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BMJ Health & Care Informatics

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To cite: Ebben KCWJ, de Kroon CD, Schmeink CE, *et al* . Leveraging real-world data for continuous evaluation of computational clinical practice guidelines. *BMJ Health Care Inform* 2025;**32**:e101333. doi:10.1136/bmjhci-2024-101333

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/bmjhci-2024-101333).

Received 17 October 2024
Accepted 17 April 2025

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ABSTRACT

Objectives There is a bidirectional interaction between clinical practice guidelines and clinical care, with each informing the other. Structural signalling of trends in guideline adherence in clinical practice is essential for advanced updates. Recent advances in computable care guidelines allow automated evaluation using real-world registry data. Here, we assess the feasibility by evaluating adherence to Dutch endometrial cancer (EC) guidelines.

Methods This retrospective cohort study uses real-world data of EC patients from the Netherlands Cancer Registry (NCR) between January 2010 and May 2022. The Dutch guideline for EC was parsed into clinical decision trees (CDTs). Primary outcome was guideline adherence for multiple (sub)populations, with secondary outcomes encompassing adherence trends, recommendation implementation pace, non-adherent treatment strategies and impact of additional non-guideline-based patient and tumour characteristics on adherence.

Results The Dutch EC guideline was parsed into 10 CDTs, revealing 22 patient and disease characteristics and 46 interventions. NCR data were mapped to CDT data items. Four CDTs were successfully populated with NCR data, and 21 602 cases were assessed. Adherence levels were computed, which showed a mean adherence of 82.7% (range 44–100%). Three statistically significant trends in adherence were identified: two increasing trends in the 'non-adherent' compared with the 'adherent' group, and one decreasing trend.

Discussion This study introduces a novel framework for continuously evaluating (non-)adherence to cancer guidelines. Future efforts should focus on the inclusion of health outcome measurements.

Conclusion Through the integration of real-world data with a computer-interpretable guideline, we effectively calculated various facets of adherence to guidelines for EC.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Guideline adherence leads to higher quality of care.
⇒ Guideline adherence evaluations have been frequently conducted and have led to significant insights; however, these are one-off measurements focused on specific settings and use a limited set of indicators, targeting a singular epidemiological or clinical query.

WHAT THIS STUDY ADDS

⇒ The utilisation of computational guidelines, coupled with a valid and continuously updated real-world dataset, for the multidimensional evaluation of guideline adherence.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results of this study are valuable for guideline committees; they can update their guidelines based on the obtained insights.
⇒ The ability to continuously evaluate guideline adherence based on clinical practice is an important component of a learning healthcare system.

INTRODUCTION

For optimal quality of care, it is crucial to treat patients according to the best available evidence, accessible through a clinical practice guideline (hereafter 'guideline').[1] To ensure that every patient receives the right care at the right place, results from practice-changing new research have to be incorporated in these guidelines. However, it remains a challenge to continuously incorporate such knowledge into guidelines in a timely manner while not compromising on quality standards in Clincal Practice Guideline methodology.[2] In the Netherlands, the responsibility for keeping the country's gynaecological oncology guidelines up-to-date lies with the Dutch Association of Gynecologists and Obstetrics (NVOG) guideline committee. Updates are performed in close collaboration with relevant specialist hospitals and patient representatives.

To accelerate the process of updating guidelines, the committee initiated innovative projects with various affiliates, including projects for improving endometrial cancer (EC) guidelines.[3] EC is the most common gynaecological cancer in Western countries.[4] The incidence of EC in the Netherlands has shown a constant increase, with about 1900

new cases per year, recently.[5] The NVOG project, of which this study is a part, focused on developing an approach to raise alerts for reconsidering guideline recommendations. These alerts are based on insights from both new scientific developments and observed trends in guideline implementation in clinical practice.

