Global variation in patterns of care and time to initial treatment for breast, cervical, and ovarian cancer from 2015 to 2018 (VENUSCANCER): a secondary analysis of individual records for 275 792 women from 103 population-based cancer registries in 39 countries and territories

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Summary

Background Cancers of the breast, cervix, and ovary are a major public health problem worldwide. Evaluating the consistency with clinical guidelines for treatment by use of individual high-resolution data from population-based cancer registries is a powerful tool to help interpretation of global inequalities in cancer survival. The VENUSCANCER project aims to assess the worldwide variation in patterns of care and time to initial treatment for women diagnosed with one of these three common cancers.

Methods In this secondary analysis of anonymised individual records from population-based cancer registries (VENUSCANCER), 103 registries from 39 countries worldwide contributed high-resolution data for women diagnosed with cancer of the breast, cervix, or ovary for a single year of incidence during 2015–18. High-resolution data included cancer stage at diagnosis; staging procedures; tumour grade; biomarkers (ER, PR, and HER2); and the first course of each treatment modality (surgery, radiotherapy, chemotherapy, endocrine treatment, or anti-HER2 therapy) and related dates. We examined prognostic factors, key indicators of consistency with international clinical guidelines for treatment (ESMO, ASCO, and NCCN), and median time between diagnosis and treatment, by country or territory. We analysed the odds of women receiving treatment consistent with guidelines in high-income countries (HICs) and low-income and middle-income countries (LMICs), controlling for age and tumour subtype.

Findings We received 275 792 anonymised individual records for women diagnosed with a cancer of the breast (214 111 [77·6%]), cervix (44 468 [16·1%], including in situ), or ovary (17 213 [6·2%]). In HICs, early-stage, node-negative cancers comprised over 40% of breast and cervical cancers, but less than 20% of ovarian cancers. By contrast, in LMICs, these proportions were generally below 20% for all three cancers, but higher in Cuba (30% for breast), and Russia (36% for cervix and 27% for ovary). Consistency with main international guidelines was highly variable, particularly for surgery and radiotherapy in early-stage breast cancer (from 13% in Georgia to 82% in France), chemotherapy in advanced cervical cancer (from 18% in Mongolia to 90% in Canada), and surgery plus chemotherapy in metastatic ovarian cancer (from 9% in Cuba to 53% in the USA). Some type of surgery was offered to 78% of women in HICs and 56% of women in LMICs, but initial treatment that is consistent with clinical guidelines for early-stage tumours was followed more uniformly for cervical and ovarian cancer than for breast cancer. Older women (aged 70–99 years) had lower odds of receiving initial treatment consistent with clinical guidelines than women aged 50–69 years in both HICs and LMICs. The median time between diagnosis and treatment for early-stage cancers was less than 1 month in several HICs, but up to 4 months for cervical cancer in Mongolia and ovarian cancer in Ecuador, and up to 1 year for breast cancer in Mongolia.

Interpretation The VENUSCANCER project provides the first global picture of patterns of care for three of the most common cancers in women. These findings offer crucial real-world evidence to support the implementation and monitoring of global initiatives on cancer control such as WHO's Global Breast Cancer Initiative and Cervical Cancer Elimination Initiative. Although guideline-consistent treatment has become more accessible for women diagnosed with early-stage tumours in LMICs, the proportion of these women diagnosed early remains far too low.

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Research in context

Evidence before this study

Cancers of the breast, cervix, and ovary are a major public health problem worldwide. Global differences in survival from these cancers, shown by the CONCORD programme, are striking, and inequalities in survival also exist between and within high-income countries (HICs). We searched PubMed for articles published in English between Jan 1, 1990, and May 1, 2018, using the following search terms: ("breast neoplasms" OR "ovarian neoplasms" OR "uterine cervical neoplasms") OR ("breast cancer" OR "ovarian cancer" OR "cervical cancer") AND ("global high-resolution" OR "international high-resolution" OR "EUROCARE high-resolution" OR "CONCORD high-resolution" OR "patterns of care" OR "standard care"). To our knowledge, the largest comparison of indicators of consistency with clinical guidelines to date, derived from population-based high-resolution data, was between representative samples of around 20 000 women diagnosed with breast cancer during 1996–98 in 12 countries across Europe and seven US states. Several high-resolution studies of breast cancer have been conducted between or within European countries. Population-based studies on cervical cancer have mainly described trends in incidence or mortality, or the effect of a screening programme on the cure proportion. The largest study on ovarian cancer is a trial focused on the effect of screening on mortality from ovarian cancer, whereas the largest population-based study focused on risk factors. Other studies include only a meta-analysis of indicators for ovarian cancer, produced by various centres in four HICs, as well as a study of adherence to guidelines for the treatment of breast cancer in sub-Saharan Africa based on samples from hospital-based registries only.

Added value of this study

In this worldwide secondary analysis of data from 103 population-based cancer registries, we have examined indicators of treatment consistency with clinical guidelines derived from over 250 000 anonymised individual records of women diagnosed with breast, cervical, or ovarian cancer between 2015 and 2018 in 39 countries, including 15 low-income and middle-income countries (LMICs). We have created the largest population-based, high-resolution database for the three most common cancers in women, including detailed information on stage at diagnosis, staging procedures, treatment, and biomarkers. Ten times larger than any previous high-resolution study, the VENUSCANCER project—embedded in the CONCORD programme—offers the first real-world picture of global patterns of care and consistency with clinical treatment guidelines for breast, cervical, and ovarian cancer.

Implications of all the available evidence

Population-based indicators of consistency of initial treatment with the main international clinical guidelines (ESMO, ASCO, and NCCN) and time from diagnosis to initial treatment will both be useful tools to help interpret the persistent disparities in survival for women with breast, cervical, or ovarian cancers. Global variability in the deployment of international clinical guidelines for treatment indicates the need for simplified guidelines, tailored to local needs and resources, and made available in local languages. Availability of optimal treatment for early-stage breast, cervical, and ovarian cancers in most countries worldwide highlights the importance of early detection in LMICs, where the proportion of women with cancer who are diagnosed at an early stage is still far too low. An increased number of radiotherapy facilities and trained surgeons could also help ensure the availability of breast-conserving surgery plus radiotherapy in LMICs. In these countries, wide use of chemotherapy for all three cancers might indicate availability of old drugs, which are more affordable, but might not be the optimal choice for patients.

Data on stage at diagnosis and treatment should be routinely collected by all population-based cancer registries, even in HICs. To guarantee timeliness and completeness of these data, any cancer control plan should include the provision of stable financial support from governments to population-based cancer registries as a permanent goal. As shown by this project, even limited financial support to cancer registries can improve the quality and completeness of data in most LMICs. Financial support would also be beneficial in several HICs. WHO's Global Breast Cancer Initiative and Cervical Cancer Elimination Initiative, as well as the Women, Power and Cancer Commission, should consider using the results from VENUSCANCER as baseline real-world evidence to support the implementation and monitoring of their goals and recommendations.

Introduction

Over the past decade, the public health challenge posed by the growing burden of women's cancers has attracted particular attention.[1–5] Cancers of the breast, cervix, and ovary, comprising 34% of all cancers in women in 2018,[6] are a major public health problem worldwide. More than 3·2 million diagnoses of breast, cervical, and ovarian cancers were predicted for 2022, with over 1·2 million deaths attributable to these cancers.[7] Many of these deaths are avoidable, even in low-income and middle-income countries (LMICs), where cancers in women represent a major economic burden both to families and national economies.[1] Reducing the number of deaths from breast, cervical, and ovarian cancer requires not only improvements in prevention but also more effective health systems to improve the survival of women who develop one of these cancers.[8] However, access to safe surgery varies widely between the richest and poorest countries worldwide,[9] and radiotherapy services are simply not available in more than 30 of the poorest countries.[10–12]

Worldwide differences in survival from these cancers are striking.[13,14] Inequalities in survival also exist between

and within high-income countries (HICs).[15] In 2015, the CONCORD programme established global surveillance of trends in cancer survival, from 1995 to 2009 (CONCORD-2).[13] This programme documented, for the first time, the wide global differences in survival trends for most major cancers in men and women. In 2018, CONCORD-3 updated these survival trends to 2014.[14] Differences in 5-year net survival still persisted for women's cancers between 2010 and 2014, varying from 66% in India to 91% in the USA for breast cancer, from 52% in Ecuador to 77% in South Korea for cervical cancer, and from 16% in India to 57% in Costa Rica for ovarian cancer.

The VENUSCANCER project, embedded in the CONCORD programme, was designed to develop a better understanding of the reasons that underlie the international inequalities in survival for women with breast, cervical, or ovarian cancer. The overall aim is to provide actionable evidence for health policy to reduce the burden, and to improve survival for three of the most common women's cancers worldwide. In this Article, the first from the VENUSCANCER project, we aimed to assess the worldwide variation in patterns of care and time to initial treatment for women with breast, cervical, and ovarian cancer. Separate analyses will be conducted, for each cancer, to assess whether inequalities in survival from women's cancers are attributable to differences in disease biology between populations, or to patterns of care. Trends in avoidable premature deaths, using 20 years of data from the CONCORD database, will also be presented separately.

Methods

Study design

All 322 cancer registries that contributed data on breast, ovarian or cervical cancers to the CONCORD programme were invited to contribute data to the VENUSCANCER project. Population-based cancer registries routinely collect data for every person in their territory who is diagnosed with cancer, on the patient's demographic characteristics (residence, age, and sex), tumour pathology (anatomic site, morphology, behaviour, and grade) and, at least in most HICs, the patient's last known vital status (alive, dead, or emigrated), with the corresponding date. Even in HICs, data on clinical investigations (stage at diagnosis and, where available, prognostic biomarkers), the type and date of treatment, recurrences, comorbidities, lifestyle, socioeconomic status, or educational level are still not routinely collected.

In addition to routinely collected data, therefore, the VENUSCANCER project invited cancer registries to collect so-called high-resolution data—ie, detailed data on stage, staging procedures, tumour grade, biomarkers, the first course of treatment, and related dates, comorbidities, and lifestyle—from the medical records of women diagnosed with breast, ovarian, or cervical cancer during the period 2015–18. Socioeconomic status (defined by the quintile of the patient's residential address in a national distribution of an area-based or census tract-based measure) and race or ethnicity were also collected, where possible. More precisely, cancer registries were invited to submit data for a single year of complete incidence during 2015–18, for which the availability and completeness of high-resolution variables were highest. The European Research Council (ERC) Consolidator grant enabled financial support to be offered to cancer registries in LMICs to cover the additional costs of collecting high-resolution data.

The VENUSCANCER data collection protocol was developed in collaboration with over 300 cancer registries worldwide. This process was a major undertaking that took over 1 year. Three comprehensive questionnaires on registration practice (appendix pp 3–28) were developed to help refine the protocol for data collection.[16] The protocol was discussed at working group meetings during three major international conferences: the International Association of Cancer Registries (IACR) in Peru (2018), the joint conference of the IACR and the North American Association of Central Cancer Registries (NAACCR) in Canada (2019), and the Second International Forum of Oncology and Radiology in Russia (2019). The ERC Consolidator grant also enabled support to be provided for visas, travel, accommodation, and conference fees for ten colleagues from registries in LMICs (Brazil, Colombia, Cuba, Nigeria, Russia, South Africa, and Thailand), who would not otherwise have been able to participate. The protocol was translated into Russian by colleagues in the working group. We held discussions in English, Italian, and Spanish. We maintain annual approval from the Ethics Committee of the London School of Hygiene & Tropical Medicine (#21890; last update Nov 12, 2024).

See Online for appendix

Data collection

The call to participate in the study was issued on Dec 21, 2019. The original deadline for data submission was June 30, 2020, but the COVID-19 pandemic forced several postponements. The pandemic affected various areas of the world at different times, so data collection has been ongoing for 5 years from Jan 1, 2020, to Jan 31, 2025. The last four datasets (England, UK; Ireland; Luxembourg; and Saskatchewan, Canada) were received between November, 2024, and January, 2025.

With colleagues at the Cancer Data Registry of Idaho (USA), we finalised a SAS program to map cancer registry data from the NAACCR format used in North America to the VENUSCANCER protocol. This facilitated data submissions from 13 registries in the USA and six registries in Canada.

Cancer registries were required to select primary tumours with the anatomic site (topography) coded to the International Classification of Diseases for Oncology (ICD-O-3[17] and its first revision[18]): breast (C50.0–C50.6; C50.8–C50.9), cervix uteri (C53.0–C53.1; C53.8–C53.9),

and ovary (C48.0–C48.2; C48.8; C56.9; C57.0–C57.4; C57.7–C57.9). Ovary also included peritoneum and retroperitoneum, where high-grade serous cancers originating from the fallopian tube are often detected, and other and unspecified female genital organs.

TNM[19] is the preferred classification for stage of disease, but it is not uniformly used in all countries. We offered various options to submit data on stage: TNM (pathological or clinical), condensed TNM[20] in European countries; Surveillance Epidemiology and End Results (SEER) Summary Stage 2000[21] in North America, several Asian countries (Israel, Japan, and Taiwan), and Australia; and, for cervical and ovarian cancer, International Federation of Gynecology and Obstetrics (FIGO).[22] To harmonise stage data coded to disparate classifications, we extended the algorithm developed for CONCORD high-resolution studies.[23] This algorithm summarises data on stage in up to six categories, prioritising TNM stage (pathological and clinical), then compensating for any missing information on TNM stage with the size of the tumour or the number of lymph nodes with tumour involvement, then with SEER Summary Stage 2000, condensed TNM, or FIGO stage, depending on the tumour. If pathological data on tumour size and lymph node status (pT and pN) were unavailable, clinical data (cT and cN) were used. When registries were only able to capture data on metastasis (M1) and, following advice from epidemiologists, pathologists, and clinicians, records for which the metastatic status was unknown (MX) were considered to be negative (M0) if T and N were known.

Several biomarkers were collected for each cancer. For breast cancer, ER and PR status and HER2 status were requested as core variables. Ki67 proliferation index, CA125, and *BRCA1* or *BRCA2* mutation (breast or ovary) were optional variables. Data on the first course of each treatment modality (surgery, radiotherapy, chemotherapy, endocrine treatment, and anti-HER2 therapy) were collected as binary variables (yes or no), with the related date. Type of surgery was available in broad categories: breast-conserving surgery or mastectomy (breast); simple or radical hysterectomy (cervix); bilateral salpingo-oophorectomy and hysterectomy or cytoreductive surgery (ovary).

For the **ASCO** clinical guidelines see https://ascopubs.org/guidelines

For the **ESMO** clinical guidelines see https://www.esmo.org/guidelines

For the **NCCN** clinical guidelines see https://www.nccn.org/guidelines/category_1

Data were securely submitted through the CONCORD File Transmission Utility,[14] and stored, cleaned, and analysed in the Secure Annex in the Cancer Survival Group at the London School of Hygiene & Tropical Medicine. Data were subjected to an extensive three-phase quality control procedure. To do this, we extended the quality control routines developed for international survival comparisons in the CONCORD programme over 20 years,[14,24] to enable accurate quality control for the 60 extra variables included in VENUSCANCER. We sent a detailed data quality report after each phase. We also liaised with each registry to ensure maximal data quality, using well tried approaches to discuss central correction of systematic categorical or coding errors, or resubmission of data after correction by the registry.

