPORTATION: A STATISTICAL EXAMINATION OF TRAFFIC MANAGEMENT AND PLANNING IN BANGLADESH

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ABSTRACT

This paper offers an extensive statistical investigation into the realm of traffic management and transportation planning in Bangladesh, underlining the critical focus on sustainability. In the context of rapid urbanization and escalating population density, the demand for sustainable transportation solutions in Bangladesh has grown immensely. Leveraging statistical methodologies, this study scrutinizes and assesses the current landscape of traffic management strategies and transportation planning initiatives, with particular attention to their sustainability across environmental, social, and economic dimensions. Drawing from a diverse dataset encompassing traffic flow patterns, accident records, emissions data, and infrastructure development metrics, our analysis unearths insights into the prevailing challenges and prospects. Statistical tools are deployed to gauge the efficacy of existing traffic management practices, pinpoint areas plagued by congestion, and scrutinize the ramifications of transportation planning decisions on the environment. Furthermore, this study delves into the socio-economic facets of transportation within Bangladesh, considering variables such as accessibility, affordability, and social equity. The findings underscore the imperative need to strike a balance between economic advancement and preservation of the environment, while ensuring inclusivity and social equity. The outcomes of this research make a substantial contribution by furnishing valuable recommendations for the enhancement of transportation sustainability in Bangladesh. By shedding light on the strengths and weaknesses of prevailing approaches, this research lays the groundwork for data-driven policy formulation, infrastructure enhancements, and pioneering solutions, ultimately propelling the nation toward a more sustainable and efficient transportation framework. This paper underscores the pivotal role of statistics in advancing sustainable transportation, particularly in swiftly evolving regions like Bangladesh.

Keywords: RHD, BBS, sustainability, TDM, TSMO.

1. INTRODUCTION

The sudden desire to lessen the negative effects that traditional transportation systems have on the environment, society, and economy has made sustainable transportation a global necessity. In a period marked by increasing urbanization and growing apprehensions about air pollution and climate change, sustainable mobility has emerged as a central topic in scholarly, policy, and public discussions. It is essential to urban development, especially in increasingly developing countries like Bangladesh that struggle with growing urbanization and population issues [1].

As an instrument by which people and products are transported across modern society, transportation is a major pillar. However, several issues have emerged because of traditional reliance upon fossil fuels and insufficient infrastructure, such as emissions of greenhouse gases, traffic congestion, and a declining standard of living in urban areas [2]. A new study by Qiao et al. (2023) emphasizes how important effective public transportation is for lowering emissions and reducing the use of cars [3]. The authors stress how important well-designed public transportation systems are to reducing air pollution and urban traffic congestion. Furthermore, technological developments could completely transform traffic planning and administration, as demonstrated by intelligent traffic management systems [4]. A vital aspect of sustainable transportation is the smooth integration of several modes of mobility, such as walking, cycling, and public transportation [5].

Bangladesh has become one of the world's most densely populated nations, with exponential growth primarily in its metropolitan regions [6]. The capital city of Bangladesh, Dhaka, is located in some of the most densely populated metropolitan areas on earth, making traffic jams a daily struggle for its citizens. Congestion has several negative effects, including worsening air pollution, financial losses, and a worse standard of living for the public [7]. The Bangladeshi government has launched a few initiatives to address the pressing problems of traffic control and urban planning as a response to these difficulties, working with a variety of partners [8–10]. These policy initiatives aim to improve public transportation, lessen traffic, and encourage non-motorized mobility to create more sustainable transportation systems in the country. Bangladesh has invested a lot of money in infrastructural initiatives meant to reduce traffic [11–13]. Prominent initiatives like the bus rapid transit system and Metro Rail in Dhaka have garnered a lot of attention, demonstrating the government's commitment to building a sustainable transportation network. Planning and traffic management are increasingly integrating technology [14]. Designs for an advanced traffic management system that uses real-time data to optimize traffic flow and reduce congestion are included in the "Digital Bangladesh" program [15, 16].

Bangladesh continues to face numerous difficulties, even with the advancements made in the areas of transportation planning and control of traffic [17]. These include inadequate public transportation systems, a lack of facilities for bicyclists and pedestrians, and the need for more efficient traffic law enforcement. Continuous research and data-driven insights are essential to overcoming these obstacles and realizing sustainable transportation. Our research aims to provide a statistical analysis of current traffic management initiatives, identify critical obstacles, and provide evidence-based suggestions to further the realization of sustainable transportation in Bangladesh.

