



HAL
open science

Collisions between pedestrians and reversing vehicles in public settings in France

Thierry Brenac, Jean-Yves Fournier

► **To cite this version:**

Thierry Brenac, Jean-Yves Fournier. Collisions between pedestrians and reversing vehicles in public settings in France. *Open transportation Journal*, 2018, 12, pp.33-42. 10.2174/1874447801812010033 . hal-01702228

HAL Id: hal-01702228

<https://hal.science/hal-01702228>

Submitted on 6 Feb 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Collisions between Pedestrians and Reversing Vehicles in Public Settings in France

Thierry Brenac^{1*} & Jean-Yves Fournier¹

¹IFSTTAR, TS2, LMA (French Institute of Science and Technology for Transport, Development and Networks; Department of Transport Health and Safety), F-13300 Salon-de-Provence, France

*Corresponding author; email: thierry.brenac@ifsttar.fr.

Abstract

Background: Collisions between pedestrians and reversing vehicles in public settings have received little attention in France. Yet, according to the national statistics on traffic accidents, reversing vehicles are involved in 6.5% of the 11,700 pedestrian accidents recorded each year (over the 2008-2015 period). Moreover, this proportion is probably underestimated in these statistics. **Objective:** This work aims to provide a brief assessment of this problem in the French case, in quantitative and qualitative terms. **Method:** A random sample of 882 police reports on pedestrian accidents occurring in public settings in France was studied to identify the reversing collisions among them. Then, the reversing accidents found (61 cases) were thoroughly analysed to improve our knowledge of the mechanisms involved. **Results:** Reversing collisions account for about 7% of pedestrian accidents in public settings. Pedestrians aged 60 or over (73% of the pedestrian victims) and commercial and goods vehicles are over-represented in these collisions. Pedestrians often fail to see the reversing vehicle, fail to anticipate its manoeuvre, or are not able to get out its path. Drivers generally fail to see the pedestrian before the collision. The reasons for the reversing manoeuvres are identified and suggest these manoeuvres could partly be avoided. **Conclusions:** In France, reversing accidents represent a non-negligible proportion of pedestrian accidents in public settings. It appears that, in addition to the influence of limited rearward visibility in vehicles, certain road layouts play a role in these accidents by encouraging or forcing drivers to make reversing manoeuvres (at least for large vehicles).

Keywords: Reversing accident, pedestrian, traffic safety, urban design, urban planning

1. INTRODUCTION

This paper deals with accidents between reversing vehicles and pedestrians occurring on public roads and other places open to the public, such as car parks. This problem has received little attention in France, in contrast to other countries such as Australia, Canada or the USA, for example [1-3]. In the French national file of traffic injury accidents, the manoeuvre carried out by the driver at the time of the accident was coded as “reversing manoeuvre” in 6.5% of the traffic injury accidents involving pedestrians (which will be referred to as “pedestrian accidents” throughout this article) reported in France over the 2008-2015 period. This proportion showed no significant change over the period. This category does not, however, reliably identify all reversing manoeuvres. Indeed, an unknown proportion of the accidents for which the manoeuvre carried out at the time of the accident was coded as a “parking manoeuvre” (1.5% of the pedestrian accidents reported over the 2008-2015 period) may also involve a reversing manoeuvre.

This work aims to provide a brief assessment of this problem in France, in quantitative terms (to corroborate the proportion of reversing accidents estimated from the national file), but also in qualitative terms, through the detailed analysis of accident cases, in order to contribute to reflections on possible preventive measures, notably in the field of urban planning and design. Indeed, although vehicle technology and equipment, such as reversing cameras, have the potential to reduce the number of these accidents, they cannot eliminate them, as suggested by recent research [4-6].

In this work, we do not deal with non-traffic accidents between pedestrians and reversing vehicles occurring in workplace locations [7-9] and on other private properties, such as residential driveways where young pedestrians are frequently reversed over (see *inter alia*: [10-18]). As a whole, however, this research on non-traffic accidents led to identifying some common factors involved in reversing collisions with pedestrians. Limited rear visibility often plays a role in these accidents [8, 9, 17]. Light trucks and vans are over-represented in driveway-related reversing accidents [12, 15, 16, 17], due to the large blind zones behind these vehicles. The absence of immediate child supervision in the vicinity of the driveway is also mentioned [15, 17]. Another common risk factor is the absence of physical separation of the driveway from children’s play areas [11, 15].

