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Validation of quality indicators in TYKS Urology

Advanced studies written paper
Spring semester 2026

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Spring semester 2026
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Field of study: Urology
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Title: Validation of quality indicators in TYKS Urology
Supervisor: Otto Ettala
Pages: 20 + attachments
Date: 5.4.2026

Monitoring the quality of healthcare requires reliable indicators that accurately reflect clinical performance. Turku University Hospital (TYKS) is planning to implement automated quality indicators (MILA indicators) to monitor the quality of urological cancer care. These indicators measure time intervals related to diagnosis, treatment, and patient information. The indicators focus on prostate, kidney, and bladder cancers. The aim of this study was to validate these indicators and modify them to be more appropriate before implementation.

The study cohort consisted of patients treated at TYKS Urology between years 2018 and 2024. Six MILA indicators were evaluated. Automated algorithms retrieved relevant diagnostic and procedural events from electronic patient records to calculate waiting times. Validation was performed by manually reviewing predefined patient samples.

Validation revealed several sources of error across the indicators. Some errors were present in all indicators, and some were specific to certain event selection. Several modifications were proposed to improve the algorithms, including revised inclusion criteria, additional diagnostic or procedural codes, and adjusted time thresholds. Not all modifications could be fully validated within the timeframe of this study. Further refinement of the algorithms is required to optimize event selection and time interval calculation.

In conclusion, automated quality indicators require careful validation before clinical implementation. With further refinement, the MILA indicators will provide a useful tool for monitoring treatment delays, improving resource allocation, and enabling comparison of time delays against other countries and healthcare regions.

Key words: quality indicators, urological cancers, surgery waiting time

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1 Introduction

Finnish Health Care Act, article 8, states that healthcare must be based on evidence and recognized treatment and operational practices. The provided care must be of high quality, safe, and appropriately organised (1). To date, systematic quality monitoring of urological cancer treatment has not been implemented previously in Finland. In Sweden, quality monitoring of cancer treatment has been implemented for a longer period, and several validation studies based on national cancer registries have been published (2,3).

Turku University Hospital (TYKS) is planning to monitor quality with automated algorithms, called Mitattava Laatu-indicators (MILA). MILA indicators are based on quality indicators used in Swedish healthcare (4). The six urological MILA indicators measure time intervals related to diagnosis, curative treatment, or patient notification in urological cancers. In renal cancer, time from referral to curative treatment is assessed. In prostate cancer, the indicators include time from referral to first urology consultation in men with suspected prostate cancer, time from referral to curative treatment, and from pathological diagnosis to patient notification. In bladder cancer, indicators measure time from referral to diagnostic procedures and time from referral to radical cystectomy. The automated algorithms to model these indicators have been developed with Auria Clinical Informatics (5). The six algorithms developed for TYKS urology have not yet undergone validation.

The objective of this study was to validate these indicators by identifying sources of error in the automated algorithms and assessing their ability to reflect typical, appropriately managed cancer care pathways.

2 Materials and methods

2.1 Cohorts

The cohorts consisted of patients with suspected or diagnosed prostate, bladder, or renal cancer. All the patients were treated at TYKS Urology between 2018 and 2024. Patients were referred from primary care, emergency department, other specialities within TYKS or private clinics.

2.2 Indicators

All indicators are based on diagnostic (ICD-10) (6) and procedural codes (modified NCSP) (7). The indicators are listed in table 1.

Indicator 1: Kidney cancer – time from referral to curative treatment

Patients, both female and male, were identified based on nephrectomy procedures (KAD, KAC) performed during the study period. From these, only patients with a diagnosis of kidney cancer (C64.88) recorded within ±180 days of the procedure were included. For each patient, the urology referral closest preceding the operation was selected, and the time interval was calculated between referral and treatment, with a maximum allowable interval of 365 days. The target time was 41 days, with a target proportion of 80%.

Indicator 2: Suspected prostate cancer – time from referral to first urology consultation

Male patients with suspected prostate cancer were identified using diagnostic codes (R86, R86.1) or relevant diagnostic procedures (KE1AT, KEB00, TKE00). These events were combined into a single event set per patient. The referral closest to the subsequent event was selected. The time interval from this referral to first urology consultation was calculated (maximum 365 days). The target time was 14 days, and no target proportion was defined.

Indicator 3: Prostate cancer – time from referral to curative treatment

Patients with a first occurrence of prostate cancer diagnosis(C61) were identified. Curative treatment was defined as surgery (KEC01) or radiotherapy (WF002), including radiotherapy combined with hormonal therapy (ATC code L02[AB]). For each patient, the referral served as the index event, and the treatment with the shortest interval from referral was selected. Only cases with an interval of less than 180 days were included. The target time was 68 days for surgery and 75 days for radiotherapy, with a target proportion of 80%.

Indicator 4: Prostate cancer – time from pathological diagnosis to patient notification

Patients undergoing prostate biopsy were identified using pathology records (Ts-PADPros, 4763). The pathology report date was used as the starting point, and the time to the first subsequent urology consultation was calculated, with a maximum interval of 365 days. The target time was 11 days, with a target proportion of 80%.

Indicator 5: Bladder cancer – time from referral to diagnostic procedure

Patients were identified based on diagnostic procedures, including cystoscopy or transurethral resection (UKC02, UKC05, KCD02), and only the first such procedure per patient was included. A subsequent diagnosis of bladder cancer (C67) within 180 days was required. The referral immediately preceding the procedure was identified, and the time interval from referral to diagnostic procedure was calculated (maximum 365 days). The target time was 14 days, and no target proportion was defined.

Indicator 6: Bladder cancer – time from referral to radical cystectomy

Patients undergoing radical cystectomy (KCC) were identified and linked to a bladder cancer diagnosis (C67) recorded within 180 days prior to surgery. Patients receiving neoadjuvant chemotherapy within a predefined preoperative interval were excluded, and only patients within the TYKS catchment area were included. The time interval from referral to surgery was calculated, with a maximum of 365 days. The target time was 37 days, with a target proportion of 60%.

Table 1. Table of indicators.