2. METHODOLOGY

This study's main objectives are to evaluate Bangladesh's existing level of urban design and traffic management, highlight major obstacles, and make evidence-based suggestions for promoting sustainable mobility. A thorough and organized procedure has been utilized to achieve this goal. From pertinent government departments and research institutions, such as the Bangladesh Bureau of Statistics (BBS) and the Roads and Highways Department (RHD), historical traffic data, including congestion levels, accident statistics, and vehicle emissions, have been extracted. To find trends, patterns, and trouble spots of traffic management and congestion, a time series analysis was done. Additionally, two distinct methodologies, namely Transportation Demand Management (TDM) and Transportation Systems Management and Operations (TSMO), have been examined within the framework of Bangladesh.

TDM is the term for a collection of tactics and laws designed to maximize the use of available transportation resources, lessen traffic, enhance air quality, and encourage the development of more sustainable and effective transportation systems [18]. TDM is centered on influencing traveler preferences and behaviors to decrease the need for single-occupancy cars and promote the use of more eco-friendly and different kinds of transportation. It is frequently used in cities to alleviate traffic, lower greenhouse gas emissions, and improve inhabitants' quality of life in general. TDM is a flexible method that can be adjusted to the unique requirements and difficulties of various urban settings, which makes it an important instrument for resolving transportation-related problems and advancing sustainable mobility.

TSMO is a collection of tactics and procedures intended to maximize traffic flow, lessen congestion, increase safety, and minimize disturbances to maximize the effectiveness and productivity of transport systems [18]. To create a secure and dependable transportation network, TSMO concentrates on making the most use of right now accessible infrastructure and operating resources. In places with high traffic demand and dense populations, TSMO is especially important. Optimizing the use of already-existing resources, it enhances traditional infrastructure investments, and its real-time methodology enables dynamic modifications in response to shifting circumstances. Modern transportation management is not complete without TSMO, which improves the dependability and efficiency of transportation networks.

3. ILLUSTRATIONS

In Bangladesh, road accidents are a serious issue that causes a high number of fatalities and injuries. Several variables lead to the high rate of traffic accidents in the nation, including adverse road conditions, insufficient traffic law enforcement, clogged roads, careless driving, and a lack of comprehensive driver education. All the country's administrative divisions experience these incidences; however, some record a higher frequency of such occurrences than others. Figure 1 shows that the division of Dhaka has the highest number of traffic accidents compared to all other divisions; the divisions of Chattogram, Rajshahi, and Khulna rank lower. On the other hand, the divisions of Sylhet, Barisal, Mymensingh, and Rangpur have the lowest rates of traffic accidents.

Figure 1: Proportions of road accidents across divisions in Bangladesh in 2023 [Source: RHD]

The most populous and urbanized division in Bangladesh, Dhaka, faces an increased rate of traffic accidents. The worst affected city is Dhaka, the capital, which has a comparatively high accident rate and extreme traffic congestion. The amount of traffic on the division's road network is usually

congested, which makes accidents more common. Efforts to improve public transportation and reduce traffic are ongoing. Chittagong, which has a significant port, faces a high rate of traffic accidents. In certain places, the undulating topography adds another layer of complexity to road safety. Obstacles like traffic jams, steep inclines, and abrupt turns increase the chance of collisions, especially when large cars are involved. Known for its massive system of rivers and waterways, Khulna experiences a high number of traffic accidents because of overcrowding, poor road conditions, and disregard for traffic laws. Road accidents in Rajshahi are caused by things like inadequate road infrastructure, speeding, and a lack of knowledge about traffic safety. In this area, it is essential to prioritize better road conditions and the promotion of safe driving habits. Despite being less crowded than other cities, Barisal suffers from traffic accidents caused by issues like poor road upkeep, a lack of facilities for pedestrians, and violations of traffic laws. Accidents are a result of the high topography and difficult driving conditions in Sylhet, which are made worse by things like poor road design, slick roads during the monsoon season, and disregard for safety regulations. Road accidents in Rangpur are caused by a variety of circumstances, such as inadequate road infrastructure, traffic rule violations, and a lack of public transportation options. The division is trying to improve road safety continuously. Road conditions of poor quality, inadequate pedestrian facilities, and excessive speeding are some of the issues that Mymensingh faces when it comes to traffic accidents. There are currently programs underway to improve the region's infrastructure and knowledge of road safety.

