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## **COMPARATIVE ANALYSIS OF THE WEIGHT AND QUALITY OF URBAN BUS TRANSPORT SERVICES: A CASE STUDY OF BAKU**

**Summary.** With the growth of the population and the expansion of the territory of large cities, certain difficulties arise in meeting the needs of passengers for transportation. This article studied the satisfaction of users with the city's public transport system, especially the bus transport. Thus, a survey was conducted among passengers in Baku to assess their satisfaction with public transport. The survey covered all districts of Baku in general. The study was conducted in October 2021. The questions were aimed at identifying the weight, reasons for preferring the different types of public transport, the level of satisfaction of the population with these types, assessing the quality of services and the lack of urban bus transport. The level of satisfaction of survey participants with the work of public transport by gender and age groups was determined. Subsequently, this study showed that most of the population movements are carried out by bus transport. The analysis revealed factors that reduce the quality of service on bus routes. In addition, it examined the reasons why the population chose the bus transport, the shortcomings of the bus transport, the effectiveness of dedicated bus lanes, and attitudes toward the use of alternative public transport. Summarily, this study was

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successful in identifying the shortcomings of public transport in the city, improving passenger service to increase passenger satisfaction toward attracting more people to public transport.

**Keywords:** public transport, bus, service quality, alternative transport

## 1. INTRODUCTION

The rapid growth in the number of vehicles in cities creates problems associated with congestion. Traffic jams begin to appear, especially during peak hours. The number of cars in the Azerbaijan Republic has increased by 143,000 vehicles from 2016-2020 [1]. The main reason people prefer private cars is their convenience and accessibility in comparison with public transport [2]. In most cities, alternative and high-quality public transport are used to reduce traffic congestion and the use of private cars [3, 4]. One of the alternative solutions to reduce traffic congestion is to optimize and encourage the use of public transport [5-7].

With the growth of the size and population of the city, there is a need for various types of public transport. Traditional modes of public transport (bus, trolleybus, metro, tram, taxi) used in cities have been recently supplemented with either modified versions of these modes of transport (Metrobus, metro tram, LRT, etc.) or modern modes of transport, such as PRT and maglev. Of course, for each city, these modes of transport can be used considering the historical planning structure, relief, and transport infrastructure [8-10].

The most densely populated territory of the Azerbaijan Republic is the capital city of Baku. The city's population was 2,064,600 in 2010 and 2,300,500 in 2021. Currently, taxis, subways, buses and commuter trains serve passengers in the city. The metro line network includes 26 stations and does not cover all areas of the city. The first metro lines in Baku were put into operation in 1967. Until the end of the 20th century, along with the metro, bus, tram and trolleybus transport operated in Baku. For various objective and subjective reasons, trams were dismantled in Baku, and the operation of trolleybuses was suspended.

In the subsequent period, against the backdrop of the growth of Baku, only the bus network was developed to meet mobility needs, and thus, although the population of Baku exceeds 2 million people, the bus transport still dominates. Currently, Baku has a network of bus routes covering 173 routes. An analysis of the intensity on these routes shows that many bus routes are accompanied by problems at stops [11]. The movement of buses in the general flow of traffic creates serious deviations from the traffic schedule due to traffic jams during peak hours.

In Baku, buses are both the main mode of transport and the auxiliary transport, carrying passengers to the metro. In such a situation, determining the quality of passenger service and passenger satisfaction can be important in making decisions aimed at better meeting the needs of passengers in movement. Determining passenger satisfaction with public transport is useful for enhancing the attractiveness of public transport.

The low quality of public transport services leads to an increase in the number of owners of personal vehicles among the population, which translates to traffic jams and accidents and environmental pollution [12, 13]. Therefore, it is important and necessary to take measures to improve the quality and efficiency of the services and encourage the use of public transport. Based on this, we can say that the study of passenger satisfaction with public transport services is a very topical issue.

## 2. LITERATURE REVIEW

Different methods are used in different works to assess the quality of public transport services and identify the factors that mostly affect the quality of service.

In the work of Zhang et al., passenger satisfaction with public transport was assessed using a combination of the entropy weight method (EWM), analytic hierarchy process (AHP) and the fuzzy comprehensive evaluation (FCE) method. Passenger comfort, transfer convenience, waiting time, information, station environment, interior sanitation, information, and service were chosen as the main criteria. The level of passenger satisfaction from the services of traditional bus routes and railway transport was determined [14].

