SYSTEMATIC REVIEW

What Actually Changes Passenger Behaviour: A Systematic Review of Behavioural Mechanisms and Seatbelt Use on Buses

Evidence on fifteen ways to change behaviour, drawn from thirteen fields and assessed for practical use on buses

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WHAT WE ASKED

1. Which mechanisms actually change human behaviour, and by how much?
2. Which could work under normal bus operating conditions?
3. What features should a bus seatbelt system have?

WHAT WE FOUND

1. **Changing the effort or immediate consequences of an action is generally more effective than giving information alone.** The review identifies this pattern across the fields examined (behavioural economics and nudge theory; applied behaviour analysis; safety engineering; occupational safety; road safety; criminology and deterrence; aviation cabin safety; clinical alarm management; infection control; drowning prevention; public health and public transport compliance; environmental and consumer behaviour; education). Interventions that change the effort or immediate consequences of an action tend to produce larger effects. Information alone tends to produce smaller effects that may decline over time.
2. **Bus operating conditions limit which approaches are practical.** On services with one-off passengers, operators cannot rely on repeat contact. Drivers cannot continuously check the passenger area, delaying the whole bus for one unbuckled passenger is impractical, passengers may unbuckle during the trip, and fines are rare. These conditions limit several approaches.

3. **Alerts linked to each passenger's belt use meet these operating requirements.** An alert can start when an occupied seat has an unfastened belt and stop when the passenger buckles up. Sensors can monitor each seat throughout the journey.
4. **The one bus reminder trial located reported an increase in belt use from 9.6 to 59.0 per cent.** It used a seat occupancy sensor, a buckle sensor and a light at each seat.
5. **The rules reviewed do not require buckle-sensing reminders at every bus passenger seat.** Australia's new ADR 68/01 does not require buckle or occupancy sensors. Europe's UN R16 covers cars fully but only the front seats of a bus.

WHAT IT MEANS

- Signs, briefings and announcements are among the less effective approaches in the fields reviewed (behavioural economics and nudge theory; applied behaviour analysis; safety engineering; occupational safety; road safety; criminology and deterrence; aviation cabin safety; clinical alarm management; infection control; drowning prevention; public health and public transport compliance; environmental and consumer behaviour; education). They are the measures used to encourage seatbelt use on Australian buses.
- The review identifies per-seat buckle sensing with a persistent alert as a promising approach that can operate throughout a bus journey without continuous driver supervision.
- Two further improvements deserve attention. Improving belt condition and fit addresses the most common reason passengers give for not buckling. Varying the alert may help passengers remain responsive over repeated journeys, although its long-term effect on buses has not been tested.

ABSTRACT

Australian bus passengers wear seatbelts at rates between 7 and 45 per cent. Car drivers wear them at about 97 per cent. Current measures to encourage passenger belt use rely on information: a sign, a briefing, an announcement, and a law that is

almost never enforced. This review asks which behavioural mechanisms actually change behaviour, which could work under bus operating conditions, and what features a seatbelt system should have.

Fifteen mechanisms were collected from thirteen fields: behavioural economics and nudge theory, applied behaviour analysis, safety engineering, occupational safety, road safety, criminology and deterrence, aviation cabin safety, clinical alarm management, infection control, drowning prevention, public health and public transport compliance, environmental and consumer behaviour, and education. Each mechanism was paired with the strongest effect estimate we could find for it. Across the fields reviewed, changing the effort or consequences of an action generally produces larger effects than information alone. The estimates are not directly comparable across studies.

Several approaches with large measured effects are difficult to apply on buses. Five operating conditions limit their use. Alerts linked to individual seats meet these conditions: they can respond immediately to an unfastened belt, stop when it is fastened, and remain available throughout the trip. The one bus trial of such a system raised observed belt use from 9.6 to 59.0 per cent.

Two further designs could meet these operating requirements, but no bus trial was located: making a seat amenity available only when the belt is fastened, and varying alert intensity to reduce habituation, or reduced response after repeated exposure. Section 10 discusses their likely effects and costs. Repairing and maintaining the belts may offer a cheaper way to increase use.

1 Introduction

1.1 Background

Seatbelts are highly effective safety devices, yet reported use among Australian bus passengers is low.

In the 2023 Greta coach rollover, 6 of 35 passengers were belted. Ten people died. Every one of those deaths involved the person being thrown from the vehicle. No belted passenger was thrown from their seat.[1]

This review considers ways to increase seatbelt use beyond better messaging. Research across several fields has measured the effects of different approaches to changing behaviour. We assess how that evidence could apply to bus passengers.

1.2 Objectives

The review answers three questions, in order.

1. Across every field where it has been measured, which mechanisms change human behaviour, and by how much?
2. Which could work under normal bus operating conditions?
3. Which practical approaches should guide system design, and could they improve on existing systems?

The first question brings together published findings. The second assesses their practical application on buses. That assessment informs the design recommendations in the third question.

1.3 Scope

Included. Studies of seatbelt use by drivers and passengers in cars, taxis, rideshare vehicles, buses and coaches. Behavioural evidence from aviation, occupational safety, healthcare, drowning prevention and public health, where a study isolates a single mechanism. Meta-analyses of behavioural interventions. The rules governing seatbelt reminders in Australia, Europe and the United States.

