

A Modeling Approach to Quantify the Societal Impact of De-Implementing Low-Value Healthcare Interventions: Case Study Insights

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Abstract

Previous estimates of potential cost savings from the de-implementation of low-value care have been calculated using simple modeling approaches that focus on direct medical costs and do not account for substitution. Therefore, this study aimed to develop and evaluate a modeling approach to calculate a more realistic estimate of the societal costs and benefits of de-implanting low-value care. The modelling approach was developed and evaluated in three steps: (1) reviewing studies to identify aspects that may affect the costs and benefits of de-implementation, (2) selecting three low-value care cases, (3) developing and evaluating the modelling approach for each case. Desk research and interviews with stakeholders were conducted in step 3 to define the input parameters. The modelling approach was built and evaluated for the following cases: (1) surgery for achilles tendon rupture, (2) mammography for women < 30 years with focal breast complaints, and (3) imaging for non-specific low back pain. From the interviews, it appeared that case 2 had already been fully disinvested. Hence, calculating the societal costs and benefits for this case was not considered valuable. For cases 1 and 3, it was deemed valid and feasible to calculate the societal costs and benefits. Compared to the adapted societal business case approach used in Case 1, the adapted societal cost-benefit analysis approach used in Case 3 provided a more realistic and accurate estimate of the benefits. It is feasible to calculate a more elaborate and realistic estimate of the societal costs and benefits of de-implanting low-value care than previous estimates. However, it was not possible to include the expenses of de-implementation itself as these are highly reliant on the specific de-implementation strategy employed, which is context-specific. Furthermore, the time required to calculate a more elaborate and realistic estimate underscores the need to carefully select low-value care cases for which the value of calculating such an estimate outweighs the effort involved.

Keywords: De-implementation, Low-value care, Societal costs and benefits, Cost savings, Modelling approach

Introduction

Over recent decades, healthcare spending in the Netherlands and globally has been rising faster than the gross domestic product (GDP) [1–3]. As a result, a

growing share of public budgets is being allocated to healthcare. This trend is expected to continue, with healthcare expenditures in the Netherlands projected to outpace GDP growth in the coming years, placing increasing strain on public finances [1]. Consequently, policymakers are actively seeking strategies to curb the growth of healthcare costs. One promising approach is the reduction or elimination of low-value care [4–7]. Low-value care refers to medical services and technologies that offer minimal or no overall benefit, and in some cases, may even harm certain patient groups [8, 9]. De-implementation, the process of scaling back or

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discontinuing these practices [10, 11], presents an opportunity to conserve healthcare resources without substantially compromising patient outcomes.

Several researchers have attempted to estimate the potential cost savings from de-implementing low-value care to highlight its role in controlling healthcare spending [4, 6, 7, 12–14]. However, most of these estimates rely on relatively simple models focusing exclusively on direct medical costs. They often overlook important factors such as (1) the substitution of de-implemented practices with alternative healthcare services that may require additional resources, (2) the fact that specific subgroups of patients may still derive benefit from some low-value practices, and (3) the challenge that many low-value interventions are particular and difficult to isolate within available data [4]. Additionally, many estimates concentrate on particular types of care [7, 12, 13] or are based on data from countries other than the Netherlands [6, 7, 12–14], necessitating numerous assumptions to extrapolate these findings to the Dutch context [4].

To provide policymakers with a more accurate and comprehensive understanding of the societal costs and benefits of de-implementing low-value care and its potential to slow the growth of healthcare expenditures a more sophisticated modeling approach is needed. This study aims to develop a model that can generate realistic estimates of overall societal impacts, as well as costs and benefits, for specific stakeholders. Understanding these stakeholder-level effects may help identify groups who might not gain from de-implementation efforts.

The modeling approach was constructed using a case-based methodology: for each selected low-value care case, a model was developed, and its utility in estimating costs and benefits was evaluated. Despite this case-by-case approach, the ultimate goal was to create a model general enough to aggregate results across many low-value care procedures. Therefore, the model needed to be broadly applicable to a wide range of low-value care types, sufficiently straightforward to be used repeatedly on numerous cases, yet comprehensive enough to surpass the limitations of previous simpler models.

