BMJ open accessible medical research

An investigation of the effects of the common cold on simulated driving performance and detection of collisions: a laboratory study

Andrew Paul Smith,[1] Samantha Jamson[2]

To cite: Smith AP, Jamson S. An investigation of the effects of the common cold on simulated driving performance and detection of collisions: a laboratory study. *BMJ Open* 2012;**2**:e001047. doi:10.1136/bmjopen-2012-001047

▶ Prepublication history for this paper is available online. To view this file please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2012-001047).

Received 21 February 2012
Accepted 29 May 2012

[1]Centre for Occupational and Health Psychology, School of Psychology, Cardiff University, Cardiff, UK
[2]Institute for Transport Studies, University of Leeds, Leeds, UK

Correspondence to
Dr Andrew Paul Smith; smithap@cardiff.ac.uk

ABSTRACT

Objective: The aim of the present research was to investigate whether individuals with a common cold showed impaired ability on a simulated driving task and the ability to detect potential collisions between moving objects.

Design: The study involved comparison of a healthy group with a group with colds. These scores were adjusted for individual differences by collecting further data when both groups were healthy and using these scores as covariates. On both occasions, volunteers rated their symptoms and carried out a simulated driving session. On the first occasion, volunteers also carried out a collision detection task.

Setting: University of Leeds Institute for Transport Studies.

Sample: Twenty-five students from the University of Leeds. Ten volunteers were healthy on both occasions and 15 had a cold on the first session and were healthy on the second.

Main outcome measures: In the collision detection task, the main outcomes were correct detections and response to a secondary identification task. In the simulated driving task, the outcomes were speed, lateral control, gap acceptance, overtaking behaviour, car following, vigilance and traffic light violations.

Results: Those with a cold detected fewer collisions and had a higher divided attention error than those who were healthy. Many basic driving skills were unimpaired by the illness. However, those with a cold were slower at responding to unexpected events and spent a greater percentage of time driving at a headway of <2 s.

Conclusions: The finding that having a common cold is associated with reduced ability to detect collisions and respond quickly to unexpected events is of practical importance. Further research is now required to examine the efficacy of information campaigns and countermeasures such as caffeine.

ARTICLE SUMMARY

Article focus

- The study investigated effects of the common cold on simulated driving and collision detection.
- It tested the hypotheses that people with a cold would show impairments in collision detection and aspects of simulated driving.

Key messages

- Drivers with a common cold respond more slowly to unexpected events and drive too close to the car in front.
- Collision detection is impaired when a person has a cold.

Strengths and limitations of this study

- The study used established methodologies to investigate the topic.
- This small scale study requires replication and extension to provide a more detailed profile of potential effects of the common cold on driving.

INTRODUCTION

Studies of simulated driving have played a major role in transport policy and practice. One of the early studies,[1] published in the *BMJ*, demonstrated an increase in driving error following ingestion of alcohol. Changes in state due to drugs like alcohol can be countered by appropriate legislation. Other factors, such as driver fatigue, are more difficult to legislate against—there is no breathalyser for fatigue! In the case of professional drivers, some causes of fatigue, such as time spent driving, can be controlled. This is more difficult when one considers driving outside of work or when one has to deal with fatigue produced by other factors (low levels of circadian alertness). In these situations, information campaigns[2] have to be used to prevent and manage driver fatigue, although legislation relating to being in a fit state to drive could be applied. The aim of the present research was to investigate whether individuals with a common cold showed impaired ability on a simulated driving task and the ability to detect potential collisions between moving objects.

Minor illnesses such as the common cold produce a state of reduced alertness that is associated with impaired psychomotor function and cognitive abilities.[3–6] These impairments manifest themselves as slower reaction times to unexpected events and a reduced ability to sustain attention. These are important skills involved in driving and one might, therefore, expect that individuals with such illnesses will be involved in more crashes. Anecdotal evidence, largely consisting of case reports, suggests that this is the case.[7] This has been confirmed in a survey[8] and extrapolation of this to the whole driving population suggests that 125 000 people in the UK have a crash while suffering from a cold or influenza. Results from a driving hazard perception task[8] confirmed laboratory findings that reaction times are 10% slower when the person has a cold. Again, if one applies this to a real-life driving situation, it would mean that it would add 1 m (3.3 ft) to stopping distance if travelling at 30 mph (48 km/h)—on top of a normal distance of 12 m (40 ft), and it would add 2.3 m (7.5 ft) onto the normal stopping distance of 96 m (315 ft) if travelling at 70 mph (113 km/h).

