INFLUENCE OF BUS CONDUCTORS ON PUBLIC BUS DRIVING DECISION IN DHAKA CITY

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A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree

of

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

ISLAMIC UNIVERSITY OF TECHNOLOGY

JUNE 2024

Approval

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Declaration

It is hereby declared that this thesis/project report, in whole or in part, has not been submitted elsewhere for the award of any Degree or Diploma.

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Dedication

This thesis is dedicated to our teachers and family, whose unwavering love, support, and guidance have been the cornerstone of our journey.

Acknowledgment

All glory be to Almighty Allah, whose mercy enabled us to complete our research work. We are profoundly grateful to Allah, the Most Merciful and Most Compassionate.

Our deepest thanks go to our thesis supervisor, Dr. Moinul Hossain, Professor, Department of Civil and Environmental Engineering, IUT. His expert guidance was crucial in completing our dissertation. Thank you, Sir, for your remarkable insights, continuous support, and endless inspiration.

We are also immensely grateful to Md. Asif Raihan, Associate Professor, Accident Research Institute (ARI), Bangladesh University of Engineering and Technology (BUET), for his unwavering perseverance and dedication. His constant support was essential in making this study possible.

Finally, we would like to extend our heartfelt appreciation to our beloved family members and everyone else who, directly or indirectly, assisted us in conducting our research.

Preamble

The purpose of the study is to investigate how helpers influence the decisions and action patterns of bus drivers in the context of local buses in Dhaka city. Additionally, it recommends relevant policies to address this driver-helper collaboration and road safety. In this study, Bus conductors are referred to as the people who work as a navigator to the driver on the road and occasionally collect fares from passengers. The Research is titled “Influence of Bus Conductors on Public Bus Driving Decision in Dhaka City”. The research’s final goal was achieved by integrating three independent objectives that targeted the bus conductors and drivers. The objectives are, i) Identify the role that the ‘conductor’ plays by assisting drivers in navigating. ii) Identify the degree of assistance offered by helpers under these situations – time of day, presence of competing modes, level of congestion, and, level of crowding iii) Examine the policy implications to address this driver-helper collaboration and road safety.

Abstract

Buses are more affordable and safer than private vehicles and are an essential part of urban public transportation networks. Different research suggests that urban accidents in Dhaka, Bangladesh are predominantly caused by buses. Traffic accidents are triggered by a combination of different factors such as the driver's level of skill, insufficient experience, reckless acts, and behavioral work hazards. In developing nations, particularly Bangladesh, drivers frequently receive assistance from helpers in the competitive urban bus service market. They guide drivers on stops, passenger pickups, and routes, which affects their conduct. An effort to maximize revenues frequently results in aggressive driving, overloading, and delayed stops—all of which increase the risk of crashes and fatalities. It is crucial to identify why drivers ask for help, what causes them to execute this, and how taking assistance while driving affects safety.

The study solely ascertains the reliance of Dhaka's intercity local bus drivers on conductors in urban settings. A later-synchronized video and audio configuration will be used to collect data for the study, which evaluates a few selected psychomotor characteristics of the bus drivers. The MATLAB Mobile software will keep track of several relevant physical parameters simultaneously. (Acceleration and deceleration, movement & immediate halt, etc.). Subsequently, the impact of variables is analyzed using the Peter-Clark algorithm in a Bayesian Network to verify the impact of the conductors on drivers' choices. The research aims to design and recommend policies to effectively minimize and eradicate safety-related risks related to their occupation. It will additionally help with assessing whether bus conductors are necessary or not based on how they influence driver performance.

Keywords: Conductors, Bus Driver, Developing Country, Assistance, Local Bus, Psychomotor characteristics, MATLAB Mobile, Acceleration, Deceleration, Halt, Peter-Clark, Bayesian Network.

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Chapter 1: Introduction

1.1 Background:

Buses are the foundation of all metropolitan public transportation systems because, when compared to more contemporary, high-capacity modes, they are the most economical, can be installed quickly, and are simple to operate. Buses are considered the backbone of all urban public transport systems in that they are most affordable, established shortly, and operated straightforwardly in comparison with modern and high(er)-capacity modes (Babalık-Sutcliffe & Cengiz, 2015b). Compared to other modes of transportation (such as private cars), public buses may be thought of as a safer option for traveling. Public bus transit mode may be considered a safer transportation mode as opposed to others (e.g., private cars) (Porcu et al., 2020). But it varies within developing and developed countries. In twenty of the countries composing the European Union (EU20), there are approximately 800,000 buses, equivalent to 0.35% of the total road vehicle fleet (230 million vehicles), while 10% of the road trips are made by bus. Given these rates, bus crashes account for very few events, involving less than 1% of total road fatalities (Cafiso et al., 2012b). Studies have shown public transport to be a very safe form of transportation as compared to other modes of transport (Chimba et al., 2010). In terms of bus travel, the risk of being killed or seriously injured was found to be several times lower for bus occupants compared to car occupants (Albertsson and Falkmer, 2005). However, in the context of a developing country, it is often proved wrong. Road traffic injuries are a major cause of death and disability globally, with a disproportionate number occurring in developing countries (Krug, 1999). An estimated 1.2 million road deaths occur annually worldwide, of which the majority occur in middle and low-income countries (McGee et al., 2003). In terms of developing countries, accidents are much higher than the developed countries. From research conducted in Dhaka city, it was found that the major vehicle which was responsible for accidents was the bus (Wang et al., 2021b). In urban areas of Bangladesh accidents involving trucks, buses, and minibuses account for nearly 90% of total road accidents although heavy vehicles constitute only 4% of the total vehicle fleet (Hoque et al., 2006). Also, unlike in many developed countries where buses are a relatively safe mode of transport, there is a significant safety concern in many developing countries like Bangladesh regarding transit buses. Among all the crashes in Bangladesh from 1998 to 2004, buses were involved in about 15% (MAAP database) (Kuo & Tang, 2011). In Dhaka City, 15 to 20% of accidents involve minibuses,

cars, or buses. In Bangladesh as a whole, buses and trucks are each involved in more than 20% of accidents. Inadequate road infrastructure, badly maintained cars, and careless driving are some of the causes of bus accidents in underdeveloped nations. It is crucial to address these problems to increase road safety because these difficulties frequently arise from a lack of resources and the enforcement of regulations. As low-income countries start developing, the incomes of their inhabitants start increasing and they can afford to buy vehicles to enable faster transportation. With an increasing number of vehicles and inexperienced drivers on the roads in terms of education about traffic rules or the drunken state of the driver as well as factors such as lenient traffic rules and penalties, it is seen that the rate of accidents and accidental deaths starts increasing (Sinha et al., 2021). Also, a unique feature in developing countries such as Bangladesh is the prevalence of unconventional vehicles. This vehicle type does not provide safeguards such as seatbelts or platforms to hold which exposes the occupants to potentially higher injury severity risk (Saha et al., 2021). Although the reasons of auto accidents are many, many of them are related to the traits of the drivers. Level of expertise, inexperience, and propensity for taking risks. However, in poor nations, numerous other illicit behaviors result in drivers being engaged in accidents. A series of studies in Sweden investigated the linkage between bus accident rates and acceleration behavior (af Wåhlberg, 2004b, 2007a), economical driving (af Wåhlberg, 2008a), high temperatures (af Wåhlberg, 2008b), and drivers' absence behavior (af Wåhlberg & Dorn, 2009). In Finland, the link between the occupational injury rate of bus drivers and their immigration status was explored (Salminen et al., 2009). Working condition, salary incentives and job satisfaction is also a major issue for the accidents in under developed country. In Asia, studies analyzed the linkage between bus accident rates, working condition, salary incentives, and job satisfaction in Sri-Lanka (Jayatilleke et al., 2009), and the correlation between bus accident rates and drivers' sleep problems in Teheran, Iran (Razmpa, Niat, & Saedi, 2011). In Bangladesh, 50% of collisions involving public transit reported at least one casualty in 2016–2018.The causes of motor vehicle collisions are complex, but broadly depend on characteristics of drivers. Skill level (McGwin & Brown, 1999), inexperience (McCartt et al., 2003) and risk-taking behaviors (Rolison et al., 2013). But in case of developing countries drivers are involved in accident due to many other illegal practices. This situation is partly due to the high level of psychosocial work hazards to which professional drivers are exposed (Amoadu et al., 2023). On the other hand, the situation in industrialized countries is different. As these countries have more seasoned and experienced

drivers and the authorities invest increasingly in road safety (Sinha et al., 2021). Certainly, population density can affect bus accidents. There may be more cars on the road and a higher chance of accidents in densely populated places. Furthermore, dense populations can increase the danger of accidents due to traffic jams and crowding, particularly in developing nations with inadequate infrastructure and public transportation choices which is not the same case in developed countries. Through concerted efforts, many developed nations have been able to achieve a reduction in crash related casualties. However, a contrasting trend is observed in the developing countries and the situation is worsening due to the rapid growth of motorized vehicles relative to population (Anowar et al., 2014). It also differs from city to city like in Bangladesh; Dhaka is the most populated city than the others. Most likely, it has a higher rate of accidents as well as unsafe and unreliable due to population. The bus transport system in Dhaka is unsafe, unreliable, inefficient and struggles to cope with the day-to-day mobility of its massive population (Quddus et al., 2019). Heterogeneity among vehicles sharing the road with buses can influence the likelihood of accidents. Disparities in the sizes, speeds, and handling capacities of vehicles can cause miscommunications and difficult traffic situations, which may raise the chance of bus collisions. Additionally, differences in vehicle maintenance requirements and conditions may have an impact on the general safety of bus operations, particularly in situations where a variety of vehicles are present on the road. A study in India reveals that the increased heterogeneity (more types of vehicles) significantly contributes to increasing the number of lane changes on highways. It also shows that the difference (or range) in preferred speed between the fastest and the slowest vehicle on the highway is another factor that increases the number of lane changes which may result in accidents (*Indian Journal of Otolaryngology and Head & Neck Surgery*, 2023). The presence of both motorized and non-motorized vehicles on the road can lead to increased complexity and potential crashes for buses. Traffic dynamics can be difficult to manage when there are variations in the speeds and behaviors of motorized vehicles (cars and motorcycles) and non-motorized vehicles (bikes and pedestrians). Buses need to navigate through these different elements safely, and lowering the risk of accidents in mixed traffic environments requires an understanding of these differences. Moreover, the heterogeneity of traffic- mix of motorized and non-motorized modes, makes the traffic and safety situation much more complicated in these countries.(Anowar et al., 2014) .

1.2 Problem Statement:

Bus accidents mostly get impacted by the competition among bus companies to maximize profits. Certain companies may lower their standards for safety, driver training, and vehicle maintenance in an effort to boost their bottom line. This may lead to drivers who are overworked and in poor condition, which raises the risk of accidents. Price wars can also result in overcrowding and overworked employees, which further jeopardizes safety. In developing countries, the trend of turning to the private sector for the provision of public transport services has resulted in a large number of individual operators whose main aim is (not surprisingly) to maximize profits. The drive for profitability can be achieved by increasing efficiency and cutting bloated costs, but may also lead to unfavorable behavior that can adversely affect passenger safety and comfort (Sohail et al., 2004). Bus companies must strike a balance between safety precautions and profitability in order to provide a more dependable and safe public transportation system. And behind it is the regulatory authority, BRTA, which has given many bus owners permits to operate on the same route, forcing the bus driver to take up the pressure to earn his income. It is the worst competition. And to compete with other buses, the drivers drive recklessly, ignoring road safety; and as a result, killing people on the road (The Daily Star). Bus accidents are also largely caused by the actions of bus drivers. Accidents can result from unsafe driving behaviors like speeding, careless overtaking, and exhaustion. To lower the risk of bus accidents and guarantee passenger safety, proper training, adherence to traffic regulations, and responsible driving behavior are essential. To make more money, drivers may be enticed to drive farther, work longer shifts, and take shortcuts, which could jeopardize safety and raise the risk of accidents. This can lead to a competitive environment among drivers. Majority of bus operators in developing countries, all income is derived from the fares collected from passengers and therefore collection of fare revenue becomes the key requirement for a successful operation. It is also worth mentioning that the salary system of helpers is also similar to that of drivers, so the drivers' behavior cannot be considered in isolation from the influence of conductors. The conductors' instructions to the driver, to stop/move for passengers get-on/get-off at bus stops or in-between, also influence the driving behavior. Most bus drivers do not get paid monthly salaries but earn commissions based on the number of passengers picked, leading them to race each other for passengers (The Dhaka Tribune). And then the competition among drivers be intensified by the need for helpers, such as conductors, as they compete to make more money by carrying more passengers sometimes at the price of safety and good passenger

management. It is perhaps because of the unruly nature of traffic in Bangladesh that drivers need helpers or conductors to navigate their buses or trucks. In many cases these navigators are as much responsible for an accident as the driver himself for a delayed instruction or omitting to mention that there was a lone biker at one of the driver's blind spots (The Dhaka Tribune). However, it is eventually the driver who is responsible for safe and comfortable bus travel (Htun et al., 2012). Bus conductors and helpers can have a big impact on passengers' behavior and accident rates. Conductors support fare collection, passenger management, and general service excellence. Conductors can improve passenger experience and safety if they are given the right training and resources. But if their influence and actions are not properly controlled, they may also have negative consequences that alter bus behavior and even cause accidents. Bus behavior in Dhaka varies significantly depending on the drivers and conductors operating them (Katz & Rahman, 2008). Long-term stops by local buses can also disrupt traffic flow, resulting in congestion and discomfort for drivers everywhere. Rear-end collisions may become more likely as a result of this congestion. But the helpers often do that for their own benefit risking passengers safety. Local bus will remain at a stop for several minutes until the conductor feels the bus is sufficiently loaded (Katz & Rahman, 2008). The proposed study is now a major issue only in the context of Dhaka but soon it can be spread in cities with similar socio-economic conditions like it did before with unconventional modes of transport such as two wheelers, taxi etc. It is crucial to comprehend the root cause of the issue and address it early on.

1.3 Objective:

The main goal of our research is to identify the role that the 'conductor' plays in navigating and assisting the driver and how it influences the driver in taking abrupt driving decisions. We also need to recognize the specific situations and the degree to which drivers commonly seek assistance from helpers. Examining the necessities of policy implication to address this driver-conductor collaboration and road safety will be our primary objective.

1.4 Scope

Urban area: The study aims to determine the drivers' dependency on helpers in Dhaka's intercity local buses in the urban areas exclusively. By recording numerous variables manually and

comparing them with identical parameters that have been obtained in a scientific manner, the degree of dependency can be assessed.

The results of this study will shed important light on the significant effects of bus driver-conductor interaction on urban planning and policymaking in the metropolitan area of Dhaka. The safety of the public transportation system will be clarified, which will help guide essential decisions aimed at boosting commuter well-being.

Chapter 2: Literature Review:

2.1 Introduction:

Previous studies about bus drivers in Bangladesh addressed the risk and safety factors associated with urban bus transport in Dhaka city. Nonetheless, no studies have been conducted about the role that bus conductors play in bus drivers' decision-making and how influential are they in the risk and safety factors associated with bus driving. This chapter covers research from global and Bangladesh perspective, evaluating the role of urban bus service in context of public transportation.

2.2 Role of Buses in the Context of Public Transportation

An essential component of public transportation is buses. By potentially enhancing the air's cleanliness, affordability, active commuting, and traffic safety, promoting public transit could have a positive impact on corresponding human health consequences (U.S. Department of Transit, 2015). A public transportation system's fundamental goals are to maximize urban mobility and reduce the effects of overcrowding (Carvalho et al., 2015).

Over the past forty years, since 1975, Dhaka's urban population has grown at a pace of 2.4%, placing it among the world's few megacities (Alam, 2019). The country's economy, which grew at a rate of more than 6% period between 2009 and 2020, can be partly blamed for Dhaka's development. Nevertheless, Dhaka is populated in the world for traffic jam world and its public transit infrastructure has not kept up with the city's population growth (Khan et al., 2018; Niger, 2019). The key to having smoothly running public transportation is proper planning, the execution of integrated policies (Gallagher, 2016; Niger, 2019), and the identification and elimination of problems (Rahman et al., 2023).

Bus system effectiveness and efficiency:

In an assortment of ways, buses assist the public transit network. There are several methodologies to assess how effectively the transportation system is functioning. Efficiency and effectiveness are the key concepts used in assessing an organization's performance, according to Mouzas (2006).

The system's ability to meet its goal in terms of public service is indicated by its effectiveness. Conversely, efficiency describes the organizations or systems as an essential requirement that reflects operating margin. It is crucial to take into account the best interests of both service providers and passengers when deciding on the two parameters (Carvalho et al., 2015)

The effectiveness and efficiency of the bus routes are evaluated by examining several factors. The research project included the average journey time, the number of buses operating, and stop numbers and operators as data inputs. The variables that were examined as outputs were vehicle kilometers, ridership, or passenger boarding. These variables were selected because they provided an accurate representation of the cost elements and were related to the services that the transportation system produced or utilized. Several survey formats are used to assess each of these factors. The chosen parameters aim to identify the bus system's operational performance in transportation and enhance its effectiveness and efficiency (Hawas et al., 2012).

