Diagnostic testing in pediatrics: yield and drivers

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Chapter 8

General discussion

The research reported in this thesis aimed to generate knowledge on the assessment of diagnostic yield and diagnostic test behaviour in pediatrics. Insight in the diagnostic process, the information gain of testing and test behaviour are necessary to advance the discussion on the desired diagnostic yield of testing and find ways to improve the quality of testing.

This general discussion's main focus are strategies to reduce low-value testing and promote high-value testing, in relation to the findings of this thesis. It begins with a reflection on the different aspects of diagnostic information and other expected advantages and disadvantages related to tests. Then an overview of drivers of low-value testing is presented. The last part addresses potential ways to improve test decisions.

1 Value of testing

This section reflects on the different aspects of diagnostic information and other expected advantages and disadvantages related to tests. It describes the continuum of diagnostic yield and the value judgment required for definitions of appropriate care.

Yield of testing

Obtaining information to improve management and thus create medical value for the patient is the most straightforward reason to perform testing (Chapter 5).[1] The expected medical value of a test depends on the estimated probability and severity of the disease, its natural course and the treatment effect, and the harms and burden of test and treatment. Testing to rule out a diagnosis is more likely to occur if severe or fast progressing diseases are considered. Because of the indirect link between testing and outcome the effect of test results on management and outcome is sometimes unclear, either because of insufficient data or insufficient efforts to link test and outcome (Chapter 2 and 3).[2] Planning value and psychological value, such as reassurance through negative test results, are recognized and accepted aims of testing in pediatric patients (Chapter 5) and adults.[3-6] Testing with the primary goal to improve management decisions can also deliver value in the other domains and to different stakeholders. Other reported goals of testing are testing out of curiosity or testing to increase knowledge on the disease entity in the hope this might benefit future patients (Chapter 2 and 5).

Expected value of testing unrelated to test information from the physician's perspective

In our study (chapter 5) and others, physicians reported other positive consequences of testing unrelated to the information testing provided. Testing in pediatrics was applied because of its expected positive effect on patient satisfaction and the patient-provider relationship or because it opened a way for negotiating non-medical supportive therapy to cope with unexplained complaints (chapter 5), in line with findings in adult medicine.[7-10] Congruent with previous findings, just ordering tests was perceived as easier than explaining why these tests were not beneficial and was thought to reduce the risk of negative personal consequences for the physician (chapter 5).[11,12] Though pediatricians did not consider financial incentives as a relevant

influence (unpublished), in international literature financial incentives are described as a strong and undisputed driver for testing.[13,14]

The magnitude of expected positive consequences of testing per se is influenced by provider and patient personality, experiences, knowledge and expectations, but also by local contextual and broader organizational, financial, and judicial circumstances. Figure 1 describes the simplified process of diagnostic test decisions and the factors that influence the estimated magnitude of positive and negative consequences. This figure is based on literature and own research (Chapter 5, 6).[8,9,15-23]

The spectrum of generated value

The generated net value of testing follows a continuum. Some testing decisions are straightforward and lie at either end of the continuum. At the one end lies testing that causes obvious harm, and on the other testing with obvious net medical value: without test information the outcome would be worse.[24,25] Examples of tests that are purely harmful are invasive tests in a selection of patients in which harm will outweigh any benefit, such as kidney biopsy in children with an incidental finding of isolated microhaematuria, or broadscale testing and subsequent treatment with its associated harms unequivocally outweighing benefits, such as in thyroid cancer screening.[26] An example of a test with obvious net benefit is an MRI in a patient with signs of increased intracerebral pressure, as imaging informs and improves management decisions.

Between necessary tests on the one side and harmful tests on the other side, lies a large grey area, that ranges from appropriate testing (tests with net benefit but not as large or certain as necessary tests) to unhelpful hence inefficient tests or tests with unclear benefit.[27] This spectrum from high net value to low or even negative net value could be regarded as the spectrum from high- to low-value testing, and its presence is acknowledged by physicians (chapter 5).

The value discussed above pertains to value for individual patients: the balance between expected positive and negative consequences of testing. If a societal point of view is taken, (opportunity) costs and environmental impact should be included in the calculation. Many medical interventions in high-resource countries have small incremental benefit against high costs, which translates into low cost-effectiveness. Regarded from a societal perspective, the grey zone also includes cost-inefficient tests.[28,29]

A value judgment

There is no agreement on the definition of necessary, appropriate, unhelpful/inefficient or harmful care and definitions would probably differ among stakeholders and context.[30,31] As an example, we take the definition of unhelpful/inefficient testing. In practice, physicians do not rule out every single possible disease in the diagnostic process. If the prior probability of a disease or its relevance is estimated to be very low, there comes a point at which physicians consider testing no longer warranted for medical reasons, and the threshold to withhold testing is reached.[1] However, sometimes patients desire testing, even under this threshold, e.g., to rule out a particular disease that they fear. These patients highly value the resulting reassurance of negative test results and they accept the burden of testing and associated costs to society. The

