

1 *Which interventions increase hearing protection behaviors during*
2 *noisy recreational activities? A systematic review*

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1 **Abstract**

2 **Background:** Hearing loss and tinnitus are global concerns that can be reduced through
3 hearing protection behaviors (e.g., earplug use). Little is known about the effectiveness of
4 interventions to increase hearing protection use in recreational domains. For the first time we
5 review systematically the effectiveness of such interventions.

6 **Methods:** Systematic searches of nine databases, as well as grey literature and hand-
7 searching, were conducted. Any study design was included if it assessed quantitatively a
8 purposeful attempt to increase hearing protection in recreational settings. Studies were
9 excluded if they assessed noise exposure from occupational sources and
10 headphones/earphones, as these have been reviewed elsewhere. PROSPERO protocol:
11 CRD42018098573.

12 **Results:** Eight studies were retrieved following the screening of 1,908 articles. Two pretest-
13 posttest studies detected a small to medium effect ($d \geq 0.3 \leq 0.5$), one a small effect ($d \sim 0.2$)
14 and two no real effect. Three posttest experimental studies detected small to medium effects
15 ($d \geq 0.3 \leq 0.5$). Studies were rated as “poor quality” and 17 out of a possible 93 behavior
16 change techniques were coded, with the majority targeting the intervention function
17 ‘education’.

18 **Conclusions:** Hearing loss and tinnitus due to recreational noise exposure are major public
19 health concerns yet very few studies have examined preventive interventions. The present
20 systematic review sets the agenda for the future development and testing of evidence-based
21 interventions designed to prevent future hearing loss and tinnitus caused by noise in
22 recreational settings, by recommending systematic approaches to intervention design, and
23 implementation of intervention functions beyond education, such as incentivization,
24 enablement and modeling.

1 **Keywords:** Hearing protection intervention, hearing conservation, hearing protection
2 behavior, behavior change, recreational noise-induced hearing loss, recreational noise
3 activity, systematic review

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1 **Background**

2 Approximately one billion teenagers and young adults (12 – 35 years) are at risk of noise-
3 induced hearing loss and tinnitus due to hazardous recreational noise exposure. (1)
4 Recreational activities such as attendance at live music venues (nightclubs, festivals, concerts
5 and bars), practising/producing music, do-it-yourself (DIY), engine noise and sports related
6 noise (2 – 6) contribute the majority of risk, (7) with noise levels ranging between 91.7 – 140
7 dBA (A-weighted decibel), (8 – 12) and depending on duration of exposure all have the
8 potential to cause hearing symptoms in a short space of time. (13, 14) Individuals who
9 partake in recreational activities are more likely to have hearing loss than those who do not,
10 (15) with dullness in hearing and tinnitus reported in up to 80% of people post activity. (16,
11 17) Recreational noise exposure can be reduced through the adoption of hearing protection
12 behaviors, such as the use of hearing protection devices (earplugs and earmuffs) and
13 regeneration breaks. (18, 19) However, people engaging in hearing protection behaviors
14 during noisy recreational activities has been reported as fewer than 5%, (20, 21) and it is not
15 known whether interventions have exerted measurable effect sizes post intervention in
16 changing behaviors.

17 Previous hearing protection systematic and narrative reviews have investigated occupational
18 settings, (22) recreational noise through personal listening devices that use headphones and
19 earphones, (23) and education about hearing protection (24). El Dib et al. (22) conducted a
20 systematic review of randomised controlled trials in occupational settings designed to
21 promote the wearing of earplugs and earmuffs and concluded that specifically tailored or
22 individual based education interventions improved use of hearing protection. Diviani et al's
23 (23) narrative systematic review of personal listening devices identified two interventions
24 (25, 26) indicating that warning signs and evocative imagery reduced volume levels. Kahn et
25 al's (24) systematic review focused on health education programmes targeted at youth and

1 young adults' use of hearing protection in occupational and recreational settings, identifying
2 10 studies that showed little evidence of effectiveness. However, given that education is just
3 one out of nine possible functions that an intervention might serve (see Michie et al (27)), it
4 would be valuable to examine the effects of other intervention functions, such as
5 environmental restructuring, modelling and incentivization as potential means to bring about
6 health protection behavior change among people of all ages.

7 The use of health psychology theories and models have been discussed as a means to
8 improving hearing health behavior change interventions, (28) with Coulson et al. (29)
9 suggesting the 'behavior change wheel' framework and associated capability (C), opportunity
10 (O) and motivation (M) model of behavior (B) change (COM-B) (27) as a new approach to
11 use within this domain. The COM-B model is at the core of the framework, with capability,
12 opportunity and motivation representative of the processes involved in enacting a behavior.
13 (27) The COM-B model allows intervention designers to assess which drivers of the target
14 behavior need to change. Once this has been established, then the remaining steps of the
15 behavior change wheel framework help refine the components required for the target
16 intervention, including intervention functions (categories of intervention), the behavior
17 change techniques (active ingredients of the intervention), and the mode of delivering the
18 final intervention. (27)

19 The 93 techniques in the 'Behavior Change Technique Taxonomy Version 1' (BCTTv1) (30)
20 are the smallest active ingredients of interventions and act as the catalysts energizing the
21 appropriately identified intervention functions during the design process of the behavior
22 change wheel. (27) For example, the technique 'demonstration of the behavior
23 (BCTTv1:6.1)' would serve the intervention functions of both education and modelling. In
24 previous preventative health behavior systematic reviews (e.g., physical activity) commonly
25 used behavior change techniques including 'goal setting (behavior) (BCTTv1:1.1)', (31) and

1 'feedback on behavior (BCTTv1:2.2)' have been coded. (32) The coding of the behavior
2 change techniques within hearing protection interventions will aid future intervention
3 designers during this theory driven process. However, none of the previous hearing protection
4 systematic (22, 24) and narrative reviews (23) have coded interventions to identify the
5 behavior change techniques implemented according to the BCTTv1 taxonomy, (30) alongside
6 extracting measurable hearing protection use outcome effects (Cohen's d).

7 The present systematic review looks beyond occupational settings, includes hearing
8 protection behaviors beyond personal listening device use, considers intervention functions in
9 addition to education (e.g., incentivization (27)), and codes behavior change techniques for
10 the first time in recreational hearing protection interventions. The aim of the present research
11 is therefore to review systematically the literature on interventions designed to increase
12 hearing protection behaviors in recreational settings.

13 The primary objectives of the current review are to: 1) quantify the effectiveness of hearing
14 protection interventions in recreational noise domains, and 2) identify the active ingredients
15 (behavior change techniques) of such interventions to help future designers of interventions
16 to increase uptake and use of hearing protection behaviors in recreational settings.

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1 **Methods**

2 **Search Strategy and Selection Criteria**

3 This is a systematic review that followed the ‘Preferred Reporting Items for Systematic
4 Reviews and Meta-Analyses’ guidance, (33) which was pre-registered on PROSPERO
5 [CRD42018098573] on 6th June 2018. No meta-analysis could take place due to study
6 heterogeneity. https://www.crd.york.ac.uk/prospéro/display_record.php?RecordID=98573.

