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QUANTITATIVE ASSESSMENT OF THE TRANSPORT DISADVANTAGE LEVEL

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Abstract: Although transport disadvantage is very widespread phenomenon which could influence various social groups, transport disadvantaged individuals are not affected by the same level of transport disadvantage. The aim of this paper is to determine numerical value, i.e. grade which will present the level of transport disadvantage. The research was conducted on secondary school students of the City of Zagreb. Young people are often considered as transport disadvantaged group. The level of transport disadvantage was estimated within the three segments of their everyday life (school activities, extracurricular activities and evening outings). Data were obtained through questionnaire of 826 secondary school students of the City of Zagreb. The level of transport disadvantage was determined based on the transport mode and travel time to certain activity. Based on the obtained numerical value (grade) students were differentiated as below-average and above-average transport disadvantaged students. In the segment of school activities, below-average transport disadvantaged students were mostly distributed in the city centre and around the city centre, while above-average transport disadvantaged students were mostly distributed in the peripheral part of the city. This kind of spatial distribution obtained for evening outings was somewhat less pronounced. Considering extracurricular activities spatial distribution of below-average and above-average transport disadvantaged students was not pronounced.

Keywords: transport disadvantage, level, grade, quantitative assessment, students, City of Zagreb.

1. Introduction

Transport disadvantage is a widespread phenomenon that can affect all social groups (Gašparović, 2017b). However, some social groups are in greater risk of being transport disadvantaged, including vulnerable groups such as children, older people, disabled, pregnant women, etc. (Murray and Davis, 2001; Stanley and Stanley, 2004; Dodson, et al., 2004; Hurni, 2006; Hurni, 2007). However, it can be assumed that not all transport disadvantaged individuals are affected by the same level of transport disadvantage. In spite of the mobility and accessibility problems, people differ in their living location, public transport provided being more or less frequent, the length of travel, the quality of the roads they travel on, the car ownership, financial status, etc. (Winter, 1994; Gašparović, 2016; Gašparović, Jakovčić, 2014).

The aim of this paper is to develop a method of calculating the numerical value of transport disadvantage. The method proposed is calculation of the grade that represents the level of transport disadvantage. The research was conducted on secondary school students of the City of Zagreb. Transport disadvantage is more pronounced at secondary school children compared to young children and primary school children. Small children and elementary school children do not have such a need for mobility as secondary school students, which is connected with distance from school, extracurricular activities, and leisure time (especially evening outings) (Hopkins 2010, Horton et al., 2011). The vast majority of secondary school students do not have the ability to drive a car, therefore, they depend on the organization and use of public transport, parents, friends, and taxi, or they will walk or use a bicycle (Gašparović, 2017a).

Method of grade determination is supported by several researches, especially by those concerned of children and young people. Thus, for example, Fyhri and Hjorthol (2009) determine indexes, i.e. grades in studying the influence of different parameters on child mobility for school activities, socializing with friends and leisure. Casas et al. (2009) also use grading to investigate the impact of transport based exclusion on the availability of life opportunities for children. D'Haese et al. (2011) use the method of determining grade of the impact of distance and environment criterias on the active journey of children to schools.

2. Methodology

The level of transport disadvantage of each individual was determined based on the transport mode and travel time to activity. The quantitative assesment of transport disadvantage level was carried out within three segments of students' life (school activities, extracurricular activities and evening outings outside their neighbourhood). The parameter of evening outing is processed in two sub-segments (travel to the evening outing location and return from the evening outing location). In case of students who attended more then one extracurricular activity, only one extracurricular activity was taken into consideration in the analysis. Also, some students attended evening outings outside their neighbourhood with multiple destinations, therefore, the most common destination they attended was taken into consideration.

Data required for this research were collected by survey questionnaire. It was performed in seven high schools in the City of Zagreb on 826 students (only students living in the City of Zagreb and without a driver's license were taken into consideration) of which 429 females (51.9 %) and 397 males (48.1 %). Survey included, among other issues the transport mode used by students and estimated time (in minutes) required to travel from home to the location of certain activity. The research was in line with the Code of Ethics of Research with Children (2003). A permission for the research was obtained from the Ministry of Science, Education and Sport of the Republic of Croatia and from the