The method proposed by Paulo Siga Thomas et al. for assessing the level of satisfaction of the population with public transport services on routes passing through university campuses is based on fuzzy logic. To assess passengers' satisfaction, questionnaires were developed to determine the impact of comfort, parking/terminal, vehicle performance, and driver skill [15]. The study found that satisfaction levels can be increased through comfort and mutual relationship with passengers. Particularly, these factors directly affect the comfort of riding on the vehicle.

According to the results of a survey conducted in Lisbon to determine the user experience of traveling by public transport and their satisfaction with the transport system, passenger satisfaction indices were determined using fuzzy clustering and a regression tree [16]. The average level of satisfaction on a ten-point scale of satisfaction was 6.12.

Weng et al. divided scores into 6 systems (timeliness, safety, convenience, comfort, reliability, and economy) when surveying to examine attitudes toward bus use in Beijing [17].

In the work of Karzan and Szabolcs, three hypotheses about the quality of service that affect the level of passenger satisfaction were considered, and it was concluded that the factors mostly influencing satisfaction are safety, accessibility and quality of service [18]. Two PLS models (evaluative and structural) and their principles are given. Service quality indicators were evaluated based on the obtained statistical indicators.

In a study conducted in the city of Johor Bahru (Malaysia), based on a survey of 225 respondents, attributes such as reliability, bus travel, bus performance, simplicity and accessibility, driver-passenger relationship, information and usability were grouped and analyzed. The importance of these parameters for passengers is determined [19].

In Kota Kinabalu (Malaysia), a survey was conducted in selected areas of the city, especially at bus stops, buses, shopping malls, and public and private institutions, to determine passengers' satisfaction with the quality of service of the bus route. For the analysis of 24 parameters identified during the study that affect the quality of service, descriptive statistics were used, covering mean and standard deviations, as well as factor analysis [20].

The work of Jan Chocholac et al. revealed that the results of surveys among different groups of respondents differ in their perception of various factors of service quality. Accessibility, information, availability, customer care, and comfort were taken as factors of service quality. Studies have shown that different age groups perceive comfort and service differently [21].

In addition, many other authors have used factor analysis based on individual indicators to assess the level of passengers' satisfaction with public transport [22-24]. Reliability, responsibility, safety, physical capabilities, environment, distance to stop, and travel time were taken as the main factors in these works.

One of the indicators of passengers' service on bus routes is the travel time; this indicator is influenced by various parameters. It should be noted that the level of influence of these parameters on the travel time varies [25].

Risdiyanto et al. used the analytical hierarchical process (AHP) method to assess passengers' satisfaction with public transport [26]. The main criteria were waiting time, travel time, transport costs, comfort and safety.

### 3. METHODOLOGY

A survey was conducted in Baku to determine the level of public satisfaction with public transport services. The survey covered all districts of Baku (13 districts). Using tablets and mobile phones, questionnaires were used to conduct the survey. Students and graduates of the Azerbaijan Technical University took part in the survey. In the survey conducted among 506 respondents, 40 questions were included in the questionnaires.

The purpose of using the survey method is to identify the main dissatisfaction of passengers regarding the transportation service.

The questions were divided into 3 parts related to passenger comfort level, time loss and safety. The main difficulties passengers face when using public transport were identified, the main features that they prefer in public transport and measures to solve problems are proposed.

### 4. ANALYSIS OF THE USE OF PUBLIC TRANSPORT

The respondents were divided into 5 age groups (18-25, 26-35, 36-45, 46-55, 56-65 years). Largely, 68% of the respondents were men (343 questionnaires), while 32% were women (163 questionnaires). Further, 30% of the respondents were aged 26-35. The gender distribution by age of survey participants in Baku is shown in Figure 1.

The population of Baku city mainly uses four modes of transport. Only the metro serves passengers within the city. Other modes of transport also cover suburban areas. Sometimes, residents of the city use several modes of transport for mobility. The proportion of the population using public transport modes is shown in Figure 2.