Research using a simple driving simulator[9] (resembling a computer game) has shown that people with an upper respiratory tract illness responded more slowly to unexpected events and were more likely to steer inaccurately. Another study[10] using a very realistic driving simulator found that basic driving skills were not impaired but that situational awareness was reduced when the person had a cold. The present study continued to examine this topic in detail, using a sophisticated simulation that incorporates the skills necessary for safe driving. In addition, the study also included a laboratory task which evaluated participants' ability to detect potential collisions[11] which is a key skill in driving but also something that cannot be repeatedly examined in a simulator.

METHODS

The study was carried out with the approval of the ethics committee, School of Psychology, Cardiff University, and the informed consent of the volunteers.

Experimental design

A mixed design was employed whereby two groups of participants (sample 1 and sample 2) were tested on two occasions (session 1 and session 2). Those participants in sample 1 were healthy on both occasions, while those in sample 2 reported symptoms of minor respiratory illnesses in session 1 but were symptom free in session 2. Participants carried out the driving simulation task on both occasions but only carried out the collision detection task on the first session (Table 1).

Procedure

Volunteers were students from the University of Leeds recruited by posting advertisements in the Student Medical Practice and by placing posters in the School of Psychology. On arrival at the first session, they were asked to read the experimental procedure and sign the consent form if they agreed to take part. They then completed a symptom checklist, a self-report questionnaire designed to evaluate the severity of their symptoms using a five-point rating scale (0=not all to 4= very severe). If volunteers scored above 8 on symptoms typical of a cold (pain in chest, sore throat, headache, sneezing, runny nose, blocked nose, hoarseness, cough, hot/cold, sweating, shivering, fever and phlegm), they were included in the cold group. Healthy volunteers were only included if they had a symptom score of three or less (based on the upper respiratory tract symptoms and other symptoms of minor illnesses such as digestive problems). Volunteers were excluded if they were taking medication for their colds. All volunteers were tested when their illness had been present for at least 24 h and no longer than 96 h.

Table 1 Demographic characteristics of the volunteers

	Sample 1 (healthy)	Sample 2 (colds)
Men/women	4/6	10/5
Mean age (men)	20 years (range: 18–21)	20 years (range: 18–25)
Mean age (women)	22 years (range: 20–24)	21 years (range: 19–24)

The laboratory task was then completed, followed by a familiarisation period on the driving simulator. Volunteers were asked to drive as naturally as possible through the road network. The secondary (choice reaction) task was also explained to them. On completion of the drive, volunteers were asked to contact the experimenter after seven symptom-free days in order to confirm a second session. Those who were healthy at session 1 returned for their second session approximately a week later. When they returned for this session, they completed the same symptom checklist and driving simulator task. After completion, they were debriefed, and their expenses paid.

Object movement estimation under divided attention

Object movement estimation under divided attention (OMEDA)[11] is a computerised dual task with two parts. Part 1 of OMEDA (see figure 1) allows experimenters to obtain an individual's error in time-to-collision (TTC) estimation. Different target speeds can be simulated, as can various degrees of occlusion. A secondary task is also incorporated in the form of a visual divided attention task. This requires the identification of peripheral duplication of stimuli presented centrally (in this case geometrical shapes).