The "problem of relativity," or finding a balanced equilibrium between a degree of effectiveness and efficiency, may present challenges for businesses and public transportation authorities. The ratio can be summed up as follows (Mouzas, 2006):

Performance = Efficiency/Effectiveness

A performance of less than 1 highlights a public policy that prioritizes passengers, and the transportation service provider's business revenue is highlighted if it is greater than 1 (Carvalho et al., 2015).

Data envelopment analysis can be applied to compare and evaluate the PT and IPT systems in a populated area to design infrastructure and plan an appropriate and effective route (Dawda et al., 2020). Based on the evaluation, the PT system could have been more efficient overall than the IPT method. Every route's effectiveness and efficiency were examined, and recommendations for enhancements were made. To provide sustainable urban transportation services, there is room for improved integration between PT and IPT (Dawda et al., 2020).

In summary, there is an inherent tradeoff between cost-efficient operations and passenger experience in public transit. The public sector is responsible for balancing these competing interests through governance and policymaking. This involves strategic decision-making to strike the right balance between efficient resource use and effective quality of service for the public (Carvalho et al., 2015). All these factors and evaluation techniques are also applicable to the bus system of Dhaka city in enhancing overall public transportation. For people to live their everyday lives and to influence public policy, public transportation must be efficient and effective.

Equity and Accessibility:

In the case of equity and accessibility, the public transportation system of Dhaka faces multiple types of problems. These problems must be addressed and eradicated to smooth accessibility. Through a qualitative and quantitative approach, equity and accessibility can be achieved (Rahman et al., 2023).

The accessibility study is complicated by the semi-formal public bus system in Dhaka's lack of vital data. These data constraints can be circumvented by utilizing the concept of "major destinations". The underlying assumption is that because trip aims, time of day, and destinations are interdependent, different trip numbers happen at different times. Using a spatial autocorrelation technique, the study locates statistically significant clusters of destinations during off-peak and peak hours. The Modal Accessibility Gap (MAG) is calculated and accessibility to these significant places is assessed using cumulative opportunity-based criteria. It is imperative to establish a formal public transportation system in Dhaka, paying particular emphasis to areas with greater MAG, to optimize utilization of resources, boost daytime public transportation services, and decrease dependency on cars (Debnath Kishore & Nakshi, 2020).

An enormous number of people live and work in Dhaka, a city that is constantly buzzing. Many people live in the center of the city to pursue their careers. A few people make their way into the city's heart of Dhaka from the outskirts. The majority of them prefer non-motorized modes of transportation; yet, exits are more commonly served by motorized modes such as buses and human haulers than entrances (M. Rahman et al., 2022). For longer-distance access to metro stations, Indian commuters are also more likely to select buses and autorickshaws (M. Rahman et al., 2022).

Impact on the environment and sustainability:

Transportation is at the core of many issues related to economic and social growth, given that the transportation sector (buses, electric buses, and other vehicles) accounts for 27% of all energy use, 64% of global oil consumption, and 23% of global energy-related carbon dioxide emissions. Some of the positive effects that the pandemic containment efforts have had on emission levels and air quality would be greatly enhanced if structural improvements to transit were put into effect in recent times (Mead, 2021). In comparison with private automobiles, public transportation produces fewer greenhouse emissions per passenger because of economies of scale. Shifting people from automobiles to using public transportation may drastically decrease emissions (Zheng & Krol, 2023).

The best places for public transportation to operate are congested urban areas with lots of potential passengers. Ridership is increased via transit-oriented development, which places residential and commercial properties adjacent to stations. Cars and public transportation vie for scarce urban space. When more people use the system, more frequent service, development, and money for further developing the system are assembled This is the way well-planned transportation systems may become self-reinforcing (Zheng & Krol, 2023). Since there is no alternative mass transit in Dhaka because buses are poorly organized and do not adhere to timetables, there is a lot of traffic, delays, and pollution (Bari, 2023). These challenges must be addressed to eradicate the sustainability-related issues.

Impact on the economy and policy:

For an extended period, the transportation policies of developed nations have mandated the use of public transportation more frequently. One important component of policies aimed at increasing public transportation utilization and influencing modal shifts is the provision of "good" public transportation. But 'good' public transportation has numerous qualities, including being financially sustainable and effectively delivering high-quality services (Mulley et al., 2003).

Transport and urban planners ought to extract how to improve from the overall failure of auto-friendly and unsustainable transport plans undertaken thus far to alleviate traffic conditions in Dhaka. The time has come to implement both a long-term strategy and immediate corrective

actions to undo the harm that the misguided transportation policies have caused to the environment, the economy, efforts to combat poverty, and sustainable development. The two main recommendations are strategic policy initiatives and a knowledge-intensive open-ended planning approach (Bari, 2023).

Implementing incentives including free or drastically subsidized bus, rail, or public transit passes may convince people to utilize public transportation in Dhaka by lowering the cost to the user. Additional benefits include pre-tax payroll reductions, reimbursements, partial payments, and subsidies from the employer. Research has demonstrated that providing these kinds of subsidies may promote the use of active modes of transportation like bicycling and walking as well as public transportation, most notably among college students (U.S. Department of Transportation, 2015).

Urban and Rural Comparisons:

Urban:

Buses are critical to economic growth because they give people access to reasonably priced and easily accessible transportation, which enables them to obtain employment, education, accessibility, and other necessities (Johnson et al., 2014). Sustainable transportation includes urban buses, which are more effective at moving people than automobiles (Zheng & Krol, 2023). In comparison to other cities, Dhaka's current service quality is less adequate, with system, network, and cost efficiency below average. However, usage efficiency is higher, which can be the consequence of workers using cars excessively and abusing their resources (Ahasan & Kabir, n.d.). Private vehicles and public transportation can coexist, although there is competition between them due to space constraints.

Introducing bus-only lanes slows down other traffic while facilitating quick, frequent bus travel (Zheng & Krol, 2023). In the rapidly expanding metropolitan area of Dhaka, the introduction of metro tracks, rerouting of bus routes, and the creation of a distinct public transportation system strategy offered some hope for resolving certain pressing issues (Ahasan & Kabir, n.d.).

Rural:

Due to a sparse population, passengers in rural areas have longer travel times. Analyzing historical data can increase productivity across extended distances(Ecolane, 2016).A study evaluated how rural bus stops on a regional bus service influenced dependability and average trip times. The study finds that in rural regions in contrast with metropolitan areas, the significance of a secondary bus stop is low. (Hansson et al., 2021)..

Emerging shared-use mobility practices present a potential to fill existing gaps in rural and small-town transit services by providing a convenient, dependable, and adaptable service (*Rural and Small Town Transportation*, n.d.).Due to the minimal population density and lengthy commutes, people living in rural or small towns may depend more on their vehicles than people in urban areas (*Rural and Small Town Transportation*, n.d.).

Urban long- and short-route comparisons:

Urban Long Route:

Buses are an inexpensive kind of transportation that can be used for long-distance trips in cities (Olds, 2020). Bus stations are also considered a useful option for passengers because they are nearly always located closer to the core of towns and cities than airports (Olds, 2020).

Buses are a more environmentally friendly mode of conveyance than personal automobiles since they emit fewer greenhouse gases than cars (Ridango, 2022). Subsequently, buses are capable of accommodating large groups of people, they are a dependable mode of transportation for long-distance travel in cities. Public transportation, which includes buses, is a more effective way to move people than private vehicles (Olds, 2020; Wikipedia Contributors, 2019). Many cities have designated bus lanes as a result of traffic congestion, making public transportation within the city not only more affordable but also quicker (Ridango, 2022).

Short Long Route:

Because buses can accommodate a lot of people, they are a practical form of transportation for short trips in cities (SustraMM, n.d) Moreover, the peak hour crowding and long waiting times during peak hours (*What Are the Advantages and Disadvantages of Travelling by Bus?* n.d.).

Buses also reduce the the environmental burden as it is noticed in a study that,75 cars can be replaced by a bus (SustraMM, n.d). Again, reduced need for parking spaces, which leads to easier parking spots being available for other car users (SustraMM, n.d). Not only that but also, reducing traffic congestion shortens the remaining motorized private transportation journey time (SustraMM, n.d).

Societal perception, promotion, and future trends

Societal perception:

Buses and other forms of public transportation are environmentally friendly modes of transportation that move passengers more quickly than private vehicles (Zheng & Krol, 2023) (Wikipedia Contributors, 2019). Regular bus users' satisfaction levels can be raised by changing the bus transportation system (Andaleeb et al., 2007). Adding new or extending current bus lines can act as quick investments to enhance health outcomes and raise health equity in communities. Public transportation can be a driver of health and equity.

According to a recent European multi-city poll, banning motorized vehicles in high-density parts of cities, providing dependable and reasonably priced public transportation, and dense urban surroundings will all contribute to the much-needed encouragement of public transportation use (Wikipedia Contributors, 2019).

Promotion:

Public transportation can become more preferred as a result of more awareness, a stronger attitude, and advertising and promotions (Gijsenberg & Verhoef, 2019). Regular bus users' satisfaction levels can be raised by changing the bus transportation system (Andaleeb et al., 2007).

Future trends:

There are 152 bus lines in the Greater Dhaka Metropolitan Area (DMA), and 44.7 percent of daily journeys are primarily connected to employment, while 17.7 percent are related to school, according to the Sustainable Urban Transportation Index.

Buses account for around 64% of passenger excursions among all the public transportation options offered in the DMA. This indicates that over 10 million of the 21 million people utilize local buses. Regretfully, the city's various routes are traversed by around 7,000 buses (Anik,2020).

Public transportation awareness and preference can be raised through promotions and advertising, while regular bus users' satisfaction levels can be raised through bus transportation service reform. Buses are predicted to remain a vital component of public transit in the future, helping communities achieve equity and health while facilitating access to jobs, education, and other necessities. To improve buses as public transportation in the future, policymakers and bus operators in developing as well as developed nations may focus on "clean diesel," gaseous fuels, hybrid-electric engines, biodiesel, and fuel cells. A wide range of costs associated with various technologies. It is wise to select a technology in the initial stage that is relatively simple to handle. Evaluating different low-cost solutions and progressing to much more complex and expensive solutions, like fuel cells, may eventually prove to be cost-effective (International Energy Agency, 2002). The governing body's responsibility is to minimize expenses in the years to come so that everyone can access the bus system.

2.3 Public Transport Business Model

Public Private Partnerships

Public-private partnerships, or "PPPs," can be a useful tool for managing, operating, maintaining, or developing new infrastructure as well as for constructing and implementing it. PPPs can be a win-win solution to important transportation issues in both sectors. Roads, trains, airports, ports, and urban transportation infrastructure are all essential for long-term trade and socioeconomic

growth. They connect people, places, and businesses with markets. A key factor in increased productivity is an effective transportation system (*PUBLIC-PRIVATE-PARTNERSHIP LEGAL RESOURCE CENTER*, n.d.)

P3s are contracts that permit more private ownership of project delivery between public and private entities.

The private sector assumes greater risk and accountability in transportation P3s for tasks like long-term operation, design, building, financing, and revenue collection. When addressing transportation difficulties, the Build America Bureau recommends considering P3s as a means of bringing in private funding, efficiency, and innovation

(*Public-Private Partnerships (P3)*, n.d.).

There are a few fundamental distinctions between the private and public transit systems. The low cost and widespread availability of public transit are sustained by government subsidies. The fixed tickets are reasonably priced. Profit is the primary focus of private transportation. Travelers have to shell out more for facilities. The public transit system is administered by the government. Nevertheless, in contrast

Private transportation is owned by companies and profit-oriented personnel. Compared to private transportation, public transit can be particularly unpleasant since it compels one to share a room in a packed environment with people. Public transit, on the other hand, travels at a slower pace since it has predetermined routes and stops. However, private transportation might be faster and more flexible, since it typically goes immediately to locations (IDriveYourCar, n.d.). Each kind of system of transportation has benefits that complement particular importance.

Fare revenue:

A wide range of issues plague Dhaka's public bus revenue-gathering strategy, including operator overcharging, inadequate fare collecting technologies, and subpar busses and bus stops. In Dhaka, public buses continue to make money through fares despite these restrictions. Private buses have an independent revenue model as they are run by individuals or organizations who want to generate

a profit (Chowdhury, 2014). In Dhaka, the money from public buses is derived from the fares. Local bus service is offered by both state-owned Bangladesh Road Transport Corporation (BRTC) and private bus companies throughout the city and its environs. There were 1,194 minibusses and 304 buses operating on 8 bus routes and 19 minibus routes in Dhaka in 1992(Ahasan & Kabir, n.d.). Private bus companies are extremely dispersed and disorganized tiny businesses offering exceptionally poor services (Chowdhury, 2014).

Private automobiles are comfortable, convenient, and independent, but they also come with a hefty initial cost that must be paid for by the proprietor, as well as ongoing upkeep expenses. People who want to go on time and prevent investing an excessive amount of time in transit may find private transportation to be more convenient. Absolute supervision of the vehicle's movements is made available by private transportation, making the excursion a more enjoyable experience (Alam, 2018). Subscription models, fare monitoring and improvement, revenue administration, service diversification, and optimal utilization of assets constitute typical revenue models employed in the transportation industry (Kolk, 2022).

Economic benefits:

Though it faces an assortment of obstacles, Dhaka's public transportation business model offers several financial benefits. Public transportation is a vital means of mobility for individuals residing in urban as well as rural regions considering that it may give access to employment, education, and numerous other requirements. The provided accessibility leads to greater goods (Andaleeb et al., 2007; Alam, 2018; Anik, 2020). By improving the level of contentment of frequent bus consumers, bus transportation services may be modified to draw more riders and yield additional revenue (Andaleeb et al., 2007).

The BRT project also adds up to economic benefits. Revenue sharing, fare accumulating, reimbursement, and card management are every element of the BRT system (Anik, 2020). It is also observed that three to five bus rapid transit (BRT) travel routes, which integrate several operators into a single-fare ticket system, constitute an element of Dhaka's public transportation regulations.

Profitability, which was determined using operating cost per vehicle-kilometer and revenue per vehicle-kilometer as the basis, was used for evaluating cost efficiency. The proclaimed profitability of the accumulated economic data, although has been demonstrated to be not accurate, was around 17% (Ahasan & Kabir, n.d.). When more people utilize the same transportation at the same moment, the expense per head of public transportation falls, making it more affordable than private transportation (Alam, 2018).

Government Subsidies:

Government subsidies are an element of Dhaka's public transportation economic model, which helps preserve the bus route optimization system (Report, 2023). Considering the transport owners have already invested in the streamlined routes, challenging those regulations that forbid the current buses from functioning there. When other actions, like as drives and penalties, have not been able to stop those buses from running on the rerouted routes, something needs to change (Report, 2023). As the revenue is collected through fares, appropriate measures need to be taken considering the fare collection issues.

An examination of Option 1 (the RSTP projects) revealed that over twenty years from 2016, investment from the private sector in Dhaka's urban transportation is anticipated to surpass government funding by a ratio of around 2:1(Gallagher, 2016).

To boost local bus utilization for commuting it is essential to address the range of possibilities and capacities that exist for the public and private sectors to collaborate in the establishment of a dependable public transportation network from organizational, operational, and financial (such as finance and financing) viewpoints. To address the aforementioned, it is also important to point out different organizational settings and propose recommendations grounded in funding and financing alternatives and processes originating from local socioeconomic and governmental contexts. The national government should concentrate on establishing the regulations and legislation required to create an organization of coordination that would integrate/consolidate all service providers and guarantee smooth transit service across jurisdictions (Chowdhury, 2014).

Tax funding:

According to The Business Standard, to improve the public transportation system, the 25 percent tax on electric wheelchairs and trikes should be removed, and incentives for the acquisition of low-floor accessible buses ought to be made available (*How the Budget Can Make Dhaka Better for Persons with Disabilities*, 2022). The idea put out by the finance minister has garnered significant backing inside the legislature, as well as from civil society organizations, environmentalists, and ordinary Dhaka citizens who lament the excessive traffic on the city's streets where a "carbon tax" for each successive automobile that an individual possesses would be demanded of underneath the proposal (*Not so Fast, Experts Warn as Dhaka Tries to Clear the Air with Car Tax and Bus Ban*, 2023). The fact that commuters in Dhaka who use the metro train benefit from a 15% exemption on VAT, which is charged on their train tickets is very positive, and the National Board of Revenue (NBR) deserves appreciation for coming up with this decision. To increase tax collection, the rightful authorities should cease threatening the population as a whole and prefer to concentrate on highlighting members of society who, despite their socioeconomic standing, are causing millions of dollars worth of non-payment of taxes to the state (Dhaka Tribune, 2023).

2.4 Role of Bus Drivers:

Background

Bus drivers play a critical role in the present-day transportation networks, acting as the intermediary between communities and their destinations. Bus drivers play a vital role in maintaining public safety standards by supporting the efficient movement of people within and between urban and rural regions. They have the primary responsibility for guaranteeing the safe and timely conveyance of passengers. Bus drivers frequently serve as frontline ambassadors in addition to their operational duties, offering passengers information, support, and a comforting presence. This helps to promote a favorable public perception of the transportation sector. They are an essential part of a functional society, as seen by their commitment to following traffic laws, keeping the car in good condition, and providing outstanding customer service. The bus driver and Helper duo deal directly with passengers: The favorable work environment designed to foster the

skills necessary to generate service excellence supports this organizational unity, and the driver's job in particular is ultimately accountable for the visibility of transportation excellence. In this context, providing excellent mobility for individuals—particularly those with disabilities and different needs and desires—is what it means to be a transportation excellence (Brunoro et al., 2015).