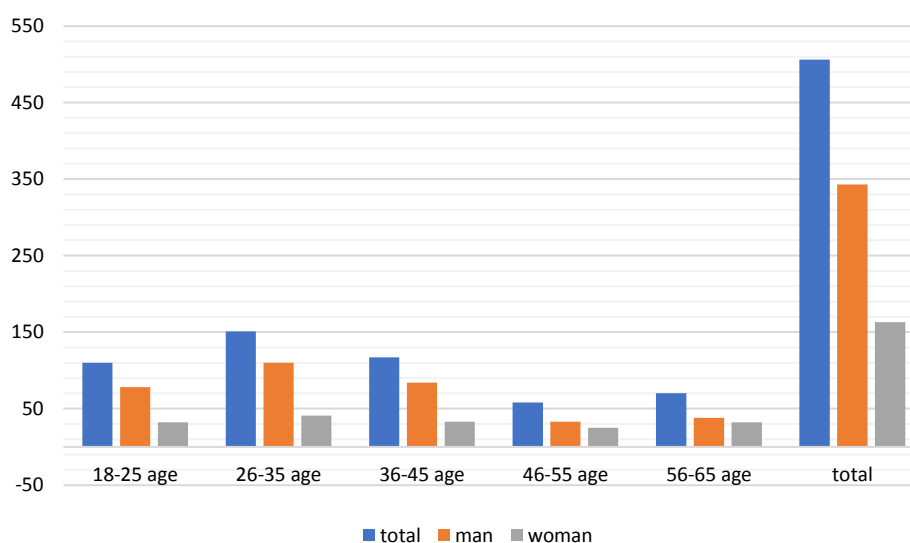


Fig. 1. Age and gender distribution of survey participants

Tab. 1.

Distribution of age groups of respondents by gender and education

No	Distribution of respondents by age	Gender		Education			Total, %
		Men, %	Women, %	Secondary, %	Vocational, %	High, %	
1.	18-25	15,6	6,4	5,6	0,6	15,8	22
2.	26-35	21,85	8,15	10,5	1,78	17,72	30
3.	36-45	16,5	6,5	9,8	2,16	11,04	23
4.	46-55	6,25	4,75	4,5	1,9	4,6	11
5.	56-65	7,6	6,4	5	1,8	7,2	14
	<b>Total, %</b>	<b>67,8</b>	<b>32,2</b>	<b>35,4</b>	<b>8,24</b>	<b>56,36</b>	<b>100</b>

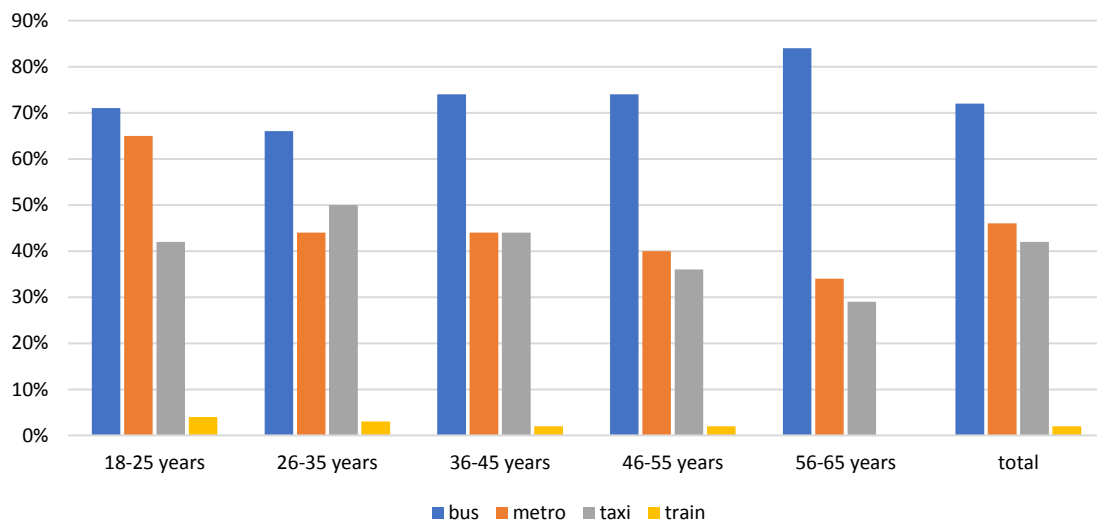


Fig. 2. Proportion of the population using public transport

As seen in Figure 2, 72% of the passengers use regular bus routes, 46% use the metro, 42% use taxis and only 2% use trains. Broken down by age group, passengers aged 56-65 (84%) tend to use regular bus routes.

