Inappropriate use of clinical practices in Canada: a systematic review

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Abstract

Background: Inappropriate health care leads to negative patient experiences, poor health outcomes and inefficient use of resources. We aimed to conduct a systematic review of inappropriately used clinical practices in Canada.

Methods: We searched multiple bibliometric databases and grey literature to identify inappropriately used clinical practices in Canada between 2007 and 2021. Two team members independently screened citations, extracted data and assessed methodological quality. Findings were synthesized in 2 categories: diagnostics and therapeutics. We reported ranges of proportions of inappropriate use for all practices. Medians and interquartile ranges (IQRs), based on the percentage of patients not receiving recommended practices (underuse) or receiving practices not recommended (overuse), were calculated. All statistics are at the study summary level.

Results: We included 174 studies, representing 228 clinical practices and 28 900 762 patients. The median proportion of inappropriate care, as assessed in the studies, was 30.0% (IQR 12.0%–56.6%). Underuse (median 43.9%, IQR 23.8%–66.3%) was more frequent than overuse (median 13.6%, IQR 3.2%–30.7%). The most frequently investigated diagnostics were glycated hemoglobin (underused, range 18.0%–85.7%, *n* = 9) and thyroid-stimulating hormone (overused, range 3.0%–35.1%, *n* = 5). The most frequently investigated therapeutics were statin medications (underused, range 18.5%–71.0%, *n* = 6) and potentially inappropriate medications (overused, range 13.5%–97.3%, *n* = 9).

Interpretation: We have provided a summary of inappropriately used clinical practices in Canadian health care systems. Our findings can be used to support health care professionals and quality agencies to improve patient care and safety in Canada.

As health care systems struggle with sustainability, there is increased recognition that a substantial percentage of the health care received is inappropriate.[1] Inappropriate health care occurs when effective clinical practices are underused, ineffective clinical practices are overused or other practices are misused. It can lead to negative patient experiences,[2] poor health outcomes[3,4] and inefficient use of scarce health care resources.[5] In response, there is widespread professional and policy interest in reducing inappropriate health care in Canada and abroad. For example, in 2014, Choosing Wisely Canada,[6] a physician-led campaign in partnership with the Canadian Medical Association, was established. This initiative encourages conversations between clinicians and patients about low-value or overused care in efforts to reduce inappropriate care. Choosing Wisely Canada is endorsed across Canada by all provincial and territorial medical associations (https://choosingwiselycanada.org/about/).

Although reducing inappropriate health care is a high priority for health care professionals, agencies and governments in Canada, designing effective initiatives for quality improvement has been a difficult goal to achieve without knowledge of which clinical practices are inappropriately used. This is further challenged because Canada

does not have a mandatory and comprehensive national tracking system for quality. The Canadian Institute for Health Information (CIHI) houses multiple Canadian health databases, but it does not collect information on all clinical practices. Therefore, a systematic synthesis is necessary to provide an overview of inappropriate health care in Canada.[7] Summaries of inappropriately used clinical practices exist for several countries: United States,[8,9] United Kingdom[10] and Australia.[11] Each of these syntheses found high levels (50% on average) of inappropriately used practices and laid the foundation for several quality improvement initiatives in these countries. We aimed to conduct a systematic review to estimate the nature and amount of inappropriately used clinical practices in Canada.

Methods

Our protocol was published[12] and registered with PROSPERO (the international prospective register of systematic reviews): registration no. CRD42018093495. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[13] statement to guide reporting.

Quality of health care is a multidimensional concept. In this review, we defined quality using the framework put forth by the Institute of Medicine,[14] which includes 6 domains of quality care: safe, effective, patient-centred, timely, efficient and equitable. We focused our review on 1 of these quality domains (effectiveness) and reported our findings in terms of inappropriateness (overuse, underuse, misuse) of clinical practices.

Data sources and search strategy

Our search strategy (Appendix 1, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content) is reported according to the PRISMA-S guideline.[15,16] It was executed by an experienced information specialist (T.R.), after peer review by a second information specialist using the Peer Review of Electronic Search Strategies (PRESS) checklist.[17] We searched MEDLINE, EconLit, Science Citation Index Expanded, Arts & Humanities Citation Index, Emerging Sources Citation and Conference Proceedings Citation Index, and Cochrane Library (all databases). Examples of key search terms used for the concept of inappropriate health care are both specific ("unnecessary procedures," "inappropriate prescribing") and comprehensive ("comparative effectiveness research," "delivery of health care," "quality of health care"). Controlled vocabulary and natural language terms were applied according to the taxonomy of each database for optimal retrieval. We limited our searching to studies published in 2007 onwards; experts in quality improvement across Canada advised us that it takes a minimum of 10 years to notice a trend in data on inappropriate health care, and that studies older than this were unlikely to be useful in determining priorities for future quality improvement activities. We did not apply language limits or study design filters. The grey literature search included targeted, iterative hand searching of 25 government or research organization websites including those of all provincial and territorial ministries of health, provincial health care quality organizations and administrative data facilities, both provincial (e.g., ICES) and national (e.g., CIHI). We conducted 3 consecutive searches, first from Jan. 1, 2007, to May 28, 2018, and again from June 1, 2018, to Sept. 1, 2019. We conducted a retrospective database search (for additional search terms found in the grey literature) from Jan. 1, 2007, to Sept. 1, 2019. We conducted an updated search using the revised database strategy and of the grey literature from Sept. 1, 2019, to July 20, 2020. We also performed citation checking: we evaluated the reference lists of all included studies to identify additional studies not captured by our search strategy.

Study selection

Two team members independently screened the titles and abstracts identified by the electronic and grey literature searches, and resolved discrepancies by discussion. We included all quantitative study designs reporting data on appropriately or inappropriately used clinical practices in Canada. We defined appropriate and inappropriate practices as ones that did and did not conform fully to an evidence-based recommendation, respectively. Inappropriate care included underuse (failure to provide a clinical practice when patient benefits clearly outweighed the risks), overuse (providing a clinical practice when its potential for harm exceeds the possible benefit) and misuse (when an appropriate clinical practice is selected but a preventable complication occurs and as a result the patient does not receive the full potential benefit of the practice).[18] All practices undertaken by a health care professional in a Canadian health care setting were eligible. In line with previous reviews of inappropriate health care in other countries,[8–11] we relied on the authors' identifications of "recommended" clinical practices in the included studies. We included only studies that reported on large or diverse populations, such as the entire nation; 1 or several provinces, territories or cities; or multiple centres.

Data extraction

Data were abstracted in duplicate using a standardized, pilot-tested form in Distiller SR software.[19] In studies where only appropriate health care was reported, we extrapolated inappropriate health care by subtracting the proportion of appropriate care from 100%. We were interested in usual or normal use of clinical practices. Therefore, in longitudinal studies, we extracted the last reported time point, whereas, in experimental studies we extracted baseline measurements for trials with baseline data and postintervention control group data in all other trials.

Assessment of methodological quality

Two reviewers independently assessed the methodological quality of all included studies using the following validated tools: Quality Assessment and Validity Tool for Before/After-Cohort Design Studies,[20,21] Quality Assessment and Validity Tool for Cross-sectional Studies,[20–23] Cochrane Risk of Bias Tool 2.0,[24] Joanna Briggs Institute Checklist for Quasi-Experimental Studies[25] and Joanna Briggs Institute Checklist for Case Series Studies.[26] Conflicts regarding all assessments in data extraction and methodological quality were resolved through team discussion.