Job Responsibilities of Bus Drivers

The primary goal of the jobs performed by transportation professionals, such as bus drivers, is to ensure mobility for the population. However, their duties come with constant challenges that significantly impact their health. To accomplish the stated objectives, ensuring mobility in circumstances that aren't always favorable requires perseverance, unceasing work, and skill mobilization (Brunoro et al., 2015).

A bus driver must safely run the bus by a specified daily schedule. This entails juggling competing requests while ensuring the bus is in good condition and can pick up and drop off passengers on schedule. In addition, the bus driver is responsible for keeping the bus secure and orderly as well as for adhering to all laws and regulations to prevent driving in a way that puts passengers at risk. The chance of an accident can be decreased by bus drivers being vigilant, especially in times of high traffic or inclement weather.

Bus drivers play a vital role in making sure that passengers are transported to their destinations in a timely and safe manner. Their responsibilities as workers include a wide range of duties, including following established routes and timetables, keeping the bus clean and in working order, and performing pre-and post-trip inspections to guarantee the vehicle's safety. They are in charge of supervising fare collecting, helping passengers board and depart, and responding to any questions or issues from customers to provide customer service

Bus drivers need to be knowledgeable about and skilled in operating the bus they drive, as well as the bus route, any relevant regulations, standard operating procedures, driving protocols, and

scheduling systems. It's also critical to have the know-how to assist customers, particularly those with specific requirements, to guarantee that bus users appreciate their trip. Bus drivers need to have strong interpersonal skills to communicate verbally and with others efficiently. In addition, bus drivers should exhibit integrity, dependability, adaptability, and a strong work ethic as key personal qualities to contribute to the delivery of a reliable bus service. (Rohani et al., 2013)

Furthermore, bus drivers are required to prioritize the safety of their passengers and other road users at all times when navigating through traffic, adverse conditions, and crowded locations.

Training and Licensing Requirements

To guarantee the safe and effective operation of public transportation systems, bus drivers must complete extensive training and licensing requirements. Typically, prospective bus drivers must complete a state-approved curriculum to get a commercial driver's license (CDL), which entails written and practical exams covering safety procedures, vehicle operation, and driving laws. Additionally, to provide bus drivers, with the abilities they need to handle a variety of circumstances on the road, specialist training in passenger management, emergency procedures, and defensive driving tactics is sometimes required. Maintaining the high standards of competence and professionalism required in this crucial function also requires regular appraisals and refresher training. It is crucial to set up standards for professional growth, such as ongoing training and acknowledging the role of drivers. These elements make up a framework for excellence. To attain and sustain excellence, these factors must be constantly observed and improved (Brunoro et al., 2015).

Challenges Faced by Bus Drivers

Bus drivers deal with a variety of intrinsic challenges related to their line of work, requiring a certain set of abilities and perseverance. Driving for extended periods, they struggle to prioritize passenger safety while navigating crowded city streets, unpredictable traffic patterns, and unruly passengers.

Bus drivers need to handle multiple responsibilities, which makes their work both mentally and physically demanding. Bus drivers must be customer-focused and keep open lines of contact with the people they transport. However, there are instances when the desire to give service clashes with the need to maintain strict control of the busy traffic and the need to drive safely by the rules of the road (Rohani et al., 2013).

Furthermore, they have to follow strict schedules, which frequently causes stress and time constraints, particularly during busy periods. severe weather increases these challenges and puts the ability for problem-solving to the test. Moreover, the continuous requirement for alertness and focus might cause mental exhaustion, which is detrimental to their well-being.

Importance of Safety Protocols

Bus drivers have an important role in upholding safety protocols, which guarantee the security and well-being of both passengers and other drivers. Bus drivers are charged with the duty of navigating through potentially dangerous situations, heavy traffic, and unexpected climates. In addition to protecting the lives of those on board, rigorous adherence to traffic laws, routine vehicle maintenance inspections, and the implementation of passenger safety measures also improve the general effectiveness of the transportation system. Bus drivers are vital in building a culture of accountability and trust by emphasizing safety and reassuring passengers of their commitment to a safe and comfortable trip.

Workplace Environment and Job Satisfaction

Bus driving has been regarded as a very stressful job owing to its high demand, lack of control over work pace, and driving conditions (Dorn, Stephen, et al. 2010). MFL Occupational Health Centre (1998) reported that city bus drivers are more likely to experience tension, mental overload, and fatigue. The atmosphere at work and job satisfaction are critical factors that impact bus drivers' productivity and well-being. An atmosphere that is favorable for bus drivers to work in includes elements like resources that are sufficient, clear lines of communication, and supportive

management. Employers may improve work satisfaction and, in turn, overall performance by creating a good environment where drivers are acknowledged and respected. Furthermore, providing chances for professional growth and skill improvement might inspire bus drivers to do well in their current positions. Bus drivers' job satisfaction is further increased when they have a safe and comfortable working environment, fair payment, and recognition for their efforts. These factors promote service quality and passenger safety.

Technological Advancements in the field and future trends

The position of bus drivers has seen a considerable transformation due to technological breakthroughs in the sector of bus transportation. These advancements have revolutionized the way bus drivers operate and ensured greater safety and efficiency. In developed countries, modern GPS tracking technology and real-time traffic monitoring have made it possible for bus drivers to plan their routes more efficiently, reduce delays, and provide passengers with precise arrival time estimates. Furthermore, the deployment of automated technologies, such as driver assistance tools and collision avoidance technology, has strengthened safety protocols, lowering the likelihood of collisions and improving road safety generally.

The driving responsibilities and tasks that drivers execute will change as a result of increased technological support and automation, and this will alter the repertoire of behaviors, abilities, and knowledge that drivers need to sustain safe driving performance (Casner and Hutchins 2019; Fisher et al. 2020; Regan et al. 2020; Spulber 2016).

Future developments in the field of bus driving are anticipated in the form of autonomous buses, which could allow drivers to take on the role of system supervisors, supervising operations and guaranteeing passenger safety while utilizing AI-driven technologies to provide smooth transportation services. Furthermore, bus drivers' roles as stewards of ecologically conscious and sustainable transportation are expected to change as a result of the integration of eco-friendly and electric buses, in line with the worldwide movement towards a more sustainable and greener future.

2.5 Role of Bus Conductors:

Definition of Bus Conductors:

The person is responsible for collecting fares from bus riders is recognized as a bus conductor. On average, the conductor continues to remain inside the bus the whole trip, accompanying the driver and helping to manage the crowd of passengers (*Bus Conductor*, 2023).

The bus conductors were seen to have originated from low socioeconomic backgrounds, where family members, including children, typically labored to provide for the family and worked in extremely densely populated regions. As a result, bus helpers were continually required to modify their profit and loss throughout the same day. There was typically a lot of competitiveness in their work environment (Chahine & Nirmala Naresh, 2013).

There are also female bus conductors. In a recent study in Maharastra, India (Urmila Vikas Patil & Babaji, 2018) the employment satisfaction of female MSRTC bus conductors was measured when 40 female bus conductors attended a survey administered through a questionnaire. They were pleased with MSRTC's operating hours in 100% of cases 52.5% of those surveyed were in the 26–35 age range. Because of their jobs and their families, 47.5% of respondents said they felt exhausted or unpleasant at work once a month. 27.5% of respondents assessed MSRTC's facilities as inadequate, while 42.5% thought they were acceptable. 47.5% said that the competition from private buses had affected MSRTC's performance .27.5% said it was because of bad management. The workplace environment affects women's productivity in the workplace in both good and bad ways.

Purpose of Conductors:

In public transportation around the globe, including in the capital of Bangladesh, the purpose of bus helpers is to support drivers in overseeing passengers and collecting fares.

Bangladesh's capital city Dhaka is the sixth fastest-growing city, with 10.9 thousand individuals living in the city and 22.3 million people residing in the metropolitan region. Even though there

are now more than 5,000 people in require of public transit, Dhaka city possesses only a little over 2,500 buses. The public bus service in Dhaka is notorious for issues such as congestion lack of comfort and security, risky driving practices, substandard and potentially hazardous boarding and alighting facilities, insufficient service frequency, lack of sanitation, and law enforcement agencies (Umme et al., 2023). To manage the overall condition of a bus to a certain extent bus helpers are an integral part, especially in local buses.

According to (*Bureau of Statistics, Work Unit of the Policy Integration Department*, n.d.)The responsibilities of bus helpers consist of gathering and issuing passes, tickets, or prices, or verifying the authenticity of already issued tickets, managing a sleeping car on a train, which includes verifying tickets, ensuring passengers' safety, and responding to information requests, making certain that safety guidelines are followed, providing passengers with information, particularly on pauses and connections, assisting the driver in adhering to timetables, acting appropriately in the event of an emergency or an accident, carrying out relevant activities, overseeing the work of others.

According to (Chahine & Nirmala Naresh, 2013) the bus helpers worked for an extended period. For example, were allowed to work up to three shifts a day, totaling fourteen hours. They executed transactions in the framework of doing the throughout-the-day job that necessitated them to make decisions instantly requiring computational skills without the use of computing resources.

Negative Impact on the conductors' health:

Bus conductors and drivers deal with a variety of challenging circumstances, including discerning passengers and delays in traffic, which can cause tension and anxiety. As a consequence of their challenging duties, bus drivers and conductors are more susceptible to mental health problems which might involve anxiety and depression (Mohamed Ali et al., 2023). Even, extended durations of either sitting or standing are characteristic of bus drivers and conductors, can trigger musculoskeletal issues including neck and back apprehension (Gangopadhyay et al., 2012).

Bus conductors frequently put in lengthy workdays, which could result in reduced relaxation and fragmented sleep cycles. Weariness may ensue from this, which may impair their performance and raise the possibility of mishaps (Bhatt & Seema, 2012). They are more likely to develop

cardiovascular disease as a consequence of their hectic occupations, sedentary lifestyle, and exposure to air pollution accompanying traffic (Vernekar & Shah, 2021).

Road traffic emissions uncover them to pollutants that might cause respiratory ailments and symptoms (Mbelambela et al., 2017). In the final analysis, the nature of their jobs renders bus drivers and conductors in jeopardy facing a variety of medical conditions.

Future trends:

In Dhaka, there is still a lack of a properly managed, reasonably priced public transit system in this metropolis of over 12 million people, most of whom are from the middle and lower income brackets (Andaleeb et al., 2007). To guarantee that the intervention is customized to the needs of the company and its workers, future initiatives should take into account a formative qualitative research process including important stakeholders and drivers and most importantly helpers mindset (Peters et al., 2021). It emphasizes avoiding adverse health effects at different levels along with pinpointing upstream reasons for helpers' health consequences and job alternatives by including all corresponding factors (Peters et al., 2021; Van et al., 2023).

2.6 Bus Safety:

Vehicle inspection and maintenance:

The maintenance and inspection of vehicles are essential to guaranteeing bus safety. They lessen the possibility of accidents brought on by mechanical breakdowns by keeping buses in good operating order. Frequent maintenance on critical parts like the tires, brakes, steering, and lights guarantees that everything is functioning properly and keeps the bus safer for both passengers and other drivers. In the United States, mass transportation vehicles such as public transit, commercial flight, and passenger rail are federally mandated to undergo safety and maintenance inspections (Peck et al., 2015).

In addition to saving money for bus operators, maintenance extends the bus's lifespan and guarantees that passengers will have reliable transportation. Buses that receive regular maintenance are less likely to malfunction suddenly, which can delay travel and inconvenience passengers.

Additionally, conforming to a maintenance schedule enables bus operators to meet government safety requirements and standards. This prevents legal problems in addition to guaranteeing passenger safety.

In conclusion, bus safety depends on routine vehicle inspections and maintenance because they avoid collisions, increase bus longevity, lower breakdown rates, guarantee adherence to safety standards, and encourage environmental responsibility. The safety of passengers and the efficient running of bus services depend on these procedures.

Driver training, behavior and performance:

Bus safety is largely dependent on the performance, behavior, and training of the drivers. The foundation of safe bus operations is having drivers who are responsible and well-trained. Drivers who have the right training will be able to operate big cars, negotiate tricky traffic conditions, and react to crises. The way they drive affects the safety of other drivers and passengers on the road, including following speed limits, obeying traffic laws, and putting away electronic devices when driving. Professional drivers perceive significantly more control and have been involved in more accidents than non-professional drivers (Nordfjærn, Jørgensen, & Rundmo, 2012). Therefore, it is essential to study the driving behavior of professional drivers, especially urban public transport professional drivers who shoulder the responsibility of public safety (Han & Zhao, 2020).

Additionally, a driver's skill in areas like decision-making, defensive driving, and alertness has a big impact in preventing accidents. It is imperative that drivers always demonstrate situational awareness, uphold self-control, and put safety first. For safety and attentiveness, especially on lengthy trips, their capacity to handle stress and exhaustion is essential. When things get urgent, rapid thinking and the following safety procedures correctly can literally save lives. Bus drivers must thus possess the necessary skills, exhibit responsible conduct, and meet high performance requirements in order to reduce the risk of accidents, protect the welfare of passengers, and maintain public trust in the dependability and safety of bus transportation systems. In Bangladesh, Almost 70% of the drivers admitted that their attitude toward driving was significantly influenced by their economic conditions but the rest disagreed with this also about 99% of the drivers did not learn driving from any formal training centre. A senior and experienced driver trained them

privately while working with him as a helper/conductor or while working in a vehicle-repairing garage (Uddin, 2003).

To maintain the highest standards of bus safety, it is the joint responsibility of the drivers, their employers, and the regulatory bodies to fund extensive training programs, keep an eye on driver conduct, and regularly evaluate performance.

Coordination and communication between bus drivers and helpers:

The efficient coordination and exchange of information between bus drivers and helpers are essential elements that significantly impact bus safety. This cooperation is essential to guaranteeing that passengers have a safe and easy ride.

The duties of helpers and bus drivers are different yet connected. The bus driver's main responsibilities are to steer the vehicle safely, pay attention to the road, and maintain the mechanical parts of the vehicle. On the other hand, helpers frequently aid passengers in getting on and off the bus as well as making sure they are secure within. A thorough comprehension of these responsibilities is necessary for effective coordination to ensure that there are no conflicts or diversions amongst them. Bus helpers serve a vital role while passengers are getting on and off the bus. They assist passengers, particularly little ones, the elderly, and those with disabilities, making sure they board and get off the bus securely. By coordinating, the chance of mishaps like slips and falls during these crucial passenger movement periods is reduced. Helpers and the driver should communicate well, particularly when it's safe to move forward or when people are still getting on or off the bus.

Helpers must be informed of the situation and given clear instructions on how to assist passengers in safety exiting the vehicle by bus drivers through efficient communication. Bus drivers must let helpers know about any difficulties arising from traffic or road conditions. For example, information on unplanned roadblocks or transit problems should be shared as soon as possible.

The driver and helper's language skills also affect how well they communicate. It is essential that they have a uniform method of delivering vital safety instructions even if they speak different

languages. To ensure their cooperation in maintaining passenger safety, drivers and assistance should also have the appropriate training in communication methods and emergency protocols.

In conclusion, bus safety depends on the cooperation and communication of helpers and drivers. Passengers are more likely to have safe and secure travels when these responsibilities are properly incorporated. In order to prevent accidents, manage difficulties, and improve overall bus safety, it is important to have clear communication, an awareness of duties, and appropriate training.

Driver and helper wellbeing:

Drivers and helpers who are physically fit and well-rested are better able to focus and remain attentive while doing their jobs. This is essential for safe bus operation, particularly when managing unexpected situations and congested traffic.

Tight deadlines and difficult passengers are two workplace pressures that affect both drivers and helpers. effective stress management is essential In order to avoid stress-related distractions and to guarantee a composed reaction in case of emergency.

Drivers and helpers can guarantee passenger safety by having the confidence and abilities that come from proper training. They are better able to manage challenging circumstances, adhere to safety protocols, and react to emergencies when they feel competent in their professions.

In order to lessen stress and exhaustion and ultimately improve the wellness of drivers and assistants, it is crucial to have a balanced work-life routine. Having employees who are happy and well-rested are less likely to make mistakes or jeopardize safety. But in case of developing countries drivers are involved in accidents due to many other illegal practices. This situation is partly due to the high level of psychosocial work hazards to which professional drivers are exposed (Amoadu et al., 2023).

It's critical to identify and treat mental health concerns. Frequent mental health examinations and the availability of support services can aid in the detection and treatment of stress, anxiety, and other mental health issues that may compromise worker safety and performance.

In summary, bus safety and the welfare of bus drivers and attendants are eternally connected. Their capacity to offer dependable and safe transportation services is influenced by a number of factors,

including their work-life balance, training, physical and emotional well-being, stress management, and mental health assistance. Putting these vital employees' health first is a crucial part of a complete bus safety strategy.

Incident reporting and analysis:

Bus safety depends heavily on the reporting and investigation of incidents. Reports of accidents or collisions offer crucial information for comprehending safety-related concerns. In order to identify the underlying reasons of the incidents, this data is evaluated.

