Traffic Study

Investigation of the Overall Traffic Reducing Effect of Closing Sections of Nørrebrogade

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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Abstract

On October 1, 2008 two sections of Nørrebrogade, a busy street in Copenhagen, Denmark, were closed to private motor vehicles. This project evaluates the traffic fluctuation on Nørrebrogade and the surrounding side streets as well as the social impacts. Traffic data was analyzed from before and after the street closure and interviews were conducted to determine public opinion. To date traffic has decreased by 7.3% in the entire area, but the road closing has affected people and businesses in different ways.
Acknowledgments

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Authorship Page

Every member of the group provided input into the creation and editing of each section in the report. All of our thoughts are equally expressed as to provide a group insight into the problems expressed in this paper.
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Executive Summary

This project evaluates the traffic fluctuation on Nørrebro and side streets after the road has been closed to car traffic, and also the social impacts involved. The sponsors for this project, Agenda 21, are an organization that encourages sustainable development. There is a heavy emphasis on encouraging travel by means of bicycle, and public transportation in this organization. This project goes further than trying to just reduce traffic though. It is an effort to decrease air pollution, as well as try to change the way people travel. In America, we often think the solution to heavy traffic is to simply widen the road. From our research we have seen widening an urban road with heavy car traffic simply treats the symptoms of the problem. It will allow for more car traffic which will turn into a larger problem later on. We have also seen from our research that closing a city street to traffic entirely has proven to reduce traffic in the area around the closed street. The team has analyzed traffic counts that were taken by a contractor paid by the city, and has interviewed people on the streets in order to understand the public opinion of the current situation. Closing the road not only affects those who were driving on the road, but it can affect the commerce of local shops as well. This is a serious situation because the shops have built themselves around the previous infrastructure of the road, and now it has suddenly changed.

There is usually an opposition to such a drastic change, and sometimes the speculation of those who are against it can be wrong. In other European cities, similar road closings resulted in a prettier, quieter atmosphere where pedestrians were more likely to come out and shop. When Nuremburg, Germany closed a busy city road in the 1970s which carried 25,000 cars/16 hours it was forecasted this would result in chaos. At first, during 2 months after the closure, there was an increase in congestion in the area. After 4 months though, the traffic adjusted to the situation by finding alternative routes or changing their mode of transportation which reduced the congestion. Over the course of 11 years, they were able to determine 10,000 cars had disappeared in the area even though there was a rising amount of car ownership.

Traffic data has been collected twice since the road closing and once before the closing. A count was performed on major roads and most surrounding side streets in September of 2008 before the road closings. Then there was a traffic count at the end of October 2008, and then at the end of April 2009 which are both after the road closure. The data was processed and
analyzed from the street that was closed as well as surrounding streets in order to show where the traffic has gone.

Figure 1 shows a map with different sized bars that represent the amount of car traffic before and after the road closing. The area shown is in Southern Nørrebro which is where the first section of the closed road is located. Traffic has decreased on many of the roads, but in this map there is one that has had a significant increase. This could be due to travelers coming from the north, and leaving the road on Elmegade which is located right before the closed section of the road. This is good because it shows there some people are complying with the posted signs. The traffic increase on this road has not been large in terms in numbers though. Elmegade has seen an increase from 900 trips before the trial to 2100 trips after the road closing which results in a large percentage increase. The road is still fully capable to handle this amount of traffic.

Figure 1: Map of Traffic Fluctuation in Southern Nørrebro
We also quantified the total amount of traffic in the Nørrebro area before the trial and after the trial to determine the amount of traffic evaporation. The data has shown there has been a 7.3% decrease in the overall personal vehicle traffic in the area. Prior to the trial there were 205,000 trips during the hours being counted, and after the road closure there were only 190,000 trips during the hours being counted, which is equivalent to about 15,000 fewer trips made in a day.

Interviews were conducted with multiple groups of people to analyze the effect of the road closure on their lives. We had interviewed 10 people of each group in order to get a strong representation of their attitudes towards the road closure. The groups of people we have interviewed are listed below:

- Car Owners
- Cyclists
- Pedestrians
- Bus Passengers
- Shopkeepers

These groups of people were all asked similar questions except for the shopkeepers whose questions related to the welfare of their respective businesses. 50 people were interviewed to collect the impression of the public.

During the interviews with 50 people traveling or working on Nørrebrogade we have also been able to gather an impression about how the population of people in the area feels about the road closing. Each different group of people interviewed had a different opinion on the road closing. Cyclists and pedestrians generally approved of the road closing more due to the fact that many of them feel safer with fewer cars on the road now. Car owners tended to dislike the road closing because it is harder for them to travel on the road since they now must find a way around the restricted areas. Many shopkeepers also tended to disapprove of the road closing since many of them have been seeing a decrease in business and they blame it on the lack of cars in the area. Around 70% of shopkeepers interviewed have seen a decrease in business, while the others have had about the same retail activity. Since taxes are very high in Denmark, a loss in business is more detrimental to the economy since the city will be receiving less money from the businesses.

Many people feel the road can be improved in a few different ways currently. Firstly, there are still cars traveling illegally through the restricted areas which only increases traffic and can
cause problems with buses or emergency vehicles having to get through those areas. In order to solve this problem we recommend that either there be permanent barriers that retract into the road installed if cost effective, or increase the number of tickets given to drivers that violate the restrictions. Both of these options should dissuade drivers from violating the car restriction on the road better than the signs that say “Through traffic prohibited for cars and motorcycles; buses on route are accepted” currently in place. The problems with these implementations is that either the city would have to pay a large amount of money installing the road blocks, or the police will need to designate more of their time handing out tickets on the road. Due to the nature of the shops on the road we also recommend that there be certain hours during the day that cars could travel freely on the road. These hours would be after the initial morning rush hour, and before the evening rush hour. This could either be a few hours each evening, or perhaps even during the entire weekend. Since we don’t have traffic data from hours after 7 or on the weekends, it is hard to recommend a specific time to open the road to cars. This could help shops maintain business that usually require customers to carry heavier products that could be troublesome while walking or cycling. The downfall for this implementation is that those people that take advantage of these open road hours may be more inclined to violate the road restrictions during the closed hours. If the permanent barriers were installed, the implementation of the open road hours wouldn’t be a problem since cars would be blocked out when the road is no longer open to private cars.
1 Introduction

Urban traffic congestion is a growing problem which stems from an increase in private transportation, such as cars. Cars with single drivers crowd the road space which increases the volume of traffic on a given road. Public transportation is much more space efficient since it is able to carry a large number of passengers in a single vehicle. A bus may hold up to 75 people and a car may only have one occupant. When an efficient public transportation system is utilized, the amount of car traffic decreases. This happens when public transportation provides a quality of service that approximates what previous drivers are used to. (ECMT, 2007) Large amounts of traffic cause many problems within a city. Cars and other motor vehicles emit particles that contribute to the increase in air pollution, which can cause an increase in respiratory problems. Motor vehicles also contribute to noise levels and vibrations in urban areas. This can cause decay of buildings near it, which is especially undesirable in places with historic buildings. (Wallström, 2004) Traffic congestion has many negative impacts on society including an annual delay per peak period driver of 47 hours. The total amount of delay due to traffic congestion was 3.7 billion hours in 2003. Idling engines in traffic result in 2.3 billion gallons of wasted fuel per year. (Schrank, David, Lomax, Tim. 2007) Safety on the street and near the street is decreased with a large volume of traffic as well.

Multiple methods have been tested in the attempt to reduce the amount of traffic in the urban centers of a city. One of these methods includes reducing the road capacity, or going as far as to shut down the road completely to vehicle traffic. When road accessibility is restricted, commuters need to find another route or change their mode of transportation.

In Denmark, the city of Copenhagen has been experimenting with closing roads in order to reduce traffic since 1962. This major city has been a pioneer in traffic reduction, which they have adopted for many years with great success. After seeing the success in Copenhagen, other European cities have adopted these policies as well. Some of the other cities that have experimented with road closures to reduce traffic congestion include Kajaani, Finland and Wolverhampton, England. In both of these cases a major road was closed completely only to personal vehicles, such as cars, and this resulted in a decrease in car transportation around the area of each street closure. Public transportation usage and reliability also increased soon after the closings. (Wallström, 2004) Public transportation methods can carry more passengers than a
car for a given road space such as a bus or in the case of trains and metros, use no road space at all. (ECMT, 2007) This transforms the once busy congested road into a more beautiful and desirable place to visit. Although there are many cities that use street closures as a method to reduce urban traffic, there are some controversies that arise due to them. It is usually harder to make deliveries onto a road if it is closed off to traffic completely. If there are a number of commercial buildings, such as stores or restaurants, on the street this could cause a problem for them. Residents that live on or near a closed road may also have difficulties reaching their home when driving a car. Retail activity is sometimes affected by the road closure, but this is not always directly related to the reduction of vehicle traffic. There are many other variables that could be affecting the traffic, but it is the shop keeper’s first notion to blame the street closing. The other variables that exist include the economy, weather, strength of currency, and quality of the products.

When the plan for the street closure is first presented to the public, there is usually a strong resentment for the plan. This resentment comes from the idea that closing the street will just cause all of the existing traffic to move to other streets which will increase the traffic in many more streets. The public generally does not give thought to other aspects of the closing which actually causes the traffic to decrease. (Wallström, 2004) It is also difficult to measure the traffic fluctuations on side streets since it is challenging to predict what other routes travelers will take, and how large of a study area is needed to account for the traffic redistribution. A noticeable trend from other studies show that there is a slight increase in traffic on neighboring streets as the commuters are looking for an alternative route to take. After a few months though, there is evidence that the traffic on the side roads decreases due to travelers finding other modes of transportation other than just a private car. The long term effects show similar results as people may move to be closer to work, which allows for them to use more sustainable forms of transportation. (Kane, 2000)

In Copenhagen, Nørrebrogade was closed at two different intersections to car traffic on October 1st, 2008, but buses and emergency vehicles have still been allowed to travel through these restricted parts of the road. The goal of this road closing was to reduce the amount of private motor transportation, including personal vehicles along with taxis, as well as to promote the use of public transportation and more environmentally-friendly forms of transportation such as cycling and walking. Agenda 21 is interested in investigating the impact of the road closing
on traffic fluctuation on Nørrebrogade and the surrounding side streets as well as the social impacts derived from this action. They are hoping to determine if this is a viable method to implement on other streets in the city by analyzing the decrease in traffic, as well as public opinion about a road closure.

In order to accomplish this objective traffic counts have been conducted on three different occasions, before the closing in September, a few weeks after the closing in October 2008 and April 2009, about six months after the closing. This data has been used determine change in traffic volume of cars, buses, cyclists, and pedestrians. The initial results of our study, conducted comparing traffic data from September 2008 with that of April 2009 show that car traffic has decreased by 7.3% in the entire Nørrebro area surrounding Nørrebrogade. There has also been an increase in cyclist traffic since the closure. (COWI, 2008) This seems to be a common effect initially in other cases that involve a road closure.

The goal of this project is to examine how traffic and people in the neighborhood have been affected six months after the closing two sections of Nørrebrogade. This study investigated the change in traffic volume along Nørrebrogade, and its surrounding streets, as well as the effect this closing has had on other means of transportation chosen by the people. This study relies on traffic counts provided by the city. The study is also based on personal interviews conducted with local travelers and pedestrians to hear their opinions on the closing; this information has been used to assess the public acceptance of the project. The interviews with pedestrians have also been used to inquire about any suggestions the public may have for the road closing.

The total amount of traffic was quantified in the Nørrebro area immediately surrounding Nørrebrogade before and after the trial to determine the amount of traffic evaporation. The data has shown there has been a 7.3% decrease in the overall personal vehicle traffic in the area. Also via interviewing those who use or work on the street we have found that cyclists, bus passengers, and pedestrians tended approved of the closing whereas car owners and shopkeepers had a tendency to dislike the closing.

There are still cars traveling illegally through the restricted areas which only increases traffic and can cause problems with buses or emergency vehicles having to get through those areas. The team has provided recommendations to enhance the project and compromise with the problems seen by those who were interviewed. In order to remedy the problem of cars still traveling through the closed sections, we suggest installing speed bumps at the entrance and exit...
of each busgade. This will hopefully be effective enough to eventually reduce the amount of illegal trips through these areas to zero. We also recommend having certain hours where private car traffic is allowed to travel through these zones in order to accommodate shops whose retail sales have suffered on account of the closing.
2 Background

This chapter has details about the research we have done before conducting this traffic study. The information in this chapter explains what we were expecting to encounter while working on this project.

2.1 Agenda 21

This section explains what Agenda 21 is, and how they came to be. It also describes what Agenda 21 does not only Copenhagen, but in other countries as well. Agenda 21 is the sponsor of this project and it is important to understand what they are looking for in the completed project.

2.1.1 History

In 1992 nations from around the world met to address the issues of the environment as well as development. The conference, United Nations Conference on Environment and Development (UNCED), delegates approved the Rio Declaration on Environment and Development. This was a statement of twenty-seven principles for sustainable development (Kushner, 2003). Also accomplished by this conference was the plan called Agenda 21 which was based largely on the Rio Declaration on Environment and Development and had a main focus on sustainable development. Agenda 21 was to ensure that the efforts of UNCED would be followed in each country.