Statistical analysis

For HICs, we only included in the analyses the data from registries with at least 70% of records with high-resolution data on stage and each type of treatment. Given the complexity of collecting these variables in LMICs, we included all registries, regardless of the availability and completeness of data on stage and treatment.

For breast cancer, stage was grouped into six categories: early, node-negative disease (T1 N0 M0), larger node-negative (T2–3 N0 M0), node-positive (T1–3 N+ M0), locally advanced (T4 any N M0), metastatic (M1), and not staged. For cervical and ovarian cancers, stage was grouped into four categories: early, node-negative disease (T1 N0 M0), locally advanced (T2–3 any N M0), advanced (T4 any N M0 or M1 for cervical cancer) or metastatic (M1 for ovarian cancer), and not staged. We used early-stage to indicate early, node-negative disease.

Countries were grouped into HICs and LMICs according to the 2015 World Bank classification.[25] Age was grouped into four categories: 15–39, 40–49, 50–69, and 70–99 years. Time to surgical treatment was calculated as the number of days from the date of diagnosis to the date of the first surgical procedure with therapeutic intent, regardless of the type of procedure.

For each cancer, we examined the distribution of stage at diagnosis and the proportion of women who received initial treatment that was consistent with clinical guidelines. We defined key indicators of consistency with clinical guidelines for initial treatment, for each cancer, according to recommendations in the main international clinical guidelines (ASCO, ESMO, and NCCN) for core resources and above. For breast cancer, the key indicators were breast-conserving surgery plus radiotherapy in early, node-negative disease; chemotherapy in node-positive disease; endocrine treatment for ER-positive tumours; and anti-HER2 treatment for HER2-positive tumours. For cervical cancer, the key indicators were surgery for early stage tumours and chemotherapy (with or without radiotherapy) for advanced disease. For ovarian cancer, the key indicators were surgery in early-stage disease, and surgery plus chemotherapy in metastatic disease.

For all three cancers, we used logistic regression to estimate the odds of being treated according to clinical guidelines compared with receiving other (or no) treatment in each country, separately in HICs and in LMICs, controlling for age and, where possible, tumour subtype. The reference category was the country with the highest number of women in the dataset. In particular, for breast-conserving surgery plus radiotherapy versus other treatment in LMICs, Cuba was chosen as reference category because it was the country with the highest

number of women and it had the highest number of radiotherapy units per capita.[12] All statistical analyses were performed with Stata (version 18).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Of the 322 registries invited to participate in the study, 103 (32%) contributed high-resolution data for a single year of incidence during 2015–18 (panel). Of the 21 cancer registries in LMICs that were offered financial support to contribute to the VENUSCANCER project, we succeeded in supporting only 11 registries in Uganda (Kampala), Nigeria (Ibadan), South Africa (Eastern Cape), Brazil (São Paulo), Colombia (Cali), Ecuador (Quito), Mongolia, Georgia, Thailand (Chiang Mai and Lampang), and Romania (Cluj). Golestan (Iran) could not receive financial support from the UK due to international sanctions. Registries in Argentina (Mendoza), Brazil (Aracaju, Jaú, and Porto Alegre), Cuba, and Russia (Arkhangelsk) could not open an international bank account. Bulgaria was experiencing political problems that led to the closure of the registry. Trivandrum (India) and Jakarta (Indonesia) could not accept this commitment. Despite the financial support, São Paulo (Brazil) could not contribute adequate data because withdrawal of municipal funding led to closure of the registry in 2022. Cali (Colombia) only provided minimal data.

We received 275 792 anonymised individual records for women diagnosed with a cancer of the breast (214 111 [77·6%]), cervix (44 468 [16·1%], including in situ), or ovary (17 213 [6·2%]). All registries contributed data for 1 year of complete incidence during 2015–18, with the exception of France and South Korea, where high-resolution data were available only for a random sample of patients. Most registries submitted data for women diagnosed in 2018, but there was some variability in the selected year of incidence in countries with

***Panel*: Countries and territories that contributed data to the VENUSCANCER project**

Africa
- Nigeria (Ibadan)
- South Africa (Eastern Cape)
- Uganda (Kampala)

Central and South America
- Brazil (Aracaju and Jahu)
- Colombia (Cali, Manizales, and Pasto)
- Cuba
- Ecuador (Quito)
- Martinique
- Puerto Rico

North America
- Canada (Alberta, Manitoba, New Brunswick, Newfoundland and Labrador, Prince Edward Island, and Saskatchewan)
- USA (Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah)

Asia
- Georgia
- Iran (Golestan)
- Jordan
- Mongolia
- Occupied Palestinian territory (Gaza)
- Singapore
- South Korea
- Thailand (Chiang Mai and Lampang)

Europe
- Belgium
- Denmark
- Estonia
- France (Bas-Rhin, Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Haute-Vienne, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, Somme, and Tarn)
- Germany (Hamburg)
- Ireland
- Italy (Emilia Romagna, Friuli-Venezia Giulia, Genoa, Milan, Naples, Palermo, Pavia, Ragusa, Siracusa, Torino, Varese, and Veneto)
- Liechtenstein
- Luxembourg
- The Netherlands
- Norway
- Portugal (north and south)
- Romania (Cluj)
- Russia (Arkhangelsk and Samara)
- Slovenia
- Spain (Basque Country, Castellon, Girona, Granada, Murcia, Navarra, and Tarragona)
- Switzerland (East Switzerland, Geneva, Graubünden-Glarus, Neuchâtel, and Ticino)
- UK (England, Northern Ireland, and Scotland)

Oceania
- Australia (Australian Capital Territory, Queensland, and South Australia)
- New Zealand

Countries had 100% coverage of the national population, unless otherwise indicated.

	Years of diagnosis	Women with breast cancer	Microscopically verified	Known stage	Stage at diagnosis					
					T1 N0 M0	T2–3 N0 M0	T1–3 N1–3 M0	T4 M0	M1	Not staged
Africa	2015–18	578	567 (99·2%)	299 (51·7%)	4 (0·7%)	30 (5·2%)	136 (23·5%)	48 (8·3%)	81 (14·0%)	279 (48·3%)
Nigeria (Ibadan)	2018	351	351 (100·0%)	176 (50·1%)	1 (0·3%)	5 (1·4%)	87 (24·8%)	35 (10·0%)	48 (13·7%)	175 (49·9%)
South Africa (Eastern Cape)	2015	116	116 (100·0%)	48 (41·4%)	3 (2·6%)	17 (14·7%)	24 (20·7%)	1 (0·9%)	3 (2·6%)	68 (58·6%)
Uganda (Kampala)	2017	111	100 (90·1%)	75 (67·6%)	..	8 (7·2%)	25 (22·5%)	12 (10·8%)	30 (27·0%)	36 (32·4%)
Central and South America	2015–18	4513	4484 (99·4%)	3215 (71·2%)	1192 (26·4%)	678 (15·0%)	1042 (23·1%)	127 (2·8%)	176 (3·9%)	1298 (28·8%)
Brazil (2)*	2016–17	261	261 (100·0%)	156 (59·8%)	33 (12·6%)	34 (13·0%)	65 (24·9%)	20 (7·7%)	4 (1·5%)	105 (40·2%)
Colombia (3)†	2015–18	1084	1071 (98·8%)	490 (45·2%)	163 (15·0%)	53 (4·9%)	179 (16·5%)	23 (2·1%)	72 (6·6%)	594 (54·8%)
Cuba	2018	284	284 (100·0%)	261 (91·9%)	86 (30·3%)	63 (22·2%)	63 (22·2%)	32 (11·3%)	17 (6·0%)	23 (8·1%)
Ecuador (Quito)	2017	475	468 (98·5%)	434 (91·4%)	98 (20·6%)	103 (21·7%)	161 (33·9%)	28 (5·9%)	44 (9·3%)	41 (8·6%)
Martinique	2016	227	226 (99·6%)	219 (96·5%)	74 (32·6%)	40 (17·6%)	74 (32·6%)	10 (4·4%)	21 (9·3%)	8 (3·5%)
Puerto Rico	2018	2182	2174 (99·6%)	1655 (75·8%)	738 (33·8%)	385 (17·6%)	500 (22·9%)	14 (0·6%)	18 (0·8%)	527 (24·2%)
North America	2017–18	71 310	71 033 (99·6%)	67 263 (94·3%)	33 867 (47·5%)	12 444 (17·5%)	16 088 (22·6%)	1409 (2·0%)	3455 (4·8%)	4047 (5·7%)
Canada (6)‡	2017–18	5533	5504 (99·5%)	5431 (98·2%)	2430 (43·9%)	1014 (18·3%)	1530 (27·7%)	123 (2·2%)	334 (6·0%)	102 (1·8%)
USA (13)§	2017–18	65 777	65 529 (99·6%)	61 832 (94·0%)	31 437 (47·8%)	11 430 (17·4%)	14 558 (22·1%)	1286 (2·0%)	3121 (4·7%)	3945 (6·0%)
Asia	2016–18	8990	8582 (99·2%)	6872 (76·4%)	1976 (22·0%)	1474 (16·4%)	2386 (26·5%)	267 (3·0%)	769 (8·6%)	2118 (23·6%)
Georgia	2018	1820	1468 (80·7%)	1596 (87·7%)	229 (12·6%)	272 (14·9%)	739 (40·6%)	93 (5·1%)	263 (14·5%)	224 (12·3%)
Iran (Golestan)	2017	305	270 (88·5%)	133 (43·6%)	..	..	..	..	133 (43·6%)	172 (56·4%)
Jordan	2016	1171	1171 (100·0%)	0	..	..	..	..	..	1171 (100·0%)
Mongolia	2017	214	206 (96·3%)	202 (94·4%)	4 (1·9%)	126 (58·9%)	29 (13·6%)	6 (2·8%)	37 (17·3%)	12 (5·6%)
Occupied Palestinian territory (Gaza)	2018	261	260 (99·6%)	230 (88·1%)	20 (7·7%)	47 (18·0%)	106 (40·6%)	12 (4·6%)	45 (17·2%)	31 (11·9%)
Singapore	2018	2348	2348 (100·0%)	2037 (86·8%)	673 (28·7%)	488 (20·8%)	610 (26·0%)	104 (4·4%)	162 (6·9%)	311 (13·2%)
South Korea	2017	2147	2144 (99·9%)	2104 (98·0%)	892 (41·5%)	389 (18·1%)	697 (32·5%)	28 (1·3%)	98 (4·6%)	43 (2·0%)
Thailand (2)¶	2018	724	715 (98·8%)	570 (78·7%)	158 (21·8%)	152 (21·0%)	205 (28·3%)	24 (3·3%)	31 (4·3%)	154 (21·3%)
Europe	2012–18	119 354	118 340 (99·0%)	100 520 (85·4%)	45 818 (38·4%)	19 098 (16·0%)	29 023 (24·3%)	2227 (1·9%)	4354 (3·6%)	17 162 (14·4%)
Belgium	2018	11 396	11 368 (99·8%)	10 441 (91·6%)	4690 (41·2%)	1909 (16·8%)	2760 (24·2%)	240 (2·1%)	842 (7·4%)	955 (8·4%)
Denmark	2017	4617	4617 (100·0%)	4162 (90·1%)	2019 (43·7%)	734 (15·9%)	1240 (26·9%)	81 (1·8%)	88 (1·9%)	455 (9·9%)
Estonia	2017	746	730 (97·9%)	723 (96·9%)	223 (29·9%)	126 (16·9%)	279 (37·4%)	24 (3·2%)	71 (9·5%)	23 (3·1%)
France (16)‖	2012–15	1565	1555 (99·4%)	1414 (96·7%)	646 (41·3%)	235 (15·0%)	392 (25·0%)	37 (2·4%)	104 (6·6%)	49 (3·1%)
Germany (Hamburg)	2017	1586	1542 (97·2%)	1353 (85·3%)	573 (36·1%)	262 (16·5%)	353 (22·3%)	43 (2·7%)	122 (7·7%)	233 (14·7%)
Ireland	2018	3693	3666 (99·3%)	3583 (97·0%)	1300 (35·2%)	833 (22·6%)	1128 (30·5%)	88 (2·4%)	234 (6·3%)	110 (3·0%)
Italy (10)**	2014–18	14 558	14 326 (98·4%)	11 532 (88·8%)	5890 (40·5%)	1525 (10·5%)	3248 (22·3%)	242 (1·7%)	627 (4·3%)	1456 (10·0%)
Liechtenstein	2018	43	42 (97·7%)	42 (97·7%)	19 (44·2%)	6 (14·0%)	13 (30·2%)	..	4 (9·3%)	1 (2·3%)
Luxembourg	2018	481	481 (100·0%)	446 (92·7%)	213 (44·3%)	84 (17·5%)	106 (22·0%)	14 (2·9%)	29 (6·0%)	35 (7·3%)
Netherlands	2018	15 779	15 758 (99·9%)	14 662 (92·9%)	7211 (45·7%)	2536 (16·1%)	3759 (23·8%)	255 (1·6%)	901 (5·7%)	1117 (7·1%)
Norway	2018	3697	3687 (99·7%)	3549 (96·0%)	1716 (46·4%)	754 (20·4%)	860 (23·3%)	124 (3·4%)	95 (2·6%)	148 (4·0%)
Portugal (2)††	2018	6960	6945 (99·8%)	6278 (90·2%)	2739 (39·4%)	1078 (15·5%)	1850 (26·6%)	183 (2·6%)	428 (6·1%)	682 (9·8%)
Romania (Cluj)	2015	689	649 (94·2%)	579 (84·0%)	81 (11·8%)	105 (15·2%)	227 (32·9%)	96 (13·9%)	70 (10·2%)	110 (16·0%)
Russia (2)‡‡	2018	2334	2324 (99·6%)	2264 (97·0%)	606 (26·0%)	588 (25·2%)	672 (28·8%)	251 (10·8%)	147 (6·3%)	70 (3·0%)
Slovenia	2019	1583	1573 (99·4%)	1476 (93·2%)	685 (43·3%)	219 (13·8%)	431 (27·2%)	19 (1·2%)	122 (7·7%)	107 (6·8%)
Spain (5)§§	2015–17	2161	2147 (99·4%)	2017 (93·3%)	813 (37·6%)	297 (13·7%)	742 (34·3%)	56 (2·6%)	109 (5·0%)	144 (6·7%)
Switzerland (5)¶¶	2016–18	1699	1686 (99·2%)	1542 (90·8%)	694 (40·8%)	277 (16·3%)	406 (23·9%)	19 (1·1%)	146 (8·6%)	157 (9·2%)
UK (3)‖‖	2018	45 767	45 246 (98·9%)	34 457 (75·3%)	15 700 (34·3%)	7530 (16·5%)	10 557 (23·1%)	455 (1·0%)	215 (0·5%)	11 310 (24·7%)

(Table 1 continues on next page)

	Years of diagnosis	Women with breast cancer	Microscopically verified	Known stage	Stage at diagnosis					
					T1 N0 M0	T2–3 N0 M0	T1–3 N1–3 M0	T4 M0	M1	Not staged
(Continued from previous page)										
Oceania	2017–18	9366	9291 (99·2%)	0	..	..	..	..	..	9366 (100·0%)
Australia (3)***	2017	5839	5776 (98·9%)	0	..	..	..	..	..	5839 (100·0%)
New Zealand	2018	3527	3515 (99·7%)	0	..	..	..	..	..	3527 (100·0%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). *Aracaju (2016) and Jahu (2017). †Manizales (2015); and Cali and Pasto (2018). ‡Alberta and Newfoundland and Labrador (2017); Manitoba, New Brunswick, Prince Edward Island, and Saskatchewan (2018). §Utah (2017); and Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, and Seattle (2018). ¶Chiang Mai and Lampang (2018). ||Bas-Rhin, Haute-Vienne, and Manche (2012); Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, and Somme and Tarn (2015). **Genoa (2014); Palermo (2016); Emilia Romagna, Friuli-Venezia Giulia, Milan, Naples, Ragusa, and Torino (2017); and Pavia and Veneto (2018). ††North and south Portugal (2018). ‡‡Arkhangelsk and Samara (2018). §§Castellon, Granada, Navarra, and Tarragona (2015); and Girona (2017). ¶¶Graubünden-Glarus (2016); Geneva (2017); East Switzerland, Neuchâtel, and Ticino (2018). ||||England, Northern Ireland, and Scotland (2018). ***Australian Capital Territory, Queensland, and South Australia (2017).