Excluded. Crashworthiness engineering, seat and anchorage design, glazing, and the biomechanics of ejection. These mattered a great deal at Greta. They are not behavioural questions. Also excluded are autonomous vehicles and child restraints below the adult seatbelt threshold, both of which have their own separate literatures.

2 Methods

2.1 How the literature was searched

The literature search had two stages.

The first stage covered a broad range of research. Thirty searches covered thirteen fields: behavioural economics and nudge theory, applied behaviour analysis, safety engineering, occupational safety, road safety, criminology and deterrence, aviation cabin safety, clinical

alarm management, infection control, drowning prevention, public health and public transport compliance, environmental and consumer behaviour, and education. The aim was to find every mechanism with a measured effect, not to find seatbelt studies.

In the second stage, for each mechanism identified, we searched for the strongest available effect estimate, preferring meta-analyses and randomised field trials over single studies, and for any study applying that mechanism to seatbelt use.

Two primary sources were retrieved in full and read directly: the Swedish bus observation study [4] and the Greta investigation report.[1] Others were read through abstracts, published summaries and secondary citation.

2.2 What was included and what was not

A study was included if it met three criteria. It reported a behavioural outcome, not an attitude or an intention. It isolated an identifiable mechanism. It reported a quantity, whether an effect size, a rate or a change in a rate.

Where a mechanism had both an original finding and a later replication or bias correction, we report the corrected figure. Re-analysis has substantially reduced several well-known estimates of behavioural effects, and section 5.2 sets out which ones.

2.3 How to read the numbers in this review

> THREE DIFFERENT QUANTITIES
>
> **Percentage points (pp)** measure an absolute change. Going from 40 to 60 per cent is a rise of 20 percentage points.
>
> **Per cent**, used without “points”, measures a relative change. Going from 40 to 60 per cent is a relative rise of 50 per cent.
>
> **Cohen’s d** is a standardised effect size used in meta-analysis. As a rough guide, 0.2 is small, 0.5 is medium and 0.8 is large.
>
> These three cannot be added, subtracted or compared with each other. Every figure in this review is labelled with which one it is.

2.4 How the mechanisms were compared

The effect estimates in this review come from different study designs, populations and outcome measures. They cannot be ranked precisely against each other. Table 2 does not support a single combined effect estimate.

The evidence supports a general pattern: changing the effort or consequences of an action tends to produce larger effects than information alone. This conclusion draws on findings across several fields rather than on a single effect estimate.

2.5 How practical use on buses was assessed

Section 6 assesses five bus operating conditions that differ from the settings of many of the studies. Each mechanism in Table 2 was assessed against those conditions and classified as practical, impractical, or requiring modification. Table 3 records the reasons. These classifications are the review's assessment, not findings from bus trials.

3 Results: the size of the problem

3.1 Belt use falls the further you sit from the driver

Seatbelt studies consistently report lower use in seats farther from the driver. Compliance drops as the occupant moves away from the driving position. It drops again when the vehicle belongs to somebody else.

A systematic review and meta-analysis of 68 studies found pooled belt use of 43.94 per cent among drivers, 38.47 per cent among front seat passengers and 15.32 per cent among rear seat passengers.[2] These are pooled global figures across countries with very different laws. They show the difference between seating positions, but do not establish wearing rates for any particular country.

Lower rear-seat use is also reported in taxis and rideshare vehicles. Observed rear seat belt use was 26 per cent in San Francisco taxis and 28 per cent in Las Vegas taxis. In rideshare vehicles it was 52 per cent and 18 per cent respectively.[3] Front seat passengers in the same cities were belted at 89 to 100 per cent.

> **A coach can carry up to 57 passengers, most seated behind the driver in a vehicle they do not own.** Several factors associated with low rear-seat belt use in taxis may also apply on a bus. On top of that, the driver cannot see most of the cabin.

3.2 Buses

The best bus dataset available is Swedish. Anund, Forward and Sjörs Dahlman combined 328 bus observations across ten cities with seven focus groups and a survey of 1,737 respondents.[4]

Table 1. Swedish observation study of buses fitted with seatbelts. All figures are percentages reporting use or announcements, rather than changes over time. The self-reported rows include buses with no belts fitted, so they are not directly comparable with the observed rows.

Measure	Charter	Commercial	Regional
Observed passenger belt use	92%	50%	27%
Observed driver belt use	100%	79%	85%
Observed driver announcement to buckle up	86%	61%	19%
Self-reported passenger belt use, last trip	44%	37%	31%
Self-reported announcement heard, last trip	34%	21%	9%

Two points are important when interpreting these rates.

First, announcements and belt use rise and fall together. Charter services announce the most and have the highest belt use. Regional services announce the least and have the lowest. The authors report this association directly. It is also confounded, because charter and regional services differ in vehicle type, road speed, trip length and who is on board. The pattern is consistent with reminders helping, but does not establish that reminders caused the difference.

Second, what passengers say about their own belt use is unreliable. Charter passengers reported 44 per cent when observation showed 92 per cent. Regional passengers reported 31 per cent when observation showed 27 per cent. The error runs in both directions. Survey estimates should not be treated as direct observations of belt use.

3.3 Australia

Reported Australian bus passenger wearing rates range from 7 to 45 per cent. Car occupant wearing rates are about 97 per cent. At Greta, 17 per cent of passengers were belted.[1]

Reported enforcement is too infrequent to provide a strong deterrent. One passenger fine was issued across the whole of New South Wales in the three years to 30 June 2025.[1] Section 6 explains why deterrence is unlikely to be effective when the chance of being fined is so low.