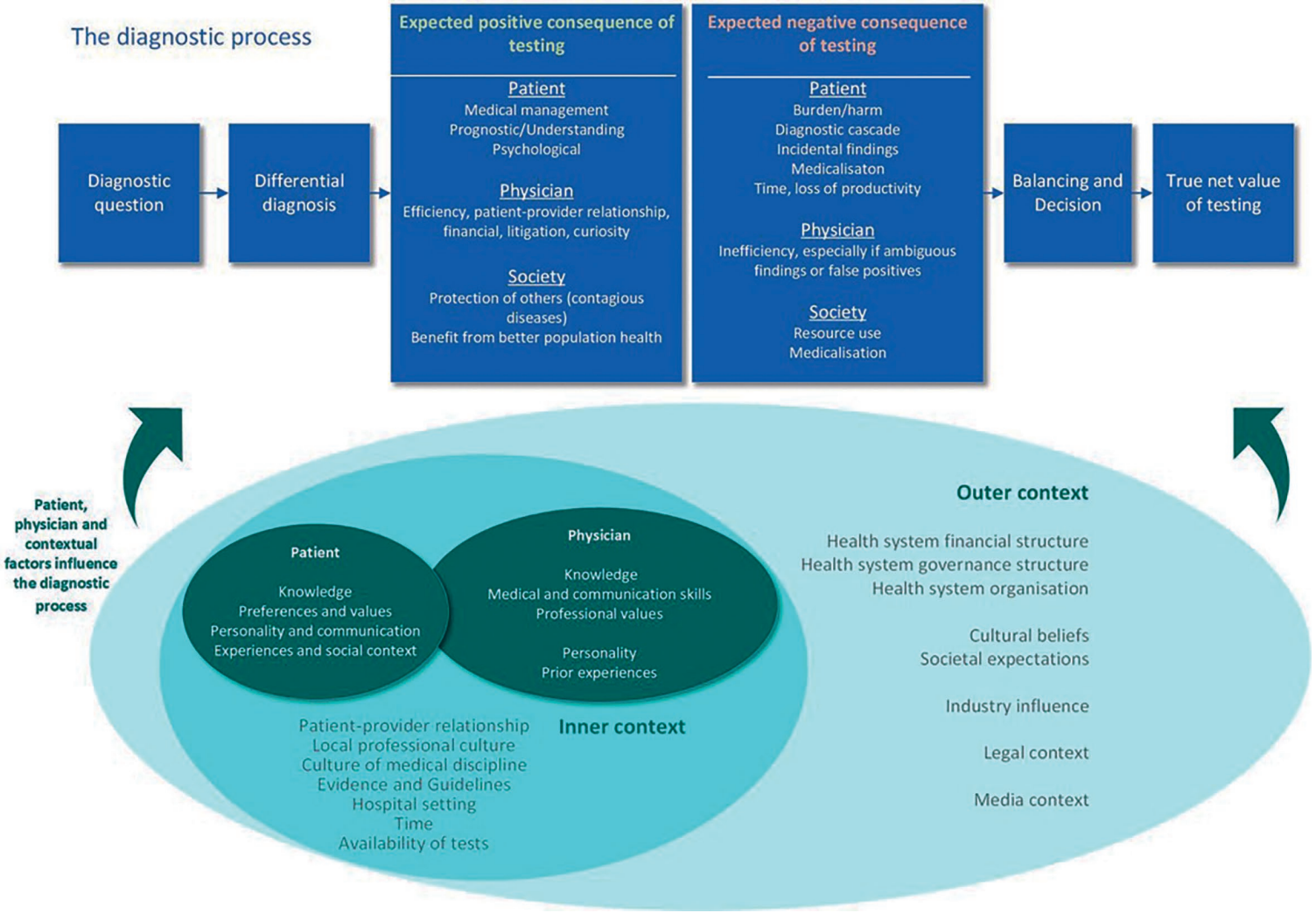
The diagnostic process
Diagnostic question
Differential diagnosis
Expected positive consequence of testing
Patient
Medical management
Prognostic/Understanding
Psychological
Physician
Efficiency, patient-provider relationship, financial, litigation, curiosity
Society
Protection of others (contagious diseases)
Benefit from better population health
Expected negative consequence of testing
Patient
Burden/harm
Diagnostic cascade
Incidental findings
Medicalisaton
Time, loss of productivity
Physician
Inefficiency, especially if ambiguous findings or false positives
Society
Resource use
Medicalisation
Balancing and Decision
True net value of testing
Patient, physician and contextual factors influence the diagnostic process
Patient
Knowledge
Preferences and values
Personality and communication
Experiences and social context
Physician
Knowledge
Medical and communication skills
Professional values
Personality
Prior experiences
Patient-provider relationship
Local professional culture
Culture of medical discipline
Evidence and Guidelines
Hospital setting
Time
Availability of tests
Inner context
Outer context
Health system financial structure
Health system governance structure
Health system organisation
Cultural beliefs
Societal expectations
Industry influence
Legal context
Media context

Figure 1. A simplified process of diagnostic test decisions (upper window) and the factors (lower window) that influence the projected magnitude of positive and negative consequences of testing and the diagnostic process in its entirety.
As an example: societal risk acceptance and societal expectations of what health care should deliver influence the way patient regard symptoms they experience and affect the threshold and timing of seeking medical care. It also influences what patients expect and how physicians behave during consultations, the test decision and how testing is valued in hindsight (chapter 5).[8,9,15-23]

question is: how much is reassurance worth, how much may it cost and who should pay for it? Importantly, real costs do not only include costs of the test, but also return visits, the cost of physician, nurse, material, facilities, and all costs of downstream consequences of testing.

The answer to these questions encompasses economical and ethical aspects. Public financial resources should be spent in an efficient way to reach formulated goals. Along that line, resources allocated to population health should be efficiently distributed over the different social domains that contribute to population health.[32] We need to reflect: what is an attainable and acceptable quality of curative health care, and what is the effect of this choice on population health now and in the future, considering the opportunity costs and other major challenges to health such as climate change, pollution and loss of biodiversity that require financial resources.[33-35] In relation to testing: What is the minimum net benefit of testing that is acceptable against the cost of testing?

Setting boundaries to healthcare – or testing, in the context of this thesis – has ethical aspects. Is reassurance a goal of our healthcare system? Are there limits? May patient autonomy be restricted for efficiency reasons?[36] What prior probability of disease justifies testing to rule out diseases against what cost? Or what level of certainty regarding a diagnosis is sufficient? Is it justifiable to accept diagnosing a disease later than possible, sometimes causing irreversible damage to that patient, but preventing test burden in many others, while saving resources that can be used more efficiently to promote health? And if so, what is an acceptable miss-rate? Where should the threshold for efficiency be set?[25] Should that patient be compensated? Then, however, this poses the question whether the right to access to healthcare should be linked to the right to be compensated in case of adverse but accepted side effects of healthcare. Answers to these questions are relevant for explicit rationing, the determination of boundaries of healthcare.

2 Low-value testing

In this section the factors that drive and sustain low-value testing are described. Understanding of underlying mechanisms provides input for efforts to improve test use.

Definition

Low-value care includes medical practices (1) of which harms exceed the benefit or which have a poor risk-benefit profile considering the alternatives, costs and preferences, (2) with evidence

for lack of clinical effectiveness, or (3) with lack of evidence for effectiveness.[30,37,38] There is no consensus on the exact definition and applied thresholds: what constitutes sufficient net benefit hinges on a value judgement which includes cost-efficiency and hence also takes a societal perspective.