From November 2000 through December 2001, a survey was implemented globally to gauge the progress of local Agenda 21 campaigns. For this survey, Local Agenda 21 was defined as “a participatory, multi stakeholder process to achieve the goals of Agenda 21 at the local level through the preparation and implementation of a long-term, strategic plan that addresses priority local sustainable development concerns.” (ICLEI, 2002) From this survey it was found that 6,416 local authorities in 113 countries had already or were currently in the process of making an official commitment to Local Agenda 21. At the time of the survey there were national campaigns taking place in 18 nations, which accounted for 2,640 processes. Of the complaints from the local authorities on obstacles between them and their success, the most commonly occurring were a lack of not only financial support, but a lack of political
commitment from national governments. It was found that the nations’ economic situation did in fact not have an effect on the financial or political support in most cases (ICLEI, 2002).

2.1.2 Purpose

Agenda 21 was divided into four sections dealing with social and economic issues, conservation and management of natural resources, the role of major groups, and the means of implementations (Kushner, 2003). To keep track of individual nations and ensure that they were still following the Agenda 21 plan, the Commission on Sustainable Development was created and set to review overall implementation. Since 1992 laws limiting and controlling pollution have been implemented in many countries and have made the land, air, and water safer for those living there. The goal of Agenda 21 is to create more sustainable societies, which many countries around the world are interested in. The U.N. defines sustainability as “meeting the needs of the present without compromising the future generations to meet their own needs.” (United Nation, 1987.) Agenda 21 is run locally instead of on a central authority which allows them to meet the needs of their local communities more specifically.

2.1.3 Role in Denmark

In the survey done November 2000-December 2001, Denmark reported having 216 Local Agenda 21 organizations. At that time, in Europe, there were 8 national campaigns with a total of 2,011 local Agenda 21 processes as opposed to North America where there were no national campaigns or Local Agenda 21 processes. (ICLEI, 2002).

Copenhagen Agenda 21 focuses mainly on the environmental aspect of sustainability. According to the Copenhagen Agenda 21 pamphlet, citizens of Copenhagen would like to decrease air pollution as well as noise from traffic; they would also like to decrease environmental health risks and increase the quality of life. (Copenhagen Agenda 21, 2004). The Local Agenda 21 of Copenhagen itself has four main goals that it strives to achieve. First and foremost, as is consistent with the purpose of Agenda 21, they are focusing on sustainable development in Copenhagen. Next, they are hoping to achieve open communication, cooperation and coordination with the local community so that they are able to achieve their objectives. Without the public’s input and help, accomplishing their goals will be a very difficult task. They are also hoping to encourage people to make more environmentally friendly decisions on a daily basis. Finally, the Local Agenda 21 would like to see Copenhagen reduce
its use of local as well as global resources by decreasing actions of environmental consequence. (EPA, 2006).

2.2 Nørrebroade Street Closing

Nørrebroade is a street in Copenhagen that the mayor has planned to close for three months as a trial. This trial is designated to improve bus and bicycle traffic on the road that normally carries 33,000 cyclists, 65,000 bus passengers, and 17,000 private cars per day. (Isherwood, 2008) Only 30-40% of the residents on Nørrebroade own cars which means the traffic isn’t a local problem. The goal of the project is to make Nørrebroade a more attractive place to visit and move around in. They also wanted to improve the use of public transportation, increase the number of cyclists, and beautify the city more. The primary goals were to improve conditions for bicycle traffic and bus services in the form of more space and slightly higher travel speeds. It was assumed in order to achieve these goals the amount of car traffic would have to be reduced, without significantly increasing traffic on the side streets. The street has had problems flourishing even though a large amount of vehicles travel down the road every day. (Copenhagenzine, 2008)

Figure 2: Nørrebroade’s first day of closing (Isherwood, 2008)

The road was officially closed on October 1, 2008, and has road signs set up to block out car traffic in order to test the project. Above in Figure 2 this is a picture of one of the closed sections of the road. It can be seen that there are still multiple cars driving on the road at that
instant. The road is closed in only two different locations on the street. These locations are between Esromgade and Farumgade, and also between Elmegade and Fælledvej. Private transportation is allowed to still travel on Nørrebrogade between these two points, but is not supposed to drive through them. The road signs posted at the entrance of each of these sections can be seen in Figure 3. Translated into English these signs roughly say “through traffic prohibited for cars and motorcycles – buses on route are excepted”.

Figure 3: Signs on Nørrebrogade Marking Closed Sections

If a car wanted to travel on Nørrebrogade, they would have to turn onto the road after one of these points and exit the road before these points as well. The points at which the road is closed can be seen in Figure 4. The red marks on the map represent where cars are not supposed to travel.
Traffic counts were conducted on Nørrebrogade, and also surrounding streets which helped to quantify the fluctuation of traffic on the roads. The data was first collected prior to the trial in September 2008, and lasted for 3 weeks until October 2008. Data collection was targeted to the most congested periods during the morning and afternoon swarm times during the weekdays. Table 1 shows what the researchers were looking for on Nørrebrogade and other side streets near there. They were looking at each type of transport and certain aspects that could be affected from the road closing.
Table 1: Data collected for evaluation of traffic impact (COWI, 2008)

<table>
<thead>
<tr>
<th>Street(s) being observed</th>
<th>Cars Driving</th>
<th>Bus Routes and Passengers</th>
<th>Cyclists</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nørrebrogade</td>
<td>Traffic Volumes</td>
<td>Traffic Volumes</td>
<td>Traffic Volumes</td>
<td>Traffic Volumes</td>
</tr>
<tr>
<td></td>
<td>Parking/stopping Behavior/Observation</td>
<td>Travel Speeds Behavior/Observation</td>
<td>Travel Speeds Behavior/Observation</td>
<td>Traffic Volumes</td>
</tr>
<tr>
<td>Major Roads</td>
<td>Traffic Volumes</td>
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<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Local Roads in Nørrebro</td>
<td>Traffic Volumes</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The information the researchers were looking to collect can be seen below:

- Counts of traffic volume (Before and during the experimental period)
    - Recorded from 8:00 to 10:00 am, and 4:00-6:00 pm.
  - Manual control count
  - Counting of bus passengers on Nørrebrogade for a three week period.

- Travel Velocity Measurements (Before and during experimental period)
  - GPS records of buses on Nørrebrogade in a three week period
  - GPS records of cyclists on Nørrebrogade

- Other observations (Before and during experimental period)
  - Detailed mapping of bus traffic pattern on Nørrebrogade in morning and afternoon rush hours for three week period
  - Observations of behavior at bus stops, extended bicycle paths.
  - Parking and stopping on Nørrebrogade and new loading zones.
Motorists had little time to get used to and understand the new traffic situation since the placement of the road signs. It is estimated road users need at least 1-2 months to find a new way to move on the road after the implementation of drastic changes such as a street closure. Before the initial closing, researchers estimated a 40 to 50% decrease in cars on Nørrebrogade eventually.

There have been a few changes on the street which were designed to help reach the intended goals of the project. The car and bus lanes were narrowed on the Dronning Louises Bro and the bike lanes were expanded on each side of the bridge. The bicycle lanes on the bridge are raised slightly higher than the motor vehicle travel lanes so that they can use the full bike lanes without worry. All vehicles are allowed to travel over the bridge, but since the lanes are narrowed, the volume of traffic that can be handled on the bridge is reduced. They narrow lanes may also help to reduce the travel speed of the cars which would also increase the safety on the bridge.

Where the sections of the road were closed, there have been changes on the road which narrow the street so only one bus can get by at a time. This is used to discourage other forms of motor traffic to travel on these parts of the roads. These two sections of the road are called the busgade. One of these busgades can be seen in Figure 5, which lies between the two streets. One can also see where signs are placed to block private traffic from entering onto the road. There was a lane created in between the bicycle lane and bus travel lane which allows for bus stop passengers to wait in these busgades. The yellow markings in Figure 5 represent these new bus lanes. These new platforms can also be seen being used in Figure 6. People can wait for the bus, and exit the bus safely since they have their own lane just for bus traffic. They don’t have to wait for cyclists to travel by before they get off now. These lanes helped to narrow the road so that it made it harder for excess motor traffic to get through. There are also the normal walking pathways on the other side of the bicycle pathway as well so there is plenty of room for walking pedestrians.
Additional traffic data was collected for 3 weeks during late October and early November 2008. These studies were conducted about a month after the trial was initially started. So far the data has shown that there have been small traffic increases in roads parallel to Nørrebrogade, but most of the increases are small, and no larger than 10%. Nørrebrogade has seen a large decline in traffic percentage of approximately 40%. This number is very close to the estimate the researchers were looking for in their estimates prior to the study. Traffic on the side streets
seems to have increased from as low as 1% up to 13% at first, but this is most likely due to travelers trying to find different routes to take. This increase is generally seen when a road has recently been closed. Also, the researchers were expecting an increase on the major side roads parallel to Nørrebrogade, which are Åboulevard and Tagensvej. Tagensvej has seen a 13% increase in one section of the road which is higher than desired, but this is subject to change with time. This increase wouldn’t affect traffic much due to the large capacity capability of these roads.

Figure 7: Traffic fluctuation on Nørrebrogade and side streets from November 2008 (COWI, 2008)
The percentage of traffic fluctuation on Nørrebrogade and other side streets can be seen in Figure 7. The red marks on the map represent the places where the road is closed to car traffic. Those red marks are also where the busgades are located.

Most drivers have complied with the ban, but there are still a few that travel on restricted areas. There are still drivers that enter onto the street, or cross the street at intersections where they are prohibited. In April 2009, a spot check was conducted on one of the closed sections by the newspaper, metroXpress. They recorded that 97 private vehicles drove through the restricted areas between the times 1:30 to 2:30. This number included cars, vans, and taxis. It is important to note that the road is only restricted by signs as of now, which some drivers may not notice or choose to ignore. Also the number of illegal journeys has a relation to how sensitive the police are to enforcing the closing. If there are no fines issued, then many drivers will think it is still alright to violate the prohibitions. There is a 500 Kroner fine in place for those who choose to drive through the restricted areas. When the metroXpress was conducting their spot check, none of the vehicles driving illegally through the restricted areas were stopped by the police. There have only been a few cases of tickets being issued as of now, which means the police are relatively relaxed.

It has been recorded that there has been a decrease in bicycle traffic volume since the closing, but it is more likely not due to the closing. There is a much larger seasonal variation for bicycles compared to cars, but it can also be due to the generally large variation in bicycle traffic volumes. A census shows that cyclist traffic volumes are generally 20% lower in November then they are in September. With this percentage correction, the results show there was actually a 15% increase during the trial. Pedestrian traffic is also affected by seasonal changes, but pedestrian traffic has not changed since 2005 which shows it is unaffected by the experiment so far. There may be an effect on the pedestrian traffic after a longer period of time and generally during the warmer weather.

Travel times have not changed significantly enough to point to a clear change of travel time. Cyclists have been shown to have a slightly shorter travel times usually in both the morning and afternoon travels. Cyclists also used to face congestion on the bicycle paths, but the path extensions have allowed faster cyclists to pass slower ones. There used to be over one hundred bicyclists waiting at a red light when crossing over the bridge, but now there is more room for travel with the lane extension. The extension is a little lower than the old path, so if
cyclists choose to pass other cyclists they generally choose to stay on the new path. This causes conflict though if they choose to cross over from one path to the other. By monitoring the buses traveling speeds and running times, there has been evidence showing travel times have been reduced by approximately between 14 to 92 seconds.

The old road setup caused some bus travelers to miss the bus, or hold the bus up due to the cyclist path being in between the road and the bus stops. People also had a hard time exiting the bus since they had to wait for the bicyclists to pass by before exiting. The new bus stop platform allows bus passengers to wait next to the road instead of on the sidewalk. This causes fewer holdups caused by the cyclists, and fewer accidents between cyclists and bus passengers. Buses have also been able to travel their routes on time since they are held up by less traffic.

Overall the trial period has been fairly successful. Traffic has been drastically reduced on Nørrebrogade, and the traffic increase on the side streets has not been significant enough to cause problems in traffic flow. Bus passengers have an easier time boarding and exiting the bus, and cyclists have a larger path to ride on. These results are from the beginning of the trial, and they will change with time. These changes will most likely result in an even larger decrease in car traffic, and possibly a slight increase in bus passengers and bicyclists. Additional information pertaining to the Nørrebrogade closing can be seen in Appendix A.