Trains serve passengers in suburban areas. Within the city limits, among the three modes of transport, 58% of the population prefer to travel by bus, 24% by taxi and 28% by metro. However, passengers prefer a particular mode of transport for various reasons. Table 2 shows that the main reason for the population choosing regular bus routes to travel in Baku was the closeness of bus stops to their place of residence (31%) and place of work (17%). Further, 15% of those surveyed use regular bus routes for convenience. However, 36% of the population prefer the metro because of the travel speed and 21% because of the ease of travel. The number of men who prefer the metro because of its high speed (42%) exceeds the number of women (33%). On the contrary, women (23%) prefer the metro more than men (19%) because of the ease of travel. Additionally, 37% of the passengers surveyed prefer taxis for convenience. While 17% of the population choose taxis because of their high travel speed.

Tab. 2.

## Reason for preferring a particular mode of transport

Reason for use	Bus	Underground	Taxi
Profitability	18%	13%	10%
High travel speed	6%	36%	17%
Price	10%	5%	4%
Convenience	15%	21%	37%
Closeness to place of work	17%	6%	4%
Security	1%	0%	1%
Need due to the COVID 19 pandemic	1%	0%	10%
Closeness to places of residence	31%	14%	2%
Time saving	1%	5%	6%
Density in other modes of transport	0%	0%	9%

Most of the respondents (37%) declared the bus transport as a dangerous mode of transport (Figure 3). The number of men who considered traveling by bus as dangerous is greater than the number of women with the same approach. On the other hand, 33% of respondents considered traveling by taxi as dangerous, 14% by metro, and 3% by train. However, only 13% of passengers consider all modes of transport safe.

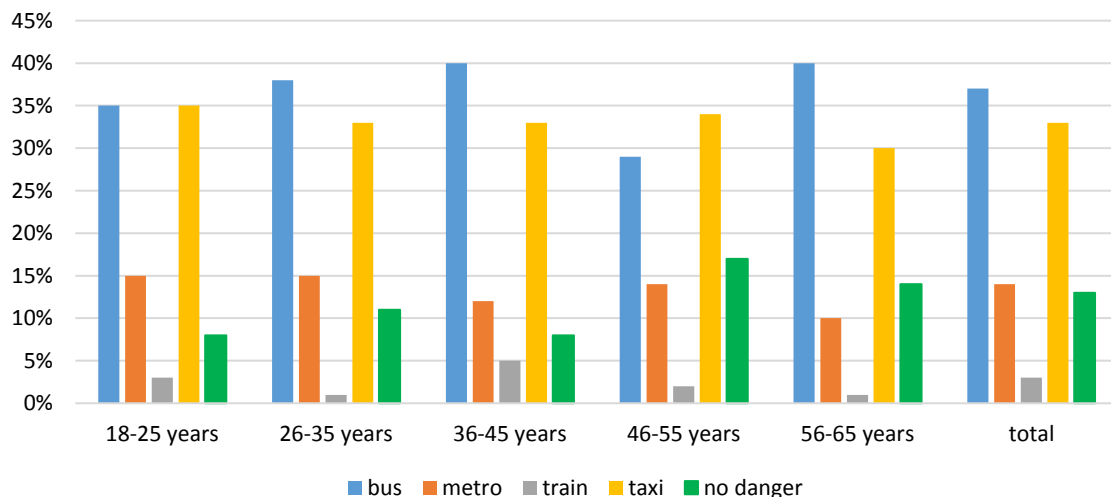


Fig. 3. Distribution of the ratio of passengers to the danger of the mode of transport

Most of the passengers (47%) are generally dissatisfied with bus transport (Figure 4). Only 8% of passengers using the metro are dissatisfied with the operation of this mode of transport. However, 37% of passengers have no complaints about the different modes of transport. Alternatively, 59% of passengers aged 26-35 are dissatisfied with the work of bus transport. While 51% of passengers aged 56-65 did not show dissatisfaction with the work of the urban transport.

