

BMJ Open Can nudge-interventions address health service overuse and underuse? Protocol for a systematic review

Mary O'Keeffe,¹ Adrian C Traeger,¹ Tammy Hoffmann,² Giovanni Esteves Ferreira,¹ Jason Soon,³ Christopher Maher¹

To cite: O'Keeffe M, Traeger AC, Hoffmann T, *et al.* Can nudge-interventions address health service overuse and underuse? Protocol for a systematic review. *BMJ Open* 2019;**9**:e029540. doi:10.1136/bmjopen-2019-029540

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2019-029540>).

Received 31 January 2019

Revised 15 March 2019

Accepted 24 May 2019



© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Institute for Musculoskeletal Health, Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Sydney, New South Wales, Australia

²Bond University, Gold Coast, Queensland, Australia

³Royal Australasian College of Physicians, Sydney, New South Wales, Australia

Correspondence to

Dr Mary O'Keeffe;
mary.okeeffe@sydney.edu.au

ABSTRACT

Introduction Nudge-interventions aimed at health professionals are proposed to reduce the overuse and underuse of health services. However, little is known about their effectiveness at changing health professionals' behaviours in relation to overuse or underuse of tests or treatments.

Objective The aim of this study is to systematically identify and synthesise the studies that have assessed the effect of nudge-interventions aimed at health professionals on the overuse or underuse of health services.

Methods and analysis We will perform a systematic review. All study designs that include a control comparison will be included. Any qualified health professional, across any specialty or setting, will be included. Only nudge-interventions aimed at altering the behaviour of health professionals will be included. We will examine the effect of choice architecture nudges (default options, active choice, framing effects, order effects) and social nudges (accountable justification and pre-commitment or publicly declared pledge/contract). Studies with outcomes relevant to overuse or underuse of health services will be included. Relevant studies will be identified by a computer-aided search of the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library), MEDLINE, CINAHL, Embase and PsycINFO databases. Two independent reviewers will screen studies for eligibility, extract data and perform the risk of bias assessment using the criteria recommended by the Cochrane Effective Practice and Organisation of Care (EPoC) group. We will report our results in a structured synthesis format, as recommended by the Cochrane EPoC group.

Ethics and dissemination No ethical approval is required for this study. Results will be presented at relevant scientific conferences and in peer-reviewed literature.

INTRODUCTION

Health professionals' underuse and overuse of health services (eg, medications, screening tests, diagnostic tests and treatments) are major problems worldwide.^{1 2} The ways in which health professionals make choices influence this overuse and underuse, and ultimately the value and outcomes of patient care.^{1 3}

Strengths and limitations of this study

- This will be the first review to explicitly examine the effect of nudge-interventions aimed at health professionals on the overuse and underuse of health services.
- This review has a comprehensive search strategy, will include many study designs, all health disciplines and outcomes related to overuse or underuse of any test or treatment.
- Nudge-interventions lack definitional and conceptual clarity and make the inclusion and exclusion criteria difficult to define.
- Only English language studies will be included.
- The results may be able to inform future strategies to address health service overuse and underuse.

There are many examples of the overuse of inappropriate care.^{4 5} This involves health professional provision of medical services that are discouraged by clinical guidelines because they are likely to cause more harm than good, or provide little to no clinical benefit. For example, a study in China found that 57% of patients received antibiotics inappropriately⁶; rates of inappropriate total knee replacement were 26% in Spain and 34% in the USA⁷; the Lancet low back pain (LBP) series^{8–10} displayed the worldwide overuse of surgery, opioids and imaging for LBP; and arthroscopic surgery for degenerative knee disease, a procedure known to be ineffective, is performed more than 2 million times a year across the world.^{11 12} A slightly different example is the prescribing of expensive brand name medications that have existing generic equivalents. For example, a study in the USA found that in 2009, Medicaid spent an unnecessary \$329 million that could have been saved by using generic instead of brand name medications.¹³ Overuse of screening tests for cancer has also been documented.¹⁴ Examples include inappropriate screening for cervical cancer,¹⁵ mammography screening for breast cancer^{16 17} and thyroid cancer screening.^{18–20}

There are also several examples of the underuse of appropriate care that is known to improve health.³ For example, the CareTrack study²¹ in Australia found that only 57% of patients received appropriate care across 35 573 healthcare encounters. A 2003 US study²² found that only 55% of patients in the USA received recommended care. High quality studies have displayed the underuse of anticoagulation in patients with atrial fibrillation who are at high risk of stroke^{23–25} and the underuse of beta blockers for patients who have had a myocardial infarction.^{26–27} There is also underuse of effective non-pharmacological treatments, including advice for acute LBP^{28–29} and exercise prescription for a range of chronic conditions including heart failure, osteoarthritis and chronic fatigue.^{30–33} Both underuse and overuse can drive physical, psychological and social harms for patients, and the wasteful misallocation of resources.^{1,2}

