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# Performance Analysis of Public Bus Transport Services in Rural Areas

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## ABSTRACT

This study investigated the performance of rural public bus transport services in Jordan Valley. The performance measures included availability, comfort and convenience, waiting time, mobility, productivity and safety. The data used in this research was collected from three sources: field survey of existing bus routes, operational data from Land Transport Regulatory Commission and questionnaire surveys which were distributed to a sample of passengers and bus drivers. The obtained data was used to compute the performance measures, as well as to develop statistical models to estimate the average waiting time of buses at peak and off-peak hours. The results indicated that the waiting time at off-peak hours was two and a half times the waiting time at peak hours. It was found that 40% of the external bus routes were within the range of overall Level of Service (LOS) C & D, 26.67% between B & D, 13.33% between B & C, 13.33% between C & E and 6.67% between D & E. Also, it was found that 60% of internal bus routes' LOSs were between C & D, 20% between C & E and 20% with LOS C. It was found that the average perceived waiting time depends on the total travel time regardless of on-peak or off-peak trips.

**KEYWORDS:** Public transport, Bus services, Performance measures, Waiting time, Jordan Valley.

## INTRODUCTION

Public transport in Jordan is divided into three official modes; buses, mini-buses and white cabs. According to the latest records of the Land Transport Regulatory Commission (LTRC), the number of buses and mini-buses in Jordan were 734 and 3521, respectively, in 2020 (LTRC, 2020). Based upon the transport and mobility master plan of the Greater Amman Municipality (GAM), about 13% of total trips were made by public transport in Amman (8% taxis and 5% buses) (GAM, 2009). Shbeeb (2018) mentioned that the rate of vehicles per 1000 people in Jordan was 0.88. This ratio is considered low if compared with the average ratio in countries with middle income (2.66 vehicles per 1000 people). Shtayat et al. (2020) found that the shortest average waiting time at peak periods was 8.7 minutes for taxis and the longest average waiting time was 26.7 minutes for mini-buses. Also, it was found that the average waiting time for all transport modes equals 13.9 min. According to the Greater Amman Municipality (GAM, 2009), about 48% of the urbanized built-up areas have access to public transport within 300 m (3½ - 9 minutes of walking time) and about 64% of the urbanized built-up areas have access to public transport within 500m (6 -15 minutes of walking time). The average travel time for a single trip on one side was about 35 minutes and the costs of the trips were between $ 0.42 and $ 2.82.

In general, the quality of bus services along a route in rural areas depends mainly on the regular operation of buses. Several factors affect the regular operation, such as route length, bus type and frequency of service. Limited public transport may delay the residents in rural areas from reaching their work places, social services

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and other needs. Public transport may be essential in more remote locations to ensure civic engagement and other community life activities. So, it is important to focus on public transport, especially in rural areas, because these areas do not receive the required attention from the responsible authorities. Furthermore, most of the studies focused on public transport in urban areas and there are only few studies in rural areas. Bus services in rural areas are divided into two types; deviated fixed-route services and demand–response services.

Bus Rapid Transit (BRT) systems are popular modes of public transit worldwide. Several studies have been conducted to evaluate the performance of these systems. Imam and Tarawneh (2012) found that the design features of the BRT contribute to higher ridership when compared to conventional bus routes. Imam and Jamrah (2012) stated that the use of BRT systems resulted in significant reductions in air pollution and fuel consumption. GAM completed a partial BRT system in 2021 after several difficulties and challenges. The efficiency and effectiveness of this system are still under investigation.

According to Eboli and Mazzulla (2012), public transport performance measurement is a very useful technique for ensuring that the quality of given public transportation services continues to improve and for allocating resources among competing public transport service providers. The measurement of public transport quality of service as perceived by commuters has drawn significant interest from both governments and operators (Dell'Olio et al., 2011; Woods and Masthoff, 2017).

The quality of service of public transport is important to all communities, even though issues with capacity are primarily centered in larger cities. The availability of public transport service in specific locations and the comfort and convenience of the service provided to passengers are two key features of transit quality of service measurement (TRB, 2003).

To measure the quality of service of public transport services, five categories of measures that fully or partially reflect the perspective of the passenger are defined in Transit Cooperative Research Program (TCRP) Report 88 (TRB, 2003). These measures are:

- Availability: how simple it is for passengers to use the transit system;
- Service monitoring: evaluation of commuters' daily transit experiences;
- Travel time: the duration of the trip;
- Safety and security: probabilities of getting into an accident or becoming a victim of crime while using public transportation;
- Maintenance and construction: implications of construction and maintenance programs on passenger trips.

The most important measure of them is availability, because, regardless of the quality of service, it defines whether or not public transport is even a viable mode option.

Service availability is defined as the measure of public transport services to deliver services on demand. Therefore, availability influences the passenger's decision to use public transportation. The availability at peak and off-peak periods is the actual time the service is really available, which depends on the time that the passenger can wait not on the headway (Polzin et al., 2002). Brechan (2017) found that reducing transport prices and increasing frequency increased the proportion of transport trips, but the most significant factor contributing to these increments was frequency. Norhishamet et al. (2020) showed that the factor which most contributed to reducing the level of using bus services for public transport was frequency. Unpredictable traffic conditions can cause a delay in service frequency and consequently increase travel time to arrive at a selected destination.

Arhin et al. (2019) developed a regression model for determining the maximum acceptable waiting time depending on average headway, temperature, bus arrival time and presence of shelter. They found that the maximum acceptable waiting time of bus patrons at bus stops was 20 minutes and about 33% of the studied sample said that the most appropriate waiting time for the passengers was around 5 minutes beyond the scheduled arrival time of buses. Also, they estimated the acceptable waiting time under different situations and conditions, such as time of the day, bus stop type (location characteristics), gender, ethnicity, alternative mode of transportation and temperature.

Stiglic et al. (2015) suggested that a ride-sharing system would contribute to improved mobility. Šipuš and Abramović (2017) found that the mobility of public bus transport services in the rural area was inadequate and the percentage of areas that were not covered by public bus transport services was 70% of Sisak-Moslavina County. Also, Cheng and Chen (2015) found that if there were many stops throughout the bus line and the bus service was not frequent at night and weekends, the mobility was considered not adequate and caused bus delay.

Productivity is considered a measure of effectiveness and efficiency. In general, efficiency is measured by comparing the available resources with the amount of service provided. It assesses whether the operator is making the best use of resources (producing more with fewer resources). On the other hand, effectiveness measures the consumption of transport bus services to determine the services' social impacts. There is a contrasting relationship between effectiveness and efficiency and the balance between them is constantly being pursued (Carvalho et al., 2015). The operating cost represents the efficiency measure, while the revenue measures effectiveness. Al-Masaeid and Shtayat (2016) found that the operating ratios of buses and mini-buses in Jordan were very high and similar to the operating ratios in the developed countries. Also, the productivity of taxis in Jordan was found lower than that of buses and mini-busses.

Litman (2014) considered public transport very safe if it had low crash and crime rates; it was found that the crashes' rate by automobile travel is more than ten times that by public transport travel. According to the report of the Central Traffic Department of Jordan (CTD) in 2020, public-transport vehicles were involved in 2.1% of the crashes, while small passenger cars were involved in about 70% of the crashes.

**Research Significance and Objectives**

The transport and mobility master plan of the Greater Amman Municipality (GAM) stated the following challenges of public transport (GAM, 2009):

1. The presence of multi-operators led to an absence of regulations and timetables.
2. Users of public transport face low fleet capacity, which sometimes forces them to stand or wait a long time to get a seat. Therefore, they tend to use private cars as an alternative option.
3. There is an absence of amenities at bus stops, especially at high- and low-temperature conditions.
4. The highest percentage of crashes was pedestrian crashes, especially for elderly above 60 years, because streets are unsuitable for walking or cycling.
5. There is a limited accessibility to transportation facilities and services.
6. The fare (tariff) of public transport in Jordan is considered the lowest compared with those in 12 European cities ($ 0.47 compared to $ 2.57), which just covers the operating cost. This is one of the problems that the owners of operating companies face.
7. The percentage of user satisfaction, which is based on spatial coverage of the services, does not exceed 60%.
8. Most urban and rural areas with low population densities suffer from limited mobility (morning and evening trips).