Measuring the impact of a guideline in clinical practice is of particular concern, as it is a central way to gain insight into how guidelines can be improved.[6] Over the past decade, several studies have been conducted worldwide to obtain insight into information on the adherence to EC guidelines.[7–14] These studies usually performed a one-off measurement of guideline adherence in a specific setting, often using a single quality indicator that aimed to answer a particular epidemiological or clinical question. These studies used indicators that aimed to measure differences in guideline adherence in specific subpopulations (eg, based on age, race, socioeconomic status), a specific phase during the continuum of care (eg, adjuvant therapy, follow-up) or health outcomes (eg, overall survival). Important insights with regard to guideline adherence were provided, but none involved follow-up or used a longitudinal design. However, it was concluded that longitudinal evaluation of guideline adherence is important to ensure the quality of care for the population of interest.[9 12]

An essential condition for continuous evaluation measures is the availability of appropriate and continuously updated real-world data. The Netherlands Cancer Registry (NCR) is a nationwide registry that has maintained data on all diagnosed cancer patients in the Netherlands since 1989.[15] The NCR aims to provide information on the characteristics and magnitude of cancer in the Netherlands and serves several purposes, such as international incidence comparisons, support of studies and evaluation of screening programmes and guidelines. Since the NCR has a high completeness rate and a consistent registration process, it is an excellent and appropriate data source for continuous analyses. In addition, the NCR dataset for EC includes a large number of relevant variables of a different nature, namely administrative (eg, incidence date, hospital, general patient characteristics), variables that are used for treatment choices in clinical practice (eg, clinical and pathological staging, treatment, adverse events) and health outcomes (eg, survival).[16] As such, the NCR dataset on EC facilitates a comprehensive analysis of guideline implementation in a heterogeneous population in a real-world setting.

Another essential component for large-scale automated evaluation of guidelines is the availability of the guideline recommendations in a computational format.[17] The EC guideline has served as a pilot for the application of a novel methodology for guideline evaluation measurements and the development of a web-based dashboard.[18] A previously developed prototype of this dashboard contains and processes a computer-interpretable version of the Dutch EC guideline and data from the NCR. It supports a variety of analyses and an interactive use for all subpopulations identified by the guideline for whom all the necessary real-world data are available.

The objective of this study is to evaluate guideline adherence related to clinical questions in EC, using this newly developed methodology and prototype dashboard. Results show that the combination of real world data with computable guidelines is capable of addressing clinically relevant questions regarding guideline implementation.

METHOD

Study design and data source

This study was a retrospective, observational cohort study that uses real-world data from EC patients obtained from the NCR. The study covered data collected between January 2010 and May 2022. Since 2015, the NCR dataset for EC has been expanded. Analyses were carried out on incidence years with sufficient data availability. In addition, a synthetic dataset was employed to facilitate the development and testing of the prototype dashboard.[19] Data collection for the NCR is employed by specially trained data managers, adhering to standardised definitions and protocols while extracting data from electronic health records. Each case is comprehensively registered following the NCR manual, ensuring the completeness of datasets for all cases. The data registration process is consistent and ongoing.

Participants

The study included adult patients diagnosed with EC with a histological subtype of endometrioid adenocarcinoma, serous carcinoma or clear cell carcinoma. This study used existing retrospective data from the NCR, with no additional data collection conducted.

Preparatory work

The study began by parsing the textual EC guideline (V.2011) into computer-interpretable clinical decision trees by using the methodology described by Hendriks *et al*.[20] An information standard was developed iteratively, encompassing all guideline data items. The information standard for EC consequently contained all patient and disease characteristics and interventions of the guideline, with Systematized Nomenclature of Medicine Clinical Terms codes applied for standardisation.[21] Next, data items from the NCR dataset were mapped onto the information standard, and additionally, relevant data items were added. Finally, for the subpopulations defined by the guideline CDTs, as shown in figure 1, an analysis was conducted to determine whether the relevant data items (eg, 'histology', 'Fédération Internationale de Gynécologie et d'Obstétrique (FIGO) stage', 'hysterectomy') were available in the NCR. Subpopulations with sufficient data were selected for further analyses, and patients were classified into categories of adherent, non-adherent or other, following a methodology previously described by Ebben *et al*.[18]