Part 2 of OMEDA (see figure 1) provides a quantified estimate of collision detection error under various degrees of occlusion and for a series of target speeds, with the same secondary task as for part 1. Participants do not need to be computer literate in order to be able

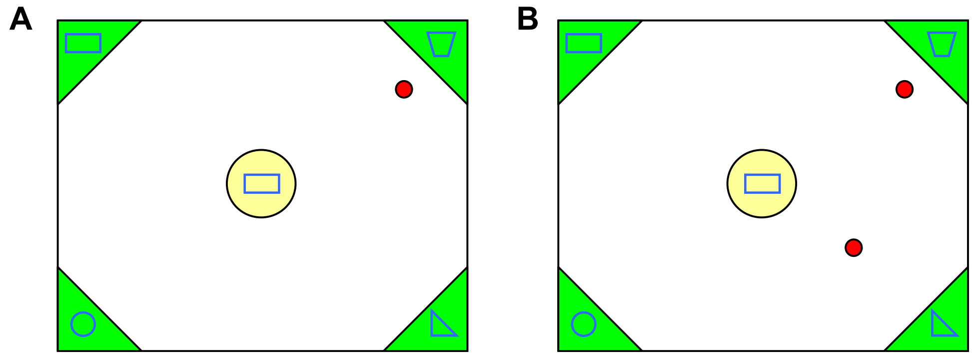

Figure 1 Object movement estimation under divided attention computer screen (part 1 and part 2). Data collected are target speed, size of the occlusion circle, time under the occlusion circle, actual time to contact (time-to-collision (TTC)), estimated TTC and TTC error and errors in shape detection.

to do this task, as the response keys are a foot pedal (for the primary task) and a hand button (for the secondary task).

In part 1, the participant is presented with a computer screen where the corners are covered by green triangles and in the centre of the screen is a yellow circle. The yellow circle varies in size between two and 250 pixels. From one of the four corners (randomly allocated), a red target, in the form of a circle travels towards the middle of the screen. Once it reaches the edge of the yellow circle, it travels underneath it and it is not visible. Therefore, the larger the circle, the more difficult is the task, due to a longer occlusion time. The participant is asked to estimate exactly when the target reaches the middle of the computer screen. They are instructed to press a foot pedal at the exact point the target reaches the middle.

In order to simulate divided attention, while participants are estimating when the target reaches the middle of the screen, they are required to complete a pattern matching task. When the target is moving, five shapes appear on the screen (one overlaid on the yellow circle and one in each of the four corners). Participants are instructed to press a hand button immediately if the shape in the middle matches any of those in the four corners of the screen.

In part 2, the participants are presented with the same screen as in part 1. However, the primary task now involves two targets moving towards the centre of the screen, emerging at different times and travelling at different speeds. The targets reach the centre of the screen either at the same time (a hit), almost at the same time (a near miss) or at a noticeable time difference (a miss). The participant is required to press the foot pedal only if and when the targets reach the centre of the screen at the same time (ie, only for hits). The secondary task is the same as for part 1. The data collected includes the error in estimating TTC and the error in shape estimation, under different occlusions and target speeds.

Driving simulator

The experiments were carried out on a fixed based driving simulator at the University of Leeds presenting a 120° forward view and 50° rear view. The system features a fully interactive Silicon Graphics (Onyx RE^2) driving simulator with a six degree of freedom vehicle model. A servo motor linked to the steering mechanism provides control over handling torque and speed and digitised samples of engine, wind, road noise and other vehicles are provided. Photo-realistic scene texturing allows presentation of various road types and features.

Studies[12] have evaluated the behavioural validity of the simulator. The results showed that overall there was a broad correspondence between driving in the simulator and the behaviour of real-world traffic. With regard to speed, the effects of road width, curvature, direction of curve and sequence between road sections were reproduced on the simulator, and there were very high correlations between speed along the real road and speeds in the simulator. Prior to the experimental drive, participants completed a 15 min familiarisation drive. The drive comprised urban, rural and motorway sections, similar to the experimental drive, but contained none of the scenarios under investigation. Once the familiarisation drive was completed, drivers were deemed ready to proceed to the next stage. The experimental route was approximately 22 miles in length and comprised of urban, rural and motorway environments, providing a range of speed limits between 30 and 70 mph. Other cars in the scenario provided the opportunity of simulating overtaking scenarios, gap acceptance tasks and car-following situations. The road environment also featured traffic lights and pelican crossings in order to instigate possible violation scenarios, and substandard curves were included in both the urban and rural sections.

Speed measurements were taken every 10 m throughout the whole journey. In addition, indices of safety critical behaviour such as minimum time to collision in following tasks and the incidence of overtaking manoeuvres were recorded. Traffic light violations, speed violations and curve negotiation behaviour were also noted.