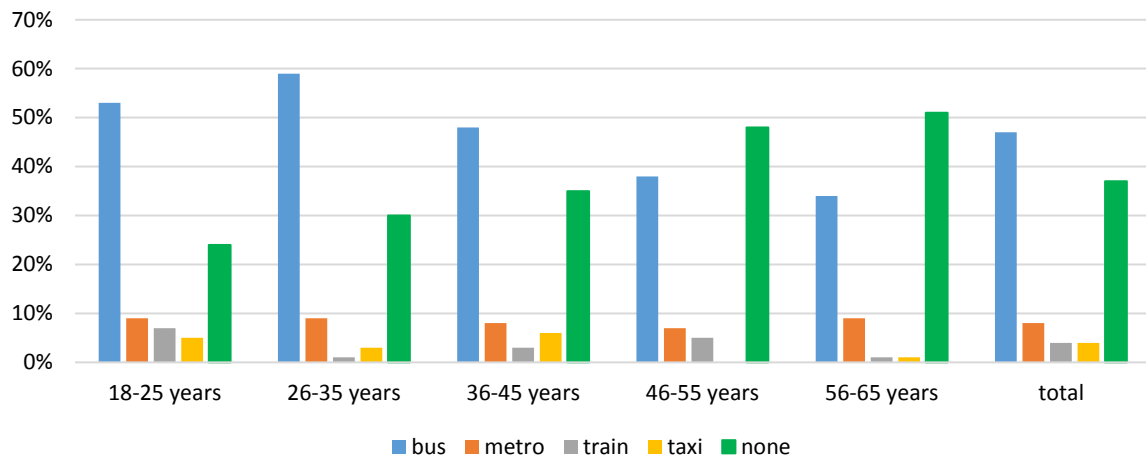


Fig. 4. Distribution of level of dissatisfaction with the work of public transport

## 5. ANALYSIS OF THE QUALITY OF URBAN BUS TRANSPORT SERVICES

To identify the most important reasons for the dissatisfaction of passengers with the work of bus transport, a separate question was included in the questionnaire. It turned out that 37% of passengers are dissatisfied with the work of buses on the route because of the density, 21% because the buses are late for a stop, and the interval is too long (Figure 5). Furthermore, 16% of dissatisfied respondents are dissatisfied because of the use of old and unsuitable buses on the routes. Dissatisfaction with the behavior of bus drivers is 12%.

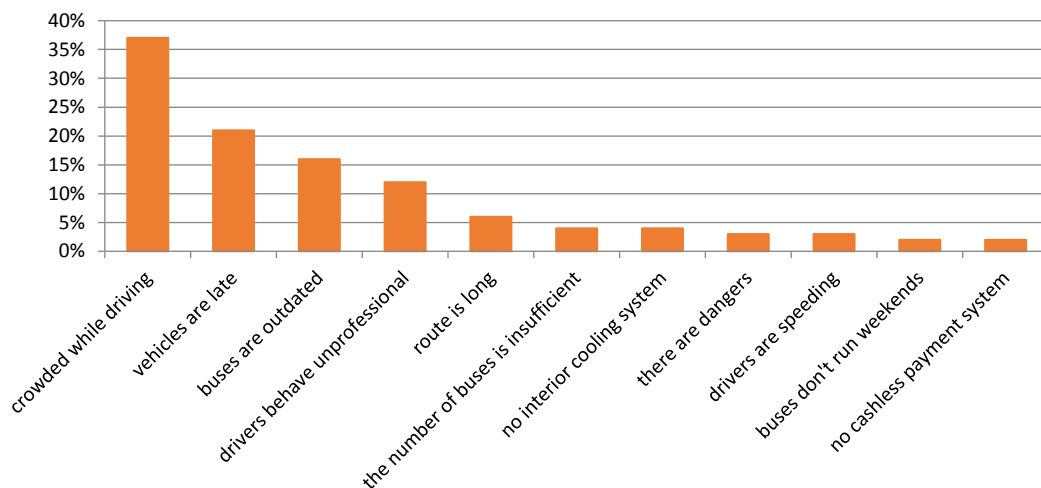


Fig. 5. Reasons for dissatisfaction of passengers with the work of buses on the route

The majority of respondents (67%) who use bus services consider safety to be the main indicator of the quality of bus services (Figure 6). Men prefer safety more than women. Further, 55% of respondents consider travel times as an indicator of quality. The most preferred indicators of the quality of bus transportation were the professionalism of the driver (42%), the comfort of the trip (38%), the cleanliness of the cabin (37%), compliance with the sanitary rules of the internal regulations (30%), and the availability of places for the disabled (23%).