In Figure 2, the following shows the monthly trends of traffic accidents in Bangladesh for the year 2023. The months with the highest frequency of accidents are notably October, November, and December. This phenomenon might be ascribed to the amplified vehicular traffic during the holiday season, as a greater number of individuals journey, hence augmenting the likelihood of mishaps. On the other hand, the lowest number of accidents occurred in January and February. People are more likely to stay at home during the winter, which reduces traffic on the roads and lowers the chance of accidents, which is probably why there has been a drop.

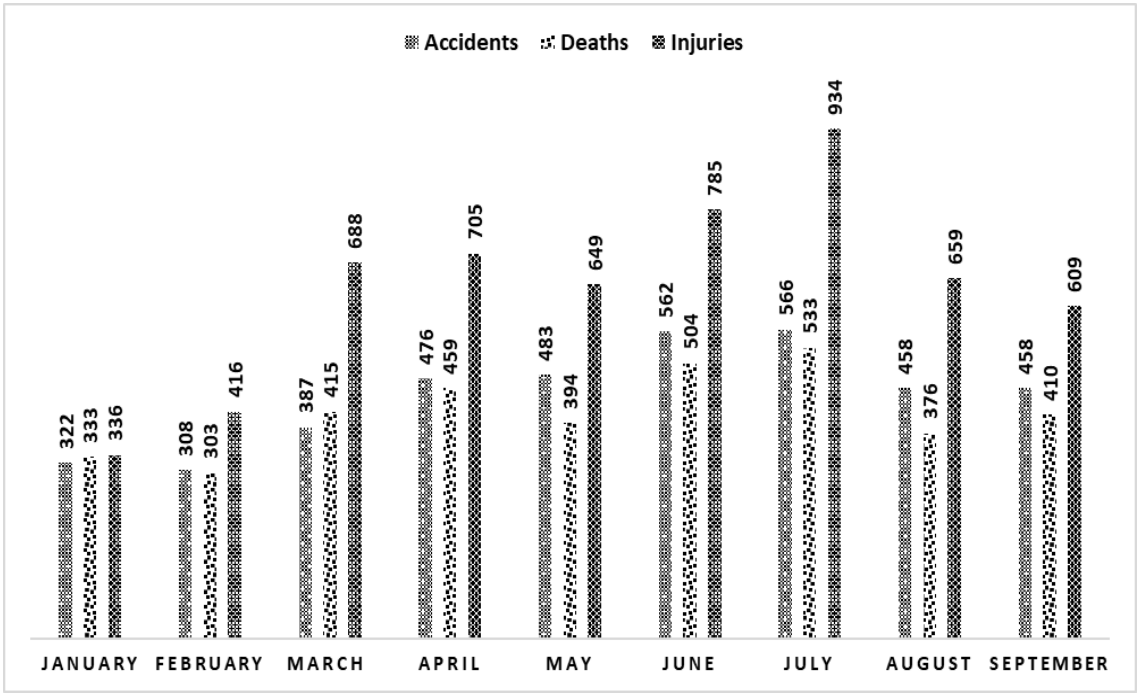

Figure 2: Monthly distributions of road accidents in 2023 in Bangladesh [Source: RHD]

The area of motor vehicle registrations in Bangladesh has significantly expanded over time, a development that is strikingly depicted in Figure 3. This expansion reflects how many cars there are on the country's roadways. It is important not to forget that the information shown here is based on data that was accessible as of January 2023, and these numbers may have changed since then. Notably, Bangladesh has seen a notable increase in the number of motorcycles registered in recent years. Motorbikes made up a sizable majority in 2022, making up 83% of all registered motor

vehicles in the nation. The motor vehicle registrations in Bangladesh have grown at an average yearly growth rate of 9.6%, with a notable increase from 1498244 in 2011 to 3585488 in 2022. Strong economic growth, which has increased people's purchasing power, a young and growing population, which is driving demand for transportation, and improved road infrastructure, which makes owning and operating a motor vehicle more accessible, are some of the main causes of this surge. The increase in automobile registrations has benefited Bangladesh's economy in several ways. It has increased the desire for automobiles, spurring expansion in the manufacturing and service industries. Additionally, it has increased mobility, making it easier to acquire chances for education and work. Furthermore, it has increased tax revenue, which can be used to support public services. But there have been some negative repercussions to this rising number of car registrations. It has caused increased gridlock in the streets, wasting time and gasoline. Additionally, it has made air pollution worse, which is bad for everyone's health. Additionally, it has increased the frequency of traffic accidents that result in fatalities and injuries.