Incident reporting promotes a culture of accountability by holding people and organizations responsible for their safety violations in addition to identifying the reasons. This responsibility serves as an obstacle for risky behavior.

In addition, the information gathered from event reporting and analysis is priceless for improving safety protocols. It provides guidance for the creation of stronger safety procedures, training curricula, and technology breakthroughs that will increase bus safety for all users. Based on the accident reports, analyzing the causes of accident, excavating the deep reasons and analyzing risk propagation paths and mechanisms of the accidents are helpful to improve the safety of urban bus operation, and conductive to prevent and control similar accidents happen again (Huang et al., 2021).

To put it briefly, incident reporting and analysis are crucial elements in the continuous battle to raise bus safety. They support our efforts to comprehend previous errors, resolve current issues, and develop a more secure and safe transportation system going forward.

Security Measures:

A variety of techniques are included in security measures for bus safety with the goal of protecting staff and passengers while discouraging illegal conduct and minimizing accidents. Installing surveillance cameras on buses, providing thorough training for drivers on security-related protocols, and utilizing emergency communication systems to immediately report occurrences are all important precautions.

2.7 Road Safety:

Traffic Rules and Regulations:

Road traffic accidents (RTAs) are increasingly being recognized as one of the greatest public health issues, incurring heavy losses of human resources along with severe socioeconomic costs worldwide. Everyday, thousands of people are killed and injured on roads across the world. The World Health Organization (WHO) estimated that over 1.25 million deaths and 50 million injuries occur worldwide due to road crashes each year. Statistics anticipate RTAs to be the third among fifteen more often causes of death by 2020 (World Health Organization, 2015). Studies performed worldwide have shown that developing countries represent 67% of world RTA fatalities although they own only 11% of the vehicle fleet (A. A. Galal, 2010). Traffic rules and guidelines act as the core values that control the way of behaving of drivers, people on foot, and all street clients. They give an organized structure that guarantees the smooth progression of traffic, limits blockage, and decreases the probability of mishaps. Through the foundation of speed limits, option to proceed conventions, and traffic light frameworks, these principles establish a normalized climate that advances consistency and deliberateness on the streets. Besides, traffic rules and guidelines contribute essentially to the development of a culture of liability and mindfulness among street clients. By ingraining the significance of sticking to somewhere safe and secure conventions, they advance a feeling of responsibility, empowering people to focus on the prosperity of themselves as well as other people. Ever since the motor vehicle became a common means for transportation, road traffic has been regulated by a network of rules and regulations. Many rules are necessary for the mobility of traffic but, especially after the Second World War, there has been a growing number of rules implemented to improve traffic safety. Today, there are few areas of human activity that are as regulated by legal restrictions as the traffic system (Åberg, 1998). It has been estimated (Evans, 1991) that world-wide more than half a million people are killed each year in traffic accidents. In more than 90% of these accidents unsafe behavior of the road users is a sole or contributory factor (Rumar, 1985) The enforcement of traffic rules and regulations significantly improves road safety. Speed limits help reduce reckless driving and the likelihood of collisions, ensuring drivers understand safe speeds for different road conditions. Safety equipment rules, like seat belts and helmets, minimize injury severity during accidents, acting as a vital defense mechanism. Additionally, strict regulations against driving under the influence deter impaired

driving incidents, safeguarding both drivers and pedestrians from the dangers of impaired judgment and coordination. Rebellion from specific gatherings of the populace, lacking foundation, and deficient policing block the effective execution of these guidelines. To handle these difficulties, legislatures need to focus on interests in foundation advancement, improve public mindfulness crusades, and force stricter punishments for the people who disrupt the guidelines. Besides, the utilization of trend setting innovations, for example, traffic reconnaissance frameworks and shrewd traffic the executive's apparatuses can fundamentally reinforce the authorization capacities of specialists.

Infrastructure and Road Design:

Road infrastructure fills in as the central system for transportation, associating networks and working with the development of individuals and products. Beyond its role in enabling efficient travel, well-designed and maintained road infrastructure plays a critical role in ensuring road safety. From the layout of roads to the installation of safety measures, the quality of road infrastructure significantly influences the overall safety of road users. Designing and constructing road infrastructure should give priority to the safety and comfort for road users. Ironically, road infrastructure often becomes the cause of traffic accidents. Road width that is too narrow or doesn't comply with standards, sharp curves, steep downhill and uphill, pavement surface damage, and non-illuminated roads are some of the factors that cause traffic accidents (Pembuain et al., 2019). Findings from several researchers support this hypothesis. It was found that the increased number of horizontal curves per kilometer on rural freeways increase the possibility of an accident (Shankar et al., 1996). In another study in the State of Illinois in the US it was found that an increase in the number of lanes and lane widths was associated with increased fatalities; and an increase in the outside shoulder width was found to be associated with reduced accidents. (Noland & Oh, 2004). Efficient design of road infrastructure significantly influences the safety of motorists, pedestrians, and cyclists. Carefully arranged road designs, which incorporate open paths, visible signs, and committed pedestrian intersections, add to bringing down the possibilities of mishaps and further developing traffic stream. Presenting components like roundabout convergences and traffic islands upholds smoother traffic signal and diminishes the chance of crashes, especially at

intersections. Also, consolidating appropriate street markings, intelligent surfaces, and adequate lighting improves perceivability during both constantly travel, diminishing the chance of mishaps coming from unfortunate perceivability. By giving need to the joining of these plan parts, specialists can lay out a more secure road climate that takes care of the prerequisites of all street clients. The integration of modern technologies within road infrastructure significantly enhances road safety measures. Implementing intelligent transportation systems (ITS) allows for real-time monitoring of traffic conditions and the immediate dissemination of alerts to drivers, enabling them to make informed decisions while on the road. Besides, the fuse of brilliant traffic the board frameworks works with the effective guideline of traffic stream, diminishing clog and the likelihood of mishaps brought about by packed streets. Moreover, the use of cutting-edge cameras and sensors supports checking and distinguishing expected gambles, empowering specialists to answer quickly to any arising security concerns. By embracing these innovative headways, legislatures can proactively reduce potential well-being dangers and guarantee a safer and dependable road network for all clients.

Public Awareness and Education:

Among the various causes of accidents, the human factor is the dominant one in the MVE system (man/vehicle/environment): a human behavioral factor is observed in 90% of crashes, an environment factor in 30% and a vehicle factor in 10% (International Transport Forum, 2008). Road safety education (RSE) is one of the main strategies of traffic safety, one of the “four E’s”: education, enforcement, engineering, emergency systems. Public awareness and education about road safety should be provided to everyone specially childrens. The world is moving towards sustainable mobility and it results in increasing use of cycle. Children riding cycle should be made aware of traffic rules. Childrens who walk to school should be made aware of how to use sidewalk or crossings. Awareness should be created among pedestrians and drivers alike. Proper education should be given on drunk driving, driving without seatbelts and safety at bus stops and use of freight or heavy vehicles. The role of public awareness and education emerges as a crucial element in contributing to responsible behavior and fostering a culture of safety on the roads. By pursuing a comprehensive understanding of road safety principles and best practices, individuals can make informed decisions that play a part to the prevention of accidents and the protection of lives. Public awareness campaigns can be an incentive to reduce road crashes and fatalities. Through assigned

informing and local area commitment programs, mindfulness crusades impart a feeling of shared liability, empowering people to focus on their welfare and that of others. Extensive road safety training assumes a significant part in sustaining dependable road conduct among all sections of society. By incorporating road safety instruction into school educational plans and driver training programs, people are outfitted with the important information and abilities to certainly explore different road circumstances. Teaching people about the dangers related with disabled driving, the significance of submitting to traffic lights, and the meaning of respecting pedestrian cultivates an aggregate comprehension of the basic rules that support road safety. Supporting the effect of public mindfulness and training endeavors requires constant commitment and support of road safety standards. By cultivating continuous exchanges, sessions, and intuitive meetings, networks can elevate an enduring obligation to road safety rehearses. Empowering the reception of safe propensities through remunerations and acknowledgment programs further builds up certain way of behaving, cultivating a culture where road security is viewed as an aggregate liability.

Location and Design of Bus Stops:

The location and design of bus stops play a significant role in maintaining road safety, principally in urban areas where bus is the primary means of public transportation. Rightly planned and strategically placed bus stops contribute to the overall safety of pedestrians, passengers, and other road users. Bus stops are associated with increased traffic risks (Cheung et al., 2008). One factor that can influence collision risk near bus stops is bus stop design. Many features can be varied when designing bus stops, but one feature thought to influence the risk of nearby traffic collisions in Norway is whether the stop is curbside or layby stop (Fearnley and Krogstad, 2017). Some considerations must be taken before designing a bus stop like: Traffic flow and visibility, pedestrian safety, shelter and conveniences, accessibility, proximity to intersections etc. Collisions in bus stop depends on many factors like frequency of buses stopping, number of driving lanes, number of pedestrians, cyclists or passengers using or passing the bus stop, cycle lane or path and position relative to bus stop, pedestrian crossing nearby (with or without signals), number of bus stops along the stretch of road, pavements or pedestrian islands, lamp posts or surrounding lighting conditions, season, weather and driving conditions, location relative to junctions and side roads, road curvature and sighting possibilities and the number of parked cars (Goh et al., 2014; Phillips et al., 2019). The location of proper area and smart plan of bus stops are fundamental components

in advancing road safety. By focusing on elements, for example, traffic stream, pedestrian security, ease of access, and joining with more extensive metropolitan preparation, specialists can make a more secure and more proficient public transportation framework that benefits both the travelers and other road users.

Lighting and Signage configurations:

Road traffic signs and signals play a vital role in establishing road safety by bestowing essential information, guidance, and instructions to drivers, pedestrians, and other road users. These signs and signals are crucial for regulating traffic flow, reducing accidents, and promoting a standardized system that fosters predictability and orderliness on the roads. A deficit of traffic lights and road signs can effect the traffic stream significantly by increasing the number of crashes. Specially in developing and low income countries as the road infrastructure there is not so advanced. In Hungary for instance, traffic signs are used to eliminate three chosen black spots with high fatal accident rates on the highways. Similarly, traffic signs helped to reduce RTAs by 41% in United Kingdom (International Road Federation, 2006). Irrespective of the role of traffic signs in promoting road safety, they are habitually neglected in most developing countries (Ezeibe et al., 2019). But its important is not only restricted to developing countries only. It is advised to be followed internationally. The Vienna Convention, officially called the Convention on Traffic Signs and Signals, is a multilateral treaty aimed at increasing road safety and standardizing international road traffic, which is still the basis for regulations in most countries, especially European ones. The convention unified colors, shapes, and basic dimensions of road signs and defined the use of symbols instead of words to make the signs more understandable to people from different countries, and cultural and linguistic origins, and to illiterate people. (United Nations Convention on Road Traffic, 1968). Traffic signs can regulate traffic flow, provide warning and cautions, guide and direct drivers, ensure pedestrian safety, enforce speed limit and enhance visibility. By following all these signs the probability of an accident can be significantly reduced.

2.8 Vulnerable populations and local bus safety:

Women, children, senior citizens, and the disabled:

When it comes to ensuring that local buses are safe, some of the most vulnerable groups include women, children, elderly people, and people with disabilities. Safe transportation rules and diligent security measures are necessary since women are frequently the targets of harassment and violence, especially when traveling alone or late at night. Due to their innate response and inadequate understanding of bus safety procedures, children require extra care to avoid mishaps and guarantee their well-being during traveling. The elderly require accessible boarding facilities, sufficient seating, and safe railings to maintain their stability and prevent falls because they frequently struggle with mobility challenges and poor health. It is essential to establish extensive safety measures and customized services to provide an inclusive and secure environment for local buses, taking into account the specific requirements of these vulnerable groups.

Personal safety and security preferences and perception

The standard of bus operation services has a significant impact on people's choices regarding public transportation as their preferred form of transportation in the city. Passengers used to be satisfied with the location of the service, the availability of routes, and basic services. Today's transit consumers, however, have higher expectations of bus companies, wanting things like low-floor buses, courteous and safe drivers, quick and dependable service, and a shorter walking distance to stations. In response to these expectations, bus operators hope to grow both their clientele and their profile. Several characteristics, including service coverage, frequency, hours, and dependability, can be used to describe bus quality services.

According to (Rahman, n.d.), regarding the scenario of Dhaka city, there are two types of bus services: local bus service and counter bus service. Tickets are sold at the counters at the designated stoppages for the counter bus service. Therefore, right before boarding such a bus, passengers must acquire their tickets from the bus counters. Only a very small percentage of counter buses have air

conditioning. On the other hand, the local bus service does not have a designated stopping; passengers can board and leave at any point along the route, and upon boarding, they pay the bus conductor the fare. A small number of buses are referred to as sitting services, and they only pick up passengers from designated stops; nonetheless, tickets are purchased on the bus

There is evidence that passengers prioritize bus service quality in terms of dependability, safety, communication, comfort, and cleanliness (Rohani et al., 2013).

In the context of local bus safety, vulnerable groups' requirements and views of personal safety and security are crucial. Special consideration and precautions are frequently required to ensure the well-being of vulnerable groups, such as the elderly, children, and people with disabilities when they are in transit. As a result, they may place a higher priority on clear signs, sufficient lighting, and conveniently accessible seating to maximize their safety. Furthermore, the availability of emergency buttons or intercom systems for prompt assistance, as well as the presence of helpful and hospitable staff, may have an impact on their impression of security. Comprehending and attending to the distinct concerns and requirements of these susceptible groups may considerably augment their perception of safety throughout local bus travel, cultivating a more comprehensive and safe public transportation network.

Programs and initiatives to improve local bus safety

According to (Sen, 2016), regular bus users for business trips rank travel time, safety, and frequency as the three most crucial indications of bus service.

According to the scenario of developing countries, among passengers traveling with children, women are particularly reluctant to use the bus. Picking up and dropping off people is not an issue for conductors or drivers. Accidents happen while a passenger is being dropped off or picked up. Bus drivers do not stop the vehicle entirely while picking up a passenger. To save time or cut down on delays, they pull over in the middle of the road. Even more dangerously, anyone may board a bus at any time because the door is always open.

The imperative need to improve local bus safety, especially for vulnerable people, has been acknowledged by governments and transportation organizations. A variety of initiatives and programs have been put into place to address this challenge. One major initiative is the

employment of accessible buses, which are outfitted with ramps and areas reserved for riders with mobility impairments, guaranteeing their safe boarding and alighting. Furthermore, safety campaigns and educational initiatives have been put in place to increase passenger knowledge of safe bus riding behaviors, particularly among vulnerable populations including children, the elderly, and individuals with disabilities. In addition, enhanced security measures at bus stops and aboard buses have resulted from cooperation with local law enforcement authorities. These procedures are intended to avert incidents and immediately address any safety problems. It is a challenge for developing countries to allocate separate lanes for public transport, non-motorized transport, bicycle lanes, and informal roads and also safeguard the dignity and security of women, children, and elderly people (Jain, 2013).

Safer stops for vulnerable customers

One of the primary methods used to prioritize the safety and well-being of vulnerable communities in the local bus network is to make sure that vulnerable customers have safer stops. Transit authorities may greatly increase the safety of the elderly, the disabled, and other vulnerable populations by putting in place strategic measures including marked signs, readily accessible bus stops, and seating arrangements. Understanding the traffic signal is essential for the enforcement of traffic regulations for citizens and necessary for their road safety (Ahmed et al., 2022).

Furthermore, the integration of covered waiting spaces that are outfitted with emergency buttons and monitoring systems may increase a sense of security and comfort, especially in high-crime or late-night locations. Including community involvement programs and providing bus drivers with specialized training on managing a range of passenger requirements will help to further establish a safe and welcoming atmosphere for everyone using public transportation.

At-stop control measures in public transport

In public transportation, at-stop control procedures are essential for guaranteeing the accessibility and safety of local bus services, especially for vulnerable groups. These protocols comprise a variety of tactics designed to improve safety and enable passengers to board and exit buses with ease. Implementing features like wheelchair ramps, priority seating, and clear signs may greatly enhance the entire travel experience for vulnerable populations, such as the elderly, the disabled,

or those with restricted mobility. Furthermore, the presence of qualified personnel at bus stops may provide help and direction, promoting a more welcoming and encouraging atmosphere.

2.9 Risk Factors:

Distraction

Distraction has a substantial negative influence on bus drivers' performance and could compromise road safety. Regan et al. (2011) defined driver-diverted attention (i.e., driver distraction) as “the diversion of attention away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving” (p. 1776)

Driving activities may be impaired by a driver's distraction from tasks essential to safe driving in favor of competing pursuits (Regan & Oviedo-Trespalacios, 2022).

The bus driver's primary source of distraction is typically activities involving passengers (D’Souza and Maheshwari 2012).

One of the many variables affecting bus drivers is distraction, which can come from both internal and external sources. Unruly passengers, heavy traffic, bad weather, and other external variables can cause a driver to lose focus on the road and make it more difficult for them to respond quickly to rapid changes. A driver's tendencies to engage in distracting activities, their ability to perform multiple tasks, and their capacity for accountability to maintain appropriate safety margins when distracted are some of the characteristics of the driver that may moderate the impact of distraction on activities essential for safe driving (Young et al. 2009, p. 340).