Numerous drivers of overuse and underuse of health services have been documented.^{1–4} Thinking strategies at the level of the health professional have been proposed as one driver of these problems.² Psychological research has identified strategies of cognition^{34–35} that influence health professional judgements in situations of uncertainty and exert a powerful influence on decision-making in healthcare.^{2,36} It is suggested that health professionals exhibit ‘predictable’ bounded rationality.^{37–40} That is, when making decisions, rather than being rational economic optimisers, they follow mind lines (internalised tacit guidelines on how to manage common problems)⁴¹ and heuristics^{35,39,42–44} (‘common sense’, educated guesses, mental rules of thumb or short cuts). Because rapid, high-volume clinical decision-making is part of the everyday routine of health professionals and requires combining and synthesising diverse data and performing complex trade-offs between benefits and risks, these mostly unconscious heuristics can be adaptive and accurate.^{2,39,45} However, this intuitive decision-making can also be dysfunctional and lead to skewed judgement.^{37,38} For example, health professionals underestimate the harms and overestimate the benefits of many tests and treatments.⁴⁶ Nineteen different types of heuristics and cognitive biases in clinical decision-making have been discussed.³⁵ Types frequently mentioned in health service improvement conversations^{44,47–50} include default bias or status quo bias (a preference for the current state of affairs), framing effects (influenced by the expression of the same information in different ways), loss aversion (care much more about avoiding losses than care about making gains), order effects (influenced by the different order of the same information), norms (tendency to uphold one’s reputations based on peer or social norms) and the salience effect (influenced by the distinctiveness of important material).

Researchers have started to focus on ways of harnessing these cognitive biases and heuristics to influence health professional judgements, choices and behaviours. This has led to increasing interest in the field of social psychology and behavioural economics. The concept

of nudge,^{51–53} in particular, has been proposed as one method of promoting ‘right healthcare’.^{47,54–57} Nudge was popularised in 2008 following the publication of the book *Nudge: Improving Decisions about Health, Wealth, and Happiness* by Thaler and Sunstein.⁵¹ They defined a nudge as ‘any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives’. In this way, choice architecture refers to the context in which people choose and make decisions. The definition of nudge has since been updated to provide further clarity for researchers and policy-makers.⁵³ The updated definition is:

‘A nudge is a function of any attempt at influencing people’s judgement, choice or behaviour in a predictable way that is

1. Made possible because of cognitive boundaries, biases, routines and habits in individual and social decision-making posing barriers for people to perform rationally in their own self-declared interests, and
2. Which works by making use of those boundaries, biases, routines and habits as integral parts of such attempts.

The nudge works independently of

- a. Forbidding or adding any rationally relevant choice options,
- b. Changing incentives, in terms of time, trouble, social sanctions, economic and so forth, or
- c. The provision of factual information and rational argumentation.⁵³

Nudge-interventions are classed as light-touch behaviour change strategies.⁵⁸ It is proposed that nudge, through making subtle, but purposeful, changes in how choices and information are presented and framed (the choice architecture)^{58,59} in the clinician environment, may tap into clinician automatic cognitive processes (heuristics) in a beneficial way and push clinicians away from both underuse and overuse of health services.^{57,60}

Nudges can be designed to remind, guide or motivate behaviour.⁵⁷ Nudges should be inexpensive and easy to implement, not involve a restriction, be implemented in the environment where the target behaviour is performed and require minimal conscious processing.^{51,58,59} Nudge is embedded in libertarian paternalism, a political philosophy in which people’s choices are actively guided in their best interests but they remain at liberty to behave differently.⁶¹ It has been suggested that nudges are often preferred over more assertive methods (eg, prohibiting the prescription of certain medications) as they do not force people to behave in a specific manner.⁶²

Some suggest that using nudges in the healthcare system may lead to reduced overuse and underuse of health services⁵⁴; and health professionals’ immediate environment and choice architecture should be purposefully designed in a way that directs them towards the provision of appropriate care. Other researchers^{63,64} have expressed concern over the potential repercussions of the hastily implementation of nudge-interventions. For example, there is a concern that nudging may drive unintended,

as well as intended, behaviour changes.^{63 64} We do not know if there is evidence that nudge-interventions are effective at changing health professionals' behaviours in relation to overuse or underuse of tests or treatments, or if results vary depending on the type of nudge, type of health professional or the target behaviour. Therefore, the objective of this review was to systematically identify and synthesise the studies that have assessed the effect of nudge-interventions aimed at health professionals on the overuse or underuse of health services.

