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PARKING AND TRAFFIC AT A LOCAL UNIVERSITY

GEORGIA N. L. J. POLACEK

CAMILLE SHAWNTEY GRAHAM

James Madison University, Harrisonburg, Virginia

ABSTRACT

Students arriving on campus for the academic year often bring their personal automobiles. This then leads to an increase in traffic, which has many health implications. To understand students' driving and parking behaviors on campus, traffic and parking lot counts were performed and a parking survey was administered to randomly selected undergraduate students (N = 1120). Results of these methods revealed primarily single occupancy vehicles in use, almost 70% of participants made multiple trips to campus and drove alone, and parking lots were not equally utilized. Convenience and safety were reasons given for driving. Efforts to improve traffic and parking are underway.

INTRODUCTION AND REVIEW OF LITERATURE

College campuses impact the communities in which they reside through ebb and flow of students and changing patterns of traffic and congestion. As students arrive on campus for the beginning of the school year, they often bring their personal automobiles as well. In a community of less than 50,000 and with a university of over 18,000, this increase in automobile traffic can be up to an additional 10,600 cars, which can have many health implications. The purpose of this article is to describe how students commute to campus and their decision-making processes surrounding their commute. Health implications of these behaviors are discussed.

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Air Pollution

One of the biggest byproducts of increased traffic is increased auto emissions (Moeller, 1992). These emissions are primary components of air pollution. Air pollution is the contamination of the atmosphere. Factors that influence air pollution in any given location are climate, population, industry, air flow (jet stream), seasonal pollens, and ozone (Friis, 2007; Moeller, 1992; Morgan, 1997). Mobile sources of pollution are automobiles. Poor air quality is the result of air pollution (Moeller, 1992).

Components of air pollution include carbon monoxide, lead, nitrogen oxides, ozone, particulate matter, ozone, and sulfur dioxide (Friis, 2007; Moeller, 1992; Morgan, 1997). Of these, carbon monoxide, nitrogen oxides, and sulfur dioxides are produced from the burning of fuel in the combustible engine, specifically automobiles (Moeller, 1992). Particulate matter is a by product of diesel fuel combustion. Ozone is a secondary pollutant that is formed from nitrogen oxides, volatile organic compounds, and other chemicals in the presence of sunlight (Moeller, 1992). It is not the beneficial ozone that provides protection from ultraviolet radiation but a pollutant formed at ground level (Friis, 2007). Each of these components are health hazards, in combination they have synergistic effects (Hilgenkamp, 2006).

Health effects of air pollution can be mild to severe, depending on the amount of exposure over time and the susceptibility of the individual exposed (Brunekreef & Hogate, 2002; Hilgenkamp, 2006). Air pollution is an irritant to the respiratory system (Hertz-Picciotto, Baker, Yap, et al., 2007; Roemer & Wijnen, 2001). Shortness of breath and difficulty breathing are the first symptoms of exposure. The human body has many mechanisms to reduce the possibility of damage by air pollutants (Friis, 2007; Moeller, 1992; Morgan, 1997). However, pollutants can and often do remain in the body. In the lungs, air pollution components cause tissue irritation which can lead to permanent cell damage. If the particles infiltrate the blood system, they are carried to vital organs where further damage can occur (Moeller, 1992). The liver, spleen and kidneys are at increased risk. Increased mortality from all causes has been correlated with increased levels of air pollution (Brunekreef & Hogate, 2002). There is a strong association between air pollution and asthma, and air pollution is suspected as a factor in lung cancer and heart disease.