In the spectrum of generated value of testing, described above, testing with insufficient to negative net benefit constitutes low-value care. Often testing is of uncertain benefit, because of lack of evidence for effectiveness. As often pointed out, this is different from evidence for lack of effectiveness. Nevertheless, benefits for the entire patient population might be small, even though selected patients might reap benefits.[39] Inefficiencies in the organisation of healthcare also lead to low-value testing, such as repeat tests because of insufficient data sharing between two providers.[24,27] Another category of low-value care is unwanted testing; testing in disagreement with patient preferences and values.[37] Whereas physicians focus on requests for unwarranted testing, studies demonstrate that physicians misinterpret patients' questions about the best course of action as requests for testing or treatment.[40] This can motivate testing based on a misunderstanding due to an insufficient exchange of information and individual preferences between physician and patient. Unwanted testing will be further discussed in Section 3.

Mechanisms that drive and sustain low-value testing

The many variables that shape test decisions are also linked to the quality of testing. Therefore, we mapped drivers of low-value care to these variables (Table 1) and added suggestions to improve testing (Section 3). In this section we will briefly describe drivers behind testing with insufficient benefit, and largely refer to Table 1. In Table 1 we arranged the factors that influence test decisions according to 4 categories: patient, physician, inner and outer context (Table 1 and Figure 1). The categories patient and physician include characteristics of these main decision makers. The inner and outer context in which test decisions take place influence these decisions. The second column describes drivers of low-value care associated with these factors, and the last column proposes ways to decrease low-value care or otherwise improve care.

There are many drivers for testing, because testing is generally valued by patients and physicians alike and they are not directly confronted with the cost. The development of new diagnostic technologies including self-tests without sufficient prior evaluation of benefit, or without subsequent review of the actual benefit when applied in routine practice, or without substitution of existing ones[41], further drives testing. In addition, indication creep, the phenomenon by which a technology initially assessed and adopted for use in a specific indication and group of patients, but subsequently spreads to wider patient groups and indications without structured assessment (Chapter 3), contributes to low-value care.[42] Imperfect knowledge and reasoning can lead to estimates of benefits and harms that are far off, which can produce over- and underuse. The positive consequences of testing tend to be overestimated and the harms underestimated by patients and physicians[43,44] and action is generally preferred to inaction.[45] Moreover, restrictive testing is perceived as ungenerously limiting patients' freedom or right to information, and may put physicians at risk for personal negative consequences. This elicits anticipated regret. The feared negative personal consequences of parsimonious testing include

the loss of health or trust of individual patients, its effect on the patient-provider relationship[11], loss of efficiency[8], negative reactions of colleagues[20], but also (legal) complaints or claims that could even result in retraction of license to practice.[46,47] Patient and physician characteristics determine the strength of the tendency for unnecessary testing, together with the smaller social context of the physicians' working environment and patient-provider relationship and the larger societal context.

Experiences during training shape practice style[48] as does the professional culture of the current practice environment. Physicians report that if they operate in a team that values appropriate test ordering this influences their test behaviour (chapter 5), but the opposite is also true: working in a risk averse environment encourages test ordering.[20,49] The better-informed and empowered patient can improve decision making[50], but misinformation or a consumerist attitude towards healthcare can drive testing.[51] Increased demand for testing requires physicians to explain why testing is not warranted and dissuade patients, for which time, energy and communication skills are needed.[8]

Additional contextual influences, such as societal beliefs regarding healthcare, tolerance of error or uncertainty, but also the financial barriers and incentives for testing, and the legal system, further shape physicians' motivations and decisions.[22] The legal system reflects and reinforces the organizational and societal environment. Healthcare industry fuels the belief that more, new and earlier testing is better, and media reinforce this message in their focus to attract readership.[51-53] Physicians and the public receive and repeat the message that earlier detection uniformly leads to better outcomes, and conversely that missing a diagnosis invariably results in worse outcomes. Industry, media and physicians emphasize values such as individual patients' right to best care, professional autonomy and innovation, while society's interests such as opportunity costs and efficiency are neglected.[51] These beliefs and messages influence interactions and decisions in the consulting room, and the interests of invisible members of society bearing the opportunity costs of their diagnostic spending are largely disregarded. Indeed, healthcare providers recognize that there are resource limits and declare to feel responsible for contributing to a sustainable health care system (Chapter 5), but this is not always reflected by the physicians' actions (Chapter 2, 4).[11,54]

The described factors stimulate inefficient or unhelpful testing and contribute to overuse both through patient demand and the physicians' own motivation. Increased doctor's visits and increased patient expectations for testing along with the described drivers, both increase the amount of grey zone diagnostic situations and the instances that testing is performed in these situations.[11,12,55,56] Increased testing changes what is viewed as the current practice norm, and through the strong influence of practice norms on individual providers' and trainees' test behaviour[48] and on patient expectations, this will further consolidate this new practice of increased testing.

Therefore, we need not only discuss where the boundaries to health care lie, but also what is necessary to actually accept and respect these boundaries in the confines of the consulting room, where testing is ordered at the discretion of individual doctors. This includes the recognition that testing is used for other means than information gain alone (also Section 1).

Table 1. Relevant factors shaping test decisions (Figure 1), linked to drivers for low-value testing and possible ways to reduce low-value testing or otherwise improve care.[9,23,31,51,57-62]

The provided solutions and the references are examples and not comprehensive. The factors of influence are organized according to factors related to the patient, physician, inner context and outer context.

Factors of influence	Drive low-value testing if:	Potential ways to reduce low-value testing
Patient		
Knowledge	Overestimation of benefit, underestimation of harm	Disease specific information (patient education)[63-65] (therapy)[66]
Preference and value	High expectations	Create a sense of shared responsibility for the healthcare system, reduce hierarchy in interaction, while maintaining professional role. *See outer context – Societal expectations of health care*
Personality	Risk averse, intolerance of uncertainty	Trustful patient-provider relationship
Experiences	Expectation for testing, a vicious circle if testing is routinely provided	Positive experiences of refraining from immediate testing, e.g. through adequate safety-netting[67]
Physician		
Knowledge of physiology and disease	Gaps and uncertainty: – More likely in unfamiliar or unusual presentations – Increases susceptibility to biases (e.g. overestimation of probability)	Continuous education Involve seniors[68] Decision support/educational interventions (part of multicomponent intervention[69]) Debiasing strategies[70]
Previous medical education	Problem based learning Focus on finding diagnosis	Sufficient basic knowledge Sufficient guidance during training[71] Educate on inherent uncertainty, importance of management in absence of diagnosis, and coping strategies for patient and physician[72]
Knowledge on effects of testing	Insufficient: susceptible to pro-testing biases and overestimation of benefit	Education on realistic estimate of benefits and downstream effects Education on epidemiology and biases Feedback on diagnostic process including[73]: – Quantification of overuse and its effects for feedback – Quantification of effects of testing for reassurance