Materials and Methods

Approach

The development and evaluation of the modeling approach followed a three-step process (**Figure 1**). First, we conducted an umbrella review (a review of existing

reviews) to identify key factors influencing the costs and benefits of de-implementing low-value care broadly. Insights from this review guided the design of the modeling framework. Second, we selected three diverse low-value care cases to ensure the model's applicability across a wide range of scenarios. Third, for each case, we created and assessed a specific modeling approach through five sub-steps: (i) defining the fundamental structure of the model, (ii) gathering existing data through desk research, (iii) conducting interviews to obtain missing information, (iv) populating the model with input parameters and estimating the societal costs and benefits of de-implementation, and (v) assessing the model's usefulness and practical value (**Figure 1**). The following sections provide a detailed explanation of these steps.

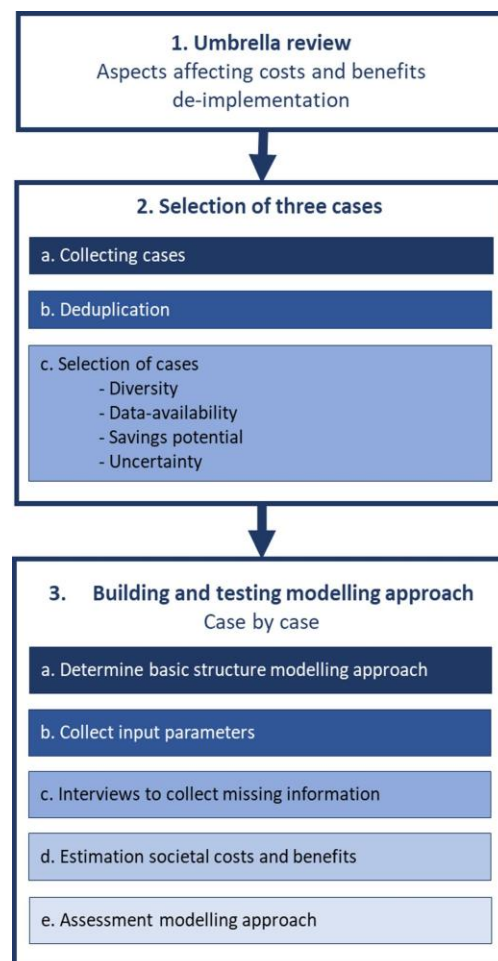


Figure 1. Stepwise approach to develop and evaluate the modelling approach

Step one: umbrella review

To inform the development of the modeling approach, we conducted an umbrella review—essentially a synthesis of existing review studies—aimed at identifying frameworks, models, or theories that address factors influencing the societal costs and benefits of reducing low-value care on a broad scale. Our focus was on de-implementation generally rather than on individual procedures. Given the abundance of prior reviews on this subject, this method was chosen as an efficient means to compile a comprehensive understanding of the topic. We searched the Embase database using a combination of relevant keywords such as ‘de-implementation,’ ‘low-value care,’ ‘contextual factors,’ and ‘framework,’ along with related terms. Since the review’s sole purpose was to support the model’s design, limiting the search to one database was deemed adequate. A single reviewer (AR) screened titles and abstracts for relevance, with half double-checked by a second reviewer (MR) to ensure consistency. Full-text screening was conducted by both reviewers, resolving disagreements through discussion. Eligibility criteria are detailed in Additional file 1. We also reviewed the reference lists of selected studies to identify any additional relevant reviews, which were then screened accordingly. Study quality was appraised using the ROBIS tool [15], but no studies were excluded solely based on quality; instead, lower-quality sources were given less weight during analysis. Key bibliographic and contextual details—including publication data, characteristics of the low-value care procedures, and applied frameworks—were systematically extracted using Excel. Subsequently, passages discussing factors affecting societal costs and benefits were coded in MAXQDA 2022 [16], guided by the extracted frameworks. Two researchers (MR and AR) conducted a thematic analysis of these coded segments, resulting in a synthesized overview of relevant factors and their documented impact on costs and benefits.

Step two: case selection

We compiled an initial comprehensive list of low-value care procedures by integrating several existing Dutch databases [17–21], which resulted in 175 unique interventions after removing duplicates. From this list, three cases were purposefully chosen using a non-structured selection process, guided by criteria intended to maximize diversity and feasibility. These criteria included: (a) variety in medical specialty, type of intervention (diagnostic vs. therapeutic), and whether discontinuation might shift patient care from secondary

to primary healthcare settings; (b) availability of sufficient data to accurately estimate societal impacts and potential cost savings; and (c) uncertainty regarding whether these procedures are universally low-value or only for specific patient groups. Information to assess these factors was gathered from clinical guidelines, scientific literature, and publicly accessible registries. The selection was made collaboratively by the research team, with input from domain experts, including policymakers and researchers involved in initiatives aimed at reducing low-value care in the Netherlands.