Jordan Valley is a fertile plain located along the Jordan River, as shown in Figure 1 (Salameh and Abdallat, 2020), including Southern Shouneh brigade, Deir Alla brigade and Northern Shouneh brigade. The aim of this study was to evaluate the public transport bus services in Jordan Valley. This is the first study conducted in Jordan to investigate the effects of regulation and operation on the performance of public bus transport services in rural areas. This research focused on transport modes, such as mini-buses and micro-buses, and determined the drivers' and passengers' main problems and satisfaction level. The collected data covered fifteen external bus routes in the whole Jordan Valley and five internal bus routes in Deir Alla brigade. The internal bus routes in Deir Alla brigade were considered, because they have fixed bus stops, limited numbers of micro-buses and regular operation. Some micro-buses in Southern Shouneh brigade and Northern Shouneh brigade were not included, because they do not have special bus stops or regular operations.

The main objectives of this study were as follows:

1. Development of a comprehensive database about the public bus transport services in Jordan Valley, including information on transportation modes, service routes and other important information.
2. Investigating the performance of public bus transport services, including availability, comfort and convenience, waiting time, mobility, productivity and safety measures.
3. Investigating the factors that affect the waiting time

as the main contributor to the choice of public bus transport services during peak and off-peak periods.

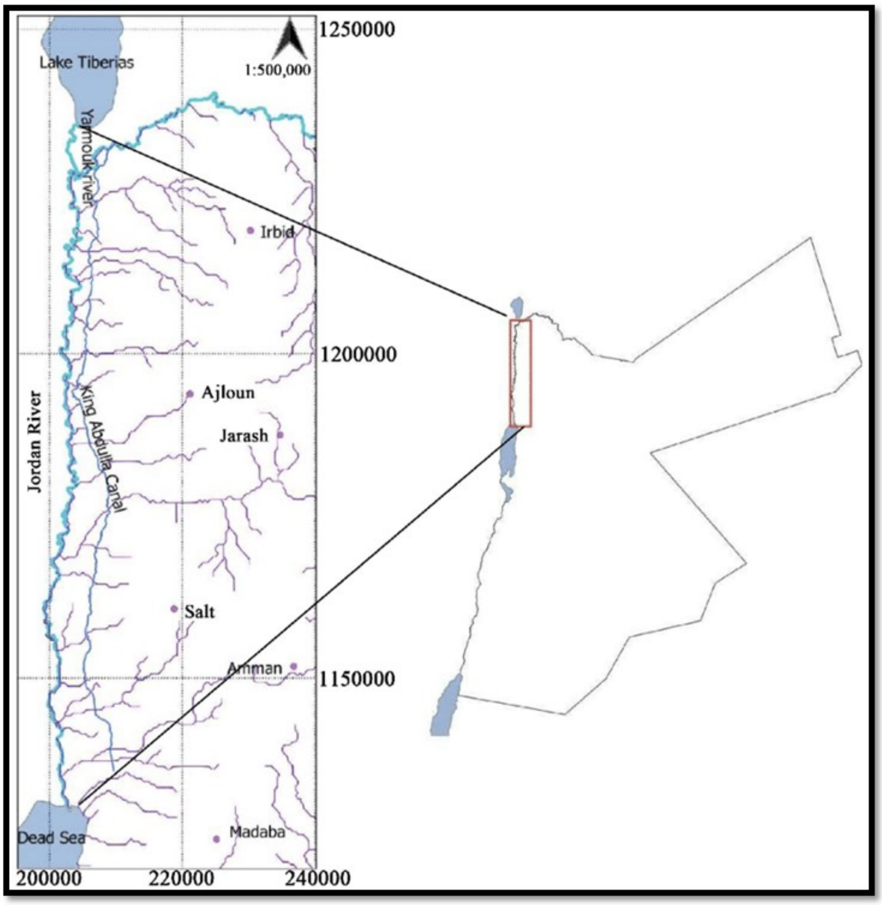


**Figure (1): The geographic location of Jordan Valley (Salameh and Abdallat, 2020)**

**Methodology and Data Collection**

The determination of the overall level of service depends on the performance measures of public transport, including availability, comfort and convenience, waiting time, mobility, productivity, safety and other measures. The level of service of each bus route and the overall level of service for these measures were determined by using the Highway Capacity Manual (HCM, 2000) and the Transit Capacity and Quality of Service Manual (TCQSM) (TCQSM, 2017). Statistical analysis and modeling were performed using Excel software and SPSS software. The flow chart of research methodology is shown in Figure 2.

The data was collected in the summer of 2020 during the COVID-19 pandemic. The study area was Jordan valley, which includes Southern Shouneh brigade, Deir Alla brigade and Northern Shouneh brigade. The collected data covered fifteen external routes in all brigades and five internal routes in Deir Alla brigade.

The data related to bus service quality was obtained from relevant records, field surveys and field observations. The information on the names of the routes, the number of buses for each route and the route fares was obtained from the LTRC. The numbers of registered and actual mini-buses for each external and internal bus route in the study area are shown in Tables 1 and 2. A Field survey was carried out to evaluate the performance of public bus services at peak and off-peak hours. The interviews were conducted with twenty- five passengers and five drivers for each route with more than five vehicles. If the routes were served by less than five vehicles, the interviews were conducted with twenty-five passengers and all the drivers.

The needed sample size is determined according to Krejcie & Morgan (1970) formula:

$$n = \frac{\hat{P} \times (1-\hat{P}) * Z^2}{MOE^2} \quad (1)$$

where,

n: sample size.
$\hat{P}$: sample proportion.
Z: found by using Z - table.
MOE: margin of error (in decimals).

With a 95% confidence level, the Z-table was used to get a Z value of 1.96. Using this equation, the sample size was found to be 385 with a margin of error of ±0.05 and an expected sample proportion of 0.5. The sample size used herein for passengers' and drivers' interviews were 500 and 177, respectively, indicating a total sample size of 677.