Table 1: **Microscopic verification and stage at diagnosis among women with breast cancer, by continent and country**

regional coverage. Cuba submitted national data for ovarian cancer; however, for breast cancer, only data for the provinces of Villa Clara (approximately 7·0% of the national population), Pinar del Río (5·3%), and Matanzas (6·4%) were submitted. For some registries in France and Italy, we also accepted data for 2012, because clinical and therapeutic guidelines had not changed much between 2012 and 2018. Not all registries could provide data on every treatment procedure or biomarker, so the denominator of each analysis varied. Cases registered only from a death certificate (1677 [0·6%]) were excluded.

Cancer stage at diagnosis was known for 214 758 (77·9%) women from 93 registries in 38 countries or territories (23 HICs and 15 LMICs). Australia did not provide data on stage. Consistency with clinical guidelines could be evaluated for 155 808 (56·5%) women from 74 registries, which met the required 70% of records with known stage and type of surgery, radiotherapy, and chemotherapy for inclusion: 131 327 (84·3%) with breast cancer, 10 447 (6·7%) with cervical cancer, and 14 034 (9·0%) with ovarian cancer. For 131 327 women with breast cancer, chemotherapy for node-positive tumours could be examined for 56 957 (43·4%) women, endocrine treatment for ER-positive tumours for 100 892 (76·8%) women, and anti-HER2 treatment for HER2-positive tumours for 7268 (5·5%) women.

In HICs, almost all breast cancer tumours (98–100%) were microscopically verified. The proportion of breast cancer records with known TNM stage ranged from 75·3% in the UK to over 95% in Martinique, Canada, South Korea, Estonia, France, Ireland, Liechtenstein, and Norway (table 1). The proportion with early-stage disease ranged from 28·7% in Singapore to 47·8% in the USA. This proportion was 40% or higher in 13 HICs. Node-positive breast cancer tumours varied from 22·1% in the USA, Luxembourg, and Germany (Hamburg) to 37·4% in Estonia. Metastatic breast cancers were rare in the UK and Puerto Rico (<1%), but occurred in over 9% of breast cancer cases in Martinique, Estonia, and Liechtenstein (table 1).

In Europe, most women with early, node-negative breast cancer were treated with breast-conserving surgery plus radiotherapy (range 67–78%), consistent with clinical guidelines. This proportion was lowest in Portugal (52·5%) and highest in France (82·2%). The proportion of women who received this modality of therapy was lower in the USA (52·7%) and Canada (59·6%), where mastectomy was offered more frequently as an alternative (table 2; figure 1A). After controlling for age at diagnosis and tumour subtype, the odds of being treated with breast-conserving surgery plus radiotherapy were two to four times higher in most European countries and 30% higher in Canada compared with the USA (reference category). In Portugal and Puerto Rico, levels of consistency with guidelines were similar to those in the USA (appendix pp 29, 33). Adjusting for country or territory and tumour subtype, the odds of being treated with breast-conserving surgery plus radiotherapy were at least 50% lower among women with breast cancer in the oldest age group (70–99 years) and in both the youngest age groups (15–39 and 40–49 years) than among women aged 50–69 years. This finding was particularly evident for women in the youngest age group (15–39 years; odds ratio [OR] 0·30 [95% CI 0·27–0·33]). Controlling for country or territory and age across HICs, compared with women with ER-positive and HER2-negative tumours (reference category), women diagnosed with all other subtypes of breast cancer showed lower odds of being treated with breast-conserving surgery plus radiotherapy (ER-positive and HER2-positive tumours: OR 0·77 [95% CI 0·72–0·82]; ER-negative and HER2-positive tumours: 0·44 [0·39–0·50]; and ER-negative, PR-negative, and HER2-negative tumours: 0·88 [0·82–0·95]).

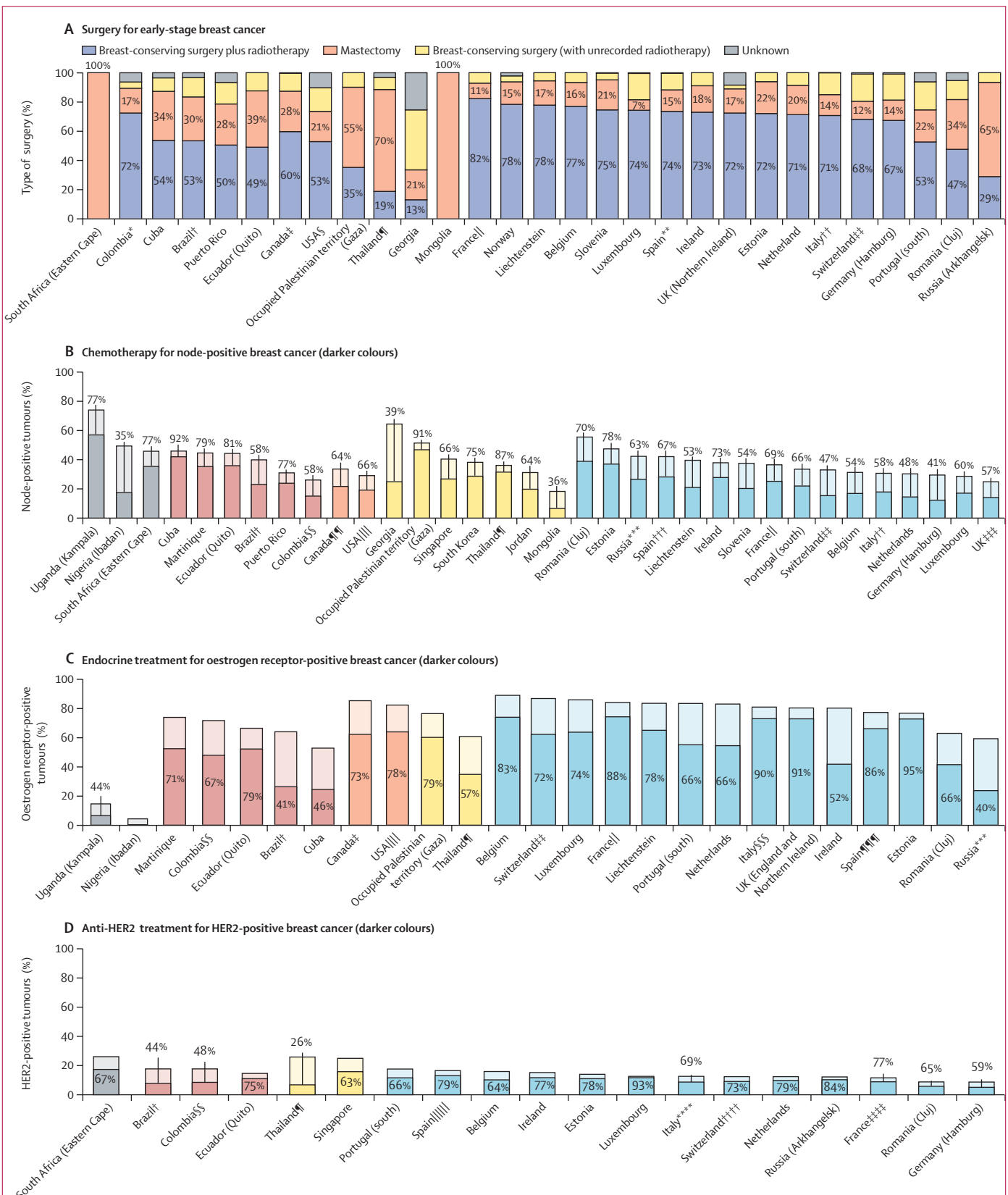
The proportion of women with node-positive breast cancer who were treated with chemotherapy varied across HICs, from 41·4% in Germany (Hamburg) to 79·2% in

	Women with breast cancer	Surgically treated: any stage	Surgically treated: early-stage tumour (T1 N0 M0)			
			Any type of surgery	Breast-conserving surgery plus radiotherapy	Mastectomy	Other
Africa	578	255 (44·1%)	3 (1·2%)	0	3 (100·0%)	0
Nigeria (Ibadan)*	351	154 (43·9%)	..	..	..	..
South Africa (Eastern Cape)*	116	66 (56·9%)	3 (4·5%)	..	3 (100·0%)	..
Uganda (Kampala)*	111	35 (31·5%)	..	..	..	..
Central and South America	3440	2943 (85·6%)	978 (33·2%)	505 (51·6%)	285 (29·1%)	188 (19·2%)
Brazil (2)*†	261	206 (78·9%)	30 (14·6%)	16 (53·3%)	9 (30·0%)	5 (16·7%)
Colombia (2)*‡	238	189 (79·4%)	47 (24·9%)	34 (72·3%)	8 (17·0%)	5 (10·6%)
Cuba	284	249 (87·7%)	86 (34·5%)	46 (53·5%)	29 (33·7%)	11 (12·8%)
Ecuador (Quito)	475	354 (74·5%)	88 (24·9%)	43 (48·9%)	34 (38·6%)	11 (12·5%)
Puerto Rico	2182	1945 (89·1%)	727 (37·4%)	366 (50·3%)	205 (28·2%)	156 (21·5%)
North America	61 942	55 443 (89·5%)	28 774 (51·9%)	15 282 (53·1%)	6089 (21·2%)	7403 (25·7%)
Canada (3)§	3760	3342 (88·9%)	1625 (48·6%)	969 (59·6%)	450 (27·7%)	206 (12·7%)
USA (11)¶	58 182	52 101 (89·5%)	27 149 (52·1%)	14 313 (52·7%)	5639 (20·8%)	7197 (26·5%)
Asia	3019	1946 (64·5%)	320 (16·4%)	54 (16·9%)	152 (47·5%)	114 (35·6%)
Georgia	1820	950 (52·2%)	141 (14·8%)	18 (12·8%)	29 (20·6%)	94 (66·7%)
Mongolia	214	171 (79·9%)	3 (1·8%)	..	3 (100·0%)	..
Occupied Palestinian territory (Gaza)	261	198 (75·9%)	20 (10·1%)	7 (35·0%)	11 (55·0%)	2 (10·0%)
Thailand (2)‖	724	627 (86·6%)	156 (24·9%)	29 (18·6%)	109 (69·9%)	18 (11·5%)
Europe	59 001	51 150 (86·7%)	23 734 (46·4%)	17 000 (71·6%)	4170 (17·6%)	2564 (10·8%)
Belgium	11 396	9414 (82·6%)	4360 (46·3%)	3357 (77·0%)	710 (16·3%)	293 (6·7%)
Estonia	746	623 (83·5%)	214 (34·3%)	154 (72·0%)	47 (22·0%)	13 (6·1%)
France (13)**	1463	1306 (89·3%)	625 (47·9%)	514 (82·2%)	66 (10·6%)	45 (7·2%)
Germany (Hamburg)	1586	1246 (78·6%)	528 (42·4%)	355 (67·2%)	74 (14·0%)	99 (18·8%)
Ireland	3693	3213 (87·0%)	1238 (38·5%)	903 (72·9%)	224 (18·1%)	111 (9·0%)
Italy (7)††	8816	8049 (91·3%)	3933 (48·9%)	2778 (70·6%)	565 (14·4%)	590 (15·0%)
Liechtenstein	43	38 (88·4%)	18 (47·4%)	14 (77·8%)	3 (16·7%)	1 (5·6%)
Luxembourg	481	438 (91·1%)	210 (47·9%)	156 (74·3%)	15 (7·1%)	39 (18·6%)
Netherlands	15 779	13 910 (88·2%)	6916 (49·7%)	4923 (71·2%)	1397 (20·2%)	596 (8·6%)
Norway	3697	3336 (90·2%)	1685 (50·5%)	1319 (78·3%)	260 (15·4%)	106 (6·3%)
Portugal (south)	4036	3392 (84·0%)	1436 (42·3%)	754 (52·5%)	316 (22·0%)	366 (25·5%)
Romania (Cluj)	689	485 (70·4%)	76 (15·7%)	36 (47·4%)	26 (34·2%)	14 (18·4%)
Russia (Arkhangelsk)	527	435 (82·5%)	136 (31·3%)	39 (28·7%)	88 (64·7%)	9 (6·6%)
Slovenia	1583	1310 (82·8%)	652 (49·8%)	486 (74·5%)	134 (20·6%)	32 (4·9%)
Spain (3)‡‡	1308	1189 (90·9%)	491 (41·3%)	361 (73·5%)	72 (14·7%)	58 (11·8%)
Switzerland (5)§§	1699	1501 (88·3%)	673 (44·8%)	458 (68·1%)	83 (12·3%)	132 (19·6%)
UK (Northern Ireland)	1459	1265 (86·7%)	543 (42·9%)	393 (72·4%)	90 (16·6%)	60 (11·0%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). Martinique, Iran (Golestan), Jordan, Singapore, South Korea, Denmark, Australia (Australian Capital Territory, Queensland, and South Australia), and New Zealand did not provide data on type of surgery. *Stage at diagnosis not available for 30% or more of records. †Aracaju and Jahu. ‡Manizales and Pasto. §Alberta, Manitoba, and Prince Edward Island. ¶Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New York, Seattle, and Utah. ‖Chiang Mai and Lampang. **Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, Somme, and Tarn. ††Friuli-Venezia Giulia, Genoa, Milan, Naples, Palermo, Ragusa, Veneto. ‡‡Spain: Castellon, Girona, and Granada. §§East Switzerland, Geneva, Graubünden-Glarus, Neuchâtel, and Ticino.

Table 2: **Type of surgery received by women diagnosed with early-stage (T1 N0 M0) breast cancer, by continent and country**

Martinique (figure 1B). After adjusting for age, the odds of being treated with chemotherapy were 15–60% higher in Portugal, France, and Ireland and two to three times higher in Martinique, Puerto Rico, and Estonia compared with the USA (reference category). Compared with women aged 50–69 years, the odds of receiving chemotherapy were four times higher among younger women (aged 15–39 years; OR 4·07 [3·64–4·54]), but 80% lower for older women (0·23 [0·22–0·24]; appendix pp 30, 33).