Step three: development and evaluation of the modelling approach for each case

The modelling approach was constructed and assessed in five sequential sub-steps for each case (**Figure 1**). We proceeded to the following case only after completing all sub-steps for the current case, allowing us to integrate lessons learned into subsequent models.

1. **Defining the model structure:** Initially, the core framework of the modelling approach was established. This design drew on existing methodologies for estimating societal costs and benefits of interventions, insights gained from the umbrella review, and, when applicable, refinements from previous cases.
2. **Data collection:** We gathered data from clinical guidelines, academic and grey literature, and publicly available registries to populate model parameters. This phase focused heavily on mapping the current care pathway and projecting how it would change following the removal of the low-value care practice. Additionally, it was crucial to determine whether the procedure qualifies as low-value care for the entire patient population or only for specific subgroups of patients. Information on procedure volumes and associated costs was also compiled during this step.
3. **Conducting interviews:** To supplement the information gaps left by secondary data sources, interviews were conducted with key stakeholders, including healthcare providers and patients. The interviews aimed to (a) obtain missing information, (b) explore contextual factors influencing the costs and benefits of de-implementation for the specific case, and (c) estimate a realistic extent of achievable de-implementation. Custom topic guides were developed for each case and respondent type, grounded in the findings from the umbrella review and the data needs identified earlier.

4. Cost-benefit estimation: Using the collected data and the defined modelling framework, we calculated the expected societal costs and benefits associated with de-implementing the given low-value care procedure.
5. Evaluation of the modelling approach: Finally, the usefulness and relevance of the developed modelling method were assessed both for the specific case and low-value care de-implementation more broadly. This evaluation took place during team meetings, where the estimated costs and benefits were considered alongside practical experiences with the model. No rigid criteria were used; instead, assessment was based on collective judgment and reflection.

Defining a realistic level of de-implementation

A critical parameter in the model is the ‘realistic level of de-implementation,’ representing the feasible extent to which the use of low-value care can be reduced. This accounts for the fact that some patients may still benefit from the procedure. The achievable reduction also depends on the choice and context of de-implementation strategies employed [22-35]. As the goal was to estimate the maximal potential societal gains (i.e., the most significant possible savings or minimal realistic costs), we did not factor in the fees or effectiveness of specific de-implementation strategies. Instead, we assumed it would be likely to implement an approach that effectively eliminates all low-value care instances while preserving necessary care for appropriate patients.

Results and Discussion

Step one: umbrella review

The Embase database was searched on September 2, 2021, yielding 350 potentially relevant reviews for initial screening. After reviewing titles and abstracts, 39 full-text articles were assessed, leading to the inclusion of 14 reviews. An additional five reviews were identified through reference checks, of which three met the eligibility criteria, resulting in a total of 17 reviews included. Quality assessment rated two reviews as low, four as moderate, and eleven as high quality.

During the analysis, we differentiated between contextual factors that influence societal costs and benefits and those that affect the success of de-implementation strategies. The included reviews generally provided qualitative insights or frequencies of reported effects but lacked quantitative measures that

could be translated into societal cost-benefit estimates. Consequently, this information could not be directly incorporated into the model’s structure. Nonetheless, the umbrella review identified key contextual factors—such as healthcare providers’ knowledge and attitudes, patient expectations, and the nature of provider-patient interactions—which informed the development of interview guides. These factors were presented alongside the quantitative cost-benefit estimates as important contextual considerations potentially influencing the real-world impact of de-implementation.

Step two: case selection process

Three representative low-value care scenarios were chosen to develop and test the modelling approach: (1) surgical treatment for ruptured Achilles tendons, (2) mammography for women younger than 30 presenting with localized breast complaints, and (3) diagnostic imaging for patients with non-specific low back pain. Although the latter two cases both involve imaging, they differ substantially in terms of patient population size and the nature of the recommended alternative high-value interventions, ranging from alternative imaging modalities to physical therapy. Based on preliminary data and complexity considerations, the Achilles tendon surgery case was deemed the simplest and thus prioritized as the initial focus. Subsequent modelling efforts progressed to the mammography case and then to the low back pain imaging case.