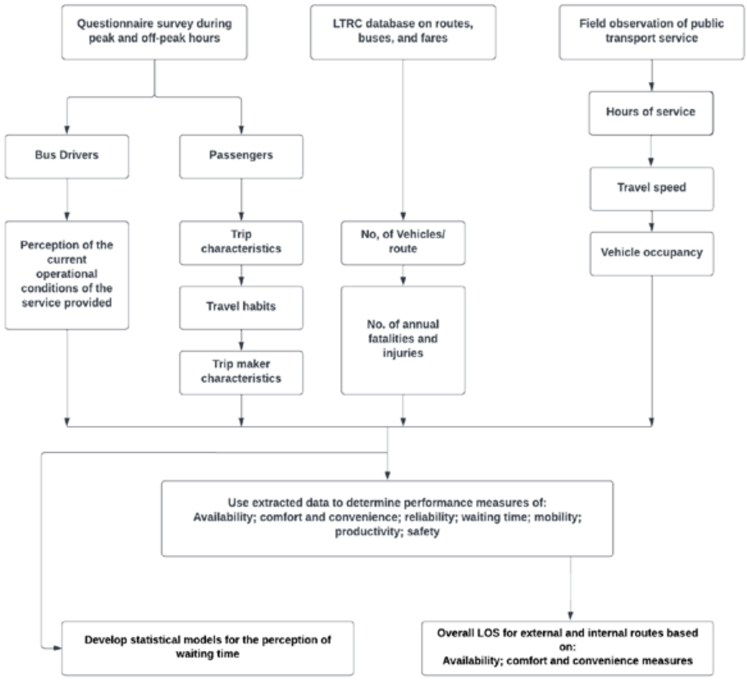


**Figure (2): Flow chart of research methodology**

**Table 1. Registered and actual numbers of mini-buses for the external routes**

| ID | Name of the bus line | Registered number of mini-buses | Actual number of mini-buses | The ratio between the actual and registered numbers of mini-buses |
|---|---|---|---|---|
| 1 | Deir Alla - Al Salt | 20 | 17 | 0.85 |
| 2 | Deir Alla - Amman | 16 | 16 | 1.00 |
| 3 | Deir Alla - Alkarameh | 17 | 16 | 0.94 |
| 4 | Deir Alla - Muadi - Muthalath Alardeh -Fnoosh | 8 | 5 | 0.63 |
| 5 | Deir Alla - Dahret Alramel | 4 | 1 | 0.25 |
| 6 | Muadi - Damia | 1 | 1 | 1.00 |
| 7 | Sawalha - Irbid | 14 | 14 | 1.00 |
| 8 | Deir Alla - Northern Shouneh | 5 | 5 | 1.00 |
| 9 | Northern Shouneh - Irbid | 19 | 16 | 0.84 |
| 10 | Almasharea - Irbid | 12 | 12 | 1.00 |
| 11 | Alkarameh – Southern Shouneh | 12 | 5 | 0.42 |
| 12 | Southern Shouneh – Al Salt | 11 | 11 | 1.00 |
| 13 | Southern Shouneh - Amman | 14 | 14 | 1.00 |
| 14 | Southern Shouneh - Alrawdeh - Alrameh | 8 | 5 | 0.63 |
| 15 | Southern Shouneh - Swameh - Dead Sea | 4 | 4 | 1.00 |

**Table 2. Registered and actual numbers of mini-buses for the internal routes**

| ID | Name of the bus line | Registered number of mini-buses | Actual number of mini-buses | The ratio between the actual and registered numbers of mini-buses |
|---|---|---|---|---|
| 1 | Sawalha -Southern Tawal | 2 | 1 | 0.50 |
| 2 | Sawalha – Northern Tawal | 4 | 1 | 0.25 |
| 3 | Al-Sawalha-Al-Ruwaha | 2 | 1 | 0.50 |
| 4 | Sawalha - Khuzma - Dirar | 1 | 0 | 0.00 |
| 5 | Sawalha -Balawneh | 3 | 1 | 0.33 |

The data was collected on weekdays at peak and off-peak hours. The interviews with passengers and drivers were conducted directly in the field. The passengers' questionnaire included the public transport users' characteristics, their satisfaction with different measures related to the performance of public transport bus services, the challenges which faced the users in their daily trips and the suggestions to improve the quality of service. The drivers' questionnaire included their satisfaction about the operation of public transport bus services, yearly revenue, operating cost and suggestions of how to improve the quality of service. More information about the questionnaires and other important data is presented elsewhere (Al-Torkman, 2021). The field survey showed that several routes were not active, which means that there were bus lines with specific routes according to LTRC, but the drivers or the owners of these bus lines did not follow the specific routes or did not cover the registered routes exactly.

**Analysis of Performance Measures**

**Availability Measure**

The availability measure depends mainly on service frequency. For external routes, the number of available vehicles per day (veh/day) was evaluated. For internal routes, the number of available vehicles per hour (veh/hr), the average headway and the hours of service were evaluated. Moreover, the bus users' satisfaction with the number of buses and the buses' availability per day was also measured.

Table 3 shows the service frequency for external routes. The level of service (LOS) was determined based on HCM 2000. The overall service frequencies for the external routes at the Southern Shouneh brigade, Deir Alla brigade and Northern Shouneh brigade were found to be D, C and B, respectively

Table 4 shows the service frequency for the internal routes at peak and off-peak hours. The level of service was determined based on HCM 2000. The overall service frequencies for the Deir Alla brigade's internal routes at peak and off-peak hours were found to be C and D, respectively.

**Table 3. Service frequency LOS for the external routes**

| ID | Frequency (veh/day) | Service Frequency LOS | Comments |
|---|---|---|---|
| 1 | 17 | A | Numerous trips throughout the day |
| 2 | 16 | A | Numerous trips throughout the day |
| 3 | 16 | A | Numerous trips throughout the day |
| 4 | 5 | D | Minimum service to provide choices of travel times |
| 5 | 1 | F | Round trip on one day is not possible |
| 6 | 1 | F | Round trip on one day is not possible |
| 7 | 14 | B | Midday and frequent peak-hour service |
| 8 | 5 | D | Minimum service to provide choices of travel times |
| 9 | 16 | A | Numerous trips throughout the day |
| 10 | 12 | B | Midday and frequent peak-hour service |
| 11 | 5 | D | Minimum service to provide choices of travel times |

| | | | |
|---|---|---|---|
| 12 | 11 | C | Midday or frequent peak-hour service |
| 13 | 14 | B | Midday and frequent peak-hour service |
| 14 | 5 | D | Minimum service to provide choices of travel times |
| 15 | 4 | D | Minimum service to provide choices of travel times |

**Table 4. Service frequency LOS for the internal routes**

| ID | Average headway (min) (Peak hours) | Veh/hr (on-peak) | Service Frequency LOS (Peak hours) | Comments | Average headway (min) (off-peak hours) | Veh/hr (off-peak) | Service Frequency LOS (off-peak hours) | Comments |
|---|---|---|---|---|---|---|---|---|
| 1 | 10 | 5-6 | B | Frequent service; passengers consult schedules | 20 | 3-4 | C | Maximum desirable time to wait if bus/train missed |
| 2 | 15 | 3-4 | C | Maximum desirable time to wait if bus/train missed | 25 | 2 | D | Service unattractive to rider's choice |
| 3 | 15 | 3-4 | C | Maximum desirable time to wait if bus/train missed | 20 | 3-4 | C | Maximum desirable time to wait if bus/train missed |
| 4 | 15 | 3-4 | C | Maximum desirable time to wait if bus/train missed | 25 | 2 | D | Service unattractive to rider's choice |
| 5 | 30-60 | 1 | E | Service available during an hour | 30-60 | 1 | E | Service available during an hour |

For the internal routes, the level of service C means that there was a maximum desirable time to wait if the bus is missed and D means that the service is unattractive to rider's choice. In general, all the internal bus services were available except for one bus route "Sawalha - Balawneh", because there was a unique mini-bus for this route and the residents tend to use private vehicles instead of waiting a long time and because of the lack of accessibility to the specific destination.

For the external routes, the level of service B in Northern Shouneh brigade means that there was a midday and frequent peak-hour service. C in Deir Alla brigade means that there was a midday or frequent peak-hour service and D in Southern Shouneh brigade means that there was a minimum service to provide choices of travel times. So, the service is not available enough and it is needed to reduce waiting time and headway. Increasing the number of mini-buses will not improve the availability, because there were enough numbers of mini-buses in this area, but there is a need to reorganize the operation of mini-buses and the distribution of service during the day.

Another criterion to measure availability is hours of service for the internal routes. Table 5 shows that the overall hours of service LOS for the internal routes in Deir Alla brigade was D, which means that daytime service was provided. This result was similar to the service frequency LOS and coincided with service frequency LOS at off- peak hours.

**Table 5. Hours of service LOS for the internal routes in Deir Alla brigade**

| ID | Number of hours of service | Hours of service LOS | Comments |
|---|---|---|---|
| 1 | 12 | D | Daytime service provided |
| 2 | 12 | D | Daytime service provided |
| 3 | 13 | C | Early-evening service provided |
| 4 | 13 | C | Early-evening service provided |
| 5 | 9 | E | Peak-hour service/limited midday service |

The service frequency LOS for the external routes was 26.67%, 20%, 6.67%, 33.33% and 13.33% of mini-buses with LOS A, B, C, D and F, respectively. The service frequency LOS for the internal routes was determined at peak and off- peak hours. At peak hours, about 20%, 60% and 20% of micro-buses were found with LOS B, C and E, respectively. On the other hand, at peak hours, about 40%, 40% and 20% of micro-buses were found with LOS C, D and E, respectively. The results showed that the availability of mini-buses per day was approximately similar to the availability of micro-buses.

