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Original Article

Nudging In MicroBiology Laboratory Evaluation (NIMBLE): A scoping review

Bradley J. Langford PharmD, BCPS[1,2], Elizabeth Leung PharmD, MsCI, BCPS AQ-ID[1,3], Reem Haj PharmD[1,3], Mark McIntyre PharmD[4], Linda R. Taggart MD, MPH[1,3], Kevin A. Brown PhD[2,3], Mark Downing MD[1] and Larissa M. Matukas MD[1,3]

[1]Unity Health Toronto, Toronto, Ontario, Canada, [2]Public Health Ontario, Toronto, Ontario, Canada, [3]University of Toronto, Toronto, Ontario, Canada and [4]Sinai Health System, Toronto, Ontario, Canada

Abstract

Background: Nudging in microbiology is an antimicrobial stewardship strategy to influence decision making through the strategic reporting of microbiology results while preserving prescriber autonomy. The purpose of this scoping review was to identify the evidence that demonstrates the effectiveness of nudging strategies in susceptibility result reporting to improve antimicrobial use.

Methods: A search for studies in Ovid MEDLINE, Embase, PsycINFO, and All EBM Reviews was conducted. All simulated and vignette studies were excluded. Two independent reviewers were used throughout screening and data extraction.

Results: Of a total of 1,346 citations screened, 15 relevant studies were identified. Study types included pre- and postintervention (n = 10), retrospective cohort (n = 4), and a randomized controlled trial (n = 1). Most studies were performed in acute-care settings (n = 13), and the remainder were in primary care (n = 2). Most studies used a strategy to alter the default antibiotic choices on the antibiotic report. All studies reported at least 1 outcome of antimicrobial use: utilization (n = 9), appropriateness (n = 7), de-escalation (n = 2), and cost (n = 1). Moreover, 12 studies reported an overall benefit in antimicrobial use outcomes associated with nudging, and 4 studies evaluated the association of nudging strategy with subsequent antimicrobial resistance, with 2 studies noting overall improvement.

Conclusions: The number of heterogeneous studies evaluating the impact of applying nudging strategies to susceptibility result reports is small; however, most strategies do show promise in altering prescriber's antibiotic selection. Selective and cascade reporting of targeted agents in a hospital setting represent the majority of current research. Gaps and opportunities for future research identified from our scoping review include performing prospective randomized controlled trials and evaluating other approaches aside from selective reporting.

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Persuasive interventions, such as prospective audit and feedback, are recommended strategies for antimicrobial stewardship programs (ASPs). These interventions aim to optimize antibiotic use by direct interaction with the prescriber after the antibiotic is prescribed. However, the clinical microbiology laboratory is an important partner in initiatives to improve antibiotic use and has the potential to influence antibiotic prescribing before the prescription is written. The Infectious Diseases Society of America (IDSA) Guidelines for Antimicrobial Stewardship recommend that ASPs implement selective or cascade microbiology reporting to guide prescribers to select an appropriate antimicrobial agent based on a limited list of reported options.[1] However, given the lack of strong supportive evidence for this strategy, it is considered a weak recommendation. The Clinical Laboratory Standards Institute (CLSI) also recommends the use of selective reporting but suggests that individual decisions are best made by the institution's infectious diseases, microbiology, and pharmacy team.[2]

Behavioral approaches to guide decision making through the strategic placement of choice architecture while still maintaining prescriber autonomy are called nudging strategies. Nudging can be used in the clinical microbiology laboratory given the need for high-yield interdisciplinary interventions to improve the initiation, selection, and/or duration of antibiotic use in all healthcare settings. In the context of susceptibility test result reports, nudging can include (1) presenting 1 or more default options that are more desirable than other options and masking nondesirable options; (2) framing recommendations by adding comments or context to guide decision making; and (3) presenting desired options at eye level by keeping desired choices at the top of the list or emphasizing the text for desired agents.[3] Despite recent interest in this approach, the type and breadth of microbiology nudging strategies studied in the literature has not yet been systematically evaluated.

