

SOCIO-SPATIAL INEQUALITIES IN ROAD TRAFFIC RISK AND DAILY TRAVEL IN ADOLESCENCE¹

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ABSTRACT

Social inequalities play a role in road traffic injuries, but this issue has been given scarce attention in France. More precisely, the high number of injuries among adolescents is generally explained by behavioral factors. However, epidemiological studies in Great Britain and Sweden suggest that there is an “over-risk” for children and adolescents among the poor and in deprived neighborhoods. This exploratory study aims at testing the hypothesis of the existence of social and spatial inequalities in road traffic injury patterns, concerning the 14-17 years old. Further analysis of household travel surveys and statistical files of road traffic injuries in the Lyons’ urban region have been conducted. Injuries appear more frequent for the residents of deprived areas. These inequalities appear to be linked to the contrasting conditions of daily mobility of adolescents of the two types of places of residence, and partly related to socio-spatial inequalities. Methodological questions are then discussed in order to obtain deeper understanding of this problem.

Key words: road injury, daily travel, walk, bicycle, motorised two-wheeler, car, youth, gender, social inequality, income per consumption unit, spatial inequality, deprived area.

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INTRODUCTION

In recent years, road safety has considerably improved in most European countries, including France. However, the progress is unequally distributed. In France, the percentage of injuries involving young people and vulnerable road users (pedestrians, cyclists and moped/scooter users) and the percentage of injuries occurring in urban and suburban areas are on the increase. Young people in the 15 to 24 year-old age group account for only 13% of the population but 27% of road fatalities (ONISR, 2006), and road traffic injuries are the primary cause of mortality for this age group. However, the fact that improvements have recently become smaller and smaller leads one to suspect that the impact of traditional methods (prevention and above all strengthening of the traffic enforcement system) of changing behaviour is diminishing.

Human behaviour while travelling (risk-taking, inappropriate driving) is not the only variable that may affect the risk of crash involvement. A whole set of environmental factors – social, economic, technical and geographical – affect the level of crash risk. When developing their road safety policy, some countries such as Sweden and the Netherlands have explicitly recognized that blame for injuries cannot be assigned exclusively to drivers but should be shared with the other actors involved (vehicle manufacturers, authorities,...). If we accept such a sharing of responsibilities, we must also take the view that part of the risk is *imposed* on road users as a result of factors that are external to them. As with the majority of health problems, the distribution of road traffic injuries is socially stratified, whatever groups are considered (Christie, 1995). A better understanding of the social dimension of the phenomenon may help us develop policies that are more appropriate for different groups. The goal is to improve the position of certain particularly exposed groups and thereby bring about an overall improvement.

The issue of inequalities with regard to injury risk during adolescence is important in a number of respects. First, among young males, the peak for crash involvement coincides with the acquisition of travel independence in the years before their 18th birthday and the possibility of driving a car. Among young females, it occurs immediately after. Understanding the habits which are formed between 14 and 17 years of age may shed light on the situations, changes and constant features that affect adult travel behaviour, in particular during the first few years of driving. However, when they have no earnings of their own, the travel conditions of adolescents, while tending towards independence, are even more closely dependent on social, family, residential characteristics which favour different transport modes to different degrees.

The hypothesis that individuals' social position and the characteristics of their residential location may influence their injury risk arises from the observation that there are social and geographical inequalities as regards access to transport modes and the travel conditions under which travel takes place. In particular, ease of access to a car depends on educational level (persons with a low level of education find it more difficult to obtain a driving licence)

and, more markedly still, on their household's standard of living (Claisse et al., 2002; Orfeuil, 2004; Mignot & Rosales Montano, 2006). Fewer low income households have two cars than well-to-do households, and they are also more frequently carless, which may have many impacts. Moreover, the fact that their vehicles are on average older (Nicolas et al., 2002) may affect their availability and also injury risk and severity. Due to the spatial concentration of poverty and deprivation, the social inequalities in road risk may be studied on a territorial basis. We can therefore make a first hypothesis that neighbourhood effects or 'place effects' may exist (Bourdieu, 1993), that is to say that socio-geographical variables provide useful information on road traffic injury risk. More precisely, a spatial approach is justified on several grounds:

- the infrastructure and the characteristics of a residential area, for example the characteristics of the access roads and public transport services, no doubt have some influence both on mobility and road traffic injury risk;
- mean speeds, traffic levels, private vehicle ownership rates (car and motorized two-wheelers), housing density, accessibility and the availability of local activities (sports grounds, playgrounds...), unemployment/participation rates and delinquency rates depend (partially, directly or indirectly) on the socioeconomic level of the zone in question;
- the socio-economic and cultural characteristics of the resident population may influence the representation of road risk, as well as behaviour in public space, particularly during adolescence. Adolescence is marked by a fairly strong "peer group effect" as adolescents tend to attach less importance to the ideas and habits they have learnt from their parents and acquire new ones from their friends.

So, the residential area's infrastructure and the socioeconomic nature of the residential area and its inhabitants may influence injury levels in the above ways.

We can thus formulate a second hypothesis: the forms taken by travel during adolescence, and the way travel changes, exhibit a high degree of social differentiation. During youth, and particularly adolescence, travel changes rapidly. These years during which young people learn to travel independently, discover new spaces with their associated sociability and behaviours, generate a large variety of practices that depend on social background, residential location and the urban experience of the young person's parents, or whether the young person is male or female (Haddak et al., 2009, Goyon, 2009). The way non-school related trips, for example leisure trips and visits, are made plays an important role in the construction of independent travel, as Massot and Zaffran (2007) have shown in the case of 10-13 year-olds in the Greater Paris Region. However, among young people, social inequalities affect long distance travel (summer holidays) more than local travel, weekend travel more than weekday travel, leisure travel more than home-to-school travel, even though the level of choice and the constraints associated with the location of the children's school,

which vary from one class to another, also influence levels of travel and the modes of transport used during the week (Paulo, 2006).

Car dependency is particularly high in sparsely populated zones and/or zones with poor public transport (Dupuy et al., 2001). Obviously, in such areas, it is much harder to be escorted, in particular when the members of the household have timetables which are difficult to synchronize (broken or out of phase working hours, single parent families), reveal other forms of inequality (Kaufmann, Flamm, 2002). While poor and precarious families have a strong need to travel, these social difficulties make it more difficult for them to synchronize the activity schedules of the various family members (Le Breton, 2005).

Our on-going exploratory research, which has given the findings set out in this paper, aims to analyze the links between economic, social and geographical factors and injury risk amongst 14-17 year-olds in the Lyon region, while also considering their travel practices, which are responsible for road risk exposure.