2.3 Effects of Traffic Reduction

Large amounts of traffic have numerous side effects that are either harmful to our health, or cause unwanted problems. These include increased road congestion, noise and air pollution, excess vibrations, increased travel times, and an increase in traffic accidents. Large amounts of traffic are also a visual disturbance which could lower the appeal of a city to visitors. Decreasing the amount of traffic will help improve many of these conditions which will be favorable for everyone wherever there are cars. A study performed in March 1999 showed that as air pollution increased, respiratory disorders worsened. It was also found that car emissions can also cause circulatory system issues such as anemia, or cytopenia. (BBC, 1999)

2.3.1 Travel Time

There is an obvious relationship between the travel time of a trip, and the amount of traffic on the route being taken. With increased traffic, the travel time will increase due to reduced speeds of travel. Travel time can also increase due to car accidents, or mechanical
failure which also correlates to increased traffic in the area. This problem stems from increased traffic volume, and the lack of road capacity to carry this volume. Although the number of licensed motor vehicles has continued to increase, traffic is still able to move without coming to a standstill except for a few serious cases. This is due to people who would change their home or workplace if having to commute each day in large amounts of traffic. Also, they could be taking a train instead of a car or bus, or just stay at home. (Smeed, 1967) An increase in travel time can cause delays which can result in late arrival for a job, meeting, or education which can result in lost business. In traffic it may also be hard for emergency vehicles to get to the destinations they urgently need to arrive at which can result in a loss of lives in serious cases.

### 2.3.2 Air Quality

A growing concern in today’s society is air quality, and an increase in harmful greenhouse gases. Although car manufacturers are striving to produce smaller, more fuel efficient cars, emissions from cars continue to increase due to increased vehicle use. Car exhaust accounts for nearly 80% of the air pollution in an urban environment. The exhaust from all the vehicles in an area combines to produce adverse effects on all people nearby. Cars release greenhouse gases as well which are responsible for climate changes. Just a few chemicals in a car’s exhaust include: Carbon Dioxide, Carbon Monoxide, Nitrogen Dioxide, and Sulfur Dioxide. Breathing in gases such as carbon monoxide, and nitrogen dioxide on a regular basis can result in an increased risk to form respiratory diseases. In traffic, wasted fuel increases air pollution due to increased idling, acceleration and breaking. It is important to reduce emissions from vehicles, and one of the easiest ways to do this is to reduce traffic by removing cars from the road. (Living Space, 2008).

### 2.3.3 Safety

Strategies that reduce total vehicle mileage, reduce traffic speeds, or provide an incentive for safer driving tend to be effective at reducing vehicle crashes. In Storuman, Sweden there was a study conducted that involved traffic calming procedures and the impact on safety. The traffic calming was aimed at reducing the total amount of cars traveling on the road, and also reducing the average traveling speed on the road as well. In order to get this effect, they reconstructed the road to slow down car drivers speeds. During the trial, traffic speeds were reduced by 2-3.5 km/h for passenger vehicles, and 2-3.3 km/h for heavy vehicles. Also, when collecting data six
months after the initial reconstruction it was found that travel speeds were even lower than initially. They also observed who was given the right of way on the road when comparing pedestrians and cars. Before the trial, 32% of pedestrians were given right of way from car drivers, but after the road reconstruction 72% of pedestrians were given right of way. The numbers for cyclists was also significantly improved from 6% before the trial up to 84% during the trial. In interviews with pedestrians and cyclists traveling on the new road, 78% considered the road safer than before. (Leden, Wikström, Gärder, Rosander, 2006). Another study conducted in Oslo, Norway found similar results. The researchers applied traffic calming methods to residential areas located close to central business districts. These methods included installing speed humps, street closures, turning bans at junctions, street narrowing, or one way streets. The results of this study found that there was a 15-20% reduction in the number of car accidents in the whole area affected by the area wide traffic calming schemes. On local roads there was a larger decrease in accidents which was about a 25-55% reduction than on main roads which saw an 8-15% reduction. (Elvik, 2001)

2.3.4 Retail Activity

After a street closure, the road generally becomes a more peaceful and prettier place than before due to less car traffic filling up the roads in many cases. This would cause more pedestrians to go out and enjoy the area. This increase in pedestrian traffic on the road would generally help retailers improve their business. In the closing of a road in Kajaani, Finland, a survey of 190 retailers found that 52% of them felt the road closing had improved or would improve their business. In Ghent, Belgium a similar road closing found similar results. The road became a large pedestrian area where festivals, art shows and music events are commonly held. This also attracts more activity in the nearby shops, where cars can no longer bother the pedestrians. An increase in retail activity is not always the case though. When Strasbourg, France closed their city center to private car traffic, many retailers believed the closing would hurt their businesses. They said pedestrians would have a harder time getting to the shops since cars would have a hard time getting through. The studies showed that after the road closure that there was no significant loss in business for retailers, and some business have actually seen an increase. There were also parking charges introduced on certain streets to encourage more efficient parking, which also seemed to improve business around those areas. In Cambridge, England there was no significant increase in retail activity after a city center closure. There was
no significant loss of retail activity either, so business stayed about normal compared to pre-road closing. Monitoring retail activity based solely on a road closing is not a very accurate study though. There could be many more factors involved that could affect the activity. Examples of this could include weather, strength of currency, quality of products, or general economic situations. In one case in Oxford, England, there was a slight decrease in retail activity for a year after the road closure. This is not blamed on the road closure though considering most retailers had been showing similar situations due to the high value of the local currency which affected the number of foreign tourists. (Wallström, 2004)

2.4 Traffic Reducing Methods

It has been widely held in literature on travel behavior that motorists are most likely to adapt their behavior when faced with significant changes to the cost of, or constraints upon their travel choices. Both induced and suppressed traffic have been observed to occur in situations where a change in road capacity causes a significant change in the generalized cost or attractiveness of car travel. In the first few days of road changing the drivers adjust their driving styles in order to deal with the new traffic conditions. Within the first few months many people start to reroute their trip or reschedule departure times. The long term effect, up to five to ten years after a capacity change, has responses that usually lead to changed form of transportation, trip frequency, or trip destination, and even trip origin. (Kane, Behrens. 2000)

2.4.1 Road Expansion

When a road capacity is increased, after a few months trips are attracted from previously quicker, but now slower routes within a network. Also trips are rescheduled to a more preferred departure time, which is usually later, in response to the initial relief in congestion. In the long term, due to the reduced generalized cost of travelling by car may cause to some people taking trips by car that were previously travelling using other methods. This might also result in more frequent trips, or farther trips due to an increase in the average travel speed. Even though the road may be wider now, more cars would decide to take that road which causes an increase in traffic. (Kane, et al. 2000) As more and more people continue to drive on the same section of road, traffic starts to build up from the increase in car volume. Also with an increase in road capacity, there can be a business increase around the area which could lead to even more unexpected traffic. A good analogy to use for traffic induction has to do with economics.
Typically the demand for an item increases as its price decreases. If this is true, then transport demands also increase with falling prices. The price in this analogy isn’t just a monetary value, but also a function of time in order to establish the true cost of transport demand. If there is a decrease in travel time, the price of driving decreases, which means the demand to drive will then increase. (Verron, Huckestein, Penn-Bressel, Rothke, Bolke, Hulsmann, 2005) A study conducted with respect to California state highway capacity showed that 60-90% of increased road capacity is filled with new traffic within five years, and also total vehicle travel increased 1% for every 2-3% increase in road capacity. The researched concluded that it appears that adding road capacity does little to decrease congestion because of the substantial induced traffic. (Litman, 2009) Also in a study of eight new urban highways in Texas, there was evidence of induced traffic at six of the locations which represented 5-12% of the total corridor volume.

2.4.2 Road Closings

Generated traffic can also work in reverse; when urban roadway capacity is reduced a significant portion of previous vehicle traffic may disappear altogether. (Litman, 2009) When traffic conditions change and the capacity of the road is decreased, it is usually seen that traffic has been observed to driver slower and closer together depending on the amount of forewarning received by media prediction of traffic chaos. After a few months, trips are re-routed to neighboring roads, or trips are rescheduled to an either an earlier or later departure time to avoid the worsening congestion. After a few years, people may choose to use non-motorized or public transport instead of their cars due to an increase in congestion at first. This would also decrease the number of non-essential trips, linking previously separate trips into chains, or finding closer destinations to travel to. There are many case studies which help to provide evidence to this theory as well. (Kane, et al. 2000) Researchers collected evidence from over forty locations using traffic counts on the impact of capacity reallocation as a result of bus lane implementation, pedestrianisation, maintenance, structural repairs, or natural disasters such as earthquakes. The results averaged out to an overall reduction in traffic on the network of 25% of the traffic previously using the road or area subject to the capacity reduction. (Kane, 2000)

2.5 Traffic Studies

Traffic studies are used to find the impact of traffic on a given road, or network of roads. There are a few different reasons why a traffic study could be used to evaluate traffic. These
include forecast additional traffic associated with new development, help to ensure safe and reasonable traffic conditions on streets after the development is complete, or evaluate traffic behavior and route preferences.

2.5.1 Purpose

Traffic studies are usually needed when there is a project or development in a part of a city that may influence traffic. These would be necessary when closing a city street, adding a street, or building new homes that will cause more residents to commute and add traffic to the existing streets. They could also be used when a street is closed due to building development on a street which needs to be blocked off for the construction. Traffic studies are not needed for every development project though. It is necessary to gather data about a given section of road while conducting a traffic study, and then to forecast future traffic, which is used to determine the new requirements of the road. Traffic volume studies are used to determine the number, movements, and classifications of roadway vehicles at a given location. It is important to collect data around the peak hours of the road due to the increased traffic volume which could lead to backups or accidents during a worst case scenario.

2.5.2 Tools and Equipment

One of the main methods of collecting traffic information involves traffic volume counting. There are several methods in which to count cars, and they can be used to measure different volumetric aspects of traffic. The two main methods for counting traffic volume are manual and automatic. Manual methods are best for gathering data regarding vehicle classification, turning movements, direction of travel, pedestrian movements, and number of passengers in a vehicle. Automatic counts work best to gather data for determination of hourly vehicle patterns, daily or seasonal traffic growth, or to estimate annual traffic. (Smith, 2002) Automatic methods are starting to be capable of performing some of the tasks that manual methods are generally used for though.

2.5.2.1 Manual Counting Tools

There are multiple options to choose from when conducting a manual count. One can either use a tally sheet, mechanical counting board, or electronic counting board. Tally sheets are a pre-prepared document on which one places tally marks over a given interval of time. Mechanical counting boards have counters mounted on a board which records each direction of
travel. Each counter has up to five buttons which allows the user to account for different vehicle or pedestrian travel. A stopwatch is required for the previous two examples in order to time the sample period. The sample periods usually only last around 15 minutes each and several samples are taken during the day. It is usually more efficient to have two or more people conducting the study so one observer can tell the other information to write down, or tally. This allows the other investigator to concentrate on keeping tally so there are fewer mistakes. The last manual option is an electronic counting board. This board is similar to the mechanical counting board, but it is battery operated and is lighter, more compact, and easier to handle. They also have an internal clock which helps keep track of the sample period so there is no need for a stopwatch. One can also download the data onto a computer which saves time when it comes to the data processing. Figure 8 shows what an automatic counting board can possibly look like. The surveyor would press one of the gray buttons on the sides in order to indicate which direction a car was turning in an intersection, and it would keep a count of how many times each button is pressed. (Smith, 2002)

![Automatic Counting Board](image)

**Figure 8: Automatic Counting Board (Smith, 2002)**

### 2.5.2.2 Automatic Counting Tools

Automatic traffic counts are usually more accurate, but they are also more expensive to set up. There is much more electrical equipment needed compared to manual methods which can raise the expense, but they are generally more accurate. The sample periods are usually taken for one hour intervals every 24 hours, and can last from weeks up to years. With the automatic count, the peak flow period can easily be identified and quantified. The three main methods of automatic counters are portable counters, permanent counters, and videotape. Portable counters use pneumatic road tubes, and a base station that records the data. These counters have a tube
running across the street which counts each time a car passes it. Permanent counters are used when conducting a study over a long period of time. They are much more expensive compared to portable counters since additional equipment and installation is necessary. They usually consist of an inductive loop placed in the road which senses when a car passes over it, and the loop needs to be imbedded 18 to 24 inches under the pavement. They are capable of detecting the speed, length, and even the occupancy of the vehicles. (Garber, 2009) The last type is video cameras, which can record an intersection or road, and then the video can be review later to collect specific data. This is similar to a manual count, but none has to actually be present on the road during the counting periods. (Smith, 2002)

2.5.3 Origin and Destination Study

Origin and destination studies are used to evaluate the travel patterns of vehicles on a given road. These are important when there is a substantial change in the road structure which could cause traffic to behave differently. The origin and destination study is used to analyze the length of trips and try and figure out the route the driver was taking. There are a few methods in which the surveyor can find the information they are looking for in the study. These mainly involve collecting data from drivers which means multiple interviews will be necessary. The larger number of driver samples collected, the more accurate the study will be. There are four common methods for collecting this type of data. This first one is a registration questionnaire which includes questions about the drivers travel habits. First a driver list from the vehicle registration form must be obtained from the Department of Motor Vehicles, and each person is sent a questionnaire to the address listed with a return date requested as well. The next is the post card method in which a pre stamped post card with questions on it is distributed to as many drivers entering the area in question as possible. A traffic volume count would usually be conducted along with these types of studies. Next there are the road side interviews. There should be interview stations set up on the side of the road, and each interview should last no longer than 40 seconds. The goal of roadside interview is to interview 50% of vehicles during non peak hours, and 25% of vehicles during peak hours. The last method is a comprehensive home interview. This method usually provides the most detailed data, but is a little harder to conduct. It is similar to the roadside interview, but more time is available to conduct the interview. The data for each of these tests should usually be expanded to represent a 24 hour time frame. With this data a route volume map can be constructed, which is used to portray the
volume of cars traveling on the road, and the direction of travel as well. Figure 9 shows what a route volume map could look like. The thicker lines indicate more traffic on the road, and the arrows show the direction of travel. (Pike, 2004)

![Route Volume Map](image)

**Figure 9: Route Volume Map (Pike, 2004)**

### 2.6 Case Studies

There are many cases in which a city street or city center has been closed to either all traffic or just private cars. These case studies may help us understand what the effect of closing a road has on the total amount of traffic, and also the amount of traffic that moves to side roads. They could provide insight to the effects we could possibly see while conducting our research in Copenhagen, and what we should be looking for.