Author for correspondence: Bradley J. Langford, Email: brad.langford@gmail.com

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We conducted a scoping review instead of a systematic review because nudging in the context of the microbiology result reporting is not well defined, and we expected that the literature yield would be sparse and heterogeneous. Unlike systematic reviews or meta-analyses, scoping reviews are designed to provide an overview of a broad range of literature rather than appraise or quantitatively synthesize data on a focused topic. Scoping reviews use a systematic and rigorous approach to map the literature and to identify the main concepts and opportunities for future research.[4,5] We sought to conduct a scoping review to identify the evidence and gaps that exist for microbiology nudging strategies. The following research question was formulated: What evidence exists for the use of nudging strategies in microbiology to improve antimicrobial use?

Methods

Protocol

This scoping review was conducted as an initial step to a broader research program entitled Nudging in MicroBiology Laboratory Evaluation (NIMBLE), to investigate opportunities to improve nudging in microbiology reporting. A scoping review protocol was developed a priori involving a team composed of a medical microbiologist, infectious diseases physicians, infectious diseases pharmacists, and a medical librarian. A Participant-Intervention-Comparator-Outcome (PICO) framework was used to guide the search strategy and article selection. The protocol is available upon request from the corresponding author. The PRISMA Extension for Scoping Reviews (PRISMA-ScR) recommendations were followed.[4]

Eligibility

All inpatient, outpatient, adult, and pediatric patient populations were eligible for inclusion. All real-life microbiology nudging interventions included, but were not limited to, default choice, framing, and eye-level nudging strategies. Case vignettes, surveys, and animal studies were excluded. We placed no restriction on comparison group or study design, nor did we restrict outcomes evaluated in each study.

Information sources and search strategy

A medical librarian formulated a search for studies in the following databases: Ovid MEDLINE: Epub Ahead of Print, In-Process and Other Non-Indexed Citations, Ovid MEDLINE Daily and Ovid MEDLINE, 1946–August 2018, Embase Classic+Embase 1947–August 2018, PsycINFO 1806–August 2018, and All EBM Reviews 2005–August 2018. The main broad concepts in the search included microbiology reports, antimicrobial treatment, and nudging strategies. The search strategy was peer reviewed by a second medical librarian and further refined. The search was conducted on August 27, 2018. Search strategies for each published literature database are available in Appendix A. Review of each article's reference list was also undertaken.

We conducted a grey literature search on December 7, 2018, for conference proceedings from the following conferences: IDWeek (Infectious Diseases Society of America), SHEA (Society for Healthcare Epidemiology of America), ICAAC (Interscience Conference on Antimicrobial Agents and Chemotherapy), ASM-Microbe (American Society for Microbiology), AMMI-Canada CACMID (Association for Medical Microbiology and Infectious Diseases Canadian Association for Clinical Microbiology and Infectious Diseases), and ECCMID (European Society of Clinical Microbiology and Infectious Diseases).

Study selection process

Search results and selection criteria were incorporated into Colandr online systematic review software, (Science for Nature and People Partnership, Conservation International, and DataKind, 2018). Two independent reviewers (B.L. and L.M.) participated in title and abstract screening and full-text screening in duplicate. Screening was performed in a blinded fashion, and disagreements were resolved by consensus. A third reviewer was available in cases in which consensus could not be reached.

Data items and data collection process

A predefined list of variables for data collection was agreed upon prior to data extraction: citation, year, country, healthcare setting, patient population, study design, sample size, organisms studied, antibiotics studied, source of samples studied , nudging strategy, other ASP strategies reported, follow up period, outcomes reported, author conclusions. Data were charted by a single reviewer (B.L.) and were verified by a second reviewer (L.M.).

Results

After duplicates were removed, a total of 1,342 articles were identified via database searching. Three additional sources were identified from reference list searching, plus 1 additional reference from the grey literature search, for a total of 1,346 potential articles for inclusion. Based on title and abstract screening, 1,325 articles were excluded. Of 21 articles that underwent full-text screening, 6 were excluded. Excluded studies were case vignettes or surveys (n = 2), did not define a clear nudging intervention (n = 3), or was a study protocol (n = 1). After exclusion, 15 studies met eligibility for inclusion in the scoping review.[6–20] Figure 1 shows the flow diagram for study inclusion.