First, we shall present some findings from the literature on road risk in relation to the social class of children and adolescents and then we will conduct a socio-geographical analysis of the road risk facing young people based on the Rhône *Département* Road Trauma Register². Last, we shall explore the characteristics of the travel of 14-17 year-olds which are likely to explain the observed differences in risk, with reference to the 2005-2006 Lyon Household Travel Survey.

RISK AND SOCIO.SPATIAL DIFFERENTIATION

While in France, the study of social and geographical disparities in road risk for adolescents and young people as well as other socio-demographic groups is still embryonic, in other European countries studies began as far back as the 1990s and have given a number of converging findings.

1.1. Literature review

The first group of studies we shall consider has examined the road risk of children and young people on the basis of their parents' social class. For example, Edwards et al. (2006) studied social inequalities in road fatality rates for young persons of under 15 years of age in England and Wales in the 1980s and 1990s. The injury incidence rate for pedestrians under 15 years of age whose parents belonged to the most underprivileged class was found to be 20 times higher than for children whose parents belonged to the most advantaged class (4.7 vs 0.2). This study confirms previous results from a North American study which stated that

² The Rhône *département* is the most populated department of Rhône-Alpes, a region located in the Southeast of France. The Rhône department had about 1.677 million inhabitants in 2007 and it is the most urbanized area of the Rhône-Alpes region. Departments are the 3rd level of the Nomenclature of Territorial Units for Statistics (NTUS), a standard geocode for referencing the subdivisions of the European countries for statistical purposes. Lyons, the second largest city in France, is the largest city of both the department and the region. The region has relatively dense, local and inter-city traffic. Heavily used European highways run through the region, in particular the road link North-South.

the severe injury rate of children of the lowest income group was seven times higher than for children of the higher income group (Mueller et al., 1990). In Sweden, a series of studies has considered the links between socioeconomic determinants and the incidence of road traffic injuries. Laflamme and Engstrom (2002) have shown that the children (0-19 year-olds) of unskilled workers (the most underprivileged social group) have a significantly higher road risk than middle and higher social class children. Zambon and Hasselberg (2006) have compared the rates of two-wheeled motorized vehicle injuries for 100,000 young people between 18 and 26. Risk for the most disadvantaged socioeconomic group was found to be 1.6 times higher than for the most advantaged group. Likewise, young drivers (18-26 years old) with parents who are working class (or manual labourers) had 1.65 the risk of being injured, and in particular sustaining several injuries in a road traffic crash (over a period of eight years) than the others (Hasselberg & Laflamme, 2005).

What emerges from these studies is that injury incidence among young people is higher the more underprivileged their parents. However, these Swedish studies did not generally take road risk exposure factors into account.

The second type of studies has examined road risk inequalities on a geographical basis. This spatial information is partly dependent on and partly different from the variables that describe the social position of the individual and his/her household. Nevertheless, in order to identify the effects that are specific to each level of influence (individual or household vs zone), the different levels should be studied simultaneously, which has not always been the case. A study of road traffic injuries involving pedestrians of under 15 years of age has shown that incidence rates were four times higher in the most disadvantaged English electoral wards than in the most advantaged wards once the effect of confounding factors such as age or sex have been controlled for (Graham et al., 2005). The results obtained by Abdalla et al. (1997):

- show that there is a significantly higher injury rate in poor districts compared to wealthier ones;
- concur with this, as do the findings of Durkin et al. (1994) from an environmental study (i.e. one based on aggregate spatial indicators) of data from the 1980s in the United States.

This last study showed that pedestrian and motor vehicle injuries involving young people aged under 17 are statistically associated with all the socioeconomic factors (poverty, single parent family, low educational attainment of the young persons and their parents,...), with the exception of residential crowding.

Few studies have dealt simultaneously with the effect of socioeconomic factors that are individual and contextual (that relate to the residential zone), and even fewer of these have focused on young people. After adjusting for individual variables (gender, age, ethnic group, *per capita* income, marital status, educational attainment and socio-occupational status), Cubbin et al. (2000) have shown that adult residents (aged 18-64) in underprivileged districts

in the United States have more motor vehicle injuries than those in well-to-do districts. These differences are explained by the physical characteristics of the residential zones. Along the same lines, Ferrando et al. (2005) have analyzed the road traffic injuries involving adults aged 19 and over in Barcelona. Controlling for the educational attainment and age of the individuals, these scholars showed that a 1% increase in the proportion of unemployed persons in the district led to a significant increase in road traffic injury risk for men.

However, a previous study by the same team that dealt with the same population (Borrell et al., 2002) failed to show the effects of contextual variables on road traffic injury risk, in contrast to individual educational attainment which was found to play a significant role amongst young adults (20-34 years of age). Last, Laflamme et al. (2009), conducted a national longitudinal study in Sweden on traffic injuries among 7-16 year-olds, distinguishing between motorized two-wheeler injuries and pedestrian or cyclist injuries. The full multilevel model showed that contextual socioeconomic variables are not associated with pedestrian/cyclist casualties once individual factors have been controlled for. In the case of motorized two-wheeler crashes, the young people from underprivileged places of residence were found to have fewer road traffic injuries than those from well-to-do places, again once individual factors have been controlled for. As a result of lower access to motorized two-wheelers, living in a poor zone seems to reduce risk exposure and therefore road risk.

After controlling for individual factors, it does not seem possible on the basis of these few studies to conclude that there is a clear association between contextual socioeconomic factors and road traffic injuries among young persons.

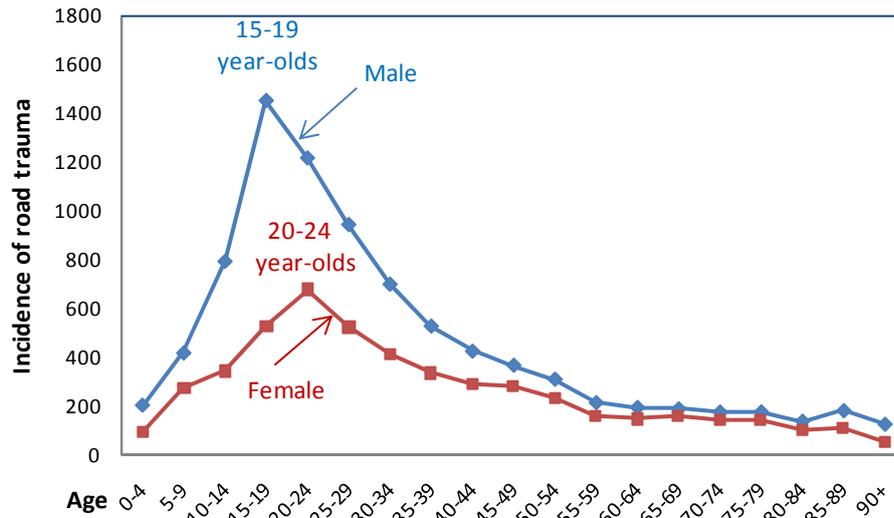
1.2. Differing levels of risk according to gender, residential location and type of road user