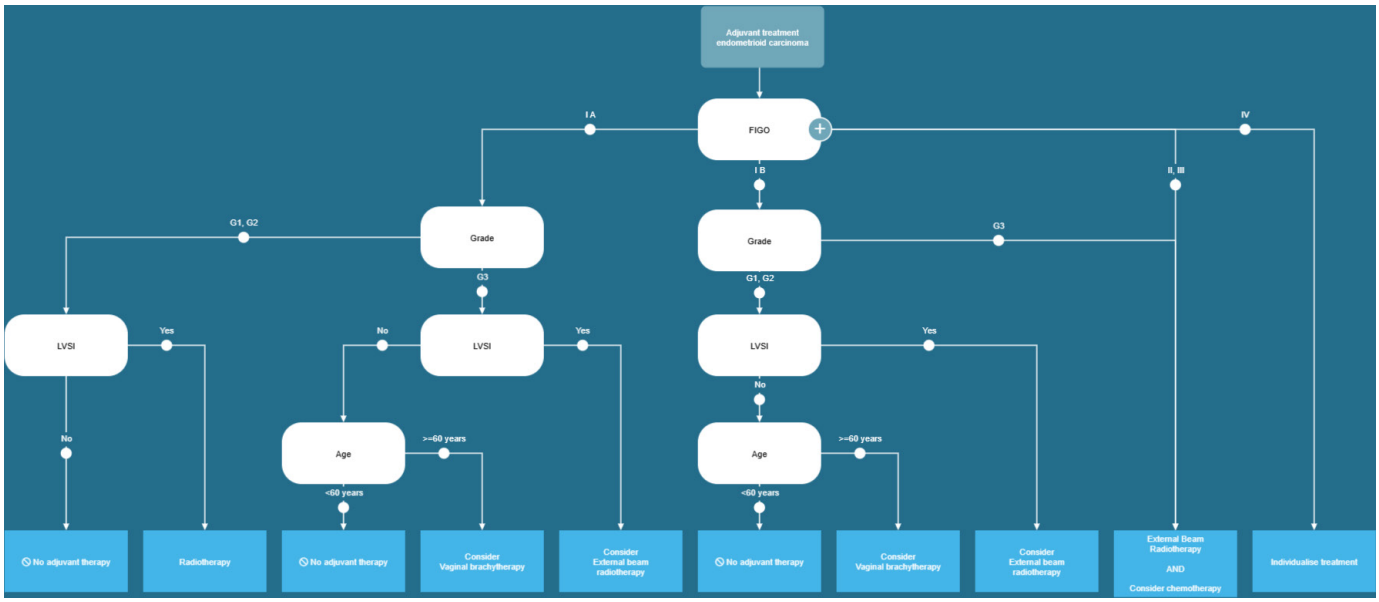

Figure 1 Screenshot of the guideline-based clinical decision algorithm for adjuvant treatment of patients with endometrioid carcinoma. A visual representation of the guideline-based clinical decision tree for the adjuvant treatment of endometrial cancer version 2011 is depicted in the screenshot. The root node, positioned at the top, is succeeded by 8 (white) nodes, representing disease and patient characteristics. Users can input values for these nodes, guiding them to the corresponding recommendation represented in a (blue) leaf. These leaves incorporate the applicable guideline recommendations for the specific subpopulation. FIGO, Fédération Internationale de Gynécologie et d'Obstétrique; LVSI, lymphovascular space invasion.

Outcome variables

The primary outcome was guideline adherence, defined as the percentage of patients who received care consistent with the recommendations outlined in the multidisciplinary NVOG guideline for EC. Secondary outcomes include: (a) adherence trends over time, (b) identification of non-guideline-based patient and tumour characteristics that may impact adherence levels, (c) listing non-adherent implemented treatments and (d) evaluating the detail level of recommended intervention (eg, 'radiotherapy' vs 'external beam radiotherapy').

Clinical questions

Four clinical questions were developed in collaboration with representatives of the guideline working group, to evaluate guideline implementation in clinical practice. For each clinical question, a variety of subpopulations were selected to showcase the analyses presented in this manuscript.

- To assess current adherence levels and adherence trends over time, we defined multiple populations to perform overall and annual adherence figures.
- To reveal the adherence levels from a clinical perspective, we used non-guideline based variables from the NCR to generate adherence figures for specific populations.
- To gain an overview of all implemented interventions, we determined which interventions align with the guideline's recommendations and which do not.
- The detail level of recommended interventions in the guideline and from the real-world dataset was evaluated.

