# RESEARCH

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Why Rudolph's nose is red: observational study

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#### bmj.com/multimedia

 Reindeer, on a treadmill (plus a bit of medicine) in the BMJ Christmas video



Fig 1 | Reindeer in Norwegian arctic region showing distinct pink coloration at tip of nose. Reproduced with permission of Kia Krarup Hansen

**OBJECTIVE** To characterise the functional morphology of the nasal microcirculation in humans in comparison with reindeer as a means of testing the hypothesis that the luminous red nose of Rudolph, one of the most well known reindeer pulling Santa Claus's sleigh, is due to the presence of a highly dense and rich nasal microcirculation. **DESIGN** Observational study.

**SETTING** Tromsø, Norway (near the North Pole), and Amsterdam, the Netherlands.

PARTICIPANTS Five healthy human volunteers, two adult reindeer, and a patient with grade 3 nasal polyposis. MAIN OUTCOME MEASURES Architecture of the microvasculature of the nasal septal mucosa and head of the inferior turbinates, kinetics of red blood cells, and real time reactivity of the microcirculation to topical medicines. **RESULTS** Similarities between human and reindeer nasal microcirculation were uncovered. Hairpin-like capillaries in the reindeers' nasal septal mucosa were rich in red blood cells, with a perfused vessel density of 20 (SD 0.7) mm/mm<sup>2</sup>. Scattered crypt or gland-like structures surrounded by capillaries containing flowing red blood cells were found in human and reindeer noses. In a healthy volunteer, nasal microvascular reactivity was demonstrated by the application of a local anaesthetic with vasoconstrictor activity, which resulted in direct cessation of capillary blood flow. Abnormal microvasculature was observed in the patient with nasal polyposis.

**CONCLUSIONS** The nasal microcirculation of reindeer is richly vascularised, with a vascular density 25% higher than that in humans. These results highlight the intrinsic physiological properties of Rudolph's legendary luminous red nose, which help to protect it from freezing during sleigh rides and to regulate the temperature of the reindeer's brain, factors essential for flying reindeer pulling Santa Claus's sleigh under extreme temperatures.

#### Introduction

The nasal microcirculation has important physiological roles such as heating, filtering, and humidifying inhaled air, controlling inflammation, transporting fluid for mucous formation, and delivering oxygen to the nasal parenchymal cells. The pathophysiology of many nasal conditions, such as congestion and epistaxis, is based on the regulatory mechanisms of the microcirculation. Moreover, the nasal mucosa play an important part in the uptake of drugs and responses to allergens. Despite the important role of nasal mucosa in health and disease, few studies have dealt with the function and morphology of its microcirculation in humans. Studies have been hampered mainly by the unavailability of techniques suitable for assessing the nose and by difficulties with nasal access from cumbersome microscopes. Some early studies used laser Doppler flowmetry,<sup>1-4</sup> but most information on the microcirculation of the healthy and diseased human nose is from immuno-histochemical studies on biopsied material.<sup>5 6</sup>

The introduction of handheld intravital video microscopes has greatly facilitated this.<sup>7-9</sup> These imaging instruments have had a special impact on intensive care medicine as they have shown the nasal microcirculation to be the most sensitive haemodynamic indicator of outcome and response to treatment.<sup>9-12</sup> These instruments have also identified the microcirculation as a key factor in a wide range of other diseases, including diagnostic support and treatment responses in oncology.<sup>13-15</sup>

Using this technique we characterised the microvasculature of the human nose and applied the same technique to reindeer for comparative purposes. Based on the central role of the nasal microcirculation<sup>16-19</sup> in the temperature regulation of reindeers' brain and an appreciation of the importance of this for flying reindeer who have to deal with extremes of temperature while pulling a sleigh, we hypothesised that the infamous red nose of the most well known of Santa Claus's reindeers, Rudolph, would originate from a rich vascular anatomy with a high functional density of microvessels.

#### Methods

#### Human volunteers

We recruited five consecutive volunteers from the department of otorhinolaryngology in the Academic Medical Center. Inclusion criteria were adult non-smokers aged 18 years or more with no history of systemic or nasal disease and who were not taking prescribed drugs. A short medical history was obtained from the volunteers before investigations began. Moreover, vascular reactivity of the nasal mucosa was tested in one of the healthy volunteers by local application of 100 mg cocaine,<sup>2</sup> a drug routinely used in ear, nose, and throat medicine as a local anaesthetic and vasoconstrictor. Also, we evaluated the utility of handheld video microscopy in assessing a patient with grade 3 polyposis.

#### Reindeer

Measurements were carried out at room temperature (18°C (SD 1°C)) on two adult reindeer (*Rangifer tarandus*, fig 1) under light anaesthesia using a single intramuscular injection of 0.2 mg/kg medetomidine hydrochloride (Zalopine; Orion, Espoo, Finland) delivered by a dart syringe.<sup>20</sup> We used the handheld microscope to video record and quan-



Fig 2 | Microcirculation in anterior septum of healthy human volunteers, showing hairpin-like vessels in a circular configuration

tify the properties of the nasal microcirculation.<sup>21</sup> <sup>22</sup> Anaesthesia was terminated by an intramuscular injection of 0.7 mg/kg atipamezole hydrochloride (Antisedan; Orion).

#### Imaging technique, measurements, and analysis

The microcirculation was imaged using a handheld intravital video microscopy system (sidestream dark field imaging technology).<sup>8</sup> One investigator (AMvK) obtained clinical measurements of the volunteers in one room kept at a constant temperature of 22°C (SD 1°C). Participants were seated upright in a chair with their head on a headrest. We measured the microcirculation of the reindeer in a similar manner to the clinical measurements by gently inserting the imaging probe, covered with a sterile disposable lens cover, into the nasal cavity.

Offline data analysis was by semi-automated microvascular imaging software developed by our group.<sup>22</sup> We quantified the vascular density of blood vessels <25  $\mu$ m to determine the perfused vessel density (mm vessel/mm<sup>2</sup>) and the microvascular flow index: absent (0), intermittent (1), sluggish (2), or normal (3).<sup>21</sup>

#### Statistical analysis

A Mann-Whitney test was used for non-parametric comparative analysis of perfused vessel density and microvascular flow index. We considered P values of differences less than 0.05 to be significant. Data are presented as means (standard deviations).

#### Results

In all volunteers the contrast of the nasal mucosa was enough to visualise the microcirculation, which consisted of flowing red blood cells (fig 2; also see the supplementary video recording). High quality images were obtained from the nasal septum and the inferior turbinate. The plexus, or Kiesselbach's area, was clearly visible in the anterior nasal septum (fig 2). Discrete, circularly arranged capillaries were observed throughout the nasal mucosa in all the healthy volunteers. The capillaries contained a central lumen-like structure (large circular structure in fig 2) and were observed at different locations throughout the nasal septum. The central circular structure seemed to be a gland for the excretion of mucus. Quantification of the nasal microcirculation in the healthy volunteers showed a mean perfused vessel density of 15 (SD 3.2) mm/mm<sup>2</sup> with a microvascular flow index of 3.0 arbitrary units.

