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Research article

Effectiveness of static detour signage on motorways during road closures – An observational study

Sunny van Leeuwen[1], A. Maria Salomons[2], Peter-Jan Hendriks[3], Jan Anne Annema[4,*]

[1] Haskoning, Delft, The Netherlands
[2] Faculty of Civil Engineering and Geosciences, Delft University of Technology, The Netherlands
[3] Traffic and More, Utrecht, The Netherlands
[4] Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands
[*] corresponding author j.a.annema@tudelft.nl

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Abstract

Road workers have raised concerns about the safety risks they face when installing static detour signs before a road closure. Their tacit knowledge is that many drivers ignore the signs. It is unknown whether road workers are correct, as the effectiveness of static detour signs on drivers' route choices has not been researched. Therefore, this paper investigated the influence of static traffic diversion signs on drivers' route choices during road closures on secondary roads adjacent to motorways in the Netherlands. The influence of static diversion signs was assessed by observing route choice and detour compliance around them. Two road closure cases were evaluated using cameras (Automatic Number Plate Recognition) and road detection loops. The two cases showed that roughly 40% to 60% of the cars affected by the closure do not follow the detour signs. So, although this paper finds that static signs affect route choices to some extent, road workers' views seem correct: many drivers affected by road closures do not follow the signs. This study's qualitative explanatory model for non-compliance with these signs reveals many reasons, ranging from intended behaviour to ignoring the signs to various unintended reasons. Future research could improve understanding of drivers' motivations, perceptions, preferences, and attitudes towards detour signage and, subsequently, route choice. Additionally, the influence of in-car navigation systems during road closures could be researched. These insights might lead to the implementation of safer, more effective measures to divert traffic during road closures.

1 Introduction

The Dutch motorways are experiencing an annual increase in vehicle traffic (Rijkswaterstaat, 2024). To keep traffic flowing smoothly, regular maintenance, repairs, and capacity expansions are necessary, which unavoidably disrupt traffic flow and pose challenges for traffic management and safety. Effective control measures, such as speed limits, lane closures, and detours, are implemented to mitigate these consequences (Skrodenis et al., 2021). These measures affect not only the construction zone but also the surrounding areas. Ensuring road workers' safety and the smooth traffic flow during roadworks is a major priority. Information about roadworks is communicated to drivers through static and variable message signs (VMS) and media announcements (Li & Bai, 2009). In the Netherlands, static road signs are the main source of information during roadworks, providing details of road closures, traffic changes, and diversions. Despite these measures, accidents are still common around roadworks, often involving vehicles colliding with roadworks vehicles. The installation of the static traffic signs for the upcoming roadworks is also a risky endeavour. In September 2024, Dutch road workers installing static road signs issued an alarm, calling for action to improve their safety (Van Hooft, 2024). The report followed an accident in which a lorry collided with a work vehicle, injuring the road worker. In another interview conducted by Kamp & Van Hooft (2023), it was observed that accidents like this occur almost every month.

In this interview, it was suggested that installing fewer traffic detour signs could be a start toward solving the safety problem for workers. The reasoning behind this idea is that, based on the perception among road workers and road-working companies, the static signs are not very effective, so why take the risk of installing them? However, the actual effectiveness of static signs remains uncertain. Some studies have shown the effectiveness of traffic control measures and safety in work zones (see Section 2). Still, they focus primarily on the contribution of variable message signs and mainly use simulation modelling. No studies on the effectiveness of static detour traffic signs on motorways using real-life observations are available, as far as we know.

Therefore, this study aims to determine the influence of temporary static message signs on road user decision-making and driving behaviour around road closures and associated diversions. This paper's unique contribution is that route choices were observed in two road closure cases in the Netherlands. One real-world case was specially developed for this study.

In Section 2, we briefly discuss the literature in this field. Section 3 explains the methodology. The results of the two observational studies can be found in Section 4. Sections 5 and 6 discuss the results and give the conclusion and recommendations, respectively.

