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Understanding Breast Cancer Patient Pathways and their impact on Survival in Mexico

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Abstract

Background: Understanding patient pathways from discovery of breast symptoms to treatment start can aid in identifying ways to improve access to timely cancer care. This study aimed to describe the patient pathways experienced by uninsured women from detection to treatment initiation for breast cancer in Mexico City and estimate the potential impact of earlier treatment on patient survival.

Methods: We used process mining, a data analytics technique, to create maps of the patient pathways. We then compared the waiting times and pathways between patients who initially consulted a private service versus those who sought care at a public health service. Finally, we conducted scenario modelling to estimate the impact of early diagnosis and treatment on patient survival.

Results: Our study revealed a common pathway followed by breast cancer patients treated at the two largest public cancer centres in Mexico City. However, patients who initially sought care in private clinics experienced shorter mean wait times for their first medical consultation (66 vs 88 days), and diagnostic confirmation of cancer (57 vs 71 days) compared to those who initially utilized public clinics. Our scenario modelling indicated that improving early diagnosis to achieve at least 60% of patients starting treatment at early stages could increase mean patient survival by up to two years.

Conclusion: Our study highlights the potential of process mining to inform healthcare policy for improvement of breast cancer care in Mexico. Also, our findings indicate that reducing diagnostic and treatment intervals for breast cancer patients could result in substantially better patient outcomes.

Policy summary: This study revealed significant differences in time intervals along the pathways of women with breast cancer according to the type of health service first consulted by the patients: whether public primary care clinics or private doctors. Policies directed to reduce these inequities in access to timely cancer care are desperately needed to reduce socioeconomic disparities in breast cancer survival.

Keywords: Breast cancer, Patient pathways, Process mining

1. Introduction

Breast cancer is the most common cancer affecting women worldwide and is the most common cause of cancer death among women in Mexico [1].While mortality rates have decreased in the last thirty years in most high-income countries due to the capacity of health systems to detect and treat more than 60% of breast cancer patients early (stage I and II)[1],[2]these improvements have not been observed in most low- and middle-income countries (LMICs) [3]. Overall five-year survival for breast cancer patients in Mexico is 72%[4], in comparison with high-income countries with survival rates above 90%[5].

The lower breast cancer survival rates in Mexico are likely due to the fact that more than 60% of patients are first diagnosed and start treatment with advanced disease (stages IIB to IV)[4]. Treatment of breast cancer at advanced stages is a consequence of very low screening rates and delayed diagnoses and referrals[6]. In previous studies, which collected data on the dates of symptom discovery, medical consultations, diagnosis and treatment of breast cancer patients treated at the main public cancer centres in Mexico City, we found a median interval of 7 months between detection and treatment start, with the longest delays occurring within the first medical consultation and diagnostic confirmation (4 months)[6],[7].

Process mining, a data analytics technique, uses timestamps of different events as inputs to develop an overall process pathway. For example, we can use process mining to characterise breast cancer patients' journey as a process, starting from when they first detect the symptoms to when they start treatment. Everything that happens to them in this journey (e.g., symptom discovery, medical consultations, diagnostic imaging tests, biopsy, referrals, and treatment start) is an event that makes up this process. Process mining allows to build these patient journeys (processes) by retrieving dates of key events and then organizing them in a visual map.

The patient pathways, defined as "the actual, unplanned journey of a patient seeking health care services to address his/her health conditions" [8],[9] for breast cancer patients have not been described in Mexico. Therefore, we used process mining to 1) understand the patient pathways from detection to treatment initiation for uninsured women, and 2) compare the length of the time intervals between patients who initially consulted a private health service and those who first used a public health centre, and scenario modelling to 3) estimate the impact on patient survival of early diagnosis and treatment for breast cancer patients.

2. Patients and Methods

2.1. Design

We had previously conducted a cross-sectional study including cancer patients who were first diagnosed between June 2016 and May 2017 and received care in two of the largest public cancer hospitals available for the uninsured in Mexico City: the Mexican National Cancer Institute (INCAN) and the General Hospital of Mexico "Eduardo Liceaga" (HGMEL)[10]. These hospitals are federally funded and can offer care for patients from any state of the country. Approximately two thirds of their patients reside in Mexico City and its Metropolitan Area (in the State of Mexico), and the rest come from other states. The present study uses process mining and scenario modelling methods to analyse the data collected for breast cancer patients.