Since the introduction of the automobile as a main source of convenient transportation, air pollution within the United States and throughout the world has increased at alarming rates (Friedman, Powell, Hutwagner, Graham, & Teague, 2001). Air pollution, mostly caused by human behavior, includes any undesirable substance that enters the atmosphere (Air pollution, 2009). While the effects of air pollution are a greater issue in major cities, the pollution caused by transportation contaminate air everywhere (Air pollution, 2009). The Agency for Toxic Substances and Disease Registry (ATSDR) cites the most common ground gaseous pollutants as "carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, and ozone," all of which can be results of automobile exhaust (Air pollution, 2009, p. 1). Ozone, an automobile pollutant, can "penetrate into the small airways and alveoli . . ." (Moeller, 1992, p. 80). It can damage the tissues within the lungs, causing reduced function, in addition to sensitizing the lungs to various irritants (Moeller, 1992). Ozone levels also affect people who have impaired respiratory systems, such as asthma, emphysema, or chronic obstructive pulmonary disease (Moeller, 1992). Perhaps the most common form of air pollution is smog. This term refers to the condition that results when "the action of sunlight interacts with exhaust gases from motor vehicles . . ." (Air pollution, 2009, para. 5). Smog is a visible component of air pollution and allows us to see the air we breathe.

Another component of air pollution that is problematic to health is particulate matter. Particulate matter is generally used to describe a combination of solid particles and liquid droplets that are found in the air (Air pollution, 2009). Particulate matter ranges in size and can be seen as smoke or can be microscopic, detected only using an electron microscope (Air pollution, 2009). Particulate matter (PM) causes irritation and damage to the lungs when inhaled (Air pollution, 2009). The size of and exposure to particulate matter is also associated with various health complications. PM of diameter of less than 10 µm (PM10, PM 2.5) is particularly problematic (Brunekreef & Hogate, 2002).

The lung's consumption of carbon monoxide, ozone, PM, and nitrogen oxides can lead to injury and death, depending on the physical and chemical properties of each (Friis, 2007; Moeller, 1992; Morgan, 1997). Though the body has several mechanisms to protect itself from air pollutants, some pollutants will still be deposited in the body resulting in chronic damage to vital organs, such as the liver and the kidneys (Moeller, 1992). Several studies have shown that there is a link between elevated levels of air pollution, decreased lung function, and increases in heart attacks (Air pollution, 2009). In Boston, Massachusetts, nitrogen dioxide and PM 2.5 was associated with life threatening arrhythmias and myocardial infarctions in a large group of patients whose exposure were higher in the days or the hours prior to the event (Brunekreef & Hogate, 2002).

College Campuses

Because college campuses are generally found in communities, the increased amount of automobiles with students' arrivals causes an increase in auto emissions, thus affecting the air quality of any community. Therefore, college campuses are beginning to seriously consider these effects and take measures to reduce their impact in the larger community.

For example, many of the college campuses in the state of California have policies about student automobiles but also provide pedestrian friendly environments to discourage driving (Balsas, 2003; Torr & Havlick, 2004). The University of Texas, Austin, with a student population of over 50,000, has policies restricting students' driving on campus (About UT, 2008). Student vehicles are identified by parking decals and they are not allowed onto campus, but must park in peripheral parking lots. They also have a very comprehensive mass transit plan that allows students to ride the city buses anywhere in the city for free, with their student IDs, and provide designated shuttles to and from campus (The University of Texas at Austin, 2008). The university studied here is a growing liberal arts institution with an enrollment of over 15,000 undergraduate students. Freshmen (approximately 3000/year) are required to live on campus, which restricts their ability to bring their automobiles. These students do not generally add to the automobiles in the community. However, as sophomore, juniors, and seniors, the majority of these students do have automobiles. The parking and traffic congestion that occurs on campus can be very problematic, despite the fact that the majority of off-campus student housing is within a one-mile radius of campus and much of that is within a half mile radius. Additionally, the campus has grown over the years and is now bisected by a major freeway. Students must traverse the campus regularly, or several times a day, to attend classes and faculty and staff must do so as well. Therefore, to better understand transportation decisions of students, traffic counts, parking lot counts, and a student parking survey were conducted over the academic year 2007-2008.

METHODS

To understand how students arrive on campus, where they choose to park, and why they make multiple daily trips to campus, data were collected over the 2007-08 academic year. Traffic counts were performed at various intersections to determine frequently used modes of transportation. Parking lot counts were performed to determine which parking lots were used most and least. A parking survey was administered via the Internet to randomly selected undergraduate students to determine their decision making processes with respect to commuting to campus and parking. The survey was approved by the University's institutional review board for protection of human subjects.