Data synthesis

We classified all practices first by type of inappropriate use (underuse, overuse or misuse) and, second, as diagnostic or therapeutic. We defined diagnostics as tests used in clinical practice to identify with

high accuracy the condition or disease in a patient, and thus to provide early and proper treatment.[27] Therapeutics referred to treatment and care of a patient for the purpose of either preventing or treating disease, or alleviating pain or injury.[28] In line with a previous review of studies of health care services in the US,[9] clinical practices that could function as either diagnostics or therapeutics (e.g., endoscopy and angiography) were classified according to their primary function as stated in the included study. Finally, within diagnostics and therapeutics, we grouped similar practices into subcategories that emerged from the data: diagnostics (referrals, assessments, screening, blood tests, imaging and multiple tests) and therapeutics (acute care procedures, biophysical therapy, psychosocial therapy and medications).

Statistical analysis

To describe the amount of practices identified, we reported proportions and ranges of proportions of inappropriate use for each practice. We determined summaries of inappropriate use by calculating medians and interquartile ranges (IQRs), based on the percentage of patients not receiving a recommended practice (underuse) and receiving a practice when not recommended (overuse). First, we calculated a median proportion and IQR for all inappropriately used practices combined. Second, we calculated an overall median proportion and IQR for all underused practices and all overused practices. Third, for both diagnostics and therapeutics, and their subcategories, we calculated median proportions and IQRs overall and by kind of inappropriate practice. We assessed for significant differences between kinds of inappropriate practice using the Mann–Whitney *U* Median Test in Statistical Package for the Social Sciences (SPSS) Version 27. We also evaluated for trends over time by reviewing the median proportions for all inappropriate care, diagnostics and therapeutics using the median publication year of 2017 as the cut point (2009–2017 and 2018–2020). All statistics reported are at the study summary level.

We conducted a sensitivity analysis to see if the median proportion estimates changed when methodologically weak studies were omitted.

Ethics approval

This study, being a systematic review, did not require ethics approval.

Results

Figure 1 (PRISMA flow diagram) shows article selection. We screened 16 530 titles and abstracts, of which 930 were potentially relevant, and 174 were included in the systematic review. Studies excluded at full text are detailed in Appendix 2, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content. Of the 174 included studies, 66 (37.9%) evaluated diagnostics, 85 (48.9%) evaluated therapeutics and 23 (13.2%) included both.

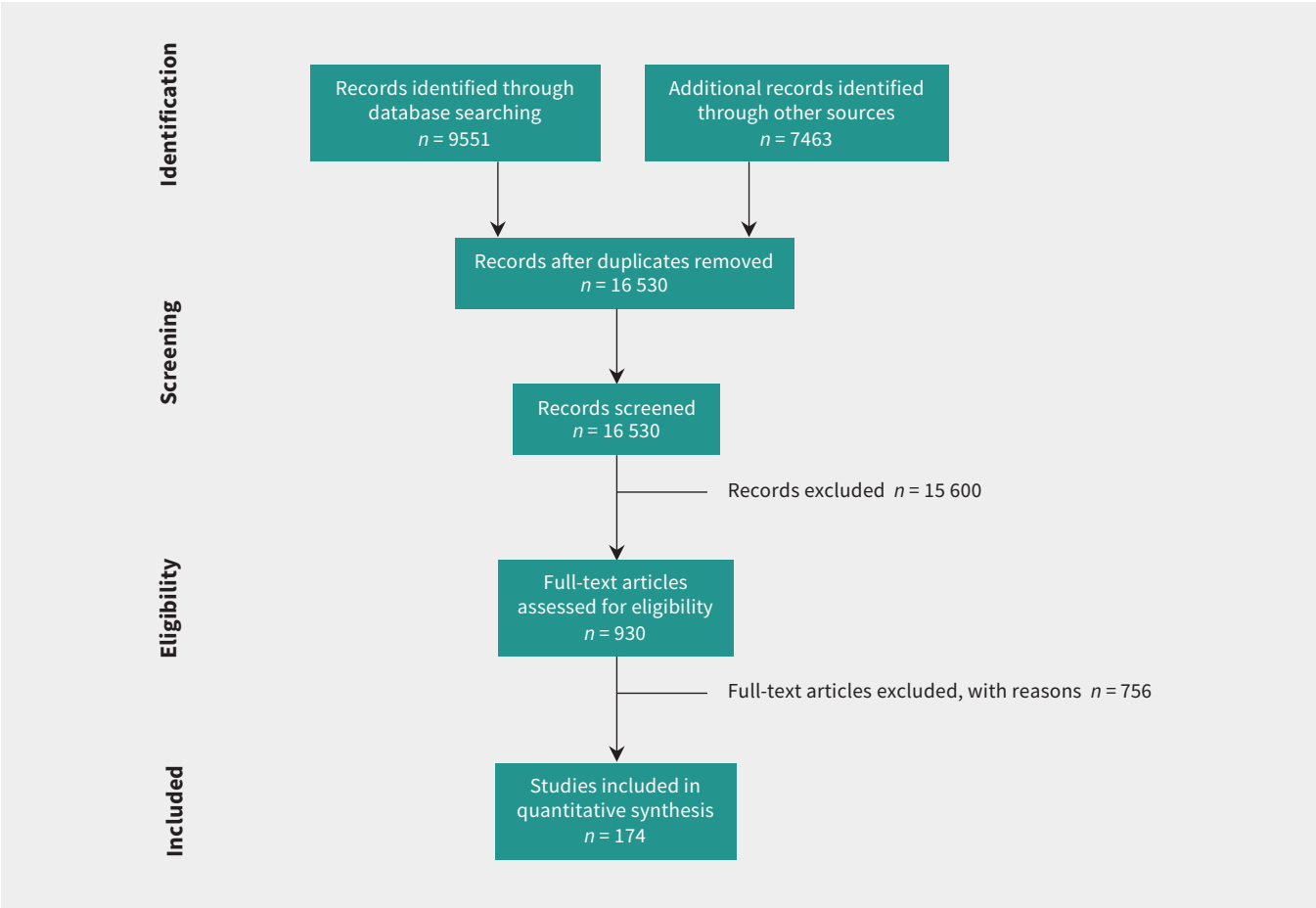

Figure 1: Flow chart for selection of articles.

Table 1 (part 1 of 2): Characteristics of the included studies

Characteristic	No. (%) of studies *n* = 174
Type of inappropriate care*	
Underuse	94 (54.0)
Overuse	95 (54.6)
Misuse	0 (0)
Health care sector*	
Acute or specialty	122 (70.1)
Primary care	57 (32.8)
Rehabilitation	24 (13.8)
Long-term care	23 (13.2)
Home or community	18 (10.3)
Public health	13 (7.5)
Unidentified	13 (7.5)
Province or territory*	
Ontario	98 (56.3)
Alberta	60 (34.5)
British Columbia	27 (15.5)
Quebec	27 (15.5)
Nova Scotia	23 (13.2)
Saskatchewan	17 (9.8)
Manitoba	16 (9.2)
Newfoundland and Labrador	15 (8.6)
New Brunswick	11 (6.3)
Prince Edward Island	9 (5.2)
Yukon	5 (2.9)
Northwest Territories	4 (2.3)
Nunavut	2 (1.1)
Unidentified	13 (7.5)
Sample size	
< 100	9 (5.2)
100–999	59 (33.9)
1000–9999	31 (17.8)
10 000–99 999	24 (13.8)
100 000–1 000 000	15 (8.6)
> 1 000 000	9 (5.2)
Not reported†	27 (15.5)