4 Results: why passengers do not buckle

4.1 Passengers report problems with belt condition, fit and convenience

There is a common assumption that not buckling reflects a considered view about risk. The evidence does not support it.

In the Swedish focus groups and survey, the reasons given were: the belt was dirty, the belt would not pull out or would not latch, the belt was too short or too long to fit, they wanted to sleep, and on short trips they were worried about not being ready to get off in time.[4] One participant described a belt that had left dirt on their clothes. About 18 per cent of respondents across all service types said the belt was simply uncomfortable.

The same pattern shows up in recreational boating, where the barriers to wearing a lifejacket are discomfort and a worry that wearing one signals inexperience.[5] Discomfort and inconvenience can discourage use even when people know the safety benefits.

4.2 Immediate discomfort can outweigh concern about a possible crash

Compare the two options as a passenger experiences them.

Not buckling has a consequence that is delayed, very unlikely, and severe. **Buckling** has a consequence that is immediate, certain, and trivial: a few seconds of effort and some discomfort.

Present bias means giving more weight to immediate effects than to possible future effects. It can explain non-use without assuming that passengers misunderstand crash risk. Workers who skip protective equipment face a similar choice, choosing the certain immediate comfort over the remote possibility of injury.[6]

This suggests an intervention should give passengers an immediate reason to buckle up, as well as explaining the safety benefit.

4.3 Bus seats may not trigger the habit of buckling up

For habitual car users, the familiar seat and belt can trigger buckling up automatically, without a conscious decision each time.[7]

A bus may have a different seat, sitting position and belt arrangement. Those differences can mean that a familiar car habit does not transfer automatically.

A regular car seatbelt user may therefore forget to buckle up on a coach. This is a possible explanation for non-use even among passengers who value their safety.

4.4 Passengers behave differently from drivers

Belt use is correlated between people travelling in the same vehicle, and the driver's own behaviour predicts the passenger's.[8]

On a coach, most passengers cannot see the driver's belt use. The driver cannot see most of the cabin. Swedish drivers said this directly. Even when they check that everyone is buckled before departure, they have no way of knowing what happens after that.[4]

5 Results: fifteen behavioural mechanisms

5.1 The fifteen mechanisms

Table 2. Behavioural mechanisms, each with the strongest effect estimate located for it. Effect types differ by row: pp is an absolute change in percentage points, per cent without "points" is a relative change, and d is Cohen's d. See section 2.3 before comparing rows.

#	Mechanism	Strongest evidence located	Measured effect
1	**Forcing function** The action is blocked until you comply	Cochrane review of alcohol ignition interlocks[9]; Community Guide review[10]	Works while the device is fitted. Re-arrest 15 to 69 per cent lower across five studies. No benefit once removed
2	**Changing the effort** Make the right act easy and the wrong act hard	Meta-analysis of 184 behavioural field trials, 2,245,373 participants[11]	d = 0.52, the largest of six categories. Convenience alone reached d = 1.18. All categories combined, d = 0.28
3	**A delay avoided by buckling up** Buckling up avoids or ends an immediate delay	Van Houten et al., 101 commercial drivers, 8-second gearshift delay[12]	Belt use rose from 48 to 67 per cent (US) and 54 to 74 per cent (Canada). Belts then stayed fastened for the trip
4	**An alert that continues until your belt is fastened** An unpleasant signal that stops when you comply	Kidd & Singer, 49 part-time belt users[13]; KATRI bus pilot[14]	Against an intermittent reminder, belt use rose 30 and 34 per cent for two persistent reminders, and 33 per cent for a speed-limiting interlock. Bus pilot: 9.6 to 59.0 per cent
5	**Money** Rewards and prizes	Meta-analysis of 34 sources[15]; national telematics trial, 1,100+ drivers[16]	+20.6 pp short-term and +13.7 pp long-term, falling to 12.0 and 9.6 pp when weighted by number of observations. Shared-prize group: 26 per cent fewer unbuckled trips during, 33 per cent fewer after payments stopped

#	Mechanism	Strongest evidence located	Measured effect
6	**Observing behaviour, providing feedback and rewarding safe actions** Behaviour-based safety	Meta-analysis of 73 interrupted time-series replications[17]	Injury reduction of 26 per cent in year one and 69 per cent by year five
7	**Enforcement**	Deterrence research[18]; US belt law and campaign evaluations[19]	Being caught matters far more than the size of the fine. National high-visibility enforcement: +4 pp. Belt use is higher in states where police can stop a vehicle solely for a seatbelt offence
8	**Gamification: using points, challenges or rewards**	Meta-analysis in education[20]; health meta-analyses	d = 0.48 in education. Inconsistent for health outcomes
9	**Getting people to commit** Pledges and promises	Nudge and sludge meta-analysis[11]; environmental reviews	d = 0.36. Public promises work better than private ones
10	**Social norms** Telling people what others do	Hotel towel reuse experiments and their replications[21]	Real but small. Works only when “most people do this” and “you should do this” are combined. Replications are smaller than the originals
11	**Prompts at the point of decision**	Stair-use reviews[22]; Flash-for-Life field studies[23]	d = 0.07 to 0.32. Between 22 and 30 per cent of unbuckled drivers complied at the moment they were prompted. No lasting effect
12	**Nudges: making the preferred choice easier or more noticeable** How choices are presented	Meta-analysis of 447 experiments[24], plus two published rebuttals[25,26]	d = 0.43 before correction, falling to between 0.08 and 0.31 after correcting for publication bias. One re-analysis finds no remaining effect after correction
13	**Feeling watched** Images of eyes	Pre-registered replication and extension[27]	No reliable effect
14	**Defaults** Applying an option automatically unless a person declines	Long-run analyses of organ donation policy[28]	Deceased donors up 7 per cent, not statistically significant. Living donors down 29 per cent, statistically significant
15	**Information and education**	Cochrane review of seatbelt interventions[29]	Education “may” promote belt use. The authors state they are not confident in the evidence