Factors of influence	Drive low-value testing if:	Potential ways to reduce low-value testing
Physical examination skills	– Insufficient to detect abnormalities important for differential diagnosis	Improve and practice
Reasoning skills	– Insufficient to make adequate differential and management plan	Improve and practice (future use of AI) Feedback on diagnostic process[73]
Communication skills for history taking	– Insufficient to collect information important for diagnosis – Insufficient to elicit cause of worry – Insufficient to explore preferences	Practice patient- centered communication[74]
Communication skills for diagnosis and management	– Insufficient acknowledgement – Insufficient communicational comfort with patients asking about tests – Insufficient (alternative) explanation of symptoms – Insufficient explanation of reason for testing and significance of possible results – Insufficient for alternative strategies than testing	Patient-centered communication Explore questions and needs potentially underlying test request Practice communication in situations of uncertainty and unexplained symptoms[75] and address symptom management[76] Inform about test and consequences of test results before testing[77,78] Safety-netting[79] and active surveillance[67,80,81]
Values	Disregard of societal effects of personal practice	Educate on responsibility of larger society (see professional culture) Reflect on the skilful clinician
Personality	Controlling, risk aversion	see inner context- culture see outer context- legal context and societal expectations
Prior experiences	Personal negative experiences associated with tests not performed	Normalize uncertainty and accept occasionally missed diagnosis, mitigate harmful effects for patient and physician (see legal context)
Inner context		
Patient-physician relationship	Distrust, misunderstanding, misinterpretation	Continuity of care and trustful relationship[82,83]
Local culture	Risk aversion with effect on practice of peers and juniors	Include seniors and local leaders Evaluate social norms, (try to) accept some level of uncertainty to reduce low-value testing (reflect on skilful clinician) Provide peer support should adverse events occur

Factors of influence	Drive low-value testing if:	Potential ways to reduce low-value testing
Culture of medical discipline and accepted roles of caregiver	Risk averse, convinced of well-doing to mankind Striving for complete certainty for own patient group, disregarding societal effects Consumerist attitude towards health care	Education/Reflection on the reality of uncertainty Reflection and education on different identities of healthcare provider- also societal (expert, caregiver, service provider, resource allocator)
Evidence	publication bias, intellectual bias, sponsored evidence	Publication of research protocols and negative findings Research on effects of provided care (evaluation research) Involve independent professionals for evidence review Funding based on need, rather than industry's financial interest
Guidelines	Conflict of interest[84,85], methodological flaws[86], overestimation of benefit. Knowledge gaps leaving room for overuse in recommendations (being on the safe side)	Evidence summary and interpretation by independent technical staff. Use of test-outcome framework Translation into recommendations with oversight from regulatory body to represent societal interests and with incorporation of negative effects of overuse. Fill knowledge gaps; e.g. by evaluating practice
Hospital/Practice setting	Financial incentives for testing[87], especially in smaller practices with diagnostic facilities[88] Inefficient organisation	See outer context financial structure and organisation Improve work processes
Time	Testing saves time- important when time constraint	Sufficient time (and reward)
Availability of tests	Overcapacity (and diagnostic facilities owned by providers)	Justification before testing
Outer context		
Health system financial structure (insurance coverage, co-payment, provider payment scheme)	No financial barriers for testing Financial incentives for testing Abundant resources for curative care	Try alternatives payment schemes focused on quality (all with undesired side effects)[89,90] Compensate for loss of revenue for institutions that try to reduce unnecessary care and help to relocate personnel if needed. Financial reward also for consultation time, not predominantly for medical interventions or revisits.

Factors of influence	Drive low-value testing if:	Potential ways to reduce low-value testing
Health system governance structure	Near complete professional autonomy of physicians that prioritize their 'own' patients and have self-interest.	Quantification of effects of healthcare practices for – New technologies before full reimbursement – Existing practice – Guidelines Dialogue with providers, priority setting and oversight Discuss desired efficiency of testing including tests for reassurance Quality measures include efficiency Insurer restrictions
Health system organisation	No gatekeeper No coordination of demand and supply	Primary care system[91] Triage and routing of patients Sufficient generalist doctors to balance and direct care, especially for complex patients Question desirability of diagnostic facilities co-owned by practitioners, due to drivers for testing
Cultural beliefs	More and earlier is better Individualism Unrealistic expectation of new technologies	Public campaigns on limits of healthcare system and lower-value care Start educating medical students and staff (very pervasive because intuitive)
Societal expectations of health care	Everything is possible and patients are entitled to it all Focus on eliminating residual uncertainty Quality of healthcare is defined by level of mistakes Medicalisation of human experiences	Educate on true costs, limits and what the public can do for a sustainable health care system Discriminate between high-value care and low-value care
Legal context	Malpractice litigation Disciplinary law – No acceptable miss-rate due to feared legal ramifications or formal complaints, which leads to errors of commission[92]	Safety-netting for healthcare workers that try to accept a certain level of uncertainty and risk in order to prevent low-value testing Safety II In case of complaint: evaluate entire chain of events and regard healthcare as network, stop unrealistic focus on individual healthcare worker's performance

Factors of influence	Drive low-value testing if:	Potential ways to reduce low-value testing
Industry influence	If industry mainly pursues its own interests and: – stimulates research and use of tests with small benefit and even smaller if indication creep – influences physicians through sponsoring education and research – influences patient organisations – influences media	Industry- healthcare partnership in formulating needs for research and development
Media influence	Telling stories of rare diagnoses and heroic individual physicians and patients, earlier is better	Realistic and less individualistic messages

3 Potential ways to reduce low-value testing

This section will address ways to reduce low-value testing and improve the quality of care. Whereas Table 1 aims to provide a broad overview of the most important factors that influence test decisions, in this section we will address a selection of solutions listed in Table 1 in more detail. These suggestions are based on our work and that of others. The proposed solutions will be discussed in 4 paragraphs. The first will describe how to improve the input and analysis of information in the diagnostic process. The second will describe how to align decisions according to professional insight and patient preference. The third will discuss guidelines, and the last paragraph addresses the circumstances that can support or hinder efforts to reduce unnecessary care.