Statistical analysis

Descriptive analyses were conducted on the mapped data items derived from the computer-interpretable guideline and NCR data using the Alertness prototype dashboard and Stata Statistical Software (V.18). Descriptive statistics were used to summarise patient and tumour characteristics, interventions, as well as guideline adherence rates. The prototype dashboard filtering functionality was used to identify patient and disease characteristics associated with guideline adherence. For the populations included in the first clinical question, additional statistical analyses were performed using logistic regression and multinomial regression in R (V.4.2.2; 2022-10-31). To evaluate trends over time, the adherent patient category served as the reference group and was compared with the other respective groups. A p value of <0.05 was considered statistically significant.

RESULTS

Preparatory work

Remodelling of the Dutch guideline for EC resulted in a total of 10 CDTs. These CDTs have been published online on the Oncoguide platform,[22] and a screenshot of one of these CDTs has been included in this publication as figure 1. The developed CDTs revealed 22 unique patient and disease characteristics and 46 unique interventions. The prototype dashboard was successfully developed and populated with synthetic data for demonstration purposes (figure 2).

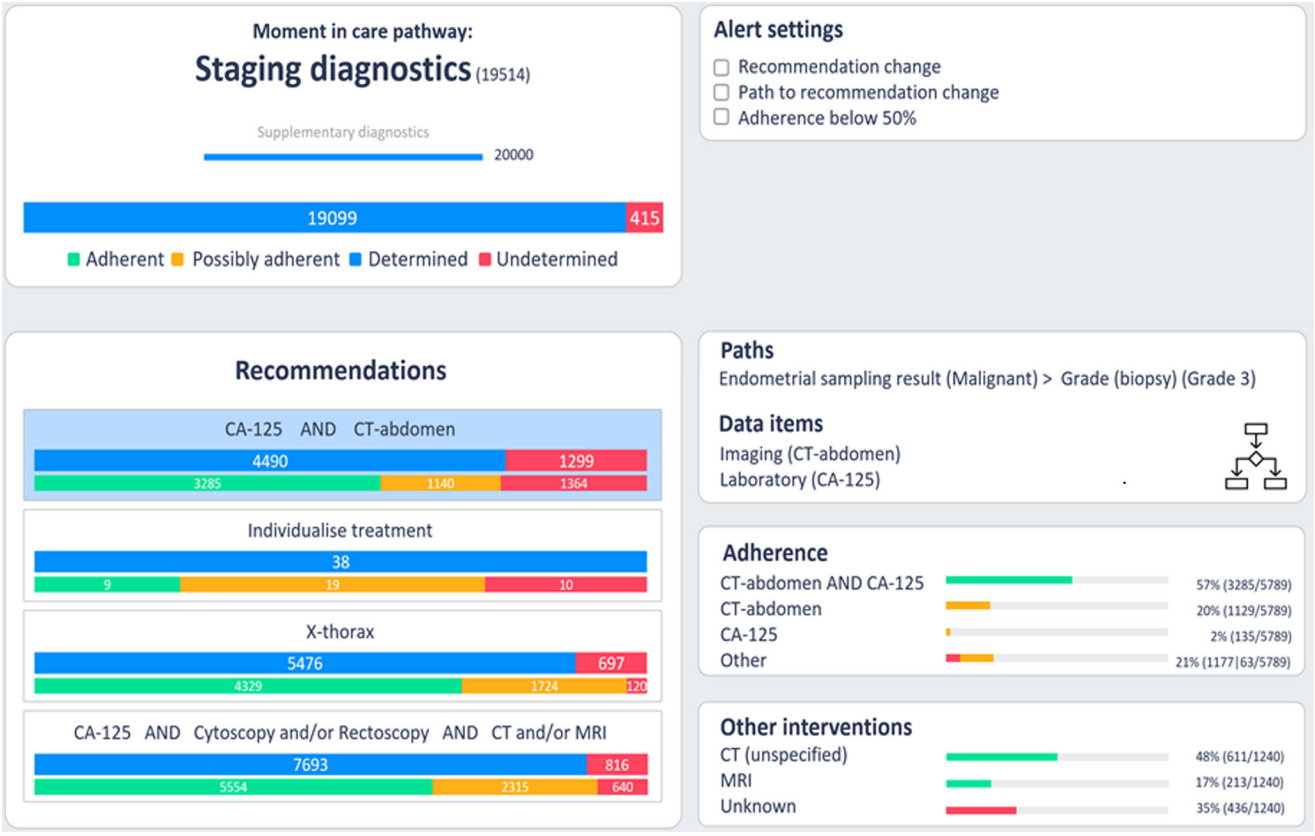

Figure 2 Screenshot of the Alertness prototype dashboard using synthetic data. Screenshot of the Alertness prototype dashboard exposing adherence levels of 'Staging diagnostics', using synthetic data for demonstration purposes (as a replacement for the real-world data from the NCR). From the total population of 20 000 cases, 19 099 are eligible for evaluation in the decision algorithm of the 'Staging diagnostics' phase in the care pathway. For all guideline recommendations being part of this phase (under 'Recommendations'), the upper bar indicates data availability and the lower bar distinguishes in adherent, non-adherent and 'other' cases. The population in scope is defined under 'Paths', accompanied by the recommended interventions under 'Data items'. Implemented interventions from the dataset are displayed under 'Adherence' (guideline recommended interventions) and 'Other interventions' (guideline non-recommended interventions). Finally, at the top right of the screenshot, the preset 'Alert settings' are accessed, including the tailored adherence level or range. CA-125, cancer antigen 125

From a total of 124 NCR data items in the dataset of EC, 22 data items were directly mappable, and another 10 were derived. All data items were listed in an information standard. A total of 4 CDTs ('Primary treatment', 'Staging evaluation', 'Adjuvant treatment endometrioid carcinoma' and 'Adjuvant treatment serous/clear cell adenocarcinoma') were successfully populated with NCR data. Analyses were performed on a cohort of 21 602 complete registered EC cases.