2.2. Setting

The Mexican health system is organized around a fragmented model, where different modalities of financing, service delivery and affiliation coexist, each of them targeting different population groups according to income and type of employment[11]. Public services are divided in two large sectors: (1) social security institutions that insure employees in the formal sector of the economy and their families -approximately 45% of the population, and (2) healthcare services provided by the federal and 32 state Ministries of Health, which are mainly used by the population that is not insured by social security schemes (54%)[12]. Only 1% of the population has private health insurance, but private services are commonly used by both the uninsured and those insured by Social Security institutions, paying out-of-pocket, to accelerate diagnostic workup and medical care[12].

Both of the study's participating hospitals are public hospitals under regulation of the Federal Ministry of Health and, at the time of the study, they both provided breast cancer treatment financed through *Seguro Popular*. This was a voluntary health insurance program available for people not covered by social security institutions, through which the government financed, among other things, treatment for selected high-cost diseases[12].

2.3. Participants and data collection

Our data collection methods have been described in detail in previous publications[7],[10]. Briefly, overall, 910 patients who first sought care for suspected breast cancer at the participating hospitals during the study period were identified. We excluded those who: (a) had a personal history of cancer (56/910, 6.2%); (b) began systemic cancer treatment before arrival to the cancer institution (46/910, 5.0%); (c) could not participate in the interview for various reasons, i.e. intellectual disability, hearing impairment, did not speak Spanish (13/910, 1.4%); (d) died shortly after their arrival to the cancer institutions before an interview was conducted (40/910, 4.4%); and e) could not be located and therefore invited to participate in the study (23/910, 2.5%).732 (80.4%) patients who fulfilled the criteria were invited to the study, and of those, 44/732 (6.0%) were not willing to participate. 688 (93.9%) of 732 patients were interviewed and their medical records reviewed. Eleven (1.59%) of 688 participants were removed from the analysis because they could not recall the dates for estimation of the intervals. In addition, we removed from our analyses participants who first consulted public services covered by social security schemes (31), consultation rooms in pharmacies (56) and services provided by non-governmental organizations (24). Thus, the final analysis includes 566 patients that first consulted a public health centre for care of those who lacked social security or a private service.

The patients were interviewed face-to-face, in waiting rooms at the participating hospitals after giving written informed consent. A validated questionnaire was used to retrieve the dates of symptom discovery, use of each of the different health services and of diagnostic tests [13]. To minimize the probability of recall bias, study participants were asked to remember dates using the aid of a calendar. Descriptive variables were also collected, including age, state of residence, education level, family monthly income and cancer stage at diagnostic confirmation. Monthly income was categorized using the poverty definitions that *CONEVAL* (the National Council for Evaluation of Social Development Policy) establishes based on access to food, education, health services, and housing. Data on each patient's final diagnosis, cancer stage, and dates of diagnostic confirmation and treatment initiation were extracted from the patients' medical records. Cancer stage at treatment start was defined according to the American Joint Cancer Committee (AJCC) and then categorized into: *a) localized* (stage I to IIA), *b) locally advanced* (stage IIB-to IIIC); and *c) metastatic* (IV).

To assess the patients' pathways to treatment, we assessed for each of the first three health services used by the participants: type of health service, location, and dates of first consultation and last consultation. The two types of services we included in our analysis were: a) "public services", which are the health facilities dependant of state ministries of health which are available mainly for use of the population who lacks social security health insurance; and b) "private doctors" which refer private doctor's offices unrelated to pharmacies. In addition to this, there were 56 patients who first consulted in doctor's offices adjacent to pharmacies, for whom the pathway is presented in supplementary figure 1. In addition, we assessed the dates and types of service where diagnostic mammography, breast ultrasound and biopsy were done, the date of the histopathologic report confirming a cancer diagnosis, and the date of first consultation at the cancer hospital.

2.4. Data Analysis

We used process mining techniques to generate the patient pathway, which is a graphic representation of the patient journey from detection to treatment start for breast cancer, including each health care utilization event along the journey and the time intervals between events[14]. Process mining uses timestamps of different events as inputs to develop an overall process pathway. An event log, containing all events and their timestamps, was developed in the form of a csv file, which then became the main input for process mining [15]. For the automatic creation of the process maps (i.e. patient pathway), we used Disco software, using the fuzzy miner algorithm [16]. The process maps were then reviewed and adjusted with opinions from a clinical expert. This exercise helped to exclude irrelevant details and focus on the most important aspects of the pathway, as the initial process map generated by the software was too complex. Along with the patient pathway obtained with process mining, we estimated the time intervals between events and in alignment with the definitions recommended by the Aarhus Statement consensus[17].