Indicator	Clinical context	Time interval	Patient definition (ICD-10)	Key procedures/events	Target time (days)	Target proportion
1	Kidney cancer	Referral → curative treatment	C64.88	Partial or radical nephrectomy (KAD, KAC)	41	80%
2	Suspected prostate cancer	Referral → first urology consultation	R86, R86.1, R74.8	Imaging or biopsy procedures (KE1AT, KEB00, TKE00)	14	Not defined
3	Prostate cancer	Referral → curative treatment	C61	Radical prostatectomy (KEC01), radiotherapy (WF002), ± ADT (L02AB)	68 (surgery), 75 (RT)	80%
4	Prostate cancer	Pathology report → patient notification	-	Prostate biopsy (Ts-PADPros)	11	80%
5	Bladder cancer	Referral → diagnostic procedure	C67	Cystoscopy / TURBT (UKC02, UKC05, KCD02)	14	Not defined
6	Bladder cancer	Referral → radical cystectomy	C67	Radical cystectomy (KCC)	37	60%

2.3 Validation

The validation strategy consisted of reviewing row-level data generated by each indicator algorithm. Predefined samples of patients treated within the target time and patients with moderate delay were reviewed. In addition, indicator-specific thresholds for potentially suspicious waiting times were defined prior to validation. These included both suspiciously long delays and implausibly short intervals relative to the expected diagnostic pathway

Indicator 1: Kidney cancer – time from referral to curative treatment, target 41 days

Validation was conducted by reviewing predefined samples of patients treated within the target time and those with moderate delays (up to 90 days). A random sample of 100 patients from each group was selected. In addition, all cases with prolonged waiting times exceeding 90 days or unusually short intervals below 14 days were considered suspicious and were reviewed in full (n = 67).

Indicator 2: Suspected prostate cancer – time from referral to first urology consultation, target 14 days.

Validation was conducted by reviewing predefined samples of patients consulted within the target time and those with moderate delays (up to 50 days). A random sample of 100 patients from each group was selected. In addition, cases with delays exceeding 100 days or intervals shorter than 1 day were considered potentially suspicious; of these (n = 245), 50 patients were reviewed.

Indicator 3: Prostate cancer – time from referral to curative treatment. Target for surgery 68 days, radiotherapy 75 days

Validation was conducted separately by treatment modality. For patients undergoing surgery, 100 patients treated within the target time and 100 with moderate delays (Up to 120) were reviewed. All patients treated with radiotherapy alone were reviewed (n = 45). For patients receiving combined hormone therapy and radiotherapy, 20 patients within the target time and 20 with moderate delays were reviewed. In addition, all cases with intervals shorter than 20 days were considered potentially suspicious and were reviewed in full (n = 16).

Indicator 4: Prostate cancer – time from pathological diagnosis to patient notification, target 11 days

Validation was conducted by reviewing predefined samples of patients informed within the target time and those with moderate delays (up to 30 days). A random sample of 100 patients

from each group was selected. In addition, all cases with intervals exceeding 31 days were considered prolonged and were reviewed in full (n = 93).

Indicator 5: Bladder cancer – time from referral to diagnostic procedure, target 14 days

Validation was conducted by reviewing predefined samples of patients treated within the target time and those with moderate delays. A random sample of 100 patients from each group was selected. In addition, all cases with delays exceeding 90 days were considered potentially suspicious and were reviewed in full (n = 41).

Indicator 6: Bladder cancer – time from referral to radical cystectomy, target 37 days

Validation was conducted on a subset of patients from the cohort totalling only 60 patients. In total, 32 random patients were reviewed, including all patients treated within the target time (n = 9).

2.4 Indicator revision and re-evaluation

After the first validation round, incorrect and inappropriate cases were identified and flagged in the data. Proposed modifications to the algorithms were reviewed with Auria Clinical Informatics. All agreed modifications were implemented in the algorithms and subsequently another, more compact, validation round was done. In this validation round flagged cases were reviewed and confirmed that corrections to the algorithm were successful. If corrections were not appropriate, another validation round was done, and flagged cases were once again reviewed.

3 Results

3.1 Common sources of error in all indicators

Errors common to all indicators are presented in table 2. In-house referrals with already established diagnosis or referrals from secondary care centre were common across multiple indicators. In these cases, patients were referred to urology department for surveillance after radiotherapy or for treatment only given in tertiary care centre such as radical prostatectomy or radical cystectomy. This usually created incorrect intervals. These are also not appropriate as we intended the cohort to consist of patients with the entire diagnostic pathway done at TYKS.

Another common source of error was referral due to another urological condition such as haematuria before priority outcome of interest. During urological monitoring, a new symptom (raised PSA) led to diagnosis and assessed the proper diagnosis, which brought the patient to the cohort. In these cases, delays were substantial.

The algorithms pick diagnoses and procedures as calculating points. If these are carelessly documented in patient records or possibly missing altogether, the algorithm cannot identify it and picks another, later, calculating point. These mistakes create falsely large intervals.

Table 2. Common sources of error identified during validation

n indicates the number of patients reviewed during validation for each indicator.
Values are presented as counts with percentages.

Error type	Indicator 1[1](n=267)	Indicator 2[2] (n=147)[10]	Indicator 3[3] (n=307)	Indicator 4[4] (n=297)	Indicator 5[5] (n=241)	Indicator 6[6] (n=32)
Diagnostic pathway[7]	3 (1.1%)	29 (19.7%)	39 (12.7%)	0 (0.0%)	7 (2.9%)	10 (31.2%)
Referrals for unrelated conditions[8]	6 (2.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	33 (13.7%)	1 (3.1%)
Missing or incorrect data[9]	8 (3.0%)	51 (34.7%)	4 (1.3%)	104 (35.0%)	10 (4.1%)	1 (3.1%)

[1] **Indicator 1:** Kidney cancer – time from referral to curative treatment.
[2] **Indicator 2:** Suspected prostate cancer – time from referral to first urology consultation.
[3] **Indicator 3:** Prostate cancer – time from referral to curative treatment.
[4] **Indicator 4:** Prostate cancer – time from pathological diagnosis to patient notification.
[5] **Indicator 5:** Bladder cancer – time from referral to diagnostic procedure.
[6] **Indicator 6:** Bladder cancer – time from referral to radical cystectomy.
[7] **Diagnostic pathway:** Referrals originating from oncology or outside the TYKS catchment area, where diagnosis had already been established and referral was for treatment or follow-up only, leading to non-representative intervals.
[8] **Referrals for unrelated conditions:** Referrals initiated for other urological conditions, where subsequent symptoms (e.g., elevated PSA or macrohematuria) led to cancer diagnosis, resulting in artificially prolonged intervals.
[9] **Missing or incorrect data:** Incomplete or inaccurate documentation of diagnoses or procedures in electronic health records, leading to incorrect identification of timepoints and overestimation of intervals.
[10] **Reviewed patients for indicator 2**: Large number of incorrect cases led to a smaller initial validation round. Another more thorough round was planned to be done after first modifications.