Table 1 (part 2 of 2): Characteristics of the included studies

Characteristic	No. (%) of studies *n* = 174
Study design	
Cross sectional	81 (46.5)
Cohort	62 (35.6)
Pre-post	11 (6.3)
Interrupted time series	10 (5.7)
Randomized controlled trial	8 (4.6)
Case series	2 (1.1)
Data source	
Administrative database or population data set	109 (62.6)
Hospital- or setting-specific data	58 (33.3)
Surveys of specific settings or databases	7 (4.0)
Number of specific practices reported	
1	125 (71.8)
≥ 2	49 (28.2)
Evidence source for the recommendation or standard*	
Guideline	165 (94.3)
Systematic review or meta-analysis	29 (16.7)
Quality indicator	1 (0.6)
Sex	
Male and female	103 (59.2)
Female only	15 (8.6)
Male only	4 (2.3)
Not specified or not reported	52 (29.9)
Age, yr	
Adults (≥ 18)	116 (66.7)
Children (1–18)	4 (2.3)
Infants (< 1)	3 (1.7)
Mixed (adults, children or infants)	5 (2.9)
Not specified	46 (26.4)

*Some studies are present in more than 1 category, therefore, values do not add to *n* = 174 (100.0%).
†Grey literature reports; sample size not reported (mostly studies using large administrative databases).

The 174 included studies included 28 900 762 patients aged from birth to 108 years. All health sectors and Canadian jurisdictions are represented in the sample (summary in Table 1). Appendix 3 (available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content) provides greater detail on the included studies.

A detailed assessment of the methodological quality of the included studies is in Appendix 4 (available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content). We rated 47 (27.0%) studies as low methodological quality. The most common reasons for lower quality scores were lack of probabilistic sampling in nonpopulation-based studies and lack of reported instrument reliability and validity.

The 174 included studies assessed 228 unique practices. Ninety-four (54.0%) of the studies reported on 144 underused practices (Table 2) and 95 (54.6%) studies reported on 109 overused practices (Table 3); 25 practices were both under- and overused (Table 2 and Table 3). No studies reported misused practices. One hundred twenty (52.6%) of the practices were diagnostic and 108 (47.4%) were therapeutic. Most practices, whether underused or overused, were reported in a single study

Table 2 (part 1 of 4): Underused clinical practices*

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of underuse
Diagnostics				
Laboratory test	Albumin-to-creatinine ratio	Diabetes mellitus,[29–32] chronic kidney disease[31,33]	5 (7)	26.4–81.6
	Urine collection (24 h)	Kidney stone disease[34]	1 (1)	64.5
	Urine protein	Diabetes mellitus[35]	1 (1)	26.0
	Sputum sample	COPD[36]	1 (1)	97.0
	Oncotype dx prognostic tool	Breast cancer[37]	1 (1)	7.0
Referral	Secondary prevention stroke clinic	CVD[38–40]	3 (3)	31.0–45.7
	Dietician or weight loss program	CVD[31]	1 (1)	81.8
	Smoking cessation program	CVD[31]	1 (1)	92.3
	Radiation oncologist	Prostate cancer[41,42]	2 (2)	20.6–57.0
	Alcohol dependence resource	Alcohol addiction[43]	1 (1)	55.0
	Orthopedic pediatric clinic†	Adolescent idiopathic scoliosis[44]	1 (1)	17.4
	Nephrology specialist	Chronic kidney disease[45]	1 (1)	55.3
	Pulmonary rehabilitation program	COPD[46]	1 (1)	34.2
Assessment	Eye examination	Diabetes mellitus[29,30,32,35,47–50]	8 (8)	22.9–80.5
	Blood pressure	Diabetes mellitus,[29,30,32,47] chronic kidney disease,[33] CVD,[31] cardiac rehabilitation[51]	7 (8)	1.9–92.7
	Electrocardiogram†	Diabetes mellitus,[29,30,50] COPD,[36] CVD[31]	5 (5)	3.6–78.8
	Foot examination	Diabetes mellitus[30,32,35,52]	4 (4)	49.0–84.1
	Body mass index	Diabetes mellitus,[29,47] cardiac rehabilitation[51]	3 (3)	12.2–65.8
	Neuropathy	Diabetes mellitus[29,30,47]	3 (3)	81.9–89.7
	Waist circumference	Diabetes mellitus,[29] CVD,[31] elevated cardiometabolic risk[52]	3 (3)	53.0–91.3
	Diabetes (6-mo visit)	Diabetes mellitus[32]	1 (1)	36.3
	Swallowing	CVD[38,40,53]	3 (3)	35.2–50.5
	Well baby visit (at 18 mo)	Well baby visit[54]	1 (1)	61.8
	Asthma control	Asthma[55]	1 (2)	95.0–100.0
	Chronic stable angina	Breast cancer[56]	1 (1)	32.8
	COPD	Breast cancer[56]	1 (1)	33.7
	Congestive heart failure	Breast cancer[56]	1 (1)	26.7
	Transient ischemic attack	Breast cancer[56]	1 (1)	28.5
	Diabetes	Breast cancer survivors[56]	1 (1)	19.1
	Anesthesia preassessment	Colorectal surgery[57]	1 (1)	22.6
	Fracture risk assessment	Fragility fractures[58]	1 (1)	22.9
	Bowel function	Prostate cancer[59]	1 (1)	41.5
	Digital rectal examination	Prostate cancer[59]	1 (1)	6.3
	Dose volume histogram	Prostate cancer[59]	1 (1)	19.4
	Sexual function	Prostate cancer[59]	1 (1)	44.5
	Urinary function	Prostate cancer[59]	1 (1)	8.0
	Audiometric testing	Tympanostomy tube insertion[60]	1 (1)	27.3
	Impedance testing	Tympanostomy tube insertion[60]	1 (1)	22.7
	Multiple assessments: expiratory airflow (spirometry, bronchial challenge testing, serial peak flow testing)	Asthma[61]	1 (1)	51.9
	Cervical cancer (multiple components)	Cervical cancer[56]	1 (1)	29.7
	Colorectal cancer (multiple components)	Colorectal cancer[56]	1 (1)	51.6
	Skin cancer (annual dermatology examination)	Skin cancer[62]	1 (1)	67.3