2 Literature review

Several studies have evaluated the effectiveness of temporary traffic control (TTC) measures in motorway work zones to improve safety and traffic flow. Li and Bai (2009) used logistic regression and significance testing to examine various TTC measures, including flaggers, traffic signs, arrow boards, and portable variable message signs (VMS). They found that the different measures could indeed control speeds and reduce crashes. They found that median speeds were reduced by 4 to 13 miles per hour from 11 PM to 7 AM during the deployment of presence lighting and speed limit trailers, compared with base conditions. They also showed increased compliance with the 55 miles per hour speed limit. The effectiveness of individual TTC methods may vary when combined with other traffic control devices or work zone conditions, as shown in their results. A driving simulator study (and a small field experiment) by Rahman et al. (2017) focused on the impacts of sign design on driver behaviour and safety. They found that overall speed limit compliance for the driving simulation study was 70%. On the other hand, the overall compliance for the field study was only 12.7%. They revealed that longer frame refresh rates on signs were more effective in influencing drivers' speed and deceleration. They also found that Dynamic Message Signs (DMS) were more

effective at night than other signs. Multiple studies, including those by Chatterjee and McDonald (2004), Horowitz et al. (2003), and Erke et al. (2007), assessed VMS performance, highlighting its role in reducing queues and congestion despite minimal impact on travel distance. These studies also noted safety concerns due to potential driver distraction.

Scientific research on driving behaviour is also relevant to this study. This field of study is abundant, so we can only give a brief snapshot. The studies indicate influencing factors on behaviour, from individual characteristics to environmental conditions (such as the presence of information). Ben-Elia et al. (2007) demonstrated the significant impact of real-time information and prior experience on decision-making. The studies by Denrell and March (2001) and Denrell (2007) showed complex patterns in decision-making and risk perception, further confirmed by Măirean and Diaconu-Gherasim (2021), who used a questionnaire to link time perspective with risky driving behaviour. This resulted in participants with higher past negativity and present fatalistic time perspectives reporting more risky driving behaviour, while those with a high future time perspective reported less. Driver characteristics and demographics also influence behaviour. Munion et al. (2019) found gender differences in navigation performance, while Weng and Meng (2011) showed that younger and male drivers were more likely to take risks. Zhu et al. (2022) examined the behaviour of older drivers and showed a preference for shorter day trips but a higher likelihood of dangerous driving situations. Charlton and Starkey (2013) found that experienced drivers had more consistent driving patterns but struggled with speed adjustments at roadworks. Steinbakk et al. (2019) linked impulsivity and conformity to norms to a preference for higher speeds in work zones. Driving style studies by Eboli et al. (2017) and Taubman-Ben-Ari and Yehiel (2011) found significant effects of behavioural-emotional factors on driving style, highlighting aggressive and careful driving behaviours. Herrero-Fernández (2021) and Miller and Taubman-Ben-Ari (2009) further explored the relationships among driving style, lifestyle, and family dynamics. The influence of navigation systems on driver behaviour was examined by SWOV (2020), which found that while these systems reduce stress, they can also distract drivers. Bos et al. (2020) examined users' experiences of roadworks, highlighting the stress caused by unexpected delays and the effectiveness of timely information in reducing inconvenience.

Despite research on digital traffic signs and their impact on work zone safety and detours, the effect of static traffic signs on diverted traffic remains unexplored. Existing studies primarily use simulation-based rather than observational approaches, leaving a gap in understanding how static signs influence driver behaviour and route choice during detours. Accordingly, it remains unclear whether the road workers' perception that static signs are largely ineffective is accurate.

3 Methodology

Two case studies were conducted to observe drivers' route choices around detour signs on the motorway in response to road closures on the secondary road network.

3.1 Case study A9 exit 6 Aalsmeer

During the observation, actual work was underway on the Schiphol viaduct extension. This viaduct is located just before exit 6 Aalsmeer (see Figure 1a) on the A9. The A9 is a motorway in the Netherlands in the busy Western part of the country, partly very close to Amsterdam and Schiphol Airport. Traffic heading north towards Schiphol Airport can exit at exit number 6 Aalsmeer on this motorway and pass below the viaduct to Schiphol Airport or villages such as Aalsmeer near Schiphol Airport. Because of the work, the road below the bridge was closed (see the orange-white stripe in Figure 1a and 1b). The work mainly occurred during the evening and night hours to minimise traffic hindrances. The exit ramp could not be closed during work nights, as the Nieuwemeerdijk would be inaccessible (see the blue-white dotted arrow in Figure 1b). This allowed us to observe route choice behaviour and the impact of static signs.

On the nights of the closure, people who wanted to exit to Schiphol Airport or one of the surrounding villages were offered a matching diversion via static traffic signs. The diversion offered was to continue on the A9 and use an exit later. Road workers put up around twenty static signs to announce the closure and signal this diversion route. However, as the exit was still open, people who ignored or failed to notice these static signs (and perhaps also their in-car information) had to turn at the roundabout (see the pink arrow with white open dots in Figure 1b), as we observed.