Characteristics of studies included

Of the included studies, the most common country of origin was the United States (n = 6)[14,15,17,18,20], followed by Canada (n = 3),[9,12,13] the United Kingdom (n = 3),[7,16,19] Ireland (n = 1),[8] Singapore (n = 1),[10] and Saudi Arabia (n = 1).[6] Most studies (n = 10) were published recently (2010–2018),[6,9–17] most studies evaluated the inpatient population (n = 13),[6–15,17,18,20] and the remaining 2 studies[16,19] focused on primary care. Study designs included a randomized controlled trial (n = 1),[9] pre- and postintervention with control (n = 3),[12,13,17] pre- and postintervention without control (n = 7),[6,10,11,14,15,18] and retrospective cohort (n = 4).[7,8,19,20] Sample size, in terms of number of patients or isolates, ranged from 72[18] to 1,522[14] (median, 179), and was not specified in 4 studies.[10,12,16,19] Table 1 displays a summary of study characteristics, nudging strategies employed, and outcomes measured.

Nudging strategies employed

Anatomical samples of interest for microbiology report modification in order of most common to least common were all samples (no restriction on anatomical site) (n = 6),[6,10,12,14,18,20] urine (n = 5),[7,9,13,16,19] respiratory (n = 2),[15,15,17] blood (n = 1),[11] and mixed (n = 1).[8] Targeted organisms included all (n = 7),[7–10,13,16,19] gram-negative bacteria (n = 5),[6,11,12,14,20] methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas aeruginosa* (n = 2),[15,17] and gram-positive bacteria (n = 1).[18,20]

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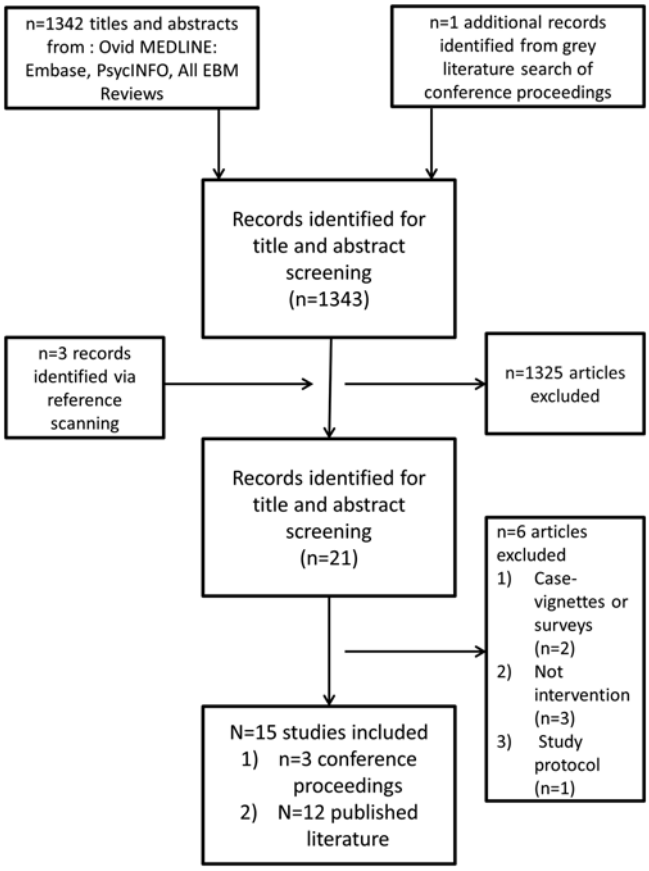


Fig. 1. Scoping review flow diagram. Details of study selection throughout the phases of the scoping review, including studies included via published and grey literature as well as studies excluded.

A default choice nudging strategy was employed in most studies (n = 13).[6–14,16,18–20] In these studies, selective or cascade antimicrobial susceptibility reporting were the most common approaches (n = 10).[6,8,10–12,14,16,18–20] Studies either evaluated the impact of masking (n = 8)[6,8,11,12,14,16,19,20] or unmasking (n = 2)[10,18] of antimicrobial agents. Although the impact of selective reporting for a broad range of antibiotics has been evaluated in several studies, fluoroquinolones[6,7,10,12,19] and broad-spectrum β-lactam agents[6,7,11,14,16,20] were the most typical targets of selective reporting strategies with the goal of reducing overuse of these agents.

Two studies aimed to reduce overtreatment of asymptomatic bacteriuria.[9,13] These studies both evaluated a "modified" reporting approach that replaced the typical culture with a susceptibility report with a standardized comment to contact microbiology for the results if clinically warranted. These studies incorporated aspects of both default-choice nudging strategies (ie, concealing results) and framing strategies (ie, comments on reports suggesting the likelihood of asymptomatic bacteriuria).