Step three: development and assessment of the modelling approach per case

Case 1: Achilles tendon surgery

Evidence from several studies suggests that there is no significant benefit of surgical intervention over conservative approaches, such as ankle braces or casting, in treating Achilles tendon ruptures. Furthermore, non-surgical treatments have been associated with high patient satisfaction and fewer complications. These findings position Achilles tendon surgery as a candidate for de-implementation, with conservative management recommended as the standard of care.

Modelling framework

For this case, the societal business case (SBC) framework was adapted to serve as the core model structure. The SBC framework is advantageous because it quantifies both the economic impact and broader societal consequences of implementing an intervention—in this

context, de-implementation—across multiple stakeholders. Importantly, it separates the costs associated with the intervention from its broader economic and societal effects. To tailor the SBC

framework to the objectives of this study, we modified its original four-step process. Details of these adaptations are summarized in **Table 1**.

Table 1. Comparison of original and adapted SBC

Step	Original SBC	Adapted SBC
	Client perspective	Cost savings
1.	What value does the innovation provide to the patient (client)?	What potential cost reductions can result from de-implementation?
	Business model	Business model
2.	What is the innovation, and what benefits does it offer?	What is the innovation, and what benefits does it provide?
	Organizational aspects	Organizational and societal aspects
3.	• What are the minimum requirements for implementation? • What impacts are expected for the involved stakeholders?	• What are the anticipated impacts of de-implementation on stakeholders? • What outcomes do stakeholders foresee? • What contextual factors might hinder de-implementation?
	Business economics and societal benefits	Business economics and societal benefits
4.	Combination of economic and societal factors: • What is required to ensure the innovation is a viable business case for all stakeholders?	Combination of economic and societal factors: • What adjustments are needed to make de-implementation a viable business case for all stakeholders?

Information gathering from guidelines, literature, and registries

Existing research indicates no significant difference in clinical outcomes or side effects between treatment with a brace versus a cast for Achilles tendon ruptures. Consequently, our model combined these conservative treatments into a single category. The treatment pathway for Achilles tendon rupture was mapped out using data from clinical guidelines and published literature. According to 2019 Dutch registry data—the most recent year unaffected by the COVID-19 pandemic—2,239 patients suffered an Achilles tendon rupture, with 63% undergoing surgical intervention. The estimated direct cost per surgery was around €2,700, compared to roughly €650 for conservative management. Both treatment options typically require several sessions of physiotherapy post-treatment, which is delivered by separate providers and not considered part of the primary intervention. However, available sources did not clarify whether the number of physiotherapy sessions differs between surgical and conservative approaches, nor was it certain if surgery qualifies as low-value care for every patient subgroup. These uncertainties guided the focus of subsequent interviews with relevant stakeholders.

Stakeholder interviews

Interviews were conducted with a range of professionals, including two orthopedic surgeons, one trauma surgeon, an emergency physician, two plaster cast technicians, three physiotherapists, and two researchers. The feedback highlighted that surgery may still be justified for young, highly active patients—such as professional athletes—because it tends to offer a somewhat quicker recovery, which is meaningful for this subgroup estimated to comprise 5–10% of cases. Regarding physiotherapy, while the timing of sessions may vary between treatments, the overall number of sessions was considered roughly equivalent. Physiotherapy following surgery is classified as surgical rehabilitation, making sessions beyond the 20th reimbursable under the Dutch basic benefits package, unlike physiotherapy after conservative treatment. Interviewees estimated that patients would require approximately 75 physiotherapy sessions over six months. These insights were incorporated into the adapted societal business case (aSBC) model.

Societal costs and benefits estimation

The aSBC analysis revealed that de-implementing Achilles tendon surgery produces a neutral financial impact for hospitals and healthcare providers, mainly because the relatively low number of cases means freed

surgical capacity can be readily reallocated to other procedures. Thus, the hospital-level budget effect is minimal. For insurers and patients, however, the picture differs: patients opting for conservative treatment face approximately €1,815 more out-of-pocket expenses for physiotherapy compared to surgical patients, since physiotherapy sessions after conservative care are not reimbursed beyond the 20th session. This cost difference creates a financial incentive for insurers but a potential barrier for patients, who bear the extra costs. Additionally, surgeons' personal preferences may pose obstacles to de-implementation.

