Original Research

Defining care trajectories: The example of endometrial cancer

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A B S T R A C T

Background: The era of patient-centered care might lead to the conclusion that there are as many configurations of healthcare utilization within episodes of care as there are patients. However, variability among episodes of care is limited by factors such as local resources or patient characteristics. As a result, the differences among episodes of care are reduced, and a limited number of care trajectories are expected.

Objective: The aim of this study was to investigate the ability to identify clinically significant care trajectories using data on healthcare services used by patients with endometrial cancer.

Methods: A retrospective review of sixteen healthcare services used by 394 patients newly diagnosed with endometrial cancer was undertaken. Latent class analysis was used to investigate care trajectories.

Results: The analyses segregated patients into six care trajectories: 1) surgery without hospitalizations and emergency room (ER) visits; 2) surgery with hospitalizations and ER visits; 3) surgery, radiation therapy, and chemotherapy, without hospitalizations and ER visits; 4) surgery, radiation therapy, and chemotherapy, with hospitalizations and ER visits; 5) surgery and radiation therapy; 6) surgery and chemotherapy, with hospitalizations and ER visits. Classification of patients in trajectories with versus without hospitalizations and ER visits could only partially be explained by age, cancer stage, and grade.

Concluding statement: Utilization of healthcare services can be grouped into a number of defined trajectories in endometrial cancer. Identifying care trajectories and parameters associated with care trajectories could have important clinical and administrative implications.

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1. Introduction

Episodes of care are series of temporally contiguous healthcare services related to treatment of an illness [1]. In the era of patient-centered care, care services are tailored to patients’ needs [2], which might lead to the conclusion that there are as many configurations of healthcare utilization within episodes of care as there are patients. However, variability among episodes of care is limited by factors such as local resources, clinical practice guidelines, patient characteristics, and severity of the condition. As a result, the differences among episodes of care are reduced, and a limited number of care trajectories are expected. However, limiting an episode of care to healthcare utilization for a single health condition leaves out significant parts of healthcare utilization for other health conditions within the same time period. Care trajectories can therefore be understood as the layout of a series of grouped and contiguous healthcare services (medical visits, interventions, prescriptions, etc.) for all conditions occurring within a time period whereby a single health issue evolves from diagnosis to discontin-
2. Materials and methods

2.1. Data collection

The data for this study were obtained from seven databases registering mandatory medical activities in a cancer center affiliated to an academic hospital in Montreal, Canada (see Supplementary Table 1). Data pertaining to diagnosis and healthcare service utilization were collected from patients’ digital files. The study includes all consecutive patients, above the age of 18, newly diagnosed with endometrial cancer from 2008 to 2012 (N = 394). The study was approved by the center’s research ethics committee.

2.2. Measures

2.2.1. Cancer

Tumor histology was categorized into endometrioid tumor and alike, clear cell and serous carcinoma, carcinosarcomas, and other. Endometrial cancer stage (I to IV) was according to the FIGO (International Federation of Gynecology and Obstetrics) classification [6], and cancer grade was categorized into well-differentiated, moderately differentiated, poorly differentiated, undifferentiated, and not determined/missing.

2.2.2. Healthcare services

Utilization of sixteen healthcare services (see Table 1) was collected from the databases. The services were classified into five domains: (i) active oncology treatment (surgery, radiation therapy, chemotherapy); (ii) outpatient contacts with a healthcare professional in oncology for medical exams or follow-ups; (iii) outpatient contacts with a healthcare professional in family medicine or in medical specialties other than oncology for medical exams or follow-ups; (iv) hospitalizations; and (v) ER visits.

A dummy variable was created for each of the sixteen services, representing whether or not patients used the services. In our sample, almost every patient had visits with a gynecologic oncologist (94%) and almost no patients had visits with a surgical oncologist (2%). These variables were excluded from the analyses as they could unlikely discriminate between trajectories. In addition, those receiving radiation therapy were invariably seen by radiation oncologists, so the latter variable was removed from the analyses.

2.3. Operationalization of episodes of care

In this study, the episode of care began with the diagnosis of endometrial cancer and was deemed completed when no active cancer treatments (i.e., cancer surgery, chemotherapy, or radiation therapy) were provided for a period of at least four months. This timeframe was selected as it represents the time period between routine follow-up visits during the first two years following remission in our institution. Care trajectories were identified using data on all healthcare services utilized at the hospital during the first episode of care. Healthcare utilization was followed from the time of diagnosis up to March 31, 2014.