7 Searches were carried out on electronic databases: Cochrane Central Register of Controlled
8 Trials; PubMed; EMBASE; MEDLINE; PsycINFO; Web of Science Core Collection;
9 ComDisDome; Database of Abstracts of Reviews of Effects and Centre for Reviews and
10 Dissemination. Grey literature was searched via: Grey Literature Report, Prospero, Open
11 Grey, ClinicalTrials.gov, International Clinical Trials Registry. Hand-searching was
12 conducted using the reference lists of papers that were included for full review. Authors of 12
13 studies were contacted for further clarification before inclusion or exclusion could be
14 determined. The most recent full search was performed on 1st May 2020. All age groups,
15 years and languages were considered for review.

16 A broad search strategy was developed alongside a research librarian to capture the large
17 variety of hearing protection interventions (hearing conservation programs, education
18 programs, hearing protection device use and noise legislation adherence). Keywords and
19 structure to each search were altered depending on each electronic database (see *additional*
20 *file 1*); each strategy followed components related to intervention types, effects of noise
21 exposure, hearing protection and different sound sources. Medical Subject Heading (MeSH)
22 terms in this instance were not used due to the close association between occupational and
23 recreational noise.

1 Studies were included if they assessed quantitatively a deliberate attempt to increase hearing
2 protection behaviors when people are exposed to noise during recreational activities; study
3 designs included ‘experimental posttest designs’ (randomized controlled trials and quasi-
4 experimental studies) and ‘single group pretest-posttest designs’ (observational studies and
5 surveys). Secondary outcomes included hearing health outcomes such as hearing loss or
6 tinnitus as well as perceptions of capabilities, opportunities and motivations to engage in
7 hearing protective behaviors. Interventions were also coded for the presence of the active
8 ingredients aimed at delivering the desired change, namely, the behavior change techniques.
9 The 93 techniques are clustered into 16 groups (e.g., goals and planning, reward and threat)
10 within the behavior change technique taxonomy (BCTTv1), each technique has its own
11 identifiable number for coding purposes, with the first digit identifying the cluster group, and
12 the second the order of the technique within said group (e.g., habit formation: BCTTv1:8.1).
13 (30) These techniques were required to be observable, replicable, irreducible and to include a
14 postulated active ingredient of the intervention. They were also required to be clearly defined
15 to the target population(s) and target behavior(s)/outcome(s) within study methodologies. (27,
16 30) Coding the included studies clarified any effects of the intervention on primary and
17 secondary outcomes. Studies were excluded if they assessed noise exposure from
18 occupational sources and noise from personal listening devices while using headphones
19 and/or earphones, as these have been reviewed elsewhere. (22, 23)

20 The screening of abstracts and titles commenced with the 1st reviewer (ML) screening all
21 articles and 2nd reviewer (SL) screening 10% of these reports for comparison. The 1st
22 reviewer (ML) read all the fully eligible studies, with the 2nd and 3rd reviewers (SL and CJA)
23 reading a proportion of the eligible studies, as well as discussing any query papers for full
24 inclusion. Several authors were contacted directly to clarify information, leading to both
25 inclusion and exclusion of studies for full review.

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2 **Data Extraction and Analysis**

3 Data were extracted using a pre-designed and piloted data extraction form, including general
4 study information, study characteristics, participant characteristics, intervention design
5 (including behavior change techniques), and outcome measures (see *table 1* and *additional*
6 *file 2*). Risk of bias and quality assessment were carried out independently by the 1st and 2nd
7 reviewers using the Cochrane Quality Assessment Tool for systematic reviews. (34) The
8 published protocol stated that the review would use the critical appraisal skills program
9 (CASP). (35, 36) However, with the included study designs not conforming to CASP
10 checklists, and high levels of heterogeneity meaning determining the level of evidence using
11 Cochrane's 'Grading of Recommendations, Assessment, Development and Evaluations' tool
12 was not possible, it was more appropriate to use the Cochrane Quality Assessment Tool for
13 systematic reviews (see *figure 1*).

14 Outcome measures were assessed in numerous different formats (often with multiple
15 categories) and so the main outcome was recoded as 'never-performers' (never performed a
16 hearing protection behavior) and 'ever-performers' (performed a hearing protection behavior
17 at least some of the time). Quantitative data were extracted by the 1st and 2nd reviewer, and
18 compared for agreement. The 3rd reviewer checked over the extracted quantitative data for
19 agreement and calculation errors. One paper written in German was translated and included
20 in the analysis. (37) Where studies included multiple time points, data were extracted from
21 the last follow-up.

22 For dichotomous data, risk ratios and Z statistics were extracted; Cohen's *d* was calculated
23 using Z statistic and sample size (N). (38) In terms of risk ratios, "ever-performers" of
24 hearing protection behaviors were coded 'positive outcomes,' and "never-performers" were

1 coded 'negative outcomes.' The cumulative incidence of the intervention group (or posttest
2 data) was then divided by the cumulative incidence of the control group (or pretest data) (see
3 *table 1*). This approach is similar to that applied in the previous systematic review of
4 occupational hearing protection behaviors. (22) One study presented data as adjusted means
5 for the proportion of time hearing protection was used; (39) Cohen's *d* could be inferred from
6 the presented adjusted means and sample sizes provided. (38)

7 The 1st and 2nd reviewers, trained via the University College London online behavior change
8 technique taxonomy v1 program, (40) coded all included papers for behavior change
9 techniques with an 80% agreement rate and a Cohen's Kappa moderate agreement ($\kappa=0.58$).
10 The 3rd reviewer coded any disagreements and from this the final list of codes were agreed
11 between all reviewers. Full coding of all behavior change techniques and associated
12 taxonomy numbering can be found in *table 1*.

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14 **Results**

15 Initial searching recovered 2616 articles, of which 1908 (73%) were eligible for screening
16 after the removal of duplicates ($n = 708$). Following screening, a total of 59 reports were
17 eligible for full review, eight of which were suitable for inclusion according to our criteria
18 (see *figure 2*). Five of these were single group pretest-posttest designs and three were
19 experimental post-test designs (two randomized controlled trials and one quasi-randomized
20 study). Fifty-one papers were excluded due to: studies missing or no behavioral data ($n = 14$);
21 measurement of 'intended behavior' and not actual behavior ($n = 13$); no recognizable
22 intervention ($n = 11$); occupational noise exposure ($n = 6$); unretrievable data ($n = 5$);
23 acoustic intervention ($n = 1$); and contained historic data superseded by a subsequent paper (n
24 = 1).

1 Individual effects were extracted for each study and are discussed in a narrative synthesis.
2 Study heterogeneity occurred due to study design differences (five single group pretest-
3 posttest designs and three experimental posttest designs), a range of follow up periods (16
4 weeks to 16 years) and a large population range (39 participants up to 1535 participants). All
5 studies examined use of earplugs, one study additionally measured regeneration breaks
6 alongside earplugs, (41) and a further study additionally measured adjustments of personal
7 stereo volume through loudspeakers. (39)

8 Seven of the included interventions were described as hearing conservation/education
9 programs, (37, 39, 41 - 45) with the final intervention focused solely on provision of free
10 hearing protection devices (earplugs) versus no provision. (46) School children were the
11 target of five studies, (37, 39, 41, 44, 45) young adults (18 – 39 years) the target for two
12 studies, (42, 43) and the final study did not define an age group or report an average age. (46)

13 **Single Pretest-Posttest Design Studies**

14 When examining the five single pretest-posttest designs we compared baseline data with final
15 follow-up. Neyen’s (37) hearing conservation program delivered two hearing health teaching
16 sessions, which included explanations of hearing loss (information about health
17 consequences: BCTTv1: 5.1), audio simulations (salience of consequences: BCTTv1: 5.2)
18 and experiments with volume levels (comparative imaging of future outcomes: BCTTv1:
19 9.3). The study detected only a very small increase in uptake of earplugs ($d = 0.14$) during
20 loud events with German school children in the 5-6 weeks following the intervention. No
21 secondary outcomes were reported. The study had high risk of allocation concealment bias as
22 there was no randomization, and detection bias (blinding of outcomes) as blinding was not
23 mentioned.