Less attention has been paid to pedestrian injuries due to vehicles reversing on public roads or other places open to the public. Older pedestrians appear to be over-involved in these injury accidents [1, 19, 20, 21].

Functional decline due to the ageing process may play a role: older pedestrians tend to have visual and hearing problems and are less able to detect moving objects [21]. The cognitive decline associated with dementia-related neuropathology is also associated with a higher risk of being hit by a reversing vehicle [22]. Older pedestrians may also have difficulties in anticipating unexpected vehicle movements, such as the reversing manoeuvre of a parked car [19]. Last, they may be limited in their capability to quickly get out of the path of a reversing vehicle as it approaches [20, 21, 23]. Preventive measures have been proposed in terms of vehicle technology (reversing aids) and safety information for pedestrians and drivers (see for example [19, 21]). Little is known, however, on the way the planning and design of roads and public spaces might contribute to preventing these reversing accidents.

The work reported here focuses on injury accidents between pedestrians and reversing vehicles in public settings (roads and other places open to the public) in France. First, a rapid examination of a random sample of police reports on pedestrian accidents occurring in public settings in France is carried out to corroborate the proportion of reversing collisions estimated from the national statistics. Secondly, the reversing accidents found are thoroughly analysed with the aim to identify the processes and mechanisms involved in their occurrence.

2. DATA AND METHOD

In France, traffic injury accidents are accidents occurring in public settings, involving at least one vehicle, and resulting in at least one injury needing medical care. For each accident, insofar as injuries are found, the police must draw up a report for the public prosecutor (*procureur de la République*). These accidents are then recorded in the French national file of traffic injury accidents. As mentioned in the introduction, however, the variables available in this file do not make it possible to identify the reversing manoeuvres clearly and without ambiguity. We, therefore, used police reports, which are more detailed and explicit. They include statements made by the persons involved and witnesses, and a map of the accident with information on the final positions of the vehicles involved and on material clues such as skid marks, debris, etc. These confidential documents can be accessed for research purposes with appropriate permission. Thus, we have had access to a random selection of 882 police reports on road traffic injury accidents involving pedestrians occurring in France from 2008 to 2011. In France, a copy of each police report is sent to the TRANSPV organisation, which is affiliated to the French Federation of Insurance. TRANSPV randomly selected a sample of 5000 police reports on traffic injury accidents for the 2008-2011 period and sent them to IFSTTAR for research purposes. This sample represents about 1.8% of the 279,100 traffic injury accidents reported in France during this period. Among these 5000 accidents, 882 were pedestrian accidents, representing 1.8% of the 49,300 pedestrian accidents reported in France during the period from 2008 to 2011. Our study sample consists of these 882 pedestrian accidents.

Firstly, a rapid examination of the 882 police reports was carried out to identify the cases where pedestrians were hit by reversing vehicles, and to estimate the proportion of these reversing collisions. Secondly, each of the reversing collisions found (61 cases) was analysed in detail, using a sequential accident model as described by Fleury [24] (see also [25]). For each road user involved, the socio-demographic characteristics of the person, conditions of her/his travel (trip purpose, vehicle used, external conditions), driving/walking activity just before the accident, manoeuvres made and perceptions of the situation when the pedestrian and vehicle interact, and the conditions of the collision, were successively analysed. These analyses were based on the police report and other data on the accident site and surrounding road network (photographs, maps). This method made it possible to identify some common accident mechanisms.

3. RESULTS

3.1. Proportion of reversing collisions among pedestrian accidents

Among the random sample of 882 pedestrian accidents, 61 accidents were identified as reversing collisions (based on the detailed police reports) and resulted in injuries to 62 pedestrians, including 4 fatal cases. This result leads us to estimate that 6.9% of reported pedestrian accidents in public settings in France involve a reversing vehicle, with a 95% confidence interval (CI) from 5.4% to 8.8%.