Route choices were observed using Automatic Number Plate Recognition (ANPR) cameras by counting vehicles passing one or more camera locations (see Figure 1a and b). A script linked the license plates, which were not stored, to protect the privacy of the road users.

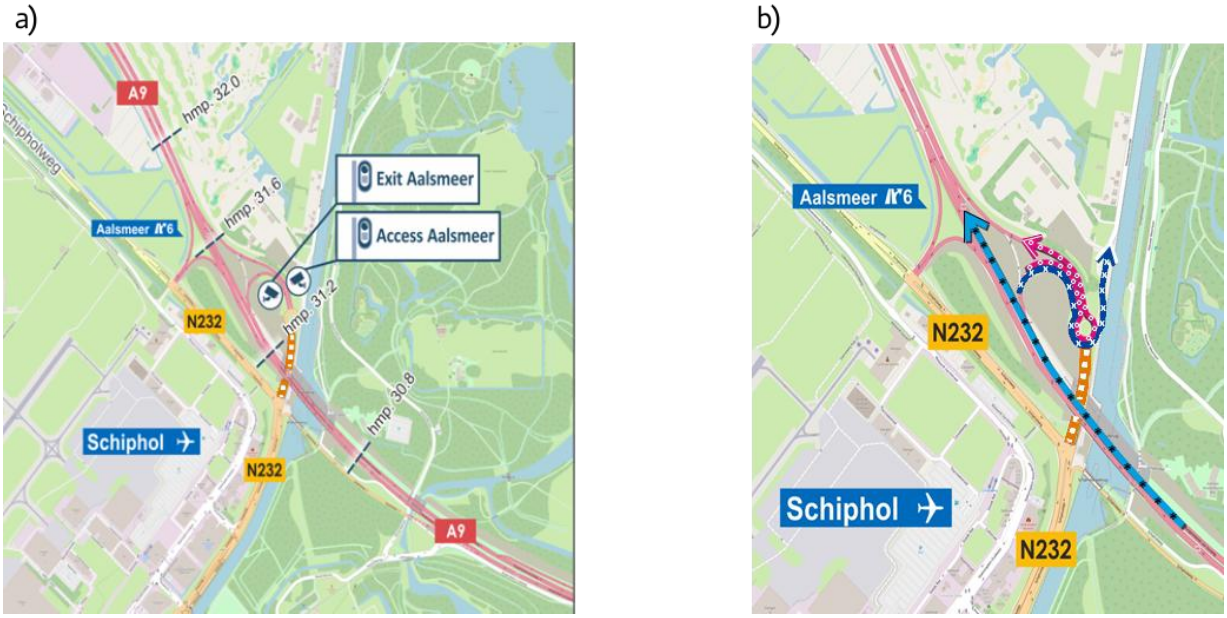

Figure 1. Study area A9 near Schiphol Airport. a) Three-segment dotted line: detection loops (e.g., hmp 31.2); orange-white stripe: road closure. b) Blue arrow with black dots: vehicles travelling on the motorway; pink arrow with white open dots: vehicles turning back towards the motorway; blue-white dotted arrow: vehicles towards Nieuwemeerdijk.

Observations were taken between 7 pm and 5 am during road works on the evenings and nights of 6 to 7 and 8 to 9 February 2024. The behaviour around the closure and the informative temporary traffic signs were observed. Three different traffic flows were measured in this case study, shown in Figure 1b. Vehicles travelling on the motorway (blue arrow with black dots), vehicles travelling towards the Nieuwemeerdijk via Exit Aalsmeer (blue-white dotted arrow), and vehicles travelling from the motorway towards the Schipholweg, but turning back towards the motorway, because the road was closed (pink arrow with white open dots in it). This pink traffic flow indicates the route choice made by vehicles that do not follow the traffic signs placed due to the closure.

By comparing the observations (the number of vehicles that turned) with a baseline measurement (the number of vehicles expected to use Schipholweg in the absence of the closure), the effectiveness of the static signs can be estimated. Unfortunately, baseline measurements in this first case could not be performed. To mimic a baseline measurement, we constructed six baseline situations. These situations represent the route choice behaviour on the 6th and 8th of February if Schipholweg had not been closed. We used different data sources and route-choice estimates for each situation. By doing so, the uncertainty associated with the baseline (which we cannot precisely determine) is accounted for in our analysis. For more on the baseline situations, see the results in Section 4. There were no unusual weather or other traffic-influencing conditions during the observation period.