1 Weichbold and Zorowka's (45) hearing conservation program "PROjectEAR" detected a
2 small effect ($d = 0.21$) with increased use of earplugs at discotheques within Austrian high
3 school children, one year post intervention. The children received four teaching sessions that
4 included information on the risks of noise exposure (information about health consequences;
5 BCTTv1: 5.1) alongside multimedia/listening examples (salience of consequences: BCTTv1:
6 5.2), and presentation of ear protection devices (instruction on how to perform a behavior:
7 BCTTv1: 4.1; demonstration of the behavior: BCTTv1: 6.1). No secondary outcomes were
8 reported. The study had high risk of allocation concealment bias, performance bias, and
9 detection bias (blinding of outcomes), due to no randomization or mention of blinding.

10 Weichbold and Zorowka (41) continued with "PROjectEAR", this time with a new and larger
11 sample size of students (see *additional file 2*) and an additional behavior measuring
12 regeneration breaks. Additionally this version clearly stated the children received a talk from
13 a hearing impaired person (credible source; BCTTv1: 9.1), with instruction to practice using
14 earplugs (behavioral practice/rehearsal; BCTTv1: 8.1), and to remove themselves from noisy
15 spaces (restructuring the physical environment; BCTTv1: 12.1); however, salience of
16 consequences (BCTTv1: 5.2) was not explicitly coded this time around. The study detected a
17 very small increase ($d = 0.14$) in earplug use one year post intervention, but no real effect (d
18 $= 0.06$) of increased regeneration breaks. There are no reported secondary outcomes within
19 this paper. Similarly, as within Weichbold and Zorowka (45) this study had high risk of
20 allocation concealment bias and detection bias (blinding of outcomes).

21 Keppler et al.'s (42) hearing conservation program was performed by an audiologist (credible
22 source; BCTTv1: 9.1) whom delivered feedback on hearing (biofeedback: BCTTv1: 2.6),
23 educated on the risks of recreational noise, and discussed protective actions, including
24 benefits/barriers (information about health consequences: BCTTv1: 5.1; information about
25 social and environmental consequences: BCTTv1: 5.3; instruction on how to perform a

1 behavior: BCTTv1: 4.1; pros and cons: BCTTv1: 9.2). The study detected a small to medium
2 effect ($d = 0.34$) in increased use of hearing protection devices from baseline (mean 3.40; SD
3 1.36; range 1.00-5.00) to six months post intervention (mean 2.94; SD 1.37; range 1.00-
4 5.00) within Belgian young adults. Secondary outcomes assessed the audiometric thresholds
5 of the participants at baseline and 6 months post intervention, but no significant effects were
6 found. Participant self-reports between sessions indicated that 28.2% of participants
7 perceived their hearing loss to have increased, with 20.5% reporting that their tinnitus
8 increased. However, the study had high risk of allocation concealment bias, performance
9 bias, and detection bias, due to no randomization or mention of blinding.

10 The aim of Gilles and Van de Heyning's (44) hearing conservation program was to make
11 students aware of the dangers of loud music (information about health consequences:
12 BCTTv1: 5.1) and therefore increase use of hearing protection; after administering
13 questionnaires to Belgian students at baseline and six months post intervention, they detected
14 a small to medium effect ($d = 0.34$) in increased use of devices while in noisy recreational
15 environments. There are no reported secondary outcomes within this paper. The study was
16 high risk of allocation concealment bias, performance bias, and detection bias, due to no
17 randomization or mention of blinding.

18 **Experimental Post-test Designs**

19 When examining the three experimental post-test designs we compared control and
20 intervention data at the final follow-up. Marlenga et al. (39) completed a 16-year follow up of
21 a hearing conservation program that was originally a clustered randomized controlled trial of
22 rural American school children. Self-reported hearing protection use revealed a small to
23 medium effect ($d = 0.30$) in the difference between groups for hearing protection use during
24 gunfire. However, no effect was found for 'all recreational activities' ($d = 0.07$) or 'personal

1 stereos' ($d = 0.03$). The program consisted of information on the ear and hearing delivered by
2 a study educator, alongside videotape examples (credible source: BCTTv1: 9.1; information
3 about health consequences; BCTTv1: 5.1; salience of consequences: BCTTv1: 5.2), and
4 demonstrations/practice of how to fit hearing protection devices (demonstration of the
5 behavior: BCTTv1: 6.1; behavioral practice/rehearsal: BCTTv1: 8.1); concluding with the
6 provision of free devices that continued over the course of the intervention, alongside
7 additional information (adding objects to the environment: BCTTv1: 12.5; habit formation:
8 BCTTv1: 8.3). Secondary outcomes assessed changes in audiometric threshold frequencies
9 from baseline across five categories, however no significant differences between groups were
10 found for any of the categories. The study had high risk of detection bias as there is no
11 mention of blinding, attrition bias due to dropouts, and reporting bias due to collection
12 methods not known to be valid or reliable. There was also a high risk of selection bias due to
13 a low agreement rate at the 16 year follow up, with an overall low risk of allocation
14 concealment bias through initial randomization.

15 Beach et al.'s (43) hearing conservation program had the incentive of free earplugs and use
16 demonstrated by an audiologist (material incentive (behavior): BCTTv1: 10.1; adding objects
17 to the environment: BCTTv1: 12.5; credible source: BCTTv1: 9.1; instruction on how to
18 perform a behavior: BCTTv1: 4.1; demonstration of the behavior: BCTTv1: 6.1), with a
19 monetary reward for intervention completion (material reward (behavior): BCTTv1: 10.2).
20 However, the experimental group received additional information on the dangers of noise, a
21 video demonstrating hearing loss, and additional time with the audiologist (information about
22 health consequences: BCTTv1: 5.1; salience of consequences: BCTTv1: 5.2; social support
23 (practical): (BCTTv1: 3.2). The study detected a small to medium effect ($d = 0.30$) in
24 differences of earplug use at live music events at 16 weeks post intervention within
25 Australian young adults who regular attended live events. However, it is worth noting for this

1 study that 82% of participants had used earplugs previously. This is unusually high and not
2 representative of the general population, which is ~5% for these types of events. (21, 47)
3 Secondary outcomes were assessed with self-reporting of temporary thresholds shifts (76%)
4 and tinnitus (92%) among all participants at follow up, with tinnitus reported as being
5 permanent in 20% of the participants. The study reported as high risk of detection bias
6 (blinding of outcome assessment) as it does not mention blinding of assessors, but with good
7 internal validity due to randomization and blinding of participants.