The proportion found (6.9%) is slightly higher than the proportion obtained from the French national file of traffic injury accidents (6.5%), although this difference is not statistically significant. It is also important to note that among the 61 reversing collisions found, 7 could not have been identified from the national file of traffic accidents: for these 7 cases, the manoeuvre was not coded as a “reversing manoeuvre” in the corresponding record in this file. This tends to confirm that the proportion obtained from the national statistics (6.5%) is somewhat underestimated.

3.2. Age of the pedestrians injured and types of vehicle involved

In descriptive terms, the particularities of these reversing collisions mainly relate to the pedestrian’s age and the category of the reversing vehicle. Only two pedestrians – two teenagers – were under twenty years of age. Pedestrians aged 60 and over represented more than two-thirds (about 73%) of the 62 pedestrians injured by

reversing vehicles. Those aged 80 and over are particularly affected: they account for 39% of the pedestrians injured in these accidents (CI: 28%–51%). By comparison, people aged 80 and over represent only 7.6% (CI: 6.0%–9.6%) of the pedestrians injured in accidents with vehicles that are not reversing.

Commercial and goods vehicles account for 39% of the vehicles involved (CI: 28%–52%). Three-quarters of these vehicles were light commercial vehicles (LCV), and the others were heavy goods vehicles (HGV). By comparison, commercial and goods vehicles account for only 9.0% (CI: 7.1%–11.5%) of the vehicles involved in accidents between pedestrians and vehicles that are not reversing.

Other descriptive data on the 61 cases studied and the parties involved are given in the Appendix.

3.3. Most common reasons for the reversing manoeuvres

Identifying the reason why the driver carried out the reversing manoeuvre leading to the collision is important, since limiting the need for reversing manoeuvres and reducing their number may contribute to the prevention of these collisions. The reasons and circumstances of the reversing manoeuvres, as far as they can be inferred from the police reports, appear in Table 1.

A large proportion of reversing manoeuvres (39%, CI: 28%–52%) were made for entering or leaving a parking space. Another common situation (15% of the reversing manoeuvres, CI: 8%–26%), corresponds to vehicles reversing into a perpendicular street to approach and reach a parking space (as shown in Figure 1) or to deliver goods in this street. In most of these cases, the destination of the vehicle could have been reached by other routes, thus avoiding reversing into the perpendicular street, but this would have involved a detour and a delay.

Table 1. Reasons and circumstances of the reversing manoeuvres ($n = 61$).

Reasons and circumstances of the reversing manoeuvre	Number of cases (and percentage)	Details
a) Vehicle reversing to leave/enter a parking space	24 (39%)	(in streets: 16 cases; in car parks: 8 cases) (to leave/enter a space: 18 cases/6 cases)
b) Vehicle reversing into a perpendicular street to reach a parking space or to deliver goods	9 (15%)	(to reach a parking space: 6 cases; to deliver goods: 3 cases)
c) Vehicle reversing down a narrow street or cul-de-sac to reach the main street	7 (11%)	(after delivering goods: 5 cases)
d) Vehicle reversing down a street to reach a given point (shop, place of residence, parking space)	4 (7%)	
e) Vehicle reversing to leave a car park or a driveway	3 (5%)	
f) Vehicle reversing to make a U-turn	3 (5%)	(in streets: 2 cases; in car parks: 1 case)
g) Vehicle reversing for a road-related work activity	3 (5%)	(street cleaning: 1 case; breakdown truck approaching to load a car: 2 cases)
h) Miscellaneous	6 (10%)	(in streets: 3 cases; in car parks: 3 cases)
i) Vehicle reversing for an unknown reason	2 (3%)	(in streets)
Total	61 (100%)	

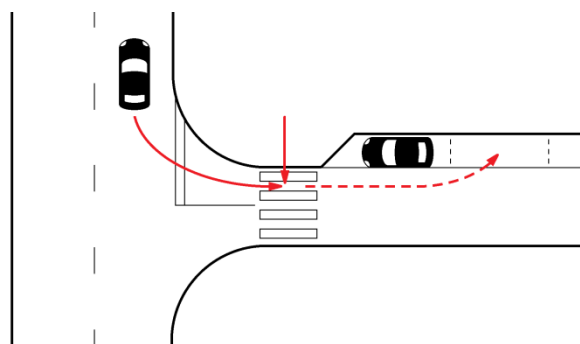


Fig. (1). Vehicle reversing into a perpendicular street to reach a parking space.