The microvasculature of the inferior turbinate presented a characteristic hairpin-like morphology analogous to other mucosal tissue surfaces. The arrangement of the capillaries varied with location, with only the tops or arches of the loops visible in some areas and the entire loop structure with its afferent and efferent arms visible in other areas. The images consistently portrayed capillaries but no large blood vessels; big venous structures could be observed only out of focus (see figure 2 on bmj.com). In addition, the configuration of the vasculature surrounding the gland-like structures on the inferior turbinate was the same as that of other capillary loops found in other mucosal tissue surfaces.

A transitory cessation of microcirculatory flow was observed in the healthy volunteer after a vasoconstrictor challenge using cocaine (fig 2). In addition, the nasal microvasculature of the patient with nasal polyposis was irregular and the characteristic angioarchitecture and hairpin-like capillaries were absent (fig 2).

#### Why Rudolph's nose is red

The reindeer's nasal mucosa was richly vascularised with an abundant microcirculation ferrying a rich concentration of red blood cells; the mean perfused vessel density was 20  $(0.7 \text{ mm/mm}^2)$  with a microvascular flow index of 3.0 arbitrary units (fig 3). An infrared thermographic image of the reindeer obtained with an AGA Thermovision IR camera (Model 750 (spectral range 2-5 µm)) connected to an AGA



Fig 3 | An infrared image of a reindeer's head after a treadmill test shows the presence of a red nose (arrow, panel A).<sup>23</sup> Colours represent different temperatures: blue 15°C, white 19°C, and red 24°C. The dark band is the harness. Real time intravital video microscopy images of reindeer nasal microcirculatory network with hairpin-like (panel B) and related ring-like vasculature (panel C), similar to human nasal microcirculation. Reproduced with permission of the Department of Arctic and Marine Biology, University of Tromsø

#### WHAT IS ALREADY KNOWN ON THIS TOPIC

The introduction of handheld intravital video microscopes has enabled direct visualisation of the microcirculation in human organs but has not previously been applied to the nasal microcirculation These instruments could be used to unlock the mystery of why Rudolph, the legendary flying reindeer, has a bright red nose

#### WHAT THIS STUDY ADDS

The nasal microcirculation in humans consists of hairpin-like vessels, microcirculatory networks, and crypt-like structures surrounded by capillaries By comparison, reindeer have a more richly vascularised nasal microcirculation, with a vascular density 25% higher than that in humans This high vascular density answers the age old mystery of why Rudolph has a bright red nose

Thermovision Colour Slave Monitor (Model OM 701; AGA, Stockholm, Sweden) after a treadmill test showed that they do indeed have red noses.<sup>23</sup> In addition to the nose having a high microvascular density (fig 3), the nasal mucosa also revealed an abundance of ring-like vascular arrangements, similar to those in humans (fig 3).

The microvascular networks and hairpin-like vessels of the nasal microcirculation in reindeer were similar to those observed in humans. The functional vascular density of the reindeers' nasal mucosa was 25% higher than that in humans (fig 3). Interestingly, the reindeers' microcirculation was pumped in pulsatile intervals with a complete lack of red blood cells in the lumen of the microvasculature during diastole followed by forceful flow hyperaemia during systole. As this effect cannot be properly justified in a static image, we produced a video recording (see supplementary material).

#### Discussion

The microcirculation of the nasal mucosa in reindeer is richly vascularised and 25% denser than that in humans. These factors explain why the nose of Rudolph, the lead flying reindeer employed by Santa Claus to pull his sleigh, is red and well adapted to carrying out his duties in extreme temperatures.

Intravital video microscopy allowed observation of the complex architecture of the nasal microcirculation, including the kinetics of flowing red blood cells, and provided new insights into the adaptive behaviour of vascular structures under varying clinical conditions. An interesting finding was the presence of gland-like structures in the nasal mucosa. The most plausible explanation for the function of these circular vascular structures is mucous secretion. These structures are scattered throughout the nose and maintain an optimal nasal climate during humid weather and extremes of temperature as well as being responsible for fluid transport and acting as a barrier. Such structures were also identified in the two reindeer, although the vascularisation was slightly different and of a higher density than in the human volunteers. Histological studies would need to be carried out to determine the exact function of these gland-like structures.

Despite successfully imaging the nasal microcirculation of both the human volunteers and the reindeer, we were limited by the diameter of the light guide on the video microscope (1 cm), at least in the humans, and could obtain measurements on only certain nasal surfaces. Further miniaturisation of the dimensions of nasal endoscopes and conventionally used imaging probes for video microscopy should resolve this limitation, allowing a more comprehensive evaluation of the nasal microcirculation. These practical concerns may be resolved by the introduction of a third generation handheld intravital imaging computer controlled sensor based microscope.<sup>9</sup>

#### Conclusions

Using handheld vital video microscopy for imaging the human nasal microcirculation in health, interventions, and disease, we were able to solve an age old mystery. Rudolph's nose is red because it is richly supplied with red blood cells, comprises a highly dense microcirculation, and is anatomically and physiologically adapted for reindeer to carry out their flying duties for Santa Claus.

We thank Santa Claus for his enthusiastic support. He was as keen as us to unravel the mystery of his friend's nose.

For details of contributors, competing interests, ethical approval, and references, see bmj.com.

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## Using a dog's superior olfactory sensitivity to identify *Clostridium difficile* in stools and patients: proof of principle study

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**OBJECTIVE** To investigate whether a dog's superior olfactory sensitivity can be used to detect *Clostridium difficile* in stool samples and hospital patients. **DESIGN** Proof of principle study, using a case-control design.

**SETTING** Two large Dutch teaching hospitals.

**PARTICIPANTS** A 2 year old beagle trained to identify the smell of *C difficile* and tested on 300 patients (30 with *C difficile* infection and 270 controls).

**INTERVENTION** The dog was guided along the wards by its trainer, who was blinded to the participants' infection status. Each detection round concerned 10 patients (one case and nine controls). The dog was trained to sit or lie down when *C difficile* was detected.

MAIN OUTCOME MEASURES Sensitivity and specificity for detection of *C difficile* in stool samples and in patients.

**RESULTS** The dog's sensitivity and specificity for identifying *C difficile* in stool samples were both 100% (95% confidence interval 91% to 100%). During the detection rounds, the dog correctly identified 25 of the 30 cases (sensitivity 83%, 65% to 94%) and 265 of the 270 controls (specificity 98%, 95% to 99%).

**CONCLUSION** A trained dog was able to detect *C difficile* with high estimated sensitivity and specificity, both in stool samples and in hospital patients infected with *C difficile*.