8 When comparing control venues (three concerts) to experimental venues (three concerts) Cha
9 et al. (46) detected a small to medium effect ($d = 0.31$) with greater use of earplugs being
10 observed when earplugs were freely available at rock concerts (prompts and cues: BCTTv1:
11 7.1; material incentive (behavior): BCTTv1: 10.1). However, no secondary outcomes were
12 measured meaning that it is not clear what was the mechanism of action. We considered this
13 to be a quasi-study as it did not randomize participants but instead had control/interventions
14 groups defined by venues, and was therefore high risk of allocation concealment bias; with
15 large discrepancies in sample size between comparison groups. The study also had high risk
16 of detection bias, attrition bias, and reporting bias, due to no mention of blinding, dropouts,
17 and collection methods not known to be valid or reliable.

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1 **Discussion**

2 This review set out to assess, the effectiveness of recreational hearing protection
3 interventions, and for the first time, to identify the active ingredients of these interventions.
4 Considering hearing symptoms through recreational noise exposure is a global concern that is
5 highly preventable, (1) only eight studies were retrieved that evaluated changes in hearing
6 protection behaviors post intervention; only three studies have been carried out within the last
7 5 years, (42, 43, 46) indicating hearing protection interventions are being chronically under
8 researched. Included studies lacked quality overall, with only three experimental post-test
9 designs (two randomized controlled trials and one quasi study). Methodologies and results
10 were poorly reported making it difficult to extract data, resulting in 12 authors being
11 contacted throughout the review process. Furthermore, the poor quality of reporting
12 highlights how difficult it would be, if not impossible, to replicate many of the interventions
13 to further test outcomes. There is a need for more high quality experimental studies;
14 improvements are required in terms of design quality and reporting to address this large gap
15 in knowledge. This review included three studies (39, 42, 44) that were included in a previous
16 systematic review, (24) but differed in interpretation because effect sizes (Cohen's *d*) and
17 behavior change techniques were extracted. Throughout screening it was apparent that
18 interventions tended to measure people's intentions to protect their hearing, as opposed to
19 their actual hearing protection behaviors, (48 – 52) with a total of 13 papers rejected on this
20 basis. Intentions do not represent the true effect of an intervention as people fail to act on
21 their intentions approximately 50% of the time, (53) and this is an area that needs to be
22 addressed with future hearing protection interventions.

23 The most common hearing protection behavior reported in each study was the use of
24 earplugs. This supports previous evidence that hearing protection devices are the most
25 accessible preventive method against overexposure to recreational noise. (18, 48, 54). While

1 examining the effectiveness of the studies five indicated a small to medium effect (Cohen's
2 *d*), measuring an increase, or difference, in earplug use across a range of recreational
3 contexts. However, those five studies had strong risk of bias, particularly detection bias
4 (blinding of outcome assessment), with poorly reported methodologies affecting replication
5 credentials.

6 The overall increase in 'ever-performers' of earplugs across all eight studies ranged from 3%
7 – 14.6%; few studies indicate people always or often use earplugs, indicating many people
8 are at risk of hearing symptoms in a short space of time, (13, 14) when these activities often
9 have noise levels recorded at over 100 dBA (10 -12). Beach et al. (43) was the outlier of the
10 group with 90% of all participants 'ever-performers'; however, 82% were 'ever-performers'
11 pre-study, which was perhaps due to targeting regular gig goers with an incentive of free
12 earplugs. The present systematic review also highlights that preventative behaviors such as
13 regeneration breaks, keeping safe distances, lowering sound levels, and adherence to
14 legislations are less frequently addressed and should be avenues for future research.

15 Unique to the present systematic review was the coding of behavior change techniques
16 deployed within hearing protection interventions, with a total of 17 coded as involving
17 behavior change from a possible 93 techniques, the majority of which link to the intervention
18 function 'education' (information about health consequences: BCTTv1:5.1). With so few
19 techniques being identified it leaves a large scope to deploy previously untested techniques to
20 bring about changes in hearing protection behaviors. Coding did reveal other less frequently
21 used intervention functions, such as 'environmental restructuring' (adding objects to the
22 environment: BCTTv1:12.5), that yielded consistent effect sizes when implemented. This
23 particular deployment provided the most reliable relationship throughout the review; it was
24 seen in all three experimental post-test studies, which provided earplugs within the

1 environment, and all three measured a small to medium effect, for at least one recreational
2 context. ‘Environmental restructuring’ should thus be considered for future recreational
3 hearing protection interventions. Based on coding it would also be valuable to try other
4 approaches in conjunction with environmental restructuring, such as incentivization (material
5 incentive (behavior): BCTTv1.10.1), enablement (prompts and cues: BCTTv1:7.1) and
6 modeling (salience of consequences: BCTTv1:5.2).

7 Studies indicate a lack of theory applied during the design process, or at least a lack of a
8 description of theory within the methodologies. These issues have been raised by health
9 psychologists previously, in that researchers face an uphill battle to replicate interventions to
10 further test outcomes, (30, 55) due in part to poor reporting. Although one included paper
11 applied the theory of planned behavior to design the evaluation questionnaires, (44) none of
12 the included studies explicitly describes the use of theory for intervention design. The
13 importance of behavior change theory and models (e.g., COM-B model) in hearing healthcare
14 has been noted in the past, (28, 29) but appears still to be lacking within recreational hearing
15 protection interventions. Therefore we would suggest better quality and more robust studies,
16 achieved through use of theory and evidence, which will help target specific behavior change
17 techniques and intervention functions to be incorporated in an effort to raise effect sizes. This
18 use of theory driven practice will address gaps in knowledge in terms of quality and reporting
19 for future systematic reviews, and help aid replication of interventions.

20 Limitations of this review include the inability to retrieve all data from the authors who were
21 contacted directly. The provision of results that were missing or unclear in the original
22 publications may have enabled a meta-analysis to be performed.

23

24 **Conclusions**

1 The present systematic review found very few hearing protection interventions addressing
2 recreational noise exposure, a global hearing health concern. However, ‘environmental
3 restructuring’ through the provision of earplugs (adding objects to the environment:
4 BCTTv1:12.5), showed promise and might be considered a starting point for future
5 interventions. Further hearing protection intervention studies should be conducted that
6 employ randomized controlled designs, use systematic approaches to intervention
7 development (e.g., the behavior change wheel (27)), consider intervention functions beyond
8 education, such as incentivization (e.g., material incentive (behavior): BCTTv1.10.1),
9 enablement (e.g., prompts and cues: BCTTv1:7.1) and modeling (e.g., salience of
10 consequences: BCTTv1:5.2), and consider deploying previously unused behavior change
11 techniques. Self-reported use of hearing protection has been widely used as a main outcome
12 measure, but more objective assessments through observation or technological solutions
13 would reduce the risk of reporting bias.

14

15 **Abbreviations**

| | | |
|----|--------|--|
| 16 | BCTTv1 | Behavior Change Technique Taxonomy Version 1 |
| 17 | CASP | Critical Appraisal Skills Program |
| 18 | COM-B | Capability, Opportunity and Motivation model of Behavior |
| 19 | dBA | A-weighted Decibel |
| 20 | DIY | Do-it-yourself |
| 21 | MeSH | Medical Subject Heading |

22 **Declarations**

1 **Ethics Approval and Consent to Participate**

2 Not applicable

3 **Consent for Publication**

4 Not applicable

5 **Availability of Data and Materials**

6 The datasets used and/or analysed during the current study are available from the
7 corresponding author on reasonable request.