METHODS

Search strategy

This review protocol has been registered on the PROSPERO database (CRD42019123261).

All relevant English studies meeting the inclusion criteria will be identified by a computer-aided search of the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library), MEDLINE, CINAHL, Embase and PsycINFO databases from the period of inception to May 2019. We will use the Polyglot Search Translator (<http://crebp-sra.com/#/polyglot>) to translate the search strategy across the different databases. The databases will be searched using a variety of subject headings, free text terms and synonyms relevant to the review in consultation with a librarian with expertise in systematic review searches. Initial terms will be drawn from a small set of key articles. We will use an iterative process to build the search strategy, run the search, scan the relevant retrieved articles for additional terms and then rebuild the search strategy with the newly identified relevant terms and related subject headings. The search will consist of two rows of terms which will be combined with the word 'AND'. The first row of search terms will be related to nudge-interventions. The second row of search terms will be related to the concepts of overuse and underuse of health services (see online supplementary appendix for proposed search strategy). We will conduct citation tracking for included studies in Web of Science and will perform reference checking on all included studies. In addition to database searching, we will examine the reference lists of key articles and relevant reviews (eg, Cochrane EPOC reviews), and hand search The US National Institutes of Health Clinical Trials Registry (<http://clinicaltrials.gov/>), The Australian and New Zealand Clinical Trials Registry (www.anzctr.org.au) and The WHO International Clinical Trials Registry Platform (www.who.int/ictrp/). We will contact investigators known to be involved in previous studies that have not yet been published. We will also contact published authors in the field of nudging/behavioural insights/behavioural economics and ask if they are aware of ongoing and unpublished trials. We will also review government department websites that develop and test behavioural approaches to public policy and service delivery (eg, UK and Australian 'Behaviour Insights' team websites) for eligible trials.

Inclusion/exclusion criteria

Study design

All study types that include a control comparison will be included. For example, randomised trials, non-randomised trials with concurrent controls, controlled before and after studies, controlled studies with only post-test measures and interrupted time series studies will all be included.

Population

Any qualified health professional, across any specialty or setting, will be included. Both real clinical and scenario-based studies will be eligible.

Interventions

Only nudges that are aimed at altering the behaviour of health professionals will be included. Nudge-interventions lack definitional and conceptual clarity in the healthcare setting. Based on examination of reviews already completed by the Cochrane Effective Practice and Organisation of Care (EPOC) group, extensive reading of the nudge literature^{52 54 59 65–68} and the Behaviour Change Taxonomy,⁶⁹ we will include the following categories of interventions:

Choice architecture nudges (environmental restructuring)

- ▶ Default option nudges (eg, changing the preselected number of medications in the order set menu).
- ▶ Active choice nudges.
- ▶ Framing and salient effect nudges (eg, require one additional click to order a certain test or treatment, test form redesign, test results report redesign, removal of certain tests from the main order menu, adding certain tests).
- ▶ Order effect nudges (eg, changing the order of items on an existing chart, form or order entry system).

Social nudges

- ▶ Accountable justification (eg, a requirement to justify a test request or treatment).
- ▶ Pre-commitment or publicly declared pledge/contract (eg, a health professional pre-committing to a particular behaviour by publicly signing a letter or poster).

Studies examining the following interventions will be excluded:

- ▶ Interventions that restrict the freedom of choice (eg, elimination or restricting the availability of certain tests or treatments, mandatory use of a request form).
- ▶ Regulatory or policy interventions.
- ▶ Audit and feedback. Audit and feedback has been defined as 'any summary of clinical performance of healthcare over a specified period of time' or 'clinical performance feedback'.⁷⁰ The feedback can include recommendations for clinical action and may be delivered in a written, electronic or verbal format.⁷⁰ This means brief feedback letters sent to clinician (peer-comparison or otherwise) will be excluded.

- ▶ Clinical decision support systems or new order entry systems that feature substantial changes and require health professional training and competence.
- ▶ Financial incentives to clinicians.
- ▶ Mass-media interventions.
- ▶ Educational interventions or involving an educational or training component.
- ▶ Opinion leaders.
- ▶ Charge display or price transparency. While these are minimal interventions, these interventions have been covered extensively in other systematic reviews.^{71 72}
- ▶ Computerised or paper-based reminders or alerts. Alerts are perceived as intrusive, and are therefore hard to avoid, and are not 'light touch' in nature.⁷³ Reminders have been covered extensively by the Cochrane EPOC group.⁷⁴⁻⁷⁶

Comparison

There will be no restriction on the comparator.