Primary outcome

Primary outcome, adherence levels per subpopulation identified by the CDTs, were established for nine selected clinically relevant populations, resulting in a mean adherence of 82.7% (range 44–100%) (table 1 and online supplemental file 1). Results are shown per subpopulation in the time period when sufficient NCR data were available.

Subgroup analyses

The formulated clinical questions resulted in the following findings: a statistically significant increasing trend in 'non-adherent' compared with the 'adherent' group was observed in two populations: (1) Primary treatment, endometrioid carcinoma, stage I (p<0.001; OR=1.09, 95% CI 1.04 to 1.13), and (2) adjuvant treatment, endometrioid carcinoma, stage IB, grade I or II, age >=60 years (p=0.025; OR=1.11, 95% CI 1.01 to 1.21). Conversely, a statistically significant decreasing trend in 'non-adherent' compared with the 'adherent' group was observed in one population: (1) primary treatment, serous or clear cell adenocarcinoma, stage I-III (p=0.002; OR=0.91, 95% CI 0.86 to 0.97). A statistically significant decreasing trend in 'other' compared with the 'adherent' group was found in one population: (1) Primary treatment, endometrioid carcinoma, stage I (p=0.008; OR=0.89, 95% CI 0.80 to 0.97). All remaining analyses yielded non-statistically significant differences (table 1).

Next, the non-guideline based variable 'age' was indicated by guideline committee representatives to further stratify guideline-defined populations for clinically relevant tweaking of adherence figures. Recommendations in incidence years 2010–2022 for primary treatment in

Table 1 Overview of adherence to the Dutch endometrial cancer guideline*

Population	Recommendation	No. cases	Evaluation (%)		
			Adherent	Non-adherent	Other
Primary treatment and endometrioid and stage I†	TAH AND BSO OR TLH AND BSO	7240	5949 (82)	806 (11)	485 (7)
Primary treatment and endometrioid and stage IIIB†	TAH AND BSO OR EBRT	57	6 (11)	35 (61)	16 (28)
Primary treatment and serous/clear cell and stage I-III†	Complete staging	1269	659 (52)	610 (48)	
Adjuvant treatment and endometrioid and stage IA and grade I OR II	No adjuvant treatment	4423	4355 (98)	68 (2)	
Adjuvant treatment and endometrioid and stage IA and grade III and <60 years	No adjuvant treatment OR Vaginal brachytherapy	128	121 (95)	7 (5)	
Adjuvant treatment and endometrioid and stage IA and grade III AND>=60 years	Vaginal brachytherapy	411	252 (61)	159 (39)	
Adjuvant treatment and endometrioid and stage IB and grade I OR II and >=60 years	No adjuvant treatment	382	332 (87)	50 (13)	
Adjuvant treatment and serous/clear cell and stage IA†	Vaginal brachytherapy	538	294 (55)	244 (45)	
Adjuvant treatment and serous/clear cell and stage IB†	EBRT	34	14 (41)	20 (59)	