5.2 What the studies suggest

Three things stand out.

The approaches differ in whether they change an action’s consequences or rely on information. Rows 1 to 4 all work by changing what happens to the person, straight away, whether or not they are persuaded. Rows 10 to 15 all work by trying to change what the person

believes, notices or intends. Section 8 describes similar findings in other fields, while section 2.4 explains why the effect estimates cannot be compared directly.

Re-analysis has reduced several reported effect estimates. The headline nudge effect of d = 0.43 is reduced after adjustment for publication bias. Two separate re-analyses published in the same journal estimate the corrected effect at between zero and d = 0.08.[25,26] The watching-eyes effect has largely failed to replicate. The organ donation analysis reports a reduction in living donors under an opt-out policy. Conclusions based on these mechanisms should account for the later, smaller estimates.

Reducing effort produced a large standardised effect in the field-trial meta-analysis. In the biggest meta-analysis of behavioural field trials we found, interventions that changed how much effort something took produced d = 0.52. Interventions aimed at attention produced 0.20. Interventions aimed at memory produced 0.20.[11] Convenience on its own reached d = 1.18. In this analysis of more than two million participants, reducing effort was more effective than directing attention or helping people remember.

5.3 Why immediate consequences may have stronger effects

Three areas of research offer explanations for this pattern.

Timing, likelihood and severity of consequences. Applied behaviour analysis holds that a consequence controls behaviour according to three properties: how soon it arrives, how certain it is, and how big it is. The first two matter most. A small, immediate and certain consequence can influence behaviour more strongly than a large but delayed and unlikely one. Industrial safety has used this framing for over forty years, and it is the standard explanation for why trained, well-informed people still take shortcuts.[30]

> **This explains why information alone may be insufficient.** Telling someone that a crash would be serious adjusts how *big* they think the consequence is. It leaves how *soon* and how *certain* untouched. It addresses severity without changing the timing or likelihood of the consequence.

The hierarchy of controls. Safety engineering ranks controls by how directly they reduce a hazard. The hierarchy starts with removing the hazard (elimination), then replacing it with a safer alternative (substitution), changing equipment or physical conditions (engineering controls), using rules and procedures (administrative controls), and providing personal protective equipment. The related Safe Systems Pyramid applies this principle to road safety: an intervention gets more effective as the effort it demands from the individual goes down.[31]

Education sits at the very top of that pyramid, which is the position of least effect and most individual effort.

A sign, a briefing and an announcement are all administrative controls. So is a law nobody enforces. The measures used to encourage bus passenger belt use rely on administrative controls, which rank below engineering controls in this hierarchy.

Control devices and warning devices. Shigeo Shingo's distinction from the Toyota Production System explains the difference. A *control* device stops the process until the error is fixed. A *warning* device notices the error and leaves it to the operator to act. Warning devices are cheaper, more acceptable, and weaker.[32]

Signs and timed announcements provide reminders without detecting whether belts are fastened. They cannot respond to an individual passenger's belt use.

6 Synthesis: which approaches are practical on buses

Section 5 reviews evidence from several settings. The following five bus operating conditions limit how some approaches can be applied.

6.1 Five conditions

1. **Passengers may be anonymous and travel only once.** Without passenger accounts or repeat journeys, operators cannot readily track individual progress, award repeat-use incentives or provide later feedback.
2. **Drivers cannot continuously supervise the passenger area.** The driver is driving. Swedish drivers said plainly that they cannot monitor belt use once the bus is moving, and asked for technical help to do it.[4]
3. **Delaying the whole vehicle is impractical.** A coach carrying 57 people cannot be immobilised because one of them is unbuckled. The concern is the effect on safe and practical operation, rather than whether an interlock can be built.
4. **Passengers may unbuckle during the trip.** Passengers unbuckle to sleep, to reach a bag, to move.[4] Being buckled at departure is not the same as being buckled at the moment of a rollover.
5. **Almost nobody is ever fined.** One passenger fine in three years, across an entire Australian state.[1]

6.2 Assessing each approach against bus operating conditions

Table 3. Each mechanism from Table 2 and the conditions that limit its use on buses. Numbers refer to Table 2 rows.