The age, gender, amount of driving experience, and psychological traits of the driver—such as their predisposition to take chances and give in to peer pressure—as well as their familiarity with and practice with the competing task are among these criteria (Huth and Brusque 2014; Oviedo-Trespalacios et al. 2020b).

Several different factors have been linked to driver distraction, including the driver's requirements, their mental state, the distraction's source, internal (to the mind) inputs, and the driver's personality

traits. According to Trick and Enns (2009) and Lee et al. (2020), for example, these processes can be generally categorized as either top-down (voluntary; endogenous) or bottom-up (involuntary; exogenous) mechanisms. A diversion of attention may be caused by several driving states, such as emotionality (e.g., affective state; Chan and Singhal 2013), social anxiety (e.g., FOMO; Atchley and Warden 2012), boredom, drowsiness, or exhaustion (e.g., Atchley and Chan 2011). The urge to converse with others is one of the driver's demands that might cause an attention divert (Oviedo-Trespalacios et al. 2020a). Distractions like these have the potential to impair a driver's response time, spatial awareness, and general attentiveness, which might endanger the well-being of other road users and passengers.

Environment and working conditions

Bus drivers' performance is significantly affected by their working environment and circumstances, which also affects their general well-being and productivity. An environment that is conducive to working and prioritizes safety measures, such as well-kept roads, adequate lighting, and visible signs, increases driver alertness and lowers the risk of accidents. Furthermore, stressful circumstances brought on by factors like bad weather, excessive traffic, and noise pollution may cause bus drivers to get tired and lose focus. The mental and physical wellness of bus drivers is greatly dependent on the availability of sufficient restrooms and amenities as well as regulations that enable regular breaks and a good work-life balance.

The conduct of bus drivers has been well-researched in several areas. These include their mental and physical well-being, their involvement in accidents, their driving abilities, and the amount of fuel used by the bus.

The state of the roads and traffic, the upkeep of the job position about its configuration, and the gradual requirement for attention and proper posture—which strains the shoulder, neck, and back muscles—all contribute to the medical service's grounds of medical leaves for musculoskeletal issues. The most common causes of absences associated with musculoskeletal diseases (RSI/WMSD) are as follows: discomfort in the neck, back, spine, bursitis, carpal tunnel syndrome, and knees brought on by obesity, and manual transmission manipulation (Alperovitch-Najenson et al., 2010; Anderson, 1992; Okunribido et al., 2007; Szeto & Lam, 2007).

The bus driver's physical and mental well-being have been examined as important variables that can affect how well the organization performs. Several issues that have been brought up in the literature include worker turnover, staff absences, and accidents. Furthermore, the bus driver's poor driving skills are always the cause of his physical and psychological ailments (Rohani et al., n.d.).

Skill of Driver and helper

When taking into account the several aspects that affect a bus driver's performance, the skill set of the driver and their helper is crucial. These individuals are essential to maintaining the effectiveness and safety of the bus ride. Crucial to passenger safety is the driver's competence with vehicle control, observance of traffic laws, and capacity for maneuvering through difficult road conditions. In addition to helping passengers and collecting fees, the helper has to be a skilled communicator and provide excellent customer service to guarantee a seamless boarding and disembarking experience. The cooperation of the driver and helper is crucial for controlling the number of passengers, adhering to the timetable, and responding to unforeseen circumstances while driving.

Passenger load

Bus drivers experience greater difficulties pushing through traffic and navigating narrow roads when their buses are crowded with passengers, particularly during rush hours or in heavily populated regions. Controlling a large number of passengers requires increased concentration and awareness since quick stops and twists can become more difficult and even dangerous. Additionally, when the number of passengers rises, the weight of the vehicle increases as well, influencing the dynamics of handling and braking, necessitating that driver modify their driving style. Furthermore, it becomes even more important to guarantee the comfort and safety of passengers, requiring drivers to find a careful balance between adhering to schedules on time and providing passengers with a secure and pleasant ride.

Time efficiency

Bus drivers have to balance their time well amid a variety of situations. First and foremost, it's critical to stick to a strict timetable while accounting for any delays brought on by bad weather, heavy traffic, or unplanned road closures. Second, time utilization may be greatly maximized by

using effective boarding and disembarking processes in addition to prompt and secure passage through scheduled stops. Furthermore, the driver must be able to swiftly address any passenger concerns or crises without compromising the timeliness of the journey. In addition, modern technology innovations like communication systems and real-time GPS navigation are essential for guaranteeing punctual departures and arrivals. All things considered, preserving time efficiency necessitates a harmonic interaction between adept navigation, proficient communication, and flexibility in the face of unanticipated events, which eventually improves the overall effectiveness and reliability of the bus service.

Route complexity

The complexity of a bus route, which is influenced by variables like the number of stops, the state of the roads, congestion, and the existence of challenging junctions, can put a significant strain on a driver's abilities and judgment. It takes a great deal of focus and attention to maneuver through crowded metropolitan regions with numerous stops and turns. Drivers must be more adept at managing their time, being aware of their surroundings, and being flexible when driving a complicated route. A simple, well-planned route can help make bus operations safer and more effective, lessening the mental and physical strain on drivers and ultimately improving passenger satisfaction as well as security. Therefore, while taking into account the elements impacting the performance of a bus driver, assessing and optimizing route complexity is essential.

Local regulations

The various factors that influence the complex dynamics influencing a bus driver's performance are greatly influenced by the local laws. These guidelines include a wide range of issues, such as following defined routes, adhering to speed restrictions, and following particular safety procedures. Local laws also frequently contain requirements for minimum rest intervals and acceptable working hours, which are intended to reduce the dangers of driver weariness and enhance general road safety. Additionally, to guarantee that bus drivers stay up to date on the most recent developments in operational best practices and road safety, these laws usually highlight the need for continuing education and certification standards.

Chapter 3: Data Collection

3.1 Study Area

The mechanical data of drivers' psychomotor actions, audio data of conductors commands, and video data recording the presence of competing vehicles and level of traffic congestion were collected from two local buses on two different routes in Dhaka city. The routes and buses were selected arbitrarily to ensure unbiased perception and to enhance the study results.

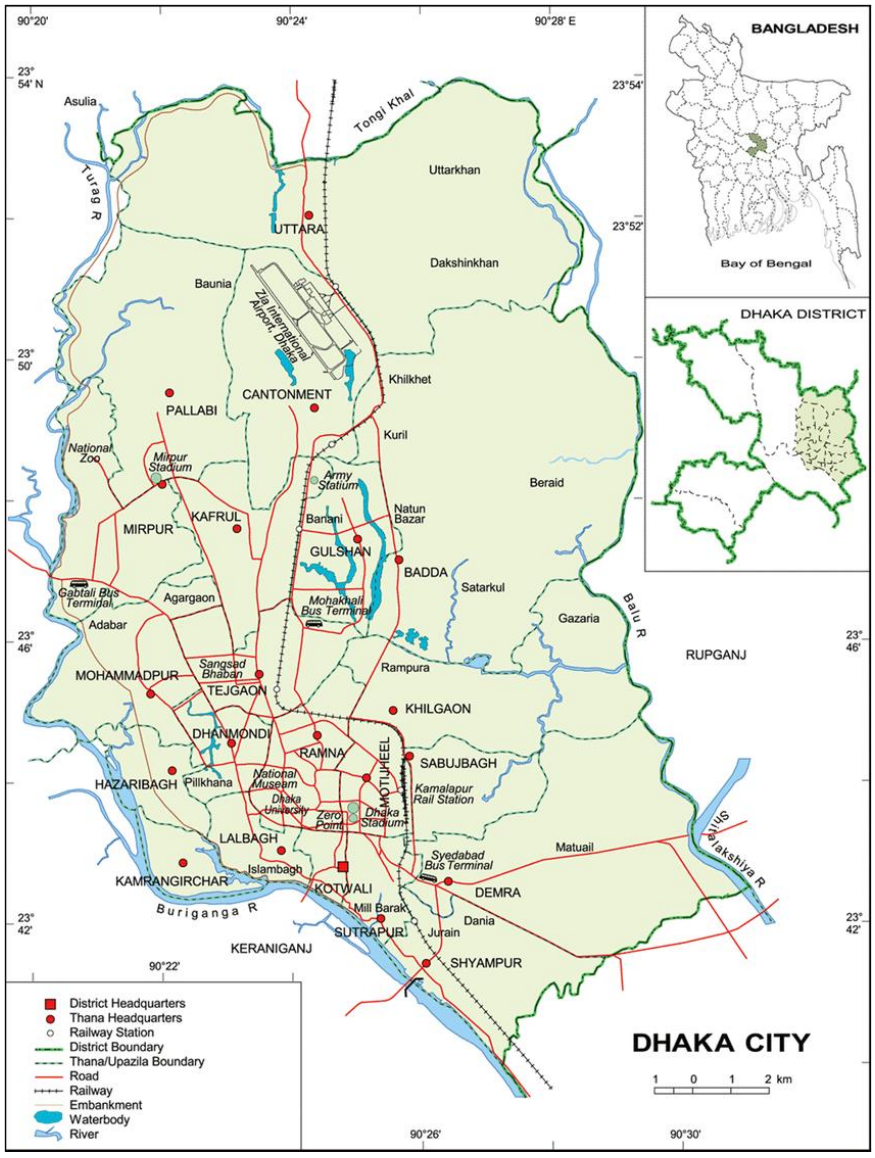

Figure 1 Study Area: Dhaka City

3.2 Data Collection:

Psychomotor Actions:

To record drivers' psychomotor actions “MATLAB Mobile” application was used. Using this application, we recorded the bus acceleration in X, Y, and Z axes respectively. The Azimuth, Pitch, and Roll data were collected to record buses' lateral movements. Latitude and Longitude coordinates were used to track the location of the bus and its speed.

Conductors Command:

A microphone was used to record the vocal command given by the helper to guide the driver. Furthermore, an action camera was employed to record the helper’s indirect command. For instance: tapping twice on the bus to move, tapping once to stop, indirect hand gestures.

Traffic Condition:

To assess the existing traffic condition, level of vehicles on the road, visibility of competing buses and to see if they were competing against each other we used an action camera with a wide-angle view and placed it at the front of the bus.

Table 1: Taxonomy of Data Variables

Name	**Attributes**	**Units**	**How will it be measured?**
Acceleration	Acceleration reading in X, Y, and Z coordinates	m/s^2 (meters per second squared)	We will take the vector component between the X and Y axis. If the magnitude increases it is Acceleration. If it

			decreases then deceleration.
Orientation	Position reading in X, Y, and Z coordinates	in degrees, for azimuth, pitch, and roll	1.Azimuth will indicate whether the vehicle is turning left or right. 2. Pitch represents whether a vehicle is climbing a slope or going down a slope.
Longitude	Position data is obtained from GPS, Wi-Fi®, or the cellular network, using whichever is available	in degrees relative to the zero meridian, with positive values extending east of the meridian	Software (MATLAB Mobile)
Latitude	Position data is obtained from GPS, Wi-Fi®, or the cellular network, using whichever is available	in degrees relative to the equator, with positive values indicating latitudes north of the equator	Software (MATLAB Mobile)

Speed	Position data is obtained from GPS, Wi-Fi®, or the cellular network, using whichever is available	m/s (meters per second)	Software (MATLAB Mobile)
Course	Position data is obtained from GPS, Wi-Fi®, or the cellular network, using whichever is available	in degrees relative to true north	Software (MATLAB Mobile)
Horizontal Accuracy	Position data is obtained from GPS, Wi-Fi®, or the cellular network, using whichever is available	Horizontal Accuracy in meters defined by a circle around the latitude and longitude	Software (MATLAB Mobile)
Conductors Command	Verbal command or hand gestures by hitting the vehicle		The audio captured via the mobile device.
Passengers Request	Verbal command		The audio captured via the mobile device.

3.3 Data Processing:

In this study, relevant variables were derived from the audio, video and mechanical data and the data were classified into several distinct categories. The categories were used to understand the accordance between the conductor's command and the driver's action. The audio, video and mechanical data were then synchronized according to the timestamps to identify the precise moment when the command was issued and to determine whether the driver complied with the command or not. Environmental and Traffic Conditions along with the type of command were also noted to understand the exact circumstances in which they tend to follow the command and the conditions when they refuse to comply. Consequently, models were developed to gain a deeper understanding of the relationships among all the variables and to identify the variable most significant in influencing drivers compliance with the conductor's commands. The variables and their degrees are represented in the figure below:

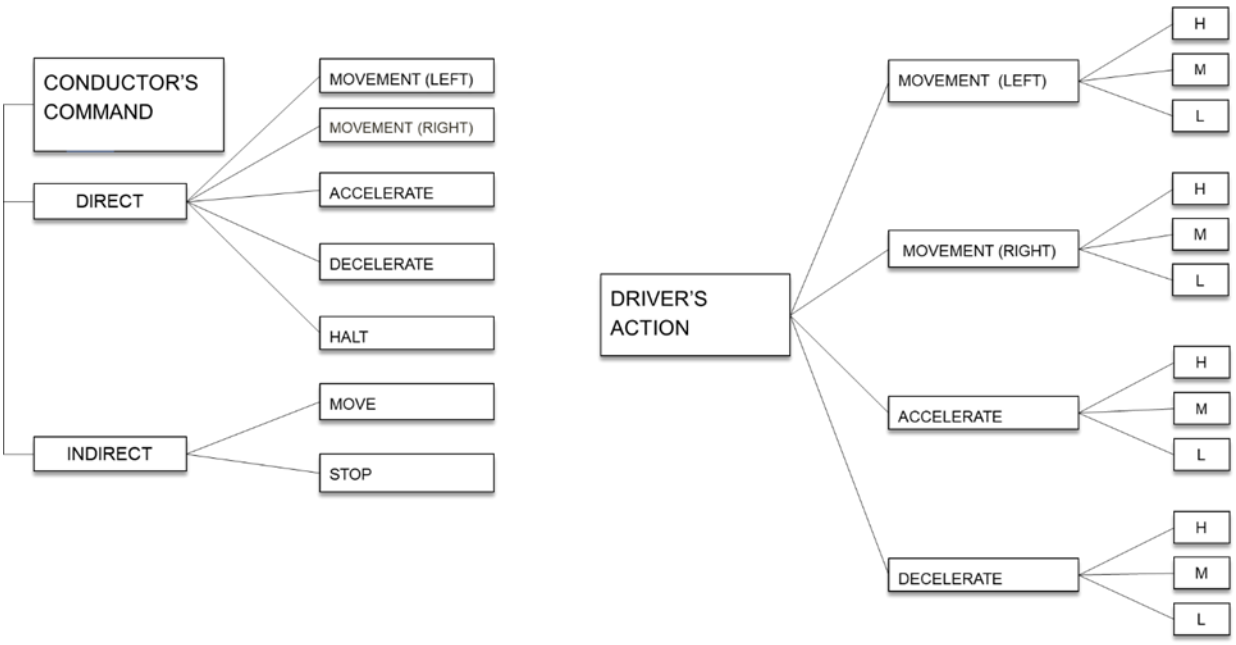

Figure 2 Data Variables

C 4: Methodology

4.1 Introduction

This chapter refers to the systematic plan and methodological approach used for the study including the selection of methods and techniques for data collection, analysis and interpretation of the research and how the research is evaluated to ensure reliable and valid results. The purpose of the study is to investigate how conductors influence the decisions and action patterns of bus drivers in the context of local buses in Dhaka city. Previous literature demonstrated that these variables are often mutually independent and impacted via previous beliefs (Ma et al., 2020). Hence, Bayesian analysis using PC algorithms has been conducted to portray the quantitative aspects of behavior pattern.

4.2 Work flow of the Research

The workflow diagram of the research is demonstrated below:

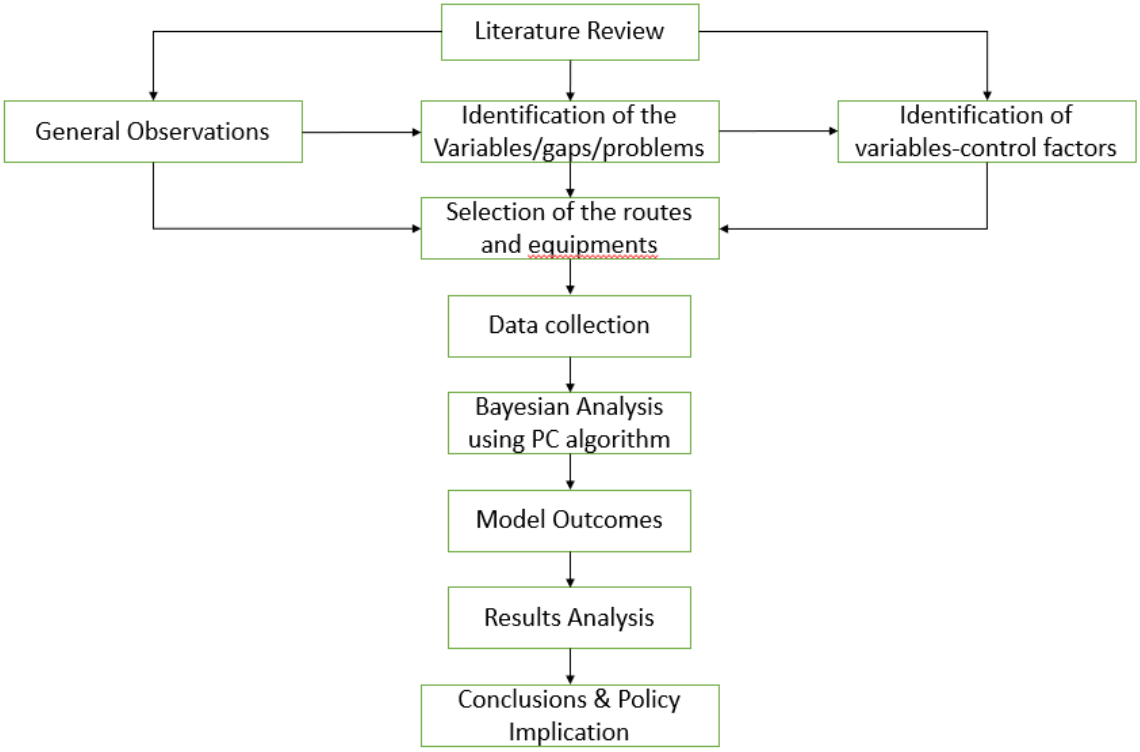

Figure 3 Workflow Diagram

Initially literature was reviewed to understand the key findings of the previous literatures. Two distinct bus routes were randomly selected for observations to gather data on public transport behavior. The study captured the commands given by the conductor both direct and indirect and the driver's psychomotor actions parallel to situational variables such as time of day, competing transportation modes, traffic congestion and passenger crowding. Then Bayesian Analysis employing PC algorithm was conducted to analyze the quantitative aspects of behavior pattern.