Total interval: time from symptom discovery to treatment start (either surgical or systemic treatment).

Patient interval: time between symptom discovery and the first medical consultation.

Diagnostic interval: time from the first medical consultation to diagnosis. The endpoint was histopathologic confirmation of cancer.

Treatment interval: time between diagnostic confirmation and the start of cancer treatment.

We then did a stratified analysis of the process maps to compare the patient pathway and the time intervals between events in the patient pathway between those who first sought care at a public health service and those who did at private doctor's office. In addition, we compared the cancer stage distribution between these two groups of patients to examine whether the differences in time intervals between them translated into clinical outcomes.

Finally, scenario modelling was used to estimate the impact of the time intervals on survival. For modelling survival in the current scenario, we used the mean survival per stage estimated according to stage-specific survival rates for women treated under *Seguro Popular* between 2007 and 2016 in Mexico[4] (more details are presented in the Appendix). We then estimated mean survival rates for patients who first consulted a public service and those who first consulted a private service, according to their respective cancer stage distributions. We then modelled an ideal scenario of down staging (i.e. increasing the proportion of patients who were diagnosed and started treatment in early stages), where we assumed that 60% of patients start treatment in early stages, and 35% in locally advanced stages, in line with the observed clinical stage distributions in countries that show sustained breast cancer mortality reductions in the last decades [2].

3. Results

Figure 1 shows the process map of the breast cancer patient pathway from symptom discovery to arrival at the cancer center. This represents the most common pattern of health service utilization and the average and median time intervals between utilization events experienced by breast cancer patients treated at the two largest public cancer centres available for the uninsured in Mexico City. As it can be seen, after first consultation either in a public primary care clinic or a private doctor, then come the diagnostic imaging studies (mammogram and breast ultrasound) and biopsy, which usually take place at different services and dates. The cancer diagnosis is confirmed at the cancer centres, either by pathology review of the sample materials of patients who previously had a biopsy or by review of a new biopsy taken at the oncologic centre.

The mean duration of the intervals were: 82 days for the patient interval, 68 days for the diagnostic interval and 37 days for the treatment interval **(Figure 1)**. In average, patients remained for 43 days using services at primary or secondary care levels, and it took them 27 days in average to get the first consultation at the cancer centre after they received their last consultation in the previous service. After arrival at the cancer centre, the patients' cancer diagnosis was confirmed in average in 16 days, and treatment began 37 days after diagnostic confirmation **(Figure 1)**.

Figure 2 shows the comparison of the patient pathways between those who first consulted a public service (in white figures) and those who first consulted a private doctor (in black figures). Patients who first used a private service unrelated to a pharmacy had comparatively shorter durations for the patient, diagnostic and treatment intervals. A mean difference of 22.4 days was observed for the patient interval between public and private services, whereas the diagnostic interval shows a mean difference of 14.3 days, and the treatment interval a mean difference of 7.3 days. Within the diagnostic interval, the times between first consultation and each of the imaging tests were shorter for patients who first consulted a private service in comparison to those who first used public services **(Figure 2).** Although the confidence intervals overlap, there seems to be a tendency of shorter time intervals to care for patients who first use private health services in comparison to those who use public health services: shorter times to first consult a doctor, between the first consultation and a mammogram, and between the mammogram and the ultrasound. **Supplementary figure 1** shows the pathway and time intervals for patients who first consulted a doctor's office adjacent to a private pharmacy. Even though, these were only 56 patients, it's noteworthy that the time that the patient interval was much longer among these patients than in the two previous groups, while the time between consultation and diagnostic tests had an intermediate length (between those who first used private and public clinics)

Table 1 summarizes the sociodemographic and clinical characteristics of the participants. Patients seen at these cancer hospitals available for the uninsured are generally characterized by a low school education and low socioeconomic status. Nevertheless, patients who first used private services unrelated to pharmacies seem to have a higher socioeconomic status in terms of maximum education level reached (28% with 6 years or less versus 44% for those who first used public) and monthly income (39% in extreme poverty vs 64% of those who first used public services). Also, patients who first sought care at private services, had a higher proportion of early-stage cancers (46%) in comparison with those who first used public services (36%) **(Table 1)**.