#### Introduction

Early detection of *Clostridium difficile* infection is important to prevent transmission.<sup>1</sup> The traditional standard for detection is by cytotoxin assay, although this technique requires cell cultures and results take at



the C difficile

bmj.com/multimedia

Watch Cliff sniff out

#### WHAT IS ALREADY KNOWN ON THIS TOPIC

Despite the availability of a wide range of diagnostic tests, CDI is still a widespread healthcare related infection WHAT THIS STUDY ADDS

A dog can be trained to identify *C difficile* with high estimated sensitivity and specificity, both in stool samples and in hospital patients with CDI The potential of using a dog for detection is the ability to

screen hospital wards for infected patients Such screening could overcome common delays in diagnosis and thus help to control and prevent CDI

outbreaks

least 1-2 days.<sup>2</sup> <sup>3</sup> The method regarded most sensitive, but also time consuming, is toxigenic culture, with cultured isolates tested for toxins.<sup>3</sup> <sup>4</sup> Easy and rapid enzyme immunoassays to detect toxins or antigens are often used, despite their limited sensitivity or specificity.<sup>3</sup> <sup>5</sup> More recently, nucleic acid amplification tests have been developed with a high diagnostic accuracy and short turnaround time; they are, however, expensive and require specialised equipment and expertise.<sup>3-6</sup> Several factors delay the identification of *C difficile* infections such as inefficient sampling and time to process samples.<sup>7 8</sup> As a result the mean time from onset of symptoms to start of treatment can range from three to eight days.<sup>7 8</sup>

*C* difficile associated diarrhoea has often been described as having a characteristic smell.<sup>9</sup> Sensitivity and specificity of the odiferous detection of *C* difficile by nursing staff are 55-82% and 77-83%, respectively.<sup>10</sup> <sup>11</sup> As dogs have a superior sense of smell to that of humans,<sup>12</sup> we investigated whether they could be trained to detect *C* difficile in stool samples and in patients.

#### Methods

A professional instructor (HL) trained a 2 year old male beagle (fig 1) to identify *C difficile* in stool samples and in patients, by sitting or lying down if a specific scent was present. A reward based training method was used, with correct behaviour reinforced by providing a treat.

The dog was introduced to the odour of toxigenic *C difficile* strains on culture plates. Wooden sticks were placed over the sample to absorb the scent overnight. The exposure time was eventually shortened to around five minutes. Early scent recognition was achieved by using simple search and find games. These were gradually



Fig 1 Detection dog on hospital ward

replaced by increasingly more difficult exercises using a reduced concentration of the odour or varying the materials used for scent impregnation and being exposed to different environments.

The dog was then taught to discriminate stool samples that were positive for toxigenic *C difficile* from those that were negative. After two months we tested the dog's diagnostic accuracy on stool samples. Finally, we explored the dog's abilities to detect *C difficile* infection in hospital patients.

#### Results

## Diagnostic accuracy for detecting *C difficile* in stool samples

The dog was presented with 100 stool samples: 50 positive and 50 negative for *C difficile*. The dog gave a positive response to all the positive samples and a negative response to 47 of the negative samples, with the remaining three recorded as inconclusive. In the primary analysis, sensitivity and specificity were both 100% (95% confidence interval 91% to 100%). If an inconclusive response was considered as a positive result (secondary analysis), the dog's sensitivity and specificity were 100% (91% to 100%) and 94% (83% to 98%), respectively.

#### Diagnostic accuracy for detecting C difficile in patients

An inconclusive response was recorded in three cases and four controls (fig 2). In the primary analysis the dog correctly identified 25 cases (sensitivity 83%, 95% confidence interval 65% to 94%) and 265 controls (specificity 98%, 95% to 99%). In the secondary analysis, the dog correctly identified 28 cases (sensitivity 93%, 76% to 99%) and 261 controls (specificity 97%, 94% to 98%).



Fig 2|Diagnostic accuracy of dog for detecting Clostridium difficile infection (CDI)

In some instances of discrepant results the dog was clearly distracted, for example, by being offered a treat. Other cases were less clear and it cannot be ruled out that the dog responded to diarrhoea not related to *C difficile* or asymptomatic carriage of a non-toxigenic strain. Of all 16 participants with diarrhoea not related to *C difficile* infection, the dog gave a negative response in 13 controls and an inconclusive response in three controls.

#### Discussion

The diagnostic accuracy of the study dog suggests the possibility of immediate identification of *C difficile* infection. Moreover, the same may be true for the rapid diagnosis of *C difficile* infection on wards. For the purposes of detection the dog did not need a stool sample or physical contact with patients (it would seem *C difficile* can be detected in the surrounding air). In addition, dogs can screen a hospital ward of patients for *C difficile* in less than 10 minutes.

The small number of patients with *C difficile* infection limits the precision of the dog's sensitivity and specificity. The study design consistently included one case per round of 10 patients. This could have influenced the dog and the trainer's results by anticipating a positive result in each detection round.<sup>14</sup> Furthermore, two thirds of the cases had been moved to a single room (to control transmission) when the dog arrived, and occupancy of one room might have prejudiced the dog or trainer in favour of a diagnosis.<sup>14</sup>

In this study, culture was not routinely carried out for controls to screen for asymptomatic carriage of *C difficile*. This is a limitation as we do not know the percentage of asymptomatic carriers in our population. Asymptomatic carriage of both toxigenic and non-toxigenic strains occurs in up to 18-30% of patients in hospital,<sup>15-18</sup> which argues against a positive response by the dog.

A concern is that the results are not easily generalisable because we used only one dog and trainer. We therefore cannot rule out the possibility that our first experience was with an exceptional dog-trainer combination. Another limitation of using an animal as a diagnostic tool is that, despite training, they are still prone to distractions such as being offered a treat.

Another limitation is that we trained the dog in a hospital setting; although outside the research protocol we did visit a few patients with *C difficile* infection on long term care facility wards. These cases spent much of the day in a shared living room and this setting proved more difficult for the dog.

For contributors, competing interests, ethical approval, and references, see bmj.com.

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### CHRISTMAS 2012: CASE REPORT A shaggy dog story

Our 35 year old patient has severe excessive daytime sleepiness, resulting from a combination of narcolepsy, sleep apnoea, and hypopnoea syndrome. She also had bipolar disorder and a body mass index of 34. Sleep attacks occurred three to six times a day. When she was depressed, she slept up to 16 hours a day.

Until recently, this severe sleepiness considerably hampered her social life and limited her use of public transport, as she usually fell asleep within a few minutes of sitting down. She'd then wake up at the end of the line and have to fight sleepiness on the way back. Sometimes she'd forget where she started from.

Over the years, treatments included modafinil, methylphenidate, lithium, lamotrigine, carbamazepine, and several combinations of antidepressants, antipsychotics, and benzodiazepines. Neurostimulating agents had only limited effects on her sleepiness and were misused during hypomanic and manic phases. Continuous positive air pressure was poorly supported. No ENT treatment was deemed useful, and the patient was reluctant to use maxillary advancement devices. Her main psychiatric symptoms are now partially under control, although affective symptoms continue to wax and wane irregularly.

The patient was put in contact with a charity that provides trained dogs for people with visual or hearing impairment. A dog was first trained to wake the patient in the morning at the sound of an alarm clock, even if this sometimes required 30 minutes of gentle biting. The dog then learnt to wake the patient at the sound of a mobile phone ringing. Eventually, he learnt to wake her up, if necessary, at every metro, tram, or bus station. There were no reports of cataplectic attacks associated with dog biting.