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principal of each school. The survey questionnaire was anonymous and voluntary. Spatial analysis was performed using the ArcInfo 10 software. As a basis for spatial analysis, data from the questionnaire was used, most preferably the address of the student. Spatial coordinates of student addresses were taken from the "Digital Orthophoto Layer 2012" (DOF 2012) of the GeoPortal of the "Zagreb Spatial Data Infrastructure" (City of Zagreb, 2012). Quantitative assessment of the transport disadvantage level can be determined by following formulas:

$$TD_s = \frac{(m + b + f) + t}{2}$$

$$TD_{ex} = \frac{(m + b + f) + t}{2}$$

$$TD_{eo} = \frac{TD_{eot} + TD_{eor}}{2} = \frac{\frac{(m+b+f)+t}{2} + \frac{(m+b)+t}{2}}{2}$$

Where TD_s: Transport disadvantage level for school activities, TD_{ex}: Transport disadvantage level for extracurricular activities, TD_{eo}: Transport disadvantage level for evening outings, TD_{eot}: Transport disadvantage level for evening outings (travel to the evening outing location), TD_{eor}: Transport disadvantage level for evening outings (return from the evening outing location), m: Transport mode, b: Buffer 400 meters / 800 meters, f: Public transport frequency, t: Travel time to certain activity

For each parameter a grade was assigned to each student depending on which category they belong to. Thus, they were assigned a grade based on the transport mode used to travel to school, extracurricular activities and evening outings (according to data from the survey) as shown in Table 1. The grades are assigned in a manner that the best grade (1) was given to students travelling to the activity on foot, or by bicycle, in-line skates, skateboard and the like. Such a form of mobility is the healthiest, i.e. the most acceptable, and it is more likely that students live closer to a particular activity. If pupils had an option of using public transport or could be driven by another person and did not want to use it, but rather use a taxi instead, they were assigned grade 2. The assumption is that an individual had no financial problems to finance this type of mobility, meaning that transport disadvantage was not so pronounced in this case. Grade 3 was given to students driven by someone else, even though they had an option of public transport. This kind of mobility is not as expensive as a taxi, but requires a person with financial and time opportunities to drive a child. The next grade (4) was assigned to a student using public transport to get to the activity. The worst grade (5) was assigned to a student who had to travel by car or taxi because there was no possibility of public transport (lack of it or it was too far). In the end, if a student could not access activity due to transport, one was received a grade 6.

Table 1
Transport mode grades

Grade	Transport mode
1	On foot, by bicycle, by in-line skates, by skateboard
2	Taxi due to comfort and simplicity
3	Car, though student has the possibility of using public transport
4	Public transport (tram, bus, train)
5	Car or taxi because they had no possibility of using public transport
6	Can not access activity due to transport

Source: Survey

For research purposes, and especially for students using public transport to access activities, GIS was used to determine buffers of 400 meters around each public transport station for daily public transport and of 800 meters for night public transport. In this case, the relationship between students' living location and its position inside or outside the buffer was determined.

As public transport operates according to the timetable, it was necessary to define the public transport operation time frame, i.e. time frame for its stations. For each public transport station, the average number of departures per hour was calculated, to differentiate the stations according to average numbers of departures (below or above) in relation to the students' activity. Calculations were made according to the official timetables of the Zagreb Electric Tramway and the Croatian Railways. As the frequency of departures of the tram transport was considerably higher in relation to bus and railway transport, for this mode the average number of departures in one hour was not calculated, but was rather assumed that all tram public transport stations had above average number of departures.

In order to calculate the public transport frequency for school activities, all the values of departures at the particular bus or train station were summed up from Monday to Friday (school days) from 06:00 to 07:59, from 11:00 to 15:59 and from 19:00 to 21:59. These periods were determined according to the survey on the basis of students' information about traveling to school and return home. It should be noted that some secondary schools of the City of Zagreb have the possibility of organizing early class in the morning shift (from 07:10) and in the afternoon shift (from 13:10). Also, some regular school classes in the afternoon shift start at 13:10 so the early class in these schools begins at 12:25. For both, bus and rail transport, values were divided by 10 (number of hours in period of traveling to school and return from school).

Extracurricular activities take place all days of the week, and therefore, the values of all departures of bus or railway transport on a particular public transport station were summed, and the values obtained were divided by 7 and then by 21. As it was obtained by the survey that some extracurricular activities began even at 7:00 am and some late in the evening, the traveling time frame for the extracurricular activities was taken to be between 05:00 am until 01:59 am (i.e. until the end of daily public transport). Due to the size of the City of Zagreb and its transport system, and the time spent on extracurricular activities, the average number of departures was taken in a slightly more extensive form.