Overview of adherence measures from 2010 onwards and in total for nine populations identified by parsing the textual guideline into clinical decision trees .
A more detailed table is provided in online supplemental file 1, where the populations are also stratified by year of incidence.
*Classification of cases from the Netherlands Cancer Registry database into guideline adherent, non-adherent and other as previously described by Ebben *et al*.[18]
†Data availability was sufficient for analysis from 2015 onwards.
‡No statistically significant difference in trend over time compared with the adherent group.
§Statistically significant increase over time compared with the adherent group.
¶Statistically significant decrease over time compared with the adherent group.
BSO, bilateral salpingo oophorectomy; EBRT, external beam radiotherapy; TAH, total abdominal hysterectomy; TLH, total laparoscopic hysterectomy.

patients with endometrioid carcinoma, FIGO stage I, with cut-off values for age set to, (<=59), (>=60-<=69), (>=70-<=79) and (>=80) reveal a decline in adherence from approximately 85% in the first three groups to 66% in the latter age group (table 2).

The recommendation for adjuvant treatment of serous or clear cell adenocarcinoma, stage IB is 'Consider radiotherapy and Adjuvant chemotherapy'; these interventions are not further specified. According to NCR data from 2010 to 2022 a total of 152 individuals meet these population characteristics, of which 26.3% had no radiotherapy, 23.6% external radiotherapy, 23.0% brachytherapy and 26.9% combined external radiotherapy and brachytherapy. Chemotherapy was not administered in 79.6% of these cases, indicating that they were not treated in accordance with the guideline.

All intended analyses were successfully conducted and provide a comprehensive insight into the various aspects of the use of the EC guideline in clinical practice.

DISCUSSION

By combining real-world data with a computer-interpretable guideline, we successfully computed multiple aspects of adherence levels to the Dutch EC guideline. These results provide insights into guideline implementation by establishing a novel system designed to continuously evaluate adherence to guidelines, applied to EC.[18] It establishes analytical standards within the context of guideline adherence, signifying the broader applicability of this approach beyond (endometrial) cancer.

The insights of adherence patterns within identified subpopulations serve as a cornerstone for discussing acceptable or optimal ranges of adherence by guideline committees and physicians.[23] In general, one would reasonably expect that a specific subset of the patients is not treated according to the guideline, because in individual cases a guideline recommendation may result in more harm than benefit. In the current study, it was found that in two populations, a statistically significant increase in non-adherence occurred, warranting further investigation to understand the underlying phenomenon. Additionally, nearly 100% adherence was observed for

Table 2 Assessing the impact of age as an influencing factor on adherence

Population	Recommendations	Age	No. cases	Evaluation (%)		
				Adherent	Non-adherent	Other
Primary treatment and endometrioid and stage I*	TAH and BSO *OR* TLH and BSO	<=59	1667	1381 (83)	161 (10)	125 (7)
		60–69	2377	2063 (87)	178 (7)	136 (6)
		70–79	2229	1873 (84)	215 (10)	141 (6)
		>=80	974	638 (66)	253 (26)	83 (9)
Adjuvant treatment and endometrioid and stage IA and grade I or II*†	No adjuvant therapy	<60	1363	1330 (98)	33 (2)	
		>=60	3062	3027 (99)	35 (1)	
		<45	95	85 (89)	10 (11)	
		>=45	4330	4272 (99)	58 (1)	
		<70	2957	2908 (98)	49 (2)	
		>=70	1468	1449 (99)	19 (1)	
Adjuvant treatment and serous/clear cell and stage IA†	Vaginal brachytherapy	<60	69	26 (38)	43 (62)	
		>=60	633	301 (48)	332 (52)	
		<70	308	152 (49)	156 (51)	
		>=70	394	175 (44)	219 (56)	