The Rhône *Département* Road Trauma Register has been gathering data from medical sources since 1996, and is managed by the ARVAC (Rhône *Département* Road Trauma Register association). It constitutes a very full and reliable injury database that records all injuries, even slight. This source of statistics is subject to a lower under-reporting bias than the national BAAC database (national road traffic injury file) built up from police road traffic crash reports. In particular, data on benign injuries, crashes involving young people or single vehicle crashes are more comprehensively collected. Therefore, this database is particularly suitable for studying road traffic crashes involving non-motorized transport modes and motorized two-wheelers during adolescence. These transport modes, and particularly motorised two wheelers are an important source of road traffic injuries among the youth (Moskal, 2009). The observations that have been built up over ten years confirm that injury risk among young people is particularly high, with a peak occurring between 15 and 19 years of age for males and a lower peak occurring later in their early twenties for females. Male excess risk is therefore at a maximum during adolescence, between the ages of 15 and 19 (Figure 1). The composition of the population of the Rhône *département* cannot explain these large differences: in Lyon Household Travel Survey (HTS), before the age of 30, male

population account approximately for 51% of the total of residents, and, in the Rhône road trauma register, for 63% of all road traffic injuries.

The under 25s thus account for almost half of all the persons sustaining injuries in road traffic crashes each year in the Rhône department (45% in 2006). The 14-17 year-old age group accounted for 10% of the injuries occurring in the Rhône *département* in the same year.

While the precise causes of this peak remain partly unexplained, our initial exploitation of the register showed that young children's risk of being run over was higher in municipalities with a deprived urban area? (ZUS for 'Zones Urbaines Sensibles'³) than in other municipalities (Magnin, 2004; Haddak & Ndiaye, 2006).



Source: Rhône Département Road Trauma Register, 1996-2007.
 Figure 1 – Incidence of road trauma (injuries and fatalities) per 100,000 inhabitants per year according to age class and gender

More broadly, the comparative overall incidences over a six year period (2001-2006) for the two groups of municipalities (with and without a ZUS) for under 25 year-olds show a significant relative risk⁴ (1.23 for males and 1.28 for females). However, in a comparison by five-year age groups, the difference in risk which is on the face of it attributable to the zone of residence was not significant for males aged 0-4, or for females aged 0-4 and 15-19. For males, the largest difference in incidence between the two types of municipality was in the 5-9 year-old age group, with a relative excess risk of 1.56 in the municipalities with a ZUS. For females, the difference between the two types of places of residence was the greatest between the ages of 5 and 14. Between 15 and 19, which is the five-year age group nearest to the one we are targeting in this study, the relative risk was significantly greater than one for males, but slightly less than one and not significant for females.

³ The ZUS represent priority targets for urban policy. These areas are characterized by the presence of large apartment buildings or poor housing and a considerable imbalance between population and jobs. In addition ZUS residents frequently have insecure jobs.

⁴ The relative risk is the ratio between the road traffic injury incidences in municipalities with and without a ZUS. The ZUS are considered to be socially deprived and are the urban areas which are given priority for urban policy.

Can the relatively small size of these differences be explained by the imprecision of the variable used to reveal socio-geographical inequalities? The dichotomy between municipalities with and without a ZUS⁵ was not able to isolate the most underprivileged zones and make a specific risk due to living in the poorest districts clearly visible.

No overall excess risk was apparent for males or females aged between 14 and 17 years living in municipalities with a ZUS. But, when we considered the transport mode used when the crash occurred, it was apparent that this overall absence of effects was the net outcome of opposing effects between motorized two-wheelers and the other modes. In spite of its relatively coarse nature, the socio-spatial indicator did point to higher risk among the 14-17 year-olds in the case of non-motorized modes in the municipalities with a ZUS (Table 1) for pedestrians, cyclists (but the incidence ratio was not significant for females) and finally in-line skaters (with ratios that were not statistically significant).

Table 1 – Mean annual incidences of road traffic injuries (per 100,000 inhabitants) and incidence ratios between the two types of municipality among 14-17 year-olds

	Incidence in municipalities without a ZUS	Incidence in municipalities with a ZUS	Incidence ratio and 95% confidence interval	Incidence in municipalities without a ZUS	Incidence in municipalities with a ZUS	Incidence ratio and 95% confidence interval %
	Males			Females		
Motorized two-wheeler	557.4	398.1	0.71 [0.63-0.80]	111.5	44.0	0.40 [0.39-0.54]
Car	41.6	59.0	1.30 [0.91-1.86]	61.4	63.9	1.04 [0.75-1.43]
Bicycle	129.3	221.8	1.71 [1.42-2.09]	12.1	20.7	1.70 [0.90-3.26]
In-line skates	39.3	51.4	1.31 [0.90-1.90]	8.1*	12.1*	1.50 [0.67-3.38]
On foot	20.8	59.9	2.88 [1.85-4.50]	22.6	60.4	2.67 [1.76-4.16]
All modes	808.8	796.8	1.01 [0.93-1.12]	220.5	213.3	0.97 [0.82-1.15]
Number of observations	1035	959		273	247	

Source: Rhône Département Road Trauma Register, all years between 2001 and 2006.

* The lowest number of observations is for In-line skates accidents: respectively 10 and 14 for females living in municipalities without / with a ZUS.

Higher risk was apparent in the communes with a ZUS for these modes, as it was for the car in the case of males, but it was not always possible to establish statistical significance because of the small numbers of individuals involved in road traffic crashes between 2001 and 2006. These higher risks were counterbalanced by a significantly lower risk of being involved in a motorized two-wheeler crash when one lives in a municipality with a ZUS, which confirms the findings of Borrell et al. (2002).

These spatial contrasts in the injury risk for the different modes point to the fact that differentiated access to transport modes and more broadly the daily travel of young people from different social classes may play a decisive role in injury risk.

⁵ In which, respectively, 46% and 54% of the 14-17 year-olds live. The small zones with a ZUS used in the 2005-2006 Lyon Household Travel Survey (HTS) contained 21% of the 14-17 year-olds living in the Rhône département.