Traffic Counts

Two intersections for entering/exiting campus selected and were counted on various days throughout the week. Data for the traffic counts were collected by students of two different academic classes in the Fall of 2007. Vehicles were monitored by students every 15 minutes in various entrances of the campus Monday through Friday, from 7:00 a.m. until 7:15 p.m. in 2-hour blocks. Commuters were identified as single occupancy vehicles (SOVs), high occupancy vehicles (HOVs), motorcycles, bicycles, and pedestrian. Common forms of transportation onto the campus as well as the traffic patterns at the two intersections were observed. An adjustment factor of 2.14 was made for HOVs due to the difficulty in determining the number of people in each HOV. An adjustment factor of 8.93 was used for the buses on Monday and Wednesday, and 7.66 on Tuesday and Thursday. Monday and Wednesday were paralleled for analytical purposes with Tuesday and Thursday. Traffic counts were provided for Friday as well; however, the data was not included due to data insufficiency.

Parking Lot Counts

Selected parking lots were counted on various days. Faculty, Resident, and Commuter parking lots were observed; however, the lots of interest were primarily used by students. One lot was counted each day with an initial count taken each morning at 8:00 a.m. and then throughout each hour following the initial count until 5:00 p.m. Students were divided into groups of two and were directed to perform parking lot counts for 1 hour Monday through Friday from 8:00 a.m. until 5:00 p.m. For record keeping purposes, students were provided with counting sheets to document when vehicles were entering or exiting the parking lots. Students were instructed to perform counts at a recommended 20 feet away from all road ways. Specific lots were observed on more than one occasion in hopes to yield a more accurate reflection of lot activity. This method of observation paints a clear portrait of which lots experience high occupancy and which lots are being neglected.

Parking Survey

A survey asking students about their parking lot choices, arrival and departure times, how they chose the lots in which to park, and how many and why they made multiple trips to campus was created using WebSurveyor. All e-mail was sent to a random sample of undergraduate students, inviting them to access the webpage containing the survey and complete it. A raffle for a $50.00 gift card from the university book store was offered as an incentive. Those respondents who were interested in entering the raffle were directed to another page to provide their names and e-mail addresses. The survey was not accessible from the raffle page and the link to the raffle page was only provided at the end of the survey. Student respondents ranged in age of 18-25, freshman to seniors. One thousand twenty-two completed surveys were received and analyzed. Five hundred eighty-seven students were eligible and entered in the raffle. No duplicate entries were allowed. Questions of interest included from "have you purchased a campus parking permit?," "how many days a week do you drive to campus?," "do you make multiple trips to campus each day?," "if so, how many?," and "where do you usually park?" Respondents were also asked to identify changes that would motivate them to drive less by using alternative transportation methods.

RESULTS

Peak Traffic

Intersection 1

Monday and Wednesday saw a much greater flow of traffic in and out of campus at this intersection. SOVs (42) and HOVs (15) were the primary modes of transit. Peak times for entering were 9:00 a.m. and 12:00 p.m., peak exit times were 12:00 p.m. and 3:00 p.m. Tuesday and Thursday was much less constant. The most common mode was SOVs (45) which entered campus at 7:30 a.m. and left at 5:00 p.m. This intersection was the main route to two of the student parking lots.

Intersection 2

This intersection is one block from a university parking deck (Parking Deck 2). Monday and Wednesday saw more pedestrians (121) and bicycles (100) than vehicles. These entered campus at 9:00 a.m. with subsequent peaks at 10:15 a.m. and 1:15 p.m. Peak exit times were 10:00 a.m., 1:15 p.m., and 4:15 p.m. Although SOVs were not as numerous entering campus, 70 were counted exiting at 4:45 p.m. Tuesday and Thursday saw peak pedestrian entrance times at 7:45 a.m. (100), 9:30 a.m. (210), and 1:00 p.m. (160). Peak exit times for pedestrians were 1:00 p.m. (100) and 2:15 p.m. (80). SOVs peak entrance time was 7:45 a.m. (60) and exit times were 10:00 a.m. (42) and 2:15 p.m. (45).