Outcomes

Studies with outcomes relevant to overuse or underuse of health services will be included. We define overuse as provision of an *inappropriate* test or treatment. We define underuse as failure to provide an *appropriate* test or treatment. Therefore, to evaluate overuse and underuse, all studies must report some measure of appropriateness. We will consider measures that reference clinical guidelines, best evidence, a recent policy decision, the Choosing Wisely initiative or expert clinician consensus to determine whether the test or treatment of interest was appropriate or inappropriate. Measures of appropriateness might include

- ▶ Rate of inappropriate test requests or treatments against national or international guidelines (overuse).
- ▶ Rate of not requesting appropriate tests or providing appropriate treatments against national or international guidelines (underuse).
- ▶ Rate of author-defined or hospital policy-defined 'inappropriate' test requests or treatments (ie, without specific reference to national or international guidelines) (*possible* or *grey zone* overuse).
- ▶ Rate of not providing author-defined or hospital policy-defined 'appropriate' tests or treatments (ie, without specific reference to national or international guidelines) (*possible* or *grey zone* underuse).

Studies will be excluded if they do not include a measure of appropriateness based on clinical guidelines, best evidence, a recent policy decision, the Choosing Wisely initiative or local clinical consensus.

All clinical tests and treatment behaviours will be eligible at all study time points.

Primary outcomes

Health professionals' overuse or underuse of tests or treatments

Dichotomous outcomes relating to health professionals' use of any test (eg, proportion of patients/requests for imaging, screening, laboratory tests that were appropriate/

inappropriate) or treatment (eg, proportion of patients/treatments provided (eg, medications, non-pharmacological therapies) that were appropriate/inappropriate) will be included. Where possible for dichotomous outcomes, we will report a single effect size for the study's stated primary outcome in each study. Below are examples of measuring our outcomes of interest:

Overuse and underuse expressed as proportion of patients with a specific clinical presentation

$$\% \text{ Overuse} = \frac{\text{Number of people who consulted with Clinical Presentation A and received an inappropriate test or treatment for Clinical Presentation A}}{\text{Number of people who consulted with Clinical Presentation A}}$$

$$\% \text{ Underuse} = \frac{\text{Number of people who consulted with Clinical Presentation A and failed to receive an appropriate test or treatment for Clinical Presentation A}}{\text{Number of people who consulted with Clinical Presentation A}}$$

Overuse and underuse expressed as proportion of tests or treatments provided

$$\% \text{ Overuse} = \frac{\text{Number of requests for Test A or Treatment A that were inappropriate for people who consulted with Clinical Presentation A}}{\text{Number of requests for Test A or Treatment A for people who consulted with Clinical Presentation A in total}}$$

$$\% \text{ Underuse} = \frac{\text{Number of requests for Test A or Treatment A that were appropriate for people who consulted with Clinical Presentation A}}{\text{Number of requests for Test A or Treatment A for people who consulted with Clinical Presentation A in total}}$$

Secondary outcomes

Health professionals' overuse or underuse of tests or treatments

Continuous outcomes relating to health professionals' use of testing and treatment (eg, duration of intervention, mean number of intervention sessions/provision) will be included. For continuous outcomes, we will report the results in natural units, as reported by the study authors, and extract data on the absolute or relative change in testing or treatment practices from baseline or across groups.

Patient outcomes

1. Dichotomous clinical outcomes: patient-important endpoints (eg, death, recurrence of illness).
2. Continuous clinical outcomes: various markers of disease (eg, disability, pain, quality of life, patient satisfaction, length of stay in hospital). Given our broad scope (all health conditions), it is not possible to pre-specify eligible patient outcomes. We will focus on the core patient-relevant outcomes as specified in that disease area. For example, in the LBP field, physical

functioning and health-related quality of life are considered core outcomes to measure in clinical trials.

Costs

Any measure of cost(s) of test orders, cost(s) of tests performed, cost(s) per diagnosis, cost(s) of treatment or overall healthcare costs will be included.

Adverse effects

Some of the interventions evaluated may have unintended impacts on patient care or health professional workflows. For example, if nudges are intended to reduce the overuse of a certain test, they may lead to the underuse of this test for appropriate populations, or the reductions in use of one test may inadvertently increase the use of another inappropriate test or treatment.