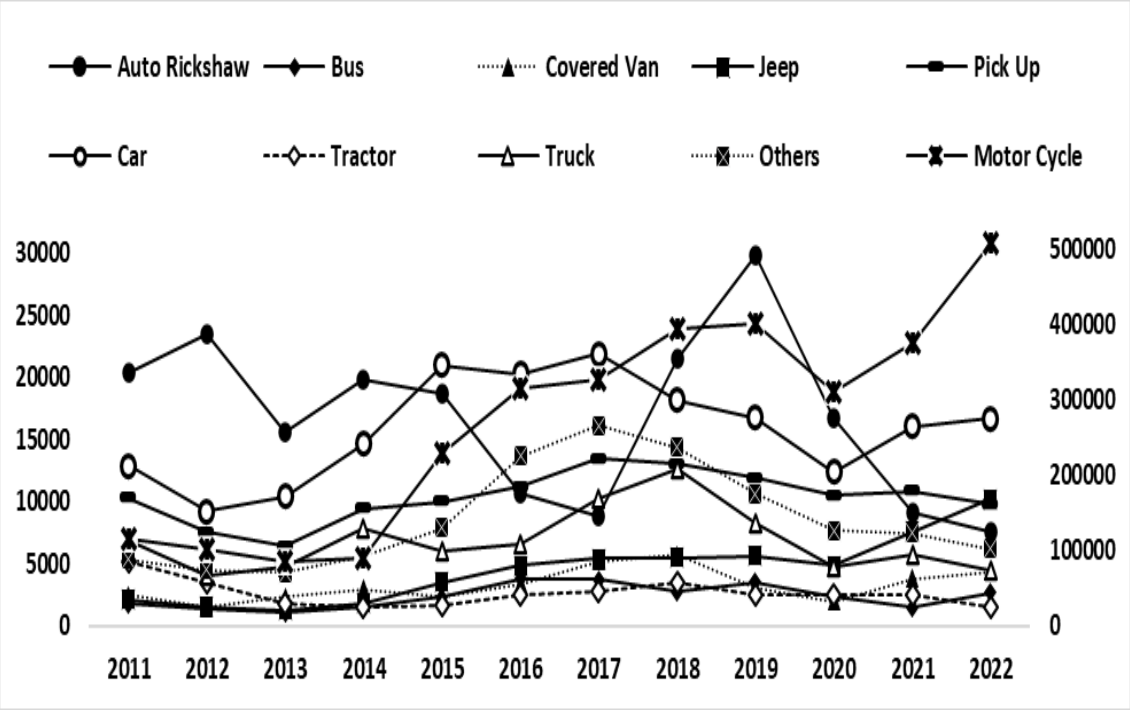

Figure 3: Motor vehicle registrations between 2011 to 2022 in Bangladesh [Source: RHD]

The need to lessen the negative effects that traditional transportation systems have on the environment, society, and economy has made environmentally friendly transportation a critical global concern. In a time of increasing urbanization, worries about climate change, and declining air quality, the idea of sustainable mobility has drawn a lot of interest from scholars, decision-makers, and the public. It is a crucial feature of urban development, especially in nations like Bangladesh which are expanding quickly. Bangladesh's transportation infrastructure is essential to the nation's economic growth, and constant attempts are made to improve its effectiveness and security while addressing its problems. The main means of transportation is roads. Restricted road infrastructure, traffic congestion, and restricted public transit options in certain places are among the problems facing the transportation system. Road conditions and careless driving are major contributing factors to the high frequency of traffic accidents, making road safety a major concern.