When addressing overuse, the goals of healthcare systems and limits to these systems need to be agreed upon. Besides ineffective, harmful and unwanted practices, practices for which there is a superior alternative or practices which are applied too unselectively can be identified as targets for improvement. Quantification of overuse, expressed as costs, direct patient harm or societal harms due to missed opportunities in other public areas, is helpful to persuade stakeholders of the relevance of this issue. It will also help to allocate sufficient resources for assessment of underlying reasons, and interventions that address feared negative consequences of deimplementation of a service for the various stakeholders, while creating circumstances that promote the desired testing behaviour. An evaluation of the most relevant factors in a particular situation might be worthwhile before the conception of any deimplementation intervention.[61,69,93] Especially financial incentives should be considered as a barrier to deimplementation; in the majority of systems delivering more care is rewarding and doing less is financially disadvantageous.[13] Effect size of deimplementation interventions may be small and not persistent and unintended effects of interventions should be monitored.[36,69] However, inaction produces many unintended effects of overuse that should also be considered when evaluating the effect of interventions.

Improve the input and analysis of patient information

The most obvious reason to perform testing is to obtain information additional to that collected during history taking and physical examination (Section 1). The expected positive and negative consequences of testing are rough and imperfect estimates because of limitations in the physician's skills in history taking and physical examination, active knowledge regarding disease manifestations, test properties, diagnostic reasoning and management options. In addition, often there is insufficient evidence and guidelines are of varying quality when it comes to diagnostic recommendations, and lack critical evaluation of the downstream benefit or harm of testing (Chapter 2).[2,51] And even without these limitations in physician's skills and knowledge, or evidence, there is uncertainty regarding the true disease status.[94] These imperfections and distortions can lead to low-value care. In this section we will focus on the improvement of the data input and processing during the decisional process.

Continuous focus on medical skills and knowledge

History taking and physical examination together with knowledge on prevalence and manifestations of disease determine the quality of the differential diagnosis and the estimated probability.[95] However, considerable attention goes to the vast array of available tests and treatments, at the expense of basic information gathering skills in medicine. This has inspired research that demonstrates the value of patient history and physical examination in comparison to advanced testing, in reappreciation of the former.[96] Knowledge on test characteristics and consideration of downstream consequences help in estimating the potential added value of testing, and reduce ineffective testing and inefficient testing, which occurs in shotgun approach testing.[52] A strong foundation for medical skills and knowledge can be built during medical training. This might also protect against common biases in diagnosis, such as confirmation, availability and hindsight bias.[70,97,98] Patients also value history taking and physical examination as a sign of careful and diligent evaluation of their complaints.[99] This increases trust and satisfaction with the diagnostic process, which in turn enables professionals to propose management according to their professional judgment and not act out of fear for dissatisfaction.

Working in a medical environment in which these core skills are valued stimulates their application in daily practice. Senior physicians can assist in further refinement. Senior physicians have accumulated experiences regarding disease manifestations and consequences of their decisions and have a deeper understanding of the nature of medicine and its uncertainty. Experience and thus exposure to various presentations of underlying diseases generates a library of examples that improve diagnosis (reviewed in[100]). Compared to less experienced colleagues, senior physicians are faster and more apt at verifying a diagnosis, while using less resources. Also, they are on average more confident, and have higher tolerance of uncertainty or risk.[68,101] This corresponds to physicians' observations that involvement of senior physicians improves diagnostic reasoning and decision making and can support more junior colleagues to accept uncertainty (chapter 5).[49,68,80,102] Input from colleagues can reduce unnecessary testing[103], a phenomenon described as crowd wisdom. However, the opposite can also be true; if these colleagues are risk averse or recall an unusual similar case that has left a large impression they can stimulate testing in low probability situations.[20,104] Structural use of senior physicians' qualities to assist junior colleagues might be a promising strategy to reduce low-value care and improve diagnosis.

Another strategy to improve the interpretation of patient information, is to focus on continuity of care. Continuity of care has been associated with less overuse[82] and facilitates interpretation of signs and symptoms. Through repeated (positive) encounters a trustful relationship can be built. Physicians report the benefit of trustful patient-provider relationship for effective communication and for balanced decision making. It can also reduce the physician's anticipated regret, and increase the feasibility and acceptance of safety-netting.[83]

Uncertainty

Diagnosis and diagnostic testing is decision making under uncertainty. 'Diagnosis is a process rather than an event, of which uncertainty is an integral part'.[105] The desire to eliminate all uncertainty in this diagnostic process leads to excessive testing and healthcare costs.

Research in the field of cognitive psychology has demonstrated that in uncertain situations consequences with strong affective meaning, such as serious diagnoses, are perceived as all or none; there is insensitivity to probability. This means that if a serious disease with strong negative consequence becomes a possibility[104] by appearing in the differential diagnosis this could form a strong driver for (over) testing, even though the disease is extremely unlikely in that particular patient. This effect is probably greater if missing such a diagnosis would have additional negative consequences for the physician, such as negative reactions from peers or official complaints by patients. Accepting remaining uncertainty, however small, is a prerequisite for delivering high quality (thus efficient) care by physicians.[106,107] This can be difficult and also depends on patient expectations and patient- provider relationship, societal or peer pressure.[108] Normalizing and promoting acceptance of inevitable uncertainty should become routine in clinical care and medical education.[72] Peer support by seniors or experts can be facilitate decisions to forego tests (discussed above and[109]), as does documenting the line of thought and decision process.[110] The willingness to accept uncertainty will depend on anticipated consequences of delayed diagnosis, which are again dependent on the judicial and societal context.

Disclosing uncertainty to patients opens up ways to safety-netting by informing patient about red flags.[79] This can actually improve diagnosis: it can help to correct a misdiagnosis earlier[111], while improving the use of time and tests in diagnosis.[112,113] In some patients disclosing uncertainty might lead to negative responses such as reduced trust of satisfaction, because safety-netting is at odds with the parents or patients desire to be reassured.[114] However, over time patients' expectations could also change as they get a better understanding of the complexity and uncertainty around a diagnostic process[105], including the fact that diagnosis is a process and a diagnostic label is not always available.[74] Patient partnership is the aim, for which communication and adequate and easily available information is a prerequisite.