3.2 Case study A27 exit 27 Hagestein

The road closure in the second case was not part of a roadwork project. The situation we created mimics an actual roadwork project perfectly, though. The setup for this case study was entirely designed for this study. The case study was around exit 27 Vianen of the A27 motorway in the northern direction (see Figure 2a to d). The A27 is a busy motorway connecting the southern and central parts of the Netherlands (cities such as Utrecht and Almere). An access road on the secondary road network in the direction of the town of Vianen was closed for the study (see the cyan dotted line in Figure 2a, labelled 'Hagenweg'), as if road works were underway there. A diversion route was arranged for this closure, and roadworkers placed static traffic signs (around 17) to inform road users about this. The signed diversion route (see the black-blue arrow in Figure 2d) was to take one exit later and access the A27 immediately on the other side. Subsequently, the static signs advised heading south and taking exit 27 to Vianen or beyond. In other words, the signed diversion directed traffic to perform a significant U-turn manoeuvre.

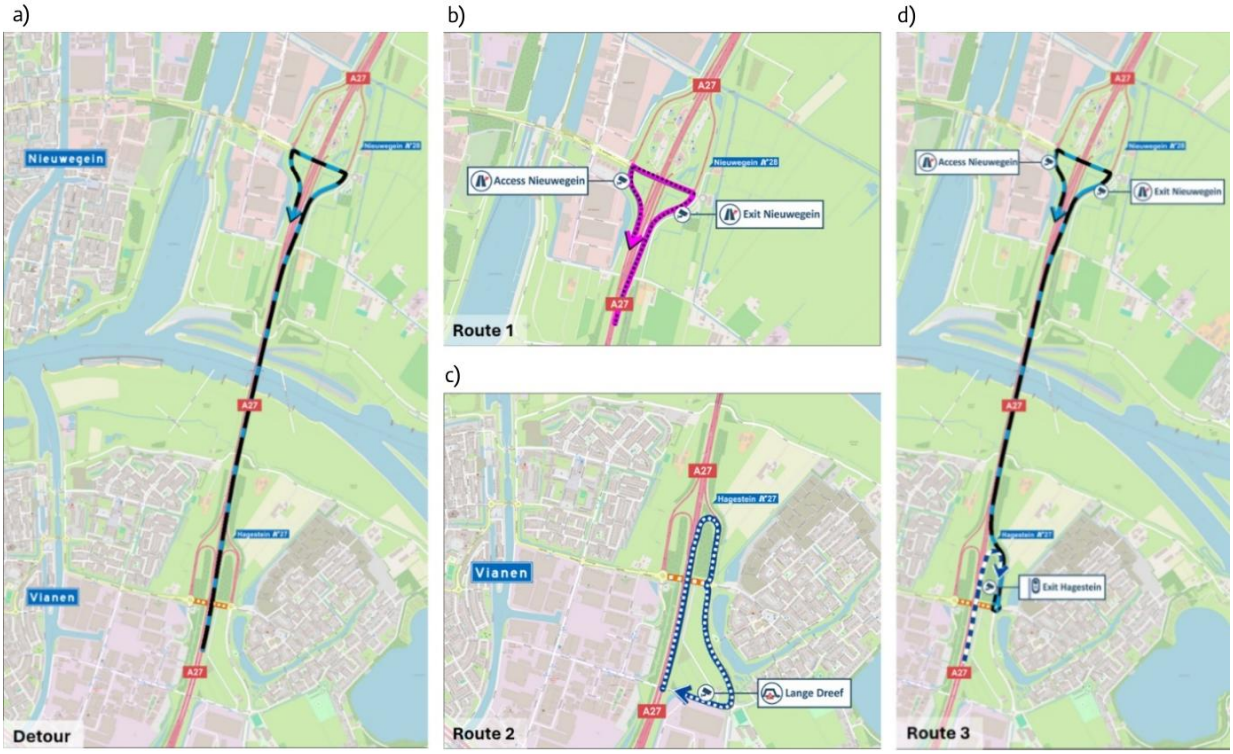

Figure 2. a) Detour. Black-blue arrow: complete detour; cyan dotted line: road closure. b) Route 1. Purple arrow with black dots: detail of the detour associated with road closure and following the static signs. c) Route 2. Blue arrow with white dots: not following the detour signs, taking the shortcut; cyan dotted line: road closure. d) Route 3. Blue-white striped line: not following the detour signs, taking the exit; black-blue arrow: returning to the detour; cyan dotted line: road closure.

This research location had several (safety) requirements, as no actual road works were carried out during the closure. The local council, the municipality of Vianen, and the Public Works Department of Rijkswaterstaat (Dutch Road Authority) gave permission.