This animal companion has allowed our patient to move around the city efficiently and carry on a social life. The intervention could benefit other patients with similarly extreme and treatment resistant daytime sleepiness.

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### Mind wandering and driving: responsibility case-control study

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cedric.galera@u-bordeaux2.fr Cite this as: BMJ 2012;345:e8105 doi: 10.1136/bmj.e8105 OBJECTIVE To assess the association between mind wandering (thinking unrelated to the task at hand) and the risk of being responsible for a motor vehicle crash. DESIGN Responsibility case-control study. SETTING Adult emergency department of a university hospital in France, April 2010 to August 2011. PARTICIPANTS 955 drivers injured in a motor vehicle crash.

MAIN OUTCOME MEASURES Responsibility for the crash, mind wandering, external distraction, negative affect, alcohol use, psychotropic drug use, and sleep deprivation. Potential confounders were sociodemographic and crash characteristics. **RESULTS** Intense mind wandering (highly disrupting/ distracting content) was associated with responsibility for a traffic crash (17% (78 of 453 crashes in which the driver was thought to be responsible) v 9% (43 of 502 crashes in which the driver was not thought to be responsible); adjusted odds ratio 2.12, 95% confidence interval 1.37 to 3.28).

**CONCLUSIONS** Mind wandering while driving, by decoupling attention from visual and auditory perceptions, can jeopardise the ability of the driver to incorporate information from the environment, thereby threatening safety on the roads.

#### Introduction

Among the potential contributors to preventable crashes, inattention plays a role, possibly contributing to more than half of crashes.<sup>2</sup> External distractions (such as from mobile phones<sup>3</sup>) are associated with traffic crashes. Inattention arising from internal distractions (such as worries) has received less consideration, possibly because of the difficulties of studying the phenomenon empirically.

The term mind wandering has been coined to describe thinking unrelated to the task at hand, a concept that has recently attracted interest from psychology and neuroscience.

#### WHAT IS ALREADY KNOWN ON THIS TOPIC

Among the potential sources of preventable crashes, inattention plays a role, possibly contributing to more than half of road traffic crashes

External distractions have been shown to be associated with crashes but inattention arising from internal distractions is still poorly understood in the context of road safety

#### WHAT THIS STUDY ADDS

Intense mind wandering was associated with responsibility for a crash and could account for a substantial proportion of all crashes

We hypothesised that this state, especially when intense, would increase the risk of being responsible for a crash, and performed a responsibility case-control study among a sample of injured drivers.

#### Methods

#### Study design and setting

We compared the frequency of exposures (mind wandering and confounders) between drivers responsible for the crash (cases) and drivers not responsible for the crash (controls). Cases and controls came from the same source (same period and location of recruitment). Trained research assistants interviewed 955 patients (89% of the 1068 eligible drivers) using questions regarding the crash, characteristics of the patient, and distraction, an average of 4 hours 34 minutes after the crash.

#### Outcome variable: responsibility for the crash

We determined responsibility levels in the crash with a standardised method adapted from the quantitative Robertson and Drummer crash responsibility instrument.<sup>8-11</sup> The method considers six different mitigating factors considered to reduce driver responsibility: road environment, vehicle related factors, traffic conditions, type of accident, traffic rule obedience, and difficulty of the driving task. Higher scores correspond to a lower level of responsibility. The allocation of summary scores was: 8-12=responsible; 13-15=contributory; >15=not responsible). Drivers who were assigned any degree of responsibility for the crash were considered to be cases; drivers who were judged not responsible (score >15) served as controls.

#### Exposure

During the interview, patients were asked to describe their thought content just before the crash. Each thought was classified in one of the following categories: thought unrelated to the driving task or to the immediate sensory input, thought related to the driving task, no thought or no memory of any thought. To capture the intensity of the thought when the mind was wandering, the participant filled in a Likert-type scale (0-10) for each thought, answering the question: "How much did the thought disrupt/distract you?"

Potential confounders included patient's characteristics (age, sex, socioeconomic category), crash characteristics (season, time of day, location, vehicle type), and self reported use of any psychotropic drug in the preceding week (for anxiety, depression, other nervous disease, sleep, epilepsy. Patients were also asked how many hours they had slept during the previous 24 hours. They were considered as sleep deprived if they reported sleeping less than six hours. External distraction was assessed by



asking participants to report their activities at the time of the crash (these included use of a mobile phone, listening to radio/television, talking with or listening to a passenger, manipulation of electronic devices, manipulation of objects, grooming, smoking, eating, drinking, reading) or if they had been distracted by an event inside or outside the vehicle. This was coded as a binary variable (any external distraction *v* no external distraction).<sup>12</sup> Blood alcohol concentration was available in the medical file ( $\ge 0.50$  g/L *v* < 0.50 g/L).

#### Results

We classified 453 (47%) participants as responsible for the crash and 502 (53%) as not responsible (responsibility scores were 8-12 in 320 (33%), 13-15 in 133 (14%), and >15 in 502 (53%). Table 1 (on bmj.com) shows the distributions of age, sex, socioeconomic category, vehicle type, time of day, season, and location of the crash. Table 2 shows the results for univariable analyses for responsibility. Multivariate modelling showed that mind wandering with highly disrupting/distracting content was independently associated with responsibility for the crash. External distraction, negative affect, alcohol or drug use, use of psychotropic drugs, and sleep deprivation were also significantly associated with responsibility (figure, bmj.com).

#### Discussion

Principal findings of the study

Over half of drivers who attended an emergency depart-

Table 2 | Univariable analyses of driver responsibility for road traffic crashes. Figures are numbers (percentages) of drivers

	Responsible (n=453)	Not responsible (n=502)	Odds ratio (95% Cl)				
Mind wandering:							
None reported	210 (46)	251 (50)	Ref				
Little disrupting/ distracting content	165 (36)	208 (41)	0.95 (0.72 to 1.25)				
Highly disrupting/ distracting content	78 (17)	43 (9)	2.17 (1.43 to 3.29)				
External distraction:							
Yes	177 (39)	153 (31)	1.46 (1.11 to 1.92)				
No	276 (61)	349 (70)	Ref				
Negative affect:							
Yes	116 (26)	88 (18)	1.62 ( 1.18 to 2.22)				
No	337 (74)	414 (83)	Ref				
Alcohol use:							
Yes	69 (15)	37 (7)	2.26 (1.48 to 3.45)				
No	384 (85)	465 (93)	Ref				
Psychotropic drug use:							
Yes	61 (14)	40 (8)	1.80 (1.18 to 2.74)				
No	392 (87)	462 (92)	Ref				
Sleep deprivation:							
Yes	70 (16)	34 (7)	2.52 (1.63 to 3.88)				
No	383 (85)	468 (93)	Ref				

ment after a road traffic crash (494/955) reported some mind wandering just before the crash, and its content was highly disrupting/distracting in 121. Those reporting a highly disrupting/distracting thought content were significantly more likely to be responsible for a road crash (adjusted odds ratio 2.12, 95% confidence interval 1.37 to 3.28). This association was significant after adjustment for a range of potential confounders. Classic risk factors such as alcohol use and sleep deprivation were strongly associated with road traffic crashes.