Three car following situations were engineered requiring drivers to maintain their desired headway over a section of road. They were unable to pass the slow moving car in front due to oncoming traffic. These situations allowed measurement of minimum time to collision and variation in headway. In addition, two overtaking scenarios were created: here oncoming traffic was present, but it had sufficient gaps to allow the driver to pass. Propensity to overtake and proximity to the oncoming car were measured. An additional overtaking scenario was created, again using a slow moving vehicle in front. Here drivers were constrained by double white lines; if they chose to overtake, a violation was recorded.

Four sets of traffic lights were placed in the road network. One was programmed to change from green to red as the driver approached. This required the driver to make a stop/go decision, and a violation was recorded if the driver passed through on the red light. Two gap acceptance tasks were incorporated into the road network. The first required the driver to merge from the minor road onto the major road, making a left turn. Traffic on the major road was approaching from the right with varying gaps. The second required the driver to make a right turn across oncoming traffic from a major to a minor road. Again the cars were separated with varying gaps.

Attention to surprise events was measured in terms of performance on a choice reaction task incorporated into the road network. Drivers were required to respond to red and green squares that appeared in front of them. If the square was green, they were asked to ignore it and continue driving. If the square was red, they were asked to continue driving and to flash the headlights once, in response. Throughout the whole drive, there appeared three red and three green squares in a random sequence. In subsequent drives, the positioning of the squares was changed, in order to prevent associative learning effects. Their response to the stimuli was recorded in terms of reaction time, false/correct hits and missing responses.

Participants

Previous research suggests that the effects of the common cold on behavioural measures are large. A sample size calculation suggested that 20 participants should be tested (minimum group size =9). Twenty-five participants were recruited for this study. Ten were assigned to sample 1 and 15 to sample 2. All participants had a full driving licence and had been driving for <5 years. A roughly equal number proportion of men and women were recruited and all ill volunteers were paid for their participation.

RESULTS

Symptom checklist

The symptom checklist showed significant differences in self-reported health. In the first test session, volunteers with a cold scored on average 19.8 (out of a maximum of 52), while on their return, this average score fell to 2, which was similar to the scores for those who were healthy on both occasions. Symptom scores for all of the upper respiratory tract symptom scales are shown in table 2. All of the individual symptoms showed significant differences between the groups except for fever and shivering. This suggests that the participants had colds rather than influenza.

Table 2 Upper respiratory tract symptoms reported by colds and healthy groups on first testing session

Symptom	Colds group	Healthy group	Significance p value
Pain in chest	0.93 (0.23)	0.0 (0.0)	<0.05
Sore throat	1.80 (0.24)	0.2 (0.13)	<0.001
Headache	1.27 (0.267)	0.0 (0.0)	<0.005
Sneezing	1.47 (0.29)	0.10 (0.10)	<0.005
Runny nose	2.47 (0.19)	0.40 (0.16)	<0.001
Blocked nose	1.93 (0.21)	0.10 (0.10)	<0.001
Hoarseness	1.33 (0.30)	0.0 (0.0)	<0.005
Cough	2.13 (0.26)	0.20 (0.13)	<0.001
Feeling hot/cold	1.47 (0.24)	0.10 (0.10)	<0.001
Sweating	1.20 (0.31)	0.10 (0.10)	<0.05
Shivering	0.67 (0.21)	0.00 (0.00)	0.06
Fever	0.80 (0.30)	0.00 (0.00)	0.10
Phlegm	2.33 (0.30)	0.20 (0.13)	<0.001
Total symptom score	19.80 (1.96)	1.40 (0.27)	<0.001

Significance tested by a Mann–Whitney test. Scores are represented as means (SES).

Object movement estimation under divided attention

Performance data on both parts of the OMEDA task are presented. Part 1 of the task provides indication of accuracy in terms of TTC estimates of a moving target. Absolute error (in seconds) was computed for both the healthy and unhealthy groups. Performance on the secondary task was also recorded, using the number of errors made in identifying the presence of a matching shape in the periphery of the screen. Part 2 of OMEDA provides data relating to the ability to detect a collision between two moving targets. The results are shown in table 3.