2.4. Statistical analyses

To investigate individual trajectories, longitudinal calendar grids [7] were constructed using the SAS software (version 9.3). Day-to-day healthcare utilization (e.g., type of service, duration, name of the healthcare professional) was mapped in the grids.

Latent class analysis [8,9] was used to group the sample into categories of individuals (the trajectories) who are similar within a category but different from individuals in other categories [10]. In latent class analysis, competing models presenting different numbers of trajectories are compared with fit indexes to determine the model that best fits the data. Criteria to decide on the number of trajectories used in this study were: (i) low Akaike’s Information Criterion (AIC), Bayesian Information Criterion (BIC) and adjusted BIC; (ii) a significant Lo-Mendell-Rubin (LMR) test; (iii) a significant parametric bootstrapped likelihood ratio test (BLRT) [11]; and (iv)

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Table 1

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N (%)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at inception</td>
<td>64.9 (12.3)</td>
<td></td>
</tr>
<tr>
<td>Tumor histology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endometrioid tumor and alike</td>
<td>341 (86.6)</td>
<td></td>
</tr>
<tr>
<td>Clear cell and serous carcinoma</td>
<td>37 (9.4)</td>
<td></td>
</tr>
<tr>
<td>Carcinosarcomas</td>
<td>12 (3.1)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>4 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Cancer stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage I</td>
<td>272 (69.0)</td>
<td></td>
</tr>
<tr>
<td>Stage II</td>
<td>31 (7.9)</td>
<td></td>
</tr>
<tr>
<td>Stage III</td>
<td>62 (15.7)</td>
<td></td>
</tr>
<tr>
<td>Stage IV</td>
<td>20 (5.1)</td>
<td></td>
</tr>
<tr>
<td>Not determined, missing</td>
<td>9 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Cancer grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well-differentiated</td>
<td>155 (39.3)</td>
<td></td>
</tr>
<tr>
<td>Moderately differentiated</td>
<td>99 (25.1)</td>
<td></td>
</tr>
<tr>
<td>Poorly differentiated</td>
<td>125 (31.7)</td>
<td></td>
</tr>
<tr>
<td>Undifferentiated</td>
<td>5 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Not determined, missing</td>
<td>10 (2.5)</td>
<td></td>
</tr>
<tr>
<td>Healthcare services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgical treatment for cancer</td>
<td>339 (86.0)</td>
<td></td>
</tr>
<tr>
<td>Radiation therapy</td>
<td>146 (37.1)</td>
<td></td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>123 (31.2)</td>
<td></td>
</tr>
<tr>
<td>Medical oncologist</td>
<td>66 (16.8)</td>
<td></td>
</tr>
<tr>
<td>Oncology nurse navigator</td>
<td>201 (51.0)</td>
<td></td>
</tr>
<tr>
<td>Oncology/radiation oncology nurse</td>
<td>167 (42.4)</td>
<td></td>
</tr>
<tr>
<td>Oncology allied health</td>
<td>83 (21.1)</td>
<td></td>
</tr>
<tr>
<td>Surgical specialist</td>
<td>73 (18.5)</td>
<td></td>
</tr>
<tr>
<td>Medical specialist</td>
<td>145 (36.8)</td>
<td></td>
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<tr>
<td>Nursing and allied health</td>
<td>121 (30.7)</td>
<td></td>
</tr>
<tr>
<td>Obstetrics/gynecology specialist</td>
<td>71 (18.0)</td>
<td></td>
</tr>
<tr>
<td>Hospitalizations</td>
<td>100 (25.4)</td>
<td></td>
</tr>
<tr>
<td>ER visits</td>
<td>126 (32.0)</td>
<td></td>
</tr>
<tr>
<td>Surgical oncologist</td>
<td>8 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Radiation oncologist</td>
<td>187 (47.5)</td>
<td></td>
</tr>
<tr>
<td>Gynecologic oncologist</td>
<td>371 (94.2)</td>
<td></td>
</tr>
</tbody>
</table>

NOTE: SD = Standard deviation.
interpretability (trajectories’ clinical meaningfulness). In the case of divergence, BLRT proved to be the best criteria for determining the number of classes [11]. Entropy (>0.80) was used to examine the separateness of trajectories from one another [12].