We will examine the adverse (undesirable) effects of interventions recommended by the Cochrane EPOC group.⁷⁷ These will include adverse effects on

1. Test and treatment delivery or utilisation.
2. Health or health behaviours.
3. Quality of care.
4. Resource use.

Where no adverse effects are reported, we will make a distinction between studies where adverse effects were investigated, studies where it is unclear whether adverse effects were investigated and studies where it is clear that adverse effects were not investigated.

Study selection

One review author (MOK) will download search results to the reference manager software Endnote. Deduplication of results will be completed in the Centre for Research in Evidence Based Practice Systematic Review Accelerator deduplication algorithm. This algorithm has greater sensitivity and specificity than Endnote for the deduplication process.⁷⁸ Data will be managed in Endnote thereafter. Two review authors (MOK and GEF) will independently assess the eligibility of studies by screening titles and abstracts in Endnote for potential inclusion according to the predefined selection criteria. Studies judged to be potentially relevant will be retrieved in full text for further analysis. Any disagreements in judgement will be resolved by discussion to reach a consensus, or if this is not possible, with a third review author (ACT) until a consensus is reached. If further information about the study is required in order to make a decision about its eligibility, an attempt will be made to contact the study corresponding author(s).

Data extraction

Two review authors (MOK and ACT) will independently extract data for each of the included studies using a modified EPOC data collection checklist. The data extraction spreadsheet will be pilot tested on two included studies to minimise misinterpretation. We will extract information about study design, characteristics of population (country, setting, specialty, number of health professionals, number of patients), details of the interventions using

TIDieR items⁷⁹, details of the outcomes (target behaviour, measure of the target behaviour, baseline performance of the healthcare professional, patient outcome) and study results. If not enough information is provided in the trial report to extract data about intervention effects, we will contact authors to attempt to obtain the required information. We will calculate data from graphs and figures using <https://www.digitizeit.de/> in cases where this information is not presented in tables or text. If any information regarding standard deviations (SDs) is missing, we will calculate them from the extracted confidence intervals (if available) of the same study.

Risk of bias assessment

Two authors (MOK and GEF) will assess the risk of bias of all eligible studies using the criteria described in the Cochrane EPOC Group Resources for review authors.⁸⁰ Nine standard criteria are suggested for all randomised trials, non-randomised trials and controlled before-after studies. Seven standard criteria are used for all interrupted time series studies. Any disagreements in judgement will be resolved by discussion to reach a consensus, or if this is not possible, with another reviewer (ACT) until a consensus is reached.

Where possible, we will assess the overall certainty of the evidence using The Grades of Recommendation, Assessment, Development and Evaluation (GRADE) approach as recommended in the *Cochrane Handbook for Systematic Reviews of Interventions*.⁸¹

Data synthesis

We will follow the Cochrane EPOC guidelines for reporting the effects of interventions.⁸²

We expect that the included studies will vary according to study design, health professionals included, setting, types of nudge and target behaviours. Therefore, we expect to report our results in a structured synthesis format, as recommended by the Cochrane EPOC group.

We will separately analyse and report outcome data from different types of study designs. Depending on the studies found, we will also separately analyse and report the outcome data for the different categories (choice architecture and social nudges) and/or subcategories of nudges (eg, defaults, pre-commitment). Furthermore, depending on the studies found, we will separately analyse and report outcome data on the interventions that target testing or treatment behaviours.

In our structured synthesis, we will try to examine if there are any patterns or variations across different factors and outcomes achieved. Subgroups of interest may include the type of nudge, type of healthcare professional, type of setting, type of target behaviour and whether the study examined a real clinical or hypothetical/simulated situation (eg, a vignette study).

Dealing with missing data

We will contact authors of included papers if important data are not available.

Patient or public involvement

Patients and members of the public will not be involved in the design of this study.

Ethics and dissemination

Formal ethical approval is not required for this study. The results will be disseminated through a peer-reviewed publication and conference presentations.

CONCLUSION

This systematic review will provide evidence in support or against the hypothesis that nudge-interventions aimed at health professionals can address health service overuse and underuse. The results will have important implications for the implementation of health system interventions to improve professional practice and patient outcomes.