Vehicles reversing down a narrow street or cul-de-sac in order to reach the main street, mostly after the driver had delivered goods, also account for a non-negligible proportion of cases (11%, CI: 6%–22%). Except in one case, these accidents involved light commercial vehicles or heavy goods vehicles. In all cases, making a U-turn would have been impossible or difficult, and there was no other possibility than reversing down the street, because of the cul-de-sac layout or the narrowness of the downstream part of the street.

3.4. Pedestrian detection by the driver

Twenty-six drivers failed to see the pedestrian before the collision and 4 saw her/him too late to avoid the collision (Table 2). Information on this point was not available in the 31 other cases. Overall, as regards the drivers' visual search strategies, information was available in only 27 cases: according to the drivers' statements, the mirrors of the vehicle were used in 25 cases, direct vision in one case, and both in another case.

3.5. Perception of the vehicle by the pedestrian

On the question of whether the pedestrian saw or did not see the reversing vehicle, information was available in only 25 cases. In 14 of these cases, the pedestrian failed to see the vehicle before the collision, because she/he had her/his back turned to the vehicle at the time of the collision (8 cases) or was looking in the direction opposite to the vehicle (6 cases). In the 11 other cases, the pedestrian saw the vehicle before the collision, but failed to anticipate the reversing manoeuvre of the vehicle (5 cases), or lacked time or did not have the capability to get out of its path (6 cases). These results are summarised in Table 2.

No clear difference was found between these situations — pedestrian failing to see the vehicle, pedestrian failing to anticipate its movement, pedestrian failing to get out of the path of the vehicle — in terms of pedestrian's age: the average age of pedestrians for these situations was 68.6, 64.4, and 68.5 years, respectively.

Table 2. Mutual detection and related accident mechanisms.

	Number of cases	Percentage
Pedestrian detection by the driver (<i>n</i> = 30)		
– failed to see the pedestrian	26	87%
– saw the pedestrian too late	4	13%
Total number of cases with sufficient information in the police report	30	(100%)
Perception of the vehicle by the pedestrian (<i>n</i> = 25)		
– failed to see the vehicle (had his/her back turned to the vehicle)	8	32%
– failed to see the vehicle (was looking in the opposite direction)	6	24%
– saw the vehicle but failed to anticipate its manoeuvre	5	20%
– saw the vehicle but lacked time or did not have the capability to get out of its path	6	24%
Total number of cases with sufficient information in the police report	25	(100%)

3.6. Reversing aids and reversing alarms

Information on the presence of reversing aids or reversing alarms (backup alarms) is generally lacking in police reports. In three cases, however, the presence of reversing sensors was indicated. In one case, according to the driver, these sensors were not activated by the pedestrian. In another case, the sensors were activated but the warning was misinterpreted by the driver. In the last case, no information was given apart from the presence of reversing sensors. Moreover, in two other cases involving commercial/goods vehicles, the reports mention the presence of reverse alarm systems in normal operation at the time of the accident, but there is no information on whether the pedestrian heard or did not hear the alarm. No clear conclusions can be drawn from these few cases.

3.7. Consequences of reversing collisions for the pedestrians involved

After the collision, 82% of the 62 pedestrian victims fell to the ground. Four pedestrians (6%) were killed or died within a few days following the accident. Among the 58 non-fatally injured pedestrians, 18 were hospitalised, 28 were not hospitalised, and information on hospitalisation was lacking for the remaining 12 cases. The average age of the fatally injured and the non-fatally injured pedestrians was 77.3 and 67.4 years, respectively. This age difference is not, however, statistically significant (Mann-Whitney test: *p*-value = 0.46). Details on the injuries were generally not available in the police reports (except for fatal cases).

Two of the four fatal cases correspond to pedestrians who were hit by reversing HGVs (both with a gross vehicle weight of 19,000 kg), fell to the ground and were run over by the wheels of these vehicles, which caused very severe injuries to the upper part of the body, resulting in the pedestrian's immediate death.