Commission for Integrated Transport (2008) showed that it might be difficult for the low service frequency to support the accessibility needs with continuity by using conventional public transport service. So, the government should find a new approach to rural public transport, such as using the conventional timetabled bus services on main corridors or the demand-responsive or car-sharing at off-peak times.

**Comfort and Convenience Measure**

The passenger load factor is used to measure comfort and convenience. The load factor is expressed by the number of passengers per seat (P/seat) and it is determined based on the ratio of the number of passengers before the departure to the maximum number of passengers (total number of seats). The passenger load was determined according to HCM 2000.

Table 6 shows the passenger load for external routes. The overall passenger load for the external routes at Southern Shouneh brigade, Deir Alla brigade and Northern Shouneh brigade was B, C and B, respectively. It is worth mentioning that B means that the passengers can choose where to sit, because the mini-buses leave the stop station without being fully loaded and are loaded through the route of trip, while C means that all passengers can sit. Table 7 shows the passenger load for the internal routes in the Deir Alla brigade. The overall passenger load for the internal routes was C, which means that all passengers could sit. The passenger load LOS for the external routes was found 33.33%, 13.33%, 40.00% and 13.33% of mini-buses with LOS A, B, C and D, respectively. The passenger load LOS for the internal routes was 20.00% and 80.00% of micro-buses with LOS A and C, respectively.

According to TCQSM, the transit/auto travel time difference was used to measure the convenience of public transport bus services. Table 8 and Table 9 show the transit/auto travel time for the external and internal routes in the study area, respectively. As shown in Table 8, the transit/auto travel time LOS for the external routes was determined at peak and off-peak hours. At peak hours, 6.67%, 40.00%, 26.67% and 26.67% of mini-buses were with LOS B, C, D and E, respectively. At off- peak hours, 13.33%, 20.00% and 66.67% of mini-buses were with LOS D, E and F, respectively.

These results were expected, because part of the drivers left the stop station with fully loaded vehicles, so the waiting time at off-peak periods was long. The other part of the drivers tends to load and unload the passengers along the trip route if they did not leave the first stop station with fully loaded vehicles, so the travel time would be too long at off-peak periods.

Also, as shown in Table 9, the transit/auto travel time LOS for the internal routes was determined at peak and off-peak hours. At peak hours, 20%, 60% and 20% of micro-buses were with LOS B, C and D, respectively. At off-peak hours, 40%, 20%, 20% and 20% of micro-buses were with LOS C, D, E and F, respectively.

Transit/auto travel time at peak hours was better than at off-peak hours, probably because buses need to be fully loaded with passengers. Hitge and Vanderschuren (2015) concluded that regarding the average trip in Cape Town, traveling by using public transport was significantly longer than by using a private car. There were several recommendations to decrease the difference between travel time by transit and travel time by auto, such as making the operation of services scheduled, stopping at specific stations along the bus route and increasing the operating speed.

**Table 6. Passenger load LOS for the external routes**

| ID | Number of passengers per seat (P/seat) | Passenger load LOS | Comments |
|---|---|---|---|
| 1 | 1.08 | D | Comfortable loading for standees |
| 2 | 1 | C | All passengers can sit |
| 3 | 0.42 | A | No passenger needs to sit next to another |
| 4 | 1.09 | D | Comfortable loading for standees |
| 5 | 0.45 | A | No passenger needs to sit next to another |
| 6 | 0.45 | A | No passenger needs to sit next to another |
| 7 | 0.45 | A | No passenger needs to sit next to another |
| 8 | 1 | C | All passengers can sit |
| 9 | 1 | C | All passengers can sit |
| 10 | 0.68 | B | Passengers can choose where to sit |
| 11 | 0.42 | A | No passenger needs to sit next to another |
| 12 | 1 | C | All passengers can sit |
| 13 | 1 | C | All passengers can sit |
| 14 | 0.67 | C | All passengers can sit |
| 15 | 0.63 | B | Passengers can choose where to sit |

**Table 7. Passenger load LOS for the internal routes in Deir Alla brigade**

| ID | Number of passengers per seat (P/seat) | Passenger load LOS | Comments |
|---|---|---|---|
| 1 | 1 | C | All passengers can sit |
| 2 | 1 | C | All passengers can sit |
| 3 | 1 | C | All passengers can sit |
| 4 | 1 | C | All passengers can sit |
| 5 | 0.42 | A | No passenger needs to sit next to another |

**Table 8. Transit/auto travel time LOS for the external routes**

| ID | Transit/auto travel time difference (peak/off - peak) (min) | Transit/auto travel time LOS (peak / off-peak) | Comments |
|---|---|---|---|
| 1 | (55/85) | E / F | Tedious for all riders; may be best possible in small cities/ unacceptable to most riders |
| 2 | (50/90) | E / F | Tedious for all riders; may be best possible in small cities/ unacceptable to most riders |
| 3 | (40/70) | D / F | Round-trip at least an hour longer by transport/ unacceptable to most riders |
| 4 | (25/50) | C / E | Tolerable for choice riders/ tedious for all riders; may be best possible in small cities |
| 5 | (35/35) | D / D | Round-trip at least an hour longer by transport/ round-trip at least an hour longer by transport |

| | | | |
|---|---|---|---|
| 6 | (35/35) | D / D | Round-trip at least an hour longer by transport/ round-trip at least an hour longer by transport |
| 7 | (55/85) | E / F | Tedious for all riders; may be best possible in small cities/ unacceptable to most riders |
| 8 | (55/85) | E / F | Tedious for all riders; may be best possible in small cities/ unacceptable to most riders |
| 9 | (30/75) | C / F | Tolerable for choice riders/ unacceptable to most riders |
| 10 | (30/75) | C / F | Tolerable for choice riders/ unacceptable to most riders |
| 11 | (20/60) | C / E | Tolerable for choice riders/ tedious for all riders; may be best possible in small cities |
| 12 | (10/55) | B / E | About as fast by transport as by automobile/ tedious for all riders; may be best possible in small cities |
| 13 | (35/65) | D / F | Round-trip at least an hour longer by transport/ unacceptable to most riders |
| 14 | (25/65) | C / F | Tolerable for choice riders/ unacceptable to most riders |
| 15 | (20/65) | C / F | Tolerable for choice riders/ unacceptable to most riders |

**Table 9. Transit/auto travel time LOS for the internal routes in Deir Alla brigade**

| ID | Transit/auto travel time difference (peak/off - peak) (min) | Transit/auto travel time LOS (peak / off-peak) | Comments |
|---|---|---|---|
| 1 | (20/30) | C / C | Tolerable for choice riders/ tolerable for choice riders |
| 2 | (40/50) | D / E | Round-trip at least an hour longer by transport/ tedious for all riders; may be best possible in small cities |
| 3 | (20/25) | C / C | Tolerable for choice riders/ tolerable for choice riders |
| 4 | (25/35) | C / D | Tolerable for choice riders/ round-trip at least an hour longer by transport |
| 5 | (10/75) | B / F | About as fast by transport as by automobile/ unacceptable to most riders |

**Waiting Time Measure**

The average waiting time for external routes at peak and off-peak hours was found 22.67 min. and 54.67 min., respectively. For internal routes in Deir Alla brigade, the average waiting time was found 12 min. at peak hours and 30 min. at off-peak hours. For both internal and external routes, the average waiting time at off-peak hours was twice the average waiting time at peak hours. This can be traced to the fact that mini-buses and micro-buses tend to leave the stop station with full loading. The average waiting time for micro-buses was less than that for mini-buses. This could be due to the difference in the number of seats, because most transport vehicles leave the transport station with a full number of passengers.