The evening outings outside the neighborhood (e.g. in a disco club, cafe bar and such) was divided into two sub-segments. The average number of departures values for a particular bus or train public transport station were considered separately: travel to the location of evening outing and return to home from the location of evening outing. Since students were engaged in evening outings on every day of the week, the total value of all departures of the bus or railway transport on certain station was divided by 7 and then by 6 (number of hours pertaining to the journey from home to the place of the evening departure). The survey found that students travel from home to the location of evening outing between 18:00 and midnight. In order to evaluate the night transport of the City of Zagreb, it was assumed that students who use public transport return from evening outings in the time when only night public transport operated. Therefore, for the bus and train public transport stations, the average number of departures on a particular station was not calculated, but stations were differentiated according to (non)operation of night public transport.

The grading were performed as follows: for student who used one of the public transport mode for a particular activity, the value of 0.5 was added if student lived outside the buffer around the public transport station and if public transport frequency at the station was below the average. As stated before, for the returns home from evening outing, public transport frequencies were not taken into consideration, but only data on (non)operating of public transport on a particular station were taken into account; therefore, for the students who returned by public transport, and it did not operate on their station, the value of 0.5 was added to their score. If the student declared that one was unable to access any activity because of transport, one was directly assigned by the highest grade (6). It should be noted that nearest public transport station was considered while not doing the differentiation in regards to the direction of lines of public transport. This procedure was used by Hurni (2006).

In addition, students were also assigned a grade based on the time distance between living location and the activity. The advantage was given to time distance in relation to the spatial distance. The reason for this is the assumption that such a measure was more suitable for this research because of the organization of public transport of the City of Zagreb, and the entire transport system, as well as some physicalgeographical factors that may affect the travel within the city (primarily relief). It should be noted that travel time values were taken directly from the student's statement in the surveys and represent the total time needed to travel from home to certain activity. For students using public transport to access an activity, this represent total time including waiting time at the station as well as walking from home to the station and from station to activity. For students who travelled by car or taxi, this included time spent in the traffic jam or waiting for taxis to arrive. Consequently, grades were given on the basis of the following classes as shown in Table 2. The UNESCO publication "Education for all" (Module A4) was used when defining the classes.

Table 2
Travel time grades

Grade	Travel time (in minutes)
1	od 0 do 15
2	od 16 do 30
3	od 31 do 45
4	od 46 do 60
5	> 60

Source: Survey

At the end, the values were summed and divided by two because two parameters were present: transport mode and travel time. This provided a grade (quantitative value) of transport disadvantage for a particular activity.

3. Results and discussion

Arithmetic mean of the final grades of transport disadvantage was calculated to further analyze the problem. In this regard, students were classified in the categories of above- and below- the average transport disadvantaged students, depending on the activity they attended (school activity, extracurricular activity and evening outing).

The arithmetic mean of transport disadvantage grade for achool activities was 3.431. Out of 826 pupils attending school, 287 students were classified as below the average transport disadvantaged (grades between 1.000 and 3.250), while 539 students were above the average transport disadvantaged (grades between 3.500 and 5.000). Their spatial distribution is shown in Figure 1.