#### 2.6.1 Copenhagen, Denmark

Strædt, a street parallel to Strøget, which is a famous pedestrian street in Copenhagen, was closed in 1989. This was due to a large amount of traffic, including buses traveling on the narrow street. There are many old buildings worth preserving on the street and traffic wasn't...
helping that. The city wanted to move the buses elsewhere, and also reduce other types of vehicular traffic. These steps would reduce vibrations, noise and air pollution in the area from mainly large vehicles like buses, and also help to preserve the historic buildings. The way the city wanted to solve this problem was to leave the street open to only cars, bicyclists and pedestrians. Also, cars must travel 15 km/h on the street by design due to parked cars and outdoor services. There were problems with illegal driving, parking, and fast driving on the street after the partial closing due to a misunderstanding of the rules. This caused the city council to design a plan to redesign the road in 1992. The results of this experiment were positive. As one can see from Table 2, almost a quarter of the cars were traveling on the street in a 24 hour period after the rebuilding in 1992. The number of bicycles doubled as well. There have been no registered accidents after the street rebuilding which indicates an increase in safety. The old shops stayed open, new small shops opened as well, and the car traffic was reduced. The buses were then rerouted to parallel streets. A survey was taken in 1996 and it concluded that Strædt was a success, and they would like the idea of the road to be expanded to other roads as well. The only problems with the road closing are deliveries to shops became a problem since they have to stop and park illegally which blocks traffic. Also a cyclist riding against the one way direction of traffic is a problem. Sometimes cars would travel above the 15 km/h speed limit as well. (ANAS)

<table>
<thead>
<tr>
<th>Traffic pr. day (6-18):</th>
<th>Motorized vehicles</th>
<th>Bikes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>4,900</td>
<td>1,390</td>
</tr>
<tr>
<td>1992</td>
<td>1,600</td>
<td>2,020</td>
</tr>
<tr>
<td>1995</td>
<td>1,300</td>
<td>2,360</td>
</tr>
</tbody>
</table>

2.6.2 Kajaani, Finland

The city center had problems in the early 1990s due to congestion in the main high street which caused increased noise and air pollution as well as a decline in business. There was also strong competition in markets, and a growing increase in empty properties. They decided to close the main square, and a section of the main high street as a response to traffic congestion in
1998. Initially traffic congestion increased for a few months, but it was only temporary. Previously there were 13,000 cars passing through the square a day. Much of the traffic did transfer to side streets, but some of the traffic did disappear in the area. There was also an increase in pedestrian traffic in the city square. According to a poll many of the residents felt the city square is now prettier, more comfortable, and safer than before. Some of them feel the best way to increase the quality of a city is to increase the number of pedestrianised areas. Also many retailers also felt the improvement increased, or would increase their business in the future. (Wallström, 2004)

2.6.3 **Wolverhampton, England**

There were problems with high unemployment levels in the 1980’s due to a decrease in the manufacturing industry, as well as increased traffic levels, decline in public transport reliability, and reduced access to city center locations caused the city to think of alternative solutions. The solution to this problem was to remove the through traffic from the town centre between 1987 and 1991. This was a very controversial decision at the time, but was backed with strong political support. At first there was an adjustment period as drivers became used to the new road layout. With the blocking of the through traffic, data suggested traffic absent from the main centre appeared not to have transferred to outer roads. Data actually showed the traffic count went down by 1% to 14% on outer streets. With the street closings, public transportation reliability started to improve and increase in usage, starting at 23% in 1994 and increasing to 26% in 2000. At first people were opposed to the road closings, but after the change many people changed their opinion after the street showed signs of becoming cleaner, safer, and more attractive. One of the roads closed to traffic was Queen Square, and as can be seen in Figure 10 this was a vast improvement to the street. (Wallström, 2004)

![Figure 10: Queen Square: Before and After (Wallström, 2004)](image)
2.6.4  Vauxhall Cross, London, England

Vauxhall Cross experienced some of the highest peak hour traffic in London with 9,000-10,000 vehicles per hour in 1998. The road was mainly built for buses, and railway stations, and pedestrians had to use aboveground or underground walkways. There were also no provisions for cyclists. The residents of London were affected by the negative impacts of cars, which included poor air quality, noise pollution, and accident rates even though local residents had one of the lowest car ownership rates. Using computer simulation models, the first outlook on the road closing looked bad. The simulation showed that with a 20% decrease in traffic would result in an up to a 267% increase in traffic queuing during the morning commute. In 1999, experimentation started with reducing the capacity of the crossing at first by 10% and then increased to 15% shortly after. The first computer models were a little flawed, and soon after more rigorous computer models and also scale models were developed which supported the capacity reduction. The public had a strong opposition for the plan since it was the first traffic reduction scheme proposed on such a large scale in such a strategic junction in London. After the actual reduction, the initial predicted traffic buildup of the first simulations never happened including in the neighboring streets. There was actually a 2-8% reduction in traffic during peak hours, and also traffic queues were shorter than before. It was not possible to evaluate the effects of traffic evaporation, since there were many routes commuters could take outside of the study area as well. (Wallström, 2004)

2.6.5  Nuremberg, Germany

In the 1970s Nuremberg was facing traffic problems due to narrow streets, historic monuments, and large shopping areas. The city was affected with air pollution which was causing decay of historic buildings, health concerns, and excessive traffic congestion. The city authorities had been adopting a strategy to give priority to more sustainable, less polluting modes of transport. They also tried to provide better access to shopping centers and office buildings, as well as improve parking space management. The authorities slowly started to close the roads entering the city in phases which resulted in the closure of the last major corridor through the city center except for public transport. This road was a major road that carried 25,000 cars/16 hours. The closure of this road was forecasted to cause traffic chaos in the surrounding streets. This change was made permanent shortly after the initial closure. The first two months resulted in increased traffic congestion, which also faced considerable
opposition from the public and media. Only two months later, the traffic adjusted to the new situation by either finding alternate routes, or a different mode of transport, and the traffic congestion was solved. Once this started happening support for the project began to grow. Traffic monitoring showed that the traffic reduction was twice as large as the previous estimate, which resulted in around 36,044 cars disappearing. For this study, they also tried to evaluate the traffic fluctuation at the 12 city bridges near the area. The data from this study showed there was a decrease of 10,000 vehicles in the course of 11 years, even though car ownership increased. There were also improved air quality conditions after the road closure. Air quality had increased significantly near the closed street which meant a reduction in particulate matter, nitrogen dioxides, and carbon monoxide. (Wallström, 2004)

2.6.6 Strasbourg, France

During the 1980s Strasbourg was facing growing traffic related problems including frequent congestion, air and noise pollution, and high accident rates. The increasing amount of traffic was making the city center less attractive to visitors. Also the city was limited in the amount of space they could expand roads for private cars due to historic streets and monuments all around. The main aim of the project was to limit the number of private cars allowed to enter the city center, and increase the use of more sustainable forms of transport such as public transport, cycling, and walking. They decided to build two new tramlines that would serve the city center. In order to do this they had to relocate private car roads and use them for tram rails. The road was closed in 1992 and the through traffic access to the city center was removed, which accounted for almost 40% of the general traffic flow at the time. Cars would still be allowed to access the city center through a few road loops that went around the city. Through traffic was redirected to an outer loop of the city though. The first of two tramlines opened in 1994, and the second opened in 2000. There were approximately 240,000 private vehicles that entered the city center per day in 1990, and in 2000 there were only 200,000 per day. It was estimated that by 2004 there would have been around 300,000 private cars if those steps had not been taken. The increase in traffic once again disappeared after drivers got used to the new street layouts. The first tramline built carried over 68,000 passengers per day during its first year in operation which is a great increase in the use of public transportation. Also, in 1989 72.5% of all trips were made by private car and 11% by public transportation. In 1999, only 60% of trips made were by private car and 30% were made by public transportation. (Wallström, 2004)
2.6.7 Oxford, England

In Oxford, England, private car access to the city center was restricted with the closure of the main High Street on June 1st, 1991. At first there were predictions of increased traffic congestion as a result of the street closing. After the initial adjustment phase, the anticipated congestion did not materialize. The results of the study showed traffic flows decreased by 20% on the inner cordon, and by 1.3% on the outer cordon in just a year. This decrease in traffic was due to an increase in public transportation use. Bus passenger use increased 8-9% by June of 1999, and this was maintained until 2000 as well. This increase equated to about 2000 additional bus passengers per day. There was also an increase in pedestrian traffic in 2000 compared to in 1998. There was an increase of about 8.5% which is approximately 6000 people. This increase in pedestrian flow marked a reversal of the declining trend of pedestrian numbers in the 1990s.

One of the major findings in this study though was related to the air quality in the city. The air quality was monitored at over 40 sites across the city, and recorded a significant improvement after the road closing. Within one week of the street closing, there was a 25% reduction in particulate matter, and a 75% decrease in carbon monoxide levels on streets around the closed street which can be seen in Figure 11. (Wallström, 2004)

![Figure 11: Air Pollution on Cornmarket Street (Wallström, 2004)](image-url)
2.6.8 Cambridge England

In January 1997, the Cambridgeshire County Council introduced an 18 month experimental road space reallocation in the city center. Cambridge is a university city with a historic city center that includes many medieval style college buildings with a high architectural value. Congestion was frequent in the city center, and public transport services were often delayed. The first street was closed to cars in 1997, but local buses, taxis, and licensed hire cars were still permitted to travel through the set of automatic hydraulic bollards installed on the street. Traffic was the major source of pollution in Cambridge, and in 1999 24 of the 27 nitrogen dioxide monitoring sites had exceeded the European guidelines. Emanuel Street was closed to through traffic in August 1999 as the second stage of the project. The goal of this project was to reduce the impact of traffic by encouraging the greater use of public transport, walking, and cycling. It did not aim to ban cars, but just make their use less attractive. This plan involved removing through traffic of private cars, and also implementing parking restrictions with increased charges making two hours of parking more expensive than taking a bus. Computer traffic models predicted a significant increase in traffic on some neighboring streets, and traffic light settings were altered to fit these new conditions. Public meetings were held to promote the scheme and emphasize the need to consider the long term benefits of reduced traffic and reduced pollution in the area. Traffic was reduced up to 78% on certain roads, and only 2,000 extra vehicles were recorded on the main adjacent routes. At the particulate matter monitoring sites, 16 of the 18 sites either improved or stayed constant. This was estimated to be a decrease of about 5% of particulate matter levels. Also the Cambridge retail group showed no real evidence of a significant loss of trade resulting from the bridge closure. The pedestrian areas established in the city center have become very popular tourist sites, and many of the retail businesses have been converted to restaurants and cafes. The quick steps taken including the installation of the automatic bollards, and the large media interactions were key steps in making the road closure such a success. (Wallström, 2004)
3 Methodology

The goal of this project is to determine what happens to traffic when portions of a busy city street, in this case Nørrebrogade, are closed to car traffic. Many prior road closing studies have not allowed for the traffic of public transportation, such as buses in this instance, so it is important to observe how this may be related to other prior studies. The city of Copenhagen is interested to find out if closing this busy road will encourage the use of public transportation as well as cause an increase in pedestrian and cyclist traffic. The city also wants to determine where the traffic previously traveling on the now closed road will go. Denmark is a very environmentally conscientious country and new innovative strategies are constantly being researched to reduce harmful emissions.