Table 2 (part 2 of 4): Underused clinical practices*

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of underuse
Screening	Fecal occult blood test	Colorectal cancer (screening)[63,64]	2 (2)	49.0–87.9
	Nutrition	Patients admitted to hospital[65,66]	2 (3)	29.6–100.0
	Mammography†	Breast cancer (screening)[67]	1 (1)	73.1
	Depression	Diabetes mellitus[29]	1 (1)	92.7
	Syphilis	Prenatal[68]	1 (1)	79.3
	Retinopathy of prematurity	Premature neonates[69]	1 (1)	69.6
	Pressure ulcer	Patients with spinal cord injury[70]	1 (1)	54.3
Blood test	Glycated hemoglobin (HbA_{1c})†	Diabetes mellitus,[29–32,35,47,49] chronic kidney disease[33]	9 (9)	18.0–85.7
	Estimated glomerular filtration rate	Diabetes mellitus[29–32,47]	5 (5)	12.7–88.7
	Serum creatinine	Diabetes mellitus,[29] chronic kidney disease[33]	2 (3)	14.5–73.3
	Blood culture	COPD,[36] *Staphylococcus aureus* bacteremia[71]	2 (2)	12.7–95.5
	Fasting blood glucose	CVD,[31] cardiac rehabilitation[51]	2 (4)	20.0–57.9
	C-reactive protein	Acute pancreatitis[72]	1 (1)	99.6
	Serum lipase	Acute pancreatitis[72]	1 (1)	77.4
	Multiple blood tests: lipids (various tests, e.g., total cholesterol, HDL, LDL and triglycerides)†	Diabetes mellitus,[29,30,32,47–49] CVD,[31] dyslipidemia,[31] cardiac rehabilitation[51]	8 (15)	3.2–47.0
	CBC,† electrolytes and cardiac enzymes	COPD[36]	1 (1)	54.9
	Gestation diabetes blood test‡	Gestational diabetes mellitus[73]	1 (1)	6.4
Imaging	Carotid imaging/Doppler†	CVD[31,38,39,53,74–76]	7 (7)	15.6–40.4
	Neuroimaging	CVD[38,40]	2 (3)	1.1–10.4
	Carotid imaging/angiography	CVD[40]	1 (1)	32.5
	Echocardiogram	CVD[31]	1 (1)	52.1
	Noninvasive cardiac imaging	CVD[77]	1 (1)	37.5
	Radiography (chest)†	COPD[36,50]	2 (2)	3.9–35.0
	CT (head)†	CVA[31,53]	2 (2)	12.0–33.8
	CT, ultrasonography	Acute pancreatitis[72]	1 (1)	65.3
	CT (abdominal)†	Acute pancreatitis[72]	1 (1)	43.9
	Ultrasonography (abdominal)†	Acute pancreatitis[72]	1 (1)	29.8
	Breast cancer imaging (mammography, breast ultrasonography or breast MRI)	Breast cancer (in remission)[56]	1 (1)	35.8
	Dual-energy x-ray absorptiometry†	Osteoporosis[56]	1 (1)	66.4
	CT or MRI	Prostate cancer[59]	1 (1)	21.0
	Bone scan†	Prostate cancer[59]	1 (1)	4.5
	Transthoracic echocardiogram†	*Staphylococcus aureus* bacteremia[71]	1 (1)	14.7
Multiple diagnostics	Diabetes care (recommended: 4 HbA_{1c} tests, 1 eye test and 1 cholesterol test in a 2-yr period)§	Diabetes mellitus[78]	1 (1)	60.5
	Ultrasonography with or without fine needle aspiration	Thyroid incidentalomas[79]	1 (2)	54.0–90.0
	Thyroid-stimulating hormone with thyroid ultrasonography	Thyroid nodules[80]	1 (1)	47.4
	Prostate cancer assessment (Gleason score, prostate-specific antigen and T-stage)	Prostate cancer[59]	1 (1)	9.8

(*n* = 174, 68.8%); 42 (16.6%) practices were reported in 3 or more studies and 15 (5.9%) practices were reported in 5 or more studies (Table 2 and Table 3).

Median proportions and IQRs for overall inappropriate use, underuse and overuse by care category (i.e., diagnostics or therapeutics) and their 10 subcategories are summarized in Table 4. We found that the median proportion of inappropriate use across all practices was 30.0% (IQR 12.0%–56.6%). Proportions of underuse were statistically higher than proportions of overuse for both diagnostic and therapeutic practices. Variance (indicated by the width of the IQR) was also consistently higher for underuse than for overuse.

Table 2 (part 3 of 4): Underused clinical practices*

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of underuse
Therapeutics				
Acute care procedure	Early repeat resection	Bladder cancer,[81] prostate cancer[41]	2 (2)	51.5–72.2
	Radical prostatectomy	Prostate cancer[41]	1 (1)	83.0
	Fine needle aspiration	Acute pancreatitis[72]	1 (1)	97.3
	Endoscopy	Colorectal cancer[63]	1 (1)	65.3
	Mechanical bowel preparation	Colorectal surgery[82]	1 (1)	41.4
	Carotid endarterectomy or stenting	CVD[83]	1 (1)	98.1
Biophysical therapy	Enhanced recovery after surgery (ERAS bundle)	Colorectal surgery,[84] breast reconstruction surgery,[85] gynecologic surgeries[86]	3 (4)	28.0–48.8
	Nutrition: clear fluids	Colorectal surgery[57]	1 (1)	58.3
	Nutrition: liquid calorie supplement	Colorectal surgery[57]	1 (1)	98.8
	Preoperative: fasting	Colorectal surgery[57]	1 (1)	91.7
	Postoperative: Foley catheter	Colorectal surgery[57]	1 (1)	42.9
	Postoperative: mobilization	Colorectal surgery[57]	1 (1)	90.2
	Influenza vaccine	Diabetes mellitus,[30,32] COPD[46]	3 (3)	20.0–58.5
	Assisted ventilation	COPD[36]	1 (1)	97.7
	Pneumococcal vaccine	COPD[46]	1 (1)	34.0
	Chemotherapy (neoadjuvant or adjuvant)	Bladder cancer[87–89]	3 (3)	64.8–81.3
	Radiation therapy†	Prostate cancer,[59] bone cancer,[90] oral cancer[91]	3 (4)	1.4–92.6
	Nutrition: regular diet	Acute pancreatitis[72]	1 (1)	100.0
	Nutrition: enteral nutrition	Acute pancreatitis[72]	1 (1)	65.4
	Implantable cardioverter defibrillator†	CVD[92]	1 (1)	27.0
	Plasma exchange†	Not specified[93]	1 (1)	63.8
	Preoperative: fasting (solids)	Parenteral procedural sedation[94]	1 (1)	48.1
	Preoperative: fasting (liquids)	Parenteral procedural sedation[94]	1 (1)	5.0
	Multiple biophysical therapies: radiation therapy with androgen deprivation	Prostate cancer[59]	1 (1)	68.0
Psychosocial therapy	Counselling: prenatal care (weight gain, smoking, alcohol, working during pregnancy, medications in pregnancy, vitamins and minerals, exercise/active living and nutrition)	Prenatal[95–98]	4 (19)	3.2–89.6
	Counselling: smoking cessation	CVD,[31,51] diabetes mellitus,[30] elevated cardiometabolic risk[52]	4 (4)	9.2–47.2
	Counselling: exercise/active living	CVD,[51] elevated cardiometabolic risk[52]	2 (2)	30.9–85.9
	Counselling: nutrition	Elevated cardiometabolic risk[52]	1 (1)	54.2
	Patient education (at least 1 type)	Patients with spinal cord injury[70]	1 (1)	71.0
	Counselling: preoperative	Colorectal surgery[57]	1 (1)	58.6
	Education postconcussion	Mild traumatic brain injury or concussion[99]	1 (1)	52.0
	Counselling: stress management	CVD[51]	1 (1)	18.7
	Counselling: self-management of heart disease	CVD[51]	1 (1)	9.2

Several evidence sources for assessing the appropriateness or inappropriateness of the 228 clinical practices were reported. Most studies (n = 165, 94.3%) cited a national or international guideline. Other evidence sources included systematic reviews or meta-analyses (n = 29, 16.7%) and quality indicators (n = 1, 0.6%). The evidence sources used in each study are listed in Appendix 3.