Adding and adjusting a continuous variable as a guideline steering parameter to alter adherence figures. Guideline recommendations for all three populations are age independent. Hence, in this example, 'age' is used to filter on the populations.
An overview of all performed interventions per guideline defined population, including interventions recommended by the guideline and interventions not recommended by the guideline in incidence years 2015–2022 is provided in table 3. In the population of primary treatment in serous carcinomas and clear cell carcinomas, stage I non-adherence is 39.7%, distributed over 10 different interventions.
*Inclusion of patients diagnosed from 2015 to 2022.
†Inclusion of patients diagnosed from 2010 to 2022.
BSO, bilateral salpingo oophorectomy; TAH, total abdominal hysterectomy; TLH, total laparoscopic hysterectomy.

adjuvant treatment in stage IA, grade 1 or 2 endometrioid carcinoma. In this case, the specific recommendation to refrain from further treatment likely accounts for the high adherence level. Optimal cut-off points for adherence will vary among different recommendations and subpopulations. Notably, anticipated adherence levels are likely correlated with the strength of the recommendation. Collaboration between clinicians, researchers and informaticians, supported by guideline adherence monitoring, is essential for enhancing these insights.

Significant variation was seen in primary treatment for stage I serous and clear cell carcinoma patients. The recommended intervention was implemented in 60% of cases; however, the remainder of the cases was distributed over 10 alternative types of interventions. We argue that this might be an indication for the guideline committee to reconsider this recommendation. In this example, the oncological outcome of the different interventions is probably quite similar, since in most of the interventions the uterus is surgically removed. In certain cases, the surgical procedures were quite extensive, as these most likely involved the diagnosis and treatment of ovarian cancer simultaneously. Ultimately, the diversity in surgical techniques and approach might result in differences in recovery, complications and long-term morbidity. Incorporating data on such outcomes would make guideline evaluation even more valuable.

The implications of our findings cascade into the broader paradigm of clinical practice guideline evaluation. Notably, our results spotlight the potential for continuous evaluation measurements as a tool for identifying areas of improvement and monitoring temporal shifts. Depending on the available data, many more analyses can be carried out, such as identifying differences per hospital (type), region, risk factors, multidisciplinary team discussion, trial participation, etc. This results in a meaningful clinical effect when acting steered by insights from daily practice. The practical application of such insights hinges on the harmonisation and technical standardisation of guideline knowledge and real-world data.[24] As suggested by the results, a straightforward example is that paying close attention to providing accurate and as specific as possible descriptions of interventions in guidelines would greatly facilitate computable analyses. Ultimately, these developments contribute to the formation of learning healthcare systems.[25]

While our study and methodology yield substantial insights, it is important to acknowledge its limitations. The use of registry data introduces a temporal lag in obtaining adherence insights, caused by the delay in data

Table 3 Overview of all implemented interventions per guideline population, regardless of (non-)adherence

Population	Interventions	Frequency (%)
Primary treatment and endometrioid and stage I	TLH and BSO*	5113 (71)
	TAH and BSO*	842 (12)
	No surgery	398 (5)
	Staging surgery	316 (4)
	TLH without BSO	270 (4)
	TAH without BSO	136 (2)
	Simple UE and BSO/unknown	79 (1)
	Radical UE	45 (1)
	Simple UE without BSO	26 (1)
	Local resection	13 (1)
	Debulking	9 (1)
	Total	7247
Primary treatment and serous/clear cell and stage I	Staging surgery*	601 (60)
	TLH and BSO	198 (20)
	TAH and BSO	88 (9)
	No surgery	48 (5)
	TAH without BSO	14 (1)
	TLH without BSO	13 (1)
	Simple UE without BSO	12 (1)
	Debulking	10 (1)
	Simple UE and BSO/unknown	6 (1)
	Radical UE	6 (1)
	Local resection NOS	1 (0)
	Total	997
Adjuvant treatment and endometrioid and stage IA and grade III and age <60 years	No adjuvant therapy*	96 (75)
	Vaginal brachytherapy*	26 (20)
	Adjuvant EBRT	4 (3)
	Adjuvant chemotherapy	1 (1)
	Adjuvant brachytherapy and adjuvant chemotherapy and adjuvant EBRT	1 (1)
	Total	128
Adjuvant treatment and endometrioid and stage IA and grade III and age>=60 years	Vaginal brachytherapy*	251 (61)
	No adjuvant therapy	132 (32)
	EBRT	23 (6)
	EBRT and chemotherapy	2 (1)
	EBRT and brachytherapy	1 (0)
	Adjuvant chemotherapy	1 (0)
	Adjuvant chemotherapy and adjuvant hormone therapy	1 (0)
	Total	411