In part 1, there were no significant differences between the groups. This is likely due to a ceiling effect, whereby the volunteers found the task easy to complete. Overall, they were able to estimate accurately the TTC, with 50% of the total sample estimating to within 0.3 s of the actual TTC (absolute error of TTC: healthy group: 0.40; ill group: 0.44). In addition, they found the primary task easy enough to be able to perform well on the secondary task, with only a total of four identification errors across the whole sample (shape identification error: healthy group: 0.01; ill group: 0.03). However, when the task became more difficult in part 2 of the OMEDA, performance decrements were found for those with colds. Healthy individuals were more likely to identify correctly both collisions and non-collisions. Those with colds appear to be impaired to the extent that they were less likely to be able to identify if the moving targets would or would not collide under various degrees of occlusion. Performance on the secondary task was also degraded, such that those who were suffering from a cold made more errors in identifying the matching shape in the periphery of the screen.

Table 3 Performance of healthy and unhealthy drivers on the divided attention part of the OMEDA task

	Healthy	Cold	χ^2	Significance p value
Missed collisions	6%	5%	0.122	0.727
Detected collisions	27%	22%	3.67	0.012
Correct misses	35%	27%	5.32	0.002
False hits	31%	27%	0.971	0.325
Divided attention error	0.34%	1.68%	2.87	0.014

Driving performance

In order to control for individual differences in driving ability, analyses of covariance, with the session 2 data as covariates, were carried out on the driving data. Preliminary analyses showed that the two groups were not significantly different at session 2 (when both groups were healthy).

Speed

For the purpose of data analysis, the experimental road network was divided into sections according to speed limit. Of these sections, where the driver was in free flowing conditions (ie, not engaged in a car-following task), SD of speed across the section was derived. Analyses of covariance showed no effect of having a cold on standard of speed (healthy group: mean=4.76 m/s, SE=0.36; ill group: mean=4.82 m/s, SE=0.30, F<1).

Lateral control

Edgeline/centre line encroachments were not significantly altered as a function of health status or was the SD of lane position (SD lane position: healthy group: mean=0.19 m, SE=0.3; ill group: mean=0.18 m, SE=0.3, F<1).

Gap acceptance

Two gap acceptance tasks were included in the road network. The first required the drivers to merge left into traffic approaching from the right, while the second required drivers to turn right across oncoming traffic. Gaps in the traffic increased by 1 s, with each vehicle, and the size of the gap that drivers accepted as well as a minimum time to collision to the on-coming car was calculated. There were no significant effects of cold status on gap acceptance.

Overtaking behaviour

In addition to the car-following tasks detailed above, two scenarios were created to examine overtaking behaviour. Drivers encountered lead cars travelling below the posted speed limit on a straight stretch of road. There was little opposing traffic, providing the opportunity for drivers to overtake. Both overtaking attempts and successful overtakings were recorded. However, it was found that these values were identical (thus once committed to an overtaking manoeuvre, drivers tended to complete it). There was no difference in overtaking behaviour between the two groups.

Car following

The road network allowed the inclusion of several car-following tasks. In two of these tasks, the driver was unable to overtake the car in front due to oncoming traffic. This created a 'boxed-in' situation that allowed the measurement of the time headway distribution. The lead cars in these scenarios were travelling at a speed that was constant and below the speed limit. Thus in the urban situation, the lead car was travelling at 25 mph, in the rural area at 40 mph. Therefore, even if speed limited, it was possible for drivers to adopt short headways if they wished to. Table 4 shows the time headway distribution for both healthy and ill drivers in an urban environment (30 mph).

It can be seen that those drivers who reported cold symptoms spent a larger proportion of time at a shorter headway (in the safety critical area of <2 s).

Vigilance

A choice reaction task required drivers to differentially respond to randomly appearing targets in the visual scene. It was hypothesised that there may be differences in either response times or error rates depending on the health status of the participants. Such differences may arise as a result of decreases in vigilance associated with cognitive impairment. Probably due to the ease of the task, a floor effect was found with regard to the error rates in that drivers demonstrated a high degree of accuracy. Further analysis of the response times to targets however revealed a significant difference between response times of the healthy and ill volunteers with those with a cold being significantly slower (see table 4).