Mechanism	Limiting condition	Why
1. Forcing function	Condition 3	Preventing departure affects all passengers, and the passenger has already paid for the seat
5. Money	Condition 1	Requires identifying passengers across repeat journeys. The strongest recent result depended on a ten-week streak across repeated journeys[16]
6. Observation and feedback	Conditions 1 and 2	Needs named, supervised people observed over years
7. Enforcement	Condition 5	Deterrence depends on the perceived chance of being caught. When that chance is very low, a larger fine may have little effect
8. Gamification	Condition 1	Requires enrolment and tracking progress across repeat journeys
9. Commitment	Condition 1	Requires an opportunity to ask passengers for a commitment during booking or boarding
10. Social norms	Condition 2, partly	May be practical, but expected effects are small. Only about 10 per cent of surveyed bus passengers thought social pressure would help[4]
11. Prompts	Condition 4	A single prompt may have a short-lived effect, while passengers can unbuckle throughout the trip
13. Feeling watched	Evidence, not setting	Replication studies have not shown a reliable effect
14. Defaults	Not applicable	There is no default to set. A belt is either fastened or it is not
15. Information	Conditions 2 and 4	Requires passengers to notice, understand, accept and act on the message, then maintain belt use without continuous supervision
2. Changing the effort	**Practical**	Belt fit, cleanliness and latch action can all be changed at the seat, and this is the highest-effect category in Table 2
3. A delay avoided by buckling up	**Practical with modification**	Access to a seat amenity could depend on belt use without delaying the vehicle. See section 10.2

Mechanism	Limiting condition	Why
4. An alert that continues until your belt is fastened	**Practical**	Can operate throughout the trip without identifying passengers, continuous supervision, enforcement or delaying departure

6.3 Design requirements for alerts linked to belt use

> The review proposes an alert that is **immediate**, **certain**, **triggered by an occupied seat with an unfastened belt**, **ended by fastening the belt**, and **active for the whole journey** . It must work without identifying passengers, continuous supervision, enforcement or delaying the bus.

These requirements describe sensors at each seat linked to an alert at that seat. The review identifies this as a promising approach under the operating conditions considered.

6.4 Passengers may bypass more restrictive systems

Evidence on bypassing systems provides another reason to consider less restrictive designs.

In the Kidd and Singer trial, part-time belt users were observed defeating the systems in their vehicles. **44 per cent got around the speed-limiting interlock. 21 per cent got around a persistent reminder.**[13] The two produced gains in belt use that were statistically indistinguishable. Bypassing was about twice as common with the interlock, without a statistically detectable additional improvement in belt use.

The interlock literature shows the same thing on a longer timescale. Alcohol interlocks work while they are fitted, and no lasting benefit was found after removal.[9] These findings do not establish lasting behaviour change after removal. Effects measured while a device is installed should be distinguished from behaviour after it is removed.

7 Results: evidence for alerts linked to buckle sensors

7.1 Cars

Persistent alerts tied to the buckle have been tested repeatedly in cars, and they work.

Kidd and Singer gave 49 part-time belt users two vehicles for a week each. Compared with an intermittent reminder, belt use rose 30 and 34 per cent, and the persistent reminder performed on a par with a speed-limiting interlock.[13] A survey of 1,218 drivers and passengers found that people who do not always buckle up said they were more likely to respond to a sound or a

vibration than to a light.[33]

Reducing the effort needed to comply, or allowing compliance to avoid a delay, can also increase belt use. Van Houten and colleagues fitted 101 commercial vehicles with a device that stopped the driver shifting out of park for up to eight seconds unless the belt was fastened. Belt use rose from 48 to 67 per cent in the United States and from 54 to 74 per cent in Canada. Once fastened, the belt tended to stay fastened for the whole trip.[12]

The important detail is that the driver could avoid the delay entirely by buckling first. Both designs give the driver an immediate reason to buckle up: avoiding a delay or stopping an alert.

7.2 The one bus reminder trial located

We located one trial of a per-seat reminder on a bus. KATRI fitted an interurban bus with an occupancy sensor and a buckle sensor at every passenger seat, a warning light at each seat, and a monitoring display at the driver's position.

Observed belt use was 9.6 per cent without the system and 59.0 per cent with it.[14]

Three features of that result deserve attention.

- **The baseline was measured in bus passengers.** 9.6 per cent is a bus baseline, not a car baseline. The intervention was tested on the population that actually has the problem.
- **The warning was a light only.** Section 6.3 does not specify sound, vibration or light. The bus trial used light, which surveyed car occupants rated as less likely to prompt a response than sound or vibration.[33]
- **Occupancy was sensed separately from the buckle.** Section 8.3 explains why separate occupancy sensing is needed to avoid alerts at empty seats.

7.3 What has never been tested

We found no published trial of a per-seat buckle-sensed *audible* alert on a bus. The entire bus evidence base is one trial, using a light. This limited bus evidence is the main limitation discussed in section 13.

Separately, the Swedish authors reached the same design conclusion from their own data, and said so plainly:

> *"Ideally, the announcements could be replaced by seat belt reminders as used in passenger cars."*
>
> Anund, Forward & Sjörs Dahlman (2023), recommendations[4]

The researchers recommend replacing announcements with reminders that respond to belt use.

8 Results: the same pattern in other industries

Each case below was chosen because it isolates one mechanism cleanly.

8.1 Drink driving: interlocks work while installed

The Cochrane review of alcohol ignition interlocks found the programmes effective while the device was installed, and found no lasting benefit after removal.[9] The Community Guide review reported re-arrest reductions of 15 to 69 per cent across the five studies showing a significant effect.[10]

The benefit depended on keeping the device installed. Preventing an action through an interlock does not establish that people will continue to comply after the device is removed.