Figure 3 and Figure 4 show the maximum and minimum waiting time at peak and off-peak hours for the internal and external routes. Most passengers tend to wait longer if they were given the choice to pay more fare or to wait. According to the passenger interviews, most passengers tend to wait for a maximum of 15-20 min. The waiting time depends on the purpose of trip, type of bus (mini-bus or micro-bus) and travel time. Figure 5 shows the percentage of passengers who tend to pay more or wait. According to Arhin et al. (2019), the maximum acceptable waiting time at peak hours was found 20 minutes. Herein, at peak hours, 46.67% of the mini-buses had unacceptable waiting times and about 53.33% had acceptable waiting times. However, at off-peak hours, the waiting times for all mini-buses were unacceptable. All waiting times for micro-buses were acceptable at peak hours and those of about 60% were unacceptable at off-peak hours.

**Mobility Measure**

The degree of mobility is determined in terms of travel speed (HCM, 2000), the average travel speed varied between 40 and 100 km/h on the external routes and between 30 and 90 km/h on the internal routes. The passengers were asked whether the operating speed was appropriate for each bus line in the study area. 21.33% of the bus users said that the operating speed was always appropriate, while 52.2% of those users said that it was sometimes appropriate. In addition, 4.53% of the bus users said that it was seldom appropriate, while 21.95% of those users said that it was never appropriate.

**Productivity Measure**

Productivity is determined by evaluating effectiveness and efficiency. The operating cost represents the efficiency measure, while the revenue of vehicles represents the effectiveness measure. The operating ratio is the ratio of the yearly revenue to the yearly operating cost, which gives an indicator of productivity (Benjamin and Sen, 1982). The operating ratio was determined for each route in this study based on the drivers' answers. The yearly operating costs included fuel, licensing, maintenance, oil, tax, depreciation, salaries and overhead, tires, traffic fines and insurance costs. The yearly revenue included all amount of money collected during a given 12-month period without subtracting the operation costs and other expenses. The maximum values of the operating ratio were found 1.87 for the external routes and 2.46 for the internal routes. The minimum values for the external and internal routes were 0.84 and 1.35, respectively.

**Safety Measure**

The passengers were asked whether they feel safe when using public transport inside the bus or at the bus stop or when moving between buses. It was found that 82.85% of the users feel safe always, 14.95% feel safe sometimes, 0.70% feel safe seldom and 1.5% never feel safe.

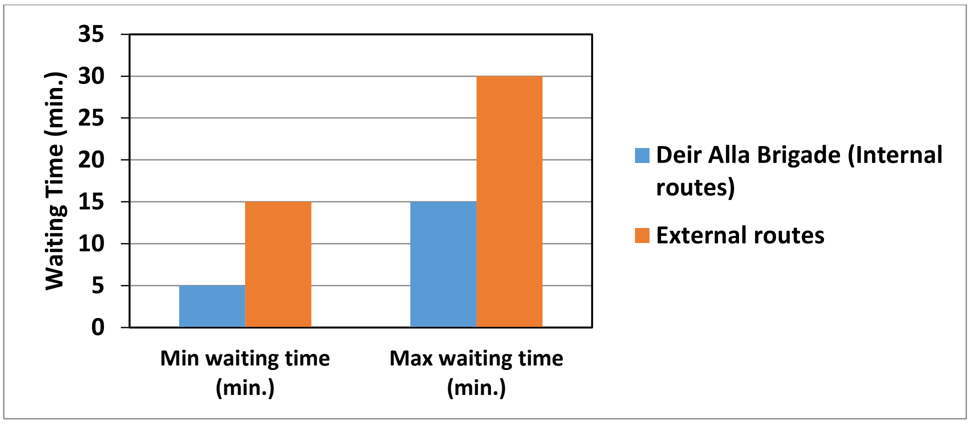


**Figure (3): The maximum and minimum waiting times at peak hours for the external and internal routes**

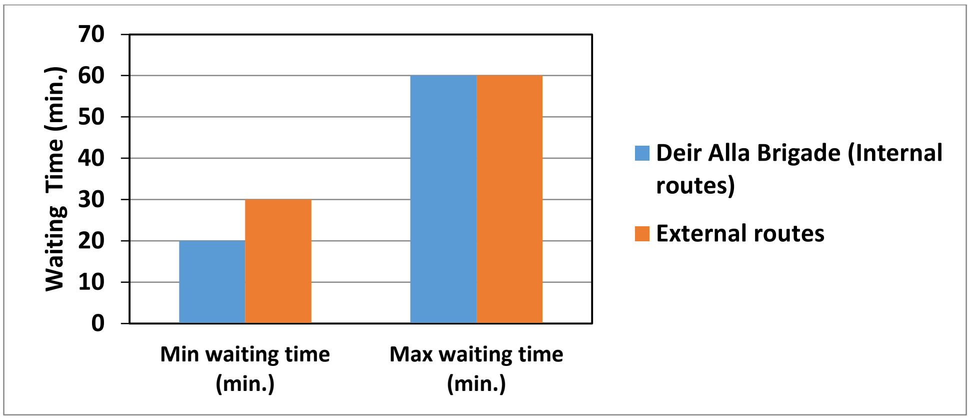


**Figure (4): The maximum and minimum waiting times at off-peak hours for the external and internal routes**

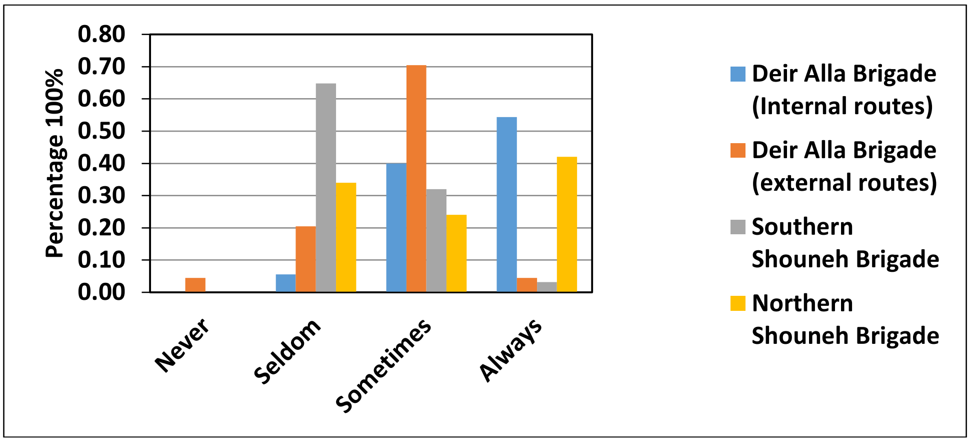


**Figure (5): Passengers' satisfaction with the waiting time**

**Overall Level of Service of Performance Measures**

The overall level of service (LOS) for each bus route was determined based on the three performance measures; availability, comfort and convenience. The reason of using these measures was to find the overall LOS as an average value (arithmetic mean) for each external and internal routes. Each LOS has a score starting with 5 points for LOS A and ending with 0 points for LOS F. The overall LOS for external and internal routes is shown in Tables 10 -13.

As shown in Table 11, it was found that 40% of the external bus routes were within the range of LOS between C & D, 26.67% within the range of LOS between B & D, 13.33% within the range of LOS between B & C, 13.33% within the range between C & E and 6.67% within the range between D & E. As shown in Table 13, it was found that 60% of the internal bus routes were within the range of LOS between C & D, 20% within the range of LOS between C & E and 20% within the range of LOS C.

**Statistical Analysis and Modeling**

**Descriptive Statistical Analysis**

Descriptive statistical analysis was performed on the performance measures for the external and internal routes. Table 14 shows the statistical characteristics of performance measures for the external routes. As shown in this table, transit/auto travel time difference, average waiting time and average travel speed had the highest standard deviations and were spread out across wide ranges. The high values of standard deviation were related to the differences in travel distances and the conditions of the roads. Table 15 shows the statistical characteristics of performance measures for the internal routes. Availability (headway), transit/auto travel time difference, average waiting time and average travel speed, especially outside the residential area, had the highest standard deviations. The high values of standard deviation for availability were related to the difference of the headway which differs from a route to another, because all micro-buses depend on fully loading of passengers which varied during the day and the week. Also, the number of seats could increase the value of headway and the average travel speed outside the residential area. This measure depends on the class of the road (primary or secondary) and the length of the route.