2. SPATIALLY AND SOCIALLY DIFFERENTIATED TRAVEL PRACTICES

To ensure comparability with road traffic injury studies data, the daily travel of residents of the Rhône *département* was studied, distinguishing between males and females. The sample taken from the 2005-2006 Lyon HTS included 1129 individuals of 14 to 17 years of age inclusive, of which 860 were residents of the Greater Lyon conurbation. However, the attempt to link road traffic injury involvement with travel behaviour involved a number of difficulties:

- with the exception of the national transport survey (which produces very small local samples), no survey collects data both on travel practices and the injuries which occur during a given period. Combining the register and the HTS only allowed us to conduct semi-aggregate comparisons;
- the Rhône Road Trauma Register does not record the occupation and socio-occupational group of the subject's parents;
- the HTS does not collect data on weekend travel practices, in particular sporting use of certain modes such as two-wheelers which takes place during weekends;
- the study areas are different: nevertheless the extended perimeter of this HTS meant that we were able to define a common study area for the purposes of this study without too much difficulty. This survey was conducted with a representative sample of 11,229 households in the greater Lyons area, in which 25,656 individuals of more than 4 have described all their trips on the weekday before the administration of the questionnaire. The Rhône *département* sub-sample contains 8,195 households, of which 985 include at least one person aged 14 to 17. The daily mobility of 1167 individuals of 14-17 years old living in the Rhône can therefore be analysed, this sample size being sufficient to give ways to analyses broken up by gender and type of place of residence.
- obtaining homogeneous social characterization between the Register and the HTS was more problematic. Location is identified in the register on the basis of the municipality and the address (of the crash and the casualty's residence), and the latter information makes it possible to perform very detailed spatial coding (IRIS coding). The HTS provides information on the area of residence, but not the home address. The division of the area into the greatest number of zones (694 in all) gives zones that are slightly larger than the IRIS division, but above all does not employ the

same boundaries, which gives rise problems of comparability with other sources⁶. The level of analysis we employed here is the municipality (or, the case of Lyon, the district) which allowed us to identify two spatial classes: municipalities with a ZUS and those without. A more detailed subdivision in the HTS in which the presence of a ZUS (or part of one), in the small zone of residence, was also tested.

Is it possible, at semi-aggregated level, to identify a direct link between higher risk and specific daily travel behaviour? Can the differences in travel behaviour be linked unambiguously with the social characteristics of the zone of residence? Or are they more due to geographical or urban characteristics (density, distance from the main centre and public transport service)? It would seem essential to control for geo-urban factors because ZUS's are urban by definition. This analysis of the correlation between factors that are specifically socioeconomic and the characteristics of zones will concern both the car ownership data and the results concerning the travel practices of adolescents.

2.1. Persistent inequalities with regard to car access

For adolescents, as for adults, household car ownership is the most decisive factor as regards travel conditions. In particular, beyond simple car ownership, the number of cars that are available to the household gives a good idea of the possibilities of escorting the children. Household car ownership (and multi-car ownership especially) was found to be linked both to the household standard of living and whether its residence was in a central, peripheral or rural location. However, the fact that car ownership is considerably lower in municipalities with a ZUS is not principally due to the fact that municipalities without a ZUS have a more peripheral or rural geographical position. Indeed, when we restricted the comparison to the Lyon conurbation, the contrasts were almost as strong as in the whole Rhône *département*, to the disadvantage of the municipalities with a ZUS (Table 2).

Table 2 – Car ownership rate of households of the 14-17 year-olds living in the Rhône *département*, according to types of zone of residence (%)

Type of zone	No car	1 car	2 cars	3 + cars	All
Municipality* without a ZUS	1.7	22.6	57.4	18.3	100
<i>of which: in the Lyon conurbation</i>	2.1	25.7	58.9	13.4	100
Municipality* with a ZUS	7.5	49.8	34.9	7.9	100
<i>of which: in the Lyon conurbation</i>	8.1	51.2	33.3	7.4	100
Municipality* with a ZUS, small zone without ZUS	4.1	45.5	41.2	9.3	100
<i>of which: in the Lyon conurbation</i>	4.7	47.3	39.2	8.8	100
Municipality* with a ZUS, small zone with a ZUS	11.3	54.8	27.5	6.3	100
<i>of which: in the Lyon conurbation</i>	12.0	55.9	26.3	5.8	100
All	3.4	33.1	48.7	14.3	100

* or district in the case of Lyon. Source: 2005-2006 Lyon HTS. Sample size: 985 households.

⁶ Analyses of the HTS has benefited from data enrichment made by the LET, especially Caroline Bayart, Cécile Godinot, Florian Vanco, Jorge Cabrera Delgado and Louafi Bouzouina, in particular by using a GIS to create a correspondence between the two types of zones (and calculate the percentage of the surface area which is shared by the different divisions).

A spatial subdivision into smaller zones with or without a ZUS revealed even clearer differences according to the wealth of the zone of residence. The zones with relatively low car ownership (compared to the norm provided by the wealthiest zones) were not at all marginal in the conurbation as a whole.

Beyond this influence of the socioeconomic level of the residential area, we need to consider the dominant standard of living of the households residing there. The differences relate mainly to household multi-car ownership (two or more cars) and revealed a contrast in particular between the first two quintiles of income per consumption unit (CU) and the wealthiest quintile: 37% of the households in the first quintile were multi-car owners, compared with 57% in the second, 72% in the third and fourth and 90% in the wealthiest quintile.

Crossing individual (household) socioeconomic levels with area socioeconomic levels confirmed the very high impact of household income, particularly in the case of municipalities with a ZUS, even if the type of municipality also appeared to play a role:

- in municipalities with a ZUS, only 20% of the households in the first quintile were multi-car owners, compared with 40% in the second and 90% in the fifth. Conversely, 21% of the households in the first quintile were carless (less than 5% for the other quintiles of income per CU).
- the multicar ownership levels in municipalities without a ZUS were respectively 56% (based on only 37 households), 54% and 94%. 15% of the households in the first quintile were carless (2% for the second quintile, 0 for the others).

Not only were the vehicles used scarcer, they were also older in the municipalities with a ZUS (Table 3). The household's most recent car was thus first put on the road at least nine years ago or at an undisclosed date⁷ in 30% of cases, compared with 15% in the municipalities without a ZUS. When we focused on small zones with a ZUS, the high age of the car fleet in the underprivileged areas was even more clearly apparent.

Table 3 – Age class of the most recent car owned by the household of the 14-17 year-olds according to zone of residence (%)

Type of zone	Under 4 years old	4-8 years old	9 years old and over	Non- responses	Total
Municipality* without a ZUS	52.8	31.6	13.8	1.7	100
Municipality* with a ZUS	29.8	39.6	22.5	8.2	100
<i>of which: small residential zone without a ZUS</i>	<i>29.7</i>	<i>44.4</i>	<i>21.2</i>	<i>4.6</i>	<i>100</i>
<i>of which: small residential zone with a ZUS</i>	<i>29.8</i>	<i>33.1</i>	<i>24.3</i>	<i>12.3</i>	<i>100</i>
Total	42.1	35.3	17.9	4.7	100

* Or district in the case of Lyon. Source: 2005-2006 Lyon HTS. Sample size: 985 households.