We found that 120 unique diagnostic practices were investigated in 89 studies; 78 (65.0%) diagnostic practices were underused (Table 2), 56 (46.7%) were overused (Table 3) and 14 (11.7%) were both underused and overused. Diagnostics were inappropriately used, on average, 28% of the time (IQR 12.7%–50.4%). The lowest overall proportion of inappropriate use of

Table 2 (part 4 of 4): Underused clinical practices*

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of underuse
Medication	Statins	CVD,[51,100,101] diabetes mellitus,[102] elevated cardiometabolic risk,[52] chronic kidney disease[33]	6 (6)	18.5–71.0
	Multiple medications (cardiovascular)	CVD,[31,38,40,103,104]¶,**,††,‡‡,§§,¶¶ diabetes mellitus,[104]*** hypertension[104]†††	5 (9)	3.3–98.8
	ACE inhibitors or ARB	Chronic kidney disease,[33] CVD,[51] microalbuminuria,[30] diabetes mellitus[102]	4 (5)	9.1–77.1
	Antihyperglycemics	Gestational diabetes mellitus,[105] diabetes mellitus[30,31,106]	4 (4)	1.1–70.5
	Antiplatelet therapy	Diabetes mellitus,[102] CVD[51,107]	3 (4)	14.8–93.5
	Proton pump inhibitors†	Diabetes mellitus[102]	1 (1)	72.3
	Thiazides	Diabetes mellitus[50]	1 (1)	83.0
	Smoking cessation	CVD,[31] COPD[46]	2 (2)	52.1–76.9
	ASA	CVD[31,51]	2 (4)	21.1–30.0
	Tissue plasminogen activator	CVD[38,74]	2 (2)	67.6–88.1
	ACE inhibitor, ARB or β-blocker	CVD[31]	1 (1)	11.5
	β-Blockers	CVD[51]	1 (1)	30.1
	Venous thromboembolism prophylaxis†	Cancer[108–111]	4 (7)	7.3–61.3
	Antimicrobials†	Community-acquired pneumonia,[112] urinary tract infections,[112] nonpurulent cellulitis,[112] bacterial infections,[113] COPD[36]	3 (5)	3.8–80.1
	Short-acting β-agonists†	Asthma,[114] COPD[36]	2 (2)	41.4–87.6
	Corticosteroids†	COPD[36]	1 (1)	72.6
	Corticosteroids	COPD[36]	1 (1)	57.0
	Short-acting anticholinergics	COPD[36]	1 (1)	51.1
	Domperidone (antiemetic)	Colorectal surgery[57]	1 (1)	100.0
	Epidural	Colorectal surgery[57]	1 (1)	76.8
	Magnesium hydroxide	Colorectal surgery[57]	1 (1)	98.8
	Nonsteroidal anti-inflammatory drugs†	Colorectal surgery[57]	1 (1)	65.2
	Probiotics	Colorectal surgery[57]	1 (1)	100.0
	Lipid lowering	Dyslipidemia[31]	1 (1)	8.5
	Cancer: adjuvant imatinib therapy	Gastrointestinal stromal tumours[115]	1 (1)	22.0
	Antihypertensives†	Hypertension[31]	1 (1)	5.8
	Cancer	Lung cancer[116]	1 (1)	93.0
	Oral anticoagulation therapy	Not specified[117]	1 (1)	37.0
	Continuous midazolam infusion	Palliative sedation[118]	1 (1)	95.8
	Antiemetics	Pediatric oncology[119]	1 (1)	71.0
	Magnesium sulfate†	Pregnancy: fetal neuroprotection[120]	1 (1)	23.6
	Cancer: radium-223	Prostate cancer[121]	1 (1)	53.5
Multiple therapeutics	Endoscopic hemostasis with high-dose IV proton pump inhibitor	Upper gastrointestinal bleeding[122]	1 (1)	92.9

Note: ACE = angiotensin-converting enzyme, ARB = angiotensin receptor blocker, ASA = acetylsalicylic acid, CAD = coronary artery disease, CBC = complete blood count, COPD = chronic obstructive pulmonary disease, CT = computed tomography, CVA = cerebral vascular accident (stroke), CVD = cardiovascular disease (includes the 4 main types of CVD: coronary heart disease, stroke/TIA, peripheral arterial/vascular disease and aortic disease), HDL = high-density lipoprotein, IV = intravenous, LDL = low-density lipoprotein, MRI = magnetic resonance imaging, PVD = peripheral vascular disease, TIA = transient ischemic attack.
*A higher number of findings is reported than the number of studies for some categories, because some studies reported more than 1 finding pertinent to that category
†Both underused and overused.
‡Glucose challenge, oral glucose tolerance, HbA_{1c} or random/fasting glucose.
§60.5% of patients did not receive the recommended biannual diabetic tests. However, 15.3% received no diabetic tests, whereas 60.5% received some but not all tests.
¶Angiotensin-converting enzyme inhibitors/ARBs, β-blockers or mineralocorticoid receptor antagonists.
**β-Blocker, lipid-lowering or other antihypertensive therapy with an ACE inhibitor, ARBs and β-blocker, an ACE inhibitor or ARB.
††Acetylsalicylic acid, clopidogrel, combination of ASA and dipyramidole or warfarin.
‡‡Antiplatelet or anticoagulation therapy with a lipid-lowering drug.
§§Angiotensin-converting enzyme inhibitor with a lipid-lowering drug with another antihypertensive drug.
¶¶Antithrombotic drug with an antihypertensive drug with a lipid-lowering drug.
***Angiotensin-converting enzyme inhibitor with an ARB.
†††β-Blocker, with an ACE inhibitor or ARB or both, with an antihypertensive drug.