In order to analyze the traffic levels, quantitative and qualitative data was collected. The city of Copenhagen has taken traffic counts on the closed road before its closing, and twice after its closing. They have also taken traffic counts on surrounding roads to determine if traffic has in fact decreased, or simply migrated to adjacent streets. Traffic counts were taken during mid-April 2009 in order to show an updated set of data from prior counts. We analyzed this traffic data to reach a conclusion on whether traffic volumes have changed or not. Public opinion is a significant portion of this project as well, so interviews were administered to attain qualitative aspects of the project alongside the quantitative aspects that was gathered by the traffic counts. The interviews were conducted with a variety of people including pedestrians, cyclists, car drivers, shop keepers, and those who use the busses. One of the goals of Agenda 21 in this project is to uncover the level of public acceptance. We interviewed a total of 50 people who frequent the street and work in shops on the street to get a sense of how they felt about the closing. Another way to help us determine if the community accepts the project was to observe the traffic behavior on and around Nørrebrogade. It was important to observe how traffic moves in the area, and if there were any sort of illegal movements on the street. These observations played a role in helping us to draw conclusions as to if the project can be considered a success. This overall methodology can be seen in the flowchart represented by Figure 12.
3.1 Traffic Data Analysis

Before analyzing the change in traffic since the road closing, it must be understood how traffic behavior was before the road closing. Data including how many cyclists, cars, and buses passed through the street and surrounding streets before the road was closed is very important to this research. It is then also important to compare the data prior to the experiment to data during the trial at multiple periods of time. We used traffic counts from September 2008 before the closing of Nørrebrogade as well as traffic counts two weeks after the road closing in October 2008. Data was collected both manually from the city, and through a contractor, COWI, in order to provide unbiased data. The latest traffic counts came from April 2009. This allows for
drawing a conclusion on what the effect of closing a road has on traffic in the area. In order to sift through the data that is collected over these weeks, it was inserted into an Excel spreadsheet. An example of this spreadsheet can be seen in Figure 49 in Appendix F. With this spreadsheet we were able to look at the change in traffic on each individual road, as well as the entire area around the closing. This allowed us to determine if any traffic has evaporated since the road closing, and if so how much. The data provided by the city depicts traffic counts total for the day, and hour by hour. Identification of the two or more peak hours of traffic can be easily found with these numbers. The city of Copenhagen has provided data that has been taken on multiple roads during different periods of time. Smaller roads adjacent to Nørrebrogade, as well as the main roads, have been counted over the past 5 years. Many of these roads were counted manually. Larger roads are always being counted by automated counters and the data is accessible at any time. Small traffic increases on Åboulevard and Tagensvej are acceptable since they can handle a much larger capacity of traffic than Nørrebrogade. This allowed us to quantify the number of cars on both Nørrebrogade and on the side streets. This information from before the road closing, a few weeks into the road closing, and then a few months into the road closing was readily available. After meeting with city officials who were closely related to this project, we learned that we had access to all of the traffic counting data. We were then able to compare these numbers and determine if the car traffic in fact as decreased or simply migrated to other streets.

3.2 Collect Public Opinion

Interviewing those who use the road provided a broad spectrum of public opinion and modes of transportation. Most importantly it needed to be known how they used the road prior to the closing, and if it has changed since then. Factual information was important to know due to the nature of the study, but subjective matters were also identified. In order for the project to achieve the best results, people must accept the project and the results of it as well. The interviews helped to understand how different types of people felt about the road closing. We conducted interviews with 50 people total, 10 from each of the following groups:

- Car drivers on and near Nørrebrogade
- Bicyclists traveling on Nørrebrogade
- Bus passengers
- Shopkeepers on Nørrebrogade
- Pedestrians walking on Nørrebrogade

A list of the questions we liked to ask each group of people can be seen in Table 5 in Appendix C. The questions are also discussed briefly in the next few sections. We also will explain how we will go about getting the desired information from each group of individuals. The sheet that we took notes on for each interview can be seen in Figure 46 in Appendix D. This sheet allowed us to take notes of each interview quicker than having to write out what each person said. In the event that we did need to take specific notes we had room on the right side of the sheet to document each person’s opinion.

3.2.1 Car drivers on and near Nørrebrogade

In order to understand the effect of closing the road in relation to cars, we planned to interview people who drive either on Nørrebrogade and/or surrounding streets. We were interested in finding if the closing had in any way affected their driving routine. We could also see if they had noticed an increase in traffic or travel times in the general area. In order to get this information we approached drivers who had parked their cars on the street, so as to not impede the flow of traffic. When speaking with pedestrians walking on the street we were able to ask if they owned a car and if they drove on Nørrebrogade as well.

We also talked with workers in the area who drove cars. It was important to find out if they do anything different now that they cannot drive through the closed sections of the road. Speaking with those who work in the area was an important part of this project. The project is heavily involved with transportation, so it needed to be known how employees travel to work. To know if automobile traffic had been cut down, informal surveys were taken throughout the area. By asking certain questions we hoped to find out as much information from them as we could. These questions included the following: How did they travel to work before the road was closed? How do they travel to work now? Does it take longer to get to work now, than it did before the road was closed? Those who reside within walking distance may not have changed their methods of travel; however those who are commuting from a further distance may have more problems with the new system.
3.2.2 Bicyclists Traveling on Nørrebrogade

We conducted interviews with bicyclists on Nørrebrogade to find out similar information to those with cars. We were looking to find out if they had changed their mode of transportation at all, as well as how far they traveled to get to Nørrebrogade. We also planned to find out how the cyclist traffic volume had been affected since the road closing. Since there are more bicycle lanes in certain areas of the road now, the flow of bicycle traffic should be more readily handled. We approached cyclists stopped at intersections in order to ask them these questions. Often, cyclists walk with their bikes when crossing a street, or are nearing their destination which was an opportune time to approach them in order to get their opinions.

3.2.3 Bus Passengers and Drivers

We sought to find similar information from the bus passengers in the area. We wanted to know if they used to take the bus before the road closing and if not why they decided to take the bus instead of bicycle or a car. We also liked to know if they thought the buses run faster on Nørrebrogade since the road has been closed. We were able to conduct interviews with the bus passengers on lines that run through Nørrebrogade when they were riding the bus to their destination since they were usually unoccupied. We also were able to talk to the bus passengers while they were waiting for the bus on the new bus stops created on the street. This was usually easier than trying to talk to them while they were riding on the bus as it could sometimes distract them or hold up traffic on and off the bus. We hoped to find out how much the bus system has been affected since the road closing in both transport speeds and amount of passengers.

3.2.4 Shopkeepers on Nørrebrogade

Speaking with employees with different means of getting to work was an important part of the research as well. Some of the shopkeepers and workers have had a harder time getting to work now that it is more difficult to access the road. It was also important to find out if the workers had changed their mode of transportation since the road closure. The road that has been closed has many cafes and shops along it. Many felt that cutting car traffic has had a negative impact on their businesses. In order to determine whether or not this will have a negative impact, we spoke with the storeowners and employees. By asking about sales, and observational opinions we have gained an understanding of how the road closing has affected sales. We have
collected the information from the shopkeepers that have felt comfortable releasing the information.

3.2.5 Pedestrians walking on Nørrebrogade

Pedestrians may find the road to be easier to navigate with less car traffic. It was important to understand the changes from their perspective because the road closing is not only in effect to improve environmental standards, but to encourage an infrastructure without cars. In order to discuss these problems with pedestrians, they were interviewed before crossing a street or politely stopped on a sidewalk. We wanted to know how far they were traveling as well since many of them lived in the neighborhood of Nørrebrogade. If they did live near Nørrebrogade we found out if they had a car, and if they found it harder to use since the road has been closed. This also helped us determine if they had changed their mode of transportation since the road closing.

3.3 Observe traffic behaviors

It was helpful to watch the traffic behavior both on Nørrebrogade and on the surrounding streets. We watched for illegal travel on the street, as well as parking or other activities that are not permitted. This helped us judge the amount of public cooperation with the street closing. If there were still cars that travel on the closed sections of Nørrebrogade, it would be deemed that the closure was not completely accepted by certain people; though we could not judge the success of the project based solely on observation of a few violations. These illegal behaviors could have impacted the total effect strived for by Agenda 21, so it was important to ensure the number of illegal moves are reduced. If we found out why some people were violating the set rules, we may be able to make recommendations to help improve upon this in the future. This data, along with the data from traffic counts and interviews have allowed us to draw a conclusion on the effectiveness of closing Nørrebrogade, as well as the general public opinion of the closure.

3.4 Assess usefulness of the road closing

In order to determine if closing this road is worthwhile for the community and environment, conclusions need to be drawn. The information and data gathered two weeks after the road closure is not sufficient to draw these conclusions because it has not allowed enough time to pass for residents, and workers to change their modes of transportation if they choose.
The conclusions drawn have relied heavily on the difference between the initial data collection before the road closing, and the data collected in April. The closing has been successful if those who used to drive on the road have changed from driving their personal vehicles, to traveling on foot, bicycle or public transportation. If the roads surrounding the closed road simply increase in traffic flow, it may be determined that there are not less cars, but the same amount in another location. This would prove that goal of the project unsuccessful because there would be more traffic elsewhere, and the goal of changing people’s modes of transport would not have been achieved. Analyzing the surrounding roads was very important for this reason. It has been discussed that decreasing traffic has also decreased emissions, which has consequently improved the air quality, increased safety for those using the road, decreased noise levels, and increased the general quality of life. Through public opinion and interviews we were able to determine if people feel safer. Is it easier to ride a bicycle without worrying about personal car traffic? Is it safer to board the bus using a pedestrian lane rather than walking across a lane of cars? Is it quieter or possibly less stressful with less noise due to heavy traffic flow? In order to determine whether the road closing is successful these important factors must all come into play.

Agenda 21 is looking to increase the sustainability of the city and this local project has taken a step in achieving that goal. The first thing that they have attempted to do is make a beneficial change for the sake of the environment. They must also be sure that the local economy is thriving while the road is shut down. If there is little traffic on the street and plans do not happen as predicted, there may not be enough traffic to keep the stores running. This would not encourage the sustainability of the city.
4 Results and Analysis

The following section contains a thorough analysis of both the traffic data we received from the city, and the interviews that were conducted with pedestrians on Nørrebro.

4.1 Quantitative Results (Traffic Counts)

Using the traffic count data gathered by city of Copenhagen, we are able to determine if the total number of car trips has decreased since the road closing. We can graph the traffic data and determine the peak hours of travel, as well as how many trips are being made each hour on multiple different streets. It is important to note that the numbers in the traffic data sheets do not represent the amount of vehicles, but more specifically the amount of trips made by those certain vehicles during the counting period. Some of the traffic data sheets did not include all of the information we were looking for in them, so we were not able to make graphs for every street. Some data sheets only showed car counts instead of including bus and bicycle counts as well. We were also unable to get traffic data for some streets from the newest count in April, so we left those streets out of the analysis. This means the results are not fully complete, but they will give us an idea of the events happening since the road closure.

An example of one of these graphs with traffic count data before the closing can be seen in Figure 13. This graph looks at the Dronning Louises Bridge because it is a main artery onto Nørrebro, and it is important to understand how traffic has changed on major arteries such as this. The peak hours on the graph can be seen at around 8:00, and between 15:00-16:00 depending on the mode of transport. The number of trips during that hour can also be seen during the beginning and peak hours. The numbers on the graph are not the number of vehicles, but rather the number of trips made by those vehicles during the counting hours. A sample sheet of the data received from the city can be seen in Figure 47 and Figure 48 in Appendix E. Each of these graphs shows three main types of traffic that we looked for both on the streets with the available data. We were able to look at personal motor traffic such as cars and motorcycles, bus traffic, and bicycle traffic. Due to the reasons for closing the road, we were expecting to see a decrease in personal motor traffic, and an increase in bicycle and bus traffic. These graphs depict the amount of traffic traveling on a given street each hour over the course of 11 hours. Similar graphs for other streets in the area can be seen in Appendix G.
In order to graphically represent the traffic fluctuation in the area, we constructed several maps that display the traffic fluctuation of a given street. This fluctuation of car traffic is
represented by different sized lines, which can be seen in Figure 15. This map shows the Southern part of Nørrebro which is around the first closed section of the road. There is a line for the amount of traffic before and after the road closure. This helps to visualize how each road has been affected since the road closure. In this map there is a decrease in traffic percentage on multiple streets, but there is also a large increase in the traffic percentage on a few streets near the closed section of the road. It can be seen there has been a large decrease in traffic crossing over the Dronning Louises Bridge, and this accounts for a decrease of 5200 car trips per day. This is a large decrease compared to the increase in cars seen on Elmegade.

Dronning Louises Bridge has seen such a large decrease most likely due to the fact drivers cannot travel very far on Nørrebro before they would need to turn off if they wanted to comply with the restriction. Elmegade is the road that drivers can exit off right before the closed section of the road if they choose to drive on Nørrebro. It can be seen that traffic has increased around 153% on this street, but this only account for an increase of 1250 car trips per day. This increase in traffic could be due to drivers that are coming from the Northern sections of Nørrebro and then turn off the road at the last turn before the restricted area. The closed section of the road has seen a large decrease in vehicle traffic though. The 80.2% decrease is equivalent to a decrease in 2700 car trips per day during the peak hours. The recent traffic count data shows there were only 429 personal vehicles that traveled through the restricted area during those peak hours. This equates to around 107 cars still traveling through the restricted area per hour. This is around the same amount of the 97 cars per hour reported in the newspaper on April 9th 2009. There are still many people that travel through the restricted areas seen by those numbers.
Below in Figure 16 there is a map for the Central section of Nørrebro. This is the same kind of map as above which is useful in determining where traffic is going and why. In this map it can be seen there is a significant increase in traffic on Blegdamsvej. This increase is representative of around 1700 car trips per day. Blegdamsvej is a large road that can handle a lot of traffic, so drivers that are looking for alternative routes of travel may find this road is more convenient to drive on. Many of the other roads in this area have also been seeing an increase in traffic. This could be due to drivers trying to get to Blegdamsvej from Nørrebrogade. They could be exiting Nørrebrogade onto Elmegade, or come down from Guldbersgade, and then turn onto Blegdamsvej. This could explain why all of these streets are seeing an increase in traffic. Møllegade has seen a decrease in traffic and this could be explained since it is a one way street flowing away from Nørrebrogade. If the general amount of traffic on Nørrebrogade has decreased this means there are fewer cars that will take this one way street to exit the road.
Three out of the four section of the Jagtvej - Nørrebrogade intersection have seen a decrease in traffic as well. There is usually a large amount of traffic on these streets so a decrease there is encouraging.