8 **Competing Interests**

9 There are no conflicts of interest to report.

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15 access to data and had final responsibility to submit for publication.

16

17 **Authors Contributors**

18 ML and CJA conceived the project, designed the study, and wrote the first draft of the
19 manuscript. ML carried out database searches, screened titles, abstracts and full texts,
20 extracted data from citations, prepared for analyses, carried out analyses and scored quality.
21 CJA provided full supervision to ML throughout all stages. SL provided assistance with

1 screening titles, abstracts and full texts, data extraction and analyses. SL scored quality and
2 helped resolve conflicts. CJA helped resolve conflicts for inclusion of articles, data extraction
3 and data analyses. SL and CP helped prepare the final manuscript. CP provided secondary
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8 The views expressed are those of the authors and not necessarily those of the NHS, the NIHR
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1 **Table 1 – Inclusion table with effect estimates and behavior change techniques**

| <i>Paper and Study Design</i> | <i>Study Aims</i> | <i>Characteristics</i> | <i>Behavior Change Techniques (BCTTv1)*</i> | <i>Outcome measures</i> | <i>Effect estimate</i> |
|--|--|---|---|---|---|
| <p>Beach et al, 2016 <i>Australia</i></p> <p>Experimental post-test design</p> | <p>Examine whether the presentation of hearing health information would result in increased use of earplugs, or whether provision of earplugs alone would be sufficient to change behavior.</p> <p>Experimental group (high level information) vs control group (low level information)</p> | <p>Age range: 20 – 39 Median age: 26, Average age: 27.1</p> <p>Initial recruitment: 14 females and 37 males</p> | <p>3.2. Social support (practical)</p> <p>4.1. Instruction on how to perform a behavior</p> <p>5.1. Information about health consequences</p> <p>5.2. Salience of consequences</p> <p>6.1. Demonstration of the behavior</p> <p>9.1. Credible source</p> <p>10.1. Material incentive (behavior)</p> <p>10.2. Material reward (behavior)</p> <p>12.5. Adding objects to the environment</p> | <p>Main: earplug use in music venues</p> <p>Time point: 16 week follow up</p> <p>Earplug use: Control: 85.7% Experimental: 94.4%</p> | <p>RR = 1.1</p> <p>95% CI = 0.9 - 1.36</p> <p>Z = 0.916</p> <p>Cohen's <i>d</i> = 0.3 (small to medium effect)</p> |
| <p>Cha et al, 2015 <i>Canada</i></p> <p>Experimental post-test design</p> | <p>To provide information at three rock concerts (150 - 300 capacity) advertising free orange foam earplugs (intervention). With comparison to three other concerts with no earplugs available (control). The study wanted to measure and compare prevalence of earplug use at baseline (control) and when earplugs were available (intervention).</p> | <p>No age provided</p> <p>955 participants; 318 intervention group (218 males, 100 females)</p> <p>637 control group (410 males, 227 females)</p> | <p>7.1. Prompts/cues</p> <p>10.1. Material incentive</p> <p>12.5. Adding objects to the environment</p> | <p>Main: earplug use at Rock and Roll concerts</p> <p>Time point: In real time during concerts</p> <p>Earplug use: Control: 1.3% Intervention: 8.2%</p> | <p>RR = 6.51</p> <p>95% CI = 2.98 - 14.22</p> <p>Z = 4.702</p> <p>Cohen's <i>d</i> = 0.31 (small to medium effect)</p> |
| <p>Gilles & Van de Heyning, 2014 <i>Belgium</i></p> <p>Single group pretest-posttest design</p> | <p>Governmental preventive campaign (PrevC) to help prevent hearing damage caused by noise exposure. It was promoted via various ways such as television and radio commercials, social network sites (Facebook/Twitter), posters and a website. The campaign wanted to make young people more aware of the risks of loud music and therefore increase the use of hearing protection in noisy environments.</p> | <p>547 school children aged between 14 – 18 years</p> <p>Mean age = 16.8</p> | <p>5.1. Information about health consequences</p> | <p>Main: hearing protection use in noisy recreational environments</p> <p>Time point: 6 months post intervention</p> <p>Earplug use: Baseline: 3.7% Follow up: 14.3%</p> | <p>RR = 3.9</p> <p>95% CI = 2.42 – 6.28</p> <p>Z = 5.594</p> <p>Cohen's <i>d</i> = 0.34 (small to medium effect)</p> |
| <p>Keppler et al, 2015 <i>Belgium</i></p> <p>Single group pretest-posttest design</p> | <p>The study aim was to evaluate the effect of a hearing education program, including: attitudes and beliefs toward noise, hearing loss, and hearing protection device use in young adults.</p> | <p>18 years - 30 years</p> <p>Median age = 21.01</p> <p>68 females; 10 males</p> | <p>2.6. Biofeedback</p> <p>4.1. Instruction on how to perform a behavior</p> <p>5.1. Information about health consequences</p> | <p>Main: hearing protection use during noisy recreational activities</p> <p>Time point: 6 months post intervention</p> | <p>Baseline: mean score = 3.40 S.D = 1.36</p> <p>Follow up: mean score = 2.94</p> |