Table 3 (part 1 of 4): Overused clinical practices

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of overuse
Diagnostics				
Referral	Neurosurgery	Nonspecific lumbar spine issues[123]	1 (1)	43.0
	Orthopedic pediatric clinic*	Adolescent idiopathic scoliosis[44]	1 (1)	32.4
Assessment	Electrocardiogram*	Annual health examination (low-risk adults),[124] preoperative testing (low-risk surgeries)[125]	2 (2)	21.5–31.0
	Oxygen saturation	Acute bronchiolitis[126]	1 (1)	42.0
	Erythema migrans (rash)	Lyme disease[127]	1 (1)	63.0
	Pulmonary function test	Noncardiothoracic surgery[128]	1 (1)	3.0
	Cardiac stress test	Preoperative testing (low-risk surgeries)[125]	1 (1)	2.1
	Multiple assessments: electrocardiogram, cardiac stress test, echocardiogram, chest radiography	Preoperative testing (low-risk surgeries)[129]	1 (1)	25.1
Screening	Papanicolaou test	Cervical cancer (screening)[130–133]	4 (4)	8.0–15.7
	Mammography*	Breast cancer (screening)[129,134]	2 (2)	22.2–25.8
	Colorectal cancer screening (tests not specified)	Colorectal cancer screening (adults 75 yr and older)[133]	1 (1)	1.7
	CVD screening	Elevated cardiometabolic risk[52]	1 (1)	51.0
	Cell-free DNA prenatal screening	Prenatal[135]	1 (3)	0.7–17.9
Blood test	Thyroid-stimulating hormone	Diabetes mellitus,[136–138] not specified[139,140]	5 (5)	3.0–35.1
	Glycated hemoglobin (HbA_{1c})*	Diabetes mellitus[136,141]	2 (2)	22.9–28.1
	Lipids (various tests, tests not specified)*	CVD,[100] not specified[136]	2 (2)	10.5–18.0
	Homocysteine	CVD[133]	1 (1)	0.4
	Hypercoagulability testing	Deep vein thrombosis/pulmonary embolism[133]	1 (1)	3.5
	Antinuclear antibody	Not specified[142]	1 (1)	30.6
	CBC	Not specified[143]	1 (1)	5.4
	Ferritin	Not specified[136]	1 (1)	35.8
	Electrolyte panel	Not specified[143]	1 (1)	35.6
	Red blood cell folate	Not specified[144]	1 (1)	0.3
	Vitamin B_{12}	Not specified[136]	1 (1)	28.4
	Vitamin D	Not specified[136,140]	2 (2)	0.7–24.5
	Testosterone	Prostate cancer[145]	1 (1)	3.1
	Prostate-specific antigen	Suspected prostate cancer[133]	1 (1)	55.5
	Multiple blood tests: CBC,* PT, PTT or metabolic panel	Preoperative (low-risk surgeries)[146]	1 (2)	36.8–63.2
Imaging	Radiography (chest)*	Bronchiolitis,[147,148] asthma,[147] preoperative (low risk surgeries),[125] annual health examination (adults at low risk)[149]	4 (5)	2.4–34.0
	Transthoracic echocardiogram*	CVD,[150–152] preoperative (low-risk surgeries)[125]	4 (4)	2.9–13.8
	Carotid imaging/doppler*	CVD[133]	1 (1)	0.1
	Ultrasonography (abdominal)*	Constipation,[147] abdominal pain,[147] preoperative (orchiopexy surgery),[145] not specified[153]	3 (4)	6.1–58.0
	CT or MRI (lower spine)	Lower back pain[129,132,134]	3 (4)	1.6–4.6
	Radiography (type not specified)	Lower back pain[134]	1 (1)	29.1
	CT (head)*	Febrile convulsion,[147] seizure,[147] headache,[147] delirium[129]	2 (5)	0.5–24.2
	MRI (type not specified)	Lumbar spine pain,[154] not specified[155]	2 (2)	1.0–28.5
	Dual-energy x-ray absorptiometry*	Osteoporosis[132,133]	2 (2)	11.6–21.0
	Bone scan*	Prostate cancer[59,145]	2 (2)	22.0–77.6
	CT or MRI (pelvic)	Prostate cancer[59]	1 (1)	77.6
	Imaging (type not specified)	Breast cancer (stage I)[156]	1 (1)	79.6
	Radiography (abdominal)	Constipation,[147] abdominal pain[147]	1 (2)	13.2–25.9
	CT (abdominal)*	Constipation;[147] abdominal pain[147]	1 (2)	0.1–0.5
	MRI (head)	Concussion,[147] seizure,[147] headache[147]	1 (3)	0.4–4.9
	CT pulmonary angiogram	Not specified[157]	1 (1)	27.0

Table 3 (part 2 of 4): Overused clinical practices

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of overuse
Imaging	CT (type not specified)	Not specified[155]	1 (1)	2.0
	Chest radiography or echocardiogram	Preoperative (cardiovascular surgeries)[134]	1 (1)	25.1
	Radionuclide imaging	Thyroid nodules[158]	1 (1)	6.3
	Ultrasonography (carotid)	Not specified[153]	1 (1)	25.2
	Ultrasonography (pelvic)	Not specified[153]	1 (1)	1.6
	Ultrasonography (soft tissue)	Not specified[153]	1 (1)	2.4
	Ultrasonography (thyroid)	Not specified[153]	1 (1)	18.8
	Multiple imaging (cardiac imaging: coronary CT, cardiac stress test)	CVD[133]	1 (1)	1.0
	Cardiac imaging (transthoracic echocardiography transesophageal echocardiography, single-photon emission tomography myocardial perfusion imaging, diagnostic cardiac catheterization)	Suspected CVD[152]	1 (1)	5.0
	Combined surveillance breast imaging (mammogram, breast ultrasonography and breast MRI)	Breast cancer survivors[56]	1 (1)	4.0
	Head scans (brain/cranial radiography, CT, MRI)	Minor head trauma[129]	1 (1)	28.9
	CT or MRI (head and lumbar)	Not specified[159]	1 (1)	12.0
Therapeutics				
Acute care procedure	Cesarean delivery	Pregnant women[160,161]	2 (5)	21.7–69.0
	Angiography	CVD,[162] ischemic heart disease[163]	2 (2)	10.8–16.0
	Cystoscopy	Asymptomatic microscopic hematuria[164]	1 (1)	57.1
	Peripherally inserted central catheters	Not specified[165]	1 (1)	16.5
Biophysical therapy	Implantable cardioverter defibrillator therapy*	After out-of-hospital cardiac arrest,[166] had life-threatening ventricular tachyarrhythmia or at high risk for sudden cardiac death,[167] cardiovascular arrhythmia[168]	3 (3)	< 1.0–16.7
	Cardiac resynchronization therapy	Had life-threatening ventricular tachyarrhythmia or at high risk for sudden cardiac death[167]	1 (1)	10.0
	Withdrawal of life-sustaining treatment	Cardiovascular arrest[169]	1 (1)	32.0
	Red blood cell transfusions	Not specified[170,171]	2 (2)	22.0–61.0
	Intravenous immune globulin transfusion	Not specified[172]	1 (1)	56.7
	Plasma exchange*	Not specified[173]	1 (1)	28.6
	Bowel preparation	Colorectal surgery[57]	1 (1)	32.4
	Nasogastric tube	Colorectal surgery[57]	1 (1)	7.4
	Albumin transfusion	Fluid resuscitation[109]	1 (1)	20.0
	Radiation therapy*	Oral cavity squamous cell carcinoma[91]	1 (1)	1.0
	Physical restraints	Physical restraint use in long-term care facilities[174]	1 (1)	7.8
Medication (single class or single medication)	Antimicrobials*	Various bacterial infections (pneumonia, urinary tract infection, pharyngitis, cellulitis),[113] ventilator-associated pneumonia,[175] *Clostridium difficile* infection,[176] acute pancreatitis-infected necrosis,[72] asymptomatic bacteriuria,[177,178] nonbacterial acute upper respiratory infection,[179] acute pancreatitis (general),[72] *Staphylococcus aureus* bacteremia,[71] viral infection[113]	8 (11)	11.8–76.0
	Antipsychotics	Studies of potentially inappropriate medications,[174,180–183] Parkinson disease[184]	6 (6)	5.6–76.5
	Opioids	Dental pain,[185,186] studies of potentially inappropriate medications[187–189]	5 (7)	0.1–23.9