![Figure 16: Street traffic map of Central Nørrebro](image)

There is also a map for the Northern section of Nørrebro which can be seen in Figure 17. It can be noted that there has been a decrease in traffic on one of the streets that feed into Nørrebrogade after the closed section of the road in this area. There has been an increase on many of the other roads that are entrances or exits on Nørrebrogade though. The decrease on the other streets could be due to drivers changing their routes to streets that run parallel to Nørrebrogade such as Mimersgade. Car owners can drive down Mimersgade most of the length of Nørrebrogade which is more convenient than having to turn every few streets if taking smaller side roads. Mimersgade has seen a pretty large increase in traffic from the prior to the trial. Prior to the trial the traffic counts on Mimersgade had recorded 6,300 car trips. There were over 11,000 car trips after the road closure though, which is a significant increase in car trips. This behavior can also be seen on Lundtoftegade. That road travels almost parallel to Nørrebrogade, so drivers may take this road more now to avoid having to travel on Nørrebrogade. There has
been a 15% increase on Lundtoftegade which accounts for around 1000 car trips. Stefansgade has also seen a slight increase in car traffic as well as Hillerødgade. These streets could be seeing an increase in traffic because drivers would use these streets as exits before reaching the closed section of Norrebrogade. Ægirsgade has seen a slight decrease in traffic but this is a small road that only carries 700 cars now. There has only been a decrease of around 100 cars since the road closing and this could just be a result as the decrease in traffic on Nørrebrogade.

![Figure 17: Street traffic map of Northern Norrebro](image17.png)

We also constructed a map that shows the entire area around the road closing. This map can be seen in Figure 18. The map shows the percentage of traffic fluctuation on a given road in the area around the road closing. This map is able to show many more streets and how each one reacts compared to the previous map. It is important to analyze the streets near the closed sections of the road in order to quantify the fluctuation in traffic on these streets from cars taking other routes of travel. It can be seen that many roads have seen a decrease in traffic, but this doesn’t provide a definitive answer in the amount of traffic evaporation. There have also been a few roads that have seen a large percentage increase in traffic, but this doesn’t necessarily mean there has been a large increase in the number of cars on those certain streets. We have mapped...
the data for the 30 different street counting locations we had available to us. We expected an increase in traffic on both Tagensvej and Åboulevard, and we have seen this since the newest count. These increases are small, and these roads are large enough to handle to traffic increase. The roads before the restricted parts of the road have seen a general increase in traffic since many cars will leave Nørrebrogade on these roads in order to follow the rules of the closing. All of the sections on Nørrebrogade have seen a decrease in traffic which is a good result too. Less people are traveling on Nørrebrogade, but there has been a noticeable increase in traffic on many of the other side roads as well.

![Figure 18: Traffic fluctuation map of entire Nørrebro](image-url)
The chart in Figure 19 shows the percentage of roads in the Nørrebro area that have seen an increase or decrease in personal motor traffic since the road closing. The majority of roads have seen a decrease in traffic, but there are still a fair amount of roads that have seen an increase in traffic as well.

![Street Fluctuation of Private Motor Traffic](image)

**Figure 19: Personal Motor Traffic on Streets in Nørrebro**

Similar charts can be seen below in Figure 20 and Figure 21 for bus traffic and bicycle traffic respectively. From these charts we are able to see both bus traffic and bicycle traffic have increased on the majority of the roads. This suggests that more people are riding their bikes, which could correlate to people changing their mode of transportation. Bus traffic could have increased due to faster travel times, or the need for more buses to travel a certain route if the number of passengers has increased since the road closing. It’s important to note though, that we didn’t have access to data for buses and bicycles for all the roads, so this is just using the data we had available to us. This means the charts aren’t fully accurate, but they are accurate for the roads we had data for.
Using the spreadsheet we constructed from the traffic data provided to us, which can be seen in Appendix F, we have been able to quantify the amount of traffic fluctuation in the Nørrebro area around the road closing. As mentioned before the numbers in the traffic data
sheets don't represent the amount of vehicles, but more specifically the amount of trips made by those certain vehicles during the counting period. This is the case because some cars may have made multiple trips on the street during the counting which would result in them being counted multiple times. We also used the hard number from the traffic data sheets instead of the percentages. This allowed us to add up the number of vehicle trips made on every street before the trial and after the road closing and find the difference during the two times. The difference in the two traffic count totals would be considered the amount of traffic evaporation. That number is the number of vehicles trips that have disappeared since the road has been closed. The difference in the amount of traffic before the trial and after the road closing can be seen in the chart shown in Figure 22.

![Personal Motor Traffic in Norrebro Area](chart)

**Figure 22: Personal Motor Traffic Chart**

We found there had been around 205,000 trips made by personal motor vehicles during the hours of traffic counting before the road closure. This is compared to the 190,000 trips made by personal motor vehicles in April, 2009 after the road closing. This results in a 7.3% decrease in traffic accounting for 15,000 vehicle trips. With this data we are able to show hard evidence that traffic has indeed evaporated in the area since the road closing using the traffic data provided to us. This evaporation just means there are fewer trips made by personal motor vehicles after
the road closure compared to prior to the closure. There could still be the same number of people driving, but they could be driving less and taking fewer trips in their cars since the road closing. We found there had been approximately 205,000 trips made by personal motor vehicles during the hours of traffic counting before the road closure. This is compared to the 190,000 trips made by personal motor vehicles in April, 2009 after the road closing. This results in a 7.3% decrease in traffic accounting for 15,000 vehicle trips. We have also calculated the traffic fluctuation on the areas that were counted on Nørrebrogade. Nørrebrogade saw a decrease in personal motor traffic equivalent to about 16,700 trips. We also wanted to determine the number of trips that had moved from Nørrebrogade to other streets in the Nørrebro area. The increase in personal vehicle trips on all the side streets, including large streets such as Tagensvej and Aboulevard, was 10,300 trips. This is equivalent to 61.7% of the traffic that decreased on Nørrebrogade, and 5.4% of the total traffic in the Nørrebro area. Since the large roads like Tagensvej have more traffic on them, this number doesn’t represent the increase on just side streets very well. Using the data from just the side streets that saw an increase in traffic, we calculated there were 6,800 more trips on those side streets. This is 59.2% of the traffic that was decreased on Nørrebrogade, and 3.6% of the total amount of traffic. This shows that not all of the traffic on Nørrebrogade was moved to other roads; instead, there was traffic that disappeared. With this data we are able to show hard evidence that traffic has indeed decreased in the area since the road closing using the traffic data provided to us. This partial evaporation just means there are fewer trips made by personal motor since the road closing. There could still be the same number of people driving, but they could be driving less and taking fewer trips in their cars since the road closing.

The amount of bus traffic before the trial and after the closing can be seen in Figure 23. Not all the traffic data received includes information about bus traffic, so we used all the data we could. From the data we had, we can see the number of bus trips has increased from 2370 up to 2630 which is a 260 trip increase. This results in an 11% increase in bus traffic. This most likely isn’t very accurate since we were only able to use 9 roads to compare the bus traffic fluctuation on. More street data would need to be analyzed to have a more accurate result.
A similar graph for the amount of bicycle traffic in the Nørrebro area can be seen in Figure 24. There has been an 18.6% increase in bicycle traffic since the road closure. This is a difference of about 13,000 bicycle trips. Once again, we were only able to analyze 11 streets with bicycle traffic data so the results may be slightly inaccurate. Another factor to consider is that the most recent traffic counts were conducted in April when the weather is much better than in September when the first counts were made. The better weather could have resulted in more people riding their bicycles instead of driving or taking the bus. These numbers aren't a full representation of the fluctuation of bicycle traffic due to the road closure.
4.2 Public Opinion through Interviews

Interviews that were conducted with multiple people associated with the road closure experiment are summarized below. Using the responses we received from different groups of people we are able to make estimations on how each group of people feels toward the closure of the road. The summary table of the interview responses can be seen in Table 3. This table shows how many people of each group we interviewed fit into each category of our major questions. This table doesn’t cover all the questions that were asked to the interviewees, but it summarizes the ones that we found were more important during the study. The more detailed questions are covered in the sections for each different group of people interviewed.
Table 3: Interview Response Summary Table

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<th>Pedestrians</th>
<th>Bus Passengers</th>
<th>Shopkeepers</th>
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</tbody>
</table>

Graphs were made that show what percentage of each group of people accepts to road closing. We then made a graph that depicts the overall feeling towards the road closing for everyone we have interviewed. This overall acceptance level can be seen below in Figure 25. From this chart it can be seen that the majority of people accept the road closing so far, and are happy with the way it is going. There is, however, also a large percentage that dislikes the road closing. This chart combines all the interviews we conducted with people so this includes the people that drive cars and own shops. Since the majority of these people dislike the road closure they increased the amount of people that disliked the road closure. The majority that liked the road closure were those that rode bicycles, walked or rode the bus. They liked that cars were being moved away from the central areas of the city and in many cases felt safer traveling on the road with less car traffic.
The graph in Figure 26 represents the overall safety perception of the people that we interviewed. Half of the people have found the road safer, and they believe this because they think the traffic has decreased so there are fewer accidents. There is also 23% that believes the road is less safe since the road closure because they believe cars drive down the road faster and more aggressive since there are fewer cars on the road. This is especially true in the closed sections of the road. There is also 27% that believes the road is just the same as before, even if there may be less car traffic on the road.
4.2.1 Bicyclists

One of the objectives of closing the road was to increase the ease of riding a bicycle on Nørrebrogade. Throughout our interviews with ten cyclists we are able to estimate how much the road closure is accepted by these cyclists. From our interviews we have found that many of the cyclists like the decrease in the amount of car traffic. They feel this makes the street safer which allows them to travel more freely on the road as well. Since people in Denmark are also very environmentally conscientious, they find the decrease in cars to be good for the environment as well. Cyclists riding with their children on Nørrebrogade find the closing especially beneficial. There was much more car traffic on the road prior to the closing which made riding a bicycle much more dangerous. Now the parents do not need to worry as much about their children riding their bicycles on Nørrebrogade since there are much fewer cars on the street. Many of the cyclists interviewed have not noticed a large increase in bicycle traffic, but this depends on what time of the day they are traveling. The city has been conducting manual counts of bicyclists at the same time as the other traffic counts. From the data we have received from the city, we have seen an 18.6% increase in bicycle traffic since the road closing. This data is not entirely accurate though since we do not have bicycle traffic for every road in the area, and also since it is warmer out there could be more people riding their bikes to places instead of driving their cars. There are many other factors that could be affecting the increase in bicycle traffic.

There are some cyclists that have tended to dislike the road closing though. We have found that the cyclists that dislike the road closing generally own a car, and used to travel on Nørrebrogade frequently. A few have changed their mode of transportation from the car to a bicycle after the road closing though.
From the people interviewed we have found the majority of the bicyclists have found the road safer since the closure. This could be due to the increased bicycle lane size as well as the decreased amount of traffic in the area. They are able to ride their bikes more peacefully on the road since fewer cars are driving by and they do not have to worry about looking out for other bicycle traffic in the wider lanes. The chart of the safety perception of bicyclists we interviewed can be seen in Figure 27.