Parking Lot Utilization

Selected faculty and student lots were counted and analyzed. The intent of studying these parking lots was to calculate the flow of vehicles entering and exiting the lots. Doing this allowed us to gain accurate statistics concerning the traffic trends in each parking lot counted. The map provided (see Figure 1) shows the campus boundaries and selected lot locations.

Lot A, which is a commuter lot located on the southwest corner of campus, was counted on Wednesday, January 23, 2008. This lot consists of 137 total spaces. There was a large influx of vehicles between the hours of 9:00 a.m. and 2:00 p.m. The lot reached capacity by 10:00 a.m. The data collected showed that at 11:00 a.m. there were more cars exiting the lot than entering the lot due to lack of parking spaces. This lot experienced frequent activity during the middle of the day as well.

Lot B, also a commuter lot located on the east periphery of campus, was counted on Thursday, January 24, 2008. This lot has 349 spaces available. Between 8:00 a.m. and 11:00 a.m., the lot reached capacity and remained so for the following 3 hours. Spaces did not open up until 2:00 p.m.

Figure 1. Campus and selected parking lots.

Lot C, a commuter lot located on the west end of campus, was counted Monday, January 28, 2008. It has 132 total spaces. At the initial 8:00 a.m. count there were 62 spaces available, and by 9:00 a.m. there were no spaces available, causing more traffic to enter the lot than exit the lot. By 11:00 a.m. the spaces began to gradually open but then decrease once again. More spaces became available at 3:00 p.m.

Lot D is both a residential and commuter lot, located on the east side of campus, across the street from Lot B. This lot consists of 704 spaces. At the initial 8:00 a.m. count, this lot had almost half of its spaces available. Between 11:00 a.m. and 3:00 p.m. there were more cars entering, searching for a space, then leaving, resulting in traffic that never finds a space. Spaces did not become available again until late in the afternoon.

Lot E is a residential and commuter lot, located on the southeast periphery of campus. This lot consists of 256 spaces and was counted on Monday, February 11, 2008. The initial 8:00 a.m. count found 70% of spaces were open. At 9:00 a.m. there were 135 spaces open. The number of spaces available began to decrease at 9:00 a.m. but there were spaces available all throughout the day.

Parking Deck 1, centrally located on the west side of campus, has 499 available spaces. This lot was counted on Tuesday, January 29, 2008. The ground level has spaces designated for Faculty and Staff, while levels two through five have spaces designated for commuters. This lot experienced moderate activity with spaces available during most of the day, with more space availability in the early morning hours and in the evening. However, the highest occupancy time for this lot was between 1:00 p.m. and 2:00 p.m.

Parking Deck 2 is the largest parking lot area at the university. It is located off campus, slightly north and across a major street from main campus. This parking deck consists of 784 total spaces. This lot has a computerized counter located at the entrance, with the ground level and level two designated for faculty and staff parking, while levels three through five are for commuter parking. At the 8:00 a.m., the initial count found 30% of spaces were occupied. Between the hours of 9:00 a.m. and 1:00 p.m. space availability continuously declined with 180 spaces consistently available between 11:00 a.m. and 1:00 p.m. More spaces became available between 4:00 p.m. and 5:00 p.m. This parking deck never reached capacity.

Lots with fewer available spaces were Lot B between the hours of 9:00 a.m. and 2:00 p.m., Lot C between the hours of 9:00 a.m. and 1:00 p.m., and Lot D between 10:00 a.m. and 3:00 p.m. These lots either had no spaces available or they had negative availability meaning that cars enter the lots looking for spaces that were not available and would then leave.