Overall, a fatal outcome is more likely when a heavy goods vehicle is involved: 2 out of the 6 pedestrians injured by reversing HGVs were killed, whereas among the pedestrians injured by other reversing vehicles, 2 out of 56 were killed. This difference is statistically significant (Fisher test: p -value = 0.04).

4. DISCUSSION

The proportion of reversing accidents among police-reported pedestrian accidents occurring in public settings in France is estimated to be about 7%, which is in agreement with results found in other countries (see for example [1, p. 21] and [2]). Thus, among the 11,700 pedestrian accidents reported each year in France (over the 2008-2015 period), about 800 involve reversing vehicles.

Older pedestrians appear to be over-involved in these accidents, which is consistent with the findings of previous literature [1, 19, 20, 21, 22, 23]. According to these publications, this result can be partly explained by various aspects of their functional decline due to the ageing process. These publications suggest possible measures of safety information on the danger of reversing manoeuvres for pedestrians, oriented towards older pedestrians or towards drivers.

The over-involvement of commercial and goods vehicles can be compared to the over-involvement of light trucks and vans found in previous studies for reversing accidents occurring in residential driveways (see for example [16]). This over-involvement could be explained by the poorer visibility to the rear of these vehicles, as compared to cars. In addition, in some circumstances, the large dimensions of some of these vehicles may oblige their drivers to make reversing manoeuvres, such as reversing down a narrow street or cul-de-sac. A significantly higher risk of fatal outcome is found when heavy goods vehicles are involved, although this result is based on a small number of fatal cases. This could be related to specific crash mechanisms, such as pedestrians being run over by the wheels of these heavy vehicles.

In a substantial proportion of reversing accidents, the pedestrian failed to see the reversing vehicle before the collision (result based on a subsample of 25 cases for which the police report contained information on this point). This may suggest the need to expand the use of reversing alarms, but the effectiveness of this device, commonly used in industrial contexts and work areas, appears to be moderate [26, 27].

The high proportion of accidents where the driver failed to see the pedestrian (result based on a subsample of 30 cases for which the police report contained information on this point) confirms the interest of reversing aids. According to the National Highway Traffic Safety Administration, reversing cameras may reduce the number of reversing accidents by 28% to 33%, whereas “the other systems afford little or no measureable safety benefit” [28]. A number of factors, however, contribute to moderating the use and performance of reversing cameras [5, 29]. Automatic reverse braking systems could also be considered. According to Kochhar *et al.* [30], these devices could be effective provided they are associated with reversing cameras. Indeed, without a reversing camera, drivers tend to continue the reversing manoeuvre after the system has stopped their vehicle.

Reversing collisions related to parking manoeuvres appear to be frequent. There is no clear way of improving the visibility conditions of reversing manoeuvres through the design of roads and car parks, but some designs could probably reduce the need for reversing manoeuvres, as illustrated in Figure 2 (although this layout seems to be space-consuming).

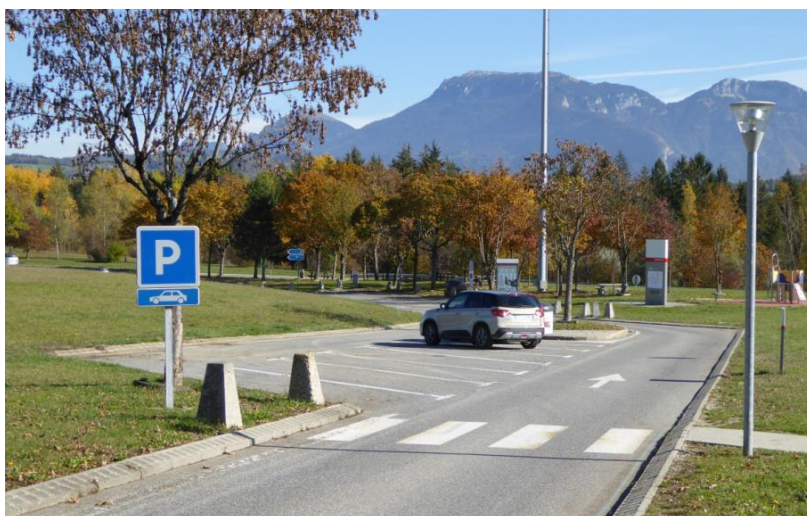


Fig. (2). Example of a car park design reducing the need for reversing manoeuvres (photo: author).