Table 3 (part 3 of 4): Overused clinical practices

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of overuse
Medication (single class or single medication	Benzodiazepines	Sedative hypnotics for insomnia, agitation or delirium;[129] studies of potentially inappropriate medications[182,183,187]	4 (4)	11.1–50.7
	Nonsteroidal anti-inflammatory drugs*	Studies of potentially inappropriate medications[182,183,187,190]	4 (4)	0.5–21.7
	Antihyperglycemics*	Diabetes mellitus and chronic kidney disease,[191] studies of potentially inappropriate medications[183,190]	3 (3)	3.3–21.0
	Proton pump inhibitors*	Studies of potentially inappropriate medications[182,183,187]	3 (3)	8.3–27.0
	Short-acting β-agonists*	Asthma[114,192]	2 (2)	3.2–5.3
	Antileukotriene	Asthma[61]	1 (1)	5.9
	Asthma	Asthma[61]	1 (1)	79.3
	Corticosteroids*	Asthma[61]	1 (1)	33.5
	Antidepressants	Studies of potentially inappropriate medications[182,183]	2 (2)	5.0–10.0
	Antispasmodics	Studies of potentially inappropriate medications[182,183]	2 (2)	0.1–1.0
	Antithrombotic	Studies of potentially inappropriate medications[182,183]	2 (2)	0.1–0.1
	Barbiturates	Studies of potentially inappropriate medications[182,183]	2 (2)	0.1–0.1
	Central α,-blockers	Studies of potentially inappropriate medications[182,183]	2 (2)	1.3–4.3
	First-generation antihistamines	Studies of potentially inappropriate medications[182,183]	2 (2)	1.9–4.4
	Peripheral α-1 blockers	Studies of potentially inappropriate medications[182,183]	2 (2)	1.2–4.7
	Skeletal muscle relaxants	Studies of potentially inappropriate medications[182,183]	2 (2)	3.0–5.2
	Antidiuretic (desmopressin)	Studies of potentially inappropriate medications[183]	1 (1)	0.1
	Non-benzodiazepine and benzodiazepine receptor agonist hypnotics	Studies of potentially inappropriate medications[182,183]	2 (2)	0.01–0.01
	Sedative hypnotics	Studies of potentially inappropriate medications[190]	1 (1)	9.0
	Selective α-1-adrenergic blocking agents (e.g., alfuzosin, tamsulosin, silodosin)	Studies of potentially inappropriate medications[187]	1 (1)	5.6
	Magnesium sulfate*	Fetal neuroprotection[120]	1 (1)	9.3
	Quetiapine	Insomnia (children)[129]	1 (1)	0.2
	Venous thromboembolism prophylaxis*	Not specified[109]	1 (1)	45.3
	Multiple: potentially inappropriate: multiple medications	End-stage kidney disease,[193] studies of potentially inappropriate medications[182,194–200]	9 (9)	13.5–97.3
	Antiparkinsonian: multiple medications	Studies of potentially inappropriate medications[182,183]	2 (2)	0.1–0.3
	Analgesics (pentazocine and meperidine)	Studies of potentially inappropriate medications[183]	1 (1)	0.1
	Cardiovascular: multiple medications	Studies of potentially inappropriate medications[182]	1 (1)	1.6
	Cardiovascular (disopyramide, dronedarone, digoxin, short-acting nifedipine, amiodarone)	Studies of potentially inappropriate medications[183]	1 (1)	0.6
	Gastrointestinal (other than proton pump inhibitors): multiple medications	Studies of potentially inappropriate medications[182]	1 (1)	0.1
	Genitourinary: multiple medications	Studies of potentially inappropriate medications[182]	1 (1)	0.2
	Pain medications: other than NSAIDs and skeletal muscle relaxants: multiple medications	Studies of potentially inappropriate medications[182]	1 (1)	0.3
	Polypharmacy in older adults: multiple medications	Studies of potentially inappropriate medications[201]	1 (1)	48.0
	Potentially inappropriate: nonsteroidal anti-inflammatory drugs, selective serotonin reuptake inhibitors, serotonin–norepinephrine reuptake inhibitors, antiplatelets or anticoagulants, oral corticosteroids, alendronate, ACE inhibitors, angiotensin II receptor blockers, diuretics or β-blockers	Studies of potentially inappropriate medications[202]	1 (1)	72.0

Table 3 (part 4 of 4): Overused clinical practices

Care subcategory	Clinical practice	Disease or condition	No. of studies (No. of findings)	Percentage or range of overuse
	Potentially inappropriate: benzodiazepines, H2-receptor antagonists, antipsychotics, anticholinergic	Studies of potentially inappropriate medications[203]	1 (1)	44.3
	Pharmacotherapy (epinephrine, salbutamol, hypertonic saline, corticosteroid)	Acute bronchiolitis[148]	1 (1)	46.0

Note: ACE = angiotensin-converting enzyme, CAD = coronary artery disease, CBC = complete blood count, CT = computed tomography, CVD = cardiovascular disease (includes the 4 main types of CVD: coronary heart disease, stroke/TIA, peripheral arterial/vascular disease, aortic disease), H2 = histamine type 2, MRI = magnetic resonance imaging, NSAID = nonsteroidal anti-inflammatories, PT = prothrombin time, PTT = partial thromboplastin time.
*Both underused and overused.

Table 4: Inappropriately used clinical practices

		Inappropriate use (total)			Underuse			Overuse		
Category of care		No. of total practices (no. of unique practices)*	No. of studies (no. of findings)	Median (IQR), %	No. of total practices	No. of studies (no. of findings)	Median (IQR), %	No. of total practices	No. of studies (no. of findings)	Median (IQR), %
Diagnostics	Laboratory test	5 (5)	9 (11)	48.4 (26.4–73.0)	5	9 (11)	48.4 (26.4–73.0)	0	0 (0)	–
	Referral	10 (9)	11 (13)	43.0 (31.7–56.2)	8	10 (11)	45.7 (31.0–57.0)	2	2 (2)	–
	Assessment	35 (34)	32 (66)	38.2 (24.0–63.7)	29	25 (59)	39.1 (24.3–65.8)	6	6 (7)	25.1 (3.0–42.0)
	Screening	12 (11)	17 (21)	29.6 (14.1–68.3)	7	9 (10)	68.3 (53.0–82.7)	5	8 (11)	14.2 (2.9–22.2)
	Blood test	25 (22)	27 (65)	24.7 (16.4–38.8)	10	14 (42)	27.8 (18.2–49.0)	15	13 (23)	22.4 (3.5–35.1)
	Imaging	43 (35)	34 (77)	13.8 (4.5–29.0)	15	15 (25)	21.3 (13.4–36.7)	28	21 (52)	9.7 (3.0–24.9)
	Multiple diagnostics	4 (4)	4 (5)	54.0 (28.6–75.3)	4	4 (5)	54.0 (28.6–75.3)	0	0 (0)	–
	Subtotal	134 (120)	89 (258)	28.0 (12.7–50.4)	78	52 (163)	35.2 (21.3–61.8)	56	42 (95)	13.2 (3.3–28.1)
Therapeutics	Acute care procedure	10 (10)	12 (16)	53.5 (21.8–71.4)	6	6 (7)	72.2 (51.5–97.3)	4	6 (9)	22.0 (16.3–56.3)
	Biophysical therapy	29 (26)	28 (42)	45.8 (19.2–64.8)	18	18 (28)	57.5 (36.2–78.0)	11	12 (14)	18.4 (6.4–32.1)
	Psychosocial therapy	9 (9)	11 (31)	37.8 (30.5–54.2)	9	11 (31)	37.8 (30.5–54.2)	0	0 (0)	–
	Medications	70 (62)	69 (159)	25.9 (5.8–60.2)	32	34 (71)	51.1 (24.0–71.0)	38	39 (88)	10.6 (1.7–38.5)
	Multiple therapeutics	1 (1)	1 (1)	–	1	1 (1)	–	0	0 (0)	–
	Subtotal	119 (108)	108 (249)	34.0 (10.0–61.1)	66	60 (138)	51.1 (30.1–71.0)	53	55 (111)	13.6 (3.0–38.9)
Total		253 (228)	174 (507)	30.0 (12.0–56.6)	144	94 (301)	43.9 (23.8–66.3)	109	95 (206)	13.6 (3.2–30.7)

Note: IQR = interquartile range.
*Unique practices: excludes practices that are both underused and overused ($n = 25$).