Parking Questionnaire

The Student Parking Questionnaire provided interesting results. The responses analyzed here focused on how students arrived to campus, how many times they drove to campus, which parking lots they frequented the most, if they currently had a parking pass and their main reasons for parking lot selection. Of those who participated in the survey, 65.5% of them made multiple trips to campus on any given day and the majority of these students drove to campus by car alone. Seventy-six percent of students made two trips to campus, 17.5% made three trips to campus, approximately 4.0% made four trips to campus, less than 1.0% made five trips to campus and 2.0% made six or more trips to campus. Students responded that they could be motivated to reduce the number of trips to campus per day if they had better class schedules (28.5%), if there were better bus schedules (15.4%), and if they had incentives to ride the bus (7.3%). Twenty-two percent of students responded that they could not be motivated to reduce their number of trips to campus. Of the students who chose to carpool, 22.0% carpooled one to two times per week and 7.5% of students reported doing so three to five times per week. Exactly 70.0% of students answered "I don't carpool," and 20.2% of students neglected to answer the question. Of those who did not drive to campus, approximately 30.0% utilized the city bus system, 7.0% rode their bikes, 1.4% carpooled, and .4% got dropped off by a friend. Of those students who didn't use a vehicle, 61.0% of them walked as their primary source of transportation.

When students drove to campus, over 50% of them drove to campus 5 days a week, 22% drove 4 days a week, 16% drove 3 days a week, 7% drove 2 days a week, and a little less than 1% drove 1 day a week. The most popular reasons for why students chose to drive to campus over other methods of transit were largely due to "convenience" (22.6%), followed by "bus schedules are not compatible" (10.7%), "time" (9.7%)., "work schedule" (2.9%), and "other" (5.2%). The follow-up to this question asked the respondents to specify why they selected "other." The most frequent response was that there was "no bus route available" (40.0%), followed by "bus schedules do not work" (23.0%), "I live more than 30 minutes away" (20.0%), and finally, "I need my car for work" (7.0%).

When arriving at campus, students selected Parking Deck 1 first, followed by Lot F, Parking Deck 2, and Lot B. Students determined parking lot preference mainly due to proximity to their first classes (65.8%). Other reasons for parking lot choice are "only space available" (10.2%), "It is easy to get on/off campus from this lot" (9.7%), and lastly, "It is easy to find a spot in this lot" (7.0%). Students were not as likely to look for parking in areas unfamiliar to them or near their last class. When these lots were full, participants sought parking first in Lot D (7.1%), Lot G (6.1%), and then Lot H (4.6%). The questionnaire found that most students arrived to campus 5-10 minutes before class and more than 50% of surveyed students had purchased a parking pass for the 2007-2008 school year.

In the last section of the survey students were asked to respond to a series of questions on the level that they agreed or disagreed with the statements. The choices were as follows: *Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree,* and *Strongly Agree.* Only a few of the responses are included here. When asked if they would carpool if guaranteed spots in prime parking lots, 58% of student respondents agreed or strongly agreed. The second question analyzed suggested the creation of remote lots that would be accessible by campus shuttles. Almost 63% either agreed or strongly agreed with this suggestion. The third question analyzed asked if students would be willing to park at more remote lots if permits for those lots were 30% less expensive. Sixty-four percent agreed and only 18% disagreed with the idea of utilizing a cheaper, remote parking lot. The fourth question inquired about electronic counters for open spots as found in Parking Deck 2, and 83% of respondents agreed with this idea. The final question analyzed from this survey dealt with the idea of restricting traffic on campus to faculty, staff, buses, shuttles, and student residents only. Less than half of students (48%) disagreed or strongly disagreed with this idea.

DISCUSSION

Traffic congestion and parking challenges are frequent complaints on most college campuses. As seen in the results, students generally chose to drive, alone, to campus, and many made multiple trips per day. To compare the traffic counts to the arrival and departure of students, data from the Student Parking Questionnaire Survey yielded some insight. Almost 70% of students reported making multiple trips to campus. The results suggest that the peak times seen throughout the day can be attributed to students arriving, leaving, and then returning to campus. Also, with a low percentage of students using non-motorized means of transit, as found in the Student Parking Questionnaire, it is no surprise that most vehicles reported were SOV's versus HOV's.