Collision with a pedestrian

A critical event was added as an additional measure of vigilance. At a pedestrian crossing, a pedestrian stepped into the road and crossed in front of the driver's path.

Table 4 Significant effects of health status on outcomes from the driving task

	Healthy	Ill	
Mean percentage of time spent at a headway of <2 s (SES)			
	39.2% (5.4)	51.7 (4.3)	F=4.80, p<0.05
Mean response times (seconds) in choice reaction task (SES)			
Target 1	1.01 (0.10)	1.33 (0.11)	F=4.35, p<0.05
Target 2	0.95 (0.06)	1.21 (0.06)	F=6.09, p<0.05

This event was staged such that drivers were able, with severe braking, to avoid collision with the pedestrian, if braking was initiated immediately. In the first session, the healthy volunteers had no collisions whereas those with a cold had 8 (χ^2=7.06, p<0.01). In the second session, both groups had zero collisions.

These types of critical scenarios are inherently difficult to manipulate and test in the simulator environment, not least due to exposure effects. It could be postulated that on the second trial, participants were anticipating an event of this kind to occur again and thus be cautious on approach to pedestrian crossings. However, several precautions ensure that this is not the case. First, the location of the surprise event was different on the two driving sessions. In the first session, it was located at the end of the road network, and in the second session, it was moved to half way along the network. Second, as a measure of anticipation, speed measures were recorded within the vicinity of the event. Thus, speed was measured at 50 m before the event (50 m was chosen as drivers could see the pedestrian but had not yet begun to brake). In addition, speed was also measured at the point at which they initially began to brake. There were no significant difference in these values between the first and the second driving session. This indicates that drivers were not anticipating the event in the second session.

These results demonstrate that drivers with reported symptoms of minor respiratory illnesses are impaired to the extent that they have longer response times and thus negative safety effects with regards to critical events in the driving environment.

Traffic light violations

A situation was created whereby drivers were forced to make a rapid stop/go decision at one set of traffic lights that turned from green to amber as drivers approached. In concordance with the previous results found on the longer response times and reaction to surprise events, drivers who reported cold symptoms violated the traffic lights twice as often as drivers who were symptom free. However, due to the small number of violations, this effect was not significant.

DISCUSSION

The present results confirm the earlier findings that having a cold may impair aspects of simulated driving performance. There appears to be reliable evidence that volunteers presenting with symptoms respond more slowly to unexpected events and spent a greater percentage of time driving too close to the car in front compared with healthy volunteers. As described in the introduction, this decrement in driving performance could have implications for road safety. The slowing of reaction times associated with having a cold is comparable to effects of known hazards, such as consumption of a dose of alcohol that would lead to a ban from driving (80 mg alcohol/100 ml blood) or having to perform at night. The OMEDA task also demonstrated that those suffering from a cold were less able to detect potential collisions. Comparison with a previous study[11] using elderly participants (over 65 years) shows that the detection performance of young adults with a cold falls to that of elderly drivers. There is now a need for an information campaign to provide accurate information about the potential hazards associated with driving while suffering from an upper respiratory tract illness.

There is also evidence that the direct effects of having a cold are not the only ones that need to be considered. A number of studies have shown that individuals who are ill are more susceptible to the effects of other factors that could influence driving (alcohol,[13] prolonged work[14] and noise[15]). Research also shows that impairments associated with the common cold are not restricted to the time the person is symptomatic but may be observed in the incubation period and a few days after symptoms have gone.[6]

One must now ask what underlies the effects here. Previous research has shown that the low alertness state associated with a cold can be reversed by a drug that increases the turnover of central norepinephrine.[16] Indeed, ingestion of caffeine, which increases alertness, has been shown to remove the cold-induced performance impairments seen in laboratory tasks.[17] This suggests that a further study examining whether caffeine can remove the effects found here is required. Similarly, it will be important to determine whether medications aimed at producing symptomatic relief also remove the behavioural problems associated with the common cold.