Evaluation of the modelling approach

The research team appreciated that the aSBC framework effectively highlighted how de-implementation affects various stakeholders differently and helped integrate contextual factors. However, the approach was criticized for its limited scope and lack of nuance, particularly in accounting for non-monetary aspects, such as patient quality of life and well-being. Moreover, the aSBC did not yield an overall monetary estimate of net societal benefits or costs. The extent of modifications needed to the original SBC framework raised questions about whether the resulting model should still be classified as an accurate SBC.

Case 2: mammography for women under 30 with focal breast complaints

Clinical guidelines recommend ultrasound over mammography for women under 30 who present with focal breast complaints, as younger women tend to have denser breast tissue, which reduces mammography accuracy. Additionally, ultrasound is considered more comfortable for patients. For this reason, mammography is regarded as low-value care as the initial imaging method in this group.

Modelling approach for case 2

Having gained insights from the previous case, the research team took a more streamlined approach. Initially, relevant data were gathered from registries and the literature. Next, interviews were held with stakeholders to fill gaps and understand contextual nuances. Finally, the most appropriate modelling framework was chosen based on these inputs.

Information gathered from guidelines, literature, and registry data

The care pathway for imaging in women presenting with focal breast complaints was identified from existing literature. The main distinction between pathways was the imaging modality used—either mammography or ultrasound. Cost data from 2019 showed that mammography procedures ranged between €75 and €105, while ultrasound costs ranged from €57 to €98. In that year, approximately 100,000 imaging procedures were performed in hospital settings. This year was chosen because it was the most recent unaffected by the COVID-19 pandemic. However, the registry data did not specify the percentage of these imaging procedures that were mammographies versus ultrasounds, nor could it differentiate between the number of patients who were younger than 30 years. Moreover, the data did not clarify if there are subgroups of women under 30 with focal breast complaints for whom mammography might still be appropriate. Therefore, interviews were primarily aimed at determining the size of the relevant patient population and whether any patients require mammography. Additional goals were to understand the frequency of mammography performed following ultrasound or vice versa, and to identify contextual factors influencing potential deimplementation.

Stakeholder interviews

The interviews included three radiologists, who perform the imaging, and one general practitioner, as in the Netherlands, patients require a GP referral for imaging services. The research team had initially planned to interview patients as well. Still, feedback from healthcare providers revealed that ultrasound has been the preferred imaging standard for women under 30 with focal breast complaints for approximately 18 years. Consequently, mammography is no longer commonly used in this group, indicating that no current low-value care is being eliminated. This was corroborated by an expert researcher from Health Care Evaluation and Appropriate Use (ZE&GG), based on preliminary, non-public analyses of registration data. Given also the minor cost difference between ultrasound and mammography, any potential savings from de-implementation would be minimal. For these reasons, the team decided against further interviews or detailed economic modeling for this case. This scenario highlighted the importance of early expert involvement and stakeholder interviews in estimating the societal costs and benefits of de-implementation.

Case 3: imaging for non-specific low back pain

Campaigns such as Belgium's "no scan without a plan" and clinical guidelines, including the Dutch GP guideline for low back pain, recommend against imaging for patients suffering from non-specific low back pain—pain without an identifiable underlying cause. The rationale includes: (1) imaging results typically do not affect subsequent treatment decisions, and (2) incidental findings often lead to unnecessary additional care and increased costs. Thus, imaging in this context is considered a form of low-value care. Instead, patients should be encouraged to engage in exercise, physiotherapy, and/or psychological counseling.

*Modelling approach framework***Table 2.** Differences between the original and adapted SCBA