Trajectory differences were investigated in function of age, tumor histology, cancer stage, and cancer grade using equality tests of means (Bolck, Croon, and Hagenaars method [13]) for continuous variables [14] and distal categorical (DCAT) method for categorical variables [15]. These analyses weigh the probability of being categorized into a class and results are comparable to Chi-square. Because these analyses involved multiple comparisons, the Holm-Bonferroni method was used to provide appropriate alpha level for each comparison [16]. All analyses were conducted using Mplus (version 7.3; Muthén & Muthén, 1998–2014).

3. Results

3.1. Participant characteristics

Participant characteristics are described in Table 1. The mean age of participants was 64.9 years (range: 29–93 years; SD = 12.3). Histology was mostly endometrioid tumor and alike (86.6%). For nearly 70% of the patients, the cancer was diagnosed at Stage I, and in most cases cancers were well-differentiated (39.3%), moderately differentiated (25.1%), or poorly differentiated (31.7%).

![Fig. 1. Example of healthcare utilization from the time of first endometrial cancer diagnosis of three modified cases based on real patients.](image-url)
3.2. **Individual care trajectories**

Fig. 1 (Panels A to C) illustrates three longitudinal calendar grids representing the day-to-day utilization of healthcare services of three patients diagnosed with endometrial cancer and presenting with the same tumor histology, stage, and grade (data modified to preserve anonymity). In the first example (Panel A), the episode of care was short, and comprised surgery and multiple sessions of adjuvant radiation therapy, followed by medical visits. In the second example (Panel B), the patient had surgery, received six sessions of chemotherapy, and then received multiple sessions of radiation therapy. Follow-up medical visits were recorded. The third example (Panel C) illustrates a more complex case with long sequences of hospitalizations and ER visits interspersed with active oncological treatments. These examples illustrate that there are differences in individual care trajectories even in cases with the same cancer site, tumor, stage, and grade.

3.3. **Care trajectories**

Two- to eight-class (trajectory) models were investigated using latent class analysis. The fit indexes of the different models did not

![Graph](Image)

**Fig. 2.** Relative importance of utilization of healthcare services stratified by trajectories.

**NOTE.** S: Surgery without Hospitalizations and Emergency Room [ER] visits; SCP: Surgery and Chemotherapy, with Hospitalizations and ER Visits; SH: Surgery with Hospitalizations and ER Visits; SR: Surgery and Radiation Therapy; SRC: Surgery, Radiation Therapy, and Chemotherapy, without Hospitalizations and ER Visits; SRC: Surgery, Radiation Therapy, and Chemotherapy, with Hospitalizations and ER Visits.
suggest a single solution (see Table 2). Using BLRT and interpretability of the classes as decisive criteria for determining the number of classes, the six-class solution was deemed to best fit the data.

The first trajectory, “Survival without Hospitalizations/ER Visits” [S], represented patients (44% of our sample) who in large proportion received surgical interventions only (89% of those in this trajectory). A small proportion of these patients (<7%) had hospitalizations or ER visits. The second trajectory, “Survival with Hospitalizations/ER Visits” [SH] (14% of our sample), also characterized patients who in large proportion received surgery (86%). In contrast to the first trajectory, 68% of these patients had hospitalizations and 72% had ER visits. The third trajectory, “Survival, Radiation Therapy, and Chemotherapy, without Hospitalizations/ER visits” [SRC] (12% of our sample), characterized patients who tended to receive the three types of oncological treatments (surgery 85.1%, radiation therapy 85.1%, and chemotherapy 100%). A small proportion of these patients (<5%) had hospitalizations or ER visits. The fourth trajectory, “Survival, Radiation Therapy, and Chemotherapy, with Hospitalizations/ER Visits” [SRCH] (14% of our sample), also characterized patients who in large proportion received the three oncological treatments (surgery 94.6%, radiation therapy 94.6%, and chemotherapy 89.3%)). In contrast to the third trajectory, 54% of these patients were hospitalized and 91% had ER visits. The fifth trajectory, “Survival and Radiation Therapy” [SR] (11% of our sample), characterized patients who tended to get surgery (79.5%) and radiation therapy (100%). The sixth trajectory, “Survival and Chemotherapy, with Hospitalizations/ER Visits” [SCH] (4% of our sample), showed a high proportion of patients who had both surgery (47.1%) and chemotherapy (88.2%); everyone of these patients (100%) had hospitalizations and ER visits. The six trajectories were highly effective when predicting class membership, with coefficients ranging from 0.86 to 0.97. Fig. 2 depicts, for each trajectory, the relative importance of the utilization of the thirteen healthcare services that were included in the analyses in the left part of the graphs and of the three healthcare services that were excluded from the analyses in the right part of the graphs.