A Surgery for early-stage breast cancer
Breast-conserving surgery plus radiotherapy
Mastectomy
Breast-conserving surgery (with unrecorded radiotherapy)
Unknown
Type of surgery (%)
South Africa (Eastern Cape)
Colombia*
Cuba
Brazil†
Puerto Rico
Ecuador (Quito)
Canada‡
USA§
Occupied Palestinian territory (Gaza)
Thailand¶
Georgia
Mongolia
France||
Norway
Liechtenstein
Belgium
Slovenia
Luxembourg
Spain**
Ireland
UK (Northern Ireland)
Estonia
Netherlands
Italy††
Switzerland‡‡
Germany (Hamburg)
Portugal (south)
Romania (Cluj)
Russia (Arkhangelsk)
B Chemotherapy for node-positive breast cancer (darker colours)
Node-positive tumours (%)
Uganda (Kampala)
Nigeria (Ibadan)
South Africa (Eastern Cape)
Cuba
Martinique
Ecuador (Quito)
Brazil†
Puerto Rico
Colombia§§
Canada¶¶
USA|||
Georgia
Occupied Palestinian territory (Gaza)
Singapore
South Korea
Thailand¶
Jordan
Mongolia
Romania (Cluj)
Estonia
Russia***
Spain†††
Liechtenstein
Ireland
Slovenia
France||
Portugal (south)
Switzerland‡‡
Belgium
Italy††
Netherlands
Germany (Hamburg)
Luxembourg
UK‡‡‡
C Endocrine treatment for oestrogen receptor-positive breast cancer (darker colours)
Oestrogen receptor-positive tumours (%)
Uganda (Kampala)
Nigeria (Ibadan)
Martinique
Colombia§§
Ecuador (Quito)
Brazil†
Cuba
Canada‡
USA|||
Occupied Palestinian territory (Gaza)
Thailand¶
Belgium
Switzerland‡‡
Luxembourg
France||
Liechtenstein
Portugal (south)
Netherlands
Italy§§§
UK (England and Northern Ireland)
Ireland
Spain¶¶¶
Estonia
Romania (Cluj)
Russia***
D Anti-HER2 treatment for HER2-positive breast cancer (darker colours)
HER2-positive tumours (%)
South Africa (Eastern Cape)
Brazil†
Colombia§§
Ecuador (Quito)
Thailand¶
Singapore
Portugal (south)
Spain|||||
Belgium
Ireland
Estonia
Luxembourg
Italy***
Switzerland†††
Netherlands
Russia (Arkhangelsk)
France‡‡‡
Romania (Cluj)
Germany (Hamburg)

The proportion of women with ER-positive breast cancer treated with endocrine treatment varied across HICs, ranging from 65·5% in the Netherlands to 94·8% in Estonia (figure 1C). After controlling for age, compared with the USA (reference category), the odds of being treated with this treatment modality were 45% higher in Belgium, 70% higher in Spain, and two to five times higher in France, Italy, the UK, and Estonia, but 20–45% lower in Canada, Switzerland, Martinique, the Netherlands, and Portugal. Older women (aged 70–99 years) tended to receive endocrine treatment less often than younger women (aged 15–39 years; OR 0·81 [95% CI 0·79–0·84]; appendix pp 30, 34).

Over 50% of women with HER2-positive breast cancer were treated with anti-HER2 treatment across all HICs, from 58·8% in Germany (Hamburg) to 93·3% in Luxembourg (figure 1D). The median time between diagnosis of breast cancer and breast-conserving surgery for early-stage tumours in women living in HICs was less than 1 month in Belgium, Estonia, Germany (Hamburg), Liechtenstein, Norway, Switzerland, and the UK; 1–2 months in Spain, Slovenia, Canada, the USA, and Puerto Rico; and around 3 months in Portugal. The median time to mastectomy for early-stage tumours was less than 1 month in Norway, Germany (Hamburg), and the UK; typically within 2 months in most other countries or territories; up to 3 months in Puerto Rico; and over 4 months in Portugal (figure 2B).

In most LMICs, the proportion of microscopically verified breast cancer tumours was high overall (96–100%), but somewhat lower in Romania (Cluj; 94·2%), Uganda (Kampala; 90·1%), Georgia (80·7%), and Iran (Golestan; 88·5%). The proportion of tumours with a recorded TNM stage at diagnosis varied widely, from up to 50% in Nigeria (Ibadan), Colombia, Iran (Golestan), and South Africa (Eastern Cape), to 90% or above in Russia, Mongolia, Cuba, and Ecuador (Quito; table 1). The proportion of early-stage tumours was low in Nigeria (Ibadan) and Uganda (Kampala; <1%) and less than 15% in most LMICs, but up to 20·6% in Ecuador (Quito), 26·0% in Russia, and 30·3% in Cuba. In sub-Saharan Africa overall, fewer than 3% of women with a known stage were recorded to have an early-stage breast cancer. Node-positive tumours ranged from 14% in Mongolia to 41% in Georgia and occupied Palestinian territory (Gaza), and metastatic tumours ranged from 2% in Brazil to 44% in Iran (Golestan; table 1).

In Cuba and Ecuador (Quito), around 50% of women diagnosed with breast cancer were offered breast-conserving surgery plus radiotherapy, with the remaining half of women treated with breast-conserving surgery alone or with mastectomy. In Romania (Cluj), 47·4% of women were treated with breast-conserving surgery plus radiotherapy, 34·2% with mastectomy, and 18·4% with breast-conserving surgery alone, either without radiotherapy or with unrecorded radiotherapy status. Most women with breast cancer in Thailand (69·9%) and occupied Palestinian territory (Gaza; 55·0%) received mastectomy, whereas 41·1% of women in Georgia received breast-conserving surgery alone. In South Africa (Eastern Cape) and Mongolia, mastectomy was the only treatment option offered to women diagnosed with early-stage breast cancer (table 2; figure 1A).

After controlling for age and tumour subtype, the odds of being treated with breast-conserving surgery plus radiotherapy were 80% lower in occupied Palestinian territory (Gaza) and Thailand than in Cuba (reference category); however, 95% CIs are wide. Across LMICs, older women (aged 70–99 years) with early-stage breast cancer had 65% lower odds of being treated with breast-conserving surgery plus radiotherapy than women aged 50–69 years. After controlling for country or territory and age, we found no differences in the odds of being treated with breast-conserving surgery plus radiotherapy by tumour subtype across LMICs (appendix pp 29, 33).

For women diagnosed with node-positive breast cancer in LMICs, the proportion treated with chemotherapy varied from 35% in Nigeria (Ibadan) to over 80% in occupied Palestinian territory (Gaza) and Cuba (figure 1B). After adjusting for age, the odds of being treated with chemotherapy were three to eight times higher in Russia, Ecuador (Quito), and Romania (Cluj); 11 to 14 times higher in Thailand and occupied Palestinian territory (Gaza); and up to 17% higher in Cuba compared with Georgia (reference category), albeit 95% CIs were wide. Compared with women aged 50–69 years, the odds of being treated with chemotherapy were 40–80% higher

Figure 1: **Proportion of women with breast cancer who received treatment consistent with clinical guidelines between 2015 and 2018, by continent and country**

Results are based on a 100% coverage of the national population, unless otherwise indicated. Two countries did not provide data on stage, eight on type of surgery, three on chemotherapy, 13 on endocrine treatment, and 17 on anti-HER2 treatment. (A) Proportion of women with early-stage (T1 N0 M0) tumours who received breast-conserving surgery plus radiotherapy versus any other type of surgery. (B) Proportion of women with node-positive tumours who received chemotherapy. (C) Proportion of women with ER-positive tumours who received endocrine treatment . (D) Proportion of women with HER2-positive tumours who received anti-HER2 treatment. *Manizales and Pasto. †Aracaju and Jahu. ‡Alberta, Manitoba, and Prince Edward Island. §Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New York, Seattle, and Utah. ¶Chiang Mai and Lampang. ||Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, Somme, and Tarn. **Castellon, Girona, and Granada. ††Friuli-Venezia Giulia, Genoa, Milan, Naples, Palermo, Ragusa, and Veneto. ‡‡East Switzerland, Geneva, Graubünden-Glarus, Neuchâtel, and Ticino. §§Cali, Manizales, and Pasto. ¶¶Alberta, Manitoba, Prince Edward Island, and Saskatchewan. ||||Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. ***Arkhangelsk and Samara. †††Castellon, Girona, Granada, and Navarra. ‡‡‡England, Northern Ireland, and Scotland. §§§Milan, Naples, Palermo, Ragusa, and Veneto. ¶¶¶Castellon, Girona, Granada, Navarra, and Tarragona. ||||||Castellon, Granada, Navarra, and Tarragona. ****Genoa, Milan, Palermo, Ragusa, and Veneto. ††††Geneva, Neuchâtel, and Ticino. ‡‡‡‡Bas-Rhin, Calvados, Haute-Vienne, Manche, and Poitou-Charentes.

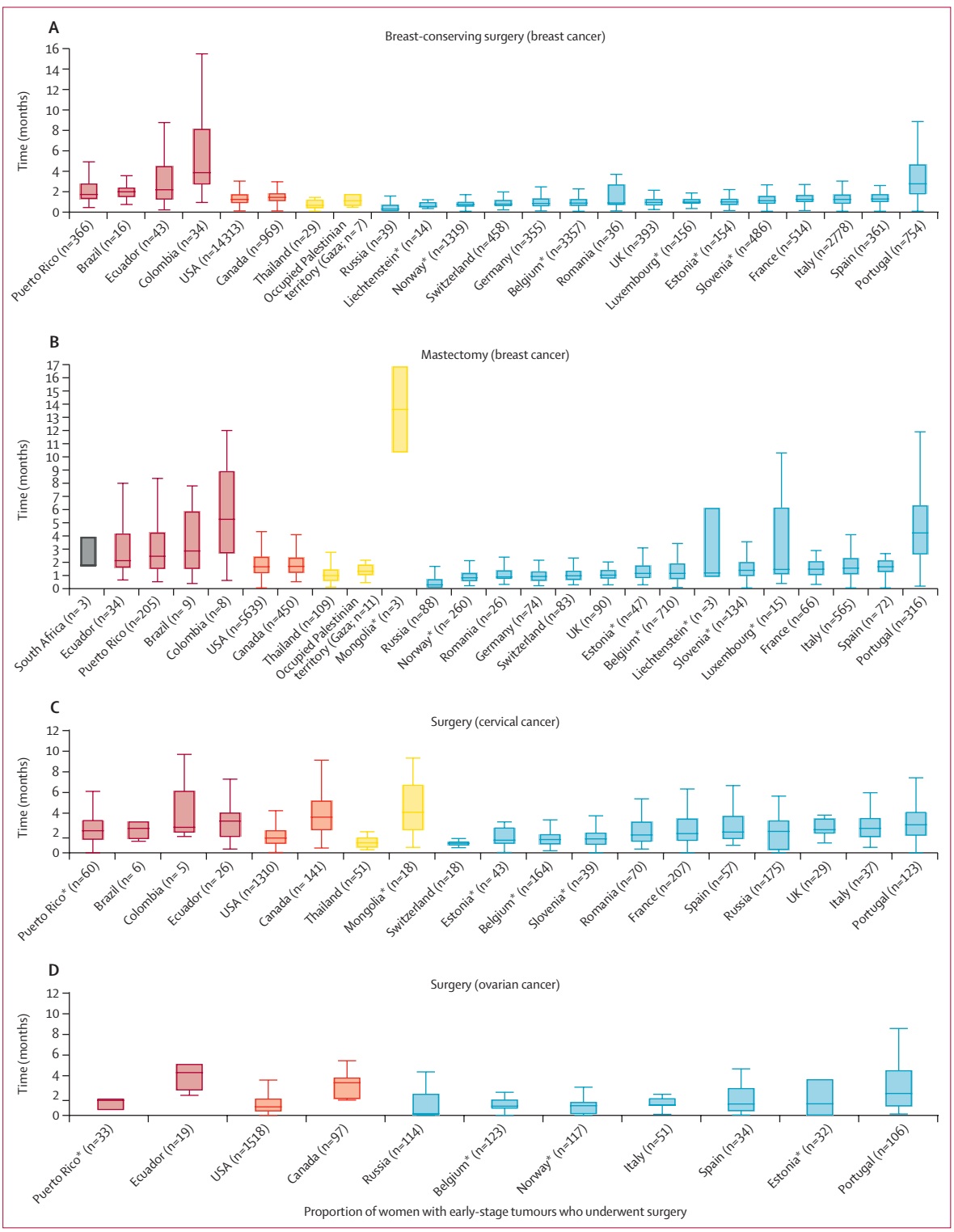


Figure 2: **Median time between diagnosis and surgery in women with early-stage breast, cervical, or ovarian cancer**
Median time between diagnosis and breast-conserving surgery (A) or mastectomy (B) for early-stage (T1 N0 M0) breast cancer. Median time between diagnosis and surgery for early-stage cervical (C) and early-stage ovarian (D) cancer. *100% coverage of the national population.