As shown in Table 16, the average actual waiting time at off-peak hours was found twice that at peak hours, but the difference between average actual waiting time and average willing waiting time at peak hours was too short in comparison with the difference at off-peak hours, which is related to the high flow of passengers at peak hours.

**Development of the Regression Models**

Waiting time is the most important factor which contributes to the choice of using public transport bus services. The effects of type of bus, purpose of the trip, travel time, number of trips and education level (independent variables) on the average passenger perception of waiting time at peak and off-peak hours (dependent variable) were investigated.

Table 17 shows the differences between the average perception of waiting time (min) and average willing waiting time at peak and off-peak hours for each category of the independent variables. As shown in this table, the average perception of waiting time was between 20 and 48.5 min. at peak and off-peak hours for all categories except for the type of bus (mini-buses and micro-buses); The average perception of waiting time for mini-buses was between 22.67 and 54.67 min. and for the micro-buses between 12 and 30 min. at peak and off-peak hours, respectively. The average willing waiting time varied between 14.96 and 21.25 min. The values of the differences between average perception of waiting time and average willing waiting time varied between 1.42 and 33.42 min. for mini-buses and between 2.96 and 15.04 for micro-buses.

**Table 10. Overall LOS for each external bus route**

| ID | Score | | | | |
|---|---|---|---|---|---|
| | Availability | Comfort | Convenience (peak/ off – peak) | Average score | Overall LOS |
| 1 | 5 | 2 | 1/0 | 2.67/2.33 | Between C & D |
| 2 | 5 | 3 | 1/0 | 3/2.67 | Between C & D |
| 3 | 5 | 5 | 2/0 | 4/3.33 | Between B & C |
| 4 | 2 | 2 | 3/1 | 2.33/1.67 | Between C & E |
| 5 | 0 | 5 | 2/2 | 2.33/2.33 | Between C & D |
| 6 | 0 | 5 | 2/2 | 2.33/2.33 | Between C & D |
| 7 | 4 | 5 | 1/0 | 3.33/3 | Between B & C |
| 8 | 2 | 3 | 1/0 | 2/1.67 | Between D & E |
| 9 | 5 | 3 | 3/0 | 3.67/2.67 | Between B & D |
| 10 | 4 | 4 | 3/0 | 3.67/2.67 | Between B & D |
| 11 | 2 | 5 | 3/1 | 3.33/2.67 | Between B & D |
| 12 | 3 | 3 | 4/1 | 3.33/2.33 | Between B & D |
| 13 | 4 | 3 | 2/0 | 3/2.33 | Between C & D |
| 14 | 2 | 3 | 3/0 | 2.67/1.67 | Between C & E |
| 15 | 2 | 4 | 3/0 | 3/2 | Between C & D |

**Table 11. Summary of the overall LOS for external routes**

| ID | LOS | Number of bus routes within range of LOS | Percentage % |
|---|---|---|---|
| 1 | Between C & D | 6 | 40 |
| 2 | Between B & C | 2 | 13.33 |
| 3 | Between C & E | 2 | 13.33 |
| 4 | Between D & E | 1 | 6.67 |
| 5 | Between B & D | 4 | 26.67 |

**Table 12. The overall LOS for each internal bus route**

| ID | Score | | | | | |
|---|---|---|---|---|---|---|
| | Availability (service frequency/ peak+-off peak) | Availability (hours of service) | Comfort | Convenience (peak/ off – peak) | Average score | Overall LOS |
| 1 | 4/3 | 2 | 3 | 3/3 | 3/2.75 | Between C & D |
| 2 | 3/2 | 2 | 3 | 2/1 | 2.25/2 | Between C & D |
| 3 | 3/3 | 3 | 3 | 3/3 | 3/3 | C |
| 4 | 3/2 | 3 | 3 | 3/2 | 3/2.5 | Between C & D |
| 5 | 1/1 | 1 | 5 | 4/0 | 2.75/1.75 | Between C & E |

**Table 13. Summary of the overall LOS for the internal routes**

| ID | LOS | Number of bus routes within range of LOS | Percentage % |
|---|---|---|---|
| 1 | Between C & D | 3 | 60 |
| 2 | Between C & E | 1 | 20 |
| 3 | C | 1 | 20 |

**Table 14. Descriptive statistical analysis of the performance measures for the external routes**

| Measure | N | Mean | Mode | Standard deviation |
|---|---|---|---|---|
| Availability (vehicles per day) | 15 | 9.47 | 5 | 5.90 |
| Hours of service | 15 | 12.20 | 12 | 2.62 |
| Number of passengers per seat (P/seat) | 15 | 0.7 | 1 | 0.27 |
| Transit/auto travel time difference (peak/off-peak) (min) | 15 | 34.67/66.33 | 35.55/65.8 | 14.07/17.27 |
| Average waiting time (peak/off-peak) (min) | 15 | 22.67/54.67 | 30/60 | 7.29/11.25 |
| Average travel speed (km/h) | 15 | 64.67/76.67 | 60.70/70 | 15.52/17.59 |
| Operating ratio | 15 | 1.77 | - | 0.43 |

**Table 15. Descriptive statistical analysis of the performance measures for the internal routes**

| Measure | N | Mean | Mode | Standard deviation |
|---|---|---|---|---|
| Availability (headway) (peak/ off-peak) | 5 | 17/30 | 15/20.25 | 7.58/16.96 |
| Hours of service | 5 | 11.8 | 12,13 | 1.64 |
| Number of passengers per seat (P/seat) | 5 | 0.88 | 1 | 0.26 |
| Transit/auto travel time difference (peak/off-peak) (min) | 5 | 23/43 | 20/- | 10.95/20.19 |
| Average waiting time (peak/off-peak) (min) | 5 | 12/30 | 15/20.25 | 4.47/16.96 |
| Average travel speed (inside/outside) (km/h) | 5 | 30/74 | 30/70 | 0/8.94 |
| Operating ratio | 5 | 2.25 | - | 0.48 |

**Table 16. Difference between average actual waiting time (min) and average willing waiting time (min) at peak and off-peak hours**

| Time period | Average actual waiting time (min) | Average willing waiting time (min) | Difference between average actual waiting time (min) and average willing waiting time (min) |
|---|---|---|---|
| Peak | 20 | 19.86 | 0.14 |
| Off- peak | 48.5 | 19.86 | 28.64 |

**Table 17. Differences between average perception of waiting time and average willing waiting time at peak and off-peak hours for each category of the independent variables**

| Category | Average perception of waiting time (peak / off – peak) (min) | Average willing waiting time (min) | Difference between average perception of waiting time (min) and average willing waiting time (min) (peak/ off - peak |
|---|---|---|---|
| **Type of bus** | | | |
| Mini-bus | 22.67/54.67 | 21.25 | 1.42/33.42 |
| Micro-bus | 12/30 | 14.96 | 2.96/15.04 |
| **Purpose of trip** | | | |
| Work | 20/48.5 | 21.34 | 1.34/27.16 |
| Education | 20/48.5 | 19.09 | 0.9/29.41 |
| Treatment | 20/48.5 | 17.73 | 2.27/30.77 |
| Official transactions | 20/48.5 | 19.84 | 0.16/28.66 |
| Visits and entertainment | 20/48.5 | 17.4 | 2.6/31.10 |
| Other | 20/48.5 | 16.47 | 3.53/32.03 |
| **Travel time** | | | |
| 0-15 min | 20/48.5 | 15.12 | 14.88/33.38 |
| 15-30 min | 20/48.5 | 16.54 | 3.46/31.96 |
| 30-45 min | 20/48.5 | 20.31 | 0.31/28.19 |
| 45-60 min | 20/48.5 | 22.91 | 2.91/25.59 |
| 60-75 min | 20/48.5 | 29.66 | 9.66/18.84 |
| 90-120 min | 20/48.5 | 23.8 | 3.8/24.7 |
| **Number of trips** | | | |
| Daily | 20/48.5 | 20.47 | 0.47/28.03 |
| Two to three times weekly | 20/48.5 | 17.95 | 2.05/30.55 |
| Once a week | 20/48.5 | 18.68 | 1.32/29.82 |
| Once a month | 20/48.5 | 18.75 | 1.25/29.75 |
| Seldom | 20/48.5 | 17.22 | 2.78/31.28 |
| **Educational level** | | | |
| Uneducated | 20/48.5 | 20.91 | 0.91/27.59 |
| Primary level | 20/48.5 | 20.36 | 0.36/28.14 |
| Secondary level | 20/48.5 | 18.35 | 1.65/30.15 |
| Diploma | 20/48.5 | 19.29 | 0.71/29.21 |
| Bachelor's degree and above | 20/48.5 | 20.14 | 0.14/28.36 |