Table 5: Trends in amount of inappropriately used practices over time

Category of care	2009–2017 *n* = 92		2018–2020 *n* = 80	
	No. of studies (no. of findings)	Median (IQR), %	No. of studies (no. of findings)	Median (IQR), %
Diagnostics subtotal	52 (154)	28.5 (17.0–50.4)	35 (99)	26.7 (7.0–42.2)
Therapeutics subtotal	58 (128)	42.2 (18.9–67.3)	50 (120)	24.5 (3.9–55.0)
Total	92 (282)	32.6 (18.0–58.7)	80 (219)	25.9 (5.0–52.1)

Note: IQR = interquartile range. Multiple diagnostics subcategory removed: only 1 data point in 2018–2020; multiple therapeutics subcategory removed: only 1 data point in 2009–2017.

diagnostics was in imaging tests (median 13.8%, IQR 4.5%–29.0%), whereas the highest proportions were in laboratory tests (median 48.4%, IQR 26.4%–73.0%). The most frequently investigated underused diagnostics were glycated hemoglobin (blood tests), lipid tests (blood tests) and diabetic eye examinations (assessments). Glycated hemoglobin, assessed in 9 studies, had underuse proportions of 18.0%–85.7%. Lipid tests, assessed in 8 studies, had underuse proportions of 3.2%–47.0%. Diabetic eye examinations, also assessed in 8 studies, had underuse proportions of 22.9%–80.5%. The most frequently investigated overused diagnostic was thyroid-stimulating hormone (blood tests), investigated in 5 studies with overuse proportions ranging from 3.0%–35.1%. The next most frequently investigated overused diagnostics, evaluated in 4 studies each, were radiography of the chest (imaging; overused 2.4%–34.0%), Papanicolaou test (screening; overused 8.0%–15.7%) and transthoracic echocardiogram (imaging; overused 2.9%–13.8%).

We found that 108 therapeutic practices were investigated in 108 studies: 66 (61.1%) therapeutics were underused (Table 2), 53 (49.1%) were overused (Table 3) and 11 (10.2%) were both underused and overused. Therapeutics were inappropriately used, on average, 34.0% of the time (IQR 10.0%–61.1%), with the lowest overall proportions of inappropriate use for medications (median 25.9%, IQR 5.8%–60.2%) and the highest proportions for acute care procedures (median 53.5%, IQR 21.8%–71.4%). Although acute care procedures (e.g., carotid endarterectomy) had the highest median proportion of inappropriate use, they were among the least investigated therapeutics (10 procedures in 12 studies). The most frequently investigated therapeutics that were underused were statins (medications), with underuse proportions of 18.5%–71.0% (n = 6), and combinations of cardiovascular drugs (medications), with underuse proportions of 3.3%–98.8% (n = 5). The most frequently investigated overused therapeutics were also all within the medication subcategory: overuse ranged from 11.8% to 76.0% for antimicrobials (n = 8), 5.6%–76.5% for antipsychotics (n = 6) and 0.1%–23.9% for opioids (n = 5).

Table 5 displays the medians for inappropriate use over the 12 years of data included in this review, for which we used the median publication year of 2017 as the comparison point (Table 5). The largest difference was in therapeutics, which showed a decrease of 17.7% in inappropriate care in recent years. When assessed by subcategory, only medications showed a noteworthy reduction in inappropriate care (41.0% down to 14.0%). This reduction was due to fewer medications being overused (38% down to 5.0%); underuse of medications increased during the same time frame (46.0% up to 63.0%) (Appendix 5, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content).

When we omitted studies that were methodologically weak, median proportion estimates were largely unchanged (Appendix 6, available at www.cmaj.ca/lookup/doi/10.1503/cmaj.211416/tab-related-content).

Interpretation

We identified 174 studies that investigated 228 unique clinical practices that were underused or overused in Canada over the last decade. The dominant finding from our review is that there are large gaps between the care people should receive and the care they do receive. We found that, on average, 30.0% of the care received by people in Canada as assessed in the included research papers using the Institute of Medicine's definitions of underuse and overuse,[18] was deemed inappropriate. This was true for both diagnostic and therapeutic practices across different health sectors, all age groups, and whether the nation or select cities, provinces or territories were evaluated.

Estimates of the amount of inappropriate care from our review are similar to those reported in reviews from other countries. In the germinal 1998 review of inappropriate health care in the US,[8] patients received inappropriate care in 45% of encounters. Like our findings, there was substantial heterogeneity in inappropriate use in the US review based on the clinical practices evaluated, ranging from 21.3% to 89.5%. Similar findings were reported in reviews from other countries: in the UK,[10] 51%–97% of care was reported to be inappropriate, and in Australia,[11] 10.0%–87.0% was inappropriate.

Inappropriate care is a pressing problem in health care, largely because it causes iatrogenic harm to patients and often interferes with the delivery of high-value care.[2,4] It also leads to negative patient experiences,[2] poor health outcomes[3,4] and inefficient use of scarce health care resources.[5] Previous reviews[8–11] on inappropriate care provided much needed stimuli to the field of health care quality by elevating global recognition that inappropriate care is not only a serious and widespread problem, but one to which no health sector is immune. These reviews also laid the foundation for several successful quality improvement initiatives in their countries (e.g., the *100 000 Lives* and *Protecting 5 Million Lives from Harm* campaigns in

the US).[18,19] The findings from our review provide examples of clinical practices that are underused and overused in Canada. Knowledge of these indicators is necessary to underpin initiatives in Canada to improve the quality of health care. Our results can be used by provincial and territorial governments and quality improvement organizations to prioritize future quality improvement initiatives. Our findings also provide a critically needed benchmark tool against which future progress in quality improvement can be measured.

Proportions of inappropriate use of many of the clinical practices identified in our review varied widely; however, some practices were studied frequently and others infrequently. As a result, large gaps in our knowledge of inappropriately used clinical practices in Canada remains. Although we were able to provide a substantial listing and summary of inappropriately used practices in Canada, it is not a comprehensive summary of all practices delivered in the Canadian health care system. Additional research, especially on practices not yet investigated and on those less frequently investigated, are critical next steps to expand the list of inappropriately used practices.

Limitations

Studies were heterogeneous with respect to the practices investigated, populations used, data collection time points and how inappropriate care was measured. Although we retrieved and evaluated each cited practice recommendation, it was not feasible to assess the quality of the evidence behind each recommendation. There may be valid reasons not reported in the included studies for why some patients did or did not receive a recommended practice. Our review was limited to studies that evaluated practices against a criterion standard such as a guideline recommendation; this may have led to some missed reports on inappropriate care. We only captured instances of appropriate or inappropriate care that were studied and, thus, where researchers speculated that there was a problem of appropriateness. Many of the included practices were evaluated in a single study, which limited the conclusions that could be drawn on these practices. Finally, a common reason for lower quality scores (i.e., lack of probabilistic sampling in non-population-based studies) may have affected the reliability of some of the inappropriate proportions that we reported.

Conclusion

We found that many clinical practices received by people in Canada are inappropriate; whether that practice is diagnostic or therapeutic, it frequently does not meet recommended standards. Although we identified a considerable range of clinical practices that are inappropriate, it is not an exhaustive listing of all practices delivered in Canada. Further research is necessary to expand on this list. Clinicians and organizations could use the list of clinical practices from this review (especially the 42 most-studied practices) to identify priorities for their work on quality improvement.

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