	Years of diagnosis	Women with cervical cancer	In-situ tumours	Invasive tumours	Microscopically verified	Known stage	Stage at diagnosis			
							T1 N0 M0	T2–3 any N M0	T4 any N M0 or M1	Not staged
Africa	2015–18	545	10 (13·0%)	535 (87·0%)	507 (94·8%)	378 (70·7%)	1 (0%)	321 (60·0%)	56 (10·5%)	157 (29·3%)
Nigeria (Ibadan)	2018	77	10 (13·0%)	67 (87·0%)	67 (100·0%)	67 (100·0%)		63 (94·0%)	4 (6·0%)	0
South Africa (Eastern Cape)	2015	349	..	349 (100·0%)	345 (98·9%)	206 (59·0%)	1 (0·3%)	170 (48·7%)	35 (10·0%)	143 (41·0%)
Uganda (Kampala)	2017	119	..	119 (100·0%)	95 (79·8%)	105 (88·2%)		88 (73·9%)	17 (14·3%)	14 (11·8%)
Central and South America	2016–18	1123	432 (47·0%)	697 (53·0%)	681 (57·0%)	397 (57·0%)	122 (17·5%)	182 (26·1%)	93 (13·3%)	300 (43·0%)
Brazil (2)*	2016–17	68	20 (29·4%)	47 (70·6%)	46 (97·9%)	28 (59·6%)	6 (12·8%)	16 (34·0%)	6 (12·8%)	19 (40·4%)
Colombia (2)†	2018	347	90 (25·9%)	257 (74·1%)	246 (95·7%)	31 (12·1%)	7 (2·7%)	16 (6·2%)	8 (3·1%)	226 (87·9%)
Ecuador (Quito)	2017	378	209 (55·3%)	169 (44·7%)	167 (98·8%)	153 (90·5%)	28 (16·6%)	72 (42·6%)	53 (31·4%)	16 (9·5%)
Martinique	2017	126	113 (89·7%)	20 (10·3%)	20 (100·0%)	15 (75·0%)	3 (15·0%)	9 (45·0%)	3 (15·0%)	5 (25·0%)
Puerto Rico	2018	204	..	204 (100·0%)	202 (99·0%)	170 (83·3%)	78 (38·2%)	69 (33·8%)	23 (11·3%)	34 (16·7%)
North America	2017–18	4570	..	3832 (83·9%)	3812 (99·5%)	3628 (94·7%)	1673 (43·7%)	1428 (37·3%)	527 (13·8%)	204 (5·3%)
Canada (5)‡	2017–18	794	..	301 (37·9%)	300 (99·7%)	294 (97·7%)	181 (60·1%)	92 (30·6%)	21 (7·0%)	7 (2·3%)
USA (13)§	2017–18	3776	..	3531 (93·5%)	3512 (99·5%)	3334 (94·4%)	1492 (42·3%)	1336 (37·8%)	506 (14·3%)	197 (5·6%)
Asia	2016–18	1753	353 (30·5%)	1400 (69·5%)	1334 (97·4%)	1261 (92·4%)	422 (30·9%)	668 (49·0%)	171 (12·5%)	103 (7·6%)
Georgia	2018	293	9 (3·1%)	284 (96·9%)	247 (87·0%)	274 (96·5%)	83 (29·2%)	150 (52·8%)	41 (14·4%)	10 (3·5%)
Iran (Golestan)	2017	27	..	27 (100·0%)	23 (85·2%)	8 (29·6%)	..	..	8 (29·6%)	19 (70·4%)
Jordan	2016	41	5 (12·2%)	36 (87·8%)	36 (100·0%)	..	..	..	..	36 (100·0%)
Mongolia	2017	320	52 (16·3%)	268 (83·7%)	248 (92·5%)	254 (94·8%)	21 (7·8%)	199 (74·3%)	34 (12·7%)	14 (5·2%)
Singapore	2018	502	287 (57·2%)	215 (42·8%)	215 (100·0%)	197 (91·6%)	81 (37·7%)	90 (41·9%)	26 (12·1%)	18 (8·4%)
South Korea	2017	345	..	345 (100·0%)	343 (99·4%)	339 (98·3%)	180 (52·2%)	124 (35·9%)	35 (10·1%)	6 (1·7%)
Thailand (2)¶	2018	225	..	225 (100·0%)	222 (98·7%)	189 (84·0%)	57 (25·3%)	105 (46·7%)	27 (12·0%)	36 (16·0%)
Europe	2015–18	34 152	28 299 (83·9%)	5317 (16·1%)	5274 (99·2%)	4040 (83·4%)	1547 (35·4%)	1565 (35·8%)	535 (12·2%)	728 (16·6%)
Belgium	2017	14 941	14 325 (95·9%)	616 (4·1%)	613 (99·5%)	458 (74·4%)	176 (28·6%)	204 (33·1%)	78 (12·7%)	158 (25·6%)
Denmark	2018	375	..	336 (100·0%)	333 (99·1%)	236 (70·2%)	141 (42·0%)	78 (23·2%)	17 (5·1%)	100 (29·8%)
Estonia	2017	173	24 (13·9%)	149 (86·1%)	140 (94·0%)	141 (94·6%)	48 (32·2%)	59 (39·6%)	34 (22·8%)	8 (5·4%)
France (13)‖	2015	618	..	618 (100·0%)	614 (99·4%)	606 (98·1%)	243 (39·3%)	215 (34·8%)	148 (23·9%)	12 (1·9%)
Germany (Hamburg)	2017	529	424 (80·2%)	105 (19·8%)	103 (98·1%)	66 (62·9%)	..	..	..	39 (37·1%)
Ireland	2018	2518	2214 (87·9%)	304 (12·1%)	303 (99·7%)	266 (87·5%)	110 (36·2%)	104 (34·2%)	52 (17·1%)	38 (12·5%)
Italy (2)**	2016–17	1340	751 (56·0%)††	126 (44·0%)	122 (96·8%)	102 (81·0%)	49 (38·9%)	41 (32·5%)	12 (9·5%)	24 (19·0%)
Netherlands	2018	6002	5165 (86·1%)	837 (13·9%)	833 (99·5%)	327 (39·1%)	..	..	..	510 (60·9%)
Norway	2018	378	..	378 (100·0%)	377 (99·7%)	290 (76·7%)	174 (46·0%)	83 (22·0%)	33 (8·7%)	88 (23·3%)
Portugal (2)‡‡	2018	2357	1879 (79·7%)	478 (20·3%)	477 (99·8%)	434 (90·8%)	144 (30·1%)	223 (46·7%)	67 (14·0%)	44 (9·2%)
Romania (Cluj)	2015	391	44 (11·3%)	347 (88·7%)	339 (97·7%)	283 (81·6%)	78 (22·5%)	190 (54·8%)	15 (4·3%)	64 (18·4%)
Russia (2)§§	2018	670	87 (13·0%)	583 (87·0%)	582 (99·8%)	404 (69·3%)	215 (36·9%)	159 (27·3%)	30 (5·1%)	179 (30·7%)
Slovenia	2018	1146	1040 (90·8%)	106 (9·2%)	105 (99·1%)	104 (98·1%)	40 (37·7%)	59 (55·7%)	5 (4·7%)	2 (1·9%)
Spain (5)¶¶	2015–17	1065	848 (79·6%)	183 (20·4%)	182 (99·5%)	175 (95·6%)	66 (36·1%)	86 (47·0%)	23 (12·6%)	8 (4·4%)
Switzerland (4)‖‖	2016–18	617	560 (90·8%)	57 (9·2%)	57 (100·0%)	56 (98·2%)	19 (33·3%)	29 (50·9%)	8 (14·0%)	1 (1·8%)
UK (Northern Ireland)	2018	1032	938 (90·9%)	94 (9·1%)	94 (100·0%)	92 (97·9%)	44 (46·8%)	35 (37·2%)	13 (13·8%)	2 (2·1%)
Oceania	2017–18	2325	1883 (87·9%)	442 (12·1%)	433 (98·0%)	145 (79·2%)	79 (43·2%)	41 (22·4%)	25 (13·7%)	38 (20·8%)
Australia (3)***	2017	2142	1883 (87·9%)	259 (12·1%)	252 (97·3%)	0	0	0	0	259 (100%)
New Zealand	2018	183	0	183 (100·0%)	181 (98·9%)	145 (79·2%)	79 (43·2%)	41 (22·4%)	25 (13·7%)	38 (20·8%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). Cuba, occupied Palestinian territory (Gaza), Liechtenstein, and Luxemburg did not provide data on cervical cancer. *Aracaju (2016) and Jahu (2017). †Cali and Pasto (2018). ‡Alberta and Newfoundland and Labrador (2017); and Manitoba, Prince Edward Island, and Saskatchewan (2018). For in-situ tumours: Newfoundland and Labrador only. §Utah and Iowa (2017); and Alaska, Greater Bay Area, Greater California, Idaho, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, and Seattle (2018). For in-situ tumours: Montana only. ¶Chiang Mai and Lampang (2018). ‖Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Haute-Vienne, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, and Tarn (2015). **Siracusa (2016) and Milan (2017). ††For in-situ tumours: Milan only. ‡‡North and south Portugal (2018). §§Arkhangelsk and Samara (2018). ¶¶Castellon, Granada, and Navarra (2015); Basque Country (2016); and Girona (2017). ‖‖Graubünden-Glarus (2016); Geneva (2017); and East Switzerland and Neuchâtel (2018). ***Australian Capital Territory, Queensland, and South Australia (2017).

Table 3: **Microscopic verification and stage at diagnosis among women diagnosed with cervical cancer, by continent and country**

in younger women (aged 15–49 years) and 70% lower in older women (aged 70–99 years; appendix pp 30, 33).

For LMICs, the proportion of women with ER-positive breast cancer who were treated with endocrine treatment ranged from 7% in Nigeria (Ibadan) to 79% in Ecuador (Quito) and occupied Palestinian territory (Gaza; figure 1C). Compared with Thailand (reference category), the odds of receiving endocrine therapy were higher in Romania (Cluj; OR 1·45 [95% CI 1·10–1·91]), Colombia (1·52 [1·05–2·21]), occupied Palestinian territory (Gaza; 2·64 [1·78–3·90]), and Ecuador (Quito; 2·84 [2·04–3·95]), but 40–50% lower in Cuba and Brazil. Women aged 40–49 years received endocrine treatment less often than women aged 50–69 years (0·70 [0·55–0·90]; appendix pp 30, 34).

Across LMICs, the median time between diagnosis of breast cancer and breast-conserving surgery in early-stage tumours was up to 1 month in Romania (Cluj), Russia (Arkhangelsk), and Thailand; 1–2 months in occupied Palestinian territory (Gaza), and Brazil; and up to 4 months in Colombia (figure 2A). The median time to mastectomy was less than 1 month in Romania (Cluj), Russia (Arkhangelsk), and Thailand; 1–2 months in Ecuador (Quito) and occupied Palestinian territory (Gaza); almost 3 months in Brazil; more than 5 months in Colombia; and more than 1 year in Mongolia (figure 2B).

Across HICs, almost all cervical cancer tumours were microscopically verified (97–100%), but this proportion was slightly lower in Estonia (94·0%; table 3). Not all countries or territories routinely collect information on in-situ tumours. Where available, the proportion of in-situ tumours varied from 13·9% in Estonia to 95·6% in Belgium. The proportion of in-situ tumours was provided only by Montana (89·5%) in the USA; New Foundland and Labrador (91·1%) in Canada; and the Milan Cancer Registry (82·7%) in Italy. Among invasive cervical cancer tumours, the proportion with a known stage ranged from 75·0% in Martinique to at least 98% in South Korea, France, Slovenia, Switzerland, and Northern Ireland. Around 30–40% of tumours were diagnosed as early-stage in most HICs, but the proportion of early-stage tumours was as low as 15·0% in Martinique and over 40% in Denmark (42·0%) and the USA (42·3%), New Zealand (43·2%), Norway (46·0%), the UK (46·8%), South Korea (52·2%), and Canada (60·1%). The proportion of women diagnosed with advanced cervical cancer was generally around 13–15%, but as low as 5% in Denmark and Slovenia and as high as 23% in Estonia (table 3).

For early-stage tumours, at least 85% of women diagnosed with cervical cancer were treated with surgery in most HICs, with a range from 65·9% in Northern Ireland to 97·5% in Slovenia (table 4; figure 3A). The most frequent type of surgery for these tumours was simple hysterectomy in Belgium (60·0%) and radical hysterectomy in almost all other HICs (data not shown).

After adjusting for age, the odds for women with early-stage cervical cancer to be treated with surgery were two times higher in Belgium but 60–80% lower in Puerto Rico, Italy, and the UK compared with the USA (reference category). Accounting for country or

	Women with cervical cancer	Women with early-stage tumour (T1 N0 M0)		Women with advanced stage tumour (T4 M0 or M1)	
		Total number	Treated with surgery	Total number	Treated with chemotherapy
Africa	535	1 (0·2%)	0	56 (10·5%)	17 (30·4%)
Nigeria (Ibadan)	67	..	..	4 (6·0%)	0
South Africa (Eastern Cape)*	349	1 (0·3%)	..	35 (10·0%)	4 (11·4%)
Uganda (Kampala)	119	..	..	17 (14·3%)	13 (76·5%)
Central and South America	677	119 (17·6%)	97 (81·5%)	90 (13·3%)	59 (65·6%)
Brazil (2)*†	47	6 (12·8%)	6 (100·0%)	6 (12·8%)	3 (50·0%)
Colombia (Pasto)	257	7 (2·7%)	5 (71·4%)	8 (3·1%)	0
Ecuador (Quito)	169	28 (16·6%)	26 (92·9%)	53 (31·4%)	38 (71·7%)
Puerto Rico	204	78 (38·2%)	60 (76·9%)	23 (11·3%)	18 (78·3%)
North America	3832	1673 (43·7%)	1451 (86·7%)	525 (13·7%)	371 (70·7%)
Canada (4)‡	301	181 (60·1%)	141 (83·9%)	19 (6·9%)	17 (89·5%)
USA (13)§	3531	1492 (42·3%)	1310 (87·8%)	506 (14·3%)	354 (70·0%)
Asia	1364	422 (30·9%)	358 (84·8%)	171 (12·5%)	71 (41·5%)
Georgia	284	83 (29·2%)	54 (65·1%)	41 (14·4%)	16 (39·0%)
Iran (Golestan)*	27	..	..	8 (29·6%)	5 (62·5%)
Mongolia	268	21 (7·8%)	18 (85·7%)	34 (12·7%)	6 (17·6%)
Singapore	215	81 (37·7%)	72 (88·9%)	26 (12·1%)	13 (50·0%)
South Korea	345	180 (52·2%)	163 (90·6%)	35 (10·1%)	21 (60·0%)
Thailand (2)¶	225	57 (25·3%)	51 (89·5%)	27 (12·0%)	10 (37·0%)
Europe	4039	1406 (34·8%)	1221 (86·8%)	418 (10·3%)	280 (67·0%)
Belgium	616	176 (28·6%)	164 (93·2%)	78 (12·7%)	57 (73·1%)
Estonia	149	48 (32·2%)	43 (89·6%)	34 (22·8%)	17 (50·0%)
France (13)‖	618	243 (39·3%)	207 (85·2%)	148 (23·9%)	118 (79·7%)
Ireland	304	110 (36·2%)	103 (93·6%)	52 (17·1%)	36 (69·2%)
Italy (2)**	126	49 (38·9%)	37 (75·5%)	12 (9·5%)	8 (66·7%)
Norway	378	174 (46·0%)	156 (89·7%)	..	..
Portugal (2)††	478	144 (30·1%)	123 (85·4%)	..	..
Romania (Cluj)	347	78 (22·5%)	70 (89·7%)	15 (4·3%)	7 (46·7%)
Russia (2)‡‡	583	215 (36·9%)	175 (81·4%)	30 (5·1%)	9 (30·0%)
Slovenia	106	40 (37·7%)	39 (97·5%)	5 (4·7%)	0
Spain (5) §§	183	66 (36·1%)	57 (86·4%)	23 (12·6%)	13 (56·5%)
Switzerland (4)¶¶	57	19 (33·3%)	18 (94·7%)	8 (14·0%)	6 (75·0%)
UK (Northern Ireland)	94	44 (46·8%)	29 (65·9%)	13 (13·8%)	9 (69·2%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). Martinique, Jordan, Denmark, Germany (Hamburg), the Netherlands, Australia (Australian Capital Territory, Queensland, and South Australia), and New Zealand did not provide data on treatment. *Stage at diagnosis not available for 30% or more of records. †Aracaju and Jahu. ‡Alberta, Manitoba, Prince Edward Island, and Saskatchewan. §Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. ¶Chiang Mai and Lampang. ‖Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Haute-Vienne, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, and Tarn. **Milan and Siracusa. ††North and south Portugal. ‡‡Arkhangelsk and Samara. §§Basque Country, Castellon, Girona, Granada, and Navarra. ¶¶East Switzerland, Geneva, Graubünden-Glarus, and Neuchâtel.