The main difference between the two case studies lies in the route options. In the first case, drivers ignoring the road closure detour signs left the motorway and encountered the closed road, forcing them to turn back to rejoin the motorway to reach Schiphol Airport. In this second case, drivers had the extra option of taking a shortcut. This shortcut is Route 2 (see the blue arrow with white dots in Figure 2b). On Route 2, people took the A27 exit, drove to Hagenweg, which was closed, and continued south to another secondary road ('Lange Dreef') to enter the town of Vianen. This

shortcut option is next to route option 3 (see the blue-white striped line in Figure 2c, and returning to the detour, black-blue arrow), a turning-back option, as in the A9 case.

This second case was included in this study for two reasons. First, although the two case studies remain limited, they provide a more informative basis for evaluating the effectiveness of static signs than a single case. Second, this additional case could show the effect of static detour signs on route behaviour in a detour situation with multiple route change options.

In this case, the different routes were also analysed using ANPR camera measurements. Measurements were taken on four Tuesday evenings between 8 pm and 4 am, on the nights of 27 February and 28 February, 5 and 6 March, 12 and 13 March, and 19 and 20 March 2024. The Hagenweg was closed from 9 pm until 4.40 am from 27 to 28 February and 12 to 13 March.

Four ANPR cameras were used for the case study to monitor the traffic routes. The ANPR cameras counted the number of vehicles passing routes based on their number plates. In addition, by recording license plate numbers, the cameras could identify which vehicles were detected at multiple locations within a given period, providing information about the routes travelled. Traffic on the motorway was analysed using NDW data retrieved from the detection loops.

In this case, the baseline measurement consists of route choice observations on the two days without closure. By comparing these choices with those made during the two days of closure, the effectiveness of the static signs could be estimated. In this case, there were also no special weather or other traffic-influencing circumstances during the observation time.

4 Results

4.1 A9 exit 6 Aalsmeer

For Tuesday, 6 February, and Thursday, 8 February 2024, the number of vehicles that turned around because they did not follow the static signs and could not continue toward Schiphol was counted with ANPR cameras. During the pre-closure phase (before 7 pm), there was no unusual traffic behaviour and no vehicles reversing at the roundabout, as the Schipholweg was still open to traffic. On the 6th of February, we counted 245 vehicles turning at the roundabout, and on the 8th of February, this number was 189.

As explained, baseline measurement situations had to be constructed to estimate the effectiveness of the static signs (see Table 1). Six baseline situations were built to include the variance in day-to-day traffic volumes. Different observations were used in the first row (A) to estimate the number of vehicles exiting the A9 at Aalsmeer on the 6th and 8th of February if no closure had occurred. The mean for all Tuesdays and Thursdays between January and March 2024 was used in situations 1 and 4. Additionally, situations 2, 3, 5, and 6 represent observations from two days before the closure nights. Interestingly, the outcomes across these six situations are relatively stable. Thursdays seem busier than Tuesdays for exiting at Aalsmeer.

On the nights of closure, the number of vehicles exiting at Aalsmeer was counted as 504 and 603 for 6 and 8 February, respectively. Compared to row A, where a ‘normal’ 6 and 8 February are mimicked, the closure clearly results in a lower percentage exiting, namely 25-40% for the 6th and 25% for the 8th. This shows that the signs impacted people's route choice.

The number of vehicles that would have used the Aalsmeer exit to Schiphol if no closure had occurred was estimated to assess the effectiveness of the static signs. To do this, first, the number of vehicles towards Nieuwemeerdijk on the 6th and 8th February was established based on observations, namely the difference between the vehicles exiting at Aalsmeer and the turners. The closure is assumed not to impact the people heading towards Nieuwemeerdijk. Thus, this number is considered the same for a closure and a non-closure night. By subtracting the number of vehicles on Nieuwemeerdijk (row B, Table 1) from the number of vehicles exiting at Aalsmeer (row A, Table

1), the number of vehicles heading towards Schiphol without closure on the 6th and 8th of February was determined. Finally, by comparing these numbers with the number of vehicles that turned (row D), it is estimated that 40-60% of car users in this A9 case followed the static signs.

Table 1. Six baseline situations that vary in day-to-day traffic volumes.