Trip-purpose categories included; work, education, treatment, official transactions, visits, entertainment and others. Travel-time categories included these ranges; 0-15 min., 15-30 min., 30-45 min., 45-60 min., 60-75 min. and 90-120 min. Type of buses category included mini-buses and micro-buses. Number of trips categories included; daily, two to three times weekly, once a week, once a month and seldom. Education level categories included; uneducated, primary level, secondary level, diploma and bachelor's degree and above.

Preliminary analysis using stepwise regression technique revealed that the highest correlation coefficients with the perception of waiting time were for travel time and type of bus. Therefore, regression models were developed between perception of waiting time as a dependent variable and travel time and type of bus as independent variables. The sample size is relatively small (15 external routes and 5 internal routes) and most of the data concentrated at the maximum value of the average perception of waiting time. Also, the data points of micro-buses were very limited and covered mainly the minimum range of data. Therefore, to check the non-linearity of the regression models, both bus types should cover the whole range of data.

The regression models of the average perception of waiting time at peak and off-peak hours excluding the type of bus are shown in Equations 2 and 3:

$$APWT_{peak} = 7.910 + 0.191\ (TT_{peak}) \quad (2)$$

$$APWT_{off\text{-}peak} = 14.353 + 0.371\ (TT_{off\text{-}Peak}) \quad (3)$$

where,

$APWT_{peak}$: average perception of waiting time at peak hours (min.).

$APWT_{off\text{-}peak}$: average perception of waiting time at off-peak hours (min.).

$TT_{peak}$: travel time at peak hours (min.).

$TT_{off\text{-}Peak}$: travel time at off-peak hours (min.).

The statistical characteristics of the regression models in Equations 2 and 3 are shown in Table 18. It is clear in this table that the effect of travel time on the APWT was significant in both models at α-level < 0.05. The coefficient of determination for the off-peak model ($r^2$ = 0.673) was found higher than that for the peak model ($r^2$ = 0.505). This can be traced to the fact that the variation in APWT at off-peak hours was higher than that at peak hours. Table 19 shows the analysis of variance (ANOVA) for the regression models in Equations 2 and 3. The results in this table confirmed the significance of the regression relationships at α-level < 0.05.

To improve the regression relationships, the type of bus was introduced as an indicating independent variable. Figures 6 and 7 show the scatter plots for the AAWT *versus* travel time at peak and off-peak hours, respectively. The scatter plots in these figures indicated that the relationships were approximately linear. The developed regression models at peak and off-peak periods are shown in Equations 4 and 5.

**Table 18. Statistical characteristics of the regression models in Equations 2 and 3**

| Equation | Variable | Unstandardized Coefficients | | t | Sig. | r | $r^2$ |
|---|---|---|---|---|---|---|---|
| | | B | Std. Error | | | | |
| 2 | Constant | 7.910 | 3.113 | 2.541 | 0.020 | 0.710 | 0.505 |
| | $TT_{peak}$ | 0.191 | 0.045 | 4.282 | .000 | | |
| 3 | (Constant) | 14.353 | 6.019 | 2.384 | 0.028 | 0.820 | 0.673 |
| | $TT_{off\text{-}Peak}$ | 0.371 | 0.061 | 6.084 | 0.000 | | |

**Table 19. Analysis of variance (ANOVA) for the regression models in Equations 2 and 3**

| Equation | Source | Sum of squares | df | Mean of squares | F | Sig. |
|---|---|---|---|---|---|---|
| 2 | Regression | 630.802 | 1 | 630.802 | 18.337 | 0.000 |
| | Residual | 619.198 | 18 | 34.400 | | |
| | Total | 1250.000 | 19 | | | |
| 3 | Regression | 3501.936 | 1 | 3501.936 | 37.013 | 0.000 |
| | Residual | 1703.064 | 18 | 94.615 | | |
| | Total | 5205.000 | 19 | | | |

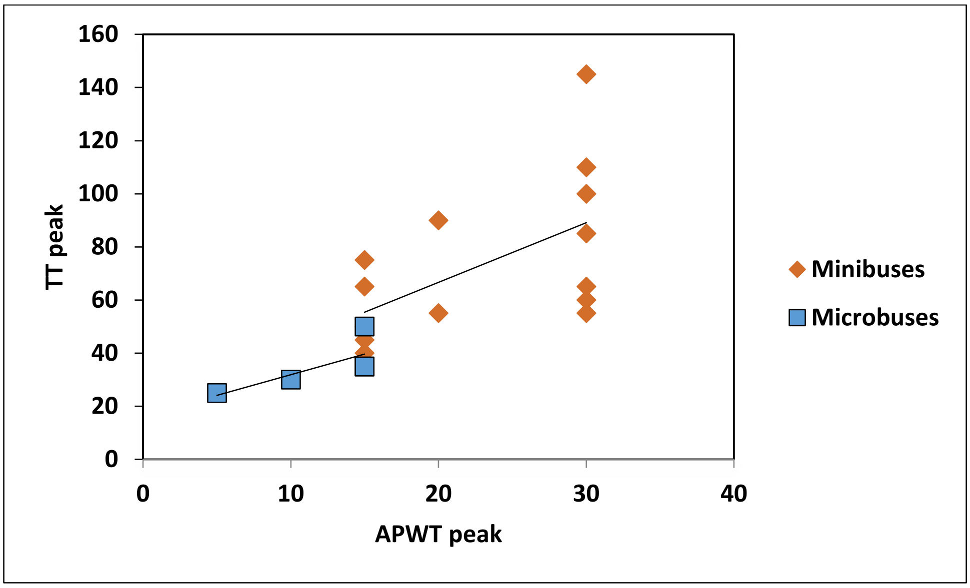


**Figure (6): APWT *versus* travel time at peak periods**

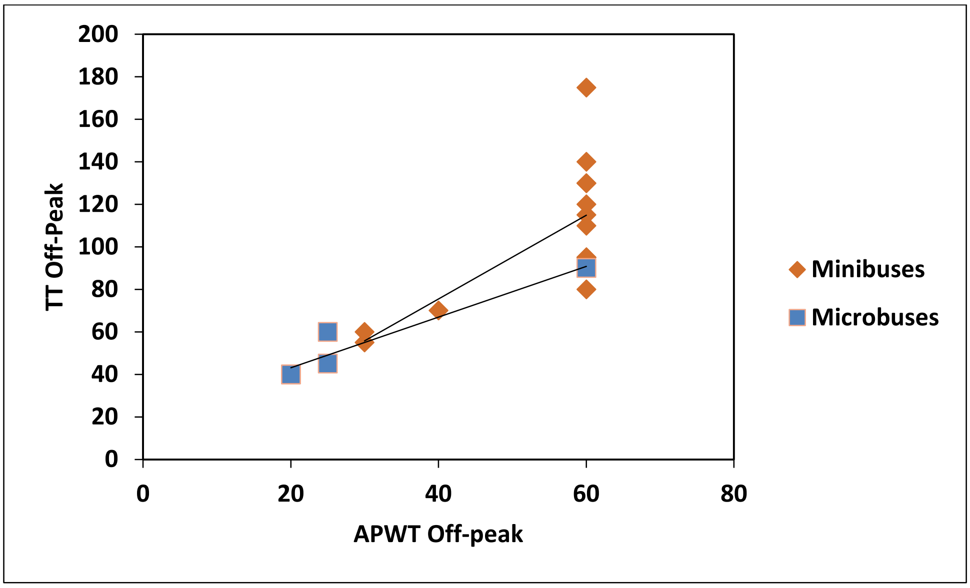


**Figure (7): APWT *versus* travel time at off-peak periods**

$$APWT_{peak} = 11.756 + 0.150\ (TT_{peak}) - 5.011\ (TB) \quad (4)$$

$$APWT_{off\text{-}peak} = 23.471 + 0.299\ (TT_{off\text{-}Peak}) - 9.916\ (TB) \quad (5)$$