A framing approach was used in 2 studies.[15,17] Authors evaluated the impact of adding additional comments to respiratory cultures where commensal flora were identified, and they were explicit about the lack of certain pathogens (ie, methicillin-resistant *Staphylococcus aureus* (MRSA) and *Pseudomonas* spp). In these cases, a statement of "no MRSA/no *Pseudomonas*" was added to the report to discourage broad-spectrum antibiotic use and encourage de-escalation of therapy.

No included studies evaluated the impact of eye-level nudging strategies in microbiology reports.

Potential for confounding

Of the 14 nonrandomized studies included in this review, only 5 reported on other activities coexisting at the time of nudging intervention implementation. Most of these studies reported ongoing ASP activities or education.[6,7,11,12,17]

Outcomes measured

A primary outcome was prespecified in 7 studies.[9–14,17] All studies reported an outcome measure of antimicrobial use including prescribing or utilization measures (eg, defined daily doses) (n = 10),[6–8,10,12,14–16,18,19] appropriateness (n = 7),[7–10,13,18,20] de-escalation rate (n = 2),[11,17] or cost (n = 1).[9] Twelve studies reported an improvement in targeted antibiotic use associated with a nudging approach,[9–20] and 2 studies showed mixed results.[6,8] Another found no improvement.[7]

Also, 4 studies evaluated the association of nudging strategy with subsequent antimicrobial resistance,[6,12,16,17] and 2 studies noted overall improvement in selected antimicrobial resistance rates.[12,17] Other safety outcomes studied included *C. difficile* infection, length of hospital stay, readmission rate, and mortality. One study found an improvement in *C. difficile* infection rates[6] after the implementation of a selective reporting policy. All other studies found no change in these outcome measures,[11,14,17] suggesting that nudging studies are not likely to be associated with adverse outcomes.

Discussion

We conducted a scoping review of nudging in microbiology reports and found 15 relevant but heterogeneous studies, most of which focused on a default-reporting nudging strategy. The bulk of this literature was published in the current decade, which indicates a recent rapid growth of interest in nudging approaches in microbiology.

Selective or cascade reporting, a strategy in which preferable default antibiotic options are displayed on the report and less desirable options are suppressed, was the most common strategy evaluated. Although most studies have shown a positive association with improved prescribing practices, the lack of prospective, randomized data in this literature as well as lack of comprehensive evaluation of clinical outcomes prevent this approach from becoming more widespread and standardized across facilities. Additionally, several studies have noted a shift from one antibiotic to another,[6,12,16] a concept termed "squeezing the balloon."[21] Generally, nudges result in a shift to a more desirable antibiotic agent, but antimicrobial stewards need to consider the potential unintended consequences of shifts in usage and subsequent resistance patterns.

A large cross-sectional survey on selective reporting policies in Europe found vast inconsistencies across and within countries in the implementation of selective reporting of susceptibility results.[22] Selective reporting of antimicrobial susceptibility results was implemented in 31% of countries, with only 3 national health authorities endorsing it as the standard of care. Lack of detailed guidelines, poor system support to implement and automate such a strategy, insufficient human resources, and lack of priority were cited as barriers to advancing this practice.

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Table 1. Characteristics of Nudging in Microbiology Studies