To improve information input and interpretation, we argue that enough focus on information gathering and analytic skills is needed. The diagnostic process is an interplay of patient, provider and their context. Diagnosis profits from time, a trustful and longer-term relationship between patient and provider and a legally and socially safe environment for the provider to create the secure space that is needed for a satisfactory and efficient diagnostic process, that allows some uncertainty. Studying the effect of the presence improbable diagnoses in the differential diagnoses would be an interesting starting point, to further understand overtesting and find ways to reduce it.

Align decisions according to professional insight and patient preference

Requests for low-value tests

Patient requests for unnecessary test usually originate from uncertainty similar to that experienced by physicians. Empathetic exploration of the concern underlying a request for testing and a discussion of potentially incorrect ideas about the origin of the complaint and about the harms and benefits of testing can increase satisfaction and help reduce unnecessary tests.[115-117] This however requires communication skills and time. Providing patients with unexplained symptoms with explanations for their experienced symptoms has the potential to reduce the need for further testing.[80,118] Acknowledgement of the severity of symptoms, suggestions how to alleviate symptoms and safety-netting through active monitoring can provide a satisfying alternative to immediate testing to patients and providers.[67,112] Words matter in this respect; rephrasing wait-and-see to 'active surveillance' was shown to increase acceptance for this approach.[115] One study comparing different communication strategies identified that only watchful waiting/active surveillance was associated with less ordering of low-value tests, whereas patient-centered communication alone was not.[81] The effect of active surveillance might be mediated through the perceived control experienced by patients that helps them to accept remaining uncertainty while validating their concerns.[81]

There is no compelling evidence that testing for reassurance is generally effective[119], though it is valued by patients. However, if physicians perform tests for medical information and explain the meaning of test results, this increases the positive reassuring side effects of testing; Petrie et al. demonstrated that information on the significance of normal test results before testing improved reassurance and reduce symptoms in patients with chest pain referred for diagnostic exercise testing.[77]

Reduce unwanted testing

Besides situations in which patients request tests that physicians find inappropriate there are situations in which physicians propose tests that patients would not prefer, had they been fully informed. The softer values of diagnostic test information such as planning value, reassurance and understanding are highly dependent on patient preferences. Exploration of these preferences is essential to prevent unwanted testing. The first steps of shared decision making should be followed to provide patients with relevant information to help them oversee the diagnostic situation and potential benefit and harm of testing.[50,120] This is a precondition for test decisions in accordance with patient values and preferences.

Though paediatricians reported to concede to parental request, e.g. to facilitate acceptance of supportive psychological therapy in case of unexplained symptoms, they also described their motivation and strategies to circumvent (or postpone) testing. They applied many of the described communication strategies, however also reported that their communication skills and confidence increased with working experience, as these strategies were not part of formal education. Including communication skills training specifically directed at dealing with uncertainty and test requests in residency curricula could improve care delivered by younger doctors. This education could be based on best practices in primary care and the growing

evidence on effective communication strategies to reduce low- value care while maintaining patient satisfaction. A simultaneous effort to inform patients and the public could reduce the burden placed on individual providers to educate and convince patients in their consulting room. Future research could focus on determinants of success for those communication strategies compared to testing for reassurance. When evaluating effects, not only measures of anxiety, satisfaction or repeat visits should be included, but also time spent by physicians and effects of testing in those subgroups of patients that cannot be dissuaded.

Improve diagnostic recommendations in guidelines

Medical guidelines are influential, especially if used as a normative standard for good medical practice. Their impact depends on their quality and practitioners' adherence to them. Practice guidelines can improve medical practice and reduce unnecessary testing.[121] However, guidelines can also promote low-value care, e.g. by confirming or establishing widened disease definitions or recommending the identification and treatment of risk factors for disease[122,123] without comparing the estimated effect of different management strategies on patient outcome.

In contrast to the comprehensive substantiation of recommendations concerning population screening, in specialist guidelines the link between diagnostic testing and patient outcome is often not explicitly made, and attempts to quantify the effects of testing on outcome are half-hearted.[2] When revising the pediatric guideline for urinary tract infection, a test-outcome framework was used (based on[124]) to identify relevant key questions for diagnostic recommendations and estimate the effects on outcome of different diagnostic strategies.[125] This approach revealed insufficient net benefit of the previous recommendation for use of radionuclide scans in all children younger than 6 months of age with urinary tract infection, a scan associated with considerable harm. The current guideline restricts radionuclide scans to those children at increased risk of actionable underlying anatomic abnormalities.

In conclusion, a framework facilitates structured discussion and can help identify low-value testing. It also results in a more transparent and explicit rationale for or against testing. This does not only provide individual practitioners with the opportunity to share this structured information with their patients, but also increases the transparency and therefore comparability of decisional thresholds across medical disciplines.

A certain degree of oversight by regulatory bodies during the guideline process is necessary to ensure balanced discussions and prevent dominance of leading experts not based on evidence but eminence, and to manage inherent conflict of interests of experts working in the field whose practice will be directly affected by their recommendations.[84,85] Also, regulatory bodies can represent the interest of other patient groups and broader society in decisions on the appropriateness of care. However, expert guideline panel members often lack methodological background[126] and diagnostic information is not easy to interpret.[127] Therefore, sufficient support by independent experts is fundamental for applying a framework and formulating relevant key questions that inform literature searches. Upon implementation of a framework it would be useful to document whether recommendations for low-value tests were identified in previous versions of the guideline. Also, it would be interesting to document current thresholds for testing

and acceptable miss-rates, and their rationale (if present). Does a more structured presentation of estimated benefit and harm of testing lead to more conservative recommendations? Are there differences between medical disciplines in that respect, and if yes, how are these explained?

Often the lack of high quality evidence is lamented. In the Netherlands this is addressed through directly funding research to fill evidence gaps and to evaluate practice.[128] For diagnostic testing, assessment of downstream consequences of testing for medical value is essential in determining the effectiveness and efficiency of testing (chapter 2,3,6). The generation of non-medical value of test information and testing itself should be included in this evaluation[4], including alternative strategies to testing. Even in the absence of high quality evidence, the structured assessment and estimation of downstream consequences improves the transparency and quality of decisions.