Variable	Situation 1	Situation 2	Situation 3	Situation 4	Situation 5	Situation 6
The number of vehicles exiting Aalsmeer between 8pm – 4am (hmp 31.2) (A)	Tuesday, 6 February Based on the mean Tuesdays, January - March 2024: 666	Tuesday, 6 February Based on Tuesday, 23 January: 666	Tuesday, 6 February Based on Tuesday, 30 January: 827	Thursday, 8 February Based on the mean Thursdays, January - March 2024: 850	Thursday 8 February Based on Thursday, 25 January: 884	Thursday 8 February Based on Thursday, 1 February: 836
The number of vehicles towards Nieuwemeerdijk 8pm – 4am (B),	Tuesday, 6 February, 257	Tuesday, 6 February 257	Tuesday, 6 February 257	Thursday, 8 February 421	Thursday, 8 February 421	Thursday, 8 February 421
Estimated number of vehicles towards Schiphol without closure 8pm – 4am ($C = A - B$)	409	409	570	429	463	415
Vehicles turned onto the roundabout (D), observed	245	245	245	189	189	189
Percentage following static signs 100% - ((D/C)*100%)	40%	40%	57%	56%	59%	54%

4.2 A27 exit 27 Hagestein

In this case, the closure phase was between 9 pm and 4 am on 27 February and 12 March. Traffic routes and changes in traffic volumes have been analysed using ANPR data for these two closure periods and the two reference cases. Table 2 shows the number of cars per route in the closure and reference periods.

It is clear from Table 2 that route 2 is hardly observed, and route 3 is not observed under reference conditions; the number of vehicles on route 1 is higher during closure than during normal conditions. So, the closure and detour signs have impacted route choices. It may seem strange that, even on the non-closure night, some people still take the 'detour' route (route 1). The presence of some fast-food restaurants around Exit Hagestein may explain this. For some people, visiting these restaurants and taking route 1 might be their preferred option for getting home.

The number of vehicles that would have used Hagenweg on 27 to 28 February and on 12 to 13 March if no closure had occurred was estimated to determine the effectiveness of the static signs. In this case, the baseline situation was based on two estimation methods (see Table 3). The first one

Table 2. Routes chosen in the A27 case during closure and reference periods

Route choices	27-28 February closure	5-6 March reference	12-13 March closure	19-20 March reference
Exit Hagestein	146	159	194	161
Lange Dreef	342	172	316	341
Exit Nieuwegein	396	339	435	318
Access Nieuwegein	492	483	555	466
Turned back to Nieuwegein (route 3)	4	0	4	0
Shortcut (route 2)	47	3	52	-
Hagenweg	Closed	No camera	Closed	64
Detour (route 1)	30	5	35	10

(E) is based on the relation between the number of vehicles exiting Hagestein and the number of vehicles on Hagenweg using an ANPR camera on the 19th of March 2024 (non-closure). The second method uses the observed routes during closure nights, minus the routes used in the reference nights. For detailed explanations, see the right column, Table 3.

Table 3. Estimates of cars not following the static signs in the A27 case (final row).

	Situation 1	Situation 2
Variable	27-28 February	12-13 March
Expected Hagenweg (E)	58	77
Expected Hagenweg (F)	72	82
Detour followed, Route 1, (G)	30	35
Effectiveness (G/E*100%)	52%	45%
Effectiveness (G/F*100%)	42%	43%

* E = the fraction of cars on Hagenweg on the night of 19 to 20 March, compared to cars exiting at Hagestein then, multiplied by the cars exiting Hagestein on the two closure nights; F = the number of cars on routes 1, 2 and 3 on closure nights minus the average number of vehicles on these routes during the two reference nights.

Table 3 shows that although the two estimation methods (E and F) differ, the outcomes are reasonably close: in the A27 case, 40-50% of the cars followed the detour signs. This is also aligned with the outcome of the A9 case.

5 Discussion

Combining the results from our two case studies shows that the static signs had a 40-60% non-compliance rate. Despite the uncertainty and the limited number of cases (only two), this study confirms the perception among road workers and road-working companies that static signs are relatively ineffective. The signs do influence route behaviour, but 40-60% of cars not following them is still a relatively large proportion. Road workers have extensive experience with traffic behaviour during road closures. They see that while working on the road, many vehicles are turning and driving past where they would not expect them, despite the detour signs they put up. This may create the impression among workers that the installation of the signs, for which they run risks, serves no meaningful purpose. We show that they are largely correct; many drivers indeed do not follow the static signs they put up, but the signs are, on the other hand, also somewhat effective.