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| | | | <p>5.3. Information about social and environmental consequences</p> <p>9.1. Credible source</p> <p>9.2. Pros and cons</p> | Answers on 5 point Likert scale; closer to 1 equals improvement | <p>S.D = 1.37</p> <p>Cohen's <i>d</i> = 0.34 (small to medium effect)</p> <p>Baseline and follow up data supplied by authors</p> |
| <p>Marlenga et al, 2011 USA</p> <p>Experimental post-test design</p> | <p>This paper is the 16 year longitudinal follow up of the rural hearing conservation intervention that is also the basis of the Berg et al (2009**) study. The aim was to assess if the prevalence of hearing loss was reduced and that the use of hearing protection was maintained over the 16 year period.</p> <p>Berg et al. (2009**) described the historic intervention in more detail and it is from this paper that the behavior change techniques were coded.</p> | <p>Intervention group: 200 total 74.3% Male Median age = 31.2</p> <p>Control group: 192 total 61.9% Male Median age = 30.8</p> | <p>5.1. Information about health consequences</p> <p>5.2. Salience of consequences</p> <p>6.1. Demonstration of the behavior</p> <p>8.1. Behavioral practice/rehearsal</p> <p>8.3. Habit formation</p> <p>9.1. Credible source</p> <p>12.5. Adding objects to the environment</p> | <p>Main: Earplug use during all recreational activities and gunfire. Stereo volume control for personal stereos</p> <p>Time Point: 16 year follow up</p> <p>Earplug use all recreational activities: Control: 16.9% Intervention: 20.4%</p> <p>Personal stereos: Control: 60.1% Intervention: 62.3%</p> <p>Earplug use gunfire: Control: 41.6% Intervention: 56.2%</p> | <p>All recreational activities: RR = 1.15 95% CI = 0.75 – 1.78 Z = 0.62 Cohen's <i>d</i> = 0.07 (no effect)</p> <p>Personal stereos: RR = 1.03 95% CI = 0.81 – 1.30 Z = 0.23 Cohen's <i>d</i> = 0.03 (no effect)</p> <p>Gunfire: RR = 1.37 95% CI = 1.04 – 1.80 Z = 2.23 Cohen's <i>d</i> = 0.3 (small to medium effect)</p> |
| <p>Neyen, 2003 Germany</p> <p>Single group pretest-posttest design</p> | <p>To assess music listening habits using questionnaires before and after a teaching unit; "hearing damage caused by loud music". The study wanted to assess the extent of the transfer of knowledge and if there are any changes in awareness and behavior, including use of hearing protection at loud music events.</p> | <p>1674 participants in study; 873 male; 801 female</p> | <p>5.1. Information about health consequences</p> <p>5.2. Salience of consequences</p> <p>9.3. Comparative imaging of future outcomes</p> | <p>Main: hearing protection use at loud events</p> <p>Time point: 5/6 weeks post teaching session</p> <p>Hearing protection use: Baseline: 14.8% Follow up: 19.8%</p> | <p>RR = 1.34</p> <p>95% CI = 1.41 – 1.58</p> <p>Z = 3.614</p> <p>Cohen's <i>d</i> = 0.14 (no effect)</p> |
| <p>Weichbold & Zorowka, 2003 Austria</p> <p>Single group pretest-posttest design</p> | <p>To measure the effects of a hearing campaign on the frequency of attendance of high school children at discotheques and whether they used hearing protection.</p> | <p>Baseline: 54 male and 115 female (169)</p> <p>Post intervention: 34 male and 93 female (136)</p> <p>Pre mean age = 16.9 Post mean age = 17.9</p> | <p>4.1. Instruction on how to perform a behavior</p> <p>5.1. Information about health consequences</p> <p>5.2. Salience of consequences</p> <p>6.1. Demonstration of the behavior</p> | <p>Main: earplug use at discotheques</p> <p>Time point: 1 year post intervention</p> <p>Earplug use: Baseline: 0% Follow up: 3.8%</p> | <p>RR = 14.17</p> <p>95% CI = 0.8 – 253.9</p> <p>Z = 1.80</p> <p>Cohen's <i>d</i> = 0.21 (small effect)</p> |

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| <p>Weichbold & Zorowka, 2007 <i>Austria</i></p> <p>Single group pretest-posttest design</p> | <p>The study aims were the same as the previous study (Weichbold & Zorowka, 2003) with additional target behavior on taking regeneration breaks when exposed to noise at music events.</p> | <p>1757 participants at baseline</p> <p>1535 at follow up</p> <p>Age pre-campaign: 16.2 +/- 1.3 years. Age post campaign: 17.0 +/- 1.2years.</p> | <p>4.1. Instruction on how to perform a behavior</p> <p>5.1. Information about health consequences</p> <p>6.1. Demonstration of the behavior</p> <p>8.1. Behavioral practice/rehearsal</p> <p>9.1. Credible source</p> <p>12.1. Restructuring the physical environment</p> | <p>Main: earplug use and taking regeneration breaks at discotheques</p> <p>Time point: 1 year post intervention</p> <p>Earplug use: Baseline: 3.5% Follow up: 6.5%</p> <p>Regeneration breaks: Baseline: 89.9% Follow up: 91.7%</p> | <p>Hearing protection: RR = 1.84 95% CI = 1.36 – 2.52 Z = 3.885 Cohen's d = 0.14 (no effect)</p> <p>Regeneration breaks: RR = 1.02 95% CI = 1 – 1.04 Z = 1.772 Cohen's d = 0.06 (no effect)</p> |
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1 * The behavior change techniques are coded according to the reference numbers provided within the behavior change technique taxonomy version 1, (BCTTv1) with the first
2 digit associated to one of the 16 groups of clusters, and the second the order of the technique within said group (e.g., habit formation: BCTTv1:8.1). Michie S, Richardson M,
3 Johnston M, Abraham C, Francis J, Hardeman W, Eccles MP, Cane J, Wood CE. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques:
4 building an international consensus for the reporting of behavior change interventions. *Annals of behavioral medicine*. 2013 Mar 20;46(1):81-95.

5 ** Berg RL, Pickett W, Fitz-Randolph M, Broste SK, Knobloch MJ, Wood DJ, Kirkhorn SR, Linneman JG, Marlenga B. Hearing conservation program for agricultural
6 students: short-term outcomes from a cluster-randomized trial with planned long-term follow-up. *Preventive medicine*. 2009 Dec 1;49(6):546-52.

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1 **Figure 1 - Cochrane Risk of Bias Table**

| | 2 | 3 | 4 | 5 | 6 | 7 |
|-------------------------------|--|---|---|---|--|--------------------------------------|
| | Random sequence generator (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) |
| Beach et al, 2015 | | | | | | |
| Cha et al, 2015 | | | | | | |
| Gilles & Van de Heyning, 2014 | | | | | | |
| Keppler et al, 2015 | | | | | | |
| Marlenga et al, 2011 | | | | | | |
| Neyen, 2003 | | | | | | |
| Weichbold & Zorowka, 2003 | | | | | | |
| Weichbold & Zorowka, 2007 | | | | | | |

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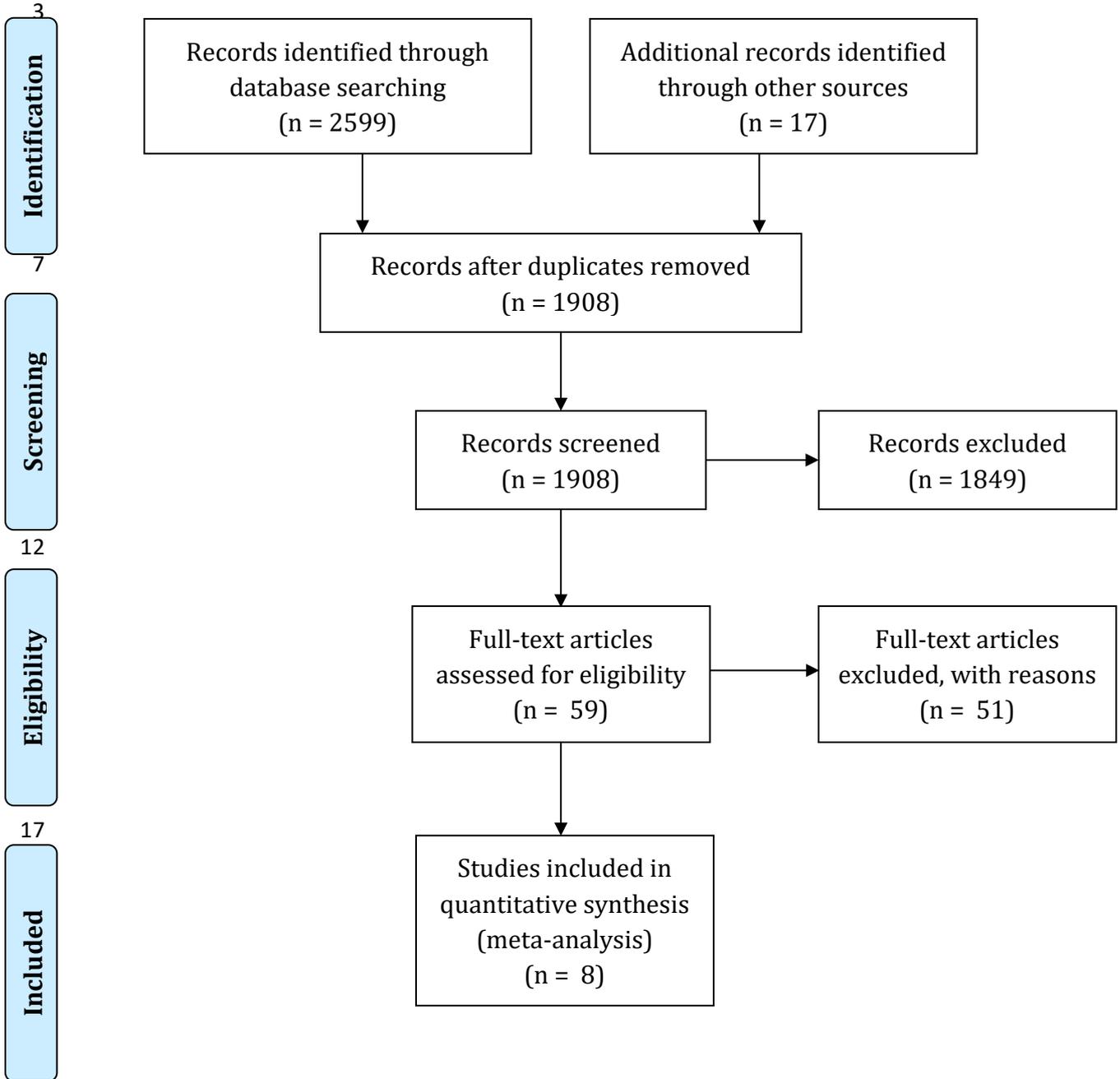
25 Low risk of bias