Create contextual circumstances that facilitate high-value care

Professional norms

Prevailing social and professional norms in the current work environment and those encountered during training shape actions. These are important levers for change and feedback interventions can build on the inclination to adjust to the social norm.[129] The tension that physicians experience when requested to perform tests against their professional judgement (Chapter 5), arises from a conflict with their professional role as expert and resource steward. In patient requests that run contrary to professional judgement, Yagil et al. found that physicians experiences 4 different identities or roles; those of clinical expert, caretaker, resource allocator and service provider.[55] Being professional refers to the role of clinical expert, which is the core of the professional identity. In our study (Chapter 5) we could identify the first 3 roles, that were partially conflicting. The role of service provider was less prominently reported. The role of caretaker was reflected in the pediatricians' goal of achieving well-being even if that meant that they sometimes performed test that were unnecessary in their judgment. They justified this decision by broadening their definition of professionalism to include the caretaker role. This justification of testing against their expert opinion is likely to increase with changing contextual factors such as a societal consumerist attitude towards healthcare, patient copayments, and the importance of satisfaction ratings for physicians' reputation and revenue.

The role of resource allocator which is described by the justice principle (the fair and equitable distribution of health resources), is difficult to reconcile with the other patient-centered roles that are linked to beneficence, non-maleficence and autonomy.[130] Only if added value of healthcare is questionable, costs are considered as an extra argument against testing in individual healthcare decisions (Chapter 5).[131] The providers response to a patient requesting tests to be reassured, depends on the individual healthcare provider's understanding of her professional responsibility towards society and individual patients and what defines an acceptable trade-off. Shared values regarding the characteristics of a skilful clinician, can be helpful in generating a professional norm about what constitutes a well-calibrated skilful clinician, that incorporates both the expert and the resource allocator role.[112]

Box 1. The skilful clinician

'The skilful clinician comfortably adopts the position of conscious inaction toward these rare diagnoses. While directing management plans towards a more probable and limited subset of diagnoses while staying alert to changes in patients' clinical status that would suggest the need to more seriously consider improbable diagnoses. They are comfortable in settings where multiple conceptualization of an illness remain possible, reflecting the feeling of being able to take a reasonable next step in managing the situation at hand despite not being certain that it will lead to the desired outcome. [Pragmatic empiricism]. Comfort does not imply a lack of vigilance. This would otherwise lead to premature closure.[132]

There are examples of professional organisations that translate these expert and resource allocator roles into their professional recommendations and best practices, such as the Dutch general practitioners (Nederlands Huisartsen Genootschap) and antibiotic committees practicing antibiotic stewardship, possibly through their assigned role as resource stewards. From other medical disciplines one could expect them not to oppose the slightest restriction of their autonomy e.g. through limited reimbursement of expensive interventions and tests if that decision is grounded in evidence of very low to no cost-effectiveness. In addition, in shared decision making one could hope that professionals only present management options that produce value[133], and have a broader understanding of their profession than that of service provider.

Professional norms are dependent on the cultural and financial context. The medical discipline is highly valued and generously funded, due to their (putative) contribution of health. Health is highly valued by the public and with increasing income more money is spent on health. Just like the overestimation of the positive effects of the physicians' individual healthcare delivery on the health of their patients, there is an overestimation of the effect of medical advances on population health as a whole and definitely an underestimation of the opportunity costs of healthcare. This unrealistic view of the positive contribution is engrained in education during and after medical training[85,134] and perpetuates the inflated estimates of physicians' positive contributions to their patients' health. Feedback and education might create a more realistic perspective on the impact of healthcare both in positive and negative sense and address pervasive biases such as 'earlier diagnosis is invariantly better'. Enthusiasm and confidence are necessary to advance medicine followed by unbiased evaluation of the true effects of new medication and diagnostic interventions on health.

Involve patients and the public

Physicians report patient expectations and demand as an important reason for unnecessary testing. Patients' endowment effect and fear of rationing have been described as barriers to deimplementation. Involving patients in efforts to attain high-value care is essential. Informational campaigns targeting low-value care were successful in influencing patient perceptions and reduced the use of low-value care.[63] This information can also be shared in the encounter between physician and patient, but this is resource intensive.[69] Verbal direct advice could be supported by (online) information that prime patients about low-value care.[135] Next

to disease- specific information, public campaigns could be helpful to address the sometimes unrealistic expectations of medicine and societal biases promoting excessive testing. In general, reliable online information on symptoms, causes and appropriate self-help could help manage expectations, and might help patients decide when they should consult a doctor and reduce the pressure to offer low-value tests.

Financial structure

Activity and quality of healthcare are importantly determined by resources, organisational and financial structures. These also determine the goals and limits of healthcare. Besides direct financial gain, physicians' medical decisions are influenced by downstream effects on the financial stability and reputation of their organisation. The organisational and financial background in the Netherlands is described in Box 2. The economic literature on the impact of different payment systems and cost-sharing with patients on healthcare volume and quality can be summarized as that each system will have both positive and negative effects, and needs countermeasures to mitigate the negative effects.[90]

Reduction of low-value care in the consulting room requires effort, skills and time. Sufficient payment for consultation time is a precondition. Improved patient information, better information for referring physicians, and improved triage of patients in specialty clinics could be successful ways to reduce patient demand and direct them to the correct physician. Further discussion of this topic is beyond the scope of thesis.

Box 2. The Dutch healthcare system: organisation and financing.

'The Dutch health care system is based on several more or less universal principles: access to care for all, solidarity through medical insurance (which is compulsory for all and available to all) and high-quality health care services'. Health insurance companies are not-for-profit cooperatives that allocate any profits they make to the reserves they are required to maintain, or they return them in the form of lower premiums. The primary care system is well developed. All residents of the Netherlands are entitled to a comprehensive basic health insurance package and there is a mandatory deductible excess for the insured population. Payment of health providers is fee-for-service based on a Diagnose-Treatment Related Group system. To reduce the incentive for quantity and stimulate quality, there are efforts under way to switch to pay-for-performance, and create care networks to maintain an affordable and high-quality healthcare system.[136]

Governance structure

Professionals enjoy great autonomy and are trusted to consider the interests of their patients and society. Although they have the necessary knowledge and intrinsic motivation to help in the fair distribution of resources, they need guidance and supervision to balance interests of different stakeholders. In absence of oversight physicians will be inclined to optimize care for their own patients for example when creating guidelines, meanwhile securing their own professional existence but disregarding needs of other patients. A mixture of medical ownership, accountability and professional discourse with regulatory bodies can help to arrive at a balance

between overuse and underuse in joint projects such as guideline production and practice evaluation.

