Urban forms, road network design and bicycle use
The case of Quebec City's metropolitan area

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Summary

With the constant rise in car use, new concerns have increased interest in planning policies that favour the reduction of car travel in urban areas. To this end, transport plans may have a demand management component to increase the use of transit, carpooling and non-motorised modes. However, the data required for such plans are often problematical, and in particular traditional transport surveys are not well adapted for the study of bicycle use. Arguably, better knowledge about cyclists' travel behaviour, about perceived constraints on the use of bicycles, and about the effects of different urban forms on bicycle travel should lead to more balanced transport planning.

This research aims to identify the urban form and roadway attributes that influence bicycle use and travel behaviour. To establish these interactions, our preferred method is the use of activity and travel diaries. These diaries allow us to describe an individual's activity set (i.e. working, leisure, shopping etc.), to reveal the constraints that s/he is facing (i.e. time, distance, destination location, travel modes available, route choice, etc.) and to link these data to the characteristics of urban form and the road network. The diaries reveal sufficient detail about each cyclist's travel that it is possible to then investigate particular conditions of their neighbourhood in order to identify the urban form factors that are linked to their travel behaviour. This disaggregated approach considers that the travel is not an end itself but it is a part of a strategy conditioned by different factors : activity type, time available for travel and for the activity, activity location, route choices available, and household and individual constraints. Taking this broad view, rather than focussing on bicycle trips in isolation, it is possible to identify which factors are linked to the urban form and which are not.

The presentation will discuss the methodology adopted and the primary results of the survey undertaken during the Summer of 1998. Almost 200 cyclists were selected in the Quebec City's metropolitan area. These cyclists recorded their travel and activities in a diary for a 7 day period. Despite the effort required, fewer than 5% of respondents abandoned their participation before the end of their 7 day period of observation.

1. Introduction

Cars have influenced neighbourhood planning and road scale, and have determined relationships between buildings (Cervero 1996). With the constant rise in car use, new concerns have increased interest in planning policies that favour the reduction of car travel in urban areas. To this end, transport plans may have a demand management component to increase the use of transit, carpooling and non-motorised modes. New planning approaches have emerged, such as "New Urbanism" and "Transit Oriented Neighbourhood" (TOD), and bicycle use has gained in interest. Researchers such as Anderson (1996), Handy (1996) and Kitamura (1997) have expressed some

hypotheses on the effects of urban form and land use planning on travel behaviour; some hypotheses can also be made concerning their effects on bicycle use. Among the elements that should be considered are: travel distance, the location of businesses and services (retail trends), topography, physical barriers (e.g. highways, rivers and waterways), road network compatibility, and safety.

2. Research problem

Bicycle use in Quebec Province is modest, but occasional bicycle use (at least once a week) has increased from 23% to 39% in the last ten years (Couture and al, 1997). Also, a new tendency has been observed in the type of bicycle use: cyclists begin with a recreational bicycle use and shift later to more utilitarian use (Couture and al., 1997). Actual knowledge of bicycle use is, however, limited. We have some information on bicycle use frequency, bicycle counts at specific sites, and some user profiles, but we do not have any information on the origins and destinations of cycling trips. Urban travel surveys have been undertaken at five year intervals in the Quebec area, but these do not allow us to assess bicycle travel from the point of view of urban form and land use planning. The main reasons are related to the survey instrument, which focuses on car and transit trips but not on non-motorised, short trips. Also, the surveys are based on one day of travel. We need to consider more than one day of travel to study bicycle behaviour, because weather conditions, the day of the week, and travel constrains linked to particular activities have a more significant influence on bicycle use than on motorised modes. Much could be learnt from variations which can be observed from multi-day data. Also, the period when the five-yearly travel surveys take place is late enough in the year (October to December) for cold weather to affect bicycle use. Finally, traditional transport surveys do not capture the travel itinerary (route choice). In the case of bicycle travel, it is important to understand the influence of urban form and road network on bicycle route choice, and the conditions under which cyclists will agree to ride. But it was also important to ensure that any new data collection would allow us to distinguish urban form effects from the other determinants of bicycle use and travel strategies, and for this an activity-based approach appeared promising.