4.3 PC Algorithm

PC is a prototypical constraint-based algorithm for learning Bayesian networks. The PC algorithm uses conditional independence tests to identify the Bayesian network's skeleton, analyzing complex relationships. The complexity of the problem, which involves the interaction of drivers' behavior, helpers' actions, and bus service quality, makes the PC algorithm an ideal choice. Its robust and flexible framework enables it to effectively handle mixed-type data, which is a hallmark of this study with both quantitative and qualitative measures of bus service quality.

The algorithm's ability to accommodate missing values is also a significant advantage when working with real-world datasets. Ultimately, the primary goal of the study is to identify the critical factors that influence the satisfaction of bus users in Dhaka city, and the PC algorithm can provide a comprehensive understanding of the relationships between the variables, including the influence of helpers on drivers. It orients edges to form Directed Acyclic Graphs, revealing variable relationships in driver behavior models. Using PC, the relationship between the conductor and drivers action was found as well as the dependency of a specific parameter on the influence of the conductor’s behavior on the driver’s actions.

Additionally, it can help pinpoint the most important factors that contribute to overall user satisfaction.

Comparison of Other Methods

In addition to the PC algorithm, other techniques like Bayesian networks (BN) and structural equation models (SEM) can be employed for this issue. However, the PC algorithm presents several advantages that make it the optimal choice:

1. Robustness: The PC algorithm exhibits greater resilience in handling missing and noisy data than other algorithms. This is particularly important in this study, as the data may contain gaps or be noisy due to various factors.

2. Flexibility: The PC algorithm is highly adaptable and can be used with both continuous and categorical data. This adaptability is essential in this study, as the data encompasses both types of variables.

3. Interpretability: The PC algorithm generates interpretable results, which is vital in this study since the objective is to pinpoint the crucial factors that affect the satisfaction of bus users. The algorithm can help identify the most important factors and their relationships, making it easier to comprehend the underlying mechanisms.

In summary, the PC algorithm is an appropriate choice for examining the influence of helpers on local bus drivers in Dhaka city. Its robustness, flexibility, and interpretability make it a suitable tool for managing intricate data and identifying the critical factors that contribute to understand the behavioral dependency of the bus drivers on the conducters. The decision to choose the PC algorithm over other methods is justified based on the complexity of the problem, the nature of the data, and the desired outcome.

4.4 GeNIe Workspace

GeNIe workspace is an advanced software designed for data exploration and manipulation. The software is used for cases like Data Analysis, Machine Learning, Data Engineering and Business Intelligence.

GeNIe 4.1 academic version was used for this research to format the network and decision analysis.

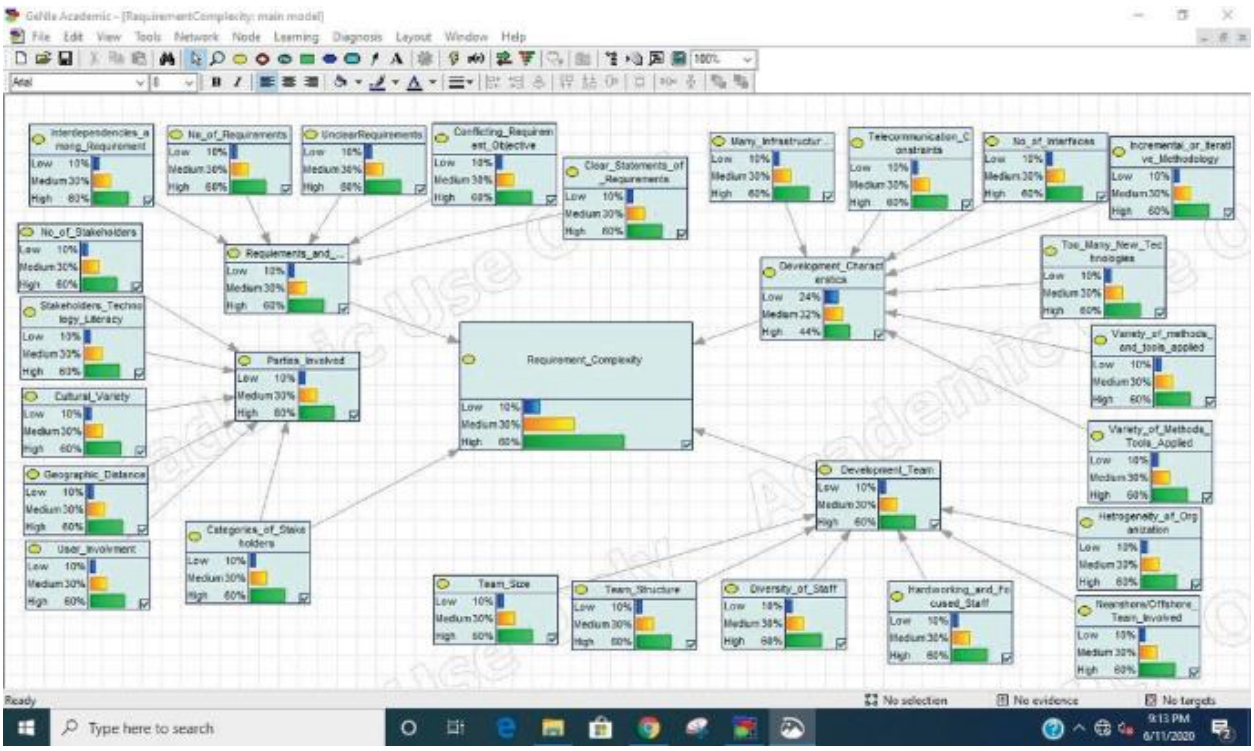

Figure 4 GeNIe Workspace

4.5 Model Development

Initially the model was developed with Bayesian search in GeNIe 4.1 academic version with a significance level of 0.01 but the results were not accurate enough. Environmental and traffic condition, Conductor and Driver's action parameters was put as Independent variables and the variable 'Accordance' was dependent on the other variables. So, after several trial and errors the model gave the best solution using PC algorithm. The final model is demonstrated below:

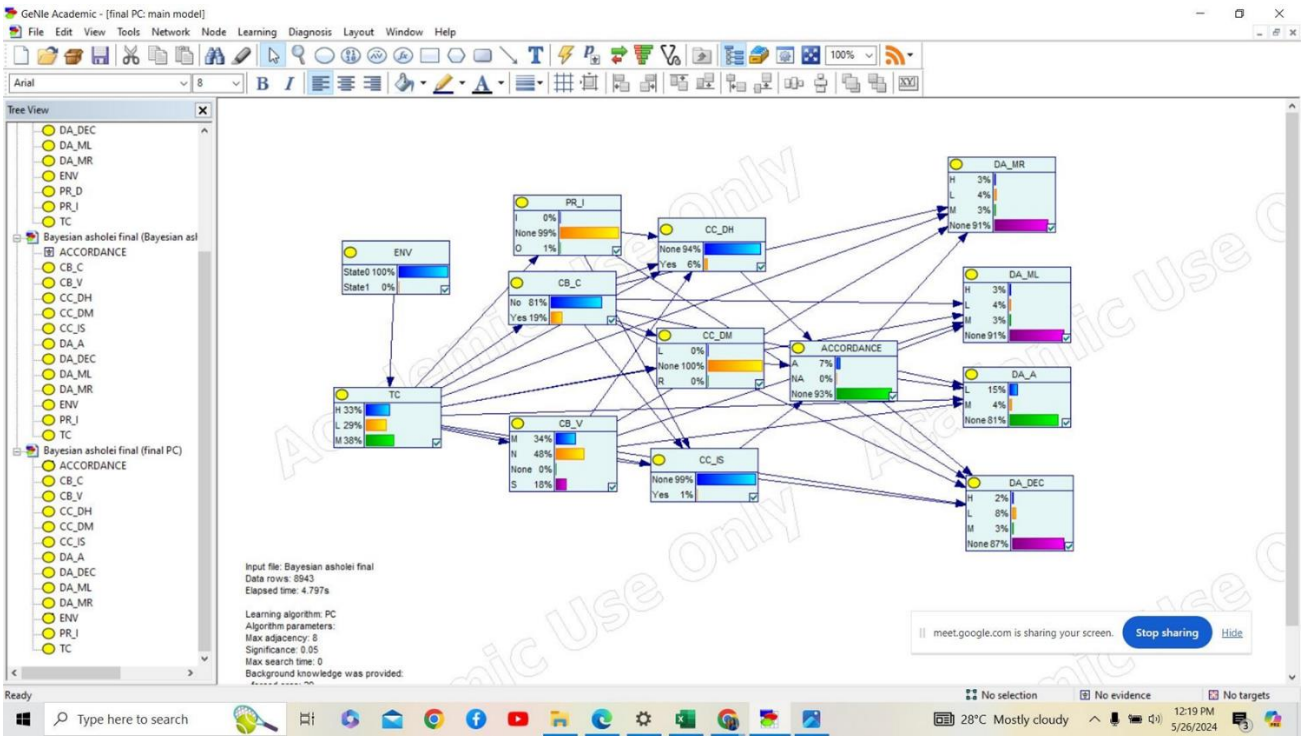

Figure 5 Final Network

4.6 Model validation

Model validation was conducted using the GeNIe tool, implementing the Leave-One-Out (LOO) method. The evaluation result is presented using a Receiver Operating Characteristic (ROC) curve, which plots the true positive rates against the false positive rates. The diagonal line on the ROC curve indicates a prediction of 50% accuracy. The area under the ROC curve(AUC) ranges from 0 to 1, where a value of 1.0 indicates perfect discrimation without any errors. The AUC represents the model accuracy where values closer to 1.0 indicates higher accuracy of the model. In practical application, an AUC above 0.7 is considered acceptable for model evaluation. The AUC value of the target variable ‘Accordance’ is 0.847016 which is greater than 0.7 and closer to 1.0 indicating a good model validation.

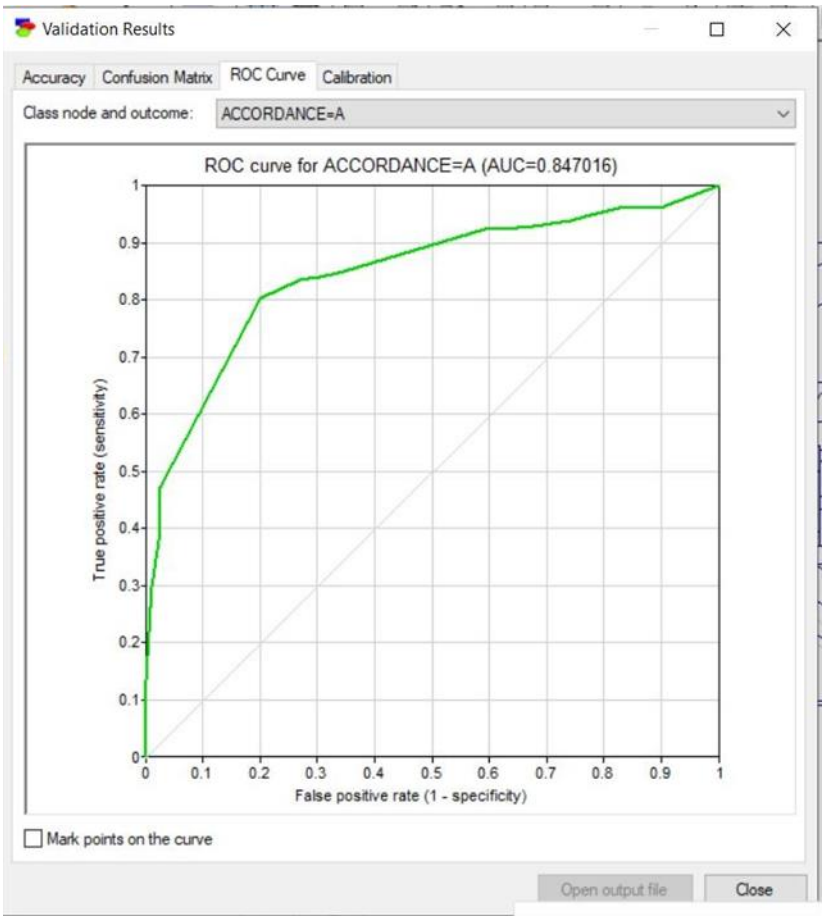

Figure 6 ROC Curve for Accordance

The confusion matrix visualizes the model performance. Confusion matrix for the target variable is demonstrated below:

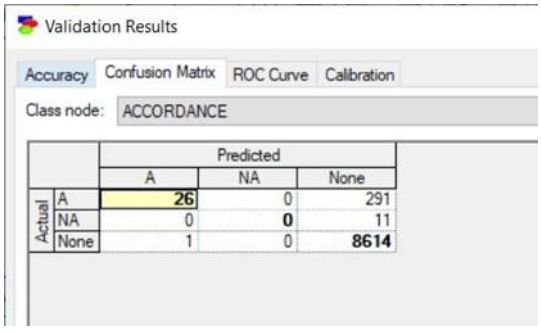

Figure 7 Confusion Matrix for Accordance

Chapter 5: Result and Analysis

5.1 Introduction:

The results of our study, which were carefully obtained by applying the PC (Peter-Clark) algorithm to the examination of survey data, are presented in this chapter. After being collected through extensive surveys, the data was subjected to a stringent categorization and restructuring procedure to guarantee its relevance and clarity for the analysis that followed. To simplify the data structure, several variables were combined for the following categories: "Passenger's request direct," "Passenger's request indirect," and "Conductor's comments on direct movement."

Actions including "Movement Left," "Movement Right," "Acceleration," and "Deceleration" about driving behaviors were carefully categorized into three groups: high, medium, and low compliance levels. The intricate interaction of driver actions was made simpler by this categorization, which also made it easier to conduct a more direct study using the PC algorithm.

The first PC structure was built using the reorganized and categorized data as the primary source. Our investigation relied heavily on the PC method, which is well-known for its capacity to identify appropriate correlations in observational data. By using it, we aimed to identify the complex interactions between different factors and how they affected the target variables. Throughout this process, several analyses and assessments were conducted to improve our comprehension of the consequences of the factors.

Sensitivity analysis and tornado diagram creation were essential parts of our approach. Sensitivity analysis gave us insights into which factors had the most effects by enabling us to determine how changes in the input parameters influenced the results.

Especially useful for showing these effects and allowing a clear assessment of the relative influence of various factors were the tornado diagrams.

Using the built-in model validation tools in GeNIe, we validated the model to make sure our findings were valid and resilient. We validated our PC algorithm model using a rigorous framework supplied by the well-known program for probabilistic graphical models, GeNIe. This was a critical step in ensuring that our model correctly captured the underlying data and could consistently forecast results depending on the input variables.

Following this thorough study, the results were intensively gathered and presented in a tabular manner. The results were succinctly summarized by this tabulation, which also made it easier to understand how the data should be interpreted.

We want to give a thorough summary of the study findings in this chapter, showing how the PC algorithm's application and further analysis have produced insightful findings. Our results are solid and dependable because of the organized data display, thorough validation, and sensitive analysis.

Data Reclassification and Restructuring:

We started by reorganizing and classifying the survey data as part of our analytical procedure. To handle the raw data's complexity and make sure the PC program could use it, this was required. Particularly complicated variables, sometimes comprising numerous overlapping variables, were those about conductor remarks and passenger demands. We were able to reduce the data and make it easier to handle and analyze by combining these factors into consolidated categories.

The broad categories "Passenger's request direct" and "Passenger's request indirect," for example, caught the core of several variables without sacrificing important specifics. Likewise, conductor remarks, which sometimes encompassed many dimensions, were reorganized to conform to a logical structure. This categorization was necessary to improve the data's clarity and reduce noise, which increased the accuracy of the study that followed.