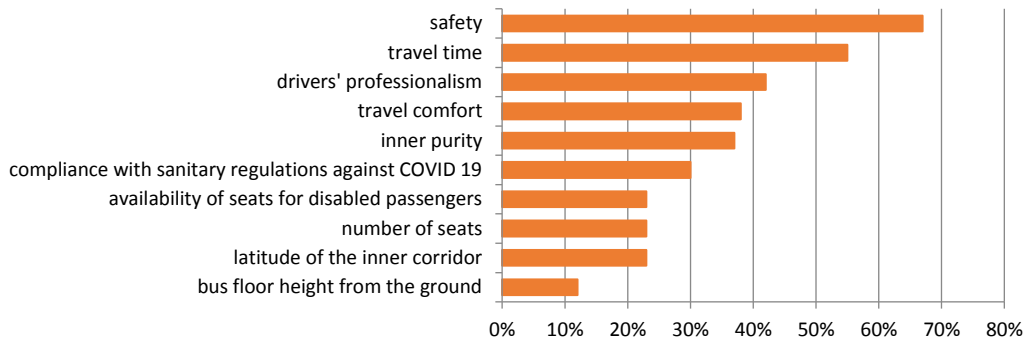


Fig. 6. Preferred indicators of the quality of bus transportation

According to 76% of the passengers surveyed, the most tangible shortcoming in the transportation of passengers on bus routes in Baku is the use of old buses (Figure 7). Further, 37% of respondents complained about the behavior of drivers, 32% about the low capacity of the bus, and 30% about the uncomfortable seats. The lack of information about the route at stops, the discrepancy between traffic intervals and traffic flows, insufficient heating and cooling of the passenger compartment, bus delays at intermediate stops, and the location of stops are also noted as attribution factors to the lack of bus passenger traffic.

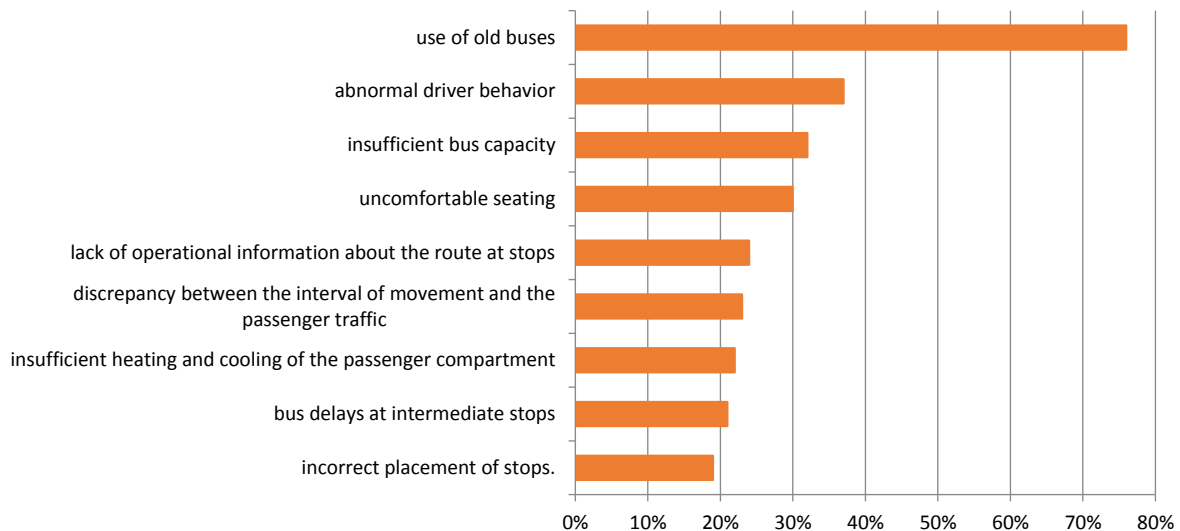


Fig. 7. The main shortcomings in the operation of the bus routes

As seen in Figure 8, How does the use of specialized lanes affect the operation of bus routes? received contrasting responses. In response, 37% of the respondents answered that by using specialized lanes they get to their destination faster, and 33% think that the creation of specialized bus lanes in Baku did not affect the operation of routes. On the other hand, 6% of respondents stated that the use of specialized lanes does not affect the operation of buses during peak hours. While 19% of the respondents believe that dedicated bus lanes were only effective for passengers who move along this part of the streets.