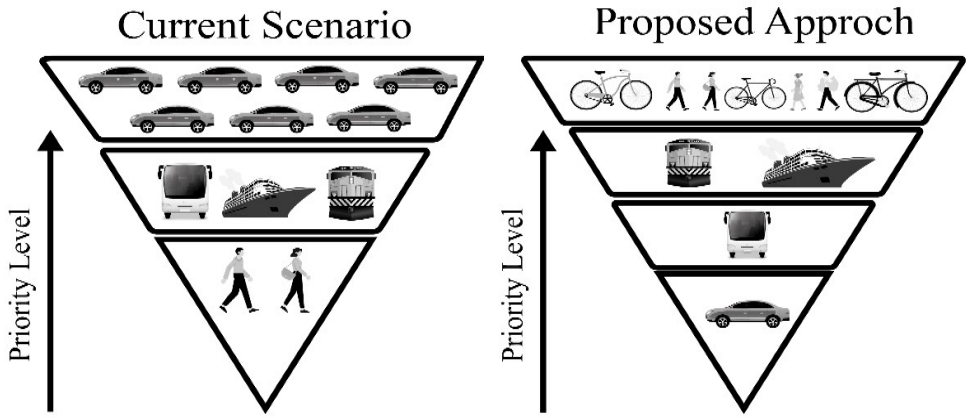

Figure 4: link vs proposed human-transport link for Bangladesh.

In cities like Dhaka, severe congestion caused by traffic is a typical problem. The goal of ongoing road infrastructure development is to improve road conditions and reduce traffic. The two main modes of public transit are autorickshaws and buses. To enhance public transportation, certain cities, like Dhaka, have implemented bus rapid transit (BRT) systems. There are now modernization initiatives underway to improve public transportation services. A large network of train services for both freight and passengers is run by Bangladesh Railway. Railroads are essential for tying together different cities and areas. Water transportation is essential in this river-rich nation, particularly in rural and isolated places. For river transportation, boats and ferries are frequently utilized. Bangladesh boasts both local and international airports, the biggest of which is Hazrat Shahjalal International Airport in Dhaka. Major cities and popular destinations for tourists are connected by domestic planes.

Both traffic management and transportation system optimization can be achieved with the help of TDM and TSMO. But a lot relies on Bangladesh's objectives and unique situation when it comes to whether or not they are appropriate for the country's traffic management. Travelers may experience a shorter journey and less stress by using TDM strategies to assist in easing traffic congestion. TDM can aid in improving air quality and lowering emissions by lowering the number of cars on the road and encouraging sustainable means of transportation. By reducing greenhouse gas emissions, TDM programs aid in the prevention of climate change. Bangladesh has serious problems with air pollution and traffic congestion in its cities, which makes TDM initiatives like promoting carpooling and enhancing public transportation extremely pertinent. In a country with a dense population, TDM is in line with sustainability objectives and can aid in reducing the release of greenhouse gases and improving air quality. When considering large-scale infrastructure construction, TDM can be more affordable. It may take some time to modify commuting habits, but public knowledge and behavioral change are necessary for TDM to be successful. Furthermore, it can be difficult to enforce TDM effectively.

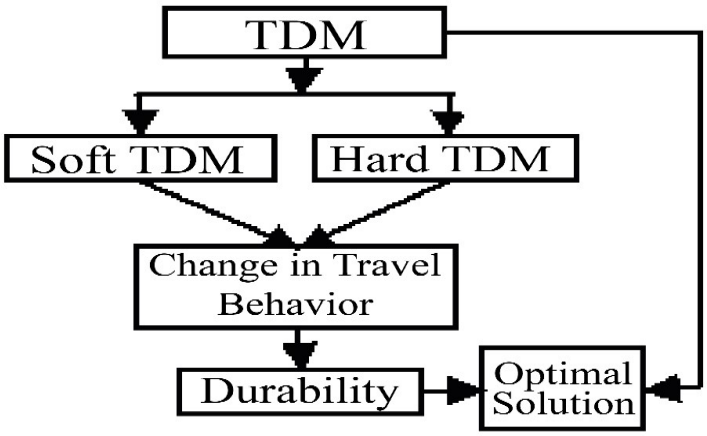

Figure 5: Proposed TDM for Bangladesh

TSMO techniques assist in easing traffic congestion and cutting down on commuter travel times. By reacting swiftly to accidents and other problems, management of incidents and actual time data analysis help create a safer transport environment. TSMO can increase the capacity and efficiency of the transportation system by making the best use of the current infrastructure. TSMO techniques can help Bangladesh by reducing current traffic jams and enhancing traffic flow in metropolitan regions. Compared to large infrastructure projects, TSMO solutions may frequently be executed more rapidly and at a lesser cost. TSMO can be used through operational and technological advancements and is less dependent on behavioral modification. While TSMO can reduce traffic, it might not deal with the root causes, which include rising car ownership and worries over air quality. Given the constantly increasing city population, TSMO might be unable to offer long-term solutions.