![Bicyclists Safety Perception](image)

**Figure 27: Bicyclist Safety Perception**

We also asked the people we interviewed if they agreed with the road closure and if they thought it was a good idea. Around 80% of the bicyclists we interviewed agreed with the road closure seen in Figure 28, which is very good since those are the kind of people the road closure was aiming to improve travel conditions for. There were a few that did not like the idea of the road closure since they felt it made the road a little less active with fewer cars. There were also a few that were indifferent about the road closure because they felt that it did not directly impact them personally.
4.2.2 Car Drivers

Through our interviews with people that own cars we have seen a general trend of dislike for the road closing. Cars are expensive to buy and own in Denmark, so when they are restricted from driving on major roads they show a dislike for this. The road closing makes it more difficult for drivers to take a direct route to the location they are intending on going to. We have noticed that there have been around 20% of car owners that we interviewed that have changed their mode of transportation since the road closing. This information can be seen in Figure 29. It may be harder to travel on Nørrebrogade, but many of them have chosen to still travel by car even if it is less convenient. Many of these drivers still use their cars just as frequently now compared to prior to the road closing. Sometimes they just use the cars to travel to work each morning, while others use them to drop off their kids at school just a few blocks away.
We also wanted to estimate the general acceptance of the street closure for people that owned a car. Through the interviews we conducted we found that about 90% of the car owners disliked the road closure which can be seen in Figure 30. Car prices are much higher in Denmark compared to the United States, so when people have enough money to buy a car they want to use it as frequently as they can. When the street was closed near where they live and restricted their car usage they were mostly unhappy about this. The only few car owners that agreed with the road closure were those that had a strong sentiment towards the environment and felt it was necessary to reduce the amount of traffic in the city. These people also tended to have to drive from farther away from the city so taking a bus or riding a bike was not a sufficient source of transport.
4.2.3 Bus Passengers

The road closing also impacts bus passengers. From interviewing bus passengers we found that a majority of those who use the bus felt that the buses were able to travel faster down Nørrebrogade since the closing while some others noted that they had not noticed a difference in travel time on the bus. The majority or about 60% of those that we interviewed also said that they felt safer with the new platform for bus passenger traffic as seen below in Figure 31. They are able to get off the bus on a raised platform in the road that is designated specifically for waiting for and exiting the bus. They no longer have to look out for fast bikes riding by and having to wait to get off the bus. For this reason, many of the bus passengers we spoke with were in favor of the closing.
We only discovered a few passengers had changed their mode of transportation to taking the bus since the closing. The vast majority had always taken the bus as their main form of transportation. This doesn’t indicate there hasn’t been an increase in public transportations use, but it may not be large enough to be significant. The acceptance level is split, however in Figure 32 it can be seen that half of the bus passengers interviewed were in agreement with the road closing.
4.2.4 Shopkeepers

In interviewing shopkeepers we have found that while many shops have seen a decrease in business, it cannot be determined whether the road closing is responsible for this change or not. Some shopkeepers speculate that the road closing is to blame for their poor business while others simply suggest that the financial crisis is at fault for their decrease in business. Unfortunately, there is no definite way to determine the cause of the change.

Also in interviewing shopkeepers we have found that the nature of the products sold at the store seems to have a significant impact on how the shopkeepers view the closing. Many shops that sell larger items, such as mattresses, seem to, in general, have a more negative outlook on the closing, as they believe that it is harder for customers to pick up larger products from the store if they cannot drive there and park right outside of the shop. They believe this deters potential customers from purchasing goods at their shop. About 80% of the shopkeepers we spoke with were opposed to the road closing as shown in Figure 33 and 70% believed they were seeing a decrease in retail sales as seen in Figure 34.

Not all shopkeepers were in opposition of the closing, however. There were a few owners who very passionately favored the closing. One went as far as to suggest that they should close the entire street to personal car traffic. Even though many had seen a decrease in business, there were also many that said they had not seen any change in business or in fact thought that business may have picked up a bit since the closing.

![Pie chart showing shopkeeper acceptance level](image)

**Figure 33: Shopkeeper Acceptance Level**

58
4.2.5 Pedestrians

From the pedestrians interviewed so far there have been some general findings. Many of them feel it is great to reduce traffic in the city. They also like how there are fewer cars driving on the road which increases their safety. They still like how busses are allowed to travel on the road which allows them to travel from one end of the street to the other in a quicker manner if necessary. The pedestrians have around a 70% acceptance level towards the street closure from the people we interviewed. The acceptance levels for pedestrians can be seen in Figure 35. Also in Figure 36 the pedestrian safety perception can be seen. 70% of the people interviewed feel the road is safer now since the road closing. The other 30% feel it is less safe due to the cars driving faster on the street since there are fewer cars now.
When interviewing a police officer walking on the street he provided many suggestions he had about how to reduce traffic. He felt it was great to move cars out of the busy city centers. He does own a car, but the only time he uses it is if he needs to travel far out of the city. He usually just rides a bike like many other Danes. We also found out that he wishes that physical barriers would be installed on the closed sections of the road to block out private traffic for good. These barriers would retract into the ground when a bus or emergency vehicle is nearing them.
The police also monitor the restricted zones about twice per week and give out fines or warnings to those who violate the restrictions.

4.3 Observations

Due to the nature of the road closing, it is possible to still drive on the street. It is only limited to motorist traffic in two locations. Since there are fewer cars on the road to inhibit them, motorists are driving noticeably faster. It can be seen especially along the stretch of road along the cemetery. The areas that are closed are also home to some aggressive drivers. Those who drive through the illegal section tend to drive faster, and more aggressively than elsewhere. They are trying to get through the “red dot” area as quickly as possible to avoid the fine should the police catch them. This could be why some people on the street believe there has been a decrease in safety on the road.

We have also noticed that since the road has been narrowed in the restricted areas by the installation of the new bus stop waiting sections, it is harder for a bus to turn onto the road if there is another bus traveling in the opposite direction. The bus must slow down significantly, and sometimes may have to wait for the other bus to move before it is capable of turning onto the street. Cars traveling through the restricted areas also inhibit the buses ability to travel through the areas. In Figure 37, there is a bus turning onto Nørrebrogade without any other vehicles in the way. The bus is taking up the majority of the road when turning on the road, so if there is another bus waiting to turn in the other direction this usually causes problems. The buses have to slow down and move in different direction in order to allow the other bus to pass by.
Figure 37: Bus turning onto Nørrebrogade
5 Conclusions and Recommendations

Through our studies we have concluded that while the road closing has seemed to be successful in reducing personal car traffic, there are some different ways in which it can be improved. From the traffic data received from the city, we have seen around at least a 45% decrease in personal vehicle traffic on Nørrebrogade. The sections that are closed on the road have seen up to an 86% decrease in personal vehicle traffic. We have been able to show there has been a personal vehicle traffic reduction of 7.3% from the traffic count data that was available to us. This showed us there was some sort of traffic evaporation in the Nørrebro area which is what the previous case studies have generally shown. Although there were many roads that did see an increase in traffic, there was an overall decrease in the total amount of traffic in the area. The roads that saw an increase in traffic were usually those at the entrances or exits before the closed sections of the road on Nørrebrogade, specifically Elmegade. We did see an increase in vehicles on Tagensvej and Åboulevard as well, but it was an acceptable level of traffic increase. These two parallel roads that lead towards the city can handle much more traffic than Nørrebrogade and part of the goal of the project was to move some of the traffic from Nørrebrogade over to those major side roads.

After interviewing people that frequent the street often, we were provided with many insightful suggestions about changes that could be made to help the closing to be even more successful. Since these are the people who are most affected by the closing, we put the highest value on their opinion. It would be easy for an outsider who is unfamiliar with the street to pass judgment on the experiment; however people who are familiar with the area are able to provide much more constructive criticisms. We spoke with 50 individuals to obtain their opinions of the road closing. It would have been ideal to talk to more, but due to our brief time to conduct interviews we decided to collect a sufficient amount of data to draw conclusions from. It was found that the opinions varied mainly depending on their mode of transportation and whether or not they owned a car. We found that the bicyclists and bus passengers had a larger percentage of positive attitudes towards the road closure. Those who the road closure affected more directly, mainly car owners and shopkeepers, had more of a negative attitude towards the road closure.

Agenda 21 is looking to increase the sustainability of the city and this local project has taken a step in achieving that goal. The first thing that they have attempted to do is make a
beneficial change for the sake of the environment. They must also be sure that the local economy is thriving while the road is shut down. If there is little traffic on the street and plans do not result as predicted, there may not be enough traffic to keep the stores running. This would not encourage the sustainability of the city. We would encourage that the city take note of those who are struggling and attempt to reach a compromise that benefits all parties involved.

5.1 Speed Bumps

If there were speed bumps installed on both sides of the busgade, this may be beneficial to reduce illegal traffic driving thought the closed areas. These speed bumps will cause any vehicle planning on driving through the restricted area to have to slow down before they get into the area. This would not affect the speed of the buses since these speed bumps would allow for the busses to travel around them. These cut outs for the bus wheels would also allow for emergency trucks for fire to pass without slowing. Also, if car drivers do decide to travel illegally through the closed section of road, their speed would be reduced so they would no longer drive as fast though the illegal areas which will make it safer for others on the street. This is also a more permanent form of closing a street compared to street signs, but it could also be easily removed if it proves to cause problems. If the cars need to slow down before driving across the restricted section, many of them will most likely try to find an alternate route where they don’t need to slow down as much. The buses would not be affected by such an installation do to the design of the speed bump. Speed bumps also would not be very expensive to install since they are made out of asphalt, and they should be relatively effective in reducing private traffic traveling though the area. Installation is not time consuming. A problem with installing speed bumps in these areas is that emergency vehicles will also have to slow down if they want to travel though the closed sections of the road. They could avoid traveling down these sections of road but this would require them to travel on other side streets, which could also increase their travel time to their destination.

5.2 Retractable Bollards

One suggestion is to install retractable bollards that can retract for buses and emergency vehicle traffic when necessary. We have calculated that around 107 private motor vehicles violate the restriction every hour from the recent traffic data provided by the city. This would prevent these cars from violating the restriction, and since we have observed that when cars drive
through the prohibited areas they tend to drive faster and more aggressively this would increase
the safety level in these areas as well. Also this will decrease traffic on the road even more since
drivers will likely try to avoid driving on Nørrebrogade if they do not have the option of
disobeying the restriction. An example of these types of barriers can be seen in Figure 38.
Figure 39 demonstrates how the bollards function, as well as what needs to be installed under the
road.

Figure 38: Retractable Bollards

Figure 39: Retractable Bollard Installation
These barriers would be able to have a number of different options in order to retract when desired. Some systems have red and green light indicators which instruct users when it is safe to pass through. Loops are also installed underneath the barriers which informs the barriers when to rise as not to rise underneath a vehicle. These barriers can recognize vehicles in a number of different ways. Each vehicle that is allowed to pass through the bollards can get a proximity card which causes the barriers to automatically retract when an authorized vehicle is nearby. There could also be automatic number plate recognition which will automatically recognize the vehicles license plate and allow authorized vehicles to pass through. The bollards are able to rise or fall in approximately 2 seconds, so this will not impede traffic flow.

There is still much to keep in mind with the suggestion of installing permanent barriers. With the implementation of permanent barriers, there would be a need for technology to be used to distinguish emergency vehicles and buses from cars so the barriers would retract and allow the proper vehicles through the blockade. This would require all vehicles allowed to travel through the restricted areas of the road to be equipped with this technology. Construction on the roads would also be necessary to install such barriers which would have a negative impact on all types of traffic. The cost of this would be quite high and more research would first need to be conducted to determine if this would be a feasible option on the road and if the benefit would outweigh the cost. Since there is not a large amount of cars driving through the restricted area currently, this option may be able to be avoided. If there were a larger number of cars violating the restriction this method may be more appropriate.

5.3 Increasing Police Intervention

As another option, it may be worthwhile to increase the number of tickets given to those who violate the restrictions. There is already a 500 kroner fine in place for those who drive through the restricted areas, but not many people have seen tickets being given out even when the police are patrolling the area. The police should start enforcing the restriction more adamantly in order to dissuade drivers from violating the restriction. This fine could provide the police department with some needed funds if drivers continue to violate the restriction. With a stronger police presence on the street, this might also decrease the amount of other various crimes in the immediate area.
5.4 Allowing Traffic during Select Hours

Another important suggestion is to provide hours where the traffic is allowed to travel through the restricted areas. At night when the traffic is low in the area and there are less cyclists and pedestrians, it would be practical to allow the personal motor vehicles to drive the entire length of Nørrebrogade without detour. From the traffic data we received from the city, it is shown that traffic peaks between 3-5 pm. After that traffic slowly diminishes, but since we only have traffic data until 7 pm it is hard for us to recommend a specific time of day for the closure. Additional traffic data would need to be gathered which covers nighttime hours more. Another time when it may be practical to allow cars is on weekends. Many shop owners have complained that the lack of cars has caused a decrease in retail sales. It has been found that a variety of stores have seen no change in business, however the shops that are showing a loss are the shops that carry larger goods. These larger goods stores are located on sections of the road that are open to private vehicles though. A mattress store claimed that the road closing has had a negative impact on finances, but since it is harder to drive directly onto Nørrebrogade, the storeowner feels customers are just going somewhere else. If the road was completely open to cars during select hours this may be able to combat this problem.

Although a strong influence in the project is aimed at stopping car traffic completely, it is also important to accommodate those it may negatively affect. By reducing the traffic during the daytime, commuting to and from the city for work will change for many people. Many are choosing to change their modes of transportation to bus or bicycle that reduces emissions. When one chooses to either cycle or walk as a mode of transportation there are not only positive environmental impacts, but also positive personal health benefits as well. Opening the road at specific hours will give the shops on the decline a chance to maintain their business, and make late night and weekend travel by car more convenient.