3.2 Indicator specific errors and made corrections

Indicator 1: Kidney cancer – time from referral to curative treatment

Figure 1: Patient distribution per year, indicator 1

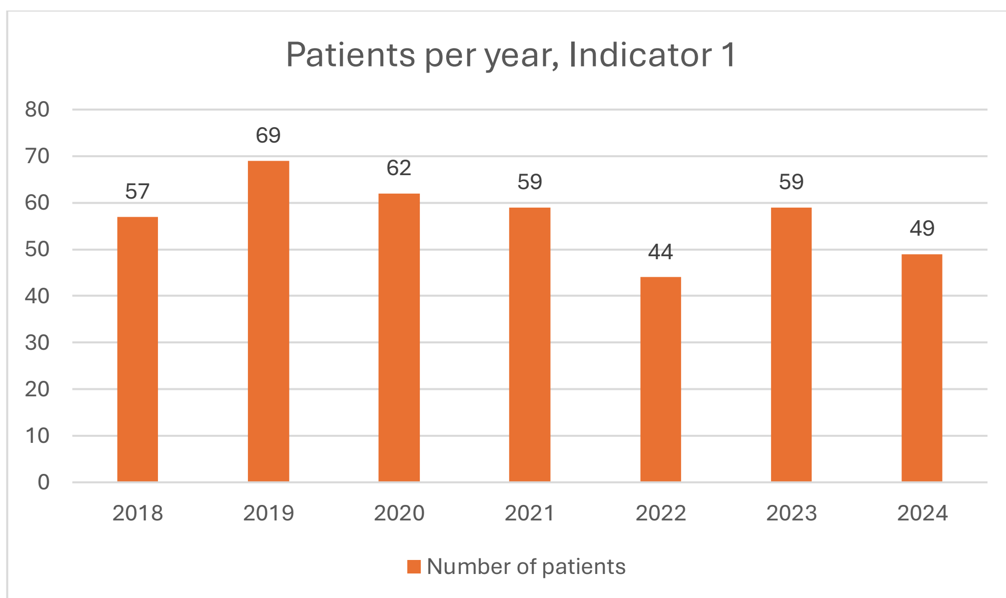
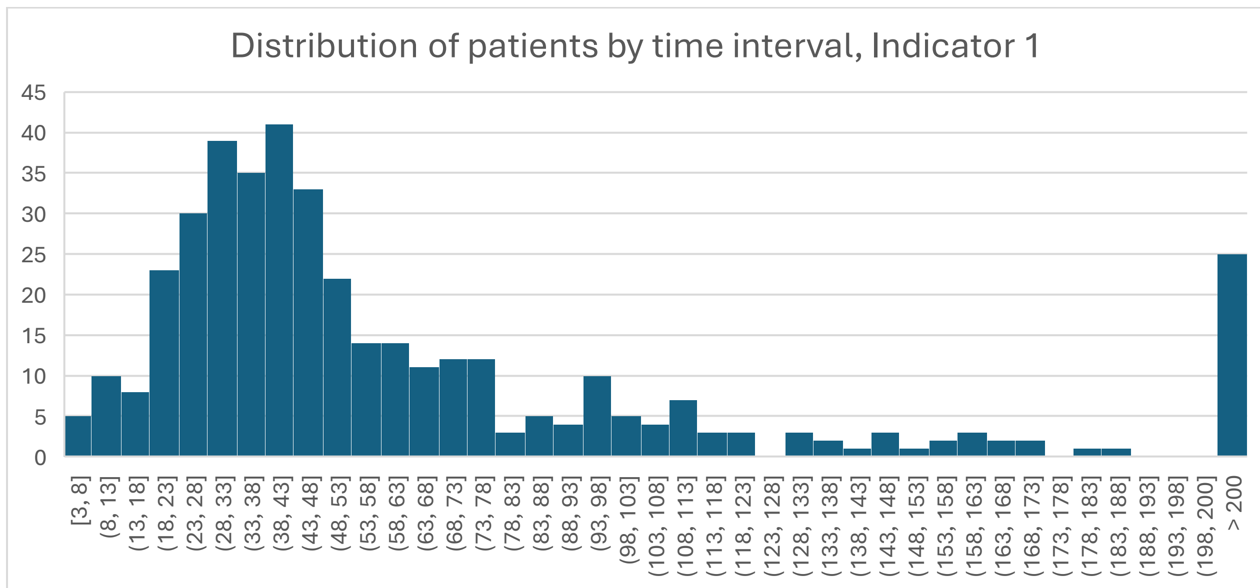


Figure 2: Patient distribution by time interval, indicator 1



Observations: The cohort consisted of 399 patients. Of these, 44.6% were within the target time of 41 days. Patient distribution by year is presented in figure 1, and distribution by time interval in figure 2.

Challenges: Several patients had an initial referral for reasons other than suspected renal tumour. These referrals were typically made for other conditions, and a renal tumour was subsequently detected during monitoring, creating large delays. Also, several duplicate cases with prior treatment and an existing diagnosis were identified and were therefore not eligible for inclusion in the indicator. RF ablation (KA3LT), a curative treatment, was not included in the initial procedure list and was therefore not captured by the algorithm.

Modifications: The maximum timeframe from referral to diagnosis was planned to be shortened. This was done to exclude referrals because of other prior urological pathology. RF-ablation was added as a curative treatment that the algorithm can pick.