These factors do increase the amount of auto emissions into the air, contributing to air pollution and compromising air quality. Mass transit is available, however, as the survey results indicate, many respondents indicated that the buses were too slow, too full, or didn't run when they were needed. A comprehensive mass transit plan, created with the city's department of transportation, is needed. The university provides an influx of money into the community through the students living and going to school here. The city and the university need to coordinate bus routes with class schedules. Since many students live in specific areas off campus, buses need to travel to and from these housing complexes and the university on a more regular basis, instead of once per hour.

Because parking lots are not equally utilized, the university needs to consider a tiered parking system where students, faculty, and staff can pay less for parking in remote lots. University shuttles would have to be routed to these lots and primary locations on campus on a quick, regular basis (every 10 minutes) to allow those who park in the remote lots to get to classes, offices, etc. in a timely manner.

Health effects of air pollution are well established. Another health effect of personal automobile transit is encouragement of a sedentary lifestyle. Since many students live within a 1-mile radius from campus at this university, walking and cycling are tangible options. College students between the ages of 16-24 are ideal target groups for increased bicycle use and walking. Walking to campus can be advantageous for students. The average walking speed for young adults is under 20 minutes per mile. Walking provides health benefits for students by providing exercise and reducing their risk for obesity (Torr & Havlick, 2004). Since many students live within a 1-mile radius to campus, these students could walk to campus from their residences. Driving to campus several times a day only contributes to air pollution and does little to provide the physical benefits one could gain by walking or cycling (Torr & Havlick, 2004).

Two concerns expressed by students regarding walking to campus were safety and weather. There does not appear to be adequate pedestrian pathways from all housing locations to campus. Safety is a concern and must be considered in a transportation plan. Safe pedestrian pathways are necessary if walking as a mode of transit is to be encouraged. The weather is outside of anyone's control. However, barring extremes and frozen precipitation, clothing is manufactured that will decrease the weather effects on walking.

Cycling is also a realistic option for many students. The same concerns exist for cycling as for walking, safety, and the weather. An additional factor is the geographic make-up of the campus. The campus is large and there are many significant hills that must be traversed. Students are less likely to bicycle if they must exert significant physical effort. Showers and changing facilities are not readily available in most buildings. These are additional barriers to encouraging cycling as a form of transportation. The university should increase bike paths and lanes on and around campus. The university could also consider amenities for their cyclists, such as bike trailers and a bicycle service center for students who want to rent bikes, get repairs or purchase parts (Balsas, 2003). Finally, the layout of the campus must be more bike friendly.

The university made a commitment to sustainability by becoming a member of the Association for Advancement of Sustainability in Higher Education (AASHE). The university president has signed the Talloires Declaration and the American College (Association of University Leaders, 2008) and University Presidents Climate Commitment (American College, 2008). The university has established an institute for sustainability which is in the process of amassing, evaluating, and prioritizing the many sources of data already collected. The institute has begun planning appropriate projects to improve traffic congestion and parking on and off campus. These include raising awareness of students, faculty, and staff about traffic and congestion and promoting the use of alternative transportation, increasing accessibility of campus shuttles, and identifying other methods of moving the campus community residents on and off of campus.

CONCLUSION

These and other solutions are realistic and cost-effective. Adding parking lots or constructing parking garages only encourages increased traffic to campus and will not have a positive effect on the air quality of the community. Much information has been gathered to aid in making informed decisions for change. Concerted, comprehensive efforts are needed to improve air quality and reduce traffic congestion on and around campus. As we move toward the goal of sustainability, transit must be a primary consideration.

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Direct reprint requests to:

Georgia N. L. J. Polacek
Department of Health Sciences
James Madison University
MSC 4301, 800 S. Main St.
Harrisonburg, VA 22807
e-mail: polacegn@cisat.jmu.edu