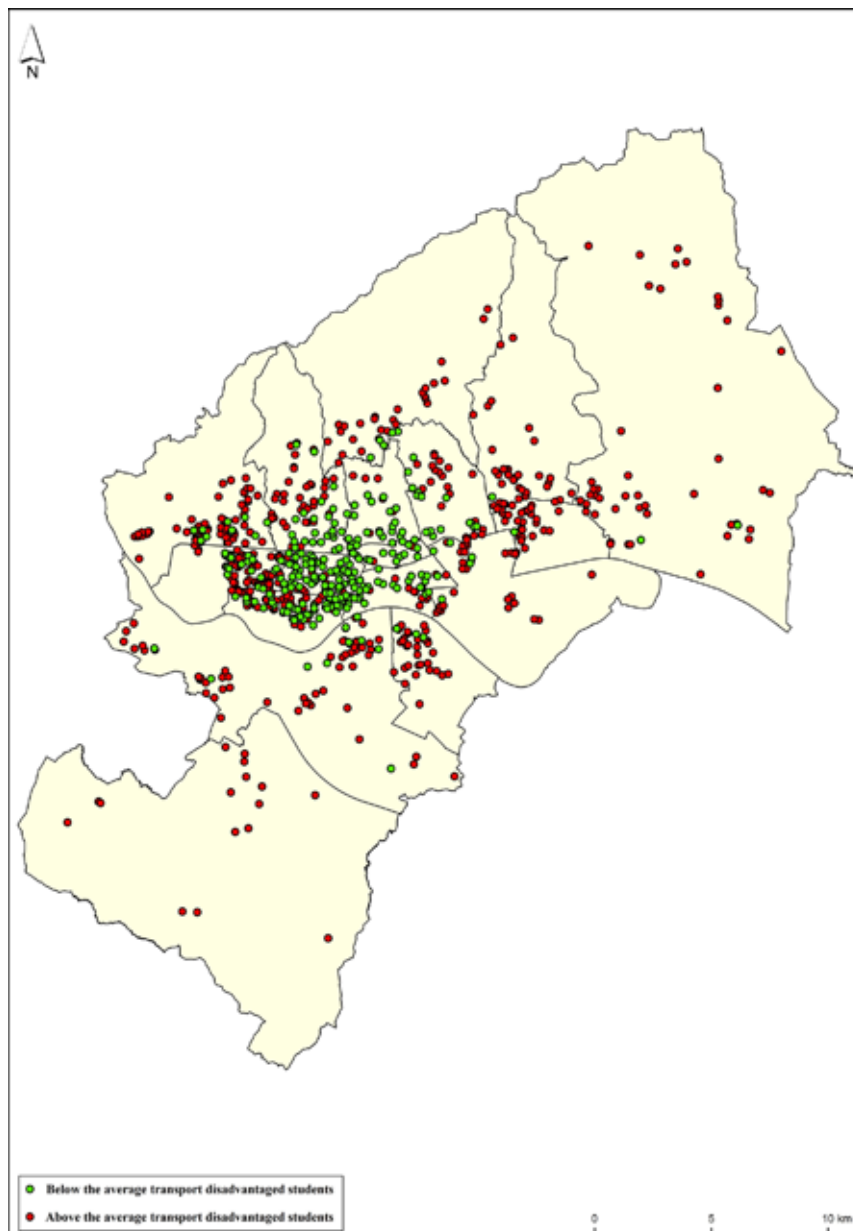


Fig. 1.
Spatial distribution of transport disadvantaged students (school activities)
 Source: Survey

Analysis of Figure 1 showed a significant polarization of students with regard to the level of transport disadvantage. Below the average transport disadvantaged students were largely grouped in the wider city center and partly in the western part of the city. Above the average transport disadvantaged students were concentrated in the areas of the city periphery, especially in southern, eastern and northern parts of the city.

These are more peripheral areas of a city where public transport is less developed (fewer lines, less frequent), and the overall transport infrastructure is not sufficiently developed (Gašparović, 2017a). Students living in these areas will have more problems with school activities such as school trips (late to school, significant travel time loss) and academic success (which can be lower compared to students living closer to the city center or in areas with better developed public transport) (Gašparović, 2014).

According to the survey, 380 students were engaged in extracurricular activities. The arithmetic mean of the grade of transport disadvantage was 2.473. Based on the arithmetic mean, 144 students were classified as below the average transport disadvantaged (grades between 1.000 and 2.000), and 236 students belonged to above the average transport disadvantaged (grades between 2.500 and 4.750). Attending extracurricular activities depends on a whole set of objective and subjective factors (e.g. child motivation, financial status, etc.). The offer of extracurricular activities is large and the locations of extracurricular activities are highly scattered throughout the city. Therefore, some students traveled shortly to the location of extracurricular activities in relation to the school. Spatial distribution of the mentioned students is shown in Figure 2. There was no noticeable spatial concentration of students as in the case of school activities, which is expected result due to the factors mentioned above.

However, it could be noticed that fewer students were engaged in extracurricular activities living in the southern parts of the city, which was heavily transport disadvantaged space itself (Gašparović, 2017a). Transport was certainly a factor that impacts students from that part of the city to participate in less extracurricular activities. (Gašparović, 2017c).