⁷ These vehicles makes one think of the “€500 vehicles”, which have had many owners and which are repaired in a makeshift manner in the district, described by Chevalier (2001) in a study on travel practices in the underprivileged suburbs of the Lyon conurbation.

Once again, the age of the cars depended very much on household income. Among the poorest 20% of households, the most recent vehicle is over 8 years of age (or its age was unspecified) in 47% of cases, compared with 27% in the second quintile and 4% in the wealthiest 20% of households⁸. When we crossed the two socioeconomic levels (the household and the area of residence), we observed that the income level of the household had a stronger impact on the age of its cars than the socioeconomic level of the municipality. This crossing of variables showed that, in the Lyon conurbation, the effect of financial constraints is clearly perceptible for the households to which the 14-17 year-olds belonged, irrespective of the type of municipality:

- in the municipalities with a ZUS, among the poorest 20% of households, the most recent car was more than 8 years old (or of undisclosed age) in 54% of cases; this percentage then fell quite considerably from the second quintile (26%), then more regularly after that, reaching 9% for the wealthiest quintile of households;
- in the municipalities without a ZUS, these levels were respectively 33, 25 and 2% in the 1st, 2nd and 5th quintiles of income per CU.

The socioeconomic level of the municipality therefore had the greatest effect on households in the first quintile; in the rest of the distribution of incomes per consumption unit, the age of the vehicles was very similar in both types of places.

The higher average age of vehicles clearly expresses the difficulties low income families experience in purchasing a car, particularly in peripheral zones: if most of these families own cars, it is because of the second hand market, and probably at the cost of considerable financial sacrifices (Vanco & Verry, 2009). This may have consequences both on the availability of the car or cars on a day-to-day basis (more frequent breakdowns), the condition of the vehicle and its most important components such as the brakes and what occupant protection devices it contains.

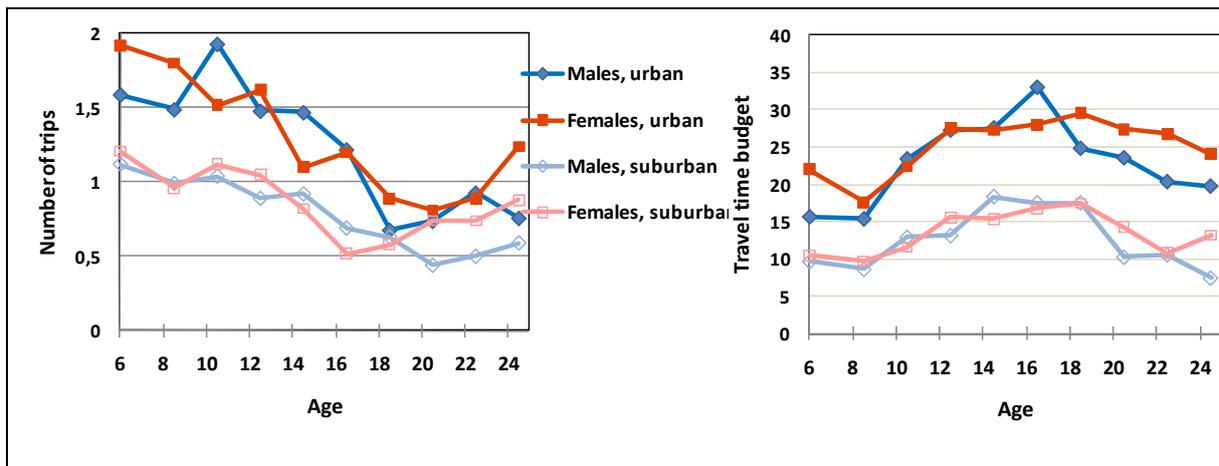
2.2. Varied use of transport modes according to residential location

Travel distances and modal use are strongly linked to whether the individual lives in an urban or suburban environment. The distances travelled by males and females aged between 14 and 17 years are 50% greater outside the conurbation (Pochet et al., 2010). In the present study, walking was found to be much less used outside the Lyon conurbation, whether as a mode in itself (Figure 2) or in including also times spent walking, before or after a mechanized trip (Figure 3). Analyzing the differences between the travel practices of young

⁸ The households living in the wealthier zones have higher car ownership and are more likely to own a recent car. However, disparities remain for a given level of car ownership (one or two cars). In the case of two-car households living in a municipality with a ZUS, in 19% of cases both vehicles are 8 years of age or over compared with 11% in a municipality without a ZUS. The respective figures are 31% and 27% for single-car households.

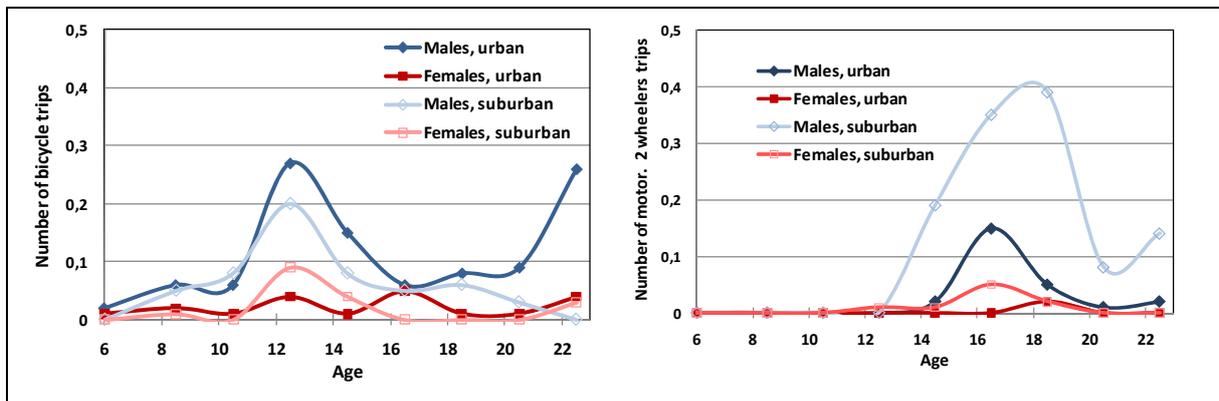
people in districts with or without a ZUS once again requires us to consider the impact of how urban the residential location is (for example by reducing the perimeter to the Lyon conurbation).