26 Moderate risk of bias

27 Strong risk of bias

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2 **Figure 2 – Preferred Reporting Items for Systematic Reviews and Meta-Analyses Flow Diagram**



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1 **Additional File 1 – Search Strategy Supplement**

2 **WEB OF SCIENCE**

| | |
|-----|---|
| #1 | Noise OR music |
| #2 | reduction OR abatement OR diminishment OR elimination |
| #3 | "hearing loss prevention" OR "hearing conservation" OR "hearing surveillance" OR "hearing education" OR "hearing protection behaviour" OR "hearing protection behavior" OR "hearing protection intervention" |
| #4 | Live music legislation* OR live music regulation* OR noise legislation* OR noise regulation* |
| #5 | Behavio* OR behavio* change |
| #6 | "ear protective device" OR "ear protective devices" OR "hearing protective device" OR "hearing protective devices" OR "hearing protector" OR "hearing protectors" OR "hearing protection" OR "ear muffs" OR "ear plugs" OR "ear defenders" OR "earplugs" OR " earmuffs" |
| #7 | Recreation* OR leisure |
| #8 | hearing OR hearing protect* |
| #9 | concert OR festival OR nightclub OR discotheque OR bar OR pub |
| #10 | Leisure activities OR firearms OR firearm* OR motorcycles OR motorcycle* OR motorbike* OR motor sport* OR sporting event* OR lawn mower* OR leaf blower* OR power tool* OR DIY |
| #11 | "Hearing loss" OR "noise induced hearing loss" OR "recreational noise induced hearing loss" OR "tinnitus" OR "noise induced" OR "recreational noise induced hearing loss" OR "noise damage" OR "noise reduction" |
| #12 | Noise OR hearing OR hearing protect* |
| #13 | #1 AND #2 |

| | |
|-----|--------------------------------------|
| #14 | #1 AND #7 |
| #15 | #1 AND #8 |
| #16 | #1 OR #8 |
| #17 | #10 AND #12 |
| #18 | #9 AND #16 |
| #19 | #5 AND #16 |
| #20 | #3 OR #4 OR #6 OR #13 OR # 19 |
| #21 | #14 OR #17 OR #18 |
| #22 | #11 AND #20 AND #21 |

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2 **COMDISDOME**

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|----|---|
| #1 | Noise OR music |
| #2 | reduction OR abatement OR diminishment OR elimination |
| #3 | "hearing loss prevention" OR "hearing conservation" OR "hearing surveillance" OR "hearing education" OR "hearing protection behaviour" OR "hearing protection behavior" OR "hearing protection intervention" |
| #4 | Live music legislation* OR live music regulation* OR noise legislation* OR noise regulation* |
| #5 | Behavio* OR behavio* change |
| #6 | "ear protective device" OR "ear protective devices" OR "hearing protective device" OR "hearing protective devices" OR "hearing protector" OR "hearing protectors" OR "hearing protection" OR "ear muffs" OR "ear plugs" OR "ear defenders" OR "earplugs" OR " earmuffs" |
| #7 | Recreation* OR leisure |

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|-----|--|
| #8 | hearing OR hearing protect* |
| #9 | concert OR festival OR nightclub OR discotheque OR bar OR pub |
| #10 | Leisure activities OR firearms OR firearm* OR motorcycles OR motorcycle* OR motorbike* OR motor sport* OR sporting event* OR lawn mower* OR leaf blower* OR power tool* OR DIY |
| #11 | “Hearing loss” OR “noise induced hearing loss” OR “recreational noise induced hearing loss” OR “tinnitus” OR “noise induced” OR “recreational noise induced hearing loss” OR “noise damage” OR “noise reduction” |
| #12 | Noise OR hearing OR hearing protect* |
| #13 | #1 AND #2 |
| #14 | #1 AND #7 |
| #15 | #1 AND #8 |
| #16 | #1 OR #8 |
| #17 | #10 AND #12 |
| #18 | #9 AND #16 |
| #19 | #5 AND #16 |
| #20 | #3 OR #4 OR #6 OR #13 OR # 19 |
| #21 | #14 OR #17 OR #18 |
| #22 | #11 AND #20 AND #21 |

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OVID: Embase, PsycINFO, Medline, DARE , CDSR, CENTRAL

Noise OR music AND (reduction OR abatement OR diminishment OR elimination)

OR

hearing loss prevention OR hearing conservation OR hearing surveillance OR hearing education OR hearing protect*

OR

ear protect* OR ear muffs OR ear plugs OR ear defenders OR earplugs OR earmuffs

OR

Live music legislation* OR live music regulation* OR noise legislation* OR noise regulation*

OR

Behavio* change AND (noise OR music OR recreational OR leisure)

AND

Noise OR music AND (recreation* OR leisure)

OR

Music OR noise OR hearing OR hearing protect* AND (concert OR festival OR nightclub OR discotheque OR bar OR pub)

OR

Leisure activities OR firearms OR firearm* OR motorcycles OR motorcycle* OR motorbike* OR motor sport* OR sporting event* OR lawn mower* OR leaf blower* OR power tool* OR DIY AND (noise OR hearing OR hearing protect*)

AND

1 Hearing loss OR noise induced hearing loss OR recreational noise induced hearing loss OR tinnitus
2 OR noise induced OR recreational noise induced hearing loss OR noise damage OR noise reduction