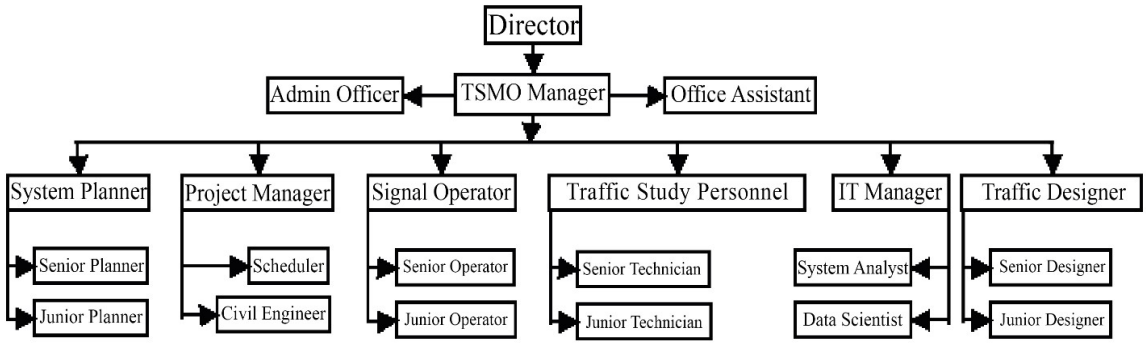

Figure 6: Proposed TSMO for Bangladesh

Depending on Bangladesh's unique objectives and traffic management difficulties, TDM or TSMO should be chosen. Considering the intricacy of the problems, a hybrid strategy could be the best course of action. While TDM can operate concurrently to fulfill long-term sustainability and air quality goals, TSMO can offer immediate respite from congestion. The best traffic management plan for Bangladesh would be an integrated one that takes into account the specific needs and goals of the country while incorporating aspects of both TDM and TSMO.

4. CONCLUSIONS

To sum up, our investigation into ecologically friendly transportation in Bangladesh has shed light on the possibility of revolutionary development in the field of traffic planning and management. We have examined two complementary strategies that could lead to a nation with a transportation network that is more effective, sustainable, and fair. With its emphasis on lowering travel demand, encouraging alternate forms of transportation, and maximizing the use of current infrastructure, TDM becomes clear as a potent instrument for easing traffic congestion and cutting emissions. Its focus on public transportation, active mobility, and smart planning fits particularly well with the pressing need to address the problems that Bangladesh's quickly urbanizing, and densely populated country is facing. However, TSMO offers a chance to completely transform how Bangladesh manages and maximizes its transportation network with its cutting-edge technology and real-time traffic management systems. One example of how technology can be used to improve traffic flow and reduce congestion is the creation of smart traffic management systems, as well as the "Digital Bangladesh" effort. Effective integration of the TDM and TSMO techniques provides a comprehensive approach to tackling the many traffic management difficulties faced by the nation. Bangladesh can greatly improve the sustainability and efficiency of its transportation system by lowering its reliance on private vehicles, enhancing public transit, making the most of the country's current infrastructure, and using real-time data to improve traffic management. There are still issues, nevertheless, such as the requirement for better road safety, infrastructure, and stricter enforcement of traffic laws. In Bangladesh, achieving sustainable transportation will require cooperation between the private and public sectors, planners for urban areas, and government agencies. We have offered evidence-based suggestions and data-driven insights to direct the path ahead in our analysis. It will take sustained research, innovation, and investment to achieve the goal of sustainable transportation. Although there are challenges along the

way, the path toward sustainable mobility offers the Bangladeshi people greater economic prospects, a better quality of life, and a cleaner environment. A more efficient and sustainable transportation system is attainable with determined work and a willingness to adapt.

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