The cases of vehicles reversing into perpendicular streets in order to reach a parking space or to deliver goods also raise issues in terms of the design and management of urban road networks. The rarity of the parking supply may encourage drivers to make such manoeuvres in order to avoid a detour and the risk that, after making the detour, the desired parking space may be occupied by another vehicle. Reversing manoeuvres into perpendicular streets are also encouraged by certain network organisations that involve long detours through their systems of one-way streets. The results presented also show that some reversing accidents are related to cul-de-sac layouts and the narrowness of certain minor streets that force some vehicles to reverse down these streets. This suggests that, at least for new urban developments, attention should be paid to the compatibility of the design of minor streets with the occasional passage of large vehicles, and to the provision of appropriate U-turn facilities at the end of cul-de-sacs.

The study reported here suffers from some limitations, however. Firstly, police-based data on accidents are affected by the under-reporting of the least severe injuries (as regards pedestrians, see [31]). Thus, the sample studied here is probably biased towards more serious injuries. Secondly, the analysis of police reports involves a degree of interpretation, since this analysis is mainly based on the collation and combination of statements made by the persons involved and other clues available. Moreover, information may be lacking for some points, depending on the degree of thoroughness of the police report. For example, regarding certain results (pedestrian detection, perception of the vehicle), sufficient information was only available in about one half of the police reports studied (30 and 25 cases, respectively). More generally, due to the limited size of the sample (61 cases), the results remain to be confirmed by further investigations on larger samples of reversing accidents. Lastly, we had access to detailed accident data for the 2008-2011 period, whereas reversing cameras have become more frequently available in cars produced in the recent years. It is therefore possible that the results presented are slightly different from what would have been obtained for more recent years.

Moreover, some of the findings may not apply to other countries. The role of road layouts, for example, may be specific to European countries where road networks have been partly inherited from past centuries and where narrow streets are common.

5. CONCLUSIONS

In France, as in other countries, traffic accidents between pedestrians and reversing vehicles represent a non-negligible proportion of pedestrian accidents. The investigation reported here made it possible to estimate this proportion and to identify some circumstances and mechanisms commonly involved in the occurrence of these accidents. Some lessons in terms of prevention could be drawn from these findings, although they remain to be consolidated by larger-scale studies. Firstly, as already found in previous studies, older pedestrians appear to be the most affected by these accidents, which suggests that this age group could be particularly targeted by prevention measures. Secondly, the problems related to drivers' limited rearward visibility suggest that the efforts made to equip vehicles with reversing aids should be continued. Thirdly, the over-involvement of commercial and goods vehicles could be taken into consideration in public policies on goods transport and delivery in urban areas (adaptation of road networks; regulation of goods transport and delivery). Lastly, the analysis of the reasons for the manoeuvres leading to these accidents shows that some road designs may encourage or force drivers to make reversing manoeuvres (at least for large vehicles). This finding notably suggests the need for studying potential solutions in the field of planning and design of roads and public spaces, mainly aimed at reducing the need for reversing manoeuvres.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

ACKNOWLEDGEMENTS

This work was supported in part by the French National Research Agency (ANR).

REFERENCES

- [1] B. Fildes, S. Newstead, M. Keall, and L. Budd, "Camera effectiveness and backover collisions with pedestrians: a feasibility study", Monash University Accident Research Centre, Clayton, Victoria, Australia, Rep. 321, 2014.
- [2] Transport Canada, "Pedestrian Fatalities and Injuries 1992-2001", Transport Canada, Ottawa, ON, Canada, Fact Sheet TP 2436E, RS-2004-01E, 2004.
- [3] NHTSA, "Fatalities and Injuries in Motor Vehicle Backing Crashes", National Highway Traffic Safety Administration, Washington, DC, Rep. to Congress DOT HS 811 144, 2008.