This study provides knowledge on compliance with static diversion signs during road closures, whereas the literature mainly focuses on the effectiveness of dynamic route information systems such as variable message signs (VMS) (see Section 3). Although there are limited directly

comparable studies, some comparisons can be made with findings from previous studies. Chatterjee and McDonald (2004) investigated drivers' responses to VMS in urban areas. The VMS provided route guidance to improve the efficiency of the road network. They found an overall compliance rate of 92% with the information. This compliance rate is significantly higher than the rate found towards detour information in this study. Other studies identified lower compliance ratios. Erke et al. (2007) investigated the impact of route guidance VMS on speed and route choice on motorways, resulting in approximately 20% changing their route. Davidsson and Taylor (2003) examined VMS, which suggested alternative routes to avoid congestion, with driver response rates of 6-41%. Additionally, Ramsay and Luk (1997) found that announcing a road closure increased the number of diverted vehicles by 30%. It seems that our study with static signs is somewhat in line with VMS studies, which showed modest compliance results.

A key question concerns the underlying factors that may explain the relatively low level of compliance with static signs. We were not allowed, due to privacy rules, to use the number plates we had identified to find compliers and non-compliers for an interview to ask about their reasons. So, we can only speculate. Drivers are faced with a wide range of possible decisions, from routine actions, such as accelerating and braking, to more complex manoeuvres, such as navigating through traffic or responding to unforeseen circumstances, such as detour signs. How drivers respond to these decisions varies by individual road user and situation (Charlton and Starkey, 2013). Based on the literature and expert knowledge from a brainstorming session, we developed a conceptual model of detour decision-making (see Figure 3). The primary decision is whether to follow the diversion or an alternative route. Possible alternatives include deviating from the recommended detour to an alternative route or staying on the intended route despite potential obstacles. Other scenarios include the driver being unaware of a detour, choosing an alternative route, or missing the initiation or route of the detour. Consequently, there are six main situational outcomes following the decision to detour or not, as shown in Figure 3.

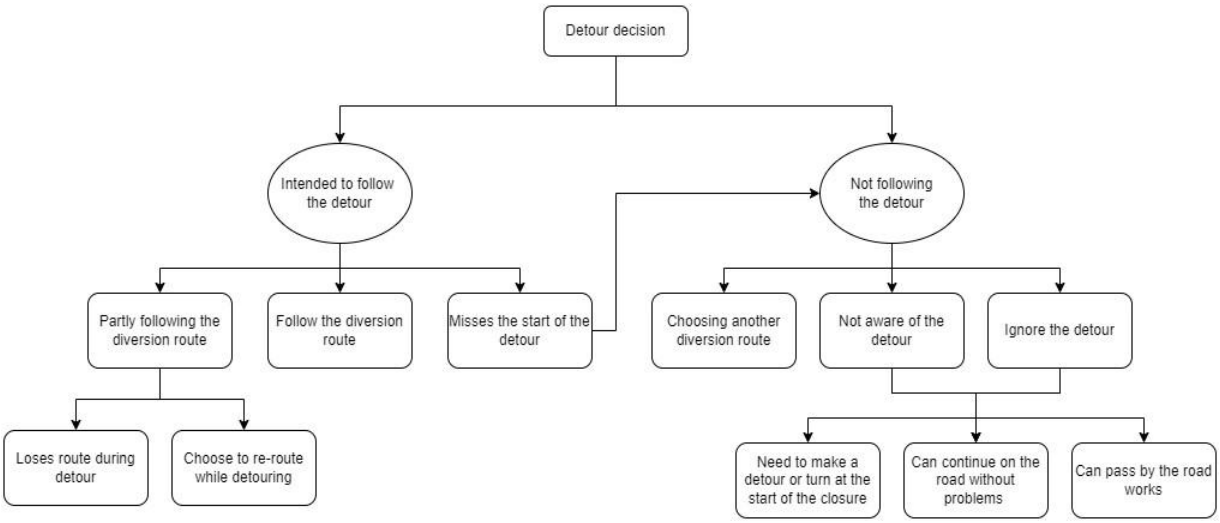

Figure 3. A conceptual model of detour decision-making

The most interesting part of this model is that it shows non-compliance is not based solely on an 'intended' choice not to follow the detour. Even people who intend to follow the detour might end up in the group that has to turn or take a detour route that is not the indicated one. People could be unaware of the detour, miss its start, fail to understand the signs, get lost during it, or experience similar navigational challenges. As mentioned before, driving behaviour is influenced by a wide range of factors, and the decision-making process involved in driving is complex (Steinbakk et al., 2019). Route choices are influenced by the driver's age, emotional state, task complexity, stress and time pressure, and trip attributes such as travel time, distance and traffic conditions (Eboli et al.,

2017). In addition to these factors, the environmental, infrastructural, and situational context also influences driving behaviour and decisions. Static detour signs change the context and influence route-choice decisions from psychological and economic perspectives. Our model (see Figure 3) refutes the idea that, psychologically and economically, only the more aggressive, hasty, and stubborn car drivers ignore static signs. Additionally, individuals who are quieter, less certain, or inattentive may fail to comply due to overlooking the signs, misinterpreting their meaning, or experiencing confusion. The wide array of factors (psychological, cognitive, and economic) that can explain non-compliance applies to a considerable number of car users. Perhaps this wide array of factors explains why relatively few drivers follow the static detour signs.