Step	Original SCBA [36, 37]	Adapted SCBA
	Problem analysis	
1	• What issue has emerged, and how will it evolve? • What policy objective follows, and what are the potential solutions?	• Outline the healthcare issue that has arisen. • Identify a potential solution to reduce low-value care (LVC¹).
2	Establish reference scenario The most likely outcome without policy changes.	The most likely outcome if low-value care is not de-implemented.
	Define policy alternatives	
3	• Describe the proposed policy. • Outline alternatives and their variations.	Describe the scenario with the ideal outcome of the de-implementation strategy.
	Assess effects	
4	Identify, quantify, and assign monetary value (in Euros) to the effects.	Identify, quantify, and assign monetary value (in Euros) to the effects of de-implementation.
	Evaluate costs	
5	Identify, quantify, and assign monetary value (in Euros) to the resources needed for policy implementation.	Identify, quantify, and assign monetary value (in Euros) to the costs of de-implementation.
	Sensitivity analysis	
6	Identify significant uncertainties and risks, and evaluate their impact on outcomes.	Use ranges for variables to conduct a deterministic sensitivity analysis.
	Present outcomes and net value	
7	• Standardize all costs and effects to the same base year. • Include all effects, even those not quantifiable.	• Standardize all costs and effects to the same base year. • Include all costs and effects, including non-quantifiable ones.
	Present results	
8	• Ensure results are relevant, clear, and accessible. • Maintain transparency and reproducibility. • Interpret results: What insights can decision-makers gain?	• Ensure results are relevant, clear, and accessible. • Maintain transparency and reproducibility. • Interpret results: What insights can decision-makers gain?

¹LVC: Low-value care*Information from guidelines, literature, and registry data*

Based on guidelines and literature, it was established that in the Netherlands, patients require a referral from their general practitioner (GP) to undergo imaging for low back pain. These patients are then typically referred to a hospital for imaging procedures. While referrals can also

Learning from the limitations of the adapted societal business case (aSBC) in case 1, the team selected an adapted societal cost-benefit analysis (SCBA) for this case. SCBA was preferred because it captures both quantifiable and qualitative societal costs and benefits and can differentiate effects across stakeholder groups. Due to the resource-intensive nature of SCBA, the method was tailored to meet the project's scope and timeline. The adaptation also incorporated contextual factors that affect costs and benefits, as well as an estimate of the impact of deimplementation on hospital labor requirements. **Table 2** outlines the key distinctions between traditional SCBA and the adapted version used in this study.

come from medical specialists, most patients with non-specific low back pain receive referrals from GPs. In contrast, referrals are not needed for physiotherapy or psychological counseling. According to the literature, the amount of physiotherapy or counseling required does not differ between patients who underwent imaging and

those who did not; however, this information was further verified through interviews. This foundational information was incorporated into an initial care pathway model, which was subsequently validated during the interviews.

Registry data from 2019 was used to understand costs and volumes related to imaging. In that year, imaging was performed 10,412 times for patients with non-specific low back pain in the Netherlands. The direct cost per imaging procedure ranged between €39 and €210. The 2019 data were chosen because they were the most recent available, unaffected by the COVID-19 pandemic. The registry data, however, did not clarify what portion of these patients who received imaging subsequently underwent unnecessary care due to incidental findings, nor what the nature of such unnecessary care entailed. It was also unclear if there is a subgroup of patients for whom imaging would not be considered low-value care. Therefore, these points, alongside the care pathway and contextual factors influencing de-implementation, were key topics during interviews with stakeholders.

Interviews with stakeholders

A total of two general practitioners, two neurologists, one orthopedic surgeon, two radiologists, and five patients with low back pain participated in interviews. The GPs explained that reducing imaging would require longer consultations to explain to patients why imaging is unnecessary. Consequently, the additional costs for these extended consultations were sourced from registry data and incorporated into the adapted societal cost-benefit analysis (aSCBA). The interviews confirmed that the amount of physiotherapy and/or counseling patients receive does not depend on whether they underwent imaging. Therefore, the costs and benefits of these treatments were excluded from the aSCBA. Additionally, interviewees reported that unnecessary medical interventions resulting from incidental imaging findings are rare in practice, so these costs were considered negligible at the societal level and excluded from the analysis.

The interviews also revealed a divergence in perception between primary and secondary care. While imaging is broadly agreed to be low-value care in primary care, this consensus is lacking in secondary care. Physicians estimated that only 7.5% of imaging requested by secondary care providers constitutes low-value care. As a result, the aSCBA assumed 100% of imaging requested

from primary care and 7.5% from secondary care could be de-implemented.

Although hospitals and healthcare providers may face some financial losses after de-implementation, these losses are expected to be temporary and limited, as freed-up resources can be redirected to other patient groups, especially considering the current imaging waitlists in the Netherlands. Thus, these potential losses were not included in the aSCBA.

Interviews also highlighted that imaging has a significant reassuring effect on patients, which adds value beyond measurable outcomes. This reassurance was challenging to quantify within the societal cost-benefit framework, but it remains an essential consideration alongside the aSCBA results.