Indicator 2: Suspected prostate cancer – time from referral to first urology consultation

Figure 3: Patient distribution per year, indicator 2

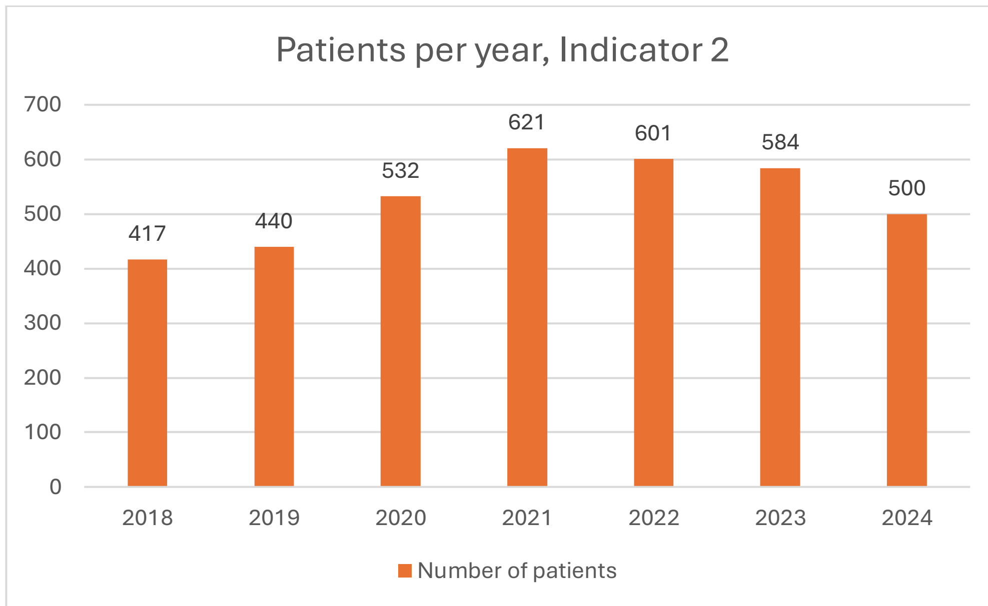
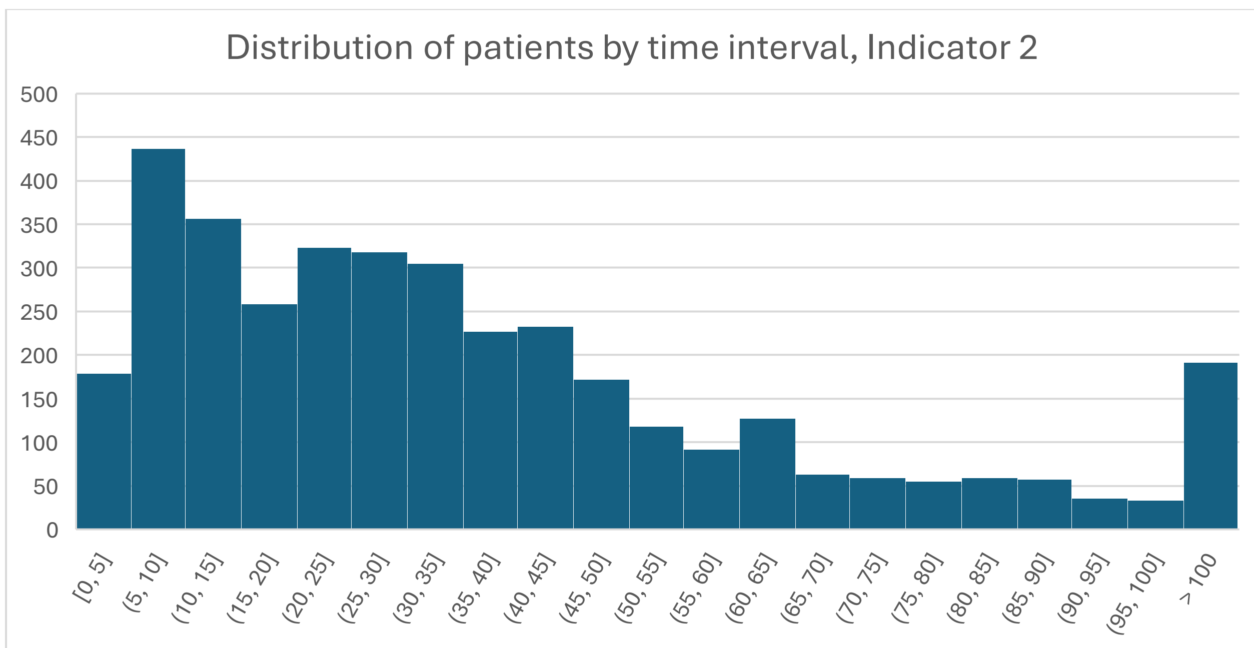


Figure 4: Patient distribution by time interval, indicator 2



Observations: The cohort consisted of 3695 patients. Of these, 25.7% were within the target time of 14 days. Patient distribution by year is presented in figure 3, and distribution by time interval in figure 4.

Challenges: It was discovered that diagnostic or procedural codes were not consistently documented in patient charts. This resulted the algorithm not identifying the first but a latter or no consultation at all, resulting a prolonged interval. The error was observed in the very

beginning of the validation process and, therefore, only 66 patients within or close to the target time, and 81 patients with suspicious interval were validated.

Modifications: The algorithm was modified to first identify the patient with diagnostic or procedural codes, as previously, and then to determine any first urological contact following the referral. In addition, diagnosis code D40 (unknown tumour of the prostate) was added to improve case identification.