3.4. Outpatient contacts with healthcare professionals

A visual inspection of Fig. 2 reveals that trajectories with high proportions of hospitalizations and ER visits (SH, SCH, and SRCH) also had high proportions of contacts with non-oncological specialists. For example, 47% of those in the SH trajectory had contacts with surgical specialists (in comparison to 1.7% of those in the 5 trajectory); 66% of those in the SRCH trajectory had contacts with medical specialists (in comparison to 38% in the SRC trajectory). In these three trajectories, a greater number of oncological treatments (SRC > SCH > SH) was not systematically associated with greater outpatient contacts with healthcare professionals (for example, see SCH versus SRCH). In contrast, trajectories with a low proportion of hospitalizations and ER visits, a greater number of oncological treatments (SRC > SCH > SH) was not systematically associated with greater outpatient contacts with healthcare professionals. In particular, the addition of chemotherapy to the regimen of surgery and radiation therapy was associated with increased contacts with oncology nurse navigators (from 43.2% to 74.5%) and oncology allied health (from 31.8% to 57.4%), but was also associated with increased contacts with non-oncological nursing and allied health (from 6.8% to 74.5%).

With the exception of SRC, high proportion of contacts with oncology nurse navigators or medical specialists were not related to low proportions of hospitalizations and ER visits (see SH, SCH, SRCH), and low proportions of contacts with oncology nurse navigators or medical specialists were not related to high proportions of hospitalizations and ER visits (see S and SR).
3.5. Care trajectory differences in patient and cancer characteristics

Descriptions of the six care trajectories in terms of patient and cancer characteristics are presented in Supplementary Figure 1. Pre-planned comparisons (based on key trajectory features) were investigated to examine whether trajectories differed on patient and cancer characteristics (Table 3). (All trajectory comparisons and significance of results are available from the corresponding author upon request.)

Two of the trajectories were characterized by having surgery as the sole oncological treatment but differentiated by whether or not patients were hospitalized and had ER visits (S and SH). Those in the S trajectory were significantly younger and had less advanced stage (more Stage I) and lower grade (more well-differentiated and less poorly differentiated) than those in the SH trajectory.

Three trajectories were characterized by having received the three types of oncological treatments, but discriminated by whether or not patients were hospitalized and had ER visits (SRC and SRCH). No significant differences were observed between these two trajectories on age, tumor histology, stage, and grade.

Three trajectories consisted of different sets of oncological treatments but all had a low usage of hospitalizations and ER visits (S, SR, and SRC). Those in the S trajectory were younger and had less advanced stage (mostly stage I) and grade (mostly well-differentiated) than those in the SR and SRC trajectories. Those in the SR trajectory had less advanced stage (less Stage III) and grade (more moderately and less poorly differentiated) than those in the SRC trajectory.

Three trajectories consisted of different sets of oncological treatments but all had a high usage of hospitalizations and ER visits (SH, SCH, and SRCH). Those in the SH and SCH trajectories were significantly older than those in the SRCH trajectory. Those in the SH trajectory had less advanced stage whereas those in the SCH trajectory had more advanced stage than those in the SRCH trajectory.

4. Discussion

The aim of this study was to investigate the ability to identify clinically relevant care trajectories using data on healthcare services used by patients with endometrial cancer. Computerized longitudinal calendar grids were developed to display a detailed history of patients’ utilization of healthcare services (Fig. 1). This platform enables physicians to grasp the complexity of service utilization at a glance, take critical decisions accordingly, and assess case management efficacy.