Author	Setting	Study Design	Anatomical Site	Nudging Strategy	Strategy Detail	Antibiotic Outcomes	Outcome Detail
Al-Tawfiq et al	Hospital	Pre- and post-intervention, no control	All	Default choice	Selective reporting for Enterobacteriaceae and *Pseudomonas* spp	Prescribing	Mixed results, decreases and increases in antibiotic prescribing of targeted agents
Barnes et al	Hospital	Cohort	Urine	Default choice, framing	Selective reporting and recommended agent in comments on the report	Prescribing, appropriateness	Broad-spectrum antibiotic prescribing persisted after introduction of nudging strategy
Brodowy et al	Hospital	Cohort	All	Default choice	Selective reporting of aminoglycosides for gram-negative bacilli and vancomycin for *S. aureus*	Appropriateness	Improved appropriate therapy from 12.5% to 24.2%
Cunney et al	Hospital	Cohort	Urine, sputum, wound	Framing, default choice	Comments on report (eg, advice regarding probable contamination, treating only if symptoms), and selective reporting	Prescribing, appropriateness	Antibiotic therapy was more likely to be started in those where antibiotic susceptibility was released compared to when it was withheld (relative risk, 2.07; confidence interval, 1.08 to 3.97); no difference in appropriateness.
Daley et al	Hospital	Randomized controlled trial	Urine, non-catheterized	Default choice, framing	Modified reporting of culture and susceptibility results; traditional reporting replaced with standardized comment to call the lab if true infection is suspected	Appropriateness, cost	Improvement in appropriateness in those in modified reporting compared to traditional reporting (80% vs 53%, respectively)
Foo et al	Hospital	Pre- and post-intervention, no control	All	Default choice	Reversal of selective fluoroquinolone susceptibility reporting	Prescribing, appropriateness	Inappropriateness increased after ending selective reporting from 50% to 61%; no change in overall use
Johnson et al	Hospital	Pre- and post-intervention, no control	Blood	Default choice	Selective reporting of cefazolin for susceptible gram-negative organisms	De-escalation	Increase in de-escalation from 48% to 71% after the intervention
Langford et al	Hospital	Pre- and post-intervention, with control	All	Default choice	Selective reporting of ciprofloxacin susceptibility for pansusceptible Enterobacteriaceae	Prescribing	Decrease in ciprofloxacin usage from 87 to 39 DDD/1,000 patient days; increase in amoxicillin-clavulanate usage from 3 to 30 DDD/1,000 patient days
Leis et al	Hospital	Pre- and post-intervention, with control	Urine, non-catheterized	Default choice, framing	Modified reporting of culture and susceptibility results; traditional reporting replaced with standardized comment to call the lab if true infection is suspected	Appropriateness	Decrease in treatment of asymptomatic bacteriuria from 48% to 12%
Liao et al	Hospital	Pre- and post-intervention, no control	All	Default choice	Selective reporting of cefepime, meropenem, and piperacillin-tazobactam for *E. coli* and *Klebsiella* spp	Prescribing	Decrease in cefepime use from 5.6 to 3.9 DOT; no significant changes in the use of other antibiotics

(*Continued*)

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Table 1. (*Continued*)

Author	Setting	Study Design	Anatomical Site	Nudging Strategy	Strategy Detail	Antibiotic Outcomes	Outcome Detail
McBride et al	Hospital	Pre- and post-intervention, no control	Respiratory	Framing	Comment added: "No MRSA, no *Pseudomonas*" for respiratory cultures only growing normal respiratory flora	Prescribing	Total and broad-spectrum antibiotic prescribing per patient decreased (from 2.3 to 1.9 and from 1.9 to 1.4, respectively)
McNulty et al	Primary care	Pre- and post-intervention, no control	Urine	Default choice	Selective reporting: switch from amoxicillin-clavulanate to cephalexin reporting	Prescribing	20% increase in cephalexin prescribing and an 8% decrease in amoxicillin-clavulanate prescribing
Musgrove et al	Hospital	Pre- and post-intervention, with control	Respiratory	Framing	Comment added: "No MRSA, no *Pseudomonas*" for respiratory cultures only growing normal respiratory flora	De-escalation	5.5-fold increase in de-escalation and decrease in anti-MRSA and anti-Pseudomonal duration from 7 to 5 days
Stefee et al	Hospital	Pre- and post-intervention, no control	All	Default choice	Reversal of selective reporting of rifampicin for gram-positive organisms	Prescribing, appropriateness	Rifampicin use increased after unmasking; inappropriate use increased from 13% to 22%.
Tan et al	Primary care	Cohort	Urine	Default choice	Interlab variability in selective reporting of cephalosporins, nitrofurantoin and quinolones	Prescribing	Prescriber's choice of first line agent was associated with the agent reported by their lab service provider (ie, more likely to prescribe nitrofurantoin for UTI if their laboratory reported it).

Note. MRSA, methicillin-resistant *Staphylococcus aureus*; DDD, defined daily dose; UTI, urinary tract infection.

Although not specifically evaluated in this review, several case-vignette studies of nudging strategies have been performed and have also shown an impact on antibiotic selection and improvement in appropriateness of therapy.[23–25] The case-vignette approach allows microbiologists and ASP teams to fine tune selective reporting to different clinical scenarios and contextual factors unique to each region in a test environment. This step may be helpful before moving forward to prospective studies.