Table 4: **Women with early-stage cervical cancer (T1 N0 M0) treated with surgery, and women with advanced cervical cancer (T4 M0 or M1) treated with chemotherapy, by continent and country**

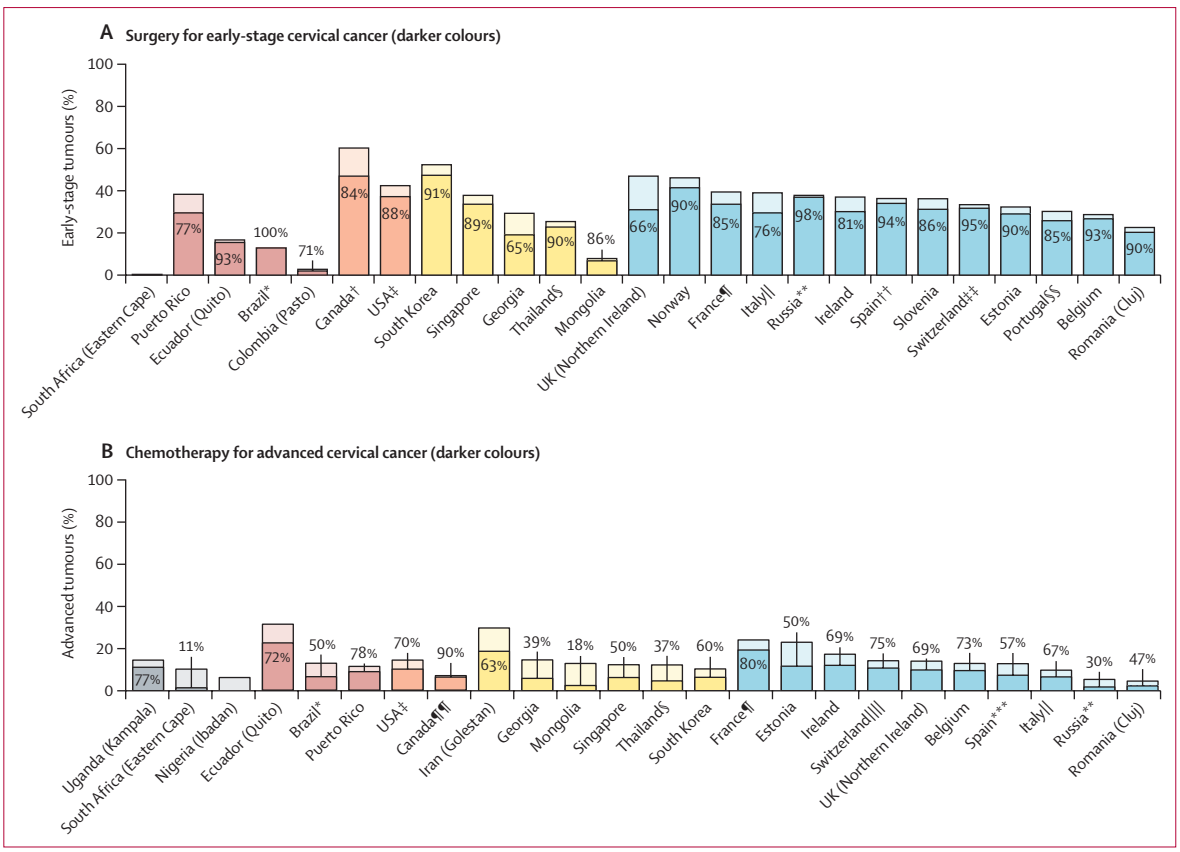


Figure 3: **Proportion of women with cervical cancer who received treatment consistent with clinical guidelines between 2015 and 2018, by continent and country**

Results are based on a 100% coverage of the national population, unless otherwise indicated. Four countries did not provide data on cervical cancer. Seven countries did not provide data on treatment. (A) Proportion of women with early-stage (T1 N0 M0) tumours who received surgery. (B) Proportion of women with advanced (T4, M0, or M1) tumours who received chemotherapy. *Aracaju and Jahu. †Alberta, Manitoba, Prince Edward Island, and Saskatchewan. ‡Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. §Chiang Mai and Lampang. ¶Calvados, Côte-d'Or Gynaecologic, Doubs, Gironde General, Haut-Rhin, Haute-Vienne, Hérault, Isère, Lille Metro, Loire-Atlantique, Manche, Poitou-Charentes, and Tarn. ||Milan and Siracusa. **Arkhangelsk and Samara. ††Basque Country, Castellon, Girona, Granada, and Navarra. ‡‡East Switzerland, Geneva, Graubünden-Glarus, and Neuchâtel. §§North and south Portugal. ¶¶Alberta, Manitoba, and Saskatchewan. ||||East Switzerland and Neuchâtel. ***Basque Country, Girona, and Granada.

territory of origin, the odds of being treated with surgery for early-stage cervical cancer were 80% lower in older women (aged 70–99 years) than in women aged 50–69 years (appendix pp 31, 35).

The proportion of women with advanced cervical cancer treated with chemotherapy was more variable, ranging from 50·0% in Estonia to 89·5% in Canada (table 4; figure 3B). After adjusting for age, the odds of women with advanced cervical cancer being treated with chemotherapy were two times higher in France but 60% lower in Estonia compared with the USA (reference category). Compared with women aged 50–69 years diagnosed with advanced cervical cancer, the odds of being treated with chemotherapy were two times higher for younger women (aged 15–39 years) but 80% lower for older women (aged 70–99 years; appendix pp 31, 35).

The median time between diagnosis of cervical cancer and surgery for women with an early-stage tumour was slightly less than 1 month in Switzerland; less than 2 months in the USA, Estonia, Belgium, Slovenia, and France; 2–3 months in Spain, Puerto Rico, UK (Northern Ireland), Italy, and Portugal; and more than 3 months in Canada (figure 2C).

Across LMICs, almost all cervical tumours were microscopically verified (96–100%), but this proportion was slightly lower in Uganda (Kampala; 79·8%), Iran (Golestan; 85·2%), Georgia (87·0%), and Mongolia (92·5%; table 3). In Jordan, data on stage were not available except for in-situ tumours (12·2%); in Iran, only data on women with advanced cervical cancer were submitted by the Golestan registry (29·6%). The proportion of records with known stage varied from 12·1% in Colombia to 100·0% in Nigeria. Less than 1% of cervical cancers were diagnosed at an early stage in South Africa (Eastern Cape), but this proportion was much higher in Romania (Cluj; 22·5%),

Thailand (25·3%), Georgia (29·2%), and Russia (36·9%; table 3). Almost all tumours were diagnosed at a regional stage in Nigeria (Ibadan; 94·0%); this proportion was also high in Uganda (Kampala; 73·9%) and Mongolia (74·3%). Up to 6·0% of cervical cancers were diagnosed at advanced stage in Nigeria (Ibadan), Russia,

	Years of diagnosis	Women with ovarian cancer	Microscopically verified	Known stage	Stage at diagnosis			
					T1 N0 M0	T2–3 any N M0	M1	Not staged
Africa	2015–18	99	92 (92·9%)	49 (49·5%)	3 (3·0%)	27 (27·3%)	19 (19·2%)	50 (50·5%)
Nigeria (Ibadan)	2018	41	41 (100·0%)	18 (43·9%)	..	2 (4·9%)	16 (39·0%)	23 (56·1%)
South Africa (Eastern Cape)	2015	27	27 (100·0%)	7 (25·9%)	2 (7·4%)	2 (7·4%)	3 (11·1%)	20 (74·1%)
Uganda (Kampala)	2017	31	24 (77·4%)	24 (77·4%)	1 (3·2%)	23 (74·2%)	..	7 (22·6%)
Central and South America	2016–18	889	803 (89·6%)	821 (93·7%)	79 (9·0%)	69 (7·9%)	673 (76·8%)	55 (6·3%)
Brazil (2)*	2016–17	37	34 (91·9%)	23 (62·2%)	1 (2·7%)	2 (5·4%)	20 (54·1%)	14 (37·8%)
Cuba	2018	589	523 (88·8%)	574 (97·5%)	25 (4·2%)	28 (4·8%)	521 (88·5%)	15 (2·5%)
Ecuador (Quito)	2017	78	67 (85·9%)	68 (87·2%)	19 (24·4%)	15 (19·2%)	34 (43·6%)	10 (12·8%)
Martinique	2017	13	13 (100·0%)	0	..	..	..	13 (100·0%)
Puerto Rico	2018	172	166 (96·5%)	156 (90·7%)	34 (19·8%)	24 (14·0%)	98 (57·0%)	16 (9·3%)
North America	2016–18	8073	7822 (96·8%)	7599 (94·1%)	1685 (20·9%)	2913 (36·1%)	3001 (37·2%)	474 (5·9%)
Canada (5)†	2016–18	555	521 (93·9%)	501 (90·3%)	111 (20·0%)	245 (44·1%)	145 (26·1%)	54 (9·7%)
USA (13)‡	2017–18	7518	7301 (97·1%)	7098 (94·4%)	1574 (20·9%)	2668 (35·5%)	2856 (38·0%)	420 (5·6%)
Asia	2016–18	915	810 (92·7%)	722 (78·9%)	199 (21·7%)	305 (33·3%)	218 (23·8%)	193 (21·1%)
Georgia	2018	273	215 (78·8%)	256 (93·8%)	37 (13·6%)	134 (49·1%)	85 (31·1%)	17 (6·2%)
Iran (Golestan)	2017	42	36 (85·7%)	23 (54·8%)	..	..	23 (54·8%)	19 (45·2%)
Jordan	2016	96	96 (100·0%)	0	..	..	..	96 (100·0%)
Mongolia	2017	50	20 (40·0%)	47 (94·0%)	2 (4·0%)	23 (46·0%)	22 (44·0%)	3 (6·0%)
Singapore	2018	365	365 (100·0%)	332 (91·0%)	141 (38·6%)	118 (32·3%)	73 (20·0%)	33 (9·0%)
Thailand (2)§	2018	89	78 (87·6%)	64 (71·9%)	19 (21·3%)	30 (33·7%)	15 (16·9%)	25 (28·1%)
Europe	2015–18	6344	6056 (94·5%)	5092 (80·3%)	864 (13·6%)	2672 (42·1%)	1556 (24·5%)	1252 (19·7%)
Belgium	2018	874	849 (97·1%)	732 (83·8%)	127 (14·5%)	371 (42·4%)	234 (26·8%)	142 (16·2%)
Denmark	2016	484	473 (97·7%)	409 (84·5%)	70 (14·5%)	124 (25·6%)	215 (44·4%)	75 (15·5%)
Estonia	2017	152	140 (92·1%)	152 (100·0%)	32 (21·1%)	70 (46·1%)	50 (32·9%)	0
Germany (Hamburg)	2017	185	164 (88·6%)	137 (74·1%)	22 (11·9%)	66 (35·7%)	49 (26·5%)	48 (25·9%)
Ireland	2018	452	415 (91·8%)	334 (73·9%)	79 (17·5%)	166 (36·7%)	89 (19·7%)	118 (26·1%)
Italy (2)¶	2017	395	366 (92·7%)	346 (87·6%)	58 (14·7%)	213 (53·9%)	75 (19·0%)	49 (12·4%)
Liechtenstein	2018	3	3 (100·0%)	3 (100·0%)	..	2 (66·7%)	1 (33·3%)	0
Netherlands	2018	1458	1403 (96·2%)	1075 (73·7%)	..	709 (48·6%)	366 (25·1%)	383 (26·3%)
Norway	2018	511	494 (96·7%)	480 (93·9%)	117 (22·9%)	230 (45·0%)	133 (26·0%)	31 (6·1%)
Portugal (2)‖	2018	460	453 (98·5%)	422 (91·7%)	106 (23·0%)	184 (40·0%)	132 (28·7%)	38 (8·3%)
Romania (Cluj)	2015	143	127 (88·8%)	107 (74·8%)	25 (17·5%)	62 (43·4%)	20 (14·0%)	36 (25·2%)
Russia (2)**	2018	471	470 (99·8%)	420 (89·2%)	126 (26·8%)	229 (48·6%)	65 (13·8%)	51 (10·8%)
Slovenia	2019	232	218 (94·0%)	0	..	..	..	232 (100·0%)
Spain (4)††	2015–17	194	181 (93·3%)	176 (90·7%)	40 (20·6%)	81 (41·8%)	55 (28·4%)	18 (9·3%)
Switzerland (3)‡‡	2016–18	126	120 (95·2%)	122 (96·8%)	21 (16·7%)	65 (51·6%)	36 (28·6%)	4 (3·2%)
UK (Northern Ireland)	2018	204	180 (88·2%)	177 (86·8%)	41 (20·1%)	100 (49·0%)	36 (17·6%)	27 (13·2%)
Oceania	2017–18	893	843 (94·4%)	357 (40·0%)	56 (15·0%)	55 (14·7%)	246 (65·8%)	17 (4·5%)
Australia (3)§§	2017	519	494 (95·2%)	0	..	..	..	519 (100·0%)
New Zealand	2018	374	349 (93·3%)	357 (95·5%)	56 (15·0%)	55 (14·7%)	246 (65·8%)	17 (4·5%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). Colombia (Cali, Manizales, and Pasto), occupied Palestinian territory (Gaza), South Korea, France, and Luxembourg did not provide data on ovarian cancer. *Aracaju (2016) and Jahu (2017). †Saskatchewan (2016); Alberta and Newfoundland and Labrador (2017); Manitoba and Prince Edward Island (2018). ‡Utah and Iowa (2017); and Alaska, Greater Bay Area, Greater California, Idaho, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, and Seattle (2018). §Chiang Mai and Lampang (2018). ¶Milan and Naples (2017). ||North and south Portugal (2018). **Arkhangelsk and Samara (2018). ††Castellon, Granada, and Navarra (2015); and Girona (2017). ‡‡Graubünden-Glarus (2016); East Switzerland and Neuchâtel (2018). §§Australian Capital Territory, Queensland, and South Australia (2017).

Table 5: **Microscopic verification and stage at diagnosis among women diagnosed with ovarian cancer, by continent and country**

	Women with ovarian cancer	Women with early-stage tumour (T1 N0 M0)		Women with metastatic tumour (M1)	
		Total number	Treated with surgery	Total number	Treated with surgery plus chemotherapy
Africa	99	3 (3·0%)	2 (66·7%)	19 (19·2%)	3 (15·8%)
Nigeria (Ibadan)*	41	..	..	16 (39·0%)	1 (6·3%)
South Africa (Eastern Cape)*	27	2 (7·4%)	1 (50·0%)	3 (11·1%)	2 (66·7%)
Uganda (Kampala)	31	1 (3·2%)	1 (100·0%)	..	..
Central and South America	876	79 (9·0%)	75 (94·9%)	673 (76·8%)	121 (18·0%)
Brazil (2)*†	37	1 (2·7%)	1 (100·0%)	20 (54·1%)	3 (15·0%)
Cuba	589	25 (4·2%)	22 (88·0%)	521 (88·5%)	46 (8·8%)
Ecuador (Quito)	78	19 (24·4%)	19 (100·0%)	34 (43·6%)	23 (67·6%)
Puerto Rico	172	34 (19·8%)	33 (97·1%)	98 (57·0%)	49 (50·0%)
North America	8073	1685 (20·9%)	1615 (95·8%)	3001 (37·2%)	1572 (52·4%)
Canada (4)‡	555	111 (20·0%)	97 (94·2%)	145 (26·1%)	60 (47·2%)
USA (13)§	7518	1574 (20·9%)	1518 (96·4%)	2856 (38·0%)	1512 (53·2%)
Asia	819	199 (24·3%)	182 (91·5%)	218 (26·6%)	73 (33·5%)
Georgia	273	37 (13·6%)	26 (70·3%)	85 (31·1%)	13 (15·3%)
Iran (Golestan)*	42	..	..	23 (54·8%)	17 (73·9%)
Mongolia	50	2 (4·0%)	1 (50·0%)	22 (44·0%)	0
Singapore	365	141 (38·6%)	136 (96·5%)	73 (20·0%)	38 (52·1%)
Thailand (Chiang Mai)	89	19 (21·3%)	19 (100·0%)	15 (16·9%)	5 (33·3%)
Europe	4167	794 (19·1%)	760 (95·7%)	841 (20·2%)	267 (31·7%)
Belgium	874	127 (14·5%)	123 (96·9%)	234 (26·8%)	119 (50·9%)
Estonia	152	32 (21·1%)	32 (100·0%)	50 (32·9%)	26 (52·0%)
Germany (Hamburg)	185	22 (11·9%)	19 (86·4%)	49 (26·5%)	13 (26·5%)
Ireland	452	79 (17·5%)	77 (97·5%)	89 (19·7%)	32 (36·0%)
Italy (2)¶	395	58 (14·7%)	51 (87·9%)	75 (19·0%)	31 (41·3%)
Norway	511	117 (22·9%)	117 (100·0%)	..	..
Portugal (2)‖	460	106 (23·0%)	106 (100·0%)	132 (28·7%)	8 (15·4%)
Romania (Cluj)	143	25 (17·5%)	25 (100·0%)	20 (14·0%)	9 (45·0%)
Russia (2)**	471	126 (26·8%)	114 (90·5%)	65 (13·8%)	18 (27·7%)
Spain (4)††	194	40 (20·6%)	34 (85·0%)	55 (28·4%)	..
Switzerland (3)‡‡	126	21 (16·7%)	21 (100·0%)	36 (28·6%)	4 (21·1%)
UK (Northern Ireland)	204	41 (20·1%)	41 (100·0%)	36 (17·6%)	7 (19·4%)

Data are n or n (%), unless otherwise indicated. Results are based on a 100% coverage of the national population, unless the number of participating registries is shown in parentheses (see footnote). Martinique, Denmark, Liechtenstein, the Netherlands, Slovenia, Australia (Australian Capital Territory, Queensland, and South Australia), and New Zealand did not provide data on treatment. *Stage at diagnosis not available for 30% or more of records. †Aracaju and Jahu. ‡Alberta, Manitoba, Prince Edward Island, and Saskatchewan. §Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. ¶Milan and Naples. ‖North and south Portugal. **Arkhangelsk and Samara. ††Castellon, Girona, Granada, and Navarra. ‡‡East Switzerland, Graubünden-Glarus, and Neuchâtel.