On the contrary, in suburban zones, trips made as a car passenger are more frequent than public transport trips, while they are outnumbered two to one by the latter in Greater Lyon (Pochet et al., 2009). Finally, our study found that bicycle use among 14-17 year-olds was slightly more common in the Lyon conurbation than in the suburbs (respectively 0.11 and 0.07 trips per day for males and 0.03 and 0.02 for females), while motorized two-wheelers were above all used by males in the suburbs (0.26 trips compared with 0.08 in the entire conurbation and, respectively 0.03 and 0 among females, see Figures 4 and 5).



* including walk access journey times to and from public transport stops. Source 2005-2006: Lyon HTS, whole survey area. Sample sizes: 1930 (males, urban), 1903 (females, urban), 1767 (males, suburban), 1626 (females, suburban).

Figures 2 and 3 – Number of walking trips and travel time budget on foot*, according to age, gender and residential location



Source: 2005-2006 Lyon HTS, whole survey area. Sample sizes: 1930 (males, urban), 1903 (females, urban), 1767 (males, suburban), 1626 (females, suburban).

Figures 4 and 5 – Number of daily bicycle and motorized two-wheeler trips, according to age, gender and residential location

Socio-spatial inequalities in road traffic risk and daily travel in adolescence
HADDAK, Mouloud; POCHET, Pascal; LICAJ, Idlir; RANDRIANTOVOMANANA, Eliette;
VARI, Judit; MIGNOT, Dominique

The particularly high road risk among adolescent males may be linked primarily to their use of motorized two-wheelers, which is confined mainly to suburban areas, and secondarily to their bicycle use, which is more evenly distributed spatially.

The apparent specific nature of the travel behaviours of adolescents in municipalities with a ZUS, whether this is evaluated on the basis of trips made the day before, during the week (Table 4) or by the frequency of their use of the various mechanized transport modes on weekdays (Table 5), must be considered within the following context:

Table 4 – Modal split (%) and daily mobility level indicators among 14-17 year-olds living in the Rhône département, according to gender and type of residential zone

Mode	Males		Females	
	Municipality without a ZUS	Municipality with a ZUS	Municipality without a ZUS	Municipality with a ZUS
Walk	31.3	45.6	21.6	42.9
Bicycle	3.7	2.6	2.0	0.0
Motorized two-wheeler	4.6	0.9	0.3	0.3
Car as a passenger	20.6	14.0	30.2	18.6
Public transport	39.6	36.8	45.2	38.3
Other mode	0.3	0,3	0.7	0.0
<i>All</i>	<i>100</i>	<i>100</i>	<i>100</i>	<i>100</i>
Number of trips by all modes	3.28	3.51	3.05	3.53
Travel distance budget for all modes (km)	18.0	12.2	20.4	12.6
Travel time budget for all modes (TTB, min.)	73	70	77	71
<i>of which: TTB on foot (min.)</i>	24	32	21	30
<i>Sample size</i>	<i>319</i>	<i>294</i>	<i>289</i>	<i>265</i>

Source: 2005-2006 Lyon HTS, limited to the Rhône département area.

- the total number of trips was slightly higher in the municipalities without a ZUS, but total daily travel time was slightly lower and travel distances were a third lower for males and almost 40% lower for females;
- walking played an important role and accounted for the largest number of trips between Mondays and Fridays;
- use of motorized and non-motorized two-wheelers was less common;
- fewer trips were made as a passenger in a car,
- the modal share of public transport was slightly lower.

Socio-spatial inequalities in road traffic risk and daily travel in adolescence
HADDAK, Mouloud; POCHEP, Pascal; LICAJ, Ildir; RANDRIANTOVOMANANA, Eliette;
VARI, Judit; MIGNOT, Dominique

Table 5 – Percentage of 14-17 year-olds reporting use of different mechanized transport modes either usually or exceptionally, according to gender and type of residential zone*

	Males		Females	
	Municipality	Municipality	Municipality	Municipality
	without a ZUS	with a ZUS	without a ZUS	with a ZUS
Bicycle	57.7	57.7	39.6	36.4
Motorized two-wheeler	17.3	6.0	7.0	2.9
Car as a passenger	92.6	88.9	94.9	91.6
Car as driver	5.9	2.3	9.5	3.0
Public transport	61.8	89.5	61.6	89.6
<i>Sample size</i>	<i>319</i>	<i>294</i>	<i>289</i>	<i>265</i>

* Only Rhône *département* inhabitants. Source: 2005-2006 Lyon HTS.

Are all these phenomena socioeconomic in origin? In order to compare the two types of zone on a more uniform basis, we set out (Table 6) the same indicators for the Lyon conurbation on its own. The differences in the travel level indicators between municipalities with and without a ZUS were generally attenuated (number of trips, travel time budget for walking and, above all, the distance covered which fell by 4km for females in municipalities without a ZUS), with the exception of the travel time budget for all modes which was now lower by a slightly greater factor in the zones with a ZUS.

Table 6 – Modal split (%) and travel level indicators among 14-17 year-olds living in the Lyon conurbation, according to gender and the type of zone of residence

Transport mode	Males		Females	
	Municipality	Municipality	Municipality	Municipality
	without a ZUS	with a ZUS	without a ZUS	with a ZUS
Walk	34.3	44.8	23.5	42.7
Bicycle	3.6	2.6	2.6	0.0
Motorized two-wheeler	3.9	0.9	0.0	0.0
Car as a passenger	14.2	12.5	23.5	17.5
Public transport	44.0	39.0	50.2	39.8
Other mode	0.0	0.3	0.3	0.0
All modes	3.34	3.45	3.17	3.49
Travel distance budget	16.0	12.1	16.1	12.8
Travel time budget (min.)	77	69	78	71
TTB on foot (min.)	28	32	25	30
<i>Sample size</i>	<i>204</i>	<i>254</i>	<i>170</i>	<i>232</i>

Source: 2005-2006 Lyon HTS.

The modal split was slightly more similar in the two types of zones, but the fundamental differences remained. The distances travelled as a car passenger (for males) and by public transport (for both males and females) were considerably lower in municipalities without a ZUS when the analysis perimeter was reduced to the Lyon conurbation. These differences reveal that travel practices are more marked by walking and less by mechanical modes. In particular, in the Lyon conurbation public transport use is not greater in municipalities with a ZUS than in the others.

Household income, and the car ownership level which it permits, were once again at the centre of these effects, modifying travel levels and modal use. The figures in each column concern about one hundred individuals. Situations in which an adolescent had access to a car (at least as many cars available as parents in the household) were less frequent in municipalities with a ZUS (54%, and even 44% if we focus on the small zones with a ZUS) than in the other municipalities in the Lyon conurbation (82%).