There seems to be a tendency of patients reporting longer time intervals having been diagnosed in more advanced stages **(Table 2)**. Also, for each cancer stage, patients who first sought care at public services faced longer times to receive diagnostic confirmation compared with those who first consulted a private service (except for *in situ* carcinomas, which comprised very few cases) **(Table 2)**.

Table 3 illustrates the scenario modelling results. Early-stage cancer patients have an expected mean survival of 14.33 years, while locally advanced and metastatic patients have expected mean survivals of 7.47 and 3.65 years respectively. For patients who first consulted a public health centre, the cancer stage distribution was 38.9% early stage, 46.4% locally advanced, and 14.6% metastatic, resulting in an expected mean survival of 9.6 years. For patients who first consulted a private health centre, the cancer stage distribution was early-stage (48.2%), locally advanced (41.5%) and metastatic (10.3%) patients, resulting in an expected mean survival of 10.6 years. In the ideal scenario, if there were 60% early-stage, 35% locally advanced and 5% metastatic patients, the expected mean patient survival would be 11.7 years.

4. Discussion

This study allowed mapping of the most common pathway for uninsured breast cancer patients from symptom detection to the start of treatment in Mexico City. The pathway is characterised by multiple healthcare events that take place at different dates and facilities, and therefore contribute to the lengthening of time before arrival to the public cancer centres. We found that patients who first sought care in private offices unrelated with pharmacies presented shorter mean times to get the first medical consultation and complete diagnostic workup in comparison with those who first used consultation rooms adjacent to pharmacies, and public services. Our scenario modelling shows that down staging to achieve 60% of patients starting cancer treatment in early stages in Mexico, would translate into an average increase of 2 years in patient survival.

The Global Breast Cancer Initiative (GBCI) suggests breast cancer should be diagnosed within 60 days (two months) and treatment should be started within 90 days of initial presentation.[18] The European Society of Breast Cancer Specialists (EUSOMA) establishes as a quality indicator for non metastatic BC patients that the time from first imaging exam to first treatment should be ideally within 6 weeks and maximum 8 weeks.[19],[20] In comparison with these international standards, in our study all participants started treatment after the recommended 90 days (3 months).

To our knowledge, the present study is the first to use process mining to describe the patient pathways of breast cancer patients from detection of the problem to treatment start. Our study adds to the scant literature where process mining has been used to analyse cancer care at other phases of the cancer care continuum: post-surgical care procedures in Portugal[21], clinical pathways of patients with solid tumours admitted to intensive care units in the USA[22], and clinical pathways of metastatic breast cancer patients under treatment with different chemotherapy schemes in the UK[23]. These studies provide examples of how process mining can help represent complex processes that occur in patient pathways with clear visualisations of how patients move through the health system. This can help to gain insights on the clinical and administrative processes that can be improved in the benefit of patient care and outcomes.

In addition to the visualization of the breast cancer patient pathways, our study shows that first consulting a private doctor unrelated to a pharmacy resulted in reduced times to get first seen by a doctor, and to complete diagnostic workup (mammogram, ultrasound and biopsy) for referral to the cancer centre. These differences in waiting times translated into differences in cancer stage at treatment start, where patients who first sought care in these private services were more likely to receive care in early stages than those who first sought care in public clinics. In our sample all patients were either affiliated to *Seguro Popular* or uninsured. Thus, they were entitled to receive cancer care at Ministry of Health facilities. Despite this, they paid out-of-pocket to first use private services. Even though *Seguro Popular* improved access to breast cancer treatment through financing of medical costs once cancer was confirmed[24], timely access to primary care services, diagnostic tests and referral to the cancer centres remained a problem[10]. The use of both, doctors' offices adjacent to pharmacies and private doctors, have been increasing in Mexico, as they are generally perceived as more convenient and with shorter waiting times than both social security and Ministry of Health services[25],[26].

Participants who first used a private service had a higher socioeconomic status (education and income) than those who first consulted a public health centre, and thus, could probably pay out-of pocket to accelerate their care more easily. In addition, there is evidence that higher education is associated with better health literacy, which in turn has shown to favourably impact prompt seeking of medical care, and better engagement with medical staff[27][28]. All this could lead to faster patient decisions to seek appointments for consultations and tests, and thus shorter waiting times for them.