Contributors MOK is the guarantor. All authors contributed to the conception and design of the study. MOK drafted the manuscript and CM provided overall guidance. MOK, JS and ACT developed the nudge-intervention categories. MOK and GEF designed the search strategy and picked the risk of bias assessment tool. TH gave specific feedback on data extraction and the analysis plan. All authors commented on drafts of the protocol and added subject-specific expertise where necessary. All authors read the final draft of the manuscript and provided feedback. All authors read and approved the final manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

REFERENCES

- Brownlee S, Chalkidou K, Doust J, *et al*. Evidence for overuse of medical services around the world. *Lancet* 2017;390:156–68.
- Saini V, Garcia-Armesto S, Klemperer D, *et al*. Drivers of poor medical care. *Lancet* 2017;390:178–90.
- Glasziou P, Straus S, Brownlee S, *et al*. Evidence for underuse of effective medical services around the world. *Lancet* 2017;390:169–77.
- Mafi JN, Parchman M. Low-value care: an intractable global problem with no quick fix. *BMJ Qual Saf* 2018;27:333–6.
- Berwick DM, Hackbarth AD. Eliminating waste in US health care. *JAMA* 2012;307:1513–6.
- Quan-Cheng K, Jian-Guo W, Xiang-Hua L, *et al*. Inappropriate use of antibiotics in children in China. *The Lancet* 2016;387:1273–4.
- Katz JN. Appropriateness of total knee replacement. *Arthritis Rheumatol* 2014;66.
- Buchbinder R, van Tulder M, Öberg B, *et al*. Low back pain: a call for action. *Lancet* 2018;391:2384–8.
- Foster NE, Anema JR, Cherkin D, *et al*. Prevention and treatment of low back pain: evidence, challenges, and promising directions. *Lancet* 2018;391:2368–83.
- Clark S, Horton R. Low back pain: a major global challenge. *Lancet* 2018;391:2302.
- Siemieniuk RAC, Harris IA, Agoritsas T, *et al*. Arthroscopic surgery for degenerative knee arthritis and meniscal tears: a clinical practice guideline. *BMJ* 2017;357:j1982.
- Järvinen TL, Guyatt GH. Arthroscopic surgery for knee pain. *BMJ* 2016;354:i3934.
- Brill A. Overspending on multi-source drugs in Medicaid. 2011.
- Prasad V, Lenzer J, Newman DH. Why cancer screening has never been shown to "save lives"—and what we can do about it. *BMJ* 2016;352:h6080.
- Teoh D, Hultman G, DeKam M, *et al*. Excess Cost of Cervical Cancer Screening Beyond Recommended Screening Ages or After Hysterectomy in a Single Institution. *J Low Genit Tract Dis* 2018;22:184–8.
- Welch HG, Prorok PC, O'Malley AJ, *et al*. Breast-cancer tumor size, overdiagnosis, and mammography screening effectiveness. *N Engl J Med* 2016;375:1438–47.
- Miller AB, Wall C, Baines CJ, *et al*. Twenty five year follow-up for breast cancer incidence and mortality of the Canadian National Breast Screening Study: randomised screening trial. *BMJ* 2014;348:g366.
- Park S, Oh CM, Cho H, *et al*. Association between screening and the thyroid cancer "epidemic" in South Korea: evidence from a nationwide study. *BMJ* 2016;355:i5745.
- Ahn HS, Kim HJ, Welch HG. Korea's thyroid-cancer "epidemic"—screening and overdiagnosis. *N Engl J Med* 2014;371:1765–7.
- Ahn HS, Kim HJ, Kim KH, *et al*. Thyroid cancer screening in South Korea increases detection of papillary cancers with no impact on other subtypes or thyroid cancer mortality. *Thyroid* 2016;26:1535–40.