Key contextual factors affecting the societal costs and benefits of imaging de-implementation identified during interviews included financial incentives tied to imaging, time constraints in consultations, the potential impact on shared decision-making, and the challenge of managing demanding patients.

Societal costs and benefits estimate

The aSCBA estimated that de-implementing imaging for low back pain would result in societal savings of approximately €19.8 million, with a possible range between €9.1 million and €32.7 million. These savings primarily result from reduced patient travel expenses, decreased productivity losses due to fewer hospital visits, and avoided out-of-pocket imaging costs, as imaging expenses are factored into the Dutch patient deductible system. In the Netherlands, patients pay the first €385 of annual healthcare costs out of pocket; insurers cover costs exceeding this amount. Consequently, insurers also benefit from reduced imaging costs for patients who have already met their deductible.

Furthermore, the analysis indicated a potential labor savings of 11,267 hours annually within hospitals (6,526 hours for imaging technicians and 4,741 hours for radiologists), equating to 5.4 full-time equivalent positions (3.1 FTE imaging technicians and 2.3 FTE radiologists). Note that these labor savings estimates do not account for the increased time GPs may require for extended consultations.

Evaluation of the modelling approach

The adapted SCBA offered comprehensive insights into (1) total and actor-specific societal costs and benefits, (2) contextual influences on these costs and benefits, and (3)

the impact on hospital labor demand. However, despite adaptations intended to simplify the process, the approach remained relatively time-consuming.

This study aimed to develop a modeling approach capable of producing a more advanced and realistic estimation of the societal costs and benefits associated with the de-implementation of low-value care. A secondary objective was to create a method that also reveals the varying effects of de-implementation on different stakeholders. The modeling approach was developed and tested across three cases: (1) surgery for Achilles tendon ruptures, (2) mammography for women under 30 with focal breast complaints, and (3) imaging for non-specific low back pain.

Interviews for the mammography case revealed that this low-value procedure had already been fully de-implemented. Since no low-value care remains to be removed, there are no societal costs or benefits from de-implementation in this case, making further modeling unnecessary. However, this case highlighted the critical importance of conducting interviews with relevant actors in each case. It also illustrated that the inclusion of a procedure on a low-value care list in the Netherlands does not necessarily mean it is still being practiced. The interviews suggested the procedure was added to the list only after it had already been fully phased out. This underscores the need to verify whether a low-value care practice is still in use before estimating societal costs and benefits or initiating de-implementation efforts. Such verification can be achieved by analyzing accessible data on the procedure and supplementing it with interviews or discussions with healthcare professionals and researchers.

For the Achilles tendon rupture surgery case, an adapted societal business case model (aSBC) was used as the foundational framework. The aSBC's strengths include its ability to reveal the differential impacts of de-implementation on various stakeholders and to consider contextual factors influencing de-implementation. However, the aSBC had limitations, including insufficient flexibility for nuance, inadequate incorporation of non-monetary and non-quantifiable factors, and the inability to generate a single monetary estimate of societal costs and benefits. Consequently, a different modeling approach was adopted for the low back pain imaging case to address these issues—an adapted societal cost-benefit analysis (aSCBA). The aSCBA's advantages lie in its comprehensive insight into (1) total and actor-specific societal costs and benefits, (2)

contextual influences on these costs and benefits, and (3) effects on hospital labor requirements. A significant drawback of the aSCBA, however, was its considerable time intensity, despite efforts to streamline it.

Reflection on the developed modeling approach

This study demonstrated that it is feasible to produce a more realistic estimation of the societal costs and benefits of low-value care de-implementation using an adapted societal cost-benefit analysis (aSCBA). This represents a significant improvement over previous methods, which primarily focused on direct cost savings without accounting for substitution effects or recognizing that low-value care may not apply uniformly across all patient groups. Nevertheless, gathering the necessary input data for a realistic aSCBA proved very time-consuming. While some information can be sourced from literature, guidelines, and publicly available registry data, interviews with involved stakeholders are essential to understand actual care pathways, identify any subgroups for whom the care is not low-value, and assess how and to what extent other appropriate procedures replace the discontinued care. Since these factors vary by case, conducting interviews for each case is critical.