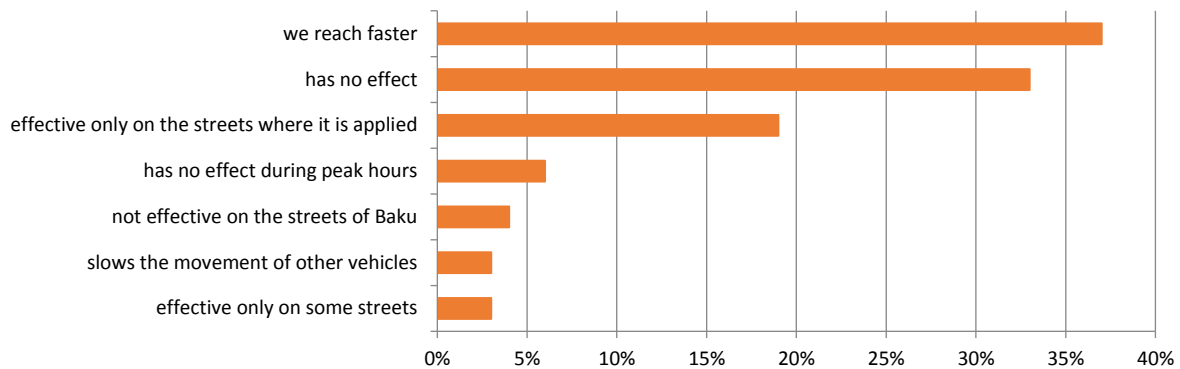


Fig. 8. The impact of the use of specialized lanes on the operation of bus routes

In different cities, depending on the characteristics of the city's public transport network, the walking distance of passengers to the bus stop may vary. In Sydney, for example, 1,906 out of 1,952 passengers walk from their homes to a public transit stop less than 2,000 meters long. Most of these trips were made at a distance of less than 1,200 meters [27].

According to the results of surveys, for 62% of the population, the distance from the place of residence to the bus stop is 50–200 m. For 24%, this distance is 200–400 m, and for 8%, 400–500 m. While for 6%, it is 500–750 m long and more. The vast majority of the population walks less than 500 meters (approximately 6 minutes on foot) to reach their bus stop. However, this can lead to the formation of complex networks with low frequencies [28].

Due to bus overcrowding during peak hours, 40% of passengers sometimes have difficulty boarding the bus. Then 19% of respondents several times and 11% once a week cannot get on the bus. While 14% of respondents have difficulty getting on the bus every day. Only 16% of those surveyed have no difficulty getting on the bus during rush hours.

With the expansion of the city boundaries, the need of the population changed its volume and character. Special measures are required, including the use of alternative modes of public transport. To identify the opinion of the urban population regarding the use of an alternative type of public passenger transport, the questionnaires included questions related to the advisability of using alternative types of public transport in Baku.

As seen in Figure 9, 74% of the respondents consider it expedient to use the tram in Baku. According to the survey, 27% of the city's population consider it expedient to use the metro bus (high-speed bus transport), and 22% - trolleybuses. The greatest positive response to the use of the metro bus is observed among respondents aged 36–45 years. While 11% of respondents do not consider it expedient to use any of the above types of public transport.

Majorly, 51% of respondents consider it more expedient to use this type of transport in the central part of the city, and 37% in all districts of the city (Figure 10). Then 15% of respondents consider it expedient to use the tram in suburban areas, and 3% - in micro districts. However, 2% of respondents consider the area of application as insignificant.

Since bus transport is the main mass street mode of transport, the density of the bus route network is very high. Despite this and the use of specialized bus lines in the provision of services, there are still problems associated with the loss of passengers' time. A good alternative would be to create a network of light rail transport.