#### Interpretation

The association between intense mind wandering and crashing could stem from a risky decoupling of attention from online perception, making the driver prone to overlook hazards and to make more errors during driving. Interestingly, research supports the decoupling hypothesis during mind wandering in other circumstances. Neuroimaging, electrophysiological, and neuropsychological studies<sup>5-7</sup> <sup>14-16</sup> show functional interactions between large scale brain networks during mind wandering: a positive connectivity between areas of the executive and default networks and a negative connectivity between primary sensory cortices and the default network. This is corroborated by findings from electroencephalography measuring reduced cortical analysis of sensory visual and auditory inputs during mind wandering.

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## Pain over speed bumps in diagnosis of acute appendicitis: diagnostic accuracy study

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Cite this as: *BMJ* 2012;345:e8012 doi: 10.1136/bmj.e8012 **OBJECTIVE** To assess the diagnostic accuracy of pain on travelling over speed bumps for the diagnosis of acute appendicitis.

**DESIGN** Prospective questionnaire based diagnostic accuracy study.

SETTING Secondary care surgical assessment unit at a district general hospital in the UK.

PARTICIPANTS 101 patients aged 17-76 years referred to the on-call surgical team for assessment of possible appendicitis. MAIN OUTCOME MEASURES Sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios for pain over speed bumps in diagnosing appendicitis, with histological diagnosis of appendicitis as the reference standard.

**RESULTS** The analysis included 64 participants who had travelled over speed bumps on their journey to hospital. Of these, 34 had a confirmed histological diagnosis of appendicitis, 33 of whom reported increased pain over speed bumps. The sensitivity was 97% (95% confidence interval 85% to 100%), and the specificity was 30% (15% to 49%). The positive predictive value was 61% (47% to 74%), and the negative predictive value was 90% (56% to 100%). The likelihood ratios were 1.4 (1.1 to 1.8) for a positive test result and 0.1 (0.0 to 0.7) for a negative result. Speed bumps had a better sensitivity and negative likelihood ratio than did other clinical features assessed, including migration of pain and rebound tenderness.

**CONCLUSIONS** Presence of pain while travelling over speed bumps was associated with an increased likelihood of acute appendicitis. As a diagnostic variable, it compared favourably with other features commonly used in clinical assessment. Asking about speed bumps may contribute to clinical assessment and could be useful in telephone assessment of patients.

#### Introduction

Speed bumps are a commonly used traffic calming device to reduce the speed of vehicles.<sup>1</sup> Although controversial, traffic calming measures have been associated with a 70% decrease in injuries among child pedestrians in some areas,<sup>2</sup> and they may be a promising intervention for reducing the overall number of road traffic injuries and deaths.<sup>3</sup> However, speed bumps may have a useful alternative benefit in the diagnosis of acute appendicitis.

Acute appendicitis is the most common surgical abdominal emergency.<sup>4</sup> Rapid diagnosis is important, because increased time between onset of symptoms and surgical intervention is associated with increased risk of appendiceal perforation and therefore potential peritonitis, sepsis, and death.<sup>5</sup> However, the rate of negative appendicectomy (when appendicectomy is performed, but the appendix is found to be normal on histological evaluation<sup>4</sup>) ranges from 5% to 42%,<sup>6</sup> and this can be associated with considerable morbidity.<sup>7</sup> Clinical diagnosis can be challenging, particularly in the

Table 1   Pain over speed bumps in relation to appendicitis						
Pain over speed	Appendicitis					
bumps	Positive	Negative	Total			
Positive	33	21	54			
Negative	1	9	10			
Total	34	30	64			

#### WHAT IS ALREADY KNOWN ON THIS TOPIC

Clinical diagnosis of acute appendicitis can be difficult, and presence of various clinical features, such as migration of pain and rebound tenderness, can be used in assessment Some doctors routinely ask about pain on travelling over speed bumps as part of their clinical assessment, but no evidence base exists for this

#### WHAT THIS STUDY ADDS

Pain on travelling over speed bumps had a high sensitivity (97%) but a low specificity (30%) for the diagnosis of appendicitis

It compared favourably with other clinical features used in diagnosis of appendicitis, and therefore provides a useful addition, particularly in terms of excluding appendicitis It may also be useful for the diagnosis of other important abdominal conditions, and its use could be extended to all presentations of the "acute abdomen"



early stages of appendicitis when clinical manifestations may be quite non-specific or atypical. Different elements of history, examination, and laboratory findings have varying predictive power in the diagnosis of appendicitis,<sup>6</sup> and algorithms and scoring systems for clinical evaluation exist,<sup>4</sup> but appendicitis can nevertheless be easily missed.<sup>8</sup>

Patients with appendicitis have sometimes been noted to complain of a worsening of their abdominal pain when they travel over speed bumps. Some doctors ask about this routinely as part of history taking, believing it to be a highly diagnostic feature (personal communication). We sought to determine whether any evidence supports this practice and to determine its predictive power as a diagnostic sign.

#### Methods

We did a prospective study at a district general hospital in Buckinghamshire in the United Kingdom. We asked participants to complete a questionnaire survey about their symptoms, including four specific questions related to their journey into hospital: mode of transport, whether they had travelled over speed bumps, whether they had had pain on the journey, and whether the pain changed when they went over a speed bump. We defined patients as "speed bump positive" if they had a worsening of pain from baseline over speed bumps and as "speed bump negative" if their pain stayed the same, if they were unsure, or if their pain improved on going over speed bumps.

We then followed participants through their admission to determine the outcome and whether they were taken to theatre for presumed appendicitis. For those who had been to theatre, we obtained the subsequent histology report. We used histological diagnosis of appendicitis as the reference standard, which is the usual practice in studies of appendicitis.<sup>6</sup> A positive or negative histological diagnosis of appendicitis was made in participants who went to theatre and had their appendix removed. We assumed participants whose symptoms resolved without surgery to have a negative diagnosis.

#### Results

One hundred and one patients were recruited into the study. The median age was 34 (range 17-76) years. Sixty one participants were taken to theatre for presumed appendicitis, of whom 54 had their appendix removed. Acute appendicitis was confirmed histologically in 43 of these, giving a negative appendicectomy rate of 20%.

Sixty eight participants had travelled over speed bumps. We excluded four patients from diagnostic accuracy analysis: one because histology was not available, and three because they were treated with antibiotics as an alternative to surgery, so diagnosis was not confirmed histologically. Table 1 shows pain over speed bumps in relation to diagnosis of appendicitis. Table 2 shows how this compares with other clinical variables commonly used for diagnosis of appendicitis and also assessed in our sample.

Seven patients who were "speed bump positive" but did not have appendicitis had other important abdominal diagnoses, such as a ruptured ovarian cyst or diverticulitis. A post hoc secondary analysis of the diagnostic accuracy of pain over speed bumps for the diagnosis of important abdominal pathology requiring treatment (including appendicitis) increased the sensitivity to 98% (87% to 100%) and the specificity to 39% (20% to 61%).