8.2 Aviation: limits of briefings and announcements

Aviation is the most useful comparison available. Commercial aviation uses briefings, signs and crew supervision, yet some passengers still do not wear belts.

Aircraft have a mandatory briefing, a lit sign at every row, repeated announcements, uniformed crew walking the aisle, and legal powers to detain and prosecute. Even so, more than 90 per cent of turbulence injuries involve people who were not wearing a belt.[34] About 37 per cent of surveyed passengers say they did not watch the pre-flight briefing video at all, and recall of the key safety messages averages around half.[35]

A relevant finding comes from Cranfield’s evacuation research programme for the UK Civil Aviation Authority. Comparing crew behaviour across full-scale evacuation trials, **evacuation rates with non-assertive cabin crew were about the same as with no cabin crew present at all.** Assertive crew produced the fastest evacuations.[36]

> **Possible relevance to coaches.** The Cranfield findings suggest that passive requests may be less effective than active direction. However, evacuation trials do not directly measure the effect of coach seatbelt briefings or recordings. At Greta, the driver did not give the briefing and there was no system to detect the omission.[1]

8.3 Hospitals: why sensing the seat is occupied is not optional

Hospital research has measured how staff respond when frequent alarms do not indicate a problem requiring action.

Between 72 and 99 per cent of physiological monitor alarms are technically false or clinically irrelevant. Staff become less responsive to the alarms, a process called desensitisation.[37] Staff delay their responses, dismiss alarms, and adjust the thresholds to make them stop.

This provides a reason to include occupancy sensing on buses. Repeated alerts at empty seats may lead drivers and passengers to ignore valid alerts as well. Over a coach's service life, which may approach 26 years, limiting false alerts is important for maintaining trust in the system.

8.4 Hand hygiene: the warning about habituation

Healthcare studies provide evidence on reminders used routinely over time. Electronic hand hygiene monitoring with instant prompts, including audible ones, does improve compliance. The systematic reviews question whether those benefits continue indefinitely:

> *"For most automated systems, the visual or auditory cue was an integral part of the system and there appeared to be a naive assumption that simple reminders would be sufficient to boost hand hygiene compliance indefinitely."*
>
> Systematic review of electronic hand hygiene monitoring[38]

This concern also applies to the seatbelt reminders recommended in this review. It is addressed in section 10.2 and again in section 13.

8.5 Boating: reported use can exceed observed use

A cluster randomised trial of peer-led training among boaters on Lake Albert, Uganda, measured lifejacket wear two ways.

Self-reported wear in the intervention group rose from 30.8 to 65.1 per cent. **Observed wear rose from 1.0 to 26.8 per cent.** In the control group, self-report went from 29.9 to 43.2 per cent while observation went from 0.6 to 8.8 per cent.[5]

Self-report overstated the outcome by more than double, in both groups. This matters directly for bus policy, because the Australian evidence base is thin and several figures come from surveys and crash samples rather than systematic roadside observation.

8.6 Public transport during COVID-19

Mask mandates on public transport were the closest recent test of announcements plus a legal requirement, in exactly the setting of interest.

Announcements and regulations did raise correct mask wearing. Observed compliance still ran well below self-report. In one European study, 41.6 per cent of passengers wore masks correctly, against 74.7 per cent of transport workers.[39] A rule, plus signs, plus repeated announcements, plus a live public health emergency, produced correct compliance in a minority of passengers.

9 Results: what the rules require

9.1 Cars are covered. Bus passengers are not.

Table 4. Seatbelt reminder requirements by jurisdiction and seating position. “Buckle sensing” means the system responds to whether one specific belt is fastened.

Instrument	Applies to	Seats covered	Buckle sensing
UN Regulation No. 16, all new vehicles from 2021[4,40]	Europe and adopting states	All front and rear seats of M1 cars. **Front seats only of M2 and M3 buses**	Yes, for the seats covered
FMVSS 208 as amended, final rule December 2024[41]	United States	Enhanced front warning from 1 Sep 2026. Rear seats from 1 Sep 2027	Yes
ADR 4/05	Australia, light vehicles	Driver’s seating position	Yes
ADR 68/01, approved December 2024[1]	Australia, buses and coaches. New models 1 Nov 2026, all new builds 1 Nov 2027	All seats, covered by signage and one announcement	**No. No buckle sensor, no occupancy sensor, no per-seat detection of any kind**

9.2 What ADR 68/01 actually does

ADR 68/01 requires three things: a label on the back of each seat, an illuminated sign at the front of the cabin lit for at least 60 seconds after the last door closes, and one recorded announcement before the vehicle travels 500 metres or exceeds 25 km/h.

Put the two systems side by side.

A car chimes because it has detected that your specific belt is undone. It stops when you fasten it. The warning responds to your unfastened belt.

A bus under ADR 68/01 plays a recording on a timer. It is identical whether every belt is fastened or none are. It broadcasts the same message to everyone in the cabin.

9.3 This is not only an Australian gap

UN Regulation No. 16 has required reminders on all front and rear seats of cars since 2021, and on the *front seats only* of M2 and M3 buses.[4,40] The rear passenger area of a European coach has no sensor-based reminder requirement either.

The gap in sensor-based reminder requirements also exists outside Australia.

9.4 The cost-benefit case for bus reminders needs assessment

Driver seatbelt reminders were made mandatory in light vehicles on the finding that the safety benefit over a vehicle's life outweighs the cost of fitting them. That reasoning does not depend on the type of vehicle, and the following factors support examining the case for buses.