Table 6: **Women with early-stage ovarian cancer (T1 N0 M0) treated with surgery, and women with metastatic ovarian cancer (M1) treated with surgery plus chemotherapy, by continent and country**

and Romania (Cluj), compared with 31·4% in Ecuador (Quito; table 3).

Most women with early-stage cervical cancer were treated surgically, with a range of 80–90%; however, only 65·1% of women were treated with this modality in Georgia (table 4; figure 3A). Tumours were mostly treated with simple hysterectomy in Uganda (Kampala; 75·0%), whereas radical hysterectomy was the most common treatment in South Africa (Eastern Cape), Ecuador (Quito), and Brazil (data not shown). After adjusting for age, the odds of being treated with surgery for women with early-stage cervical cancer were three to five times higher in Thailand, Romania (Cluj), and Russia than in Georgia (reference category). Accounting for country or territory, older women (aged 70–99 years) had 70% lower odds of being treated with surgery than women aged 50–69 years (appendix pp 31, 35). Across LMICs, the median time between diagnosis of cervical cancer and surgery for early-stage tumours was slightly less than 1 month in Thailand; around 2 months in Russia, Romania (Cluj), Brazil, and Colombia; more than 3 months in Ecuador (Quito); and 4 months in Mongolia (figure 2C).

The proportion of women diagnosed with advanced cervical cancer who were treated with chemotherapy

ranged from 17·6% in Mongolia to 76·5% in Uganda (Kampala; table 4; figure 3B). After adjusting for age, compared with Georgia (reference category), the odds of being treated with chemotherapy were four times higher in Uganda (Kampala) and Ecuador (Quito) but 70% lower in Mongolia, although 95% CIs are wide. Nevertheless, older women (aged 70–99 years) were consistently less often treated with chemotherapy than women aged 50–69 years (OR 0·24 [95% CI 0·09–0·63]; appendix pp 31, 35).

Across HICs, almost all ovarian tumours were microscopically verified (97–100%). The proportion of ovarian tumours with a known stage was around 74% in Germany (Hamburg; 74·1%), Ireland (73·9%), and the Netherlands (73·7%), but over 80% in most HICs, and above 90% in Puerto Rico, Canada, the USA, Estonia, Norway, Portugal, Spain, Switzerland, and New Zealand (table 5). Early-stage tumours ranged from 14·5% in Belgium and Denmark to 23% in Norway (22·9%) and Portugal (23·0%). The proportion of women diagnosed at metastatic stage varied widely, from 17·6% in Northern Ireland to 65·8% in New Zealand.

Most women with an early-stage ovarian tumour (≥98%) were treated with surgery in most HICs, but this proportion was slightly lower in Germany (Hamburg; 86·4%), Italy (87·9%), and Spain (85·0%; table 6; figure 4A). After adjusting for age, the odds of being treated with surgery were 80% lower in Italy and Spain than in the USA (reference category). Compared with women aged 50–69 years, this treatment was rarely offered to older women (aged 70–99 years; OR 0·12 [95% CI 0·07–0·21]; appendix pp 32, 36).

The proportion of women diagnosed with metastatic ovarian cancer who received both surgery and chemotherapy ranged from 15·4% in Portugal to 53·2% in the USA (table 6; figure 4B). After adjusting for age, the odds of being treated with surgery and chemotherapy

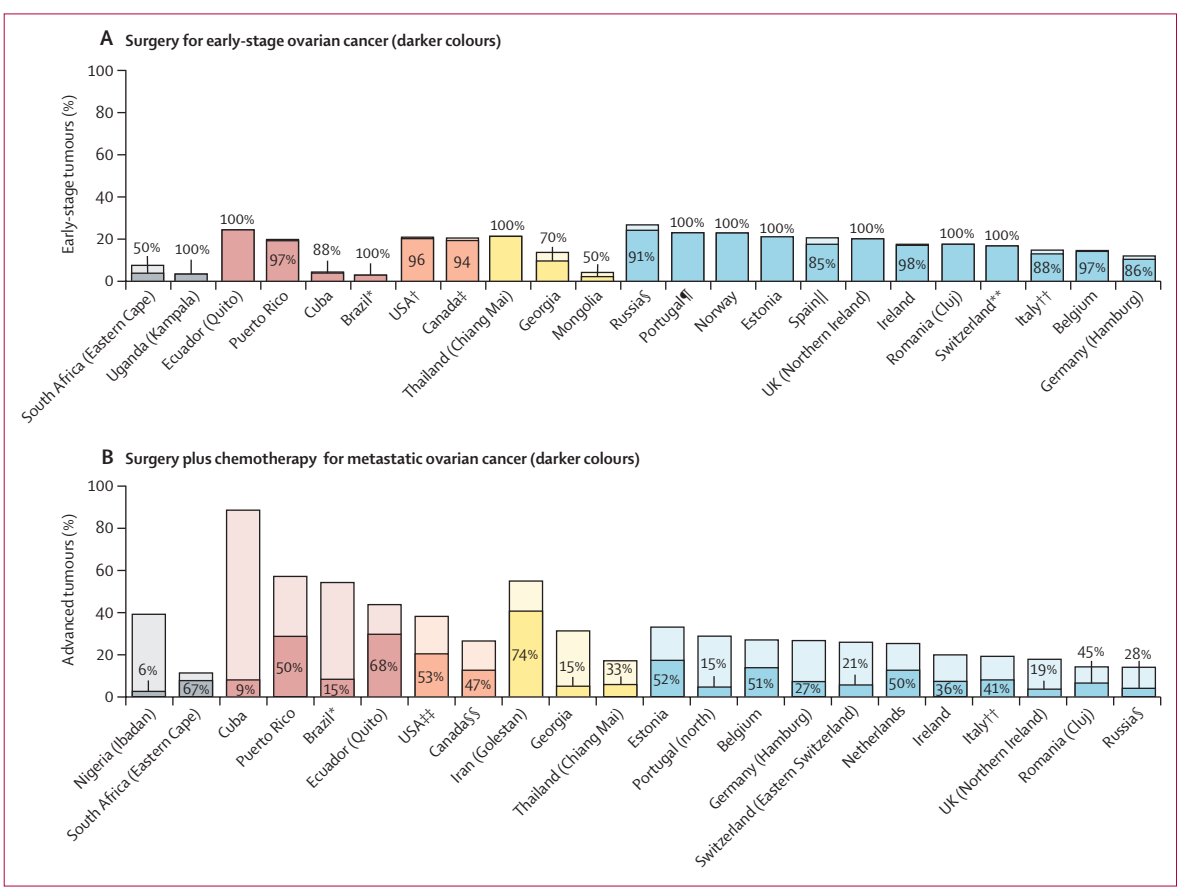


Figure 4: **Proportion of women with ovarian cancer who received treatment consistent with clinical guidelines between 2015 and 2018, by continent and country**

Results are based on a 100% coverage of the national population, unless otherwise indicated. Five countries did not provide data on ovarian cancer. Seven countries did not provide data on treatment. (A) Proportion of women with early-stage (T1 N0 M0) tumours who received surgery. (B) Proportion of women with metastatic (M1) tumours who received surgery plus chemotherapy. *Aracaju and Jahu. †Alaska, Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. ‡Alberta, Manitoba, Prince Edward Island, and Saskatchewan. §Arkhangelsk and Samara. ¶North and south Portugal. ||Castellon, Girona, Granada, and Navarra. **East Switzerland, Graubünden-Glarus, and Neuchâtel. ††Milan and Naples. ‡‡Greater Bay Area, Greater California, Idaho, Iowa, Kentucky, Los Angeles, Minnesota, Montana, New Jersey, New York, Seattle, and Utah. §§Alberta, Manitoba, and Saskatchewan.

versus receiving neither modality were 40–50% lower in Italy and Ireland and up to 80% lower in UK (Northern Ireland) and Switzerland compared with the USA. After controlling for country or territory, the odds of older women (aged 70–99 years) with metastatic ovarian cancer receiving surgery and chemotherapy were 70% lower than those of women aged 50–69 years (OR 0·31 [95% CI 0·27–0·35]; appendix pp 32, 36). The median time from diagnosis of ovarian cancer to surgery for early-stage tumours was slightly less than 1 month in the USA, Belgium, and Norway; 1–2 months in Italy, Spain, Estonia, and Puerto Rico; and over 2 months in Portugal and Canada (figure 2D).

Across LMICs, more than 80% of ovarian tumours were microscopically verified, reaching 100% in Nigeria (Ibadan), South Africa (Eastern Cape), and Jordan (table 5). Microscopic verification was somewhat lower in Georgia (78·8%) and Uganda (Kampala; 77·4%), and even lower in Mongolia (40·0%). The proportion of records with known stage of ovarian cancer varied widely across LMICs, from 25·9% in South Africa (Eastern Cape) to 94% in Mongolia (94·0%) and Georgia (93·8%), and 97·5% in Cuba. The proportion of early-stage tumours ranged from 4·0% in Mongolia to 26·8% in Russia; that of metastatic stage ranged from 14% in Romania (Cluj; 14·0%) and Russia (13·8%) to 88·5% in Cuba (table 5). Data on stage were not available from Jordan.

The proportion of early-stage ovarian tumours treated with surgery ranged from 70·3% in Georgia to 100·0% in Ecuador (Quito), Thailand and Romania (Cluj; figure 4A). After adjusting for age, the odds of early-stage ovarian cancers being treated with surgery were 70% lower in Georgia than in Russia (reference category). After adjusting by country or territory these odds did not differ by age (appendix pp 32, 36). The median time between diagnosis of ovarian cancer and surgery for early-stage tumours ranged from less than 1 month in Russia to over 4 months in Ecuador (Quito; figure 2D).

The proportion of women diagnosed with metastatic ovarian cancer who received surgery and chemotherapy ranged from 8·8% in Cuba to 67·6% in Ecuador (Quito; table 6; figure 4B). After adjusting for age, the odds of being treated with surgery and chemotherapy versus neither modality were eight times higher in Ecuador (Quito) than in Russia. After controlling for country or territory, the odds of older women (aged 70–99 years) being treated with both modalities were 80% lower than those of women aged 50–69 years (OR 0·20 [95% CI 0·05–0·35]; appendix pp 32, 36).

Discussion

The VENUSCANCER project has created the largest global database of population-based, high-resolution data from over 250 000 anonymised individual records of women diagnosed with a cancer of the breast, cervix, or ovary during 2015–18, in 39 countries and territories worldwide. Including detailed data on stage at diagnosis, staging procedures, treatment, and biomarkers that are not routinely collected by most population-based cancer registries, this study offers the first real-world picture of the patterns of care and the consistency of treatment with clinical guidelines, on a global scale, for three of the most common cancers in women.

To our knowledge, the largest such comparison to date, for breast cancer only, was between representative samples of around 20 000 women diagnosed during 1996–98 in 12 countries across Europe and seven US states.[23] Several high-resolution studies of breast cancer have been conducted between[26,27] or within[28,29] European countries. Population-based studies on cervical cancer have mainly described trends in incidence or mortality, or the effect of a screening programme on the cure proportion (ie, the proportion of patients who no longer have higher mortality than that of the general population).[30,31] The largest study on ovarian cancer to date is a trial focused on the effect of screening on mortality from the disease,[32] while the largest population-based study focused on risk factors.[33]

Access to early diagnosis and optimal treatment is essential for positive outcomes in patients with cancer. Stage at diagnosis is a key element to select the most appropriate treatment. We have described the stage distribution for cancer of the breast, cervix, and ovary in women across 23 HICs and 15 LMICs (97% of participating countries and territories). As evidenced by the wide variation of known stage at diagnosis around the world, data on stage are still not routinely collected by many population-based cancer registries, even in HICs. To improve comparability, in HICs, we only included registries if at least 70% of records contained high-resolution data on stage at diagnosis and each type of treatment. We included all data available in LMICs due to the paucity of such information and the need to highlight this scarcity of evidence. Nevertheless, provision of financial support enabled the collection of complete data on stage at diagnosis in several LMICs (Ecuador, Georgia, Mongolia, Thailand, Romania, and Uganda), with some variation between breast, cervical, and ovarian cancer.

Although data on in-situ tumours are not routinely collected by all cancer registries, in most HICs, we found high proportions of data on in-situ tumours in women with cervical cancer, reaching over 80%. By contrast, in LMICs, this proportion was in the range 3–55%, and below 20% in Nigeria, Georgia, Mongolia, Romania, and Russia. Although Australia and Jordan did not submit data on stage at cancer diagnosis, they provided data on in-situ tumours. The registry in Iran (Golestan) only had access to clinical records for metastatic cancers.

The effectiveness of early detection initiatives (ie, the extent to which the health system achieves early diagnosis) differed widely between HICs and LMICs, but seemed more pronounced for breast and cervical cancer than for ovarian cancer, which is still widely known as the silent

killer.[34] Early detection of breast and cervical cancer is often enhanced by mass screening programmes, although screening is still opportunistic in many countries.

In most HICs, the proportion of women with early-stage cancer was well over 40% for breast and cervical cancer, but below 20% for ovarian cancer. In the past two decades, this proportion has increased across Europe (from 32% in 1996–98[23] to 39% in 2015–18, as shown in this study) and in the USA (from 39% in 1996–98[23] to 48%, as shown in this study). Despite a general improvement, early detection of cancer in Europe is less effective than in the USA. However, the lower proportion of women with early-stage breast cancer in Europe was mainly driven by the low proportion in LMICs in eastern Europe.

Early detection campaigns for cervical cancer seem to be quite effective in Canada and South Korea, where the proportion of early-stage tumours reached 60% in Canada and 52% in South Korea. By contrast, in most LMICs, these proportions were generally below 20% for all three cancers, but reached 30% for breast cancer and 36% for cervical cancer in Cuba, and 27% for ovarian cancer in Russia, despite the absence of a national screening programme in both countries. Metastatic breast cancers comprised less than 10% in most HICs, but were more frequent in LMICs. However, ovarian cancers were still mostly diagnosed at metastatic stage worldwide. For cervical cancer, there was a less clear-cut difference between HICs and LMICs. Diagnosis of advanced cervical cancer was generally below 15% worldwide.