#### Discussion

Our results confirm that an increase in pain while travelling over speed bumps is associated with an increased likelihood of acute appendicitis. Absence of pain over speed bumps is associated with a significantly decreased likelihood of appendicitis. Although the specificity was relatively low, as a diagnostic variable pain over speed bumps compared favourably with other features commonly used in diagnostic assessment, with a better sensitivity and negative likelihood ratio than all other features assessed. Moreover, some patients who were "speed bump positive" but did not have appendicitis had other important abdominal diagnoses, such as a ruptured ovarian cyst, diverticulitis, or pelvic inflammatory disease. We hypothesise that the worsening of pain when travelling over speed bumps in appendicitis may occur because the movement involved irritates the peritoneum in a similar way to that produced by testing for rebound tenderness on examination.

#### **Conclusions and implications**

The high sensitivity of pain over speed bumps gives it a strong "rule-out value" and makes it a useful tool to use in excluding appendicitis and other important abdominal diagnoses. The low specificity, however, means that many patients with pain over speed bumps will not necessarily have appendicitis (that is, it is a poor "rule-in" test). Potential exists for it to be incorporated into clinical prediction rules for appendicitis. Our study was based in secondary care, so our results are not necessarily generalisable to a primary care population. However, pain over speed bumps could potentially have a useful role in primary care in assisting in the telephone assessment of patients with abdominal pain. As all our group of patients had already been assessed by a clinician who thought they might have appendicitis, the pre-test probability is quite high; the speed bump test might also be useful in assessment of all types of abdominal pain, not just when appendicitis is suspected.

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Table 2   Diagnostic performance (with 95% CI) of pain over speed bumps compared with other clinical diagnostic variables for appendicitis								
Diagnostic variable	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Positive likelihood ratio	Negative likelihood ratio		
Pain over speed bumps	97 (85 to 100)	30 (15 to 49)	61 (47 to 74)	90 (56 to 100)	1.4 (1.1 to 1.8)	0.1 (0.0 to 0.7)		
Migratory pain	65 (46 to 80)	33 (17 to 53)	52 (36 to 68)	45 (24 to 68)	1.0 (0.7 to 1.4)	1.1 (0.5 to 2.1)		
Nausea or vomiting	79 (62 to 91)	17 (5.6 to 35)	52 (38 to 66)	42 (15 to 72)	1.0 (0.8 to 1.2)	1.2 (0.4 to 3.5)		
Rebound tenderness	71 (53 to 85)	50 (31 to 69)	62 (45 to 77)	60 (39 to 79)	1.4 (0.9 to 2.2)	0.6 (0.3 to 1.1)		

## Nutritional content of supermarket ready meals and recipes by television chefs in the United Kingdom: cross sectional study

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**OBJECTIVES** To compare the energy and macronutrient content of main meals created by television chefs with ready meals sold by supermarkets, and to compare both with nutritional guidelines published by the World Health Organization and UK Food Standards Agency. **DESIGN** Cross sectional study.

**SETTING** Three supermarkets with the largest share of the grocery market in the United Kingdom, 2010.

**SAMPLES** 100 main meal recipes from five bestselling cookery books by UK television chefs and 100 own brand ready meals from three leading UK supermarkets.

MAIN OUTCOME MEASURES Number of meals for which the nutritional content complied with WHO recommendations, and the proportion of nutrients classified as red, amber, or green using the UK FSA's "traffic light" system for labelling food.

**RESULTS** No recipe or ready meal fully complied with the WHO recommendations. The ready meals were more likely to comply with the recommended proportions of energy derived from carbohydrate (18% v 6%, P=0.01) and sugars (83% v 81%, P=0.05) and fibre density (56% v 14% P<0.01). The recipes were more likely to comply with the recommended sodium density (36% v 4%, P<0.01), although salt used for seasoning was not assessed. The distributions of traffic light colours under the FSA's food labelling recommendations differed: the modal traffic light was red for the recipes (47%) and green for ready meals (42%). Overall, the recipes contained significantly more energy (2530 kJ v 2067 kJ), protein (37.5 g v 27.9 g), fat (27.1 g v 17.2 g), and saturated fat (9.2 g v 6.8 g; P<0.01 for all) and significantly less fibre (3.3 g v 6.5 g, P<0.01) per portion than the ready meals.

**CONCLUSIONS** Neither recipes created by television chefs nor ready meals sold by three of the leading UK supermarkets complied with WHO recommendations. Recipes were less healthy than ready meals, containing significantly more energy, protein, fat, and saturated fat, and less fibre per portion than the ready meals.



To get Nigella's look you'll need unsalted butter, brown sugar, caster sugar, golden syrup, double cream, and fleur de sel

#### Introduction

In the United Kingdom, chefs on television programmes often advocate home cooking, and participants in UK studies have cited them as sources of cookery based knowledge.<sup>1 2</sup> It is possible therefore that these chefs influence people's diets, although the type and degree of this influence is unclear.<sup>3</sup>

One alternative to cooking recipe based meals is to use ready meals, which are defined by the food industry as preprepared main courses that can be reheated in their containers, require no further ingredients, and need only minimal preparation.<sup>4</sup> According to the food industry, around £9.5bn (€11.4bn; \$15bn) worth of ready meals are sold annually in western Europe, around 37% of the global market.<sup>5</sup> The

Table 1 | Median percentage energy derived from macronutrients, and sodium and fibre density, of 100 television chef recipes and 100 supermarket ready meals, United Kingdom, 2010

	Recipes (n=100)		Ready meals (n=100)		All items		_		
Nutritional content	Median (interquartile range)	% within WHO range	Median (interquartile range)	% within WHO range	Median (interquartile range)	No (%) within WHO range	WHO range	χ <sup>2</sup> *	P value*
Macronutrient (% energy):									
Protein	23.8 (18.8-33.9)	7	22.7 (18.2-27.3)	9	22.9 (18.5-30.5)	16 (8)	10-15	0.27	0.60
Carbohydrate	31.6 (19.0-42.1)	6	42.9 (37.0-52.5)	18	38.7 (28.9-48.4)	24 (12)	55-75	6.82	0.01
Sugars	5.3 (3.3-8.8)	81	5.7 (3.8-8.7)	83	5.5 (3.3-8.8)	164 (82)	<10	0.14	0.71
Fat	42.2 (30.1-54.0)	24	32.4 (25.9-39.2)	37	35.6 (27.9-45.9)	61 (31)	15-30	3.99	0.05
Saturated fat	14.9 (9.0-20.9)	33	13.9 (7.8-18.7)	34	14.0 (8.0-19.8)	67 (34)	<10	0.02	0.88
Fibre density (g/MJ)	1.4 (0.8-2.6)	14	3.2 (2.4-4.4)	56	2.5 (1.4-3.7)	70 (35)	>3.0†	38.77	<0.01
Sodium density (g/MJ)	0.2 (0.1-0.4)	36	0.4 (0.3-0.5)	4	0.4 (0.2-0.5)	40 (20)	<0.2‡	32.00	<0.01

 $\star \chi^2$  tests with one degree of freedom comparing proportion of recipes with proportion of ready meals in World Health Organization range.