Our scenario modelling, based on our participants' cancer stage distributions suggested that delays to diagnosis and treatment among patients who used private health services first would result in an average 1-year gain of life expectancy compared to those who used the public health center first. This gain of life expectancy increased to two years when compared to a hypothetical scenario where 60% cases are treated in early stages. Improving the distribution of breast cancer cases requires shortening the time between breast cancer detection and treatment initiation[3]. This could be achieved by speeding access to diagnostics and creating fast-track referral systems to ensure rapid specialised treatment[29],[30],[31],[32]. If we could improve timeliness and shift BC stage distribution to achieve at least 60% of BC cases starting treatment in early stages (I and II), we could expect to observe reductions in the BC mortality rate as has been observed in most high-income countries in the last decades.[1],[2]

While process mining can be a valuable tool in analysing patient pathways, there are certain limitations to consider. First, our analysis relied on data collected through patient interviews and dates available in their medical files. For example, data was not collected for the entire healthcare trajectory previous to arrival at the cancer centre, but only for up to the first three different health services used. In this study, data was abstracted to manage complex processes, but this can result in a loss of detail and make it harder to identify specific factors that could affect the patient pathway. However, data abstraction can be helpful in simplifying complex processes, identifying patterns, and pinpointing areas for improvement. Finally, our findings cannot be generalized to the wider population of breast cancer patients in Mexico, as we included patients treated only at two federal hospitals located in Mexico City, which primarily serve the uninsured segment of the population.

5. Conclusions

The patient pathway of breast cancer patients treated at the main public cancer centres available for the uninsured in Mexico City is very complex with multiple consultations at different healthcare facilities, diverse administrative procedures and long waiting times between the different health services. This is a common challenge of fragmented healthcare systems and those without universal health coverage, like the Mexican Health System. Our study also indicates that those who first use private services get treatment more quickly in public cancer centres, than those who utilise the public primary care services which they are entitled to use. This is a reflection of the inequitable access in the public sector for use of primary care services, imaging and diagnostic services needed for cancer care, where women from poor socioeconomic backgrounds are exposed to longer waiting times and worse outcomes than women who can afford private services to accelerate their care. Health policies directed to improve cancer outcomes need to consider not only treatment financing, but also interventions directed to reduce wait times in the cancer pre-treatment pathways.

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Conflict of Interest Statement

No potential conflicts of interest were reported by the authors.

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Figure 1: Overall breast cancer patient pathway.
This figure presents an overall process chart illustrating the sequential steps and corresponding time durations involved in the patient pathways from the discovery of breast symptoms to treatment.

Figure 2: Patient pathway comparing time intervals between patients who first consulted public and private services.
This figure presents a comparison of the time durations for patients who initially sought healthcare from public and private services, respectively. It depicts the sequential stages and transitions involved in their respective healthcare journeys, highlighting the differences in time taken at each step.

Figure 1: Overall breast cancer patient pathway.