Indicator 3: Prostate cancer – time from referral to curative treatment

Figure 5: Patient distribution per year, indicator 3

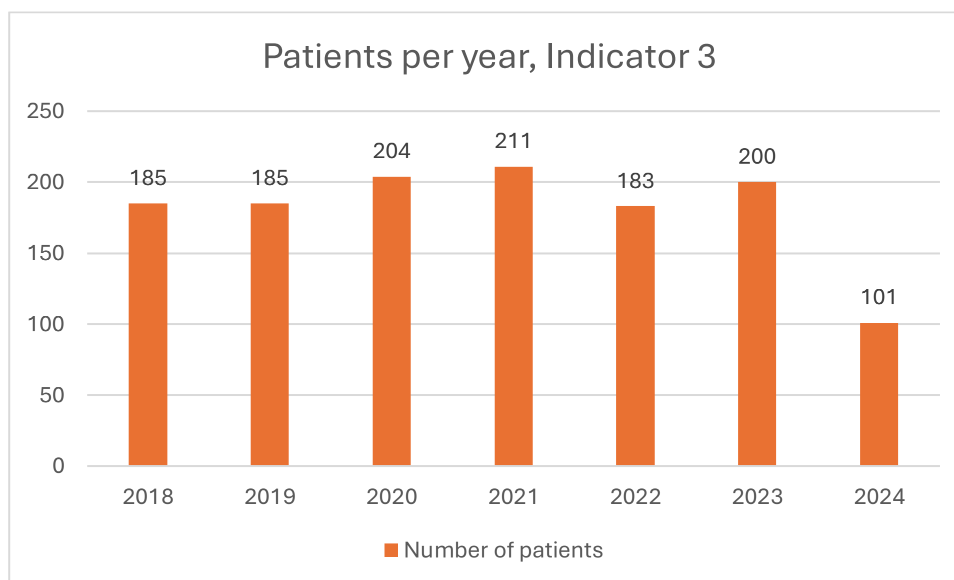
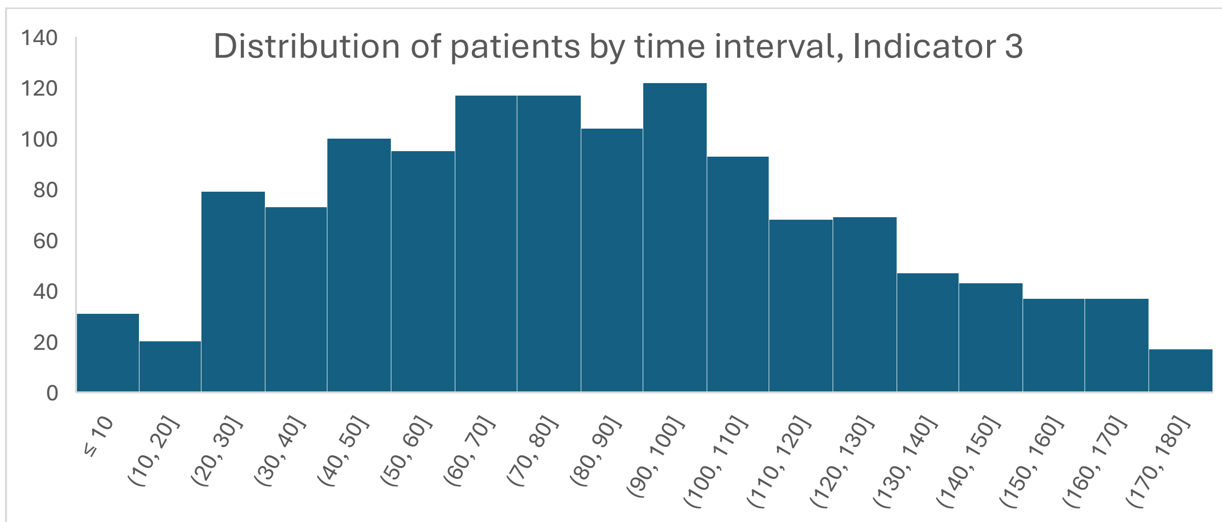


Figure 6: Patient distribution by time interval, indicator 3



Observations: The cohort consisted of 1269 patients. 767 patients were treated surgically. Of these, 39.6% were within the target time of 68 days. 457 patients received both hormonal- and radiotherapy. Of these 44.6% were within the target time of 75 days. 45 patients received only radiotherapy. Of these, 40.0% were within the target time of 75 days. Patient distribution by year is presented in figure 5, and distribution by time interval in figure 6.

Challenges: The original algorithm included patients who had undergone their diagnostic workup at an external urological unit and therefore captured the secondary referral, rather than the original primary care referral. Many patients were treated with a delay of 160-179 days, creating a hypothesis that appropriately treated patients had been excluded because of an overly restrictive time window.

Modifications: The maximum allowable interval from referral to diagnosis was planned to be extended.

Indicator 4: Prostate cancer – time from pathological diagnosis to patient notification

Figure 7: Patient distribution per year, indicator 4

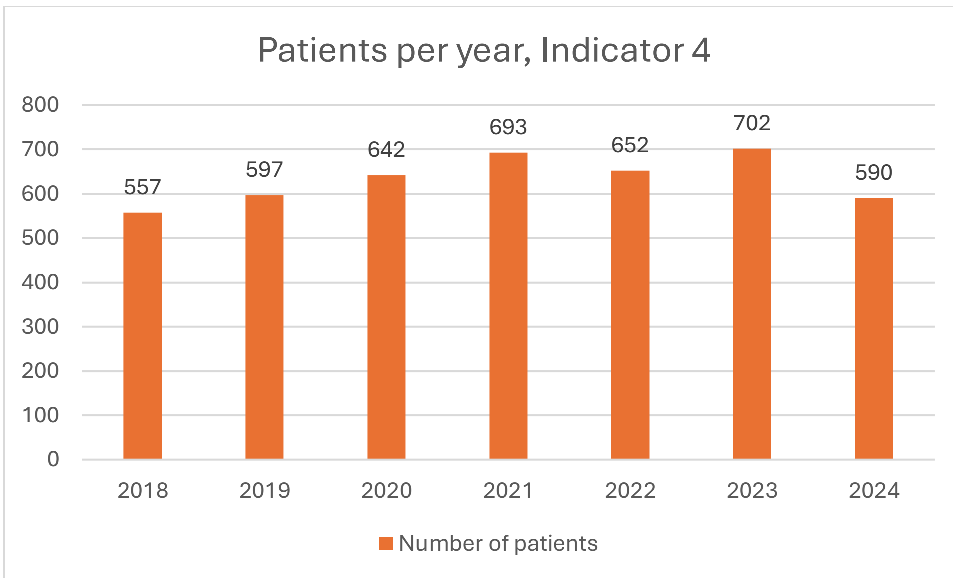
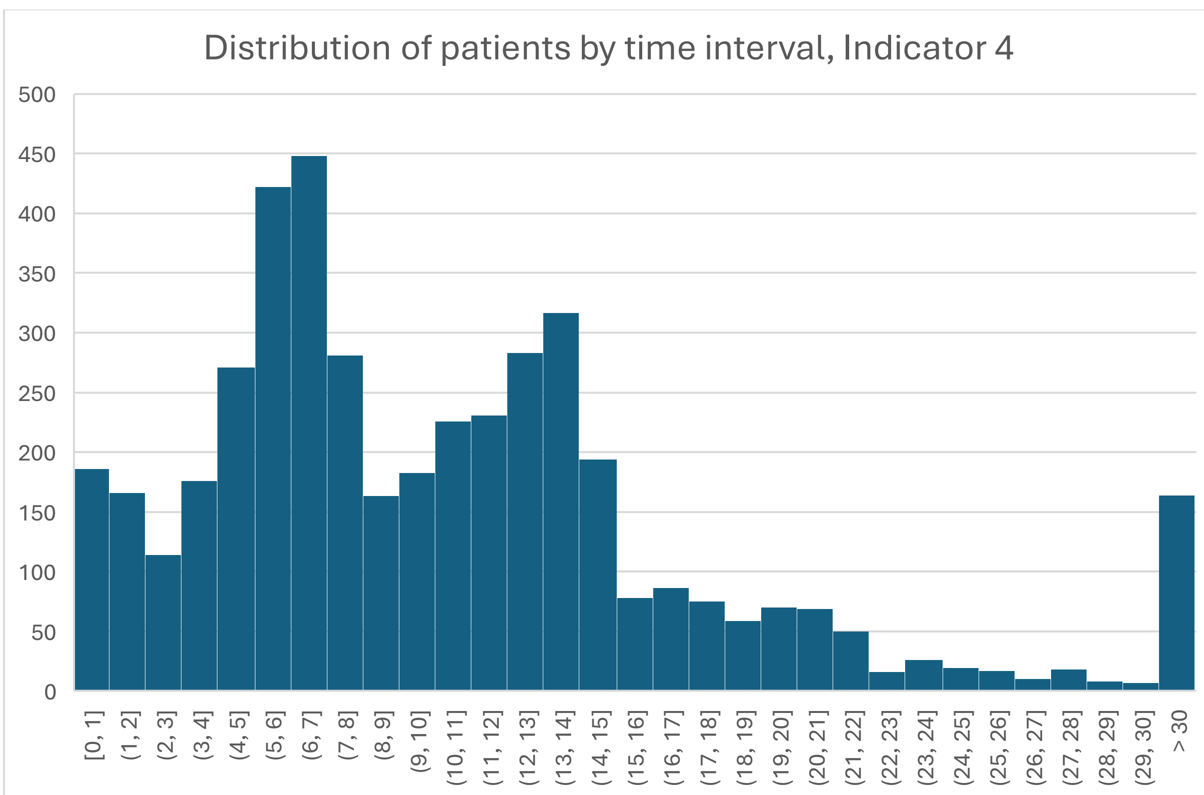