It is important to recognise and address the limitations of this study. Firstly, we have studied only two cases, which makes generalisation difficult. We have no reason to believe that studying many more road closures would yield significantly different results. Perhaps the impact range we found (40% to 60% of non-compliance) might differ in a specific case, but the general qualitative notion that many people do not follow static signs seems valid. Second, the closures in both case studies were on secondary networks, limiting the understanding of driver behaviour in response to alternative closures, such as motorway closures. Thirdly, the study period was limited to specific nights in February and March 2024, which may not accurately represent typical traffic patterns throughout the year. Seasonal variations or specific events during these nights could have influenced the results, making them perhaps not representative of all days of the year. Fourth, the available data for analysis covered a short period, limiting the ability to identify and understand long-term trends in road closure and diversion behaviour.

It is important to recognise the influence of non-quantifiable factors such as navigation systems on route choice behaviour and compliance with diversion signs. Navigation systems play a valuable role in guiding drivers during road closures, but their impact on route choice and compliance is difficult to measure. This study did not consider whether drivers used navigation systems, their activation status, or compliance with suggested routes. In addition, navigation systems allow for dynamic route adjustments based on real-time traffic conditions, which may deviate from predetermined detour routes indicated by static signage. While these effects could not be measured in this research, they remain important considerations in understanding and interpreting observed route choice and compliance behaviour during road closures.

6 Conclusion and recommendations

The empirical findings from two case studies of access road closures in the secondary road network showed that many drivers, ranging from roughly 40% to 60%, did not follow the static detour signs. Instead, these drivers either tried to continue their original route towards the closed road or took available shortcuts. This behaviour demonstrates the limited effectiveness of temporary static signs in influencing motorway drivers' route choice. This research confirms the tacit knowledge of road workers and road worker companies that many drivers do not comply with static signs, leading them to wonder why they must install these signs and run safety risks in doing so.

The observed low compliance rate has practical implications, requiring adjustments to current traffic management systems to direct more drivers to diversion routes. This research was motivated by several accidents involving road workers installing diversion signs. This emphasises the need to review and improve sign placement strategies to ensure the safe diversion of all traffic around roadworks and the safety of road workers installing the signs. Given the relatively low compliance with static diversion signs and the high risks associated with their placement, it is recommended to explore and implement alternative traffic management methods. This could include using dynamic, real-time information, such as smart traffic systems and mobile applications, to guide road users more effectively and improve the safety of road workers.

Future research is recommended to improve the understanding of drivers' motivations, perceptions, preferences, and attitudes towards detour signage and route choice. The use of surveys and interviews can help to build this knowledge. Future research into the effectiveness of different traffic management strategies could improve the effectiveness and safety of road closures. Conducting controlled experiments or observational studies across different roadwork environments to investigate optimal sign configurations and communication strategies can improve understanding of the effective provision of detour information and compliance rates. Exploring the implications and possibilities of navigation systems is another interesting area for future research. Investigating how drivers use guidance systems to influence route choice and the potential for these systems to override traditional signage could lead to new traffic management strategies. In addition, the impact of navigation systems on the road user's attention to traffic signs and the road situation enhances understanding of the factors influencing driving behaviour.

Data/Software Access Statement

The vehicles' route choice data underlying the studies presented in this paper are not publicly available due to privacy restrictions. More data analyses and figures than presented in this paper can be found in: https://resolver.tudelft.nl/uuid:26745d91-b44f-4583-93dc-0154a8a6b11b

Contributor Statement

Sunny van Leeuwen: Conceptualisation, Investigation, Methodology, Writing – original draft; Maria Salomons: Conceptualisation, Supervision, Writing – review & editing; Peter Jan Hendriks: Conceptualisation, Methodology, Supervision; Jan Anne Annema: Conceptualisation, Supervision, Writing – review & editing.

Use of AI

During the preparation of this work, the authors used Grammarly in order to polish language issues. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

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Conflict of Interest

There is no conflict of interest.

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