where,

TB: type of bus (0: mini-bus, 1: micro-bus).

The statistical characteristics of the models in Equations 4 and 5 are shown in Table 20. As shown in this table, the coefficient of determination ($R^2$) improved, but not significantly. $R^2$ value for the off-peak model improved from 0.673 (Eq. 3) to 0.718 (Eq.5). $R^2$ value for the peak model improved from 0.505 (Eq. 2) to 0.557 (Eq. 4). The effect of type of bus on APWT was found insignificant at α-level< 0.05. This can be explained by the big differences between mini-buses and micro-buses in travel distances and numbers of seats. At peak periods, the type of bus was found less significant than at off-peak periods. This may be related to the limited data points for micro-buses.

Table 21 shows the analysis of variance (ANOVA) for the regression models in Equations 4 and 5. It is clear in this table that the regression relationships were found significant at α-level< 0.05 at peak and off-peak periods. The results indicated that the APWT depends only on the travel time, which means that Equations 2 and 3 are valid. This is consistent with the study of Algers et al. (1975), in which it was found that the waiting time values are between 7 and 12 times the value of in-vehicle travel times.

## CONCLUSIONS AND RECOMMENDATIONS

This research aimed at evaluating the performance of public transport bus services in rural areas during COVID-19. Fifteen external bus routes and five internal bus routes were taken as a case study in Jordan Valley. Interviews with passengers and drivers and field investigations were conducted to collect the required data. The performance measures which were used to evaluate the quality of service included availability, accessibility, comfort and convenience, reliability, waiting time, mobility, productivity and safety.

Based on the results of this research, the following conclusions can be drawn:

1. Most public transit users did not own a car, so most of them were captive riders.
2. More than a half of the public transport passengers are daily users.
3. About 77% of the public transport users in Jordan Valley made trips for work and education. The rest trips were for visits and entertainment, treatment, official transactions and other reasons.
4. The average waiting time for both the mini-buses and micro-buses at off-peak hours was twice and a half the waiting time at peak hours. Most passengers tend to wait longer if they were given the choice to pay more or to wait. According to the passengers' interviews, most of them tend to wait for 15 min. to 20 min. as a maximum waiting time. However, the passengers were not satisfied with the waiting time because they said that it was too long.
5. The average waiting times for the external routes at peak and off-peak hours were 22.67 min. and 54.67 min., respectively. For internal routes, the average waiting times were 12 min. at peak hours and 30 min. at off-peak hours.

**Table 20. Statistical characteristics of the regression models in Equations 4 and 5**

| Equation | Variable | Unstandardized Coefficients | | t | Sig. | R | $R^2$ |
|---|---|---|---|---|---|---|---|
| | | B | Std. Error | | | | |
| 4 | Constant | 11.756 | 4.072 | 2.887 | 0.010 | 0.746 | 0.557 |
| | $TT_{peak}$ | 0.150 | 0.052 | 2.874 | 0.011 | | |
| | TB | -5.011 | 3.544 | -1.414 | 0.175 | 0. | |
| 5 | Constant | 23.471 | 7.962 | 2.948 | 0.009 | 0.847 | 0.718 |
| | $TT_{off\text{-}Peak}$ | 0.299 | 0.073 | 4.109 | 0.001 | | |
| | TB | -9.916 | 5.991 | -1.655 | 0.116 | 00. | |

**Table 21. Analysis of variance (ANOVA) for the regression models in Equations 4 and 5**

| Equation | Source | Sum of squares | df | Mean of squares | F | Sig. |
|---|---|---|---|---|---|---|
| 4 | Regression | 695.942 | 2 | 347.971 | 10.677 | 0.001 |
| | Residual | 554.058 | 17 | 32.592 | | |
| | Total | 1250.000 | 19 | | | |
| 5 | Regression | 3738.283 | 2 | 1869.142 | 21.664 | 0.000 |
| | Residual | 1466.717 | 17 | 86.277 | | |
| | Total | 5205.000 | 19 | | | |

6. The minimum travel speed was found to be 30-40 km/h, while the maximum speed was found to be 90-100 km/h. A half of the passengers and drivers said that the average travel speed was appropriate.
7. The average operating ratio for the mini-buses was 1.38 and 2.09 for the micro-buses. The average

operating ratio for micro-buses was higher than that for mini-buses. This may be due to the increase in the yearly operating cost or the decrease in the yearly revenue.

8. All mini-buses adhered to the required fares for the external routes, but for the internal routes, only about 60% of the micro-buses followed the required fares.
9. 82.85% of the public transport users feel safe always inside the bus or at a stop station and when moving between buses.
10. The average perception of waiting time at off-peak hours was found twice that at peak hours, but the difference between average perception of waiting time and average willing waiting time at peak hours was too short in comparison with the difference at off-peak hours, which is related to the high flow of passengers at peak hours.
11. It was found that 40% of the external bus routes were within the range of LOS between C & D, 26.67% within the range of LOS between B & D, 13.33% within the range of LOS between B & C, 13.33% within the range between C & E and 6.67% within the range between D & E. Also, it was found that 60% of the internal bus routes were within the range of LOS between C & D, 20% within the range of LOS between C & E and 20% within the range of LOS C
12. The regression model between the average perception of waiting time (APWT) as a dependent variable and travel time as an independent variable was found significant at α-level < 0.05, with $r^2$ = 0.505 at peak periods and with $r^2$ = 0.673 at off-peak periods.

Based on the conclusions of this research, the following recommendations are presented:

1. Some bus routes need to increase the number of buses.
2. Responsible governmental agencies should construct bus stop stations, because most of the buses stop to load and unload passengers on the roads causing traffic congestion and therefore, they should provide amenities to improve the comfort of the bus users.
3. The government should establish a responsible institution to improve and organize micro-buses besides merging them in the public transit modes.
4. The operation of public transport should be scheduled to improve the quality of service.
5. The government should concentrate on intense censorship to monitor the bus routes, fare, loading and vehicle safety requirements. The competent authorities' role is to achieve integration between private (micro-buses) and public transport bus services.
6. Reducing seat density and using smaller vehicles will increase the comfort level that plays an important role in improving the service quality.
7. Demand responsive transport could be considered another choice to be used in rural areas.
8. Expanding the use of mobile phone applications could improve the mobility of public transit services, such as Uber and Kareem applications.
9. Micro-buses and car-sharing would be a good choice in rural areas with low population density.
10. The government should provide financing for local public-transport services to improve the conditions of stop stations and roads, monitor bus operation, increase the number of buses and hours of service and coverage of unserved areas.
11. In order to verify the results of this research, similar studies in the same area should be performed under normal conditions (after COVID-19).
12. Further research should be conducted to improve the predictability and check the non-linearity of the developed regression models. More external and internal routes (data points) should be added to achieve this task.

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