3. Methodology adopted

To establish the interactions between urban form, roadway attributes and bicycle use, our preferred method is the use of diaries of both activity and travel. This disaggregate approach considers that the travel is not an end itself but it is a part of a strategy conditioned by different factors: activity type, time available for travel and for the activity, activity location, routes available, and household and individual constraints. The diaries allow us to describe an individual's activity set (i.e., working, leisure, shopping, etc.), to reveal the constraints that s/he is facing (i.e. travel time, distance and comfort for alternative feasible destinations, considering the travel modes and routes available, etc.) and to link these data to the characteristics of urban form and the road network.

We have developed a new diary adapted to bicycle travel inspired, in part, by a design of Stopher (1992). This diary is a small booklet for seven days. For each day, there is a memory jogger to write down all the out-of-home activities and travel during the day, and ten "stop" sheets for each activity that implies travel. These "stop" sheets are divided into six parts: 1) destination type (work place, childcare, school etc.), 2) destination location, 3) activity performed, 4) transportation mode used, 5) bicycle trip details and 6) arrival and departure time.
Also, we included a city map at the end of each day to trace all bicycle itineraries. The diaries reveal sufficient detail about each cyclist's travel that it is possible to then investigate particular

conditions of their neighbourhood in order to identify the urban form factors that are linked to their travel behaviour. Taking this broad view, rather than focussing on bicycle trips in isolation, it is possible to identify which factors are linked to the urban form and which are not. Also, during the first meeting with the respondents, we asked questions about respondents' socio-economic characteristics, mobility and residential choices. At the end of the seven day diary period, we met the respondents again to pick up the diary, and to ask them some questions on their motivations for bicycle use, their perceptions about safety, their experience with falls and accidents, and route choice. At the same time, we improved data quality by checking the diary with the respondent to detect and correct any missing or unclear entries.

4. Survey

We undertook the survey during summer 1998 (May to September). We chose cyclists from three different residential locations in the Quebec City metropolitan area with quite different roadway characteristics, land-use and neighbourhood layouts. The first zone is a "suburb", crossed by a major highway, with a curvilinear road pattern and segregated land-uses. The Quebec City area has a complex topography, essentially a "hog's back" in a large basin, and the two other zones reflect this. The second zone, "Lower-Town/ Limoilou/ Vanier", is located on a river plain at the bottom of the "hog's back", and has a mostly orthogonal road grid and mixed-use. The last zone is "Plateau/ Upper-Town" located on the top of the "hog's back"; it also has an orthogonal road grid and mixed-use but is a higher income area than the second zone. The cyclists were recruited only if they made at least four bicycle trips per week, and according to a quota sample which ensured that within zones, respondents were drawn from four different household life stages (without children; with children 12 or under; with children over 12; and retired people). Overall, 189 cyclists with an average age of 43 took part in the survey.

5. Results

The data from the survey are particularly rich in behavioural and spatial detail and offer numerous possibilities for analysis. We must emphasise that the results reflect behaviours of active cyclists and not the overall population: there is more utilitarian bicycle use in this study owing to the "active" criterion (at least 4 times a week). The respondents within different life stages were widely distributed over the three large zones. We note that, among these cyclists, car ownership was higher in the suburban zone than in the other two zones. In general, the first motivation of respondents for cycling was to stay in shape (expressed by 25% of respondents), pleasure (expressed by 22% or respondents) and convenience (expressed by 20% of respondents). The respondents did not generally use transit during summer time, but many did during cold weather.