Six care trajectories were identified using latent class analysis. Two of the trajectories were characterized by having surgery as the sole oncological treatment but differentiated by whether or not patients were hospitalized and had ER visits (S and SH). Two other trajectories were characterized by having received the three types of oncological treatments, again discriminated by whether or not patients were hospitalized and had ER visits (SRC and SRCH). A fifth trajectory included patients who had surgery and received radiation therapy (SR). A sixth trajectory characterized patients who had surgery, received chemotherapy, and had hospitalizations and ER visits (SCH).

Our results suggest that care trajectories in endometrial cancer revolve around two axes: specific sets of oncological treatments and whether the sets of treatments were associated with hospitalizations and ER visits. The three trajectories that were not associated with hospitalizations and ER visits seem to mirror clinical pathways corresponding to straightforward endometrial cancer treatment. Trajectories associated with clinical pathways were also reported in breast cancer [4]. However, the three trajectories that were associated with hospitalizations and ER visits seem to deviate from these pathways and they can thus be considered to be “not classical”. These trajectories also had higher proportions of patients having contacts with non-oncological specialists, such as surgical or medical specialists, suggesting that the individuals in these trajectories may either have comorbidities, treatment complications, or be medically more complex.

In our study, low outpatient contacts with healthcare professionals such as oncology nurse navigators or medical specialists was not associated with high hospitalizations/ER visits. This suggests that low outpatient contacts with healthcare professionals was not the cause of increased hospitalizations/ER visits. In addition, high contacts with oncology nurse navigators or medical specialists were not related to low hospitalizations and ER visits. This could reflect the nature of the patient, their medical complexity, or perhaps that these health professionals do not have the right tools to prevent patients from being hospitalized or using the ER. Alternately, this may suggest that they refer to the ER and hospitalizations when they deem it indicated [17].

In our study, we observed significant differences between most trajectory comparisons on age, stage, and grade, but, unexpectedly, trajectories did not differ on tumor histology. In addition, age, tumor histology, stage, and grade could not explain, among those receiving the three types of oncological treatments, why some have hospitalizations and ER visits (SRC) while others do not (SRCH). Possible explanations are that those with hospitalizations and ER visits have more chronic illnesses or lower social support, but this could not be investigated with the administrative and clinical data at hand. Despite differences in age, stage and grade, a visual inspection of Supplementary Figure 1 reveals that these variables are distributed in almost every trajectory, suggesting that other factors are involved in the making of care trajectories. Therefore, other characteristics must be considered to increase our understanding of care trajectories. Parameters that can be prevented or that are amenable to change (such as chronic illnesses or social support) are of special interest, in order to increase patients’ health and decrease the proportion of patients in trajectories with high service utilization.

Care trajectories could be a useful, evidence-based tool for clinicians and administrators. For clinicians, the identification of patient and disease characteristics associated with specific trajectories enables clinicians to identify and perhaps predict complex cases that may require special attention or a greater use of healthcare services. The clinician could thus take pre-emptive measures to decrease hospitalizations, tailor the management of the disease to the patient, and optimize treatment algorithms and time management, thereby enhancing quality of care. For administrators, identifying trajectories allows for more accurate budget planning and allocation of resources based on service utilization rates. For example, a change in best practice guidelines towards a combination of surgery, radiation therapy, and chemotherapy would increase the proportion of patients in SRC and SRCH trajectories. Given these trajectories are associated with contacts with oncology nurse navigators, administrators could hire additional staff ahead of time. Identifying trajectories with particularly high resource use could also help isolate problem areas and manage accordingly. Indeed, trajectories with high hospitalization and ER visits are likely costly and may, in some instances, be markers of lower quality of care.

A limitation of the study is its retrospective design, with limited information to investigate sociodemographic, psychosocial, and social differences among trajectories. Among the strengths of this study, care trajectories were entirely delineated using statistical procedures and were derived from objective rather than self-reported data.
We conclude that the utilization of healthcare services can be grouped into a limited number of care trajectories. Knowledge of care trajectories and their components may be used to adjust treatment goals, enhance healthcare management, and improve efficiency and cost-effectiveness, resulting in higher value of care. Further studies in this area should actively be pursued to develop the full potential of care trajectories as an assessment tool and planning aid for effective patient care.

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**Appendix A. Supplementary data**

Supplementary data associated with this article can be found, in the online version, at [http://dx.doi.org/10.1016/j.jcpo.2016.12.001](http://dx.doi.org/10.1016/j.jcpo.2016.12.001).

**References**