Classification of Driver Actions:

Three levels of agreement were identified for driver actions, including "Movement Left," "Movement Right," "Acceleration," and "Deceleration": high, medium, and low. To ensure that the categorization correctly reflected the activities of drivers, it was based on expert feedback and observed behaviors. The results were easier to read and the analysis was made simpler by classifying the data into compliance levels.

To guarantee accuracy and consistency, each driver action category was thoroughly specified. A "high" accordance level for acceleration, for instance, would represent a notable increase in speed in response to particular circumstances, whereas a "low" accordance level might represent little or no acceleration. We were able to simplify and concentrate on the most important facets of driver behavior by classifying these behaviors.

Classification of Conductor Commands

According to our investigation, comprehending the general dynamics among passengers, conductors, and drivers required a comprehension of the conductors' directives. We categorized the conductors' orders according to their type and purpose to properly examine these exchanges. The data has to be categorized for the analysis to be more understandable and simpler.

Application of the PC Algorithm:

We used the PC method to find the appropriate links in the data after reclassifying the data and categorizing the driver activities. This kind of study is especially well suited for the PC method as it can handle complicated, high-dimensional data and uncover underlying causal patterns. We want to clarify how different factors affected the target variables by applying them.

Sensitivity analysis was essential to our study as it let us assess how reliable our conclusions were. We were able to determine which factors had the most effects on the outcomes by methodically changing the input parameters and tracking the changes in the outputs. The tornado diagrams gave these effects a visual form and made it evident how one variable affected the others about one another.

A crucial step in guaranteeing the precision and dependability of our conclusions was model validation. We thoroughly validated our model using GeNIe's built-in validation tools to ensure that it could consistently predict results and properly reflect the data. This validation approach was crucial to proving the validity of our findings and guaranteeing that they could be applied with assurance to actual situations

To sum up, this chapter describes the whole procedure we used to apply the PC algorithm to the survey data analysis. Every stage of the process, from data reorganization and classifications to sensitivity analysis, model validation, and the presentation of the last findings, was carefully carried out to guarantee the precision and dependability of our outcomes. The research yielded useful findings that further our knowledge of the intricate interactions among driver actions, conductor remarks, and passenger demands.

5.2 Model Analysis:

Our research model's analysis was conducted using GeNIe, a powerful tool for constructing and analyzing probabilistic graphical models. Our primary objective was to explore the relationships between various variables and their impact on the target variable, "accordance." To achieve this, we employed GeNIe's default Expectation-Maximization (EM) algorithm for parameter learning and model construction.

The analysis was carried out in two stages. The first stage involved using the EM algorithm to estimate the marginal probabilities of nodes in our probabilistic graphical model. This algorithm is well-suited for dealing with incomplete data, making it ideal for our survey data that contained missing values. By alternating between the expectation (E) step and the maximization (M) step, the algorithm estimated the marginal probabilities of nodes in our probabilistic graphical model(Arnaud Nguembang Fadja and Fabrizio Riguzzi).

The structure created by GeNIe effectively represented these marginal probabilities, providing a visual and quantitative understanding of the relationships between variables. This structure served as the foundation for our subsequent analyses, enabling us to examine the influence of various factors on the target variable, "accordance."

The second part of our analysis focused on the impact of other variables on "accordance." "Accordance" refers to the degree to which driver actions align with the conductors' commands, categorized into high, medium, and low levels. By setting "accordance" as the target variable, we aimed to identify which factors most significantly influenced whether driver actions were in accordance or not.

The third step of our analysis involved examining the conditions under which "accordance" and "not in accordance" occurred at a rate of 100%. This process enabled us to investigate the impact of other variables under these extreme circumstances, which provided deeper insights into the factors that promote or impede accordance.

Analysis of Accordance (A) Condition:

When we set "accordance" to 100%, we were able to explore situations where driver actions were fully aligned with anticipated behaviors. In this context, we analyzed the role of other variables in achieving this perfect alignment. For instance, we assessed the influence of direct conductor commands, specific passenger indirect requests, and other contextual elements such as time of day or traffic conditions.

This analysis revealed that conductors' direct commands had a substantial positive impact on driver accordance. Drivers were more likely to comply and align their actions when conductors provided clear and direct instructions on movement and even indirect commands on stops. Additionally, the analysis demonstrated that certain types of passenger requests, particularly those that were indirect and ambiguous, also contributed to increased levels of accordance.

Analysis of Not in Accordance (NA) Condition

Alternatively, setting "not in accordance" to 100% allowed us to investigate scenarios where driver actions differed from expected behaviors. This process helped us identify the factors that contributed to non-compliance or misalignment. Similar to the previous analysis, we examined the influence of various commands, requests, and contextual factors.

This analysis revealed that a lack of direct conductor commands and ambiguous passenger requests were significant contributors to not-in-accordance scenarios. When conductors did not provide clear instructions or when passenger requests were unclear, drivers were more likely to deviate from expected behaviors.

The study's results revealed that the indirect commands given by conductors to stop and direct commands concerning movements from conductors are instrumental in achieving non-concordance. Moreover, the analysis indicated that ambiguous or indirect passenger requests also play a significant role in non-concordance levels.

The two-step analysis conducted in GeNIe provided a comprehensive understanding of the factors affecting driver concordance. By utilizing the EM algorithm to determine the parameters and build the model structure, we were able to systematically examine the impact of various variables on the target variable. The conditional analyses conducted under "concordance" and "not in accordance" conditions yielded valuable insights into the specific factors that drive or hinder compliance.

Overall, the model analysis highlighted the crucial role of clear and direct communication from conductors and passengers in ensuring that driver actions align with expectations. These findings emphasize the importance of explicit instructions and unambiguous requests in promoting safe and efficient transportation operations. The insights gained from this analysis can inform future strategies for enhancing driver compliance and overall system performance.

5.3 Marginal Probabilities of All Nodes for Evidence of Target Variable Set from 100% Accordance (A) to 100 % Not in accordance (NA)

Table 2: Marginal Probabilities of All Nodes for Evidence of Target Variable Set from 100% Accordance (A) to 100 % Not in accordance (NA)

Variable	Variable Attribute	Evidence (%)		Difference in (%)
		A(100%)	NA(100%)	A and NA
Environment	S_25C Light rain	11	10	1
	S_27C Passing Clouds	0	0	0
	S_27C Passing Clouds	3	3	0
	S_31C Clear Sky	87	87	0
TC	High	65	70	-5
	Medium	15	17	-2
	Low	20	13	7
CB_C	YES	68	46	22
	NO	32	54	-22
PR_I	I	3	6	-3
	NONE	92	88	4
	O	5	6	-1
CB_V	M	16	40	-24
	N	75	40	35
	NONE	0	0	0
	S	9	20	-11
CC_DM	L	2	29	-27
	NONE	98	65	33
	R	0	6	-6
CC_DH	NONE	28	72	-44
	YES	72	28	44
CC_IS	NONE	93	79	14
	YES	7	21	-14
DA_A	L	31	32	-1
	M	23	26	-3
	NONE	46	42	4
DA_ML	H	17	19	-2
	L	18	19	-1
	M	17	19	-2
	NONE	48	42	6
DA_MR	H	17	19	-2
	L	17	21	-4
	M	17	19	-2
	NONE	49	40	9
DA_DEC	H	18	20	-2
	L	20	20	0
	M	18	20	-2
	NONE	44	39	5

5.4 Analysis for Accordance:

When the accordance between the driver's action and the conductor's command was set to 100%, We found the significant following results for the variables as mentioned earlier:

- **TC (Traffic Conditions)**

  When there was 100% accordance between the driver's action and the conductor's command, the traffic conditions were observed to be 65% heavy traffic, 15% medium traffic, and 20% low traffic. This indicates that perfect alignment between the driver and conductor's actions occurred predominantly in heavy traffic conditions, with less frequent occurrences in medium and low traffic conditions.

- **CB_C (Competing Vehicles, Competing)**

  When the accordance between the driver's action and the conductor's command was set to 100%, competing vehicles were present 68% of the time and absent 32% of the time. This indicates that the presence of competing vehicles was significantly more common in scenarios where the driver followed the conductor's commands. The high presence of competing vehicles suggests that perfect accordance may be more critical in environments with higher traffic density.

- **PR_I (Passenger's Request, Indirect)**

  Generally, passenger requests did not show a significant difference in the data we collected. When the accordance between the driver's action and the conductor's command was set to 100%, passengers indirectly requested to move in 3% of the time and to move out 5% of the time. This means that perfect alignment between the driver's actions and the conductor's commands had little impact on the frequency of passengers' requests to move in or out of the bus, suggesting that such requests are relatively independent of driver-conductor coordination.

- **CB_V (Competing PT Info/Behavior, Visible)**

  When the accordance between the driver's action and the conductor's command was set to 100%, multiple competing vehicles were visible 16% of the time, a single competing vehicle was visible 9% of the time, and no competing vehicles were visible 75% of the time. This indicates that in scenarios of perfect coordination, the absence of competing

vehicles was the most common situation, suggesting that optimal driver-conductor alignment might be more frequently achieved in less congested traffic conditions.

- **CC_DH (Conductor's Command, Direct, Halt)**

  When the accordance between the driver's action and the conductor's command was set to 100%, in all events where the conductor directly commanded to make a halt, the driver complied 72% of the time. This indicates that the driver mostly followed the command to halt, though there were instances (28% of the time) where the driver did not halt as instructed, suggesting the influence of other factors.

- **CC_IS (Conductor's Command, Indirect, Stop)**

  When the accordance between the driver's action and the conductor's command was set to 100%, the conductor indirectly commanded a stop (such as by banging the bus door or using other gestures) 7% of the time. This indicates that in 7% of all instances where the conductor signals for the bus to stop, these commands are made through indirect methods.

- **DA_A (Driver's Action, Accelerate)**

  When the accordance between the driver's action and the conductor's command was set to 100%, the results showed that in all events where the conductor commanded to accelerate, the driver responded with low acceleration 31% of the time and medium acceleration 23% of the time. This indicates that despite the command to accelerate, the driver's response varied in intensity, with a low acceleration occurring more frequently than a medium acceleration.

- **DA_ML (Driver's Action, Move Left)**

  When the accordance between the driver's action and the conductor's command was set to 100%, in all events where the conductor commanded the driver to move left, the driver responded with a sharp left turn 17% of the time, a medium left turn 17% of the time, and a low left turn 18% of the time. This indicates that while the driver complies with the command to move left, the degree of the turn varies.

- **DA_MR (Driver's Action, Move Right)**

  When the accordance between the driver's action and the conductor's command was set to 100%, in all events where the conductor commanded the driver to move right, the driver

responded with a sharp right turn 17% of the time, a medium right turn 17% of the time, and a low right turn 17% of the time. This indicates that similar to left turns, the driver consistently complies with the command to move right. However, unlike left turns where low turns were slightly more frequent, in right turns, all degrees of turn occur with equal frequency (17% each)

- **DA_DEC (Driver's Action, Decelerate)**

  When the accordance between the driver's action and the conductor's command was set to 100%, in all events where the conductor commanded the driver to decelerate, the driver responded with a sharp halt 18% of the time, a medium deceleration 18% of the time, and a slow deceleration 20% of the time. This suggests that while the driver consistently complies with the command to decelerate, the intensity of the deceleration varies.

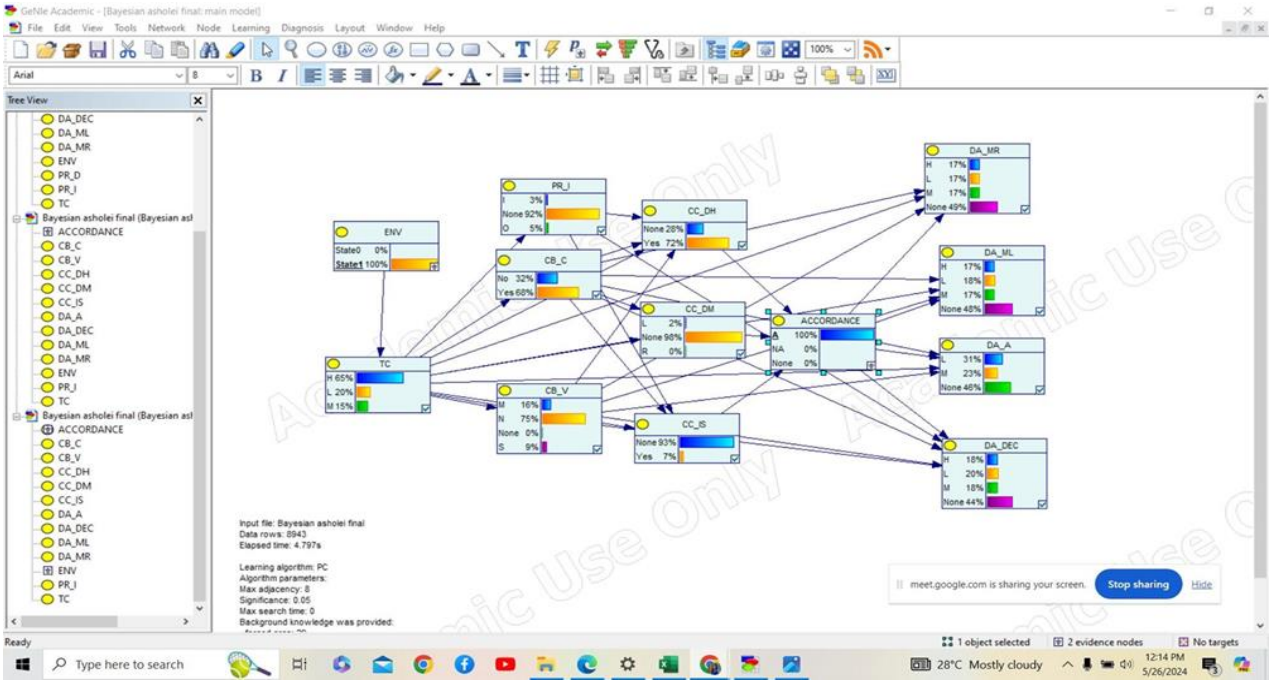

Figure 8 Marginal Probabilities of All Nodes for Evidence of Target Variable Set from 100% Accordance (A)

5.5 Analysis for In-accordance:

When the "Not in accordance" between the driver's action and the conductor's command was set to 100%, We found the significant following results for the variables as mentioned earlier:

- **Traffic Conditions (TC)**

  In instances of 100% non-accordance, heavy traffic conditions were observed 70% of the time. This indicates that misalignment between the driver and conductor is more likely to occur during periods of significant traffic congestion. Medium traffic conditions were recorded 17% of the time, suggesting that non-accordance is less prevalent in moderate traffic than heavy traffic. Low traffic conditions were noted 13% of the time, showing that misalignment was least likely to occur when traffic was light.

- **Competing Vehicles (CB_C)**

  The incidence of competing vehicles notably decreased in non-accordance scenarios, being present 46% of the time, compared to 68% during accordance. This implies that the absence of competing vehicles may lessen the need for precise alignment between the driver and conductor. Conversely, the absence of competing vehicles was noted 54% of the time, indicating that non-accordance was more frequent in situations with fewer competing vehicles on the road.

- **Passenger's Request Indirect (PR_I)**

  There was a slight increase in indirect passenger requests in non-accordance scenarios. Indirect requests to move in occurred 6% of the time, compared to 3% in accordance with scenarios. Similarly, indirect requests to move out increased to 6% from 5%. This suggests that passenger requests might be marginally more frequent in non-accordance situations, though the overall impact remains minimal.

- **Competing PT Info/Behavior Visible (CB_V)**

  The visibility of competing vehicles' information or behavior exhibited significant changes. Multiple competing vehicles were visible 40% of the time in non-accordance scenarios, up from 16% during accordance. A single competing vehicle was visible 20% of the time, an increase from 9% by scenarios. The absence of competing vehicles dropped to 40% in non-accordance scenarios from 75% during accordance, indicating that non-accordance is more prevalent in environments where competing vehicles are visible.

- **Conductor's Command Direct Halt (CC_DH)**

In non-accordance scenarios, the driver complied with direct halt commands from the conductor only 28% of the time, a substantial decrease from 72% compliance during accordance. This suggests that non-accordance significantly affects the driver's response to direct halt commands, with other factors likely influencing the decision not to halt.

- **Conductor’s Command Indirect Stop (CC_IS)**

  Indirect stop commands from the conductor were more frequent in non-accordance scenarios, occurring 21% of the time, compared to 7% during accordance. This indicates that indirect methods of commanding a stop are more common when there is a lack of alignment between the driver and conductor.

- **Driver’s Action Accelerate (DA_A)**

  The driver's response to acceleration commands showed minimal variation in non-accordance scenarios. Low acceleration occurred 32% of the time, and medium acceleration occurred 26% of the time, both slightly higher than the rates during accordance. This suggests that the driver's response to acceleration commands remains relatively consistent regardless of accordance.

- **Driver’s Action Move Left (DA_ML)**

  When commanded to move left, the driver's response in non-accordance scenarios exhibited slight variations. Sharp left turns occurred 19% of the time, medium left turns 19%, and low left turns 21%. This distribution shows a minor increase in the intensity of turns compared to accordance scenarios, where low left turns were slightly more frequent.