Figure 8: Patient distribution by time interval, indicator 4



Observations: The cohort consisted of 4433 patients. Of these, 59.5% were within the target time of 11 days. Patient distribution by year is presented in figure 7, and distribution by time interval in figure 8.

Challenges: This indicator proved to be problematic in the way the algorithm identified the notification to the patient. The algorithm did not reliably identify the correct first response after referral. This was hypothesized to be due to the algorithm selecting data from the patient's resource history rather than from direct entries in the patient record.

Modifications: Modification was made that allowed the first contact to be defined as either a urological response, a visit, or a call recorded in direct entries, or a letter retrieved from the resource history, whichever occurred first.

Indicator 5: Bladder cancer – time from referral to diagnostic procedure

Figure 9: Patient distribution per year, indicator 5

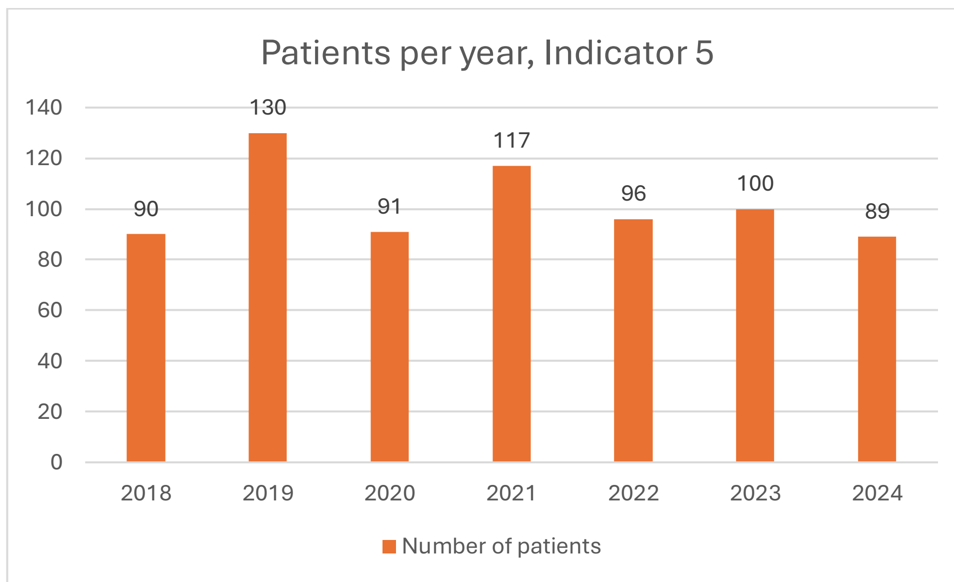
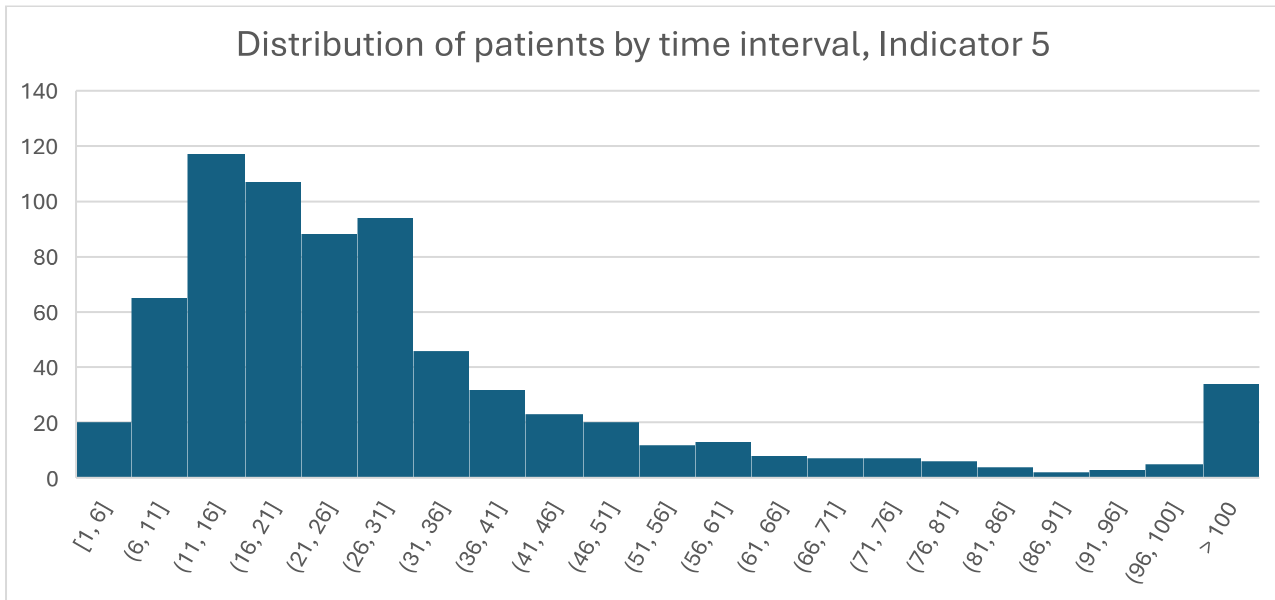