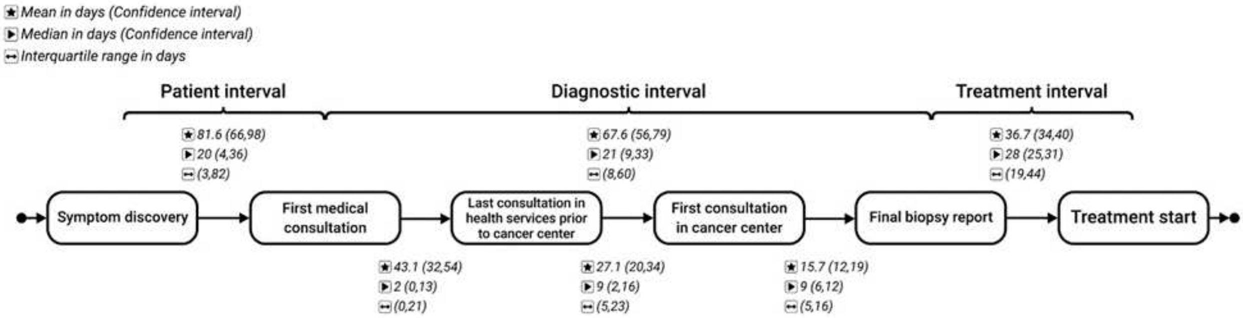
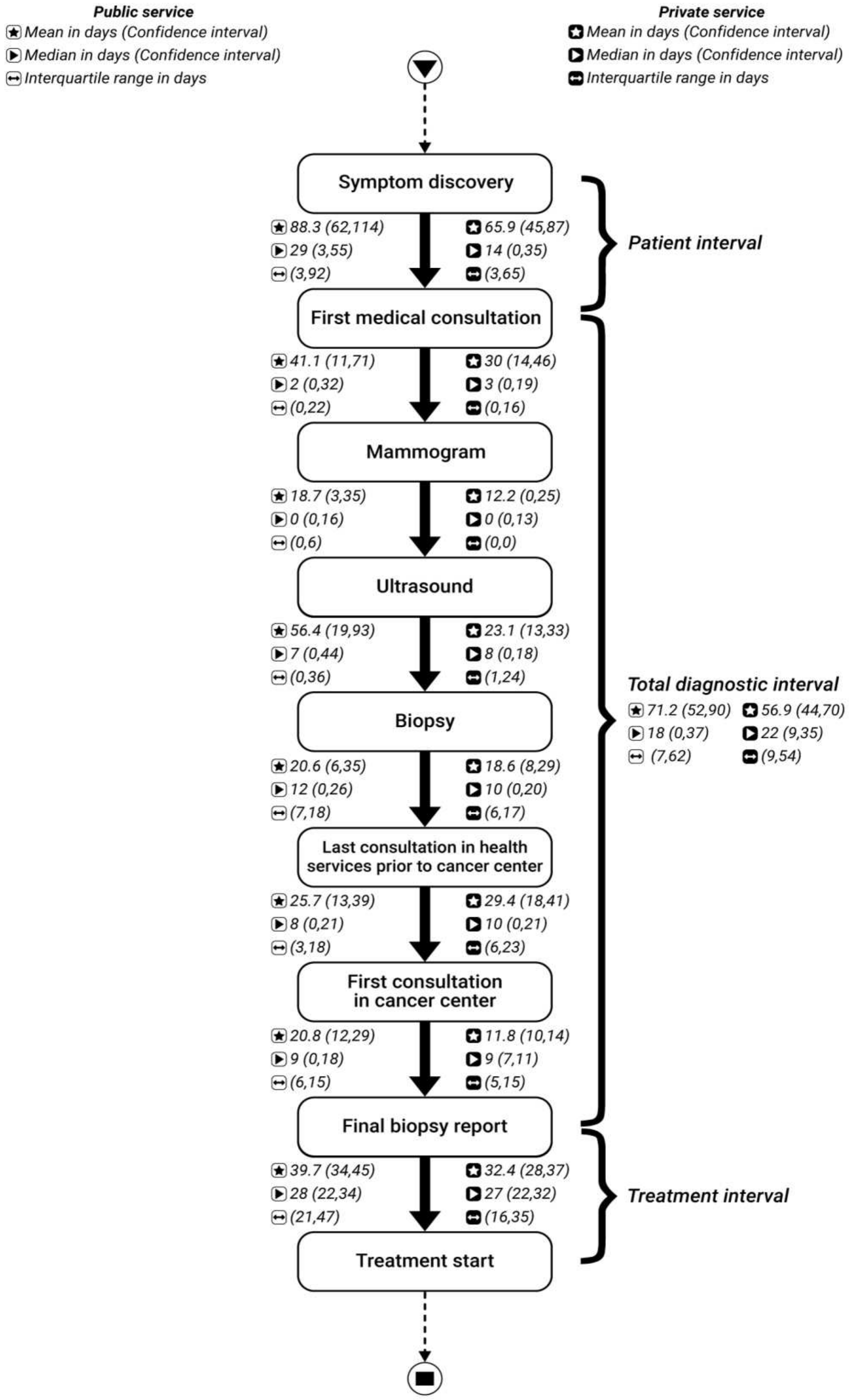


Figure 2: Patient pathway comparing time intervals between patients who first consulted public and private services.



List of Tables

Table 1: Characteristics of participants who first used private and public services.