- Runciman WB, Hunt TD, Hannaford NA, *et al*. CareTrack: assessing the appropriateness of health care delivery in Australia. *Med J Aust* 2012;197:100–5.
- McGlynn EA, Asch SM, Adams J, *et al*. The quality of health care delivered to adults in the United States. *N Engl J Med* 2003;348:2635–45.
- Ogilvie IM, Newton N, Welner SA, *et al*. Underuse of oral anticoagulants in atrial fibrillation: a systematic review. *Am J Med* 2010;123:638–45.
- Palomäki A, Mustonen P, Hartikainen JE, *et al*. Underuse of anticoagulation in stroke patients with atrial fibrillation—the FibStroke Study. *Eur J Neurol* 2016;23:133–9.
- Ferro D, Loffredo L, Polimeni L, *et al*. Underuse of oral anticoagulants in patients with nonvalvular atrial fibrillation in Italy. *Intern Emerg Med* 2007;2:24–8.
- Lipworth B, Skinner D, Devereux G, *et al*. Underuse of β -blockers in heart failure and chronic obstructive pulmonary disease. *Heart* 2016;102:1909–14.
- Egred M, Shaw S, Mohammad B, *et al*. Under-use of beta-blockers in patients with ischaemic heart disease and concomitant chronic obstructive pulmonary disease. *QJM* 2005;98:493–7.
- Williams CM, Maher CG, Hancock MJ, *et al*. Low back pain and best practice care: a survey of general practice physicians. *Arch Intern Med* 2010;170:271–7.
- Ramanathan SA, Hibbert PD, Maher CG, *et al*. CareTrack: Toward Appropriate Care for Low Back Pain. *Spine* 2017;42:E802–e09.
- Hoffmann TC, Maher CG, Briffa T, *et al*. Prescribing exercise interventions for patients with chronic conditions. *CMAJ* 2016;188:510–8.
- Glauser TA, Salinas GD, Roepke NL, *et al*. Management of mild-to-moderate osteoarthritis: a study of the primary care perspective. *Postgrad Med* 2011;123:126–34.
- Persson G, Brorsson A, Ekvall Hansson E, *et al*. Physical activity on prescription (PAP) from the general practitioner's perspective - a qualitative study. *BMC Fam Pract* 2013;14:128.
- Dhawan A, Mather RC, Karas V, *et al*. An epidemiologic analysis of clinical practice guidelines for non-arthroplasty treatment of osteoarthritis of the knee. *Arthroscopy* 2014;30:65–71.
- Kahneman D, Egan P. Thinking, fast and slow: Farrar, Straus and Giroux New York. 2011.
- Blumenthal-Barby JS, Krieger H. Cognitive biases and heuristics in medical decision making: a critical review using a systematic search strategy. *Med Decis Making* 2015;35:539–57.
- McGettigan P, Sly K, O'Connell D, *et al*. The effects of information framing on the practices of physicians. *J Gen Intern Med* 1999;14:633–42.
- Gerben K, Fd M, Diana E-W, *et al*. Deliberate clinical inertia: Using meta-cognition to improve decision-making. *Emerg Med Australas* 2018;30:585–90.
- Scott IA, Soon J, Elshaug AG, *et al*. Countering cognitive biases in minimising low value care. *Med J Aust* 2017;206:407–11.
- Gigerenzer G. Why heuristics work. *Perspect Psychol Sci* 2008;3:20–9.
- Kahneman D. Maps of bounded rationality: Psychology for behavioral economics. *Am Econ Rev* 2003;93:1449–75.
- Gabbay J, le May A. Evidence based guidelines or collectively constructed "mindlines?" Ethnographic study of knowledge management in primary care. *BMJ* 2004;329:1013.