In summary, the present study has used established methods to examine effects of the common cold on simulated driving and collision detection. The findings that having a cold reduces the ability to detect collisions and respond quickly to unexpected events are of practical importance and can be related to plausible underlying mechanisms. The study was small scale using relatively inexperienced drivers, and further research is required to determine whether there are additional smaller effects and whether there are contexts and individuals (eg, the elderly) in which the impairments may be even greater than those seen here. Similarly, further research is required to address the issue of awareness of these effects by using information campaigns and prevention by using countermeasures that increase alertness.

Contributors APS wrote the research proposal, designed the study, wrote the statistical analysis plan, analysed the data and drafted and revised the paper. He is the guarantor. SJ implemented the study, analysed the data and revised the paper.

Funding Funded by the ESRC.

Competing interests None.

Ethics approval Ethics approval was provided by School of Psychology, Cardiff University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement There is no additional data available.

REFERENCES

1. Drew GC, Colquhoun WP, Long HA. Effect of small doses of alcohol on a skill resembling driving. *Br Med J* 1958;2:994–8.
2. http://www.dft.gov.uk/publications/think-fatigue/
3. Smith AP. Respiratory virus infections and performance. *Philos Trans R Soc Lond B Biol Sci* 1990;327:519–28.
4. Smith A, Thomas M, Kent J, *et al*. Effects of the common cold on mood and performance. *Psychoneuroendocrinology* 1998;23:733–9.
5. Bucks RS, Gidron Y, Harris P, *et al*. Selective effects of upper respiratory tract infection on cognition, mood and emotion processing: a prospective study. *Brain Behav Immun* 2008;22:399–407.
6. Smith AP. Respiratory tract illnesses and fatigue. In: Matthews G, Desmond PA, Neubauer C, *et al*, eds. *The Handbook of Operator Fatigue*. Farnham, Surrey, UK: Ashgate Publishing, 2012:291–305. ISBN: 978-0-7546-7537-2.
7. Tye J. *The Invisible Factor: an Inquiry into the Relationship Between Influenza and Accidents*. London: British Safety Council, 1960.
8. http://www.insurance.lloydstsb.com/personal/general/mediacentre/sneeze_and_drive.asp
9. Smith A. Effects of the common cold on simulated driving. In: Bust PD, ed. *Contemporary Ergonomics 2006*. London: Taylor & Francis, 2006:621–4. ISBN: 10 0415398185.
10. Ramaekers JG, Kuypers KP, Wood CM, *et al*. *Experimental Studies on the Effects of Licit and Illicit Drugs on Driving Performance, Psychomotor Skills and Cognitive Function*. 2004. Report D-R4.4. IMMORTAL. Contract GMAI-2000–27043 S12.319837. European Commission 5th Framework Programme. Brussels: European Commission.
11. Read N, Ward N, Parkes A. The role of dynamic tests in assessing the fitness to drive of healthy and cognitively impaired elderly. *J Traffic Med* 2000;28:34–5S.
12. Carsten OMJ, Groeger JA, Blana E, *et al*. *Driver Performance in the EPSRC Driving Simulator: a Validation Study*. 1997. Final report to EPSRC Contract No. GR/K56162. Swindon: EPSRC.
13. Smith AP, Whitney H, Thomas M, *et al*. A comparison of the acute effects of a low dose of alcohol on mood and performance of healthy volunteers and subjects with upper respiratory tract illnesses. *J Psychopharmacol* 1995;9:225–30.
14. Smith AP, Thomas M, Whitney H. Effects of upper respiratory tract illnesses on mood and performance over the working day. *Ergonomics* 2000;43:752–63.
15. Smith AP, Thomas M, Brockman P. Noise, respiratory virus infections and performance. *Proceedings of 6th International Congress on Noise as a Public Health Problem*. 1993. Nice: Actes Inrets 34: Vol 2, pp. 311–14.
16. Smith AP, Sturgess W, Rich R, *et al*. Effects of idazoxan on reaction times, eye movements and mood of healthy volunteers and subjects with upper respiratory tract illnesses. *J Psychopharmacol* 1999;13:148–51.
17. Smith AP, Thomas M, Perry K, *et al*. Caffeine and the common cold. *J Psychopharmacol* 1997;11:319–24.