- [4] C.M. Rudin-Brown, P. Burns, L. Hagen, S. Roberts, and A. Scipione, "Behavioural adaptation as a consequence of extended use of low-speed backing aids", in *Advances in Traffic Psychology*, M. Sullman and L. Dorn, Eds. Burlington, VT: Ashgate, 2012, pp. 285–294.
- [5] D.G. Kidd and A. Brethwaite, "Visibility of children behind 2010–2013 model year passenger vehicles using glances, mirrors, and backup cameras and parking sensors", *Accident Anal. Prev.*, vol. 66, pp. 158-167, 2014.
- [6] D.G. Kidd, B.K. Hagoski, T.G. Tucker, and D.P. Chiang, "The effectiveness of a rearview camera and parking sensor system alone and combined for preventing a collision with an unexpected stationary or moving object", *Hum. Factors*, vol. 57, pp. 689-700, 2015.
- [7] W. Murray, "Auditing the safety of vehicles backing-up (reversing)", Selected Proceedings of the 9th World Conference on Transport Research, 2001.
- [8] J.W. Hinze, and J. Teizer, "Visibility-related fatalities related to construction equipment", *Safety Sci.*, vol. 49, no. 5, pp. 709-718, 2011.
- [9] F. Kitching, C.B. Jones, J.E. Ibrahim, and J. Ozanne-Smith, "Pedestrian worker fatalities in workplace locations, Australia, 2000–2010", *International J. of Injury Control and Safety Promotion*, vol. 21, no. 2, pp. 163-169, 2014.
- [10] I. Roberts, A. Kolbe, and J. White, "Non-traffic child pedestrian injuries", *J. of Paediatrics and Child Health*, vol. 29, no. 3, pp. 233-234, 1993.
- [11] I. Roberts, R. Norton, and R. Jackson, "Driveway-related child pedestrian injuries: a case-control study", *Pediatrics*, vol. 95, no. 3, pp. 405-408, 1995.
- [12] P. Robinson, and T. Nolan, "Paediatrics slow-speed non-traffic fatalities: Victoria, Australia, 1985–1995", *Accident Anal. Prev.*, vol. 29, no. 6, pp. 731-737, 1997.
- [13] A.J. Holland, R.W. Liang, S.J. Singh, D.N. Schell, F.I. Ross, and D.T. Cass, "Driveway motor vehicle injuries in children", *Med. J. of Australia*, vol. 173, no. 4, pp. 192-197, 2000.
- [14] J.M. Mayr, C. Eder, J. Wernig, D. Zebedin, A. Berghold, and S.H. Corkum, "Vehicles reversing or rolling backwards: an underestimated hazard", *Injury Prevention*, vol. 7, no. 4, pp. 327-328, 2001.
- [15] F. Murphy, S. White, and P. Morreau, "Driveway-related motor vehicle injuries in the paediatric population: a preventable tragedy", *New Zealand Med. J.*, vol. 115, no. 1160, pp. 1-7, 2002. [Online] Available: <http://www.nzma.org.nz/journal> [Accessed Sept. 28, 2017].
- [16] K.A. Pinkney, A. Smith, N.C. Mann, G.D. Mower, A. Davis, and J.M. Dean, "Risk of pediatric back-over injuries in residential driveways by vehicle type", *Pediatr. Emerg. Care*, vol. 22, pp. 402-407, 2006.
- [17] T.M. Rice, R.B. Trent, K. Bernacki, *et al.*, "Trauma center-based surveillance of nontraffic pedestrian injury among California children", *Western J. of Emergency Med.*, vol. 13, no. 2, pp. 139-145, 2012.
- [18] K. Hamilton, W. Macken, C. McGarvey, T.G. Matthews, and A.J. Nicholson, "Pedestrian deaths in children – potential for prevention", *Irish Med. J.*, vol. 108, no. 1, pp. 8-11, 2015.
- [19] D. Sheppard and M.I. Pattinson, "Interviews with elderly pedestrians involved in road accidents", Transport and Road Research Laboratory, Crowthorne, UK, TRRL Research Rep. 98, 1986.
- [20] J. Oxley and B. Fildes, "Safety of older pedestrians: strategy for future research and action initiatives", Monash University Accident Research Centre, Clayton, Victoria, Australia, Rep. 157, 1999.
- [21] G. Dunbar, C.A. Holland, and E.A. Maylor, "Older pedestrians: a critical review of the literature", Department for Transport, London, UK, Road Safety Research Rep. 37, 2004.
- [22] C.A. Gorrie, J. Brown, and P.M.E. Waite, "Crash characteristics of older pedestrian fatalities: Dementia pathology may be related to 'at risk' traffic situations", *Accident Anal. Prev.*, vol. 40, pp. 912-919, 2008.
- [23] N. Charness, W. Boot, A. Mitchum, C. Stothart, and H. Lupton, "Aging Driver and Pedestrian Safety: Parking Lot Hazards Study", Florida State University, Tallahassee, FL, Final Technical Report No. BDK83 977-12, 2012.
- [24] D. Fleury, "About theories and concepts behind accident analysis: a French contribution". *Adv. Transp. Stud.*, vol. 29, pp. 83-96, 2013.
- [25] D. Fleury and T. Brenac, "Accident prototypical scenarios, a tool for road safety research and diagnostic studies", *Accident Anal. Prev.*, vol. 33, pp. 267-276, 2001.
- [26] J.P. Purswell and J.L. Purswell, "The effectiveness of audible backup alarms as indicated by OSHA accident investigation records", *Adv. Occup. Ergo. Saf.*, vol. 4, pp. 444-452, 2001.
- [27] D.C. Holzman, "Vehicle motion alarms: necessity, noise pollution, or both", *Environ. Health Persp.*, vol. 119, pp. A30-A33, 2011.
- [28] NHTSA, "Federal motor vehicle safety standards; rear visibility", *Federal Register*, vol. 79, no. 66, pp. 19178-19250, 2014.
- [29] R.E. Llaneras, M.L. Neurauter, and C.A. Green, "Factors moderating the effectiveness of rear vision systems: what performance-shaping factors contribute to drivers' detection and response to unexpected in-path obstacles when backing?", *SAE Technical Paper*, no. 2011-01-0549, 2011.