Opening the road for only specific hours of days could also be problematic. This could cause more confusion to the public of when they can and cannot drive through the designated areas. If drivers are able to drive through at certain times, they might be more likely to violate the car restriction at other times, though they would eventually likely adapt, given time, so this is a suggestion to keep in mind. This change would, however, not cost the city anything and may be worth trying if there are continued problems with commerce on the street, as many shopkeepers we spoke with reported there were. Further traffic data would be able to be
gathered if a plan like this was implemented which would allow the city to decide whether or not to keep the change based on the traffic numbers.

### 5.5 Multiple Implementations

Another option would also be the implementation of two of these ideas, simultaneously. If traffic was allowed during certain hours of the night or perhaps on weekends, this could have a positive impact on commerce and the retractable barriers would make sure that drivers of cars do not take advantage of this freedom and travel in the restricted sections during times when it is not permitted. Again, the main concern would be with the total cost of using the permanent barriers. If this method was used, the police would be able to focus their efforts elsewhere though since traffic will be automatically regulated.

### 5.6 Final Recommendation

Our final recommendation at this point in the trial is to install speed bumps at the entrance and exit of each busgade. This will hopefully be effective enough to eventually reduce the amount of illegal trips through these areas to zero. They are also very cost effective, and can be easily removed if desired. This also is a more permanent restriction on the road compared to the signs in place already. They would not impede the traffic flow of busses due to the cut out for bus wheels to travel through.

We also recommend that plans be made to beautify the street more. There should be a section on the road where trees could be planted. This will make the road look more natural and appealing to shoppers and tourists visiting the area. Other smaller plants could also be planted in areas along the road. These small improvements to the road may draw a larger shopping crowd, which could help to stimulate business in the area. The trees and plants in the area could also help to reduce CO$_2$ in the area since those plants will use the CO$_2$ from car exhaust for energy.

When further similar studies are conducted we also have recommendations on how they could be studied in the future. The first step before closing a road is to conduct traffic volume counts on the street that is planned to be closed, and also on the streets around the area. It is also important to inform the community about the planned closure and get feedback from the public so when a plan is made they may be more inclined to follow the rules. Since many Danes care about the environment, it may also be important to provide previous case studies involving street closures that resulted in a decrease amount of car traffic. There could also be special rates.
provided for public transportation for those who live in the area that may help them change their mode of transportation. The next main step would be a few weeks after the closure. Traffic counts of the same data should be taken on the same streets as the counts conducted prior to the road closing. Much of our data was not presented in a consistent manner so it was a difficult task to compare the traffic count data before and after the street closing. The counts should be made on the same day of the week as the previous counts, during the same hours, and they should look for the same types of traffic. A month or two after the road closing should be enough time for traffic to adjust to the new traffic situations. After that, there should be police intervention for at least a month if many cars are still driving through the closed street. The police should issue a citation to any driver that passes through the area instead of giving a simple warning. This will enforce the idea that the road is closed and there will be a consequence for violating the law. After these steps have been taken, the city should order another traffic count six months after the closure. Once again, the same data should be collected consistent with the prior count. Once all this data is collected it will be possible to create a clear picture as to where the traffic has gone, and if any traffic has disappeared in the area. This will be able to provide further evidence towards traffic evaporation after closing a city street.

http://find.galegroup.com/ips/start.do?prodId=IPS

http://ibyen.dk/article612037.ece.


Bikes Only Travel: Copenhagen Closes Road to Cars. Jaunted.com


Appendix A – Additional Nørrebro Information

This appendix provides more detailed information regarding the closing of Nørrebrogade. The information includes extra Figures which show information about the street closure, as well as more detailed information on traffic count data.

In order to compare the traffic from the two time periods, seasonal variation must be taken into account as well. For car travel, the count data is normally multiplied by a factor of .95 in September, and by .97 in November.

Figure 40 shows the turn restriction signs and bike lanes on the Queen Louise’s Bridge which were improvements which helped manage the closed street. The bike lanes are marked in yellow on each side of the road.

![Figure 40: Signs, markings, and bicycle lanes on Queen Louise’s Bridge. (COWI, 2008)](image)

Other closing signs at the Jagtvej and Nørrebrogade intersection can be seen in Figure 41. This intersection allows for cars to travel across Jagtvej, but they can only turn off of
Nørrebrogade. Cars are not allowed to travel across Jagtvej on Nørrebrogade, but buses and emergency vehicles are still allowed to. Jagtvej is a main street that crosses perpendicular to Nørrebrogade.

Figure 41: Changing the signs and markings on Nørrebrogade ban exit straight across Jagtvej except for buses (COWI, 2008)

The old bicycle paths have been decommissioned between Kapelvæj and Jagtvej, and a new cyclist path was created by the narrowing of the vehicle road. The reason for this closing was to narrow the roads so they were only wide enough for two buses to pass by each other. There would be no room for parking or stopping on this section of the road. The closed cyclist path was converted into an extra space for pedestrians, which may also include bicycle racks, benches, and small shops. This is also called a flex zone. The closings can be seen in Figure 42, and the flex zone areas can be seen in Figure 43.
There have been loading zones designated on Nørrebrogade which are designed to help vehicles load or unload their cars on the street. Since there is no stopping on the street, these specific areas allow for loading and unloading of goods to happen. These loading zones are similar to parking lots in which you will pull off the street and park while you take care of the business you need to do. These zones can be seen in Figure 43.
Figure 43: Example of the loading zone on side and “flex zone” on old bicycle path. (COWI, 2008)

The overall effect of the traffic redistribution can be seen in Table 4. The general trend is that there is either a decrease in traffic, or a slight increase which could just resemble normal traffic volume levels. This suggests that the project seems to be working as planned currently.

Table 4: Assessment of changes of capacity load around Nørrebro (COWI, 2008)

<table>
<thead>
<tr>
<th>Street Crossing</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ndr. Fasanvej / Frederikssundsvej / Lygten/Nørrebrogade</td>
<td>Large drop in traffic volumes on Frederikssundsvej-Nørrebrogade and small decrease of traffic on Lygten-Ndr. Fasanvej shows a significant change in the distribution of turn movements. Overall, smaller capacity load on the road.</td>
</tr>
<tr>
<td>Ndr. Fasanvej / Hillerødsgade</td>
<td>Only small fluctuations in traffic volumes and stable distribution of turn movements. Overall, this points to the same load capacity.</td>
</tr>
<tr>
<td>Jagtvej / Tagensvej</td>
<td>Increases in traffic volumes particularly in Tagensvej but in total only increased by approx. 5% on volumes of traffic entering the junction. Overall, this points to the same capacity loading.</td>
</tr>
<tr>
<td>Jagtvej / Nørrebrogade</td>
<td>Large drop in traffic volumes on Nørrebrogade and smaller decrease on Jagtvej. Been little change in the distribution of the</td>
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</table>
The initial data shows that there has been a significant decrease in traffic load on major intersections on Nørrebrogade. The other major road crossings experienced only small changes which indicated a generally unchanged traffic capacity. The Søgade intersection saw the biggest decrease of vehicle traffic volume, and turn movements during the morning and afternoon traffic. These changes in the load capacity have not necessarily proven the trial yet. There has been a large decrease in traffic around Nørrebro though which can be seen in Figure 44 and Figure 45.
Figure 44: Traffic fluctuation on Norrebrogade in outer Norrebro (COWI, 2008)
Figure 45: Traffic fluctuation on major roads around Nørrebro (COWI, 2008)

An initial poll showed that 67% of the district’s citizens want the closure to remain permanent, 24% would like the street reverted back, and 9% have not decided yet. Shop owners on the other hand report that 61% reject the idea that the study should remain permanent, and 25% agree with the closure. Around half of them believe since the road closure, the circulation in their store has gone down. (Astrup, 2008)
### Appendix B – List of Streets with Traffic Data

<table>
<thead>
<tr>
<th>Name of Street</th>
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<th>Bus Traffic Data</th>
<th>Bike Traffic Data</th>
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81
<table>
<thead>
<tr>
<th>Street Name</th>
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<tbody>
<tr>
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<td>Tagensvej North of Jagtvej</td>
<td>X</td>
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<tr>
<td>Stefansgade</td>
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<tr>
<td>Sortedams Dossering</td>
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<tr>
<td>Stengade</td>
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<tr>
<td>Åboulevard</td>
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<td>Jagtvej South of Nørrebrogade</td>
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<tr>
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<tr>
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<td>Jagtvej North East of Nørrebrogade</td>
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## Appendix C – Sample Questions

Table 5: Sample Questions used for interviews

<table>
<thead>
<tr>
<th>Audience</th>
<th>Questions</th>
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</table>
| **Cars** |  - Has your travel time been affected by the street closure?  
  - What is your purpose for traveling on Nørrebrogade? (work, shopping etc..)  
  - Have you thought about using public transportation or bicycle?  
  - How far away are you traveling from to reach Nørrebrogade?  
  - Do you use your car any less since the road closure?  
  - Do you agree with the street closing trying to decrease vehicle traffic?  
  - Do you have any suggestions on how the road can be made better? |
| **Buses** |  - Have you noticed an increase in bus usage since the street closing?  
  - Have bus travel times been reduced on Nørrebrogade?  
  - Have you changed modes of transportation since the road closing?  
  - What do you think about the plan that has been implemented so far?  
  - Have you had any problems since the road closing?  
  - Do you have any suggestions on how the road can be made better? |
| **Cyclists** |  - Have you changed your mode of transport since the street closing?  
  - How far away do you cycle from Nørrebrogade?  
  - Do you feel safer traveling on the street since it’s been closed?  
  - Have you noticed an increase in cyclists on Nørrebrogade?  
  - What do you think about the plan that has been implemented so far?  
  - Any complaints about the road closing?  
  - Do you have any suggestions on how the road can be made better? |
| **Walkers** |  - Have you changed your mode of transport since the street closing?  
  - How far away are you walking from Nørrebrogade?  
  - Have you noticed an increase in pedestrians on the street since the closing?  
  - Do you feel safer traveling on the street since it’s been closed?  
  - What do you think about the plan that has been implemented so far?  
  - Any complaints about the road closing?  
  - Do you have any suggestions on how the road can be made better? |
| **Shopkeepers** |  - Has there been a fluctuation in business since the street closing?  
  - Do you believe the change is related to the street closing? (if they say there has been a decrease in business...ex. Economy..weather)  
  - Have you noticed a fluctuation in pedestrian traffic in the store?  
  - Has the street closing caused you any problems with deliveries or otherwise?  
  - How do you feel about the project?  
  - Do you have any suggestions for improvements? |
Appendix D: Interview Sheet

Nørrebrogade Assessment
Agenda 21

<table>
<thead>
<tr>
<th>Cyclist</th>
<th>Pedestrian</th>
<th>Car Owner</th>
<th>Bus Rider</th>
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Is this person a:

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<tbody>
<tr>
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Do you feel safer with less traffic?

<table>
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</tbody>
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Have you changed your mode of transport since the closing?

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<thead>
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<th>Walk</th>
<th>Cycle</th>
<th>Bus</th>
<th>Car</th>
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<tbody>
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</table>

If so, to what is your new mode of transport?

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Do you live in the Nørrebrogade neighborhood?

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Opinions about the road closing and how to make it better?

Figure 46: Question Sheet for Interviews
## Appendix E – Sample Traffic Data Worksheets from City of Copenhagen

**Figure 47:** Traffic Data on Norrebrogade moving away from the city

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*Note: All data in the table represents the traffic data on Norrebrogade moving away from the city.*
### Traffic Data on Nørrebrogade moving towards the city

#### Figure 48:

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<th>SØ, mod byen</th>
<th>TORSDAG D. 11 SEPT 2008</th>
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# Appendix F: Traffic Count Spreadsheet

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<th>Trial Count 2</th>
<th>% Change Before - Trial 1</th>
<th>% Change Trial 1 - Trial 2</th>
<th>% Change Before - Trial 2</th>
<th>Difference Before - Trial 2</th>
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Figure 49: Traffic Data Spreadsheet
Appendix G – Traffic Data Street graphs

Figure 50: Ægirsgade Traffic Data Graph Prior to Road Closing

Figure 51: Ægirsgade Traffic Data Graph 6 Months after Road Closing
Figure 52: Baldersgade Traffic Data Graph Prior to Road Closing

Figure 53: Baldersgade Traffic Data Graph 6 Months after Road Closing
Figure 54: Fælledvej Traffic Data Graph Prior to Road Closing

Figure 55: Fælledvej Traffic Data Graph 6 Months after Road Closing
Figure 56: Blegdamsvej Traffic Data Graph Prior to Road Closing

Figure 57: Blegdamsvej Traffic Data Graph 6 Months after Road Closing
Figure 58: Bragesgade Traffic Data Graph Prior to Road Closing

Figure 59: Bragesgade Traffic Data Graph 6 Months after Road Closing
Figure 60: Lundtoftegaede Traffic Data Graph Prior to Road Closing

Figure 61: Lundtoftegaede Traffic Data Graph 6 Months after Road Closing
Figure 62: Hamletsgade Traffic Data Graph Prior to Road Closing

Figure 63: Hamletsgade Traffic Data Graph 6 Months after Road Closing