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5 **PubMed**

6 Noise OR music AND (reduction OR abatement OR diminishment OR elimination)

7 **OR**

8 "hearing loss prevention" OR "hearing conservation" OR "hearing surveillance" OR "hearing
9 education" OR "hearing protection behaviour" OR "hearing protection behavior" OR "hearing
10 protection intervention"

11 **OR**

12 "ear protective device" OR "ear protective devices" OR "hearing protective device" OR "hearing
13 protective devices" OR "hearing protector" OR "hearing protectors" OR "hearing protection" OR "ear
14 muffs" OR "ear plugs" OR "ear defenders" OR "earplugs" OR " earmuffs"

15 **OR**

16 Live music legislation* OR live music regulation* OR noise legislation* OR noise regulation*

17 **OR**

18 Behavio* AND change AND (noise OR music OR recreational OR leisure)

19 **AND**

20 Noise OR music AND (recreation* OR leisure)

21 **OR**

22 Music OR noise OR hearing OR hearing protect* AND (concert OR festival OR nightclub OR
23 discotheque OR bar OR pub)

24 **OR**

25 Leisure activities OR firearms OR firearm* OR motorcycles OR motorcycle* OR motorbike* OR
26 motor sport* OR sporting event* OR lawn mower* OR leaf blower* OR power tool* OR DIY AND
27 (noise OR hearing OR hearing protect*)

28 **AND**

- 1 Hearing loss OR noise induced hearing loss OR recreational noise induced hearing loss OR tinnitus
- 2 OR noise induced OR recreational noise induced hearing loss OR noise damage OR noise reduction
- 3
- 4

1 *Additional File 2 - Supplement Table*

| <i>Paper</i> | <i>Participant Results</i> | <i>Intervention Type</i> | <i>Recruitment</i> |
|--|---|---|--|
| <p>Beach et al, 2016 <i>Australia</i></p> <p>Experimental post-test design</p> | <p>High information group: 18 total; 17 used earplugs (ever performers)</p> <p>Low information group: 21 total; 18 used earplugs (ever performers)</p> | <p>Hearing conservation/education program.</p> <p>All participants provided with free earplugs and shown how to use by an audiologist.</p> <p>High information group received additional material: 3 minute video presentation, 2 page brochure, 2 additional emails of audio simulation and link to music focused noise reduction campaign</p> | <p>People who attend loud events.</p> <p>Advertisements on music websites.</p> <p>Contacted by telephone and a face to face interview arranged. 82% of those recruited said they had used earplugs in the past.</p> |
| <p>Cha et al, (2015) <i>Canada</i></p> <p>Experimental post-test design</p> | <p>318 in intervention group; 26 wore earplugs (ever performers)</p> <p>637 in control group; 8 wore earplugs (ever performers)</p> | <p>Provision of free earplugs</p> <p>Earplug provision alongside signage of free earplugs being available (intervention)</p> <p>No free available earplugs and no signage (control)</p> | <p>Two venues of similar size and capacity were chosen across six similar type concerts.</p> <p>Recruitment depended upon the number of attendees that attended each concert.</p> |
| <p>Gilles & Van de Heyning, (2014) <i>Belgium</i></p> <p>Single group pretest-posttest design</p> | <p>547 at baseline; 20 used earplugs (ever performers)</p> <p>547 at follow up; 78 used earplugs (ever performers)</p> <p>(data supplied by author)</p> | <p>Government advertising campaign</p> <p>Intervention implemented through uses such as television and radio commercials, social media sites (Facebook/Twitter), posters and a website.</p> <p>Comparing before and after questionnaires within the cohort</p> <p>No hearing protection devices provided</p> | <p>Schools were contacted by the research team and if the school agreed written communication was sent out, including the questionnaire. The principle of the school could then administer the questionnaires at baseline and post intervention.</p> |
| <p>Keppler et al, 2015 <i>Belgium</i></p> <p>Single group pretest-posttest design</p> | <p>n = 78 pre and post</p> <p>(means and standard deviation supplied by author)</p> | <p>Hearing conservation/education program.</p> <p>Two sessions in which questionnaires administered. Hearing tests also completed at both sessions. Feedback on hearing was given after the first test. All then received an education teaching session from an audiologist on a one-one basis; discussing dangers of recreational noise and preventative measures.</p> <p>No hearing protection devices provided</p> | <p>Unclear - states young adults participated voluntarily.</p> |

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| <p>Marlenga et al, 2011 <i>USA</i></p> <p>Experimental post-test design</p> | <p>Hearing protection reported as adjusted mean (%) of time used</p> <p>All recreational activities Control: n =163; mean =16.9% Intervention: n =181; mean =20.4%</p> <p>Personal Stereos Control: n =93; mean =60.1% Intervention: n =84; mean =62.3%</p> <p>Gunfire Control: n =104; mean =41.6% Intervention: n =131; mean =56.2%</p> | <p>Hearing conservation/education program.</p> <p>The original 3 year intervention included a classroom teaching session with the distribution of hearing protection. The intervention was reinforced by mailing the participants information at different time points throughout, as well as making hearing protection available at different time points.</p> | <p>392 participants from the original study were recruited through searching medical records, telephone directories and internet searches. Efforts were then made to make contact and await replies.</p> |
| <p>Neyen, 2003 <i>Germany</i></p> <p>Single group pretest-posttest design</p> | <p>1565 at baseline; 231 had used earplugs (ever performers)</p> <p>1362 at follow up; 270 had used earplugs (ever performers)</p> | <p>Hearing conservation/education program.</p> <p>Involved a teaching unit about how loud music can cause hearing damage. A questionnaire was administered before and directly after the teaching session. A third was administered 5/6 weeks post session. The teaching lesson discussed the physics of sound/music, structure of hearing, symptoms of overexposure (hearing loss/tinnitus). The session was delivered by the differing school teachers during their normal classroom time.</p> | <p>Each school was approached and asked if they would like to participate, with consent letters sent out to parents; 14 schools recruited; totalling 92 classes</p> <p>1565 participants answered hearing protection questions at baseline; 1362 at follow up</p> |
| <p>Weichbold & Zorowka 2003 <i>Austria</i></p> <p>Single group pretest-posttest design</p> | <p>169 at baseline; 0 used earplugs (ever performers)</p> <p>131 at follow up; 5 used earplugs (ever performers)</p> | <p>Hearing conservation/education program</p> <p>Program called "PROjectEAR". Consisted of four 45-minute sessions over three days which included: lectures, media presentations, group work, presentation of hearing protection devices/hearing aids, practical exercises and role-play. Participants received information on: function of ear, importance in life, adverse effects of hearing loss on everyday activities. Particularly damaged caused by continuous exposure to recreational noise.</p> <p>No hearing protection devices provided</p> | <p>PROjectEAR campaign took place at 6 high schools</p> |
| <p>Weichbold & Zorowka 2007 <i>Austria</i></p> | <p>Hearing protection: 1757 at baseline; 62 used earplugs (ever performers)</p> | <p>Intervention design remained the same as the 2003 study (PROjectEAR)</p> <p>No hearing protection devices provided</p> | <p>Austrian schools that have the campaign in the curriculum since 2002.</p> |

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| Single group pretest-posttest design | 1535 at follow up; 100 used earplugs (ever performers) Regeneration breaks: 1757 at baseline; 1580 took breaks (ever performers) 1535 at follow up; 1407 took breaks (ever performers) | | |
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