*Overview of all implemented interventions in four guideline populations, including interventions recommended by the guideline(*), and interventions not recommended by the guideline.
BSO, bilateral salpingo oophorectomy; EBRT, external beam radiotherapy; NOS, not otherwise specified; simple UE, uterus extirpation by unknown technique, including BSO; TAH, total abdominal hysterectomy; TLH, total laparoscopic hysterectomy.;

availability to the registry. However, the turnaround time for this project using real-world data is significantly faster than conducting a clinical comparative study. Furthermore, our interpretation of non-adherence remains cautious, recognising that deliberate deviations from guidelines can be prudent and context-dependent. Yet, motivations underlying such deviations are often missing in the NCR dataset, and perhaps also in clinical reports. It would be highly interesting to register the reason for non-adherence to guidelines to gain more insight into this phenomenon. Finally, although the NCR dataset is extensive, its emphasis on the initial treatment phase restricts the range of evaluable clinical decision points outlined in the guideline. Expansion of or linkage with, for example, recurrence or clinical and patient-reported outcome data will greatly enhance the value of this type of evaluation.

Finally, the reliance on guidelines on randomised controlled trials (RCTs) often results in the exclusion of relevant subsets of patients.[26] However, our study introduces a novel dimension, where variables governing RCT inclusion and exclusion, when present in real-world data, empower tailored and ongoing evaluation analyses. The implications of this approach are important, facilitating an inclusive evaluation of guideline adherence across varied patient profiles. This approach facilitates the identification of clinically relevant subpopulations that may benefit from a recommendation, adjusted to their specific characteristics. In addition, important developments are taking place in oncology in the field of, among other things, molecular diagnostics. It is likely that (endometrial) cancer subpopulations will become smaller as a result, and ongoing monitoring of guideline adherence using real world data will become increasingly important for revealing optimal interventions.[27] Particularly when international collaboration can be established in the area of standardised computable guidelines and (real-world) data.

CONCLUSION

The current study provides further evidence for the importance of ongoing evaluation of clinical practice guidelines in the field of oncology. The capability to outline areas of deficiency and monitor fluctuations in adherence over time holds substantial potential for enhancing patient care. While this study presents a pioneering effort, future endeavours should be directed towards validating the precision and reliability of similar measurements, including health outcome measurements. Strategic efforts to promote guideline evaluation in (cancer) care require thorough exploration, yet data availability remains the primary bottleneck for broader adoption. Lastly, the framework designed in this oncological domain offers promise for adaptation in other medical domains.

Acknowledgements Acknowledgements to Maarten J. Bijlsma for assisting with statistical analysis.

Contributors KE: led all aspects of the study, including conception, design, data analysis, interpretation, drafting and revising the manuscript. KE also serves as the guarantor. CK, CS, TV and MT: contributed to the study conception and design, as well as drafting and critically reviewing the manuscript for important intellectual content. OH: contributed to the study conception, performed data analysis and interpretation and participated in drafting and revising the manuscript. IH: contributed to the manuscript writing, reviewed the manuscript for accuracy and completeness. JW: contributed to the manuscript writing, reviewed the manuscript for accuracy and completeness, provided critical revisions and approved the final version for submission.

Funding The study was carried out in the context of the Alertness project, funded by the Netherlands Organisation for Health Research and Development (ZonMw) under grant number 516022531.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The data used in this study is derived from the Netherlands Cancer Registry, managed by the Netherlands Comprehensive Cancer Organization (IKNL) and was provided in accordance with the applicable general terms and conditions, including approval from the board of directors (Reference number: K21.083). This study used existing retrospective data, with no additional data collection conducted. All data handling and analysis adhered to the ethical guidelines and privacy regulations set by the Institutional Board. The study was carried out in the context of the Alertness project, funded by the Netherlands Organization for Health Research and Development (ZonMw). This project aims to develop methodology and a dashboard to raise alerts towards guideline committees based on new scientific developments and insights from practice variation.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data used in this study is available subject to the conditions set by the data custodian, the Netherlands Comprehensive Cancer Organisation (Integraal Kankercentrum Nederland).

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