Medical disciplinary law

In Dutch disciplinary law, providers' individual diagnostic decisions are retrospectively assessed using guidelines and professional norms. This process largely ignores the complex reality of healthcare and its efficiency-thoroughness trade-off[137], and takes a punitive attitude towards alleged mistakes. The threat of a disciplinary procedure interferes with the obvious need to accept some uncertainty and risk in sustainable health care delivery.[138] Acknowledging that there is an acceptable miss-rate in testing for efficiency reasons that benefit society, and that individual patients will therefore incidentally experience irreversible damage due to late diagnosis helps in appropriate evaluation of events with an adverse outcome in disciplinary law procedures.

Address barriers for change

Deimplementing low-value testing is an uneven playing field, because of many psychological mechanisms that steer towards preservation of practice. Deimplementation evokes loss aversion and attempts to avert loss lead to resistance to change.[139,140] Also, physicians find it hard to reconcile new evidence that conflicts with highly ingrained prior beliefs, based on individual experience, interpretation of prior evidence and professional socialisation. To reduce cognitive dissonance they are more likely to incorporate evidence that aligns with preconceptions and discredit and ignore evidence that conflicts with their idea (confirmation bias).[141,142] Physicians might reason that the evidence does not apply to their individual patient. In general, they feel more regret at foregoing potentially beneficial tests than performing unnecessary or harmful tests.[98] Also there is natural tendency to maintain the status quo. This drives testing in situations of uncertain benefit of testing, which are frequent in medical practice.

Physicians give high importance to their own clinical experience, and especially to rare or unusual emotionally laden such as the late diagnosis of a brain tumour in a child misdiagnosed with feeding problems.[104,143] When inferences are made for the whole population based on these unusual cases this sustains low-value care.[142] Finally, the tendency to attribute causality between actions and outcome, even if these are uncertain or the causal mechanism multifactorial, such as attributing bad outcome of the brain tumour patient to the late diagnosis, or reversely, attributing benefit of screening tests to the individual case, though the counterfactual situation (outcome without screening) is unknown.

The response to our proposal to only perform imaging after shared decision making (Chapter 2) can be explained by the mechanisms described above. Internationally our publication provoked controversy. Professionals warned for missing serious but extremely rare conditions (that were the authors' special area of interest) and confused the benefit of imaging for individual patients and patient groups as a whole. Nationally the controversy was less pronounced, however our findings and recommendations did not lead to a change of national practice although they were discussed at several occasions. Instead, some clinics continued their routine practice of imaging and others their routine of shared decision making.

These psychological mechanisms stand in the way of change of practice and are among reasons that deimplementation is an active process, not one that automatically follows after new evidence has shown that a certain common practice has minimal or no benefit.[144] However, curtailing low-value care might be perceived as an infringement on the highly valued physicians' autonomy, which can trigger a state of arousal named psychological reactance.[145] Reactance comprises anger and negative cognition, which can hamper deimplementation efforts.[144,146]

The proposed strategies for successful deimplementation should therefore balance between

1. Instrumentalization of physicians' intrinsic and professional motivation to do good, prevent harm and contribute to an equitable distribution of resources, to create ownership and medical leadership in applying their knowledge to identify low- and high-value care, and help effectuate improvement
2. Knowledge about the relevant factors to decision making and deimplementation science to design interventions and
3. A certain degree of external pressure to initiate and sustain change. This can take form of financial (dis)incentives, reimbursement policies, and oversight and guidance from regulatory bodies.

4 Limitations

This discussion mainly focused on what is needed to reduce low-value testing. It is the result of knowledge and experience obtained during this PhD and the immense body of literature that describes the broad array of factors that influence test behaviour and mechanisms and interventions that can help in the reduction of low-value care. The aim is to reduce waste, and to improve quality of healthcare in a sustainable way. The limitations pertain to what was not addressed in this discussion.

Low-value care

The focus was on the value and drivers for *testing*. However, low-value presentations and consultations are other similar forms of resource-intensive low-value care with overlapping drivers and countermeasures. These should be a focus of quality improvement.

Waste

There are many inefficiencies in the organisation of the healthcare system that lead to loss of resources and quality. These range from insufficient use of information technology to inefficient organisation, which results in inefficient processes and insufficient substitution of labour-intensive administrative tasks of highly paid and scarce health care professionals. And it leads to inefficient planning, with waste of time, money, and energy of patients and healthcare providers and society.

High-quality care

Achieving high-quality care includes the reduction of low-value care. In addition, it requires initiatives to promote good quality and outcomes in a cost-conscious way. Both efforts might need different strategies.[30]

For high-value care, integration of care within and outside health institutions is needed. It requires healthcare providers with generalist knowledge, that work with specialists in patient-provider networks. Practical barriers such as pharmacy deliveries, patient information, and insufficient digital access to healthcare providers for better self-management for patients at home should be the focus for improvement. In the patient-provider interaction sufficient time is required, to exchange all relevant information, to create mutual understanding and establish a relationship. Much can be won in this respect. Underuse of resources also reduces quality of care. Underuse was not the focus of this thesis.

5 General conclusion

Low-value testing includes ineffective, inefficient, and unwanted testing, is associated with costs and burden, and sometimes causes harm. Whether testing for the psychological value of reassurance should be embraced as a goal of testing or should be restricted needs to be discussed. There are many factors that stimulate testing and work together to maintain the status quo. Test decisions are complex, as is the conception of interventions that stimulate high value testing, while reducing low-value testing. Interventions can be aimed at reflective/cognitive processes (evaluation, education, guidelines, feedback) or intuitive processes (framing, negotiation, substitution). Contextual factors shape physicians' and patients' expectations and decisions and are important to address and influence. All agents in the healthcare process have responsibility to improve and sustain the system, and some professional accountability is desirable. Because diagnostic testing is indirectly linked to outcome, the effects of testing are not easily identifiable. A structured evaluation of diagnostic yield and downstream consequences can improve recommendations for testing and inform shared decision making.

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