Figure 10: Patient distribution by time interval, indicator 5



Observations: The cohort consisted of 713 patients. Of these, 20.8% were within the target time of 14 days. Patient distribution by year is presented in figure 9, and distribution by time interval in figure 10.

Challenges: Several patients had an initial referral for reasons other than suspected bladder cancer. These referrals were typically made for other conditions, and the reason for diagnostic procedure (i.e., macrohematuria, radiological finding), was subsequently identified during urological monitoring for the other condition. In these cases, the only selectable referral was for the former condition, creating prolonged intervals. The predefined maximum interval between referral and procedure was frequently exceeded, with delays of up to several years.

Modifications: The maximum interval was therefore planned to be shortened. Additional procedure codes (KCD32, KCD05) were also added to bring more patients to the cohort. Furthermore, patients with a prior diagnosis of bladder cancer were excluded.

Indicator 6: Bladder cancer – time from referral to radical cystectomy

Figure 11: Patient distribution per year, indicator 6

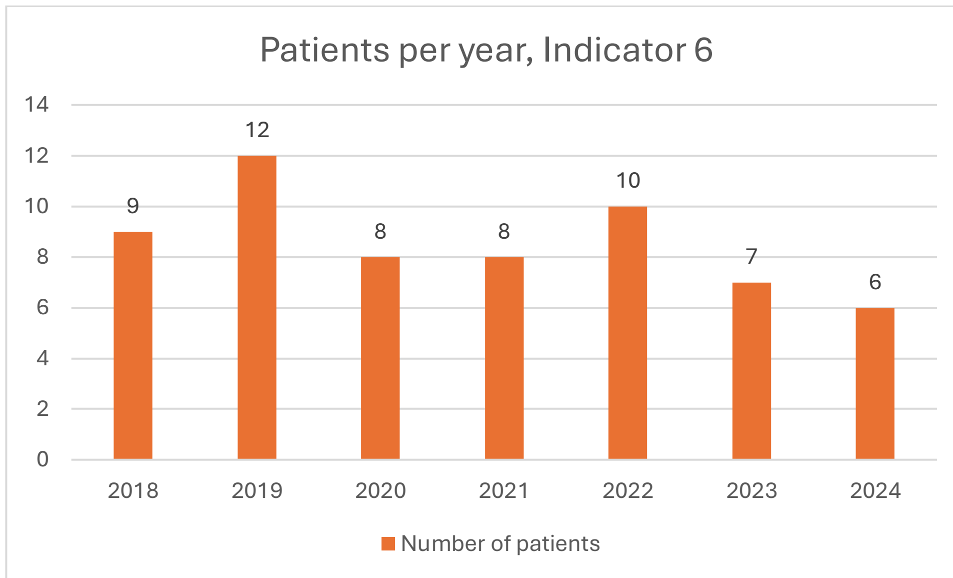
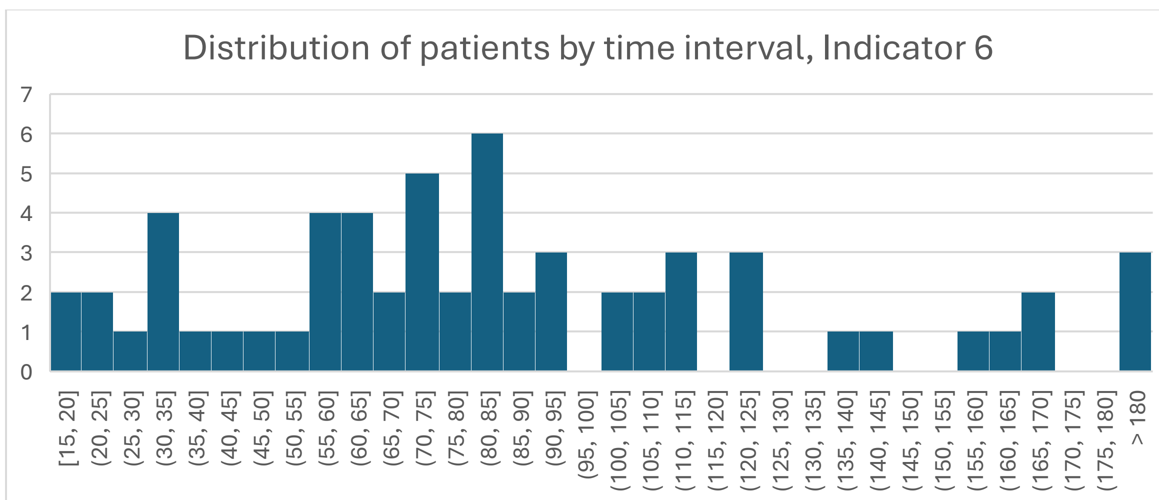


Figure 12: Patient distribution by time interval, indicator 6



Observations: The cohort consisted of 60 patients. Of these, 15.0% were within the target time of 37 days. Patient distribution by year is presented in figure 11, and distribution by time interval in figure 12.