5.1 Travel details

For the cyclists surveyed, 37,3% of all trips were made by bicycle, and there is some difference in travel mode adopted across the different residential zones. There were more non-motorised trips (bicycle and by foot) in the Lower-Town/ Limoilou/ Vanier and Plateau/Upper-Town than in the suburbs. Mainly, this difference can be observed in the mode choice for shopping and maintenance (Table 1). There is a correlation between having retail and service opportunities close to the residential location (2 km) and the use of non-motorised modes. For each trip made with a transportation mode other than bicycle, we asked the respondents to explain the choice. In general,

it was because they had too many things to carry on a bicycle or because they had to travel with someone else (bicycle is mostly a lonely transportation mode). However, there was a contrast between the suburban zone and the two other zones in other reasons given for not cycling: in the suburban zone destinations were often considered too far to use a bicycle, whereas in the other two zones, destinations were often close enough to walk.

Table 1 : Transportation modes used for seven days in the different neighborhood

Neighborhood type	Transportation modes used (7 days)			Transportation modes used for shopping and maintenance (7 days)		
	Bicycle	Walk	Car	Bicycle	Walk	Car
Suburbs	34,9%	10,7%	52,5%	19,3%	11,4%	68,1%
Plateau/ Upper-Town	38,7%	26,3%	30,5%	14,8%	42,1%	40,6%
Lower-Town/ Limoilou/ Vanier	38,7%	23,0%	34,4%	29,8%	28,6%	39,8%

5.2 Tour analysis

We also studied the relationships between trips. A better understanding of the use of non-motorised trips can be achieved by looking their role in tours, instead of just comparing their characteristics in general with trips by motorised modes. We used a home-based tour approach in which a tour was defined as a sequence of consecutive trips that begin and end at home. Tours were classified by the purpose of the activity with the longest duration. Most of the tours by cyclists (by all modes) were for shopping/maintenance (37,4%) and for work/study (28,5%). About one third (30%) of the tours were made by bicycle, and a further 11,7% combined cycling with another mode (walk, transit or car). The main difference between zones was in the distance travelled by mode, and especially by bicycle. Part of this may be linked to the land use planning and layout of the different zones, and the fact that cyclists may make some detours to avoid barriers or unsafe situations (i.e. arterial roads, highways and complex intersections), and it also depends upon the permeability of the road grid. With the use of the GIS, we are taking advantage of integrated roadway data for each cyclist's residential area, including: road Kms and number of lanes by class of road; types of bikeways; and intersection complexity based on the number of legs. Knowing this information, we are able to build a roadway index from each individual respondent's residence location, and analyse its effects on observed tours.

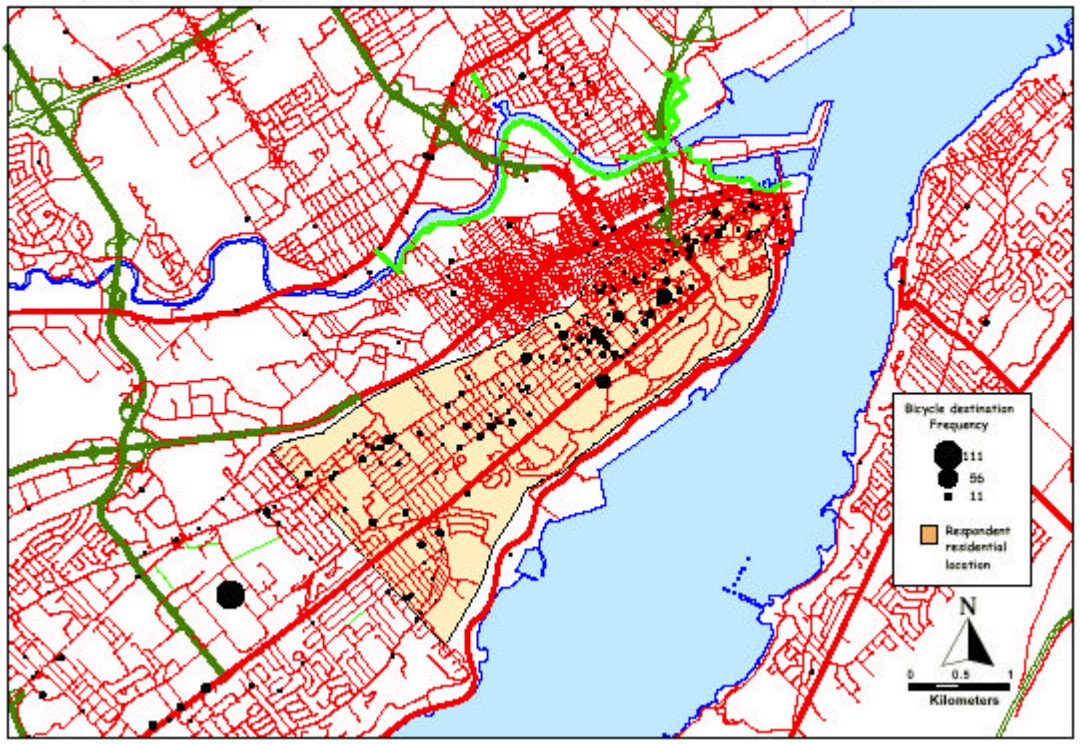
Table 2 : Tours analysis : purposes, transportation modes, distance for seven days