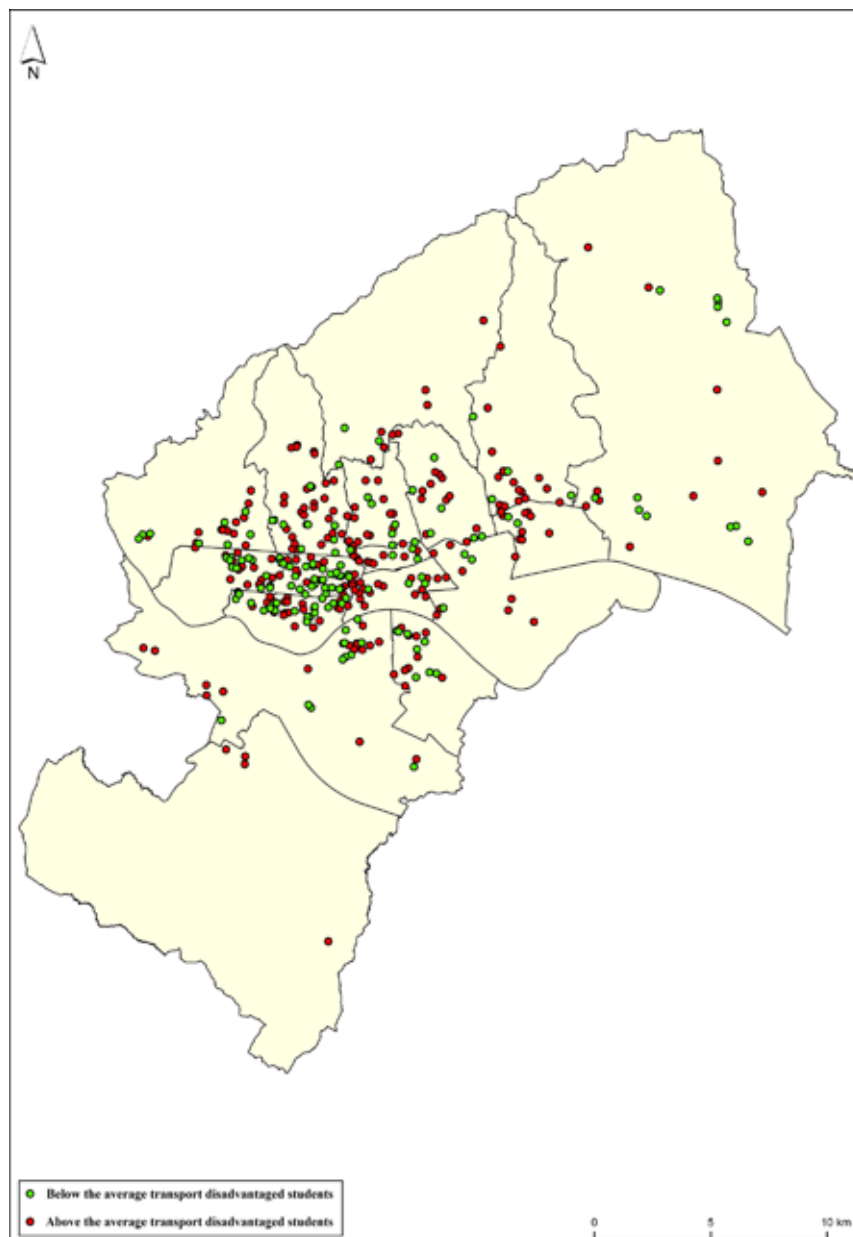


Fig. 2.
Spatial distribution of transport disadvantaged students (extracurricular activities)
Source: Survey

The arithmetic mean of the grade of transport disadvantage for evening outings was 3.056. Out of 714 students who were engaged in evening outings, 344 were classified as below the average transport disadvantaged (grades between 1.000 and 3.000), while 370 students belonged to above the average transport disadvantaged (grades between 3.125 and 4.875). Their spatial distribution is shown in Figure 3. Similarly to the extracurricular activities, not all students participated in the evening outings. Engagement in evening outing depended on various objective and subjective factors. However, although the locations of evening outings were dispersed all over the city, unlike extracurricular activities, a certain concentration of below the average transport disadvantaged students can be observed in the wider city center. Also, above the average transport disadvantaged students can be observed in peripheral parts of the city (southern and eastern part).

Students living in these peripheral parts of the city faced the problem of lack of public transport, later arrival to the home, with the need for early departure from the evening outing and of ensuring transportation (friends, parents, taxi...). (Gašparović, 2017b).