- **Driver’s Action Move Right (DA_MR)**

  Similarly, the driver's response to commands to move right in non-accordance scenarios showed minor variations. Sharp right turns, medium right turns, and low right turns each occurred 19% of the time. This equal distribution suggests that the degree of the right turn is consistently balanced in non-accordance situations, slightly more frequent than during accordance.

- **Driver’s Action Decelerate (DA_DEC)**

  When commanded to decelerate, the driver’s responses in non-accordance scenarios included sharp halts 20% of the time, medium decelerations 20%, and slow decelerations 20%. This consistency in the deceleration response indicates that non-accordance does not significantly impact the intensity of the deceleration.

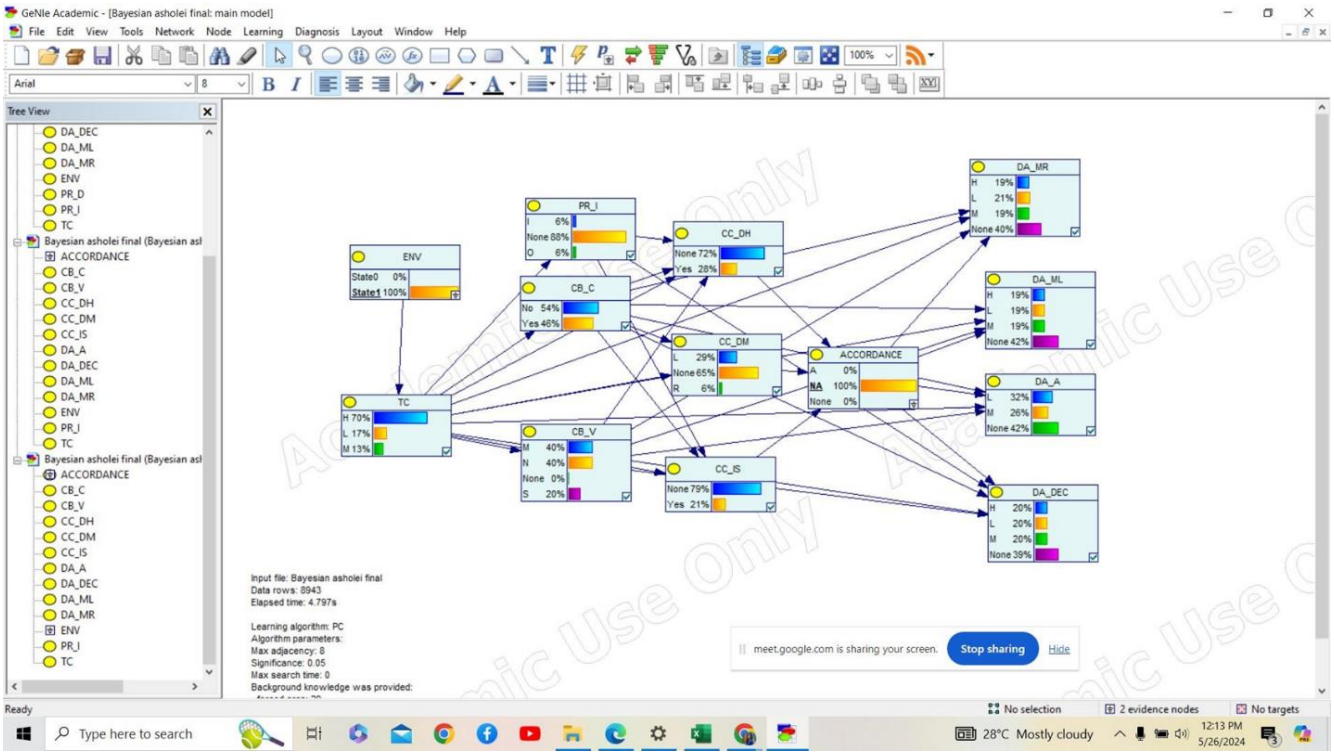

Figure 9 Marginal Probabilities of All Nodes for Evidence of Target Variable Set from 100% Not In Accordance (NA)

5.6 Sensitivity Analysis:

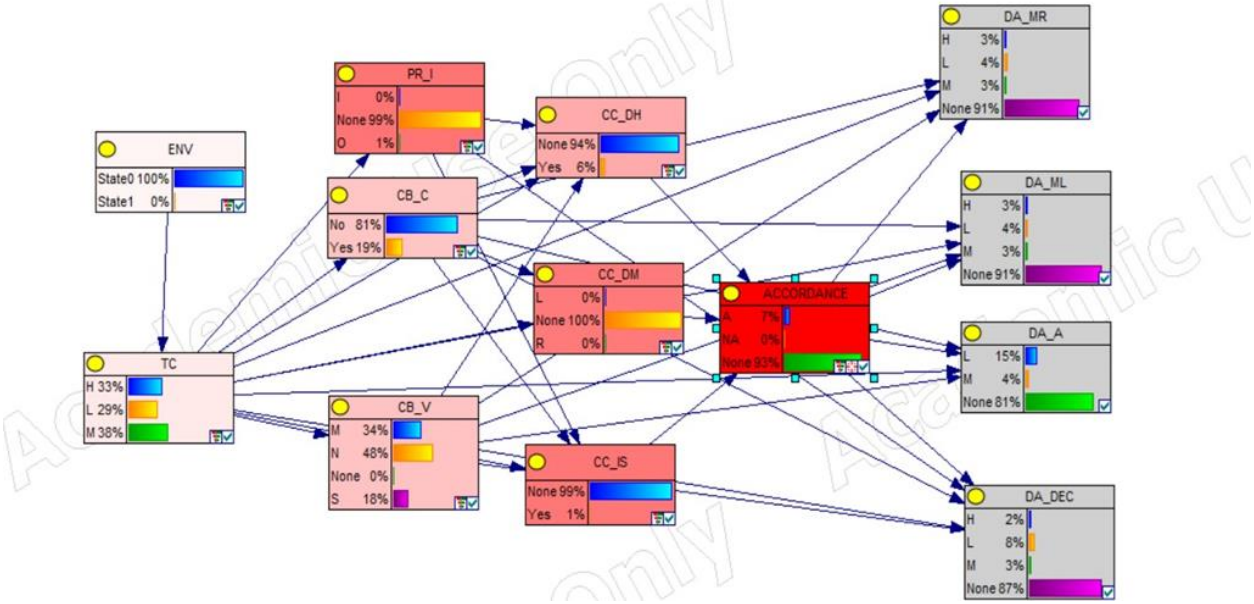

Figure 10 Sensitivity Analysis

The model underwent sensitivity analysis to determine the most influential variables. GeNIe visually represents the varying impacts of the variables, with those in dark red being the most significant. The impact of the variables diminishes as the intensity of the red color decreases, with white indicating very little impact and grey signifying zero impact on the target variables.

Passengers' Indirect request (PR-I), and the Conductor's Command on Indirect Stop and Direct Movement (CC_IS, CC_DM) are the most sensitive parameters as they are dark red.

The Conductor's Command on Direct Halt (CC_DH), Competing PT Info/Behavior (Competing)(CB_C) and Competing PT Info/Behavior (Visible) (CB_V) can be considered as the second important parameters based on color depth.

The third important parameter is Traffic Conditions (TC) and the least sensitive parameter is Environmental Conditions (EC).

The grey color parameters (Driver's Actions) have zero effect on the target parameter Accordance.

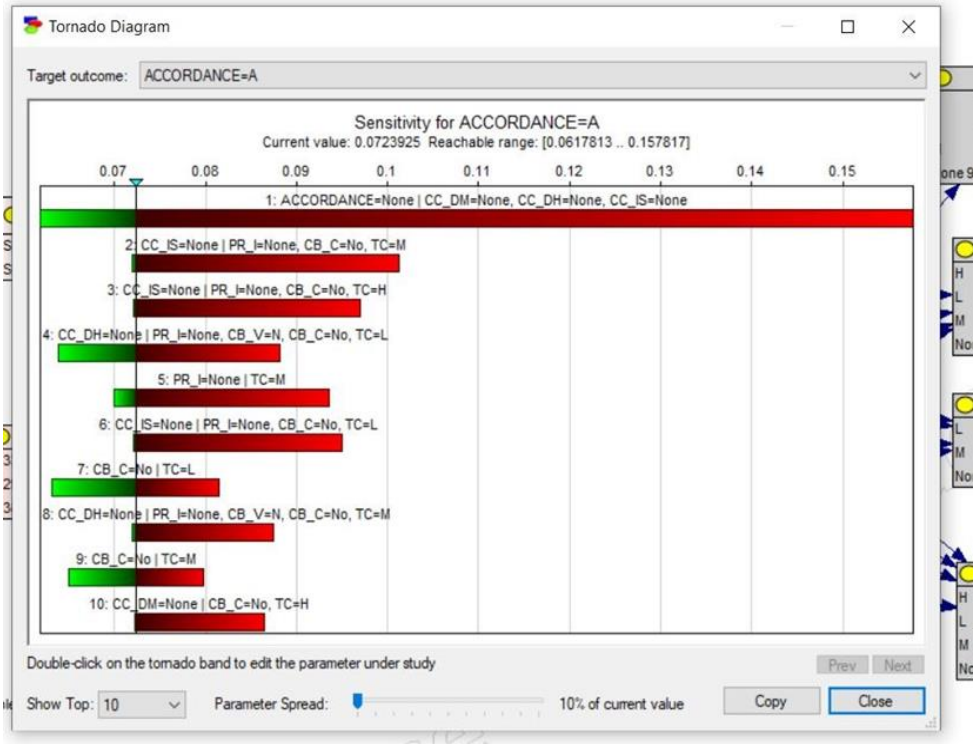

Figure 11 Tornado Diagram for Accordance = A

The tornado diagram in GeNIe under sensitivity analysis identifies the most significant situation of variables for the chosen state of the target parameter. CC_DM = None, CC_DH = None, and CC_IS = None are the most significant in accordance and CC_DM = None, CB_C= No and TC = H are the least significant state for accordance = A

If the tornado diagram shows "none" as the maximum and minimum values in the PC algorithm, instead of other conditions like high, low, or medium, it suggests that the variables do not greatly affect the output. This indicates that the variables have a low correlation with the output and do not make a substantial impact on the outcome.

Here are a few potential outcomes stemming from this observation:

- **Low Sensitivity:** The variables do not react strongly to alterations in the input parameters, resulting in a relatively steady output that is minimally impacted by the variables.
  Insignificant variables do not significantly impact the outcome, regardless of whether they are included or excluded from consideration.
- **Noise or Unnecessary Information:** The variables could contain unwanted or irrelevant data, possibly caused by issues related to data accuracy or the existence of additional factors that do not affect the result.
- **Model Restrictions:** The PC algorithm may fail to represent the true connections between variables and the output, possibly because of constraints in the model or the data.
- **Not enough data:** The data could be inadequate for understanding the connections between the variables and the final result, resulting in the absence of meaningful results.

To conclude, when both the highest and lowest values are "none" in a tornado chart of the PC method, it indicates that the variables are not influencing the result significantly. This may well be caused by reasons like moo affectability, unimportant factors, commotion or unessential information, show imperatives, or a need for adequate information (*GeNIe Modeler USER MANUAL*, 2024).

Chapter 6: Conclusion and Recommendation

6.1 Introduction:

This chapter condenses the key findings of the research. It also incorporates related policy suggestions aligned with the results. The recommended actions will assist policymakers and transportation planners in understanding the role of bus conductors in the public service of Dhaka city. In closing, the study's limitations and potential areas for future research are discussed.

6.2 Key Findings:

In conclusion, this thesis thoroughly investigated the interactions among drivers, conductors, and passengers in public transportation, with a particular focus on the coordination between drivers and conductors. Utilizing the PC algorithm and conducting extensive sensitivity analyses, several important findings were uncovered. Perfect coordination was more commonly observed in heavy traffic conditions (65%) and when there were many competing vehicles (68%), highlighting the need for policies that promote teamwork and collaboration to improve safety and efficiency. In contrast, misalignment between drivers and conductors was more common in heavy traffic situations (70%), indicating that dedicated bus lanes and improved traffic management systems could alleviate these issues. Additionally, there was a greater reliance on indirect stop commands in non-coordination scenarios (21%), suggesting a need for standardized and clearer communication protocols. Better coordination can reduce passenger disruptions, as indirect passenger requests were slightly higher in non-coordination scenarios. Implementing Advanced Driver Assistance Systems (ADAS) can help drivers follow conductors' commands, especially in competitive and high-traffic environments, thus enhancing overall safety and efficiency. Moreover, comprehensive training programs focused on effective communication and situational awareness, along with regular monitoring using technologies like GPS and CCTV, are crucial for maintaining smooth coordination and ensuring policy compliance. These findings directly address the study's objectives of understanding the dynamics among drivers, conductors, and passengers, identifying factors that influence driver-conductor coordination, and proposing recommendations to improve the efficiency and safety of public transportation. The insights and proposed measures align with and meet the study's objectives, providing a solid framework for enhancing coordination and overall efficiency in public transportation systems.

6.3 Recommended Policy Implications:

Policy Implications Based on Findings:

Development of a New Business Model for Bus Drivers and Conductors

Establishing a business model that guarantees minimum wage and facilities for bus drivers and conductors is essential, as perfect coordination between them predominantly occurs in heavy traffic conditions (65%). This approach can reduce the pressure to prioritize profit over safety, encouraging better adherence to conductor commands. Additionally, since competing vehicles are present 68% of the time in accordance with scenarios, it is vital to discourage a competitive mindset that compromises safety. Policies should focus on promoting teamwork and collaboration between drivers and conductors to mitigate the safety risks associated with competition.

Infrastructure Development

To enhance driver-conductor coordination, dedicated bus lanes are necessary, as misalignment is more common in heavy traffic (70% in non-accordance scenarios). These lanes can minimize interference from other vehicles, improving both efficiency and safety. Furthermore, improving road infrastructure with better signage and road markings can assist in navigation and compliance with traffic rules, particularly since perfect coordination is more often achieved in less congested conditions. Proper bus stop design is also crucial, as variations in driver compliance indicate the need for a controlled environment to facilitate better interactions between drivers and conductors.

Traffic Management:

Enhanced Regulation in High-Density Areas: The data indicates that perfect coordination between drivers and conductors predominantly occurs in heavy traffic conditions (65%). This suggests the necessity for stricter traffic regulations and improved traffic management systems in high-density areas to maintain smooth coordination and alleviate congestion by ensuring effective communication and execution of commands in challenging traffic environments.

Public Transportation Efficiency:

Training Programs for Drivers and Conductors: Given that the presence of competing vehicles significantly impacts driver-conductor coordination (68% in high traffic density), it is essential to implement comprehensive training programs for drivers and conductors. These programs should emphasize effective communication, situational awareness, and strategic maneuvering in dense traffic to enhance overall public transportation efficiency.

Safety Measures:

Emphasis on Direct Halt Commands: The data reveals that in scenarios of perfect accordance, drivers comply with direct halt commands from conductors 72% of the time. However, non-accordance significantly reduces this compliance to 28%. Therefore, emphasizing the importance of halting commands in training and implementing automated systems to support halt signals could significantly enhance safety

Communication Improvements:

Standardization of Indirect Stop Commands: The use of indirect stop commands (e.g., banging the bus door or using gestures) is more frequent in non-accordance scenarios (21%) compared to accordance scenarios (7%). This indicates the need to standardize and improve communication methods to reduce reliance on indirect signals, ensuring clearer and more effective instructions between drivers and conductors.

Passenger Interaction:

Minimization of Passenger Disruption: The data shows that perfect alignment has minimal impact on passenger requests to move in or out of the bus, with indirect requests remaining relatively low (3% and 5%, respectively). However, there is a slight increase in non-accordance scenarios. Therefore, ensuring better coordination between drivers and conductors can minimize passenger disruption and enhance overall service quality.

Adaptation to Traffic Conditions:

Flexibility in Response to Traffic Density: In non-accordance scenarios, heavy traffic conditions were observed 70% of the time, indicating that misalignment is more likely during significant congestion. Traffic management policies should provide flexible and adaptive strategies to support driver-conductor coordination even in fluctuating traffic conditions.

Technology Integration:

Advanced Driver Assistance Systems (ADAS) Implementation: Integrating Advanced Driver Assistance Systems (ADAS) can support drivers in adhering to conductors' commands, particularly in high-traffic and competitive environments. These systems can help maintain consistent performance and reduce the risk of non-accordance, thereby enhancing overall safety and efficiency.

Evaluation of Competing Vehicles:

Strategic Route Planning: As the presence of competing vehicles is notably higher in accordance scenarios (68%) than in non-accordance scenarios (46%), strategic planning for routes with high

competition is essential. Policies should focus on optimizing routes to minimize competition and ensure smoother coordination between drivers and conductors.

Policy Enforcement:

Regular monitoring and evaluation using technologies like GPS and CCTV cameras are essential for tracking coordination and ensuring compliance with new policies. This approach addresses the significant impact of traffic conditions and competing.

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Appendix:

Traffic Condition:

Figure 12 Screenshot of Video Data

In the above picture we can see the level of traffic congestion and presence of competing vehicle on road which we later used to interpret our data.

Conductors Action:

Figure 13 Conductors Action

In the above picture we can see how we recorded the conductors action and the direct and indirect command that was given by him to the driver.