Despite their value, the interviews did not fully resolve all data gaps. In particular, estimating the extent to which low-value care can realistically be de-implemented proved challenging. As a result, despite substantial data collection efforts, many assumptions were still necessary to calculate societal cost-benefit estimates. The aSCBA's time-intensive nature and reliance on numerous assumptions limit its scalability for assessing many low-value care cases. Moreover, this raises the question of whether the effort needed to generate a more precise estimate of societal costs and benefits is justified by the value of the forecast itself. It is possible that over time, the aSCBA will become less resource-intensive through method refinement and accumulated experience. Still, it remains essential to carefully select cases where such detailed estimation will add meaningful value, given the effort involved.

Insights on the de-implementation of low-value care

This study developed and tested a modeling approach using three distinct cases of low-value care. For Achilles tendon rupture surgery, the estimated societal costs and benefits primarily favored health insurers due to differences in physiotherapy reimbursement between surgical and conservative treatments, resulting in notable

expenses for patients. In the case of mammography for women under 30, interviews revealed that this procedure had already been fully phased out years ago. Hence, no societal costs or benefits remain from de-implementation. For imaging in non-specific low back pain, societal benefits were limited to patients, who would save on travel time to the hospital. Overall, the societal benefits of de-implementing these cases were modest, likely due to the small patient populations involved (Achilles ruptures), low procedure costs (imaging for low back pain), and the necessity of replacing the low-value care with alternative treatments in all three cases.

Given that the cases were selected partly based on their apparent savings potential, these limited benefits suggest that de-implementing other low-value care procedures in the Netherlands may also yield only modest societal gains. Many cases on the national low-value care list are particular to particular procedures or patient groups, which may similarly limit the scope of potential benefits. This finding challenges policymakers' high expectations that de-implementation will significantly curb healthcare expenditure growth. Therefore, it is essential to inform policymakers that cost savings from de-implementing low-value care might be limited. This does not imply that de-implementation should be avoided; rather, its primary goal should be to enhance healthcare effectiveness and value for money. It is worth noting, however, that the modest savings found here might partly reflect the particular cases identified so far; for example, an interviewed professional suggested that more impactful low-value care cases may exist in end-of-life care.

Strengths and limitations

This study employed a structured, stepwise, case-based strategy to develop a modeling approach that provides deeper insight into the societal costs and benefits of de-implementation compared to previous methods. Nonetheless, some limitations apply.

First, the analysis did not include the costs associated with the de-implementation process itself, despite these affecting the total societal impact. Including these costs proved difficult because they depend heavily on the specific de-implementation strategies employed, which vary by case and context. Determining the optimal approach is complex and time-consuming, and evidence on the effectiveness and costs of such methods is mixed and context-dependent. Therefore, when interpreting the

societal cost-benefit estimates, it is essential to note that de-implementation expenses were excluded.

Second, this study did not consider timing or the gradual nature of de-implementation, which can influence the realized societal costs and benefits. Timing effects are closely tied to the de-implementation strategy chosen, which falls beyond the scope of this study. For instance, patient acceptance of not receiving imaging for low back pain may improve over time, reducing the need for longer consultations and potentially increasing the net benefits of de-implementation. Future work could investigate how timing affects outcomes to enhance the modeling approach further.

Third, societal costs and benefits of de-implementation depend heavily on the healthcare context and country. Findings for the studied cases in the Netherlands may differ considerably elsewhere, especially in countries with different healthcare systems and cultural attitudes towards health. This should be kept in mind when applying the results or the modeling approach to other settings.

Fourth, as is familiar with case-based studies, the results may have varied if different cases had been selected. To mitigate this, a diverse set of cases was chosen; however, the possibility remains that case selection may have influenced the findings to some extent.

Finally, the data used to inform the models was limited to aggregated, publicly accessible registration data. The aggregated nature of the data complicated the identification of effects at the individual or subgroup level. However, interviews helped fill some data gaps, reducing the impact of this limitation.

Conclusion

This study demonstrated that using an adapted societal cost-benefit analysis (aSCBA) enables the production of a more detailed and realistic estimate of the societal costs and benefits of de-implementing low-value care. However, gathering the necessary input data for each case proved to be very time-intensive. This process may become more efficient as the aSCBA method is further refined and as more experience is gained in its application. Despite this potential, the substantial time investment required highlights the importance of carefully selecting which low-value care cases to analyze, focusing on those where the benefits of obtaining a thorough and accurate estimate justify the

effort involved, in collaboration with relevant stakeholders.

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