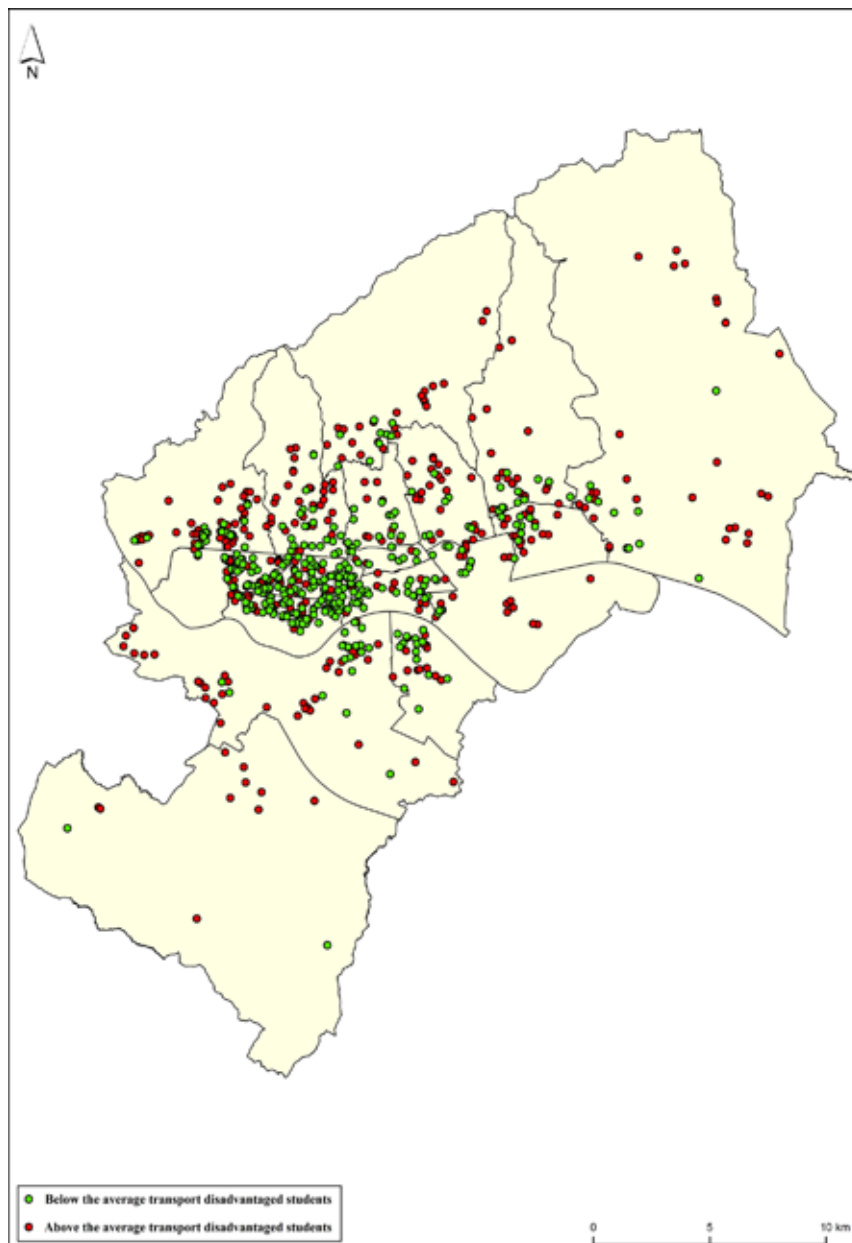


Fig. 3.
Spatial distribution of transport disadvantaged students (evening outings)
 Source: Survey

4. Conclusion

Transport disadvantage affects many social groups and is present in everyday life. However, transport disadvantage does not affect equally all individuals from a particular social group. These results showed that transport disadvantage did not affect equally all students, and depended on their activity. This paper attempted to quantitatively calculate the level of transport disadvantage for certain student activities. The paper itself opens up a series of questions and possibilities of research: should it include some other activity in calculating the quantitative level of transport disadvantage, how to calculate a common grade of transport disadvantage, can the same methodology be applied to other disadvantaged social groups (e.g. older people, disabled, etc.). These issues should include a multidisciplinary approach to research that should, as a result, reduce transport disadvantage and improve the quality of life of an individual and achieve transport and social justice.

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