Easy access to a car for one or both parents seems to increase the level of travel among the children and in particular the number of escorted trips girls make by car. The travel practices of the adolescents in both types of zone therefore become more similar when both parents have, in principle, their own car. However, the municipalities with a ZUS still retain some specific features. When we considered the same level of relative car ownership, adolescents in municipalities with a ZUS made more walking trips (30 to 50% more among the males, double this among the females, without a proportional increase in the amount of time spent walking). In view of the high risk levels of young pedestrians in poor municipalities, this result merits further investigation. Likewise, the fact that, for the males, lower parental car ownership does not seem to be compensated for by greater use of motorized two-wheelers, as is the case for those living in a municipality without a ZUS, calls for specific analyses.

CONCLUSION

It appears to be difficult to reveal socio-spatial inequalities in road risk on the basis of the existing surveys and collected data. The approach that we adopted, taking account of the constraints associated with the information from the Rhône *Département* Road Trauma Register, was to link injury rates in the zone of residence of those involved in road traffic crashes (in particular with reference to the socioeconomic wealth of these locations), and the mean characteristics of the daily travel of young males and females in the two types of municipalities. The relative risks that were observed for some transport modes among 14-17 year-olds revealed clear differences in travel practices according to socio-spatial groups. The use of IRIS coding for the addresses in the register allowed us to refine this initial diagnosis of socio-spatial inequalities with regard to road risk by distinguishing between those IRIS's with a ZUS and those without, or alternatively by distinguishing between the different IRIS's, according to a socioeconomic gradient.

The 2006 Lyon HTS shows that during adolescence mopeds and scooters are mainly used by males. In those municipalities without difficult urban areas, it is equally clear that young males' use of these modes is much higher than in the municipalities which are *a priori* less socially privileged (by a factor of five in terms of number of trips and a factor of four in terms of mileage, with an excess risk of approximately 30%). This use of motorized two-wheelers does not seem to be principally linked to the geographical position of the place of residence (whether it is inside or outside the Lyon conurbation), but more to the type of municipality. If we focus on the Lyon conurbation, motorized two-wheeler use is very much higher (still by a

factor of four in terms of number of trips) in the municipalities without a ZUS, and the differences are even greater between small zones with or without a ZUS.

With the exception of motorized two wheelers, the incidence of other road traffic injuries is higher in deprived municipalities. These results, which confirm those established by Fleury et al. (2010, forthcoming) are more outstanding when considering the fact that for adolescents of deprived areas, daily mobility is less developed (in terms of km traveled) and less easy to achieve than in more privileged environments. Likewise, the greater frequency of walking trips by adolescents in municipalities with a ZUS does not seem to be primarily linked to the fact that by definition they are all located in an urban zone (which as we have seen encourages walking), but to the low standard of living of their residents. The greatest risk observed in a ZUS for pedestrians seems to be directly linked to the greater frequency of walking for one's daily trips. This characteristic of travel practices goes hand in hand with more difficult access to passenger cars because of lower car ownership rates.

Our findings may have different policy implications. First, due to their higher road risk for young people, deprived zones should benefit from dedicated road safety measures, including simultaneously targeted measures (in secondary schools for example), global prevention campaigns (for all age groups and all type of road users) and road safety arrangements. For example, if the aim is to reduce road risk for pedestrians in deprived areas, it is essential to ease and secure their on foot trips (focussing on footpaths, crossings to access activity places and public transport stops), and simultaneously to make the children and their parents aware of this risk, but also to raise car drivers' awareness, especially when they live in these places.

From a more academic point of view, it would seem essential to consider road traffic injury risk in relation to exposure to this risk (which depends on the way day-to-day trips are made, in particular the transport modes that are used) in order to go beyond the simple observation that risks are significantly higher for one group or another. However, it was only possible to identify the nature of the link at semi-aggregate level, for groups (on a spatial, gender or socioeconomic basis) and not at an individual level, as the two databases are very different and each deals with only one aspect of the issue. Due to the lack of information on social situation or on the geographical and cultural origin of the young victims' parents in the Rhône road trauma register, a study of social determinants of road accidents at an individual level was not possible. Another limit of our study is the lack of precise description on social (employment, type of populations) as well as material and physical characteristics of the zone of residence and of the place of accidents (e.g. indicators of road infrastructures). An enrichment of our road trauma database would be necessary to distinguish, among contextual factors, between social and infrastructural ones, and to analyse the spatial dependence of accidents inside precise zones, as well as between contiguous zones (Levine et al., 1995; Anderson, 2009).

The limitations in available data show the considerable potential value of a survey among the adolescents in question, covering the crashes they have been involved in and their vehicle usage (two-wheelers and cars), their individual situation, the characteristics of their neighbourhood and the characteristics and their daily travel practices during the week and at

weekends. This would require a population-specific, case control survey. Such further study also appears necessary to identify more clearly the respective influence on the travel practices of adolescents of the different factors of inequality, be they linked to economic factors, the precarious nature of their parents' jobs, to car ownership or to cultural factors. More qualitative surveys, conducted by means of individual or group interviews, should provide some insights into the complex links between social, cultural and geographical inequalities, social representations (in particular of risk), travel practices and road risk during adolescence.

REFERENCES

- Abdalla, I. M., R. Raeside, D. Barker and D. R. McGuigan (1997). An investigation into the relationships between area social characteristics and road accident casualties. *Accid. Anal. Prev.*, 29(5), 583-593.
- Anderson, T. K. (2009). Kernel density estimation and K-means clustering to profile road accident hotspots. *Accid. Anal. Prev.*, 41(3), 359-364.
- Borrel C., M. Rodriguez, J. Ferrando, M. T. Brugal, M. I. Pasarin, V. Martinez and A. Plasencia (2002). Role of individual and contextual effects in injury mortality: new evidence from small area analysis. *Inj. Prev.*, 8(4), pp. 297-302.
- Bourdieu, P. (1993). Effets de lieux, in *La misère du monde* (P. Bourdieu, ed.), Le Seuil, Paris, pp. 159-167.
- Chevallier, M. (2001). L'usage et l'accès à l'automobile : une liberté sous contraintes pour les personnes et ménages à faibles ressources. Research report for PREDIT-PUCA, Lyon.
- Christie, N. (1995). Social, economic and environmental factors in child pedestrian accidents: a research review, TRL Research Report PR116 (Transport Research Laboratory, Crowthorne).
- Claisse, G., L. Diaz Olvera, B. Dille, Ch. Paulo, D. Plat and P. Pochet (2000). Inégalités de déplacement et équité sociale : revenus, indices et inégalités d'accès à la voiture particulière. Research report for PREDIT PUCA, LET.
- Cubbin, C., F. B. Le Clere and G. S. Smith (2000). Socioeconomic status and injury mortality: individual and neighborhood determinants. *J. Epidemiol. Community Health*, 54(7), 517-524.
- Dupuy, G., O. Coutard, S. Fol, J. Froud and K. Williams (2001). La pauvreté entre assignation territoriale et dépendance automobile. Research report PREDIT-PUCA, Univ. Paris X, LATTSENPC, Univ. de Manchester, Paris – Manchester.
- Durkin, M. S., L. L. Davidson and L. Kuhn (1994). Low-income neighbourhoods and the risk of severe pediatric injury: a small-area analysis in northern Manhattan. *Am. J. Public Health*, 84(4), 587-592.
- Edwards, P., J. Green, I. Roberts and S. Lutchmun (2006). Deaths from injury in children and employment status in family: analysis of trends in class specific death rates. *Brit. Med. J.*, 333(7559), 119.
- Ferrando, J., M. Rodriguez-Sanz, C. Borrell, V. and A. Martinez Plasencia (2005). Individual and contextual effects in injury morbidity in Barcelona (Spain). *Accid. Anal. Prev.*, 37(1), 85-92.