42. Heller RF, Saltzstein HD, Caspe WB. Heuristics in medical and non-medical decision-making. *Q J Exp Psychol A* 1992;44:211–35.
43. Tversky A, Kahneman D. Judgment under uncertainty: Heuristics and biases. *Science* 1974;185:1124–31.
44. Cho I, Bates DW. Behavioral Economics Interventions in Clinical Decision Support Systems. *Yearb Med Inform* 2018;27:114–21.
45. Goldstein DG, Gigerenzer G, Hogarth RM, et al. Why and when do simple heuristics work. Bounded rationality: The adaptive toolbox. 2001:173–90.
46. Hoffmann TC, Del Mar C. Clinicians' expectations of the benefits and harms of treatments, screening, and tests: a systematic review. *JAMA Intern Med* 2017;177:407–19.
47. Halpern SD. Using Default Options and Other Nudges to Improve Critical Care. *Crit Care Med* 2018;46:460–4.
48. Emanuel EJ, Ubel PA, Kessler JB, et al. Using Behavioral Economics to Design Physician Incentives That Deliver High-Value Care. *Ann Intern Med* 2016;164:114–9.
49. Liao JM, Fleisher LA, Navathe AS. Increasing the value of social comparisons of physician performance using norms. *JAMA* 2016;316:1151–2.
50. Ojerholm E, Halpern SD, Bekelman JE. Default options: Opportunities to improve quality and value in oncology. *J Clin Oncol* 2016;34:1844–7.
51. Thaler RH, Sunstein CR. *Nudge: Improving decisions about health, wealth, and happiness*. New Haven & London: Yale University Press, 2008.
52. Hansen PG, Jespersen AM. Nudge and the manipulation of choice: A framework for the responsible use of the nudge approach to behaviour change in public policy. *Eur J Risk Regul* 2013;4:3–28.
53. Hansen PG. The definition of nudge and libertarian paternalism: Does the hand fit the glove? *Eur J Risk Regul* 2016;7:155–74.
54. Patel MS, Volpp KG, Asch DA. Nudge Units to Improve the Delivery of Health Care. *N Engl J Med* 2018;378:214–6.
55. Patel MS, Day SC, Halpern SD, et al. Generic Medication Prescription Rates After Health System-Wide Redesign of Default Options Within the Electronic Health Record. *JAMA Intern Med* 2016;176:847–8.
56. Voyer B. 'Nudging' behaviours in healthcare: Insights from behavioural economics. *Br J Care Manag* 2015;21:130–5.
57. Patel MS, Volpp KG, Asch DA. Nudge units to improve the delivery of health care. *N Engl J Med* 2018;378:214–6.
58. Perry C, Chhatralia K, Damesick D, et al. *Behavioural insights in health care*. London: The Health Foundation, 2015:18–29.
59. Hollands GJ, Shemilt I, Marteau TM, et al. Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health* 2013;13:1218.
60. Keijzers G, Fatovich DM, Egerton-Warburton D, et al. Deliberate clinical inertia: Using meta-cognition to improve decision-making. *Emerg Med Australas* 2018;30:585–90.
61. Thaler RH, Sunstein CR. Libertarian paternalism. *Am Econ Rev* 2003;93:175–9.
62. Ubel PA, Rosenthal MB. Beyond Nudges — When Improving Health Calls for Greater Assertiveness. *N Engl J Med* 2019;380:309–11.
63. Liao JM, Navathe AS. Nudging Physicians to Reduce Quetiapine Prescribing Using Medicare Letters: Following the Letters of the Law? *JAMA Psychiatry* 2018;75:989–90.
64. Avorn J. The psychology of clinical decision making—implications for medication use. *N Engl J Med* 2018;378:689–91.
65. Thaler RH, Sunstein CR. *Nudge: Improving decisions about health, wealth, and happiness*: HeinOnline. 1999.
66. Perry C, Chhatralia K, Damesick D, et al. *Behavioural insights in health care*. 2015.
67. Dolan P, Hallsworth M, Halpern D, et al. Influencing behaviour: The mindspace way. *J Econ Psychol* 2012;33:264–77.
68. Robert M, Max V, Thomas S. A Review and Taxonomy of Choice Architecture Techniques. *J Behav Decis Mak* 2016;29:511–24.
69. Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci* 2011;6:42.
70. Ivers N, Jamtvedt G, Flottorp S, et al. Audit and feedback: effects on professional practice and healthcare outcomes. *Cochrane Database Syst Rev* 2012;6:CD000259.
71. Goetz C, Rotman SR, Hartoularos G, et al. The effect of charge display on cost of care and physician practice behaviors: a systematic review. *J Gen Intern Med* 2015;30:835–42.
72. Silvestri MT, Bongiovanni TR, Glover JG, et al. Impact of price display on provider ordering: a systematic review. *J Hosp Med* 2016;11:65–76.
73. Kesselheim AS, Cresswell K, Phansalkar S, et al. Clinical decision support systems could be modified to reduce 'alert fatigue' while still minimizing the risk of litigation. *Health Aff* 2011;30:2310–7.
74. Pantoja T, Green ME, Grimshaw J, et al. Manual paper reminders: effects on professional practice and health care outcomes. *Cochrane Database Syst Rev* 2014;160.
75. Gordon R, Grimshaw J, Eccles M, et al. On-screen computer reminders: effects on professional practice and health care outcomes. *Cochrane Database of Syst Rev* 1998(2).
76. Arditi C, Rège-Walther M, Wyatt JC, et al. Computer-generated reminders delivered on paper to healthcare professionals; effects on professional practice and health care outcomes. *Cochrane Database of Syst Revs* 2012(12).
77. Cochrane Effective Practice and Organisation of Care (EPOC). Taking account of adverse effects in EPOC reviews. EPOC Resources for review authors. 2017. <http://epoc.cochrane.org/resources/epoc-resources-review-authors>
78. Rathbone J, Carter M, Hoffmann T, et al. Better duplicate detection for systematic reviewers: evaluation of Systematic Review Assistant-Deduplication Module. *Syst Rev* 2015;4:6.
79. Hoffmann TC, Glasziou PP, Boutron I, et al. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. *BMJ* 2014;348:g1687.
80. Cochrane Effective Practice and Organisation of Care (EPOC). Suggested risk of bias criteria for EPOC reviews. EPOC Resources for review authors. 2017. <http://epoc.cochrane.org/resources/epoc-resources-review-authors>
81. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;336:924–6.
82. Cochrane Effective Practice and Organisation of Care (EPOC). Reporting the effects of an intervention in EPOC reviews. EPOC Resources for review authors. 2018. <http://epoc.cochrane.org/epoc-specific-resources-review-authors>