Modified reporting, specifically concealing positive culture results, has shown promise in reducing unnecessary treatment of asymptomatic bacteriuria in noncatheterized patients.[9,13] The only randomized controlled trial[9] in this scoping review evaluated this approach; which presents an opportunity to reduce overall antibiotic exposure for asymptomatic bacteriuria, a common condition seen in acute and long-term care populations. Preventing unnecessary treatment will likely present the highest yield antimicrobial stewardship opportunity for nudging in the microbiology laboratory. Our scoping review identifies a number of important gaps in the research that may require further evaluation to improve the scope and quality of nudging in microbiology report strategies. Given that most antibiotic use occurs in the community setting, advances in antimicrobial stewardship approaches should be developed for application to this group. Only 2 of 15 studies in the scoping review focused on an outpatient population,[16,19] revealing a gap and potential opportunity for future research. Notably, only 2 studies exclusively evaluated a framing strategy, in which comments are added to the report to guide decision making,[15,17] and none evaluated an eye-level strategy. Future research opportunities include evaluating these 3 strategies individually or in combination. An additional gap in the literature is the notable lack of prospective, randomized studies evaluating nudging approaches. Only 1 study in our review was a randomized controlled trial.[9] With concurrent ASPs and multiple initiatives at any given time, the potential for confounding variables exists. Future research should aim to evaluate nudging strategies in a randomized and controlled fashion. A limited number of studies evaluated clinical outcomes of nudging, including antimicrobial resistance, *C. difficile* infection, length of stay, and readmission rates. To improve the robustness of this evidence, clinical outcomes should be evaluated in larger studies that are adequately powered to evaluate these safety metrics.

Nudging approaches are one aspect of many potential behavioral change interventions previously described in the literature.[26] In behavioral-change taxonomy, nudging in the microbiology laboratory commonly fits under the intervention categories of "environmental restructuring" (eg, changing the environment, or in this case the microbiology report, to prompt the prescriber to select the optimal antibiotic), "enablement" (eg, reducing barriers for the prescriber to make the best decision by limiting inappropriate options) or "restriction" (eg, reducing the opportunity for physicians to select a nondesired option).[27] A broad range of other interventions can be used in place of or as an adjunct to nudging, depending on the specific antimicrobial stewardship challenges and opportunities in a given setting. However, nudging is a relatively low-cost, low-labor-intensity approach to improving antimicrobial stewardship, which is an important consideration for settings with limited funding for ASP human resources.

Nudging in microbiology reporting represents a postanalytic opportunity to influence decision making at the time of prescribing. However, upstream preanalytic approaches may hold significant promise in ensuring appropriate testing and subsequent treatment.[28] A recent study evaluated the impact of changes to computerized physician order entry order sets and the inclusion of a more restrictive reflex urine culturing system.[29] These changes were associated with a 45% reduction in urine cultures ordered. With an increasing interest in diagnostic stewardship and ways to ensure cost-effective resource use and to prevent overutilization of tests, simple nudging approaches will likely have a growing role in all aspects of microbiology.

This scoping review has several limitations. The goal of the review was to ensure breadth rather than depth of evaluation of each research output. Scoping reviews are ideal for exploring heterogeneous topics, but given the heterogeneity in outcomes, scoping reviews typically do not include meta-analyses, which prevented us from drawing conclusions about pooled outcomes among studies. Secondly, the nomenclature describing nudging activities in microbiology laboratory reports is inconsistent; therefore, some studies may have been overlooked. However, our broad search criteria, reference list searching, and grey literature search helped to mitigate the limitations of inconsistent terminology.

The results of this scoping review may be of interest to microbiologists, ASP clinicians, and administrators seeking to identify future opportunities to use or evaluate this promising approach to help guide future research and practice.

In conclusion, a limited number of heterogeneous studies have evaluated the impact of microbiology laboratory nudging, mostly evaluating the impact of altering the default choice or adding framing commentary on the selection of an antibiotic agent. Most of these studies have shown an improvement in antibiotic prescribing behavior. Gaps in research with opportunities for further study include identifying the optimal design of a report to incorporate nudging strategies, performing prospective studies, evaluating the impact of other nudging strategies (eg, including desired agents at eye level or combinations of nudging strategies), and determining the impact of nudging on patient clinical outcomes.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2019.293

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