Socio-spatial inequalities in road traffic risk and daily travel in adolescence
HADDAK, Mouloud; Pochet, Pascal; LICAJ, Ildir; RANDRIANTOVOMANANA, Eliette;
VARI, Judit; MIGNOT, Dominique

- Fleury, D., Peytavin, J.-F., Alam, T. and T. Brenac (2010, forthcoming). Excess accident risk among residents of deprived areas, *Accid. Anal. Prev.*
- Goyon, M. (2009). Jeunesses périurbaines en Dombes : mobilité quotidienne, modèles parentaux et socialisation, XLVI^{ème} colloque de l'ASRDLE, Clermont Ferrand, 6-8 juillet, 17 p.
- Graham, D., S. Glaister and R. Anderson (2005). The effects of area deprivation on the incidence of child and adult pedestrian casualties in England. *Accid. Anal. Prev.*, 37(1), 125-135.
- Haddak, M., and A. Ndiaye (2006). Relationship between neighbourhood socio-economic status and childhood road traffic injury, First European Conference on Injury Prevention and Safety Promotion EuroSafe, Vienna, Austria.
- Haddak, M., P. Pochet, J. Vari, E. Randriantovomanana, I. Licaj, M. Hours, M. Chiron and D. Mignot (2009). Inégalités sociales et territoriales de mobilité et d'exposition au risque routier chez les jeunes, état de l'art. Isomerr Jeunes project, Research report n°3. DRI – PREDIT GO2, Lyon, INRETS (UMRESTTE) – LET, 50 p.
- Hasselberg, M., and L. Laflamme (2005). The social patterning of injury repetitions among young car drivers in Sweden. *Accid. Anal. Prev.*, (37)1, 163-168.
- Kaufmann, V., and M. Flamm (2002). Famille, temps et mobilité : état de l'art et tour d'horizon des innovations. rapport de recherche pour la CNAF et l'Institut pour la Ville en Mouvement, Lausanne, Switzerland.
- Laflamme, L., and K. Engstrom (2002). Socioeconomic differences in Swedish children and adolescents injured in road traffic incidents: cross sectional study, *Brit. Med. J.*, 324(7334), 396-397.
- Laflamme, L., M. Hasselberg, A. M. Reimers, L. T. Cavalini and A. Ponce de Leon (2009). Social determinants of child and adolescent traffic-related and intentional injuries: a multilevel study in Stockholm County. *Soc. Sci. Med.*, 68(10), 1826-1834.
- Le Breton, E. (2005). L'orientation familiale des mobilités. Quelques remarques à partir de l'étude d'une population désqualifiée. *NetCom*, 3/4, pp. 179-192.
- Levine, N. Kimb, K. E., and L. H. Nitz (1995). Spatial analysis of Honolulu motor vehicle crashes: II. Zonal generators. *Accid. Anal. Prev.*, 27(5), 675-685.
- Magnin, A. (2004). Les enfants piétons ou cyclistes renversés par un véhicule en circulation dans le département du Rhône entre 1997 et 2001. Comparaison entre les communes avec et sans zone urbaine sensible. PhD thesis, Fac. de Médecine, Univ. Claude Bernard Lyon I.
- Massot, M.-H. and J. Zaffran (2007). Auto-mobilité urbaine des adolescents franciliens. *Espace Populations Sociétés*, 2-3, pp. 227-241.
- Mignot, D., and S. Rosales-Montano (2006). Vers un droit à la mobilité pour tous, *Inégalités, territoires et vie quotidienne*. Paris, La Documentation Française – PUCA.
- Moskal, A. (2009). Epidémiologie du traumatisme routier chez les deux-roues motorisés. PhD thesis, Sciences et Santé, Univ. Claude Bernard Lyon 1, Lyon.
- Mueller, B. A., F. P. Rivara, S.-M. Lii and N.S. Weiss (1990). Environmental factors and the risk for childhood pedestrian-motor vehicle collision occurrence. *Amer. J. Epidemiol.*, 132(3), 550-560.
- Nicolas, J.-P., P. Pochet, and H. Poimboeuf (2002). Mobilité urbaine et développement durable, quels outils de mesure pour quels enjeux ? *Les Cahiers Scientifiques du Transport*, 41, 53-76.

Socio-spatial inequalities in road traffic risk and daily travel in adolescence
HADDAK, Mouloud; POCHEP, Pascal; LICAJ, Ildir; RANDRIANTOVOMANANA, Eliette;
VARI, Judit; MIGNOT, Dominique

- ONISR (2006). La sécurité routière en France : Bilan de l'année 2005. La Documentation Française, Paris.
- Orfeuil, J.-P. (2004). Transports, pauvretés, exclusions, l'état des savoirs. Ed. de l'Aube, Paris.
- Paulo, C. (2006). Inégalités de mobilités : disparité des revenus, hétérogénéité des effets. PhD thesis, Sciences Economiques, mention économie des transports, Univ. Lumière Lyon 2, Lyon.
- Pochet P., Haddak M., Licaj I., Vari J., Randriantovomanana E., Mignot D. (2010), Différenciations et inégalités sociales de mobilité chez les jeunes. Analyses de l'enquête ménages déplacements de Lyon 2005-2006. Isomerr Jeunes project, Research report n°3. DRI – PREDIT GO2, Lyon, INRETS (UMRESTTE) – LET, 88 p.
- Vanco, F. and D. Verry (2009). Rising fuel price and household vulnerability: a French comparison, 2nd EuroCities-DATTA Workshop Urban mobility in Europe, impact of fuel price on car use. Namur, 8-9 janv., 18 p.
- Zambon, F. and M. Hasselberg (2006). Socioeconomic differences and motorcycle injuries: age at risk and injury severity among young drivers. A Swedish nationwide cohort study. *Accid. Anal. Prev.*, 38(6), 1183-1189.