- [30] D. Kochhar, W. Talamonti, and L. Tijerina, “Considerations in HMI design of a reverse braking assist (RBA) system”, *SAE International Journal of Passenger Cars – Mechanical Systems*, vol. 6, pp. 674-680, 2013.
- [31] J.L. Martin and D. Wu, “Accidentologie des piétons”, Institut Français des Sciences et Technologies des Transports de l’Aménagement et des Réseaux, Marne-la-Vallée, France, Research Rep., 2015.

APPENDIX: Additional descriptive information on the reversing accidents studied

Some additional information on the cases studied is provided in Table 3. The large proportion of male drivers (87%) could be partly explained by the particular involvement of delivery or professional drivers in these accidents (17 among 47 drivers whose occupation is known), since women are less represented in these kinds of occupations. The high proportion of female pedestrians (69%) at least partly reflects the fact that women represent a higher proportion of the older population, which is over-involved in reversing accidents. In France in 2009, for example, among people aged 80 or more, there were 2.51 million women and only 1.19 million men.

Table 3. Additional information on the cases studied (61 accidents involving 61 drivers and 62 pedestrians).

		Number of cases	Percentage
Time of day	Between 8 a.m. and 7 p.m.	58	95%
	Other	3	5%
Light condition	Daytime	59	97%
	Other	2	3%
Weather	Normal weather condition	57	93%
	Other	4	7%
Accident location	Car park	12	20%
	Local street	30	49%
	Main street	19	31%
Parking layout ($n = 24$)	Perpendicular parking	11	46%
	Angle parking	2	8%
	Parallel parking	11	46%
Type of vehicle	Car	36	59%
	LCV/HGV	24	39%
	Special vehicle	1	2%
Driver's age	Less than 20 years	3	5%
	20 to 59 years	52	85%
	60 years and over	6	10%
Driver's gender	Male	53	87%
	Female	8	13%
Driver's trip purpose	Private or commuting	28	46%
	Business or work	24	39%
	Unknown	9	15%
Pedestrian's age ($n = 62$)	Less than 60 years	17	27%
	60 to 79 years	21	34%
	80 years and over	24	39%
Pedestrian's gender ($n = 62$)	Male	19	31%
	Female	43	69%
Pedestrian's trip purpose ($n = 62$)	Private or commuting	44	71%
	Business or work	2	3%
	Unknown	16	26%