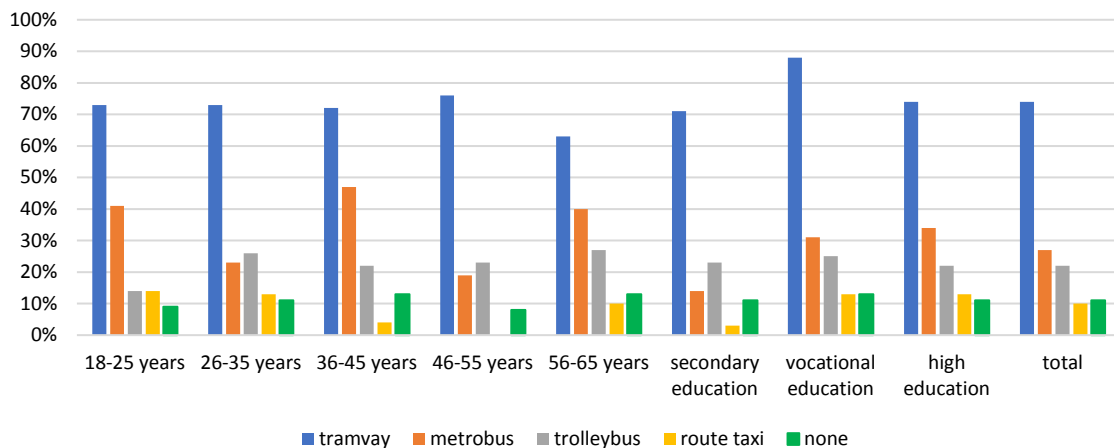


Fig. 9. Distribution of the ratio of the expediency of using an alternative type of public transport in Baku

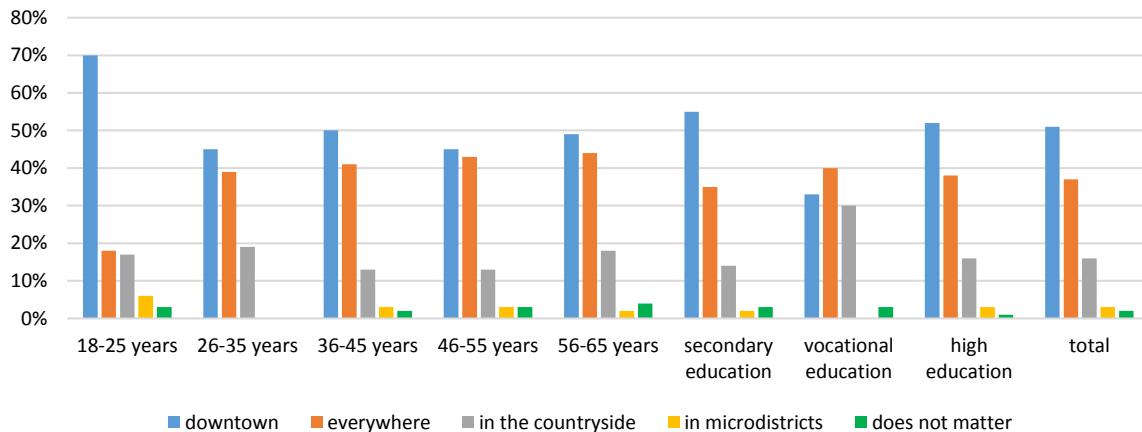


Fig. 10. Distribution of the attitude of respondents to the places where tram lines are used

## CONCLUSION

The quality of public transport services should be assessed regularly. The goal is to identify the wishes of passengers and possible ways to increase mobility in cities. Among the many indicators that determine the quality of urban public transport, passengers are more interested in safety, delivery time, professionalism of drivers, ease of travel and internal cleanliness.

An analysis of passenger service by public transport in the city of Baku shows that the most popular mode of transport for the population is the bus transport. However, the vast majority of passengers are dissatisfied with the work of the bus transport. At the same time, passengers consider the bus transport to be the most dangerous type of public transport. The reason for using buses is the closeness of bus stops, that is, the availability of this transport. The main dissatisfaction of passengers is the use of old buses, congestion and delays of vehicles plying on bus routes.

The vast majority of the population can reach their bus stop in a short time. Although advantageous in terms of bus stop availability, this could, however, result in a high density of bus routes. Although the intervals on the bus routes are not long, passengers are often unable

to board the bus due to overcrowding. The high level of use of taxi services in the city indicates a low level of ease of use of public transport.

Most respondents consider it necessary to create a network of alternative modes of public transport. Furthermore, they also advised the increased use of trams or other types of public transport in the city

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