†Based on 8.4 MJ/day (2000 kcal/day) diet and recommended daily fibre intake of >25 g.

#Based on 8.4 MJ/day (2000 kcal/day) diet and recommended daily sodium intake of <2 g.</p>

#### RESEARCH



United Kingdom represents the largest share of sales in Europe, accounting for almost £2.5bn annually.<sup>5</sup>  $^{6}$ 

No study has comprehensively examined the nutritional content of meals devised by television chefs or ready meals sold in supermarkets. We compared the energy, protein, carbohydrate, fat, sugar, fibre, and salt content of recipes devised by television chefs with those of standard range ready meals sold by supermarkets and determined whether the nutritional content of either complied with national and international recommendations.

#### Methods

We carried out a cross sectional analysis of the nutritional content of 100 main meals as described in recipes by television chefs and 100 standard ready meals sold by supermarkets as their own brand. We included meals that were designed to be eaten hot, were not described as suitable for special occasions only or for breakfast, were not soups, included substantive items from at least two of the EatWell groups described by the FSA,<sup>7</sup> and had a recommended serving size of at least 225 g. We chose these inclusion criteria to generate a comparable sample of ready meals and recipes that might be considered as typical main dishes for everyday consumption. For selection of study samples and analysis of the nutritional content see bmj.com.

#### Results

The five included recipe books contained 651 recipes (see bmj.com). Of these, 193 (29.6%) met the inclusion criteria. Overall, 234 of 1404 products listed on the supermarkets' websites were included.

Per portion, the recipes contained significantly more energy, protein, fat, and saturated fat than the ready meals, and significantly less fibre (see bmj.com). No recipe or ready Table 2 | Traffic light assessment according to modified Food Standards Agency guidelines<sup>32</sup> for 100 recipes by television chefs and 100 supermarket ready meals, United Kingdom, 2010

	No for recipes		No for ready	No for ready meals			
Macronutrients	Red	Amber	Green	Red	Amber	Green	
Sugar	17	0	83	11	0	89	
Fat	68	17	15	37	39	24	
Saturated fat	71	1	28	56	1	43	
Salt	31	28	41	30	60	10	
Totals	187	46	167	134	100	166	



Simulated front of package labels for an average recipe based meal by a television chef and a supermarket own brand ready meal

meal met all of the WHO nutrient intake goals for preventing diet related diseases (table 1).<sup>9</sup> More ready meals than recipes met the WHO goals for fibre density (56% v 14%, P<0.01) and percentage of energy derived from carbohydrate (18% v 6%, P=0.01) and fat (37% v 24%, P=0.05), but more ready meals than recipes exceeded the recommended sodium density (96% v 64%, P<0.01).

The distribution of traffic light colours assigned to the meals in each group differed between the groups (table 2).<sup>10</sup> The recipes had more red labels and the ready meals more amber, but green labels were almost equal between the groups. The modal colour was red for the recipes and green for the ready meals. The figure shows simulated front of package labels for an average recipe and an average ready meal using a design based on FSA guidelines.<sup>10</sup> For each macronutrient in this figure, the traffic light colours shown are the modal colour within each meal group, and the figures stated are the median value within each meal group.<sup>11</sup>

#### Discussion

Recipes devised by television chefs and own brand ready meals sold by three leading UK supermarket chains both tended to be high in protein, fat, saturated fat, and sodium, low in carbohydrate, and within the recommended range for sugar according to World Health Organization nutritional guidelines for the avoidance of diet related diseases.<sup>9</sup> Meals based on television chef recipes were less healthy than ready meals, as significantly fewer were within the recommended ranges for fibre density and percentage of energy derived from carbohydrate and fat, and per portion they contained

#### WHAT IS ALREADY KNOWN ON THIS TOPIC

Supermarket ready meals and recipes devised by television chefs may have an impact on dietary intake

#### WHAT THIS STUDY ADDS

Recipes devised by popular television chefs contained significantly more energy, protein, fat, and saturated fat and less fibre per portion than ready meals

Most cookery books do not provide nutritional information on recipes, which could help to inform consumers

Consideration should be given to regulation of the recipes demonstrated by television chefs similar to that limiting advertisement of foods classified as high in fat, salt, or sugar

significantly more energy, protein, fat, and saturated fat and significantly less fibre. The recipes were also more likely to achieve red traffic light labels according to the criteria of the UK Food Standards Agency (FSA).<sup>10</sup> Despite reported efforts from industry to reduce the salt content of meals,<sup>12</sup> only 4% of the ready meals met the WHO recommendation.

#### Comparison with other studies

The levels of salt found in ready meals in this study are comparable to those of another study carried out in 2008.<sup>14</sup> However, both sets of results contrast noticeably with an investigation by the FSA in 2003,<sup>15</sup> which found high salt levels in 83% of ready meals sold by supermarkets. Six products appear both in the FSA sample and in the sample in this study. In the survey by the FSA, all six products contained over 2.4 g of salt per portion, which represents 40% of the recommended daily allowance of salt.<sup>15</sup> In this study, carried out seven years later, only two exceeded this threshold. This provides some evidence that reformulation since 2003 may have had a substantial impact on the salt content of supermarket ready meals, although only 4% of ready meals met the WHO recommendation on sodium density.

#### Meaning of the study and implications

This study shows that neither recipes created by popular television chefs nor ready meals produced by three leading UK supermarket chains meet national or international nutritional standards for a balanced diet. The recipes seemed to be less healthy than the ready meals on several metrics.

Maximum nutritional benefit is likely to be derived from home cooking of nutritionally balanced recipes primarily using raw ingredients, rather than relying on ready meals or recipes by television chefs. Further reformulation of ready meals in line with international nutritional guidelines, and collaboration with television chefs to improve the nutritional quality of their recipes, may help consumers to achieve a balanced diet.

This research was undertaken by SH (supervised by JA and MW) in partial fulfilment of the requirements for the MSc in Public Health and Health Services Research at Newcastle University (degree awarded December 2011).

For full details of contributors, competing interests, ethical approval, and references, see bmj.com.

## Building a metaphor: Another brick in the wall?

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Correspondence to: D G Altman doug.altman@csm.ox.ac.uk Cite this as: *BMJ* 2012;345:e8302 doi: 10.1136/bmj.e8302 The metaphor of studies being bricks from which a wall is being built leads to new ideas about accumulating knowledge,

## explains **Doug Altman**

A common metaphor for the accumulation of scientific knowledge is of individual studies being the bricks from which a wall is being built. Each study contributes to the growing structure as "another brick in the wall," a phrase that appears in hundreds of journal article titles on PubMed. Inspired by the clear similarity of the ideas in Forscher's wonderful allegory<sup>1</sup> and a witty comment of Poincaré, <sup>2</sup> I acquired many related citations by multiple searches with Google and Google Scholar over five years (see box).

These quotations from over a century emphasise that scientific knowledge is cumulative, but also that completed research studies—the "bricks" of knowledge—have to be put together meaningfully; otherwise, we do indeed just have a pile of bricks.

Bringing together, in a systematic review or meta-analysis, multiple separate studies dealing with a particular question is a more focused variant of the same idea, dealt with in several of the quotations. And systematic reviews incorporate explicitly the notion of searching for the relevant evidence, among the countless thousands of publications.<sup>1</sup>

#### **Brick and building metaphors**

"Of metaphors applied to science, the most evocative is the building of an edifice of knowledge with every paper serving as a brick"<sup>3</sup>

"The individual primary paper is not the final form of the consensus but it is the brick from which the whole edifice is to be built."<sup>4</sup>

"Research scientists are trained to produce specialised bricks of knowledge, but not to look at the whole building."<sup>5</sup>

"We speak piously of taking measurements and making small studies that will 'add another brick to the temple of science.' Most such bricks just lie around the brickyard."<sup>6</sup>

"Science is built up of facts, as a house is built of bricks; but an accumulation of facts is no more a science than a heap of bricks is a house."<sup>2</sup>

"Authors view acceptance of a manuscript as the completion of a piece of work—but for the research content of the paper, it is only the beginning. To contribute to the research enterprise, other investigators need to take the findings and build on them. But the construction of science requires solid bricks, not cardboard."<sup>7</sup>

> "And then it came to pass that a misunderstanding spread among the

brickmakers... The brickmakers became obsessed with the making of bricks. When reminded that the ultimate goal was edifices, not bricks, they replied that, if enough bricks were available, the builders would be able to select what was necessary and still continue to construct edifices."<sup>1</sup>

"It became difficult to find the proper bricks for a task because one had to hunt among so many. It became difficult to find a suitable plot for construction of an edifice because the ground was covered with loose bricks. It became difficult to complete a useful edifice because, as soon as the foundations were discernible, they were buried under an avalanche of random bricks. And, saddest of all, sometimes no effort was made even to maintain the distinction between a pile of bricks and a true edifice."<sup>1</sup>

"After these bricks were used so well and were no longer fresh, however, they often ended up on shelves gathering dust or stacked in dark corners of offices and libraries. Indeed, many quite elegant ones went to such places directly, perhaps being too hot to handle, delivered too late to be useful, or too heavy for the users to bear. After some years the landscape was covered with bricks of many different sorts and sizes. A few brick makers began to ask if something interesting and useful could not be built with all these bricks. Some argued that what could be built with them might be as useful and important as the individual bricks themselves. Several went so far as to suggest that new bricks be crafted in such a way that they would be more useful for building something after they were used for their more immediate purposes. Needless to say, other brick makers thought these notions were a foolish waste of time and were not even what the craft of brick making was all about. Nonetheless, a few eccentric brick makers put aside their brick-making tools and began to collect used bricks and assemble them into different configurations to see what they might build from them. They soon learned to make interesting and useful constructions by stacking and arranging the thousands of bricks their colleagues had fashioned. And thus was born a new craft among the brick makers, the craft of building edifices from bricks or, as some liked to call it, Meta-brick making."

"The moment we are introduced to science we are told it is a cooperative, cumulative enterprise. Like the artisans who construct a building from blueprints, bricks, and mortar, scientists contribute to a common edifice, called knowledge. Theorists provide our blueprints and researchers collect the data that are our bricks...To extend the analogy further yet, we might say that research synthesists are the bricklayers and hodcarriers of the science guild. It is their job to stack the bricks according to plan and apply the mortar that makes the whole thing stick."<sup>9</sup>

"To... utilize Forscher's brickyard analogy, research synthesis as a primary research endeavour can both assemble random bricks into useful edifices of knowledge, and ensure that any bricks that are produced in the future contribute to the construction of such edifices rather than being thrown onto a random pile."<sup>10</sup>

#### Comment

The primary message here is that scientific progress is made in small incremental steps, by many individuals and groups over many years. It is a continuous process. Thus, the accumulation of knowledge is not like completing a giant jigsaw puzzle, with explicit boundaries, but more like building a brick wall extending without limits. This rather simplistic image fails to indicate the likelihood of many holes in the wall, perhaps large ones.

These ideas about accumulating knowledge lead to two others, which have become more familiar. Firstly, research findings should be presented in such a way that they can be incorporated into future meta-analyses. Secondly, the bringing together of existing knowledge can inform the conduct of future research. Indeed, it should do so:

"If, as is sometimes supposed, science consisted in nothing but the laborious accumulation of facts, it would soon come to a standstill, crushed, as it were, under its own weight... The work which deserves, but I am afraid does not always receive, the most credit is that in which discovery and explanation go hand in hand, in which not only are new facts presented, but their relation to old ones is pointed out."<sup>11</sup> I thank lain Chalmers for helpful discussions. Competing interests: None declared.

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## **CHRISTMAS 2012: CASE REPORT** The tooth fairy and malpractice



Anecdotal evidence suggests the tooth fairy is benevolent, but this opinion may need revising in light of mounting reports of less child-friendly activity.

The latest victim was an 8 year old boy referred to a specialist allergy clinic with a history of profuse mucopurulent rhinorrhoea. After first line medical treatment failed, computed tomography of the sinuses was performed. This revealed evidence of changes consistent with sinusitis but also a calcified foreign body in the left external auditory meatus (figure).

The family spoke of an occasion three years earlier when the boy had woken from sleep, extremely distressed because the tooth fairy had put a tooth in his left ear. The tooth had initially been left under his pillow for the tooth fairy to collect and to leave some money in its place. Thinking this was a bad dream, the parents initially reassured the boy but were unable to locate the tooth. Nevertheless, his concerns continued, and on two occasions advice was sought from different general practitioners, when auroscopy was thought to be normal.

Repeat auroscopy by the allergist confirmed the presence of a deciduous tooth in the auditory canal. The tooth was removed by an ENT surgeon under microscopic vision, and the patient decided to keep the tooth for posterity rather than taking the risk of attempting a further pecuniary reward. He kindly gave his consent for us to disseminate this information to save other children from going through this ordeal.

In the United Kingdom it is customary for children to put deciduous teeth under their pillow at night in order to receive a reward from the tooth fairy. In addition to our case, there are two other reports of possible malpractice on the part of the tooth fairy. The other cases involve a tooth in the upper oesophagus causing tracheal obstruction in a trauma situation,<sup>1</sup> and a man who developed a nipple abscess after inserting his child's milk tooth into the hole of his nipple piercing to keep his child's tooth near to his heart.<sup>2</sup>

As far as we are aware, there is no revalidation procedure for the tooth fairy and no clear guidance or standard operating procedures in place to ensure adverse outcomes are avoided. We advise that medical practitioners should have a high index of suspicion with tooth related presenting complaints.

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- 2 Ho MR, Acevedo M, Baker JE. Tooth fairy abscess. J Emerg Med 2008;35:207.

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