	Neighborhood types			Total
	Suburbs	Lower-Town/ Limoilou/ Vanier	Plateau/ Upper-Town	
Main Purpose				
Work/ Study	30,8%	30,1%	24,0%	28,5%
Shopping/ Maintenance	36,3%	39,0%	37,0%	37,4%
Ride and stroll	10,7%	10,5%	5,8%	9,1%
Leisure	21,7%	19,3%	32,3%	24,2%
Others	0,5%	1,0%	0,9%	0,8%
Transportation modes				
Bicycle	27,5%	31,0%	32,2%	30,0%
Bicycle with other modes	13,3%	12,6%	8,8%	11,7%
Walk	5,8%	18,4%	21,2%	14,4%
Car	46,0%	26,4%	28,7%	34,6%
Transit	0,6%	1,9%	2,1%	1,5%
Distance average (km)				
All modes	15,87	9,39	10,61	12,25
Bicycle	18,11	10,86	10,37	13,24

5.3 Cyclist route choices

A first, simple spatial analysis of destination frequency gives us a hint about the effect of topography on bicycle use. For example, cyclists from Plateau/ Upper-Town concentrate most of their bicycle trips in the high plateau: it seems that the topography factor plays a role in their destination choices. However, this factor must be analysed in conjunction with other factors such as the proximity of shops and services (Fig. 1). Also, with the shops and services data in the GIS, we can compute the activity opportunities within, for example, a 2 Km radius from the respondent's home. Furthermore, we are able to assess the variety and the accessibility (car oriented vs. bicycle oriented) of activity locations. Our accessibility index is the ratio of the size of the lot to the size of the building footprint: car-oriented locations have low ratios because of parking. Other indexes can be built in the GIS from each respondent's residence location, such as summary measures of the topography using contour data.