Since the 1980s, most countries worldwide have adopted population-based screening programmes for breast and cervical cancers to improve early detection.[35,36] These programmes vary by year of implementation, target age group, and periodicity, but they have contributed to a gradual increase in the overall proportion of women diagnosed with early-stage cancer. Across Asia, only Israel, Japan, Singapore, South Korea, and Taiwan had a population-based national breast screening programme in place before 2010.[37] All screening programmes for breast cancer in Central and South America and in eastern Europe are currently opportunistic. In Thailand, a national programme is available for breast and cervical cancer; however, only clinical examination is offered to all women for breast cancer due to limited resources.[38] No population-based screening programme is available in Nigeria or Uganda.[39]

Often, LMICs do not have an efficient health-care infrastructure or the resources required for population-based screening. Together with an absence of awareness campaigns, this situation could partly explain the increased frequency of breast, cervical, or ovarian cancer at a more advanced stage than in HICs. This disparity is likely to have a key role in the international differences in survival for women with breast or cervical cancer.[14,40] Results from our study offer baseline real-world evidence to support the implementation and monitoring of several goals or recommendations of WHO's Global Breast Cancer Initiative[5] and Cervical Cancer Elimination Initiative,[4] as well as the Women, Power and Cancer Commission.[41] For example, the stage distribution of breast cancer is relevant for pillars 1 (early detection) and 2 (timely diagnosis) in the Global Breast Cancer Initiative.[5] Additionally, our results provide baseline population-based evidence not only on the availability of initial treatment that is consistent with clinical guidelines but also an overview of multimodal treatment (part of pillar 3), although these results cannot be used to assess treatment abandonment. For cervical cancer, the results on treatment indicate how far most countries need to improve to reach the 90% treatment target in the Cervical Cancer Elimination Initiative.[4]

National and international clinical guidelines on all the cancers analysed were generally followed in most of the 39 participating countries and territories, but some registries documented regional variation within their countries. Our questionnaires showed that, apart from a few mentions of international guidelines,[42–49] most HICs and several LMICs are still following national or, occasionally, regional guidelines. This situation might be due to the need to adapt international guidelines to local circumstances.

Consistency with international clinical guidelines for treatment was variable, particularly for surgery in women with early-stage breast cancer, chemotherapy in those with advanced cervical cancer, and surgery plus chemotherapy in those with metastatic ovarian cancer. Surgery has become more accessible in LMICs for all three types of cancer, at least for early-stage tumours.

The proportion of women with early-stage breast cancer who were treated with mastectomy was generally higher in LMICs than in HICs. However, mastectomy was also common in the USA, Canada, Estonia, the Netherlands, and Portugal. A US study of 256 081 women diagnosed with early-stage (T1–2 N0–3 M0) breast cancer using data from the SEER program[50] showed a drop from 40% to 35% in the proportion of women treated with a mastectomy from 2000 to 2005, followed by an increase to 38% during 2005–08. A larger US study of over 1·2 million women with early-stage breast cancer (T1–2 any N M0) diagnosed between 1998 and 2011 confirmed the increase in the proportion of mastectomies (from 34% in 1998 to 38% in 2011), particularly among women younger than 40 years.[51] A woman's choice of treatment is an important factor for the decision on the type of surgery to offer,[44,47] but this decision is often based on socioeconomic factors, education, distance from the treatment facility, and fear of recurrence.[52] A study in the USA based on more recent data has highlighted an inappropriate denial of radiotherapy services within the Medicare Advantage plans, which could explain the choice of mastectomy for women older than 65 years.[53]

Breast-conserving surgery without radiotherapy is mainly offered to women older than 70 years with ER-positive breast cancer.[54] However, in most LMICs, the main reason for the high proportion of mastectomies was the scarcity of radiotherapy facilities.[12] In Thailand, older patients tend to prefer mastectomy due to the belief that it offers a better chance of curing cancer.[55]

Consistency with guidelines for systemic treatment for node-positive breast cancer showed less variation than for surgery. The proportion of women with node-positive breast cancer who were treated with chemotherapy was in the range 50–70% in most HICs. Despite its high cost, this treatment was also a frequent option in LMICs, reaching over 90% in Cuba and occupied Palestinian territory (Gaza) and 77% in Uganda (Kampala) and South Africa (Eastern Cape). Endocrine treatment was offered to 80% of women with ER-positive tumours in most countries worldwide, reaching over 90% in Italy, the UK, and Estonia. Lower proportions of endocrine treatment for ER-positive tumours in some countries (eg, the Netherlands) might be due to different guidelines adopted in these countries, or to the reluctance of clinicians to prescribe endocrine treatment, or of patients to receive it.[56] Determining the reasons behind this variation is the subject of further analyses. In LMICs, the observed low proportion of women given endocrine treatment is mainly due to a scarcity of data recording whether this treatment was administered or not.

Data on targeted treatment were generally scarce. However, our study showed that, despite the high proportion of women with HER2-positive breast cancer in Thailand, anti-HER2 treatment was offered to only 26% of women with these tumours, probably due to insufficient resources. By contrast, anti-HER2 treatment was widely offered in South Africa (Eastern Cape; 67% of eligible women).

Around 80–90% of women with early-stage cervical cancer were treated with surgery in both HICs and LMICs, but this proportion was lower in Colombia (71%) and Georgia (65%). Regrettably, this treatment was absent in sub-Saharan Africa because no women were recorded as having been diagnosed at an early stage. Treatment for advanced cervical cancer showed wide variation, with chemotherapy offered to 70–80% of women in most HICs (93% in Canada), but to less than 50% of women in most LMICs, with the exception of Uganda (Kampala; 77%) and Ecuador (Quito; 72%). These findings suggest that the delivery of treatment consistent with guidelines, especially in LMICs, depends on not only the availability of resources but also how they are deployed.

Almost all women with early-stage ovarian cancer were offered surgical treatment, both in HICs and in LMICs. Consistency with treatment guidelines for metastatic ovarian cancer showed much wider variation, both within HICs and LMICs.

Surgery has been recommended as an indispensable component of health care. Investment in surgical and anaesthesia services has been shown to be affordable, save lives, and promote economic growth.[9] Some type of surgery was offered to 78% of women in HICs and 56% of women in LMICs, but overall consistency with clinical guidelines for early-stage tumours was followed more uniformly for cervical and ovarian cancer than for breast cancer. If women in LMICs are diagnosed early, they receive the same guideline-consistent treatment as women in HICs; however, unfortunately, the proportion of women diagnosed with early disease across LMICs is still far too low.

There is no consensus on a specific target time to treatment, but it is widely recognised that delays should not exceed 8 weeks. The median time between diagnosis and treatment for early-stage cancers was generally less than 1 month in several HICs, but could reach 4 months for women with cervical cancer in Mongolia and those with ovarian cancer in Ecuador (Quito), and up to 1 year for those with breast cancer in Mongolia. Delays of this magnitude lead to a more advanced stage at diagnosis and suboptimal treatment.[57]

As previously reported for patients with breast cancer in Europe in the late 1990s,[27,58] our analyses showed that, for all three cancers and in all participating countries, older women (aged 70–99 years) were still less likely to receive treatment consistent with guidelines than women aged 50–69 years, with 50–80% lower odds. This disparity is probably due to barriers to accessing health services related to socioeconomic status or education level. Comorbidities might also explain part of these inequalities. Of the 103 registries, only 29 submitted data on comorbidity, 19 on socioeconomic status, and 11 on education; these data could be the subject of prospective analyses.

Cancer care in HICs is increasingly oriented towards personalised medicine, requiring more complex and often sensitive genetic data to assess care quality. Genetic data are not yet available in population-based cancer registries. However, it is worth highlighting that in many countries, access to life-saving treatment is still challenging. Therefore, monitoring population-wide consistency with guidelines for life-saving treatment remains crucial—ie, appropriate surgery for early-stage tumours, followed by radiotherapy or chemotherapy where indicated. Such monitoring is only possible with high-quality data from population-based cancer registries.

One of the most important features of the ERC Consolidator grant that funded this project was to enable financial support to be offered to cancer registries in LMICs. Providing this support turned out to be far more difficult than expected due to the need to set up complex legal contracts between our institution and each registry, especially where English was not the main language. For some cancer registries, it proved impossible even to open a bank account or receive financial support from another

country, (ie, the UK). These processes were further complicated by the disruption caused by the COVID-19 pandemic during 2020–22.

We finalised the legal contracts to allow transfer of funds for new data collection from primary medical records by selected cancer registries in 11 LMICs. We also completed data-sharing agreements with 18 cancer registries in seven EU member states, Canada, and the USA to enable secure transmission of anonymised but sensitive personal data in compliance with the General Data Protection Regulation (GDPR)[59] or similar laws and regulations. This phase was an extremely time-consuming exercise, especially because it does not take account of GDPR Article 9(2)(i),[59] which permits the processing of anonymised individual records for public health research.

GDPR came into force as a law in 2018 and was designed to apply uniformly to all EU member states, but has actually introduced a further barrier to international research. In many European countries, GDPR is often misinterpreted or interpreted too strictly by administrators, and it has become much more difficult to obtain essential data for research.[60–62] Similar regulations have created problems for the release of detailed data for research in North America. The UK's departure from the EU in 2021 (Brexit) did not help,[63] despite the European Commission's adoption of an adequacy decision about the UK data protection regime, under GDPR Article 45(3), in the same year.[59]

Data cleaning and harmonisation of high-resolution data from over 250 000 individual records was extremely demanding, but it has allowed production of the most robust and comparable set of indicators of worldwide consistency with clinical guidelines available to date. Previous studies have included only a meta-analysis of indicators for ovarian cancer produced by various centres in four HICs,[64] and a study of consistency with guidelines for the treatment of breast cancer in sub-Saharan Africa was based on samples from hospital-based registries only.[65]

Most of the cancer registries that received financial support for data collection in LMICs were able to submit complete data on stage, type of treatment, and biomarkers for patients diagnosed in 1 year between 2015 and 2018. These data, especially on stage at diagnosis and type of surgery, are still not available in many HICs, even though record linkage with clinical databases should not be an obstacle.

It is important to interpret the findings of this study in light of its limitations. Some registries only provided data on stage and initial treatment; some registries only provided data on the number of positive lymph nodes, with or without tumour size, and systemic treatment; and some other registries only provided data on biomarkers and systemic treatment. Therefore, it was not possible to evaluate every indicator of consistency with international clinical guidelines for all 37 countries with complete data on stage and treatment (appendix pp 37–40).

Unfortunately, data on the type of surgery offered to women with breast cancer were not available even from five HICs. 27 of the 103 registries only sent information on stage at diagnosis and whether surgery was available or not; therefore, consistency with clinical guidelines for the treatment of early-stage breast cancer could not be assessed in these countries. For registries in Australia, data on tumour size and nodal involvement were available, but not on whether the tumour was metastatic, so it was impossible to derive TNM stage. Although data on node-positive breast cancer were available, data on chemotherapy were not. Likewise, data on ER-positive breast cancer were submitted, but data on endocrine treatment were not. New Zealand submitted data on stage at diagnosis only; therefore, regrettably, it was not possible to describe compliance with treatment guidelines in Oceania (appendix pp 37–40).

Complete dates to enable precise calculation of time to treatment were provided by only 25 countries. With a few exceptions, population-based cancer registries do not routinely collect all the clinical variables that would be required to assess the complete course of treatment for each patient, including treatment abandonment. We attempted to collect data on the whole clinical follow-up period (eg, recurrences and distant metastasis), but only a few registries in HICs were able to collect these data, and even then, with variable completeness.

Consistency of treatment with the main international clinical guidelines (ESMO, ASCO, and NCCN) is highly variable, particularly for surgery in early-stage breast cancer, for chemotherapy in advanced cervical cancer, and for surgery plus chemotherapy in metastatic ovarian cancer. Prompt access to optimal treatment for patients with breast, cervical, or ovarian cancer is available for early-stage tumours in most countries, where some type of surgery is offered to women with one of these three cancers.

The median time to treatment for women with an early-stage cancer was generally less than 1 month in several HICs, but as long as 4 months to 1 year in some LMICs, leading to more advanced stage and suboptimal treatment. Despite the delays caused by the COVID-19 pandemic, Brexit, and political or administrative issues in some LMICs, the VENUSCANCER project has shown the feasibility of creating a worldwide population-based database that includes detailed data on the clinical therapeutic pathway, as well as biomolecular information, collected by over 100 population-based cancer registries in both HICs and LMICs. These data are essential to monitor consistency with clinical therapeutic guidelines and to set recommendations for future cancer policies. Long-term financial and political support for cancer registries should be a key priority for any government that wishes to implement and maintain robust strategy for cancer control.[66]

Population-based cancer registries are key to assessing the consistency of treatment with clinical guidelines and their impact on the survival of patients with cancer.

Registries should be supported to collect clinical data on the entire course of treatment, on a routine basis, to produce indicators of adherence to clinical guidelines or treatment abandonment. In HICs, the inclusion of key clinical variables (eg, pathology and genomics) in cancer registration records would be feasible if clinicians systematically included these variables in medical records in a timely fashion and they were then promptly transmitted to the cancer registry through efficient record linkages. This project has proven that, in most LMICs, financial support for cancer registries (eg, the salary of one registrar for 6 months) can make a big difference to the quality and completeness of data. Financial support would also be beneficial for cancer registries in several HICs. Policy makers should ensure that international regulations on data protection are not misinterpreted to compromise access to anonymised individual data, which are crucial for rigorous public health research.

Our findings highlight several key messages for governments and policy makers worldwide. Prompt access to optimal treatment for breast, cervical, and ovarian cancers was available in most countries for early-stage tumours; therefore, efforts to promote improvement of early cancer detection should continue, both in HICs and LMICs. An increased number of radiotherapy centres and trained staff in LMICs, together with an increase in the coverage of public health insurance to include radiotherapy for economically disadvantaged women in some HICs, would improve consistency with treatment guidelines involving radiotherapy. International agreement on clinical guidelines is crucial, but they need to be tailored to local needs and resources, simplified, and made available in local languages.

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CA designed the project; acquired the funding; obtained statutory and ethical approvals; drafted the protocol; supervised data acquisition, data quality control, and analyses; checked the results; and drafted the report. VDC, PM, and FG contributed to the study protocol. CA, VDC, and PM contributed to the preparation of legal contracts for financial support to 11 LMICs. VDC, PM, BM, MV, and FM contributed to data acquisition. CA, VDC, and PM had access to all raw data. VDC and PM conducted the data preparation, quality control and analyses, and checked the results. VDC reviewed and edited the draft report. All authors had access to all the quality control reports and the results of the analyses, contributed to writing the final report, and approved the version to be submitted. All members of the VENUSCANCER Working Group had access to the results of all steps of data preparation, quality control, and analyses; and contributed to the interpretation of the findings.

Declaration of interests

We declare no competing interests.

Data sharing

This publication contains the results of a secondary analysis of anonymised individual records provided by more than 100 population-based cancer registries in 39 countries. We hold these data in trust from each participating registry to perform only the analyses agreed in the study protocol, which prohibits the sharing of raw data without express approval from the participating registries.

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