Challenges: The original algorithm included patients who had undergone their diagnostic workup at secondary care centre and were referred to TYKS only for the radical cystectomy. This cohort was also suspiciously small. It seems that only a fraction of cystectomies done in TYKS are included. The excluding criteria must be reviewed to make the indicator more purposeful and clinically relevant. Otherwise, the algorithm picked the operation and referral correctly.

Modifications: Exclusion of patients with referral from secondary care centre.

4 Discussion

4.1 Summary

This study evaluated the validity of six automated quality indicators (MILA) for urological cancer care at TYKS. Several sources of error were identified, including inappropriate referrals, incomplete diagnostic pathways, and inaccuracies in electronic health record documentation. After targeted modifications to the algorithms, the indicators more accurately reflected clinically meaningful care pathways. However, further refinement is required before full clinical implementation.

4.2 Clinical significance and key findings

4.2.1 Surgery waiting time

Surgery waiting time (SWT) is defined as the interval between cancer diagnosis and definitive surgical treatment. Prolonged SWT in urological cancer surgery has been associated with inferior oncological outcomes, including both cancer-specific survival (CSS) and overall survival (OS). SWT can also be subdivided into intervals such as waiting from treatment decision to surgery (WTS) and waiting from radiological diagnosis to treatment (WRS).

Due to their clinical relevance and measurability, time to diagnostic procedure and time to curative treatment were selected as key components of the quality indicators in TYKS Urology.

4.2.2 Renal cancer

Prolonged waiting time has been linked to increased mortality in patients with non-metastatic renal cell carcinoma (RCC) (8), delays exceeding 120 days from diagnosis have been associated with worse OS (9). In pT3-graded RCC, 5-year OS was decreased after 10-week

delay (10). SWT less than 3 months does not seem to affect outcomes (11). This underlines the difficulty to define a specific number for a clinically significant SWT.

The algorithm lacks clinical context and cannot account for justified delays, such as active surveillance. For example, in renal cysts, the EAU guidelines support active surveillance as reasonable alternative to immediate surgery (12). In MILA indicator, all carcinomas were included, as TNM classification data was not available. A more appropriate approach would have been to include only cT1b or higher tumours (≥4 cm), which are typically initially treated, whereas cT1a tumours (<4 cm) can be managed with surveillance.

Although only a proportion of patients met the MILA target time, most underwent surgery within 120 days of referral. As the interval was defined from referral rather than diagnosis, the measured times are inherently longer than those reported in the literature, suggesting that overall performance is comparable despite the stringent criteria. Also, most delays exceeding 120 days were due to either data inaccuracies or clinically justified management.

4.2.3 Prostate cancer

In high-risk prostate cancer, delays to surgical treatment have been shown to increase cancer-specific mortality (13). However, EAU guidelines state that even in high-risk cases, 3-month delay in radical prostatectomy is safe (14). No statistically significant impact of treatment delay was observed in low-risk disease. This is consistent with current Finnish clinical guidelines (Käypä Hoito), which recommend active surveillance or watchful waiting in selected low-risk patients (15).

The algorithm does not account for ISUP grade, Gleason score, or PSA level, resulting in high- and intermediate-risk patients being grouped within the same cohort and assessed against identical target times. It should be noted that MILA interval is from referral, making true SWT shorter in our indicator 3. Although delays in prostatectomy may have a limited impact on oncological outcomes, target times appeared to be achieved relatively poorly. The radiotherapy cohort appeared to meet target times more consistently. Prolonged intervals in prostate cancer care can negatively affect patient experience. Waiting times for diagnosis should therefore be minimized, as reflected in indicators 2 and 4. However, due to the high

number of errors in these indicators, further validation is required before drawing conclusions about algorithm’s performance.

4.2.4 Bladder cancer

More definitive findings have been reported in bladder cancer, where shorter waiting times to radical cystectomy have been associated with improved CSS and OS. The studied SWT has differed between 84 and 93 days (16, 17). Another study instead calculated the hazard ratio in time delay (18). European urology association (EAU) states in guidelines regarding muscle invasive bladder cancer (MIBC) that while absolute time delay is difficult to assess, should radical cystectomy be done without delay to maximise survival (19).

The target time of 37 days used in the cystectomy indicator is considerably stricter than thresholds reported in the literature. In addition, the indicators interval is defined from referral to treatment, whereas the literature typically measures from diagnosis (cystoscopy) to treatment. While this may reflect an intention to optimize care pathways, it may also lead to an overestimation of clinically relevant delays. Given the ambitious target time, nearly all appropriate cases were classified as delayed. Some delays exceeded 120 days, which may be associated with worse oncological outcomes. Furthermore, the number of patients was low compared to the expected annual volume of cystectomy patients, suggesting that the inclusion criteria for the cohort should be reviewed to improve representativeness.

4.3 Strengths and limitations

This study has several strengths. It is based on real-world data extracted from electronic health records, reflecting routine clinical practice. A systematic validation strategy was applied, including predefined sampling, identification of outliers, and iterative refinement of the algorithms as validation progressed. Several indicators included large patient cohorts, improving the robustness of the findings. The indicators focused on clinically meaningful time intervals, such as surgery waiting time, which have established relevance for oncological outcomes.

Several limitations should be acknowledged. The total number of eligible patients was unknown for all indicators except indicator 4, preventing assessment of cohort completeness. The indicators rely on the accuracy of electronic health record documentation and missing or incorrectly recorded events may lead to misclassification and incorrect time intervals. Finally, the single-centre design and relatively small sample sizes in some indicators may limit generalizability.

Due to time constraints, not all modifications could be fully validated within the timeframe of this project. Further refinement of the algorithms is required to optimize event selection and time interval calculation. In addition, the parameters used to include or exclude patients from the cohort need to be re-evaluated. A broader inclusion of eligible patients is necessary to ensure robust and representative indicators.

4.4 Conclusions

This study identified multiple sources of error in automated quality indicators for urological cancer care. As hypothesized prior to validation, the indicators required modification to more accurately reflect clinical care pathway intervals.

Despite these limitations, the MILA indicators show potential as a tool for monitoring treatment delays and supporting resource allocation in urological cancer care. With further refinement and validation, they may also enable meaningful comparisons between healthcare regions and countries.

Generative AI (ChatGPT, OpenAI) was used for language editing and drafting support during manuscript preparation. The author reviewed and revised all AI-generated text and takes full responsibility for the final content.

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