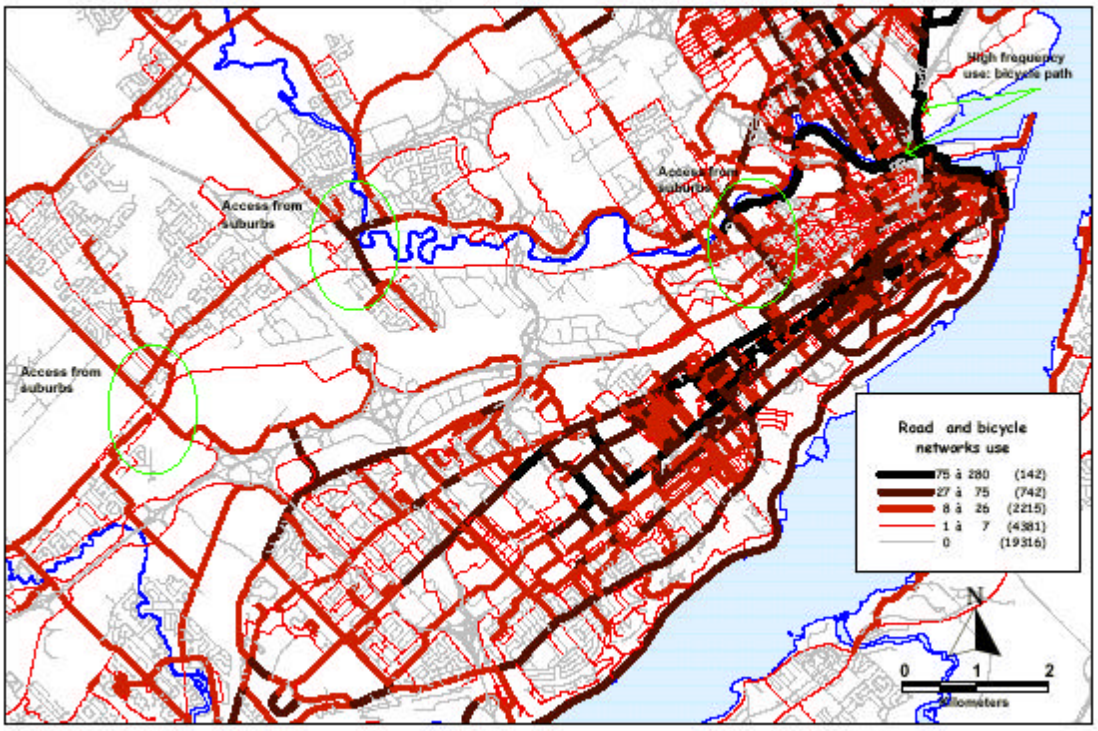
FIG. 1: Bicycle destination frequency for respondent(s) from Plateau/ Upper Town (7 days)



We also analysed the bicycle itineraries in a GIS to explore their use of the road and bicycle network. We obtained the frequency of use of each segment of the road and bicycle networks. Such information may also be treated by isolating road segments chosen by more experienced cyclists versus occasional cyclists, and such analyses can also be segmented by other respondent variables such as sex, age, etc. The image shown in Fig.2 offers us important insights into the different strategies adopted by cyclists, the access routes used, the grid permeability effects of the different neighbourhoods, and the use of the different bicycle facilities. These results may be correlated with bicycle accidents on the road network to evaluate cyclist safety, and may offer clues about possible interventions to make the network to more cyclist-friendly. We also asked the cyclists how they were choosing their routes. Cyclists prefer riding on local streets (expressed by 21% of cyclists) or look for the shortest path (14% of cyclists); other cyclists (13%) prefer to use bikeways. Also, when

we asked them about the main sources of hazards while cycling, 25% of these cyclists identified the behaviour of drivers, while others named riding on narrow streets (15%) or in dense traffic (11%). Many other interesting, multivariate analyses are possible with the data available.

FIG. 2: Frequency of cyclist use for road and cycle network segments (7 days)



6. Conclusion

The use of an activity based approach and the integration of the data into a GIS have yielded many advantages for the study of cyclists' travel behaviours and strategies. This kind of approach, using disaggregate data, separates the effects of urban form and road network design from other factors, such as socio-economic characteristics, or the relationship between activity constraints and trips. Respondent burden is high, but this may be alleviated by emerging technological developments: our research centre is now experimenting with DGPS (differential global positioning system) receivers to trace itineraries passively. This kind of in-depth survey on a small sample, when used in conjunction with the more conventional travel surveys typically carried out by transport planning agencies, can offer "more than the sum of the parts" and should help clarify the contribution of bicycle use to urban transport.

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