1. **More room to improve.** Reminders were mandated for car drivers already at about 97 per cent, and withheld from bus passengers at 7 to 45 per cent.
2. **Lower cost per protected person.** One car fitment protects one seat. One coach fitment protects up to 57, over a service life approaching 26 years.
3. **A coach crash can expose many unbelted passengers to harm.** One rollover produced 29 unbelted passengers, 14 people fully thrown from the vehicle, 3 partly thrown, and 10 deaths.[1]

We found no published analysis rebutting that reasoning for heavy vehicles. It has simply not been applied to them.

10 Discussion: what should be built

10.1 Five principles that follow from the evidence

1. **Detect whether each seat's belt is fastened.** The system needs each seat's buckle state to alert the passenger whose belt is unfastened.
2. **Only alert on seats that are occupied.** Hospital studies reporting false or irrelevant alarm rates of 72 to 99 per cent show why avoiding unnecessary alerts matters.[37]
3. **Stop the alert when the belt is fastened.** In rows 3 and 4 of Table 2, compliance ends the delay or alert. A one-off prompt in row 11 does not respond to compliance.
4. **Monitor belt use throughout the trip.** A passenger who unbuckles after departure loses the belt's protection if a crash occurs later.

5. **Reduce the effort of buckling at the same time.** Row 2 is the highest-effect category in Table 2, and routine maintenance can address it directly.

10.2 Two proposed designs without published bus trials

Make a seat amenity available only when the belt is fastened. Condition 3 makes a vehicle interlock impractical. Restricting an individual seat amenity would avoid delaying the whole bus. Two possible designs are:

- **Lock the recline until the belt is fastened.** Bus drivers suggested this unprompted in the Swedish focus groups, asking for “seats that cannot be reclined unless the belt is used”.[4]
- **Enable seat-back power, wi-fi or entertainment only when the belt is fastened.** Deployed once as a taxi marketing campaign. Never trialled properly.

Both designs make access to a seat amenity depend on belt use, applying the interlock principle without preventing the vehicle from moving. They also avoid adding audible noise.

> PRACTICAL LIMITATIONS
>
> These designs may give passengers less reason to buckle up than a persistent alert. They prevent access only to an optional amenity. A passenger who does not want to recline and does not need power has no reason to respond, whereas a continuing noise reaches everyone in the row.
>
> Both also cost more per seat. A recline lock needs an actuator in the seat frame. Controlling power requires switched circuits at each seat, adding complexity compared with a buzzer.
>
> These designs may supplement alerts. They warrant testing because they are quiet and may influence passengers who have stopped responding to sound. **No published trial of either was located.** Their effectiveness remains untested.

Varying the alert instead of holding it constant. The in-vehicle warning literature reports that responses to predictable signals can decline with repeated exposure, and that alerts that increase in intensity can convey urgency without adding constant noise. It also reports that how effective an alert is perceived to be and how annoying it is perceived to be are strongly correlated.[42] An alert that starts quietly and escalates, or that varies, may help maintain attention better than an unchanging tone, although the long-term effect on buses remains untested. This addresses the limitation in section 13.2 directly.

10.3 Belt maintenance may be the cheapest way to improve use

Two facts point at the same conclusion. The highest-effect category in Table 2 is reducing effort. The most common reasons passengers give for not buckling are dirty belts, belts that will not extend or latch, and belts that do not fit.[4]

The intervention that follows needs no electronics at all: clean and inspect the belts on a schedule, and specify belt geometry that fits both large and small passengers. The Swedish authors recommend exactly this.

Operators fitting sensors should also address belt condition and fit, since passengers report these as reasons for non-use.

10.4 An applied example

AITSC manufactures a system that implements the specification in section 6.3.

Two passive switch sensors sit at each seat, one in the cushion and one inside the buckle. Together they establish which seats are occupied and which belts are fastened. After a 20-second grace period once the doors close, any seat that is occupied and unbelted triggers an 80 dB alert in that row, and the alert continues until the belt is latched. Monitoring runs for the whole trip, so the system also detects a passenger who unbuckles later. An optional seat-mounted unit adds a flashing indicator that makes the location of the unbelted seat visible from the aisle.

Measured against the five principles in section 10.1: it senses each seat, it alerts only occupied seats, the alert ends when the belt is fastened, and it monitors belt use throughout the journey. It does not reduce the effort of buckling. That fifth principle requires the operator to maintain the belts and address fit under section 10.3.

Measured against section 10.2, neither untested design is implemented. The aisle indicator may draw attention to the unbuckled seat and create social pressure. Evidence for that effect is limited, as rows 10 and 13 of Table 2 show, so it should be treated as a supporting feature.

11 Discussion: what this review does not show

Listed separately from the limitations, because these are conclusions a reader might reach that the evidence does not support.

- **It does not show that alerts are the best behavioural mechanism.** Interlocks and reductions in effort have produced larger measured effects in other settings. The review identifies alerts as a promising approach that can operate under the bus conditions considered.
- **It does not show that a reminder would have prevented the deaths at Greta.** Several factors contributed to the risk of being thrown from the vehicle. Glazing, seat design, the road environment and driver health all contributed.[1] Raising belt use addresses one factor among several.
- **It does not show that information is worthless.** Prompts at the point of decision produce real, measurable, short-lived effects. They may supplement other measures, but have limited support as the main way to increase belt use.
- **It does not establish an effect size for an audible per-seat alert on a bus.** That trial has not been run.