Variable	**Public service (n=256)** Num. (%)	**Private service (n=321)** Num. (%)
Age		
Mean(range)	*52 (23-91)*	*51 (24-85)*
State of residence		
State of Mexico	58 (22.6)	116(36.1)
Mexico City	83 (32.4)	92 (28.7)
Other states	115(45.0)	113(35.2)
Education		
None	16 (6.3)	8(2.5)
6 years or less	97(37.9)	82(25.5)
7 to 9 years	68 (26.6)	66(20.6)
10 to 12 years	54 (21.1)	93(29.0)
More than 12 years	21(8.0)	72(22.4)
Monthly personal income (USD*)		
Extreme poverty (<$76)	164 (64.0)	126 (39.3)
Poverty ($76 to $153)	64 (25.0)	106 (33.0)
Welfare (>$153)	28 (11.0)	89 (27.7)
Not reported	0 (0.0)	0 (0.0)
Cancer stage		
In situ	9 (3.5)	4 (1.2)
Early stage	93 (36.3)	148 (46.1)
Locally advanced	111(43.4)	128 (39.9)
Metastatic	35(13.7)	31(9.7)
No class	8 (3.1)	10 (3.1)

* The incomes in this study have been converted to USD using the exchange rate of $1 = $18.50 Mexican pesos.

Table 2: Total interval in days by cancer stage and type of first service used.

Cancer stage	**Public service**			**Private service**		
	Number (%)	**Mean (CI*)**	**Median (Q1, Q3*)**	**Number (%)**	**Mean (CI*)**	**Median (Q1, Q3*)**
In situ	9 (3.5)	387(43,731)	220(181,361)	4 (1.2)	474(0,914)	309(248,535)
Early stage	93 (36.3)	221(177,267)	147(94,272)	148 (46.1)	194(163,224)	124(67,260)
Locally advanced	111(43.4)	303(256,350)	249(135,399)	128 (39.9)	253(213,293)	176(93,336)
Metastatic	35(13.7)	352(240,464)	236(121,382)	31(9.7)	235(147,322)	155(86,259)

*CI refers to the confidence interval at 95%
*Q1 refers to 25% percentile of the distributions
*Q3 refers to 75% percentile of the distributions

Table 3: Mean life years gained by improving proportion of patients diagnosed in early stage.

Stage	**Mean Survival by stage in years**	**Current cancer stage distribution among patients who first used public clinic**	**Current cancer stage distribution among patients who first used private clinic**	**Ideal scenario***
Early Stage	14.33	0.389	0.482	0.60
Locally Advanced	7.47	0.464	0.415	0.35
Metastatic	3.65	0.146	0.103	0.05
Mean life years gained (in years)		9.6	10.6	11.7

*In situ stage cases were excluded from this analysis. The ideal scenario assumes a cancer stage distribution of at least 60% cases in early stages (more details presented in the Appendix).

Appendix 1: Scenario modelling

Estimating survival

We used the 5-year survival data on 52,935 women treated for breast cancer under *Seguro Popular* between 2007 and 2016 in Mexico[4]. This 5-year survival data was used to estimate the yearly mortality rate for the different stages (i.e. early stage, locally advanced or metastatic). These annual mortality rates were then compared to the general population mortality rates at age 52 (mean age of the BC cohort in the dataset), to estimate the hazard ratios for the different BC stages compared to the general population. These HRs were then applied to the age-dependent mortality rates for the whole lifetime to estimate the life expectancy for different health states, as 14.33 years for early stage, 7.47 years for locally advanced and 3.65 years for metastatic stage, respectively.

Mean survival for patients who first consulted a public health centre

The mean overall life years gained for the patients who first consulted a public health centre was estimated as 9.6 years by multiplying the proportions of patients in different stages of breast cancer (38.9% in early stage, 46.4% in locally advanced and 14.6% in metastatic) with the mean survival in their respective stages (14.33 years for early stage, 7.47 years for locally advanced and 3.65 years for metastatic stage as shown in Table above).

Mean survival for patients who first consulted a private health centre

The mean overall life years gained for the patients who first consulted a private health centre was estimated as 10.6 years. This was estimated by multiplying the proportions of patients in different stages of breast cancer (48.2% early stage, 41.5% locally advanced and 10.3% in metastatic) with their respective mean survival (14.33 years for early stage, 7.47 years for locally advanced and 3.65 years for metastatic stage).

Mean survival for patients in an ideal scenario

In the new scenario, it was assumed that faster diagnosis and treatment will result in a low proportion of metastatic patients and higher proportions of patients in early and locally advanced stages, respectively. These proportions of patients in different stages of breast cancer were assumed as 60% early stage, 35% locally advanced and 5% in metastatic.
The overall life years gained in this scenario was estimated as 11.7 years by multiplying the proportions of patients in different stages with their respective mean survival.

Supplementary Figure 1: Process chart for patients who first consulted at consultation rooms adjacent to pharmacies (56 patients).