12 Discussion: implications

Three implications follow, in order of how directly the evidence supports them.

For regulators. ADR 68/01 requires reminders, whose effectiveness in increasing bus passenger belt use has limited direct evidence. Car reminder rules increasingly require sensing at individual seats. The cost-benefit reasoning used for car reminders warrants assessment for buses as well.

For operators. Two measures are available now and neither requires a rule change. Repair and maintain the belts, because that addresses the reason passengers actually give. Fit per-seat detection, because it can monitor buckle state when the driver cannot see the passenger area. Chain of Responsibility duties apply now, on vehicles that ADR 68/01 will never reach.

For researchers. Three areas need further trials. A per-seat audible alert on a bus, which has never been tested anywhere. Making seat amenities conditional on belt use, as described in section 10.2. And measuring whether responses to a fixed cabin alert decline over years rather than weeks.

13 Limitations

13.1 Direct evidence from buses is limited

The bus-specific evidence is one observational study and one pilot trial. The remaining evidence comes from cars, aviation, healthcare, industry and public health. Applying those findings to buses requires inference. The strongest effect-size evidence in this review comes from populations that are not bus passengers.

The estimates in Table 2 come from different study designs and support a broad qualitative assessment, rather than a precise ranking of effect sizes.

13.2 Habituation has not been measured

The controlled trials of persistent reminders ran for weeks. A coach runs for about 26 years. We found no study measuring the response to a fixed in-cabin alert over anything approaching that period, and the hand hygiene literature names the assumption that reminders work indefinitely as unexamined.[38]

Long-term response is a major uncertainty for per-seat alerts. It supports testing the varying and escalating alerts proposed in section 10.2.

13.3 A latched belt may not be worn correctly

A buckle switch detects the latch, not the person. Participants in the Kidd and Singer trial sat on fastened belts and routed belts behind their backs, and 21 per cent circumvented a persistent reminder.[13] Devices that defeat buckle sensors are sold openly. A wearing rate calculated from buckle sensors may overestimate how many passengers are correctly wearing their belts.

13.4 Seat alerts do not replace broader policy measures

Chater and Loewenstein argue that measures aimed at individual behaviour can be promoted in place of broader policy changes, benefiting those who oppose those changes.[43] A per-seat device fitted by an operator targets individual passenger behaviour, and this review is published by a company that sells one. This concern is relevant to the review’s recommendations and commercial disclosure.

Broader policy options include mandatory retrofitting and consistent enforcement. Neither exists. Australian Design Rules are not retrospective, fleet turnover is estimated to take at least 25 years, and the investigating regulator has asked for a study into whether its own new rule works rather than treating the question as settled.[1] Operators can introduce measures on

existing vehicles while broader policy changes are considered and the fleet is replaced. These measures do not remove the need to assess those policy options.

13.5 Search method

This review followed a systematic two-stage search strategy, set out in section 2.1, but it did not have access to subscription bibliographic databases. Searching was done through a general index rather than Medline, Embase, Scopus, TRID or PsycINFO. The review does not provide exact search queries that others can repeat, a count of duplicate records removed, or a PRISMA flow diagram showing how studies were selected. It was not registered in advance.

The index used is weighted towards English-language and United States sources. Australian, Korean and Scandinavian material was found only through searches using specific names. Several sources were read through abstracts and published summaries rather than full text. Readers should treat the coverage as broad rather than exhaustive.

14 Conclusion

Across the fields reviewed, changing the effort or immediate consequences of an action generally produces larger effects than information alone. The studies differ in design and population, so this pattern does not establish a precise effect size for bus passengers.

Bus operating conditions limit approaches that require repeat contact with identified passengers, continuous supervision, delaying departure or frequent enforcement. Passengers may also unbuckle during the journey. Per-seat sensors linked to alerts address these conditions: an alert responds to an occupied seat with an unfastened belt, stops when the belt is fastened, and remains available throughout the trip.

Australia’s response to the Greta rollover does not meet that specification. ADR 68/01 requires a label, a lit sign and one recorded announcement on a timer, with no sensing of any kind. These measures provide information to a population with reported wearing rates of 7 to 45 per cent; their effects on bus passenger belt use remain poorly measured. Europe stops at the front seats of a bus. The rules reviewed do not require buckle-sensing reminders throughout a bus’s passenger area.

The one bus reminder trial located reported wearing rates of 9.6 per cent without the system and 59.0 per cent with it, using visual alerts. Car studies provide further support for buckle-linked reminders. Direct trials are still needed to establish the effect and long-term acceptability of audible per-seat alerts on buses.

DISCLOSURE

This review was prepared by AITSC, which manufactures and sells a per-seat seatbelt monitoring and alert system for buses and coaches, and an ADR 68/01 compliance kit. That is a direct commercial interest in the conclusion reached at section 6.3.

Sections 1 to 9, section 11 and section 13 draw only on published third-party research and public regulatory instruments, and contain no AITSC data. Sections 10 and 12 make recommendations in which AITSC has a commercial interest, and should be read with that in mind. Section 10.4 describes an AITSC product and is the only section that does. The two designs proposed in section 10.